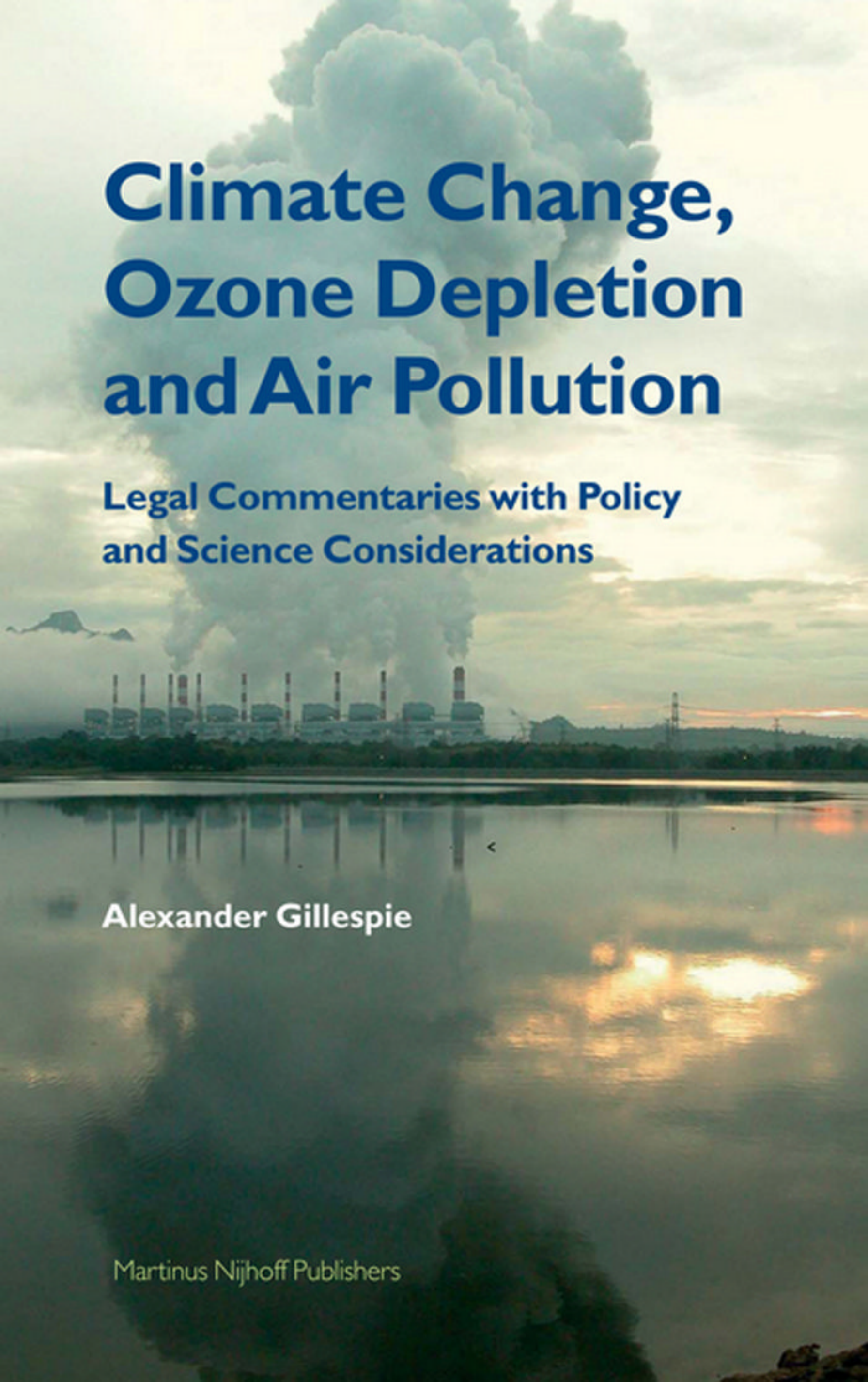

Climate Change, Ozone Depletion and Air Pollution

Legal Commentaries with Policy and Science Considerations

Alexander Gillespie

Martinus Nijhoff Publishers

Climate Change, Ozone Depletion and Air Pollution

Climate Change, Ozone Depletion and Air Pollution

Legal Commentaries within the Context of Science and Policy

Alexander Gillespie

MARTINUS NIJHOFF PUBLISHERS
LEIDEN/BOSTON

A C.I.P. Catalogue record for this book is available from the Library of Congress.

Printed on acid-free paper.

ISBN 90 04 14520 6

http://www.brill.nl

Printed and bound in The Netherlands.

ACKNOWLEDGEMENTS

A number of people and institutions have made this work possible. First, I must thank the Rockefeller Foundation for providing me with a fellowship to reside at the beautiful Bellagio centre in Italy, at which point I was able to solely concentrate and organise this study into something meaningful. Second, to the University of Waikato, for providing me with sabbatical and other support to tackle the project.

Finally, to the people who helped me during the journey. Of particular note are my brother Garry and his family in London, especially Victoria, who let me camp in their house between meetings and kept me well fuelled on coffee and bagels. But most of all, I would like to thank my wife Claire, for her love and support. This book is for her.

CONTENTS

Part I: Science and Analysis

Part II: Law

Part III: Options

PREFACE

The idea behind this book was the need for a principal collection of all of the material necessary to understand the legal debates within their scientific and policy contexts for climate change, ozone depletion and air pollution. The hope is that this manuscript will help those actively involved in the negotiations, or those struggling simply to understand the issues involved. This is a difficult task, as the amount of information coming out of the respective regimes is monumental. In places, this has got so much, that the Parties to the conventions have actually asked their fellow signatories to, 'limit, to the extent possible . . . the volume of comments submitted for consideration by the COP or its subsidiary bodies'.* The downside of all this information is that it is often overwhelming. Indeed, it has been suggested that this mountainous flow is often, 'exceeding the intellectual capacity of most negotiators . . . virtually no-one involved in the negotiations is capable of grasping the overall picture'.** My objective is to try to give the 'overall picture' back to those trying to make sense of these debates of vital international importance.

---

* Decision 17/CP.2. Volume of Documentation. This was reiterated in 1997. Decision 18/CP.3 Volume of documentation.

** Comment on the climate negotiations revolving around the Kyoto Protocol. 9 *YBIEL.* (1998) 188.

ABBREVIATIONS

AJI	Activities Jointly Implemented
AOSIS	Alliance of Small Island States
ASMC	ASEAN Specialized Meteorological Center
AQS	Air Quality Standards
BAU	Business as Usual
CC	Compliance Committee
CDM	Clean Development Mechanism
CFC	Chlorofluorocarbons
CH_4	Methane
CL	Critical Load
CLP	Chlorine Loading Potential
CNG	Compressed Natural Gas
CO	Carbon Monoxide
COP	Conference of the Parties
CO_2	Carbon Dioxide
CT	Carbon Tetrachloride
DU	Dobson Unit
EC	European Commission
EMEP	The Co-operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air pollutants in Europe
EPA	Environmental Protection Agency
ERT	Expert Review Team
ERU	Emissions Reduction Units
EV	Electric Vehicle
ETBE	Ethyl-t-butyl ether
FGD	Flue-Gas desulphurisation
G7	Group of Seven
G8	Group of Eight
G77	Group of Seventy-Seven Developing Countries
GEF	Global Environment Facility
Gg	Gigagramme
GHG	Greenhouse House Gas
Gt	Gigatonne
Gt C	Gigatonne of Carbon dioxide
GWP	Global Warming Potential
IC	Implementation Committee
ICJ	International Court of Justice

ICSU	International Council of Scientific Unions
IGO	Intergovernmental Organisation
ILM	International Legal Materials
IPCC	Intergovernmental Panel on Climate Change
JUSCANZ	Japan, New Zealand, Canada, the United States and Australia
FCCC	United Nations Framework Convention on Climate Change
FFCs	Fully Fluorinated Compounds
HCBD	Hexachlorobutadiene
HCFC	Hydro-Chloro-Fluoro Carbons
HEV	Hybrid Electric Vehicle
HFCs	Hydrofluorocarbons
HNO_3	Nitric acid
H_2SO_4	Sulphuric acid
ICAO	International Civil Aviation Organisation
KPAF	Kyoto Protocol Adaptation Fund
LDCs	Least Developed Countries
LEV	Low Emission Vehicle
LDCF	Least Developed Countries Fund
LULUCF	Land Use, Land Use Change and Forestry
LPG	Liquid Petroleum Gas
IAEA	International Atomic Energy Agency
IGCC	Integrated Gasification Combined Cycles
ILO	International Labour Organisation
IMO	International Maritime Organisation
INC	Intergovernmental Negotiation Committee
IPE	International Protection of the Environment
LRTAP	Convention on Long Range Transboundary Air Pollution
MC	Methyl Chloroform
MDIs	Measured Dose Inhalers
MB	Methyl Bromide
MCP	Multilateral Consultative Process
MPG	Miles Per Gallon
MTBE	Methyl Tertiary-Butyl Ether
NAPA	National Adaptation Plans of Action
NEA	Nuclear Energy Agency
NGO	Non Governmental Organisation
NO	Nitric oxide
NO_2	Nitrogen Dioxide
NOx	Nitrogen Oxides
NH_3	Ammonia
ODP	Ozone Depleting Potential
ODS	Ozone Depleting Substance

OECD	Organisation for Economic and Community Development
OH	Hydroxyl
O_2	Oxygen
O_3	Ozone
PAH	Polycyclic Aromatic Hydrocarbons
PFBC	Pressurized Fluidised Bed Combustion
POCP	Photochemical Ozone Creation Potential
PPB	Parts per Billion
PPM	Parts per Million
PPT	Parts per Trillion
PV	Photovoltaic
QELROS	Qualified Emissions Limitations and Reduction Objectives
SBI	Subsidiary Body on Implementation
SBSTA	the Subsidiary Body for Scientific and Technical Advice
SCCF	Special Climate Change Fund
SF_6	Sulphur Hexafluoride
SIDS	Small Island Developing States
SO_2	Sulphur Dioxide
SOMA	Sulphur Oxide Management Areas
SPM	Suspended Particulate Matter
TOMA	Total Ozone Management Areas
TOMS	Total Ozone Mappings Spectrometer
TSP	Total Suspended Particulates
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UN	United Nations
UV	Ultra Violet
VOCs	Volatile Organic Compounds
WG	Working Groups
WHO	World Health Organisation
WMO	World Meteorological Organisation
WSSD	World Summit on Sustainable Development
YBIEL	Yearbook of International Environmental Law

OFFICIAL CITATIONS FOR MEETING REPORTS

The Vienna Convention

Report of the 1st COP of the Vienna Convention on the Work of Its First Meeting. UNEP/OzL.Conv.1/5. 28 April 1989.

Report of the 3rd COP of the Vienna Convention. UNEP/OzL. Conv.3/6. 23 Nov 1993.

Report of the 4th COP of the Parties to the Vienna Convention. UNEP/OzL.Conv.4/6. 18 Dec 1996.

Report of the 5th COP of the Parties to the Vienna Convention. UNEP/OzL.Conv.5/6. 20 December 1999.

Report of the 6th COP to the Vienna Convention. UNEP/OzL. Conv.6/8. 6. 25 Nov 2002.

The Montreal Protocol

First MOP To the Montreal Protocol. UNEP/OzL.Pro.1/5. 6 May 1989.

Second MOP to the Montreal Protocol. UNEP/OzL.Pro.2/3. 29 June 1990.

Third MOP to the Montreal Protocol. UNEP/OzL.Pro.3/11. 21 June 1991.

Fourth MOP to the Montreal Protocol. UNEP/OzL.Pro.4/15. 25 November 1992.

Fifth Meeting of the Parties to the Montreal Protocol. UNEP/OzL. Pro.5/12. 19 November 1993.

Sixth MOP to the Montreal Protocol. UNEP/OzL.Pro.6/7. 10 October 1994.

Seventh MOP to the Montreal Protocol. UNEP/OzL.Pro. 7/12. 27 December 1995.

Eighth MOP Of the Montreal Protocol. UNEP/OzL.Pro.8/12. 19 December 1996.

Ninth MOP Of the Montreal Protocol. UNEP/OzL.Pro.9/12. 25 September

Tenth MOP of the Montreal Protocol. UNEP/OzL.Pro.10/9. 3 December 1998.

Eleventh MOP of the Montreal Protocol. UNEP/OzL.11/10. 7 Dec 1999.

Twelfth MOP to the Montreal Protocol. UNEP/OzL.Pro.12/9. 10 January 2001.

Thirteenth MOP of the Montreal Protocol. UNEP/OzL.Pro.13/10. 26 Oct 2001.

Fourteenth MOP of the Montreal Protocol UNEP/OzL.Pro.14/9. Dec 5 2002.

Fifteenth MOP to the Montreal Protocol. UNEP/OzL.Pro.15/9. 11 Nov 2003.

First Extraordinary Meeting of the Parties to the Montreal Protocol. UNEP/OzL.Pro.ExMP/1/3. 27 Mar 2004.

The United Nations Framework Convention on Climate Change

First COP to the FCCC. FCCC/CP/1995/7/Add.1. 6 June 1995.

Second COP to the FCCC. FCCC/CP/1996/15/Add.1. 29 Oct. 1996

Third COP to the FCCC. FCCC/CP/1997/7/Add.1. 18 March 1998.

Fourth COP to the FCCC. FCCC/CP/1998/16/Add.1. 20 January 1999.

Fifth COP to the FCCC. FCCC/CP/1999/6/Add.1. 17 January 2000.

Sixth COP to the FCCC. Part One. FCCC/CP/2000/5/Add.2. 4 April 2001.

Sixth COP to the FCCC. Part Two. FCCC/CP/2001/L.7. 16–27 July 2001.

Seventh COP to the FCCC. FCCC/CP/2001/13/Add.3. 29–10 November, 2001.

Eighth COP to the FCCC. FCCC/CP/2002/7. 28 March 2003.

Ninth COP to the FCCC. FCCC/CP/2003/6/Add 1. 22 Apr 2004.

LEGAL INSTRUMENTS CITED IN THIS BOOK

Statute of the International Atomic Energy Agency. (1957) IAEA. Vienna. (89–05761).

Agreement Between the Governments of the United States of America, France and the United Kingdom Regarding Monitoring of the Stratosphere (1976). IPE. XVI. 8289.

World Plan of Action on the Ozone Layer, 1977. In IPE XXVIII, 390.

Convention on Long Range Trans-boundary Air Pollution BH764.txt.

Protocol to the 1979 Convention on Long Range Transboundary Air Pollution on Long Term Financing of the Co-Operative Programme for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe. 27 ILM. (1988). 701.

Protocol to the 1979 Convention on Long Range Transboundary Air Pollution on the Reduction of Sulphur Emissions or Their Transboundary Fluxes by at Least 30 Per Cent. 27 ILM. (1988). 707.

1985 Protocol to The 1979 Convention On Long-Range Transboundary Air Pollution on the Reduction Of Sulphur Emissions Or Their Transboundary Fluxes by at Least 30 Per Cent (the Helsinki Protocol) BH868.txt

Vienna Convention for the Protection of the Ozone Layer. TIAS11097.txt

Agreement Between the Untied States of America and the United Mexican States on Co-Operation for Protection of the Environment in the Border Region, Annex IV. Regarding Transboundary Air Pollution Caused By Copper Smelting Along Their Common Border. 26 ILM (1987). 33.

Montreal Protocol on Substances that Deplete the Ozone Layer. UKTS 19 (1990); 26 ILM (1987) 1550.

Agreement Between the Untied States of America and the United Mexican States on Co-Operation for Protection of the Environment in the Border Region, Regarding Transboundary Air Pollution Caused By Copper Smelting Along Their Common Border. 26 ILM (1987). 33.

Protocol to the 1979 Convention on Long Range Transboundary Air Pollution Concerning the Control of Emissions of Nitrogen Oxides or Their Transboundary Fluxes. 28 ILM. (1989). 212. BH930.txt

Agreement Between the Governments of the United States of America and the Government of Canada on Air Quality. 30 ILM. (1991). 676.

Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution Concerning the Control Of Emissions of Volatile Organic Compounds or their Transboundary Fluxes (1991). BH994.txt

1994 Protocol on Further Reductions of Sulphur Emissions (the Oslo Protocol) 33 ILM (1994). 1542.

The Kyoto Protocol. 37 International Legal Materials (1998). 22.

Draft Protocol to Strengthen and Improve the Effectiveness and Efficiency of the IAEA Safeguards System. 36 ILM (1997) 1232.

I

Science and Analysis

I. BASICS

1. Ozone Depletion

A. The Ozone Layer

The word 'ozone' comes from the Greek word 'ozein' which means 'to smell'. This meaning comes from ozone at the ground level, which gives off a pungent, acrid odour. This meaning clearly reflects the problem of ozone in the lower atmosphere. However, ozone is also present in the stratosphere. The stratosphere is a region roughly ten to fifty kilometres above the Earth's surface, which exists above the planetary boundary layer.[1] This layer absorbs the middle portion of the Ultra Violet (UV) spectrum. Ozone absorbs all UV radiation with wavelengths shorter than about 290 nanometers (UV-C), most of it in the 290 to 320 nanometers range (UV-B) and little above 320 nanometer (UV-A). While UV-A is relatively innocuous, UV-C is lethal and UV-B is harmful to many life forms.[2] Due to the fact that oxygen and other gases absorb wavelengths only below 200 nanometers, the ozone is our sole defence against the middle ultraviolet.

The maximum ozone concentration, occurring between twenty and thirty kilometres above the Earth, is only a few parts per million. Since air at that altitude is about 5% as dense as at ground level, the sparse concentrations of ozone are more aptly described as a veil than as a layer. The measurement of the ozone is done in 'Dobson units' ('DUs'). The DU provides a convenient way of expressing what the total thickness of the ozone layer would be if measured at sea-level. One DU is equal to a thousandth of a centimetre at standard temperature and pressure. A hundred DUs is equivalent to a layer of ozone that, at the temperature and pressure found at the Earth's atmosphere, would be 1 millimetre thick. Three hundred DUs (the average for the globe) corresponds to the abundance of molecules that would form a layer just 3 mm thick at sea level, with the weight of the atmosphere compressing it.[3] The normal amount of ozone over Antarctica is about 400 DUs in summer and 300 in late winter/early

---

[1] Vienna Convention. Article 1, Definitions.

[2] Litfin, K. (1994). *Ozone Discourses*. (Columbia University Press, New York). 54.

[3] Gribbin, J. (1989). 'Centenary Unlocks the History of the Ozone Layer'. *New Scientist*. Feb 4. 24. Farman, J. (1987). 'What Hope for the Ozone Layer Now?' *New Scientist*. Nov 12. 50–54.

spring. This differentiation reflects seasonal variations in the ozone layer. These variations were first noted in 1968.[4]

B. The Destruction of the Ozone Layer

In 1930, an English scientist named Sydney Chapman attempted to explain how ozone was formed and destroyed in the atmosphere. The 'Chapman mechanism' suggested that ordinary oxygen molecules (O_2) was absorb short wavelength ultraviolet light. Oxygen molecules make up 21% by volume of all atmospheric molecules while nitrogen takes up the bulk at 78%. Sunlight, Chapman suggested, was splits apart oxygen molecules into two oxygen atoms (O). Atoms of oxygen would then attach themselves to other oxygen molecules to form ozone (O_3). Chapman also proposed that oxygen atoms could break up oxygen molecules by colliding with them to produce two oxygen molecules. Accordingly, the rate of ozone being produced is equal to the amount being destroyed at any one time. Given constant conditions, the net result is that ozone settles into a dynamic steady state, in which the rate of its formation is equal to its removal.[5]

The theory of a natural balance of the ozone layer is thrown into disarray by the damage caused by Ozone Depleting Substances (ODS). The chemical phenomenon at the root of the ODS theory is the ability of small amounts of chlorine or bromine to destroy ozone in quantity. Chlorine shifts that balance and reduces the amount of ozone in the stratosphere by hastening its conversion into two oxygen molecules. More important, the chlorine (like oxides of nitrogen and hydrogen) acts catalytically as it is unchanged in the process. Consequently, each chlorine atom can destroy thousands of ozone molecules before it is eventually returned to the troposphere, where precipitation as well as other processes remove it from the atmosphere.[6]

As DUs of ozone diminish, the access of UV light increases. By the late 1980s, in certain places at certain times, more than five times the amounts of UV-B light (from before the ozone layer was depleted) were penetrating to the Earth.[7] Compared to (sub-burning) UV radiation hitting the Earth in the mid 1970s, it is a 4% increase in Northern Hemisphere mid-latitudes in summer/autumn and 7% in winter/spring. Over the Arctic, it

---

[4] Gribbin, J. (1989). 'Centenary Unlocks the History of the Ozone Hole'. *New Scientist.* Feb 4. 24.

[5] Roan, S. (1991). *Ozone Crisis.* (Wiley, New York). 12.

[6] Stolarski, R. (1988). 'The Antarctic Ozone Hole'. *Scientific American.* January. 20–25.

[7] Anon. (1989). 'Radiation Flood Through Ozone Hole Is Measured'. *New Scientist.* Apr 15. 18. Anon. (1989). 'Dangerous Radiation Pierces Antarctic Ozone'. *New Scientist.* Aug 26. 7. Anderson, I. (1998). 'A Shade Too Risky'. *New Scientist.* Oct 24. 16.

is 22% more. In the Southern Hemisphere, there is a 6% increase over the entire year (and up to 12% in some regions, such as New Zealand[8] or at the bottom of South America)[9] and over the Antarctic in the Spring, 130%.[10]

Different figures for ozone measurement can be achieved upon whether they are taken as a planetary whole, or are regionally specific. With regard to ozone depletion covering the whole planet (compared to the early 1970s) the predictions of total losses have risen from a 1–2% total loss in the late 1980s,[11] 3% in the mid 1990s,[12] (although it did dip to a total 9% loss in 1993)[13] to 6–7% at the end of the century.[14]

Opposing global averages are those recorded in different regions. The most notable seasonal and geographic differences are at the Poles. However, even the more stable tropical belt experienced drops in the mid 1990s of close to 13% below normal during certain months.[15] These swings are similar to the more settled long-term reductions at Northern and Southern mid-latitudes.[16] For example, in the early 1990s during winter and Spring, research suggested an 8% reduction of ozone over all of Europe, Russia, most of North America and Northern Africa.[17] Later research suggested that relative to the ozone abundance values observed in the 1970s, at the end of the century (1997–2001) of about 4% of the ozone was disappearing over the Northern mid-latitudes in Winter/Spring, and about 2% in summer/autumn. In the Southern mid latitudes, between 1997–2001, it was a 6% loss on an all-year round basis.[18] The most extreme reductions in the ozone layer are over the Arctic and the Antarctic.

In summer over Antarctica, the ozone is usually about 400 DUs. In late Winter and Spring, it was, when measurements first began in 1957, about 300 DUs.[19] In 1987, the then lowest point was recorded at 140

[8] Anon. (1999). 'You Don't Have to Burn To Get Too Much Sun'. *New Scientist.* Dec 11. 8.
[9] Kiernan, V. (1993). 'Harmful Rays Hit Southern City'. *New Scientist.* June 19. 7.
[10] UNEP. (1998). *Environmental Effects of Ozone Depletion: 1998 Assessment.* (UNEP, Ozone Secretariat, Nairobi). x.
[11] MacKenzie, D. (1988). 'Coming Soon: The Next Ozone Hole'. *New Scientist.* Sep 1. 38.
[12] Anon. (1996). 'Burning Issue'. *New Scientist.* July 20. 13.
[13] Kiernan, V. (1993). 'Atmospheric Ozone Hits A New Low'. *New Scientist.* May 1. 8.
[14] Report of the Ninth MOP Of the Montreal Protocol. UNEP/OzL.Pro.9/12. 25 Sep 4.
[15] Anon. (1996). 'Burning Issue'. *New Scientist.* July 20. 13.
[16] UNEP. (1999). *Synthesis of the Reports of the Scientific, Environmental and Economic Assessment Panels.* (UNEP, Ozone Secretariat, Nairobi). 12.
[17] Anon. (1991). 'Ozone Cancer Risk Rises'. *New Scientist.* Apr 13. 7.
[18] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/ OzL.Pro/WG.1/23/3. 5.
[19] Gribbin, J. (1989). 'Centenary Unlocks the History of the Ozone Hole'. *New Scientist.* Feb 4. 24.

DUs.[20] The following year it fell again, but only by 15% below normal.[21] By 1989, the extent of the thinning, at all southern latitudes down to 50 degrees, was 30% in September, and 50% over the Antarctic.[22] In 1992, as the DUs fell to 105 units, the 'largest ever'[23] thinning brought a 50% decline over lower Argentina and Chile.[24] 1993 was a record year and in 1994 the ozone fell to 101 units (equal to 70% depletion) and covered more than 21 million kilometres.[25] A thinning approaching 70% was recorded again in 1996.[26] In 1997, it was shown that the ozone hole was starting earlier and covering a bigger area than previously predicted, and included a 22 million square kilometre thinning covering a section between 14–20 kilometres high where there was 'none at all'.[27] The 1998 loss of ozone over Antarctica was again the biggest on record, being three times larger than the United States.[28] The 2001 loss, although smaller than 2000 was over three times the size of continental Europe and covered 24 million square million miles.[29] In 2002 the hole was a third smaller than at the same time in the period year, due to warmer air temperatures around Antarctica. However, it went on to develop in an erratic way.[30] Given such fluctuations, in 2002 it was deemed not yet possible to say whether the area of the ozone thinning over the Antarctic had reached its maximum size.[31] This warning was sage, as the 2003 thinning ozone initially expanded to previously unforseen levels.[32] However, this initial

---

20 Anon. (1987). 'Ozone Hole Deepens'. *New Scientist.* Dec 17. 5. Verma, S. (1989). 'As Antarctica's Ozone Hole Grows'. *New Scientist.* Oct 7. 9.

21 Anon. (1989). 'Ozone Hole Surprises The Scientists Yet Again'. *New Scientist.* July 29. 12.

22 Anon. (1989). 'Ozone Loss Extends Beyond Antarctic Hole'. *New Scientist.* Dec 9. 15.

23 Report of the Fifth MOP to the Montreal Protocol. UNEP/OzL.Pro.5/12. 19 November 1993. 2.

24 Gribbin, J. (1992). 'Arctic Ozone Threatened By Greenhouse Warming'. *New Scientist.* Nov 28. 16.

25 Report of the Sixth MOP to the Montreal Protocol. UNEP/OzL.Pro.6/7. 10 October 1994. 6. Brown, J. (1994). 'Antarctic Ozone Going Fast'. *New Scientist.* Sep 10. Report of the Seventh MOP to the Montreal Protocol. UNEP/OzL.Pro. 7/12. 27 December 1995. 7.11.

26 Pearce, F. (1996). 'Frozen Clouds Accelerate Ozone Destruction'. New *Scientist.* Oct 12. 6.

27 Anon. (1997). 'Bald Patch'. *New Scientist.* Oct 25. 25. Pearce, F. (1997). 'The Hole Truth'. *New Scientist.* Oct 11. 10.

28 Anon. (1998). 'Gaping Hole'. *New Scientist.* Oct 10. 5. Editor. (1998). 'A Hole in the Greenhouse'. *New Scientist.* Oct 17. 3.

29 UNEP. (2001). 'Threats to Ozone Layer Persist'. Press Release. 01/102. (Oct 16, 2001). Anon. (2000). 'A Hole Lot Bigger'. *New Scientist.* Sep 16. 7. Pearce, F. (2001). 'Ozone Unfriendly: A Quartet of Green Chemicals Face Ban'. *New Scientist.* Oct 20. 17.

30 Anon. (2002). 'Antarctica'. *New Scientist.* Oct 5. 8.

31 Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3.11.

32 Anon. (2003). 'Ozone Hopes Holed'. New Scientist. Oct 11. 4–5. Beston, A. (2003). 'Hole in Ozone Bigger'. *NZ Herald.* Sep 22. A3.

speed of loss did not continue and the 2003 loss was not as large as that as in 2001.[33]

With regard to the Arctic in 1988, the first international scientific studies were showing a 6% reduction in ozone (since 1969) during Winter and 2% in Summer.[34] The geographical size of the loss was about half the size of the area depleted above the Antarctic.[35] Further research suggested in early 1989, 'the significant total ozone decline over the Northern Hemisphere [that cannot be attributed to natural causes] of close to 3% since 1969.'[36] Due to a very similar chemical make-up to that of Antarctica, it was believed that Arctic was 'primed for destruction'[37] and there was 'potential for ozone loss in future years in the region.'[38] The only limitation was believed to be the unique features of the Antarctic, such as the area being much colder which were believed to make large scale ozone destruction less likely in the Arctic.[39] These hopes were soon dented as the rates of ozone depletion continued to outstrip scientific predictions[40] as natural catalysts, like the Mount Pinatubo volcanic eruption, helped the ozone over the Arctic to fall by a record 20% in 1992. This led to further warnings of a potential 'large scale ozone depletion over the Arctic'.[41] Although this did not eventuate in 1993[42] or 1994,[43] in 1995[44] and 1996[45] 30% losses

---

33 Report of the 15th MOP to the Montreal Protocol. UNEP/OzL.Pro.15/9. 11 Nov, 2003. 74.

34 Pearce, F. (1988). 'Ozone Threat Spreads From the Arctic'. *New Scientist.* March 24. 22.

35 Dayton, S. (1988). 'Canadians Confirm Ozone Hole in Arctic'. *New Scientist.* June 9. 47.

36 Report of the COP of the Vienna Convention on the Work of Its First Meeting. UNEP/OzL.Conv.1/5. 28 April, 1989. 4. Final Report: Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol. UNEP/OzL.Pro.WG.1(2)/4. 15.

37 Pearce, F. (1989). 'Is There An Ozone Hole Over the North Pole?' *New Scientist.* Feb 25. 32. Gribbin, J. (1989). 'Arctic Ozone Springs A Leak. As Winter Draws to A Close'. *New Scientist.* July 22. 11. Milne, R. (1989). 'Arctic Hole Eludes Ozone Investigators'. *New Scientist.* Jan 21. 24.

38 UNEP. (1989). First MOP To the Montreal Protocol. UNEP/OzL.Pro.1/5. 6 May 1989. Paragraph 17.

39 Anon. (2002). 'Cold Shocker'. *New Scientist.* Sep 7. 17.

40 Third MOP to the Montreal Protocol. UNEP/OzL.Pro.3/11. 21 June 1991. 3. 2 YBIEL. (1991). 107. Editor. (1996). 'Disaster in the Stratosphere'. *New Scientist.* March 16. 3. Anon. (1996). 'Hole Over Britain'. *New Scientist.* Nov 16. 11. Hecht, J. (1999). 'Polar Alert'. *New Scientist.* June 12. 6.

41 Report of the Fourth MOP to the Montreal Protocol. Copenhagen, 23–25 November, 1992. UNEP/OzL.Pro.4/15. 25 November 1992. 5–6.

42 Anon. (1993). 'Perforations in Arctic Ozone'. *New Scientist.* March 6. 7. Gribbin, J. (1993). 'Deepest Hole Yet Over the North'. *New Scientist.* Sep 18. 18.

43 Anon. (1994). 'Ozone Over America Thins to Record Level'. *New Scientist.* May 28. 16. Anon. (1994). 'Ozone Warning'. *New Scientist.* Jan 29. 11.

44 Pearce, F. (1995). 'Lucky Escape For Ozone Layer'. *New Scientist.* Apr 8. 7.

45 Pearce, F. (1996). 'Big Freeze Digs A Deeper Hole in Ozone Layer'. *New Scientist.* March 16. 7.

were recorded.[46] The depletion came 'close to the deepest yet seen' in 2000,[47] and in the Spring of 2004, nearly 60% of the ozone above the Arctic was destroyed.[48] In 2005 extremely cold weather over the Arctic was leading to predictions that the thinning of the ozone for that winter/spring could be the worst on record.[49]

C. The Future of the Ozone Layer

The pre-industrial level of atmospheric chlorine is believed to have been 0.6 parts per billion (ppb). This concentration was due to naturally occurring methyl chloride.[50] By 1970, chlorine concentrations in the atmosphere were about 1.5 ppb. By 1988 they were 3 ppb, and expected to rise to 5 ppb by 2,000.[51] Reductions of ODS in the 1990s aimed to keep the total concentration down to 4 ppb.[52] These reductions were largely successful, and the total combined abundance of ODS in the lower atmosphere peaked in about 1994 (at 3.02 ppb) and is now falling.[53] Although amounts of total chlorine in the stratosphere is decreasing, total bromine (from halons) was still increasing, during the 1990s (it appeared to have leveled off in 1998) as was the build-up of chlorine from the transitional replacement ODS.[54] However, this increase in chlorine from transitional ODS does not offset the greater declines of traditional ODS which contained greater amounts of chlorine.[55] The total combination of chlorine and bromine was expected to peak in the stratosphere around the year 2000.[56]

---

46 Co-Chairs of the Assessment Panels (2003). *The Synthesis Report*. UNEP/OzL.Pro/WG.1/23/3. 11.

47 Anon. (2000). 'Vanishing Ozone'. *New Scientist*. March 25. 5. Anon. (2000). 'Ozone in Peril'. *New Scientist*. Dec 9. 23. Anon. (2000). 'A Hole Lot Colder'. *New Scientist*. Aug 26. 23. Pearce, F. (2000). 'Freezing Clouds'. *New Scientist*. Jan 22. 18. Walker, G. (2000). 'The Hole Story'. *New Scientist*. March 25. 24–28.

48 Anon. (2005). 'Arctic Ozone Wiped Out By Solar Storms'. *New Scientist*. Mar 12. 17. Note, the non-anthropocentric link to the 2004 depletion.

49 Anon. (2005). 'Ozone Wipe-Out'. *New Scientist*. Feb 5. 7.

50 Benedict, R. (1991). *Ozone Diplomacy*. (Harvard University Press, Cambridge). 128.

51 Anon. (1988). 'Farman Calls For Tighter Controls on CFCs'. *New Scientist*. March 24. 23.

52 Report of the 4th MOP to the Montreal Protocol. Copenhagen, 23–25 November, 1992. UNEP/OzL.Pro.4/15. 25 November 1992. 6. Milne, R. (1990). 'CFC Clampdown Eases Pressure on the Ozone Layer'. *New Scientist*. July 7. 9.

53 Co-Chairs of the Assessment Panels (2003). *The Synthesis Report*. UNEP/OzL.Pro/WG.1/23/3. 5. Pearce, F. (1996). 'Winning The War on Ozone Eaters'. *New Scientist*. June 8. 5.

54 Report of the 8th MOP Of the Montreal Protocol. UNEP/OzL.Pro.8/12. 19 December, 1996. 2. Anon. (2003). 'Bromine Decline'. *New Scientist*. Aug 23. 8.

55 UNEP. (1999). *Synthesis of the Reports of the Scientific, Environmental and Economic Assessment Panels*. (UNEP, Ozone Secretariat, Nairobi). 11.

56 Report of the 10th MOP of the Montreal Protocol. UNEP/OzL.Pro.10/9. December 3, 1998. 3.

Although the overall peak for chlorine and bromine concentrations was in the year 2000, due to the lifetimes of the various chemicals, the ozone layer will not, all things going to plan, return to its normal level until 2050.[57] However, this is a vulnerable recovery.[58] The rate of the fall-off of ODS in the stratosphere will be slower than the build-up of chlorine and bromine in the stratosphere, and may be disturbed by natural occurrences, such as volcanoes, or further anthropogenic ODS releases. In addition, other gases important to ozone chemistry, such as methane and nitrous oxide which are also important to climatic change have the ability to influence the recovery of the ozone layer.[59]

2. Climate Change

'Climate change' refers to a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods.[60] Anthropogenic climate change is caused by 'greenhouse gases'. Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation.[61] Metaphorically, since the gases act much like the glass in a greenhouse, they are commonly called greenhouse gases.[62] Greenhouse gases may either be sequestered into a sink from the atmosphere or emitted into the atmosphere from a 'source'. A 'source' is a process or activity which releases a greenhouse gas, an aerosol or a precursor of a greenhouse

[57] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report*. UNEP/OzL.Pro/WG.1/23/3. 5, 11. Report of the Eighth MOP Of the Montreal Protocol. UNEP/OzL.Pro.8/12. 19 December, 1996. 6. Report of the 9th MOP Of the Montreal Protocol. UNEP/OzL.Pro.9/12. 25 September 2. Anon. (1995). '6th MOP' *Environmental Policy and the Law*. (25:1/2): 21.

[58] Thus, as the 1999 Beijing Declaration noted: "we cannot afford to rest on our laurels, since scientists have informed us that the ozone hole has reached record proportions and the ozone layer recover is a long way from being achieved." Beijing Declaration on Renewed Commitment to the Protection of the Ozone Layer. Annex 1, Report of the 11th MOP. UNEP/OzL.11/10. 7 Dec 1999. 36. See also the 2001 Columbo Declaration, which noted: "much work remains to be done to ensure the protection of the ozone layer." Colombo Declaration on Renewed Commitment to the Protection of the Ozone Layer. Annex V. Report of the 13th MOP. UNEP/OzL.Pro.13/10. 26 Oct, 2001.

[59] UNEP. (1999). *Synthesis of the Reports of the Scientific, Environmental and Economic Assessment Panels*. (UNEP, Ozone Secretariat, Nairobi). 24.

[60] FCCC. Article 1. Definitions.

[61] FCCC. Article 1. Definitions.

[62] Graedel, T. (1989). 'The Changing Atmosphere'. *Scientific American*. September 28–35. Houghton, R. (1989). 'Global Climate Change'. *Scientific American*. 260(4). 18–25.

gas into the atmosphere.[63] A 'sink' is a process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere.[64] A 'reservoir' is a component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored.[65]

A. Historical Greenhouse Gas Concentrations

It is possible to ascertain the historical concentrations of greenhouse gases in the atmosphere from one of three scientific methods. These involve an examination of tree rings (dating back up to 1,000 years)[66] ice-cores from the Poles[67] (dating back 740,000 years)[68] and through the isotopic composition of marine organisms, found in mud on the ocean floor (dating back up to 60 million years).[69] These sources demonstrate three important considerations. First, carbon dioxide (CO_2) concentrations are an indispensable consideration in the Earth's naturally changing climate cycles.[70] Second, CO_2 concentrations alter. There have been periods when the atmosphere contained much more CO_2 than today. For example, during the Cretaceous period, between 144 million and 65 million years ago, the atmosphere contained CO_2 concentrations of up to 2000 parts per million (ppm).[71] Thereafter, apart from a series of oscillations, the CO_2 concentration declined, until about a million years ago. Since then, the CO_2 concentration has moved between 180 ppm and close to 270 ppm, with an occasional high point of 350 ppm. These oscillations are in step with the cycle of Ice Ages and interglacial periods, with low concentrations of CO_2 during the cold Ice Ages and high concentrations during the inter-glacials.[72] Third, climate can change very quickly (within periods of decades to centuries), and this

---

63 FCCC. Article 1. Definitions.
64 FCCC. Article 1. Definitions.
65 FCCC. Article 1. Definitions.
66 Anderson, I. (1991). 'Global Warming Rings True'. *New Scientist.* Sep 21. 13.
67 Hecht, J. (1994). 'Ice Core Throws Up Challenge From the Deep'. *New Scientist.* Jan 8. 14. Beltrami, H. (1994). 'Drilling For A Past Climate'. *New Scientist.* Apr 23. 36–38.
68 Pearce, F. (2004). 'And the Forecast for AD 17,004 Is . . .' *New Scientist.* June 12. 9. Pokar, M. (2003). 'Oldest Ever Ice Core Is a Ticket To Prehistory'. *New Scientis*t. Sep 6. 20.
69 Pearce, F. (2000). 'Gas From the Past'. New *Scientist.* Apr 22. 29–31.
70 Gribbin, J. (1984). 'Carbon Dioxide Controls Ice Age Rhythms'. *New Scientist.* Apr 19. 23.
71 Pearce, F. (1993). 'Ancient Forests Muddy Global Warming Models'. *New Scientist.* Nov 27. 6. Emsley, J. (1994). 'Cool Reception For Warming Predictions'. *New Scientist.* Oct 1944. Oct 8. 19.
72 Gribbin, J. (1984). 'Carbon Dioxide Controls Ice Age Rhythms'. *New Scientist.* Apr 19. 23. Gribbin, J. (1986). 'Temperatures Raise in the Global Greenhouse'. *New Scientist.* May 15. 32–33.

may induce relatively fast temperature changes by a number of degrees (perhaps up to 7c) which may last centuries. These changes may be due to relatively small movements (such as 50–150 ppm) in the concentrations of CO_2.[73] These sudden changes can have strong effects. For example, when the world was last as warm at it is now, within a few decades an area that was once covered in bush and forest was quickly turned into the desert we now know as the Sahara.[74]

B. Increasing Greenhouse Gas Concentrations

Projects for the measurement of atmospheric concentrations of CO_2 were incorporated into the programme of the International Geophysical Year in 1957–1958.[75] Part of this work was done by Charles Keeling, who set up highly accurate gas analysers for the continuous measurement of CO_2 at two sites. The first was near the summit of Mauna Loa in Hawaii, and the second was at Scott base in Antarctica. These sites were chosen because they were free from local contamination and offered well mixed air for sampling. The measurement of air samples was supplemented by samples taken from aircraft flying over oceans.[76] Estimates of pre-industrial concentrations of CO_2 vary, but a generally agreed level is about 275 ppm in 1860.[77] By 1959, when the first accurate modern measurements began, the concentration of CO_2 was just over 315.8 ppm by volume. From this point, the rate of increase was about 0.7 ppm per year. By the late 1970s the CO_2 concentration was 334.6 ppm and the annual growth rate was 1.4 ppm per year.[78] In the 1980s, the concentration increased from 335 ppm at the beginning of the decade to over 350 ppm at the end.[79] This increase reflected an average annual rate of 1.5 ppm (or 0.4% per year

[73] Hecht, J. (1993). 'The Changeable Past of the World's Climate'. *New Scientist.* July 24. 14. Hecht, J. (1993). 'Climate Delivers a Short, Sharp Shock'. *New Scientist.* June 12, 8. Sinclair, J. (1990). 'Global Warming May Distort Climate Cycle'. *New Scientist.* May 26. 9. Kiernan, V. (1996). 'Greenland Ice Holds Key To Climate Puzzle'. *New Scientist.* July 6. 7. Crane, A. (1985). 'Carbon Dioxide, Climate and the Sea'. *New Scientist.* Nov 21. 60. Pearce, F. (2002). 'On The Brink'. *New Scientist.* Feb 2. 18. Homes, B. (1995). 'Arctic Ice Shows Speed of Climate Flips'. *New Sceintist.* March 4. 13.

[74] Pearce, F. (2001). 'Violent Future'. *New Scientist.* July 21. 4.

[75] Plass, J. (1956). 'The Carbon Dioxide Theory of Climate Change'. *Tellus.* 8(2):140–54.

[76] Revelle, R. (1982). 'Carbon Dioxide and World Climate'. *Scientific American.* 247 (2): 33, 35.

[77] Gribbin J. (1981). 'The Politics of Carbon Dioxide'. *New Scientist.* Apr 9. 82–83.

[78] Revelle, R. (1982). 'Carbon Dioxide and World Climate'. *Scientific American.* 247 (2): 33.

[79] Anon. (1989). 'Surge In Carbon Dioxide Prompts New Greenhouse Fears'. *New Scientist.* Apr 1. 21. Joyce, C. (1985). 'Trace Gases Amplify Greenhouse Effect'. *New Scientist.* May 16. 3.

during the 1980s)[80] and was repeated in the 1990s, the concentration of CO_2 in the atmosphere climbed to 367 ppm by the end of the decade.[81] The average overall increases of the 1990s varied from 0.9 ppm (0.2%) to 2.8 ppm (0.8%). A large part of this variability was put down to the effect of climate variability on CO_2 uptake and release by land and oceans.[82] In total, by the year 2000, the atmospheric concentration of CO_2 had increased by 31% since 1750.[83] In the new century, concentrations continued to climb. In 2003, levels rose by about 3 ppm.[84] In 2004, the reading from Mauna Loa was 379 ppm.[85] This figure led to alarm.[86] A large part of the alarm is due to the concern that the present CO_2 concentration in the atmosphere has not been exceeded in the past 420,000 years, if not the past 20 million years. Moreover, the current CO_2 concentration is expected to increase further. Broadly, it is expected that a doubling of CO_2 concentrations in the atmosphere from the pre-industrial levels (from 275 ppm to about 550 ppm) will probably occur by the end of the 21st century if no adequate reductions are made.[87]

Methane (CH_4) levels in the atmosphere began to rise 400 years ago, following 27,000 years of relative stability. Although accurate measurements of methane concentrations began only in the mid 1960s,[88] it is possible to show methane concentrations began to increase after 1580, having got down to levels as low as 0.3 ppm during glacial periods.[89] Around the 16th century, the natural content of methane in the atmosphere was 0.7 ppm and was increasing at a rate of 0.114 ppm. By the twentieth century, the rate was again accelerating, and by the late 1960s methane concentrations had reached 1.4 ppm.[90] In the 1980s, methane levels were growing at an annual rate of 0.8% (or 37 million tons of methane) per year, and by the

[80] IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change.* (Cambridge University Press, Cambridge). 13.
[81] UNDP, UNEP, World Bank, WRI. (2000). *World Resources 2000–2001.* (Oxford University Press, Oxford). 285.
[82] IPCC. (2001). *Climate Change 2001: The Scientific Basis.* (Cambridge University Press, Cambridge). 7.
[83] IPCC. (2001). *Climate Change 2001: The Scientific Basis.* (Cambridge University Press, Cambridge). 7.
[84] Anon. (2004). 'Greenhouse Surge'. *New Scientist.* Mar 27. 5.
[85] Anon. (2004). 'Record CO_2 Levels in Atmosphere'. *Ecologist.* May 11.
[86] Anon. (2004). 'CO_2 Jump Triggers Climate Panic'. *New Scientist.* Oct 16. 4.
[87] IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change.* (Cambridge University Press, Cambridge). 13.
[88] Anon. (1983). 'Have Termites Increased Atmospheric Methane?' *New Scientist.* March 31. 889.
[89] See McElroy, M. (1988). 'The Challenge of Global Change'. *New Scientist.* July 28. 34.
[90] Pearce, F. (1989). 'Methane: The Hidden Greenhouse Gas'. *New Scientist.* May 6. 19.

mid 1990s methane concentrations had risen to 1.7 ppm.[91] Although the increase in the concentration of methane continued to grow through this period, the rate of the increase began to slow in the early 1990s.[92] Nevertheless, as of 2001, the atmospheric concentration of methane had increased by 1060 ppb (151%) since 1750. The concentration of methane seen at the turn of the 21st century has not been exceeded during the past 420,000 years.[93]

The atmospheric concentration of Nitrous oxide (N_2O) has increased by 35 ppb since 1750, when it was 275 ppb, to 310 ppb at the end of the 20th century.[94] The rate of increase during the 1980s alone was 0.25% (3.7 million tons) per year.[95] The present N_2O concentration has not been exceeded during at least the past thousand years.[96]

C. Future Temperature Predictions

At the end of the 19th century Swedish physicist Sven Arrhenius recognized that CO_2 allows short wavelength solar radiation to penetrate the atmosphere but traps this energy when it is re-radiated by the Earth at longer wavelengths. Accordingly, he estimated that if the CO_2 concentration were to double, the Earth would warm by 4 to 6c.[97] The interesting fact about this first prediction is that it is broadly similar to the 2001 Intergovernmental Panel on Climate Change (IPCC) predictions. The IPCC predicts that globally averaged surface temperature shall increase by 1.4 to 5.8°C over the period from 1990 to 2100, with increased temperatures being in the range of 0.1 to 0.2°C per decade over the short-term future.[98]

It is very likely that nearly all land areas will warm more rapidly than the global increases in temperature, particularly those at Northern high latitudes in the cold season. Most notable of these is the warming expected in the Northern regions of North America, and Northern and Central Asia.

---

[91] IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change*. (Cambridge University Press, Cambridge). 12, 13.

[92] Anon. (1993). 'Build-Up of Greenhouse Gas Coming to A Halt'. *New Scientist*. Oct 9. 10.

[93] IPCC. (2001). *Climate Change 2001: The Scientific Basis*. (Cambridge University Press, Cambridge). 8.

[94] UNDP, UNEP, World Bank, WRI. (2000). *World Resources 2000–2001*. (Oxford University Press, Oxford). 285.

[95] Joyce, C. (1985). 'Trace Gases Amplify Greenhouse Effect'. *New Scientist*. May 16. 3.

[96] IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change*. (Cambridge University Press, Cambridge). 12, 13.

[97] For a small history of Arrhenius, see Pearce, F. (2003). 'Land of the Midnight Sums'. *New Scientist*. Jan 25. 50–51.

[98] IPCC. (2001). *Climate Change 2001: The Scientific Basis*. (Cambridge University Press, Cambridge). 13.

Both of these areas exceed expected global mean warming by more than 40%. In contrast, the warming is expected to be less than the global mean change in south and southeast Asia in summer and in southern South America in winter.[99]

It is useful to note that the IPCC 2001 predictions represent a conclusion that has seen earlier projections change. As it stands, since the mid 1970s, individual scientists and/or national scientific institutions have predicted that a doubling of CO_2 concentrations would lead to increases in temperatures ranging from (as upper estimates) 0.25c;[100] 2c;[101] 2.8c;[102] 3.c;[103] 4.0c;[104] 4.2c;[105] 5.0c;[106] 6.0c[107] and even 12.c.[108] The more international predictions began with 1979 World Climate Conference, which notably failed to give a prediction. Rather, it was only declared that, 'it is conceivable that in the future man may be able to produce limited changes in climate on a large scale'.[109] Six years later, the 1985 Villach conference suggested that an increase in temperature from between 1.5 to 4.5c was likely.[110] This figure was reiterated at the 1988 Toronto Conference on the Changing Atmosphere.[111] The first IPCC report in 1990 suggested that on a business as usual (BAU) basis, that mean temperatures will rise by 1.c

[99] IPCC. *Ibid.* 13.
[100] Idso, S. (1981). 'Carbon Dioxide: An Alternative View'. *New Scientist.* Nov 12. 444.
[101] Lewin, R. (1977). 'Atmospheric Carbon Dioxide: A New Warning'. *New Scientist.* July 28. 211.
[102] Revelle, R. (1982). 'Carbon Dioxide and World Climate'. *Scientific American.* 247 (2): 33.
[103] The Global 2000 Report to the President. (1980). *Entering the 21st Century.* (Pelican, New York). 36. White, R. (1990). 'The Great Climate Debate'. *Scientific American.* July 18, 20. Anon. (1980). 'Australia's Weather Confirms The Greenhouse Effect'. *New Scientist.* July 3. 8. NRC (1982) *Carbon Dioxide and Climate: A Second Assessment.* (National Academy Press, Washington). Noted in Anon. (1982). 'The Science and Politics of Atmospheric Carbon Dioxide'. *New Scientist.* Sep 2. 622. Anon. (2000). 'The Heat Is On'. *New Scientist.* March 4. 21.
[104] Anon. (1982). 'The Science and Politics of Atmospheric Carbon Dioxide'. *New Scientist.* Sep 2. 622.
[105] Gribbin, J. (1986). 'Temperatures Rise in the Global Greenhouse'. *New Scientist.* May 15. 32.
[106] Anon. (1986). 'Future Global Warming'. *New Scientist.* Jan 16. 25.
[107] West, S. (1979). 'Carbon Dioxide Induces An Air of Calm'. *New Scientist.* Apr 19. 172. Anon. (2000). 'Hotting Up In The Hague'. *Economist.* Nov 18. 97.
[108] Anon. (2005). 'Sizzling Times Ahead For Earth'. *New Scientist.* Jan 29. 16. Pain, S. (1988). 'Modeling the Greenhouse World'. *New Scientist.* Nov 12. 38.
[109] WMO. (1979). *Proceedings of the World Climate Conference.* (WMO, Geneva). 709.
[110] WMO. (1986). *Report of the International Conference on the Assessment of CO_2 and Other Greenhouse Gases in Climate Vibrations and Associated Impacts.* (WMO No 661, Geneva). Houghton, R. (1989). 'Global Climate Change'. *Scientific American.* 260(4). 18–25.
[111] Anon. (1988). 'Toronto Delegates Call for a 'Law of the Atmosphere'. *New Scientist.* July 7. 24.

by 2025 and 3.c. by 2100.[112] In 1992, this figure was revised, and the BAU temperature by 2100 temperature was downgraded to 2.8c.[113] The IPCC 1996 report suggested that a doubling of CO_2 concentrations would result in a temperature rise of between 1 and 3.5c.[114] The 1 to 3.5 figure was endorsed by the Second Conference of the Parties (COP) in 1996.[115] However, in 2001 the IPCC suggested that the world could warm between 1 and 5.8c by 2100.[116] This replaced all of their earlier figures. Despite this increase, the IPCC did not pinpoint any specific temperature, as any future increases are dependent on issues such as technology, demographic change and economic development.[117]

This possible rapid increase of greenhouse gas concentrations in the atmosphere will probably cause temperatures to soar to levels which have not been seen for tens of thousands[118] if not millions[119] of years. This rapid increase may be between 10 and 40 times faster than rates of warming that humanity is traditionally familiar with.[120]

D. The Warming World

Although the twentieth century began with a period of relative temperature stability, the global average surface temperature had increased by about 0.6°C by the end of the century.[121] The twentieth century increase was in part due to a sequence of record breaking temperatures that followed in

---

112 Jager, E. (ed). *Climate Change: Science, Impacts and Policy: Proceedings of the Second World Climate Conference*. (Cambridge University Press, Cambridge). 23.

113 Pearce, F. (1992). 'Britain Keeps Its Cool As the World Warms Up'. *New Scientist*. Apr 11. 4.

114 IPCC. (1996) *Climate Change 1995: Impacts, Adaptations and Mitigation*. (Cambridge University Press, Cambridge). 3.

115 The Geneva Ministerial Declaration. Report of the Second Session of the COP. 1996. FCCC/CP/1996/15/Add.1. 29 Oct. 1996. Annex. Paragraph 2.

116 IPCC. (2001). *Climate Change 2001: The Scientific Basis*. (Cambridge University Press, Cambridge). 13.

117 IPCC. (2000). *Emission Scenarios*. (Cambridge University Press, Cambridge). 1–15. Pearce, F. (1999). 'All Bets Are Off'. *New Scientist*. Sep 18. 5. Anon. (2000). 'All Change'. Nov 4. 13.

118 Revelle, R. (1982). 'Carbon Dioxide and World Climate'. *Scientific American*. 247 (2): 33.

119 Miller, J. (1989). 'The Model Other Scientists Viewed With Suspicion'. *New Scientist*. Aug 26. 8.

120 IPCC. (1998). *The Regional Impacts of Climate Change: An Assessment of Vulnerability*. (Cambridge University Press, Cambridge). 4.

121 IPCC. (2001). *Climate Change 2001: The Scientific Basis*. (Cambridge University Press, Cambridge). 2. Anon. (2000). 'Hotting Up'. *New Scientist*. Feb 19. 5.

succession from the end of the 1970s.[122] On average, between 1950 and 1993, night-time daily minimum air temperatures over land increased by about 0.2°C per decade. This is about twice the rate of increase in day-time daily maximum air temperatures (0.1°C per decade).[123]

From a global perspective, it is very likely that the 1990s were the warmest decade and 1998 was the warmest year recorded since 1861. Analyses of data for the Northern Hemisphere indicated that the increase in temperature in the twentieth century was likely to have been the largest in any century during the past 1,000 years.[124] In terms of records, 1998, followed by 2002, 2003 and then 2004 were the hottest years on record, and nine of the ten hottest years have been in the last decade.[125] Despite the general trend, it is important to note that some regions have remained relatively stable against the global increases.

In addition to changing temperatures, evidence is also available which demonstrates increased precipitation and storm activity, and enhanced unusual weather patterns (such as El-Nino) over a number (but not all) of regions, an increase in cloud cover over some regions, increased frequency and intensity of droughts in some regions, changes in species migration, shrinkage of glaciers, thawing of permafrost, later freezing and earlier break-up of ice on rivers and lakes, lengthening of mid to high latitude growing seasons, pole-ward and altitudinal shifts of plant and animal ranges.[126] With regard to changes in animals and plants, associations between regional temperatures and observed changes, such as with the timing of phenology

[122] Anon. (1978). 'EEC To Study Climatic Change'. *New Scientist.* Sep 21. 831. Gribbin, J. (1985). 'Hot News on Global Warming'. *New Scientist.* March 21. 4. Gribbin, J. (1984). 'Another Hot Year in the Greenhouse'. *New Scientist.* March 15. 5. Gribbin, J. (1986). 'Global Warming is Linked to Sahal Drought'. *New Scientist.* April 24. 24. Anderson, I. (1988). 'Greenhouse Warming Grips American Corn Belt'. *New Scientist.* June 30. 355. Pearce, F. (1991). 'Warmer Winter Fits Greenhouse Model'. *New Scientist.* Jan 19. 6. Pearce, F. (1996). 'Global Warming Brings Early Spring'. *New Scientist.* July 13. 8. Pearce, F. (1991). 'Another Hot Year Keeps Climate Debate on the Boil'. *New Scientist.* Nov 16. 7. Pearce, F. (1995). 'Hottest Year Heralds Global Warming'. *New Scientist.* Dec 23. 5. Anon. (1997). 'Warming World'. *New Scientist.* Oct 18. 27. Pearce, F. (1999). 'Can't Stand the Heat'. *New Scientist.* Dec 26. 32–33.

[123] IPCC. (2001).*Climate Change 2001: The Scientific Basis*. (Cambridge University Press, Cambridge). 2.

[124] Editor. (2000). 'Steamed Up'. *New Scientist.* Aug 24. 3. Pearce, F. (2003). 'Climatologists Hit Back At Greenhouse Sceptics'. *New Scientist.* July 12. 5.

[125] Anon. (2005). 'Climate Respite?' *New Scientist.* Feb 19. 4. Anon. (2002). 'Hotting Up'. *New Scientist.* March 30. 15.

[126] IPCC. (2001). *Climate Change 2001: The Scientific Basis*. (Cambridge University Press, Cambridge). 5. Edwards, R. (2003). 'The Mother of All El-Nino's Revealed'. *New Scientist.* Jan 18. 4. Withgott, J. (2003). 'Refugee Species Are Feeling the Heat'. *New Scientist.* Jan 4. 4. Pearce, F. (2002). 'Its Started'. *New Scientist.* March 30. 11. Appenzeller, T. et al. (2004). 'The Heat is On'. *National Geographic*. Sept. 2–76.

(such as the date of bud breaking, hatching and/or migration) have been documented in many aquatic, terrestrial and marine environments.[127] There is also already evidence that sections of the ocean are changing in terms of salinity,[128] acidification[129] and temperature.[130]

[127] IPCC. (2003). *Climate Change and Biodiversity*. (IPCC Technical Paper V, Geneva). 12–13. IPCC. (2001). *Climate Change 2001: Impacts, Adaptation and Vulnerability*. (Cambridge University Press, Cambridge). 3. Anon. (2002). 'Heat Seeking Fish Holiday in Cornwall'. *New Scientist*. May 18. 25. Lynas, M. (2004). *High Tide: News From a Warming World*. (Flamingo, London).

[128] Edwards, R. (1999). 'Freezing Future'. *New Scientist*. Nov 27. 6. Adler, R. (1999). 'Fresher Waters'. *New Scientist*. July 31. 22.

[129] Anon. (2004). 'We've Given Oceans Acid Indigestion'. *New Scientist*. July 24. 19. Hecht, J. (2003). 'Alarm Over Acidifying Oceans'. *New Scientist*. Sep 27. 8.

[130] IPCC. (2001). *Climate Change 2001: The Scientific Basis*. (Cambridge University Press, Cambridge). 4. Anon. (1990). 'Growing Greenhouse'. *New Scientist*. March 3. 10. Anon. (2001). 'Sea For Yourself'. *New Scientist*. Apr 21. 23.

II. THE CONSTITUENTS OF THE PROBLEMS

1. The Constituents of Ozone Depletion

A. Chlorofluorocarbons (CFCs)

The five major CFCs (CFC 11, 12, 113, 114 and 115) are all listed in Annex A (1) to the Montreal Protocol. These are the 'classic' ODS. The original CFC was unveiled in 1930 when Thomas Midgley inhaled the vapours from a cup of clear liquid, and blew out a candle's flame.[1] This flamboyant display demonstrated his success in finding a non-toxic, non-flammable alternative coolant by inhaling a lungful of a newly synthesized chemical of fluorine, carbon and chlorine (and thankfully not the closely related bromine).[2] Forty-five years later, this 'perfect' chemical was shown to destroy the ozone layer.

The primary uses of CFCs was for aerosols, refrigeration, air-conditioning, foam blowing and the production of plastics. The industrialized countries which utilized CFCs had different percentages of consumption for different sectors. For example, in the United Kingdom, 80% of CFC usage was in aerosols, 7% in refrigeration and air-conditioning, and 10% in the production of plastics. Conversely, in the United States of America, 20% of CFC utilization was in air conditioning (especially for motor vehicles) and refrigeration and about 50% in aerosols.[3] By 1980, the global totals for CFC uses were, in millions of pounds totals, 415.1 for refrigeration, 356.3 for foam blowing, 536.2 for aerosols and 103.0 for other uses.[4] As domestic restrictions and consumer pressure started to bite, the structure of uses for the CFC market changed, and the dominant percentage utilized in (typically consumer) aerosols fell, by large amounts. For example, by 1979 the United States had reduced its aerosol consumption by 97%.[5] However,

---

[1] See Roan, S. (1991). *Ozone Crisis*. (Wiley, New York). 33–35. Litfin, K. (1994). *Ozone Discourses*. (Columbia University Press, New York). 58.

[2] Had Midgley chosen bromide instead of its close relative chlorine in aerosols and refrigerants, the entire ozone layer could have been destroyed. Chlorine needs ice particles to destroy ozone in large quantities, bromine doesn't. Pearce, F. (2001). 'Lucky Escape'. *New Scientist*. Sep 15. 13.

[3] Anon. (1976). 'The Official View on CFCs and the Ozone Layer'. *New Scientist*. Apr. 29. 213.

[4] CCOL. (1981). 1980 World Production and Sales of CFC 11 & 12. UNEP/CCOL/5/9. 12 Oct.

[5] Gribbin, J. (1979). 'Fluorocarbons As A Global Environmental Case Study'. *New Scientist*. Jan 18. 164–167.

no sooner were these reductions in CFC usage achieved than they began to be offset by the growth of CFC uses in the other sectors of foams, plastics and air conditioners.[6] By 1983, although the use of CFCs in aerosols had decreased by 51% since 1976, non-aerosol CFC usage increased by 56% in the same period.[7] This pattern continued into the late 1980s. For example, of the 260,000 tonnes of CFCs used by the United States in 1988, 18% were for solvents, 35% for refrigeration and air conditioning (with the air conditioning of motor vehicles responsible for about 20% of the overall national total of ODS),[8] and 35% for foam blowing. A further 5.5% was used for sterilization, and 6.5% for miscellaneous purposes.[9] Miscellaneous purposes encompass space travel, which is a clear source of ODS. Indeed, each space-shuttle flight ejects about 187 tons of chlorine, seven tons of nitrogen and 387 tons of CO_2 into the atmosphere. It has been suggested that current space travel could be responsible for up to 1% of the total destruction of the ozone layer. With regard to the propellants used for space craft, alternatives are now being investigated.[10]

Estimates suggested that at the end of the 1980s between 25 and 30% of the global consumption of CFCs went to refrigeration, air conditioning, and the heat pump sector. By 1992, of the 680,000 tonnes of CFCs produced worldwide, 230,000 tonnes went into refrigerators. In developing countries, the proportion of ODS to refrigeration has typically been much greater than in developed countries. For example, in the early 1990s, 74% of India's ODS usage, and 46% of China's ODS usage was for refrigeration.[11]

Accordingly, the once dominant use of CFCs, aerosols, became only a fraction of CFC utilization. This has been reflected internationally. By 1997, CFC consumption for aerosol purposes was less than 15,000 tonnes. All of this took place in developing countries and a few countries in economic transition.[12] Large reductions have also been achieved in the use of

[6] CCOL. (1981). An Environmental Assessment of Ozone Layer Depletion and Its Impact. UNEP/WG. 69/6. Oct 16. Annex 1. Paragraph 7.

[7] Conference of Plenipotentiaries on the Protection of the Ozone Layer. (1985). Final Report of the Ad-Hoc Working Group. UNEP/IG-53/4. January 28. Annex II.

[8] Anon. (1991). 'Inertia Threatens The Ozone Agreement'. *New Scientist.* June 22. 16. Joyce, C. (1988). 'AT & T Leads The Pack in Search For Safer Propellants'. *New Scientist.* Jan 21. 24.

[9] Joyce, C. (1988). 'AT & T Leads The Pack in Search For Safer Propellants'. *New Scientist.* Jan 21. 24.

[10] Ward, M. (1995). 'Green Rockets Blast Off Back to the Steam Age'. *New Scientist.* Oct 28. 24. Roan, S. (1991). *Ozone Crisis.* (Wiley, New York). 16–17. Bertell, R. (2000). *Planet Earth: The Latest Weapon of War.* (Women's Press, London). 73. Aftergood, S. (1991). 'Poisoned Plumes'. *New Scientist.* Sep 7. 34–38.

[11] MacKenzie, D. (1990). 'Cheaper Alternatives for CFCs'. *New Scientist.* June 30. 13. Carvalho, S. (1993). 'Reducing ODS In Brazil'. *Global Environmental Change.* Dec 350–356.

[12] UNEP. (1999). *Synthesis of the Reports of the Scientific, Environmental Effects and Economic Assessment Panels.* (UNEP, Ozone Secretariat, Nairobi). 15.

CFCs in rigid foams, which has been eliminated in all developed countries and, overall has decreased by almost 75% since reaching a peak in 1989.[13] The few remaining areas in which CFC usage remains, are with uses in laboratories and Measured Dose Inhalers (MDIs). Nevertheless, even these remaining exceptions may include relatively large amounts of ODS. For example, in 1997, 500 MDIs consumed approximately 10,000 tons of CFCs.[14]

Between 1930 and 1980, 10,677.2 million pounds of CFC 11 and 14,898.4 million pounds of CFC 12 were produced. The peak year for CFCs 11 and 12 was 1974 when 815.1 million pounds and 976.2 million pounds respectively were produced.[15] Roughly, world production of all ODS in 1974 was 805,000 metric tonnes.[16] World production of CFCs 11 and 12 fell by 18% between 1974 and 1980. Most of the decrease occurred between 1974 and 1977. The was only a 1% decrease in 1979.[17] Thereafter, ODS production began to climb again towards 1980, when 638,500 metric tonnes of CFC 11 and 772,100 tonnes of CFC 12 were consumed.[18] By 1985, total CFC production was more than 1 million tonnes.[19] On average, the per-capita consumption in developed countries was more than 10 times the per-capita consumption in most developing countries.[20]

In 1980, it was estimated that the United States was responsible for 40% of global market of CFCs.[21] By 1989, the United States, Canada, Europe and Japan cumulatively accounted for approximately 80% of the total consumption of controlled chemicals.[22] The United States at this point was consuming approximately 260,000 tonnes of the CFCs used each year.[23]

After this high point for developed country consumption, the consumption figures for ODS utilization in developed countries began to fall rapidly, in accordance with their mandated cuts. By 1992, all developed country

---

13 UNEP. (1999). Ibid. 15.
14 See Miller, D. (1997). 'Open-Ended Working Group of the Parties'. *Environmental Policy and the Law*. 27(5): 396–397.
15 CCOL. (1981). 1980 World Production and Sales of CFCs. UNEP/CCOL/5/9. 12 Oct
16 Anon. (1976). 'The Official View on CFCs and the Ozone Layer'. *New Scientist*. Apr 29. 213.
17 CCOL. (1981). An Environmental Assessment of Ozone Layer Depletion and Its Impact. UNEP/WG. 69/6. Oct 16. Annex 1. Paragraph 7.
18 CCOL. (1981). 1980 World Production and Sales of CFC 11 & 12. UNEP/CCOL/5/9. 12 Oct.
19 Editor. (1995). 'The Truth About Vienna'. *New Scientist*. Dec 16. 3.
20 Final Report: Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol. UNEP 21.
21 Joyce, C. (1980). 'America Clamps Down on Freons'. *New Scientist*. Oct 16. 142.
22 Final Report: Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol. UNEP. 21.
23 Joyce, C. (1988). 'AT & T Leads The Pack in Search For Safer Propellants'. *New Scientist*. Jan 21. 24.

parties had shown reductions beyond the percentages mandated by the Montreal Protocol, with the average reduction in consumption being about 45% less that what they consumed in 1987, and Austria and Sweden recording nearly 80% reductions.[24] By 1999, developed countries consumption of CFCs had fallen from slightly over one million ODP tonnes in 1986 to 50,000 tonnes.[25] In accordance with further mandated reductions agreed in the 1990s, by 2001 the, 'virtual elimination of the production and consumption of CFCs since January 1, 1996' by developed countries was noted in the Ouagadougou Declaration.[26]

One exception to the success of other developed countries reductions in CFC utilization is the Russian Federation. In 1997 Russia was producing 17,000 tonnes of CFCs annually.[27] By 1999, although down by 83% from its 1986 emissions (the OECD average was 97%), Russian consumption still accounted for 12% of the global total. Although Russian production of CFCs was meant to end by the year 2000, there were serious questions about this being achieved.[28]

Unlike the developed countries, the developing world was relatively slow to produce and consume ODS. Indeed, whereas developed countries accounted for about 95% of global CFC production in 1986, by 1999 the developed world accounted for less than one third of the global consumption of ODS. Conversely, the developing countries consumption of CFCs, as a global average increased from less than 15% to more than 80% by 1999.[29] This growth came from small beginnings. For example, between 1968 and 1979, only four Argentinean and Indian companies consumed 20.6 million pounds of CFC 11 and 48.4 million pounds of CFC 12.[30] By 1986 the developing world was producing 100,000 tonnes of CFCs annually. By 1996 this figure was 150,000 tonnes.[31] This increase continued as the number of developing countries rapidly expanded their production.[32] By 1997, of the 300,000 tonnes of CFCs annually produced, 47% came from Russia,

[24] Report of the 4th MOP to the Montreal Protocol. 8. 4 *YBIEL*. (1993). 140–141.
[25] Oberthur, S. (2001) *Production and Consumption of Ozone Depleting Substances, 1986–1999*. (Institute for Environmental Policy, Eschron). 39.
[26] Ouagadougou Declaration. Report of the 12th MOP to the Montreal Protocol. 48.
[27] Pearce, F. (1999). 'Ransom Demand'. *New Scientist*. Dec 4. 22.
[28] Oberthur. Ibid. 41.
[29] Oberthur. Ibid. 37. MacKenzie, D. (1995). 'Ozone's Future Up In The Air'. *New Scientist*. Dec 16. 14.
[30] CCOL. (1981). Planned Workshops on the Effects of UV Radiation. UNEP/CCOL/5/8. 12 Oct.
[31] Anon. (1997). 'Decisions on Illegal CFC Trade & the Multilateral Fund'. *Environmental Policy and the Law*. 27(2): 86–87.
[32] Report of the 5th MOP to the Montreal Protocol.. 2. 4 *YBIEL*. (1993). 140–141.

with China second at 28% and India and Korea third, at 7% each.[33] By 1999, China was producing 50,000 tonnes of the world's CFCs, India was next with 25,000 tonnes, and then South Korea with 9,000 tonnes.[34] Chinese consumption of 43,000 Ozone Depleting Potential (ODP) tonnes accounted for more than one third of the total developing countries utilization in 1999.[35]

The Chinese figure of 43,000 tonnes was a decrease from the Chinese all time high of ODS consumption in 1995 of 75,000 ODP tonnes. Indian consumption grew by 10% per year between 1986 and 1995 (from a very small total of 4,000 ODP tonnes in 1986) before falling by 40%.[36] These decreases reflect the fact that despite the sudden increase in ODS production in a number of developing countries in the 1990s, by the end of the decade, this pattern was changing. For example, by 1998, 26 developing countries had reduced their CFC consumption for the previous three years or more. Some cases are particularly not able, such as China, which after six years of rising CFC consumption, fell by 20% between 1995 and 1996, Kenya had a 35% reduction in CFC consumption in the same period, Ghana had decreased by 60%, and Uruguay reduced CFC consumption by 30%.[37] In an attempt to establish further trends in this area, the Technology and Economic Assessment Panel was directed to assess the quantities of controlled substances, likely to be needed to meet the basic domestic needs of developing countries during the period from 2004 to 2010.[38]

Overall, in terms of all countries, CFC production had decreased by 84% between 1986 and 1999. The remaining 16% represented between 145,000 and 150,000 ODP tonnes per year.[39] It was estimated in 2002 that if all of the remaining CFC consumption had been finished by 2003, the total chlorine loading in the atmosphere, relative to the goal of a reconstituted ozone layer, would have decreased by 4%. If the figure was based on emissions, it would have been 9%.[40]

---

[33] Pearce, F. (1997). 'The Hole That Will Not Mend'. *New Scientist.* Aug 30. 16–17.
[34] Pearce, F. (1999). 'Ransom Demand'. *New Scientist.* Dec 4. 22.
[35] Oberthur. Ibid. 49.
[36] Oberthur, S. (2001). *Production and Consumption of Ozone Depleting Substances, 1986–1999.* (Institute for Environmental Policy, Eschron). 50.
[37] Report of the 10th MOP of the Montreal Protocol. 16.
[38] Decision XV/2. Production for Basic Domestic Needs.
[39] Decision XII/1. Methyl Bromide Production By Non-Article 5 Parties for Basic Domestic Needs in 2001. Oberthur. Ibid. 35–36.
[40] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 22.

B. Halons

International controls on halons are recorded in Annex A (II) of the Montreal Protocol. The traditional halons were 1211, 1301 and 2402. Halons were developed by the United States Army Corps of Engineers after World War II for extinguishing fires in tanks and aeroplanes.[41] To this day, their primary use remains for extinguishing fires. As halons contain bromine, they are much more effective (typically an 8 to 1 ratio) at destroying the ozone layer than chlorine. Halons contribute about 40% of the bromine to the atmosphere. In 1998, although the bromine concentration was just 0.04 parts per trillion (PPT), it has increased fourfold since 1980, and was growing at a rate of 17% per year in the middle of the 1990s. Between 1996 and 2002 the rate of increase of bromine in the atmosphere was reduced to 3% per year.[42] The concentration of halon 1211 in the atmosphere increased by 25% between 1987 and 1999. This concentration, like that for halon 1202, was substantially higher than what was expected.[43]

Global halon production and consumption fell from 200,000 ODP tonnes in 1986 to between 25,000 and 30,000 ODP tonnes in 1999 (i.e. also more than 85%).[44] Although production of halons may be falling, it is important to note that large amounts of halons are accumulated for 'essential' uses, such as fire fighting in restricted spaces. For example, Australia has a store of 2,000 tonnes of halon 1301 to meet essential needs until 2030. Such amounts are often related to specific industries. For example, at any one time, commercial airlines carry 700 tonnes of the chemical. NASA has 40,000 fire-fighting pieces of equipment containing halon 1301.[45]

Although industrialized countries accounted for about 85% of production and consumption of halons in 1986, their share fell rapidly over the next ten years. The exception to this trend with industrialized countries was Russia, which in 1999, was still producing about 1,000 tonnes of halons per year. As the industrialized countries reduced their production of halons, the developing countries increased theirs. Halon production in developing countries increased from about 15% of the global production figures in 1986, to more than 95% by 1999.[46] By 1998, despite the sudden increases, 39 developing countries had zero consumption of halons. This figure hid

[41] Litfin, K. (1994). *Ozone Discourses*. (Columbia University Press, New York). 60.
[42] Co-Chairs of the Assessment Panels. Ibid. 9.
[43] Decision X/8. New Substances With ODS. Anderson, I. (1998). 'We Missed That One'. *New Scientist*. Sep 12. 12. Pearce, F. (1998). 'Something Nasty In the Air'. *New Scientist*. Dec 5. 23. Anon. (1999). 'Ozone Oversight'. *New Scientist*. March 13. 23.
[44] Oberthur, S. (2001). *Production and Consumption of Ozone Depleting Substances, 1986–1999*. (Institute for Environmental Policy, Eschron). 35–36.
[45] Pearce, F. (1999). 'Save Our Gas'. *New Scientist*. Dec 11. 6.
[46] Oberthur. Ibid. 37.

the fact that the growth in halon production was concentrated in only a few developing countries (China, North and South Korea's and India). Of these four countries, China makes up 90% of the developing world production. However, since China exported halons, it only made up two thirds of the consumption of the halons. By 1999, each year, China was producing 45,000 tonnes of halons and South Korea was producing 4,000 tonnes.[47] In the developing world, excluding China, the developing world consumption of halons fell by two thirds in 1999 (8,000 ODP tonnes) from the 26,000 ODP tonnes consumed in 1986.[48]

Despite these decreases, in the new century a certain amount of halon utilization remained. It was estimated in 2002 that if all halon production had been finished by 2003, the total equivalent of chlorine loading in the atmosphere from halons, relative to the goal of a reconstituted ozone layer, would have decreased by 1%. If the figure was based on emissions, and not production, the figure would have been 11%.[49]

C. Other fully halogenated CFCs

Ten other fully halogenated CFCs are listed in Annex B (1) to the Montreal Protocol. The phasing out of other fully halogenated CFCs is virtually complete. This sector never accounted for more than 0.5% of the contribution of the major CFCs. Production has fallen from 3,000 ODP tonnes in 1989, to fewer than 50 ODP tonnes in 1999. At the turn of the century, Russia (20 ODP tonnes) and China (30 ODP tonnes) were the only countries still producing the CFCs listed in Annex B (1).[50]

D. Carbon tetrachloride

Carbon tetrachloride (CT) is listed in Annex B (II) to the Montreal Protocol. CT is primarily a feedstock for making CFCs, although it is also a constituent of pesticides and a grain fumigant.[51] Although the potential risk of CT to the ozone layer was identified in 1981, it was not restricted until a decade later, at which point it was recognized that CT, accounted for between 16 to 17% of the chlorine in the atmosphere.[52]

---

[47] Pearce, F. (1999). 'Ransom Demand'. *New Scientist.* Dec 4. 22.
[48] Oberthur. Ibid. 51.
[49] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 22.
[50] Oberthur. Ibid. 61.
[51] Final Report: Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol. UNEP/OzL.Pro.WG.1(2)/4. 20.
[52] MacKenzie, D. (1989). 'Substitute CFCs Will Stoke Global Warming'. *New Scientist.* May 13. 3. UNEP. (1989). First MOP To the Montreal Protocol. UNEP/OzL.Pro.1/5. 6

Working out exactly how much CT is produced and consumed is difficult, as only those amounts of CT used as a final product (not those used as feedstock) are supposed to be included in the production and consumption data for a country. Nevertheless, since 1992, information on how much CT is used in feedstock is supposed to be reported to the Secretariat. However, reporting on this has been haphazard. The result has been unsatisfactory data records for CT.[53] Despite these difficulties, it was estimated that in 1998, 30,000 tonnes of CT, to be used as feedstock, were being produced each year.[54] At the same time, an estimated 41,000 tonnes of CT were consumed.[55]

Despite these difficulties in establishing hard facts on production and consumption, it appears that industrialised countries have largely phased out the production and consumption of CT.[56] Likewise, with developing countries, despite an initial increase in CT production and consumption, by 1998, 50 developing countries had no production or consumption of CT. Overall, in terms of both developed and developing countries, in 1998, the data suggested that compared to how much CT was being produced and consumed in 1986, by 1998, a reduction of 89% had been achieved.[57]

E. Methyl chloroform

Methyl chloroform (MC) is listed in Annex B (III) to the Montreal Protocol. The exact contribution of MC to damage in the ozone layer has been a matter of debate. Part of this debate is due to the fact that MC is both a naturally occurring substance, and one which is anthropogenically generated.[58] Originally, it was assumed that MC accounted for 16 to 17% of the total for chlorine in the atmosphere that damages the ozone.[59] However, later revisions suggested that anthropogenic MC contributed less than 10% of the total amount of chlorine in the atmosphere.[60]

May 1989. Paragraph 18. Gavaghan, H. (1990). 'Ozone Culprits Named By American Pressure Group'. *New Scientist.* Jan 27. 10.

[53] Decision VI/10. Use of Controlled Substances as Process Agents.

[54] Decision X/12. Emissions of ODS from Feedstock Applications.

[55] UNEP. (1999). *Synthesis of the Reports of the Scientific, Environmental and Economic Assessment Panels.* (UNEP, Ozone Secretariat, Nairobi). 15.

[56] Oberthur, S. (2001). *Production and Consumption of Ozone Depleting Substances, 1986–1999.* (Institute for Environmental Policy, Eschron). 57–58, 62.

[57] Report of the 10th MOP of the Montreal Protocol. UNEP/OzL.Pro.10/9. December 3, 1998. 17.

[58] UNEP. (1989). First Meeting of the Parties To the Montreal Protocol. UNEP/OzL.Pro.1/5. 6 May 1989. 13.

[59] Gavaghan. Ibid. 10.

[60] MacKenzie, D. (1989). 'Substitute CFCs Will Stoke Global Warming'. *New Scientist.* May 13. 3. UNEP. (1989). First MOP. Ibid. 16.

During the 1980s, it was estimated that anthropogenic MC emissions were increasing at the rate of 7% per year. This increase reached a peak in 1989, when production reached 70,000 tonnes per year. This fell to less than 2,000 ODP tonnes in 1996. This decrease represented more than a 95% reduction. More than 8% of the remaining MC production at the end of the twentieth century occurred in industrialized countries. The consumption of developing countries grew from 1,200 ODP tonnes in 1989 to more than 5,000 ODP tonnes in the mid 1990s, before falling back to 2,000 ODP tonnes in 1999. Most of the MC production and consumption in the developing world occurs in only a few countries, as 43 developing countries have no consumption of MC.[61] Overall, in terms of all countries, in 1998, compared with the 1986, MC production and consumption has been reduced by 96%.[62] Despite these decreases, in the new century, a certain amount of MC utilization remained. It was estimated in 2002 that if all of MC production had been finished by 2003, the total chlorine loading in the atmosphere, relative to the goal of a reconstituted ozone layer, would have decreased by 0.3%. If this figure was based on emissions, and not production, the figure would have been 4%.[63]

F. Hydrochlorofluorocarbons (HCFCs)

Hydrochlorofluorocarbons (HCFCs) are listed in Annex C (I) to the Montreal Protocol. Global production and consumption of HCFCs appears to have increased from about 14,000 ODP tonnes in 1989 to 37,000 ODP tonnes in 1999. Industrialized countries accounted for 90% of this market in 1989, but only 80% in 1999. The production of HCFCs has leveled off in recent years. The growth in the production of HCFCs in developing countries increased from about 1,400 ODP tonnes in 1989 to about 5,500 ODP tonnes in 1999. China increased production and consumption of HCFCs from 15% of the developing country total in 1992 to 35% in 1999.[64] Fluoro-form, which is a waste byproduct of the manufacture of HCFC-22 was increasing at the rate of 5% per year in 1999. This equated to a total of 135,000 tonnes of fluoro-form in the atmosphere. Fluoro-form has a lifespan of 260 years.[65] In the year 2000, HCFCs represented 6% of the total chlorine from anthropogenic sources in the lower atmosphere. The

[61] Oberthur, S. (2001). *Production and Consumption of Ozone Depleting Substances, 1986–1999.* (Institute for Environmental Policy, Eschron). 61, 67.

[62] Report of the 10th MOP of the Montreal Protocol. UNEP/OzL.Pro.10/9. December 3, 1998. 16–17.

[63] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 22.

[64] Oberthur. Ibid. 70–71, 75, 79. Report of the 10th MOP. Ibid. 17.

[65] Pearce, F. (1998). 'Grim Surprise'. *New Scientist.* Feb 7. 13.

rate of increase in chlorine from HCFCs was constant at 10 ppt per year from 1996 and 2000.[66] It was estimated in 2002 that if all HCFC production had been finished by 2003, the total chlorine loading in the atmosphere, relative to the goal of a reconstituted ozone layer, would have decreased by 5%. If this figure was changed to emissions, as opposed to production, the decrease of chlorine in the atmosphere would have been 9%.[67]

G. Hydrobromofluorocarbons & Bromochloromethane

Hydrobromofluorocarbons and Bromochloromethane were listed in Annex C (II) and C (III) respectively in the Montreal Protocol in 1996. No detailed information is available on these chemicals.

H. Methyl bromide

Methyl bromide (MB) is listed in Annex E to the Montreal Protocol. MB is used primarily as a fumigant. Most of it is pumped under plastic or glass, into soil for growing crops such as strawberries and vegetables. It is also used to fumigate crops after harvesting and during shipping.[68] Of the 1996 global MB production 71,425 tonnes, quarantine and pre-shipment use was 15,000 tonnes, or equivalent to 22% of global fumigant use.[69] In 2003, it was estimated that quarantine and pre-shipment use of MP was only about 7,000 ODP tonnes annually. In addition, 11 Parties to the Montreal Protocol were applying for exemptions for critical uses relating to agriculture of 14,899 tonnes.[70] By 2004 the figure for requested critical uses for 2005 was 15,838 tonnes (of which the MB Technical Options Committee had recommended 13,158 ODP tonnes).[71] In 2002, the United States consumed 40% of the global total of MB at 27 million kilogrammes per year.[72]

MB releases bromine. Bromine is much more effective at destroying ozone than chlorine. Scientists did not calculate the extent of the danger from MB until 1991. This was partly because it was thought that MB in the atmosphere was produced primarily by natural processes. Over time,

[66] Co-Chairs of the Assessment Panels. Ibid. 10.
[67] Co-Chairs of the Assessment Panels. Ibid. 22.
[68] Pearce, F. (1995). 'Introducing The Ozone Friendly Bacteria'. *New Scientist.* Oct 28. 10.
[69] UNEP. (1999). *Synthesis of the Reports of the Scientific, Environmental and Economic Assessment Panels.* (UNEP, Ozone Secretariat, Nairobi). 17.
[70] Report of the 15th MOP to the Montreal Protocol. UNEP/OzL.Pro.15/9. 11 Nov, 2003. 35.
[71] Report of the First Extraordinary MOP to the Montreal Protocol. UNEP/OzL.Pro.ExMP/1/3. 2004, Mar 27. 5. Anon. (2004). 'Fruit Threat to Ozone Layer'. *New Scientist.* Dec 4. 4.
[72] Report of the 11th MOP to the Montreal Protocol. 6.

this assumption has been replaced with the realization that anthropogenic MB has a direct impact on the ozone layer.[73] However, the exact contribution of anthropogenic MB to ozone loss has been a source of controversy. In 1992, this contribution was put at between 5 to 10% of the observed ozone loss since 1980. Later analysis suggested the contribution could be between 15 and 30%.[74] In 2002, it was suggested that an immediate ban on the consumption of MB would reduce the damage to the ozone layer by 4%.[75]

Accurate records of MB production and consumption are difficult to establish because of the 'quarantine and pre-shipment' exception within the Montreal Protocol. This exception results in national consumption figures of MB being partly hidden. Accordingly, part of the global production and consumption figures for MB are missing from the official data, although these are supposed to be sent to the Secretariat for general information.[76] Nevertheless, it was estimated that in 1988, quarantine and preshipment applications of MB accounted for 18% of all MB emissions in 1998 and 22% in 1999.[77] In terms of total amounts, global production and consumption of MB remained relatively stable between 35,000 and 38,000 ODP tonnes between 1991 and 1998. This stabilization followed an estimated 50% increase in production and consumption between 1984 and 1990. However, as industrialized countries began to implement their 25% mandated cut at the end of the century, global consumption dropped to around 30,000 ODP tonnes in 1999. Industrialized countries account for 95% of MB production and the United States and Israel account for 80% of this.[78] In 2004 the United States was permitted to utilize 7,659 ODP tonnes for its critical uses in 2005. Italy has the second highest critical usage at 2,133 ODP tonnes and Spain has ODP 1,059 tonnes. A further eight countries consume 1,432 ODP tonnes. The primary consuming industries within the United States quota are strawberries (1,833 ODP tonnes) and tomatoes (2,865 ODP tonnes).[79–80]

---

73 2 *YBIEL.* (1991). 385.

74 Report of the 4th MOP to the Montreal Protocol. 6. Report of the 7th MOP to the Montreal Protocol. 7.

75 Pearce, F. (2002). 'US Millers Fight for Banned Pesticide'. *New Scientist.* Oct 5. 11.

76 Oberthur, S. (2001). *Production and Consumption of Ozone Depleting Substances, 1986–1999.* (Institute for Environmental Policy, Eschron). 81–81.

77 Decision XI/13. Quarantine and Pre-Shipment. Also, Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 37.

78 Pearce, F. (1997). 'A Very Bad Atmosphere'. *New Scientist.* Sep 20. 12. Pearce, F. (1995). 'Introducing The Ozone Friendly Bacteria'. *New Scientist.* Oct 28. 10.

79 Report of the First Extraordinary MOP to the Montreal Protocol. Annex II.

80 Pearce, F. (1997). 'Promising the Earth'. *New Scientist.* Aug 30. 4.

By 2003, it was suggested that consumption of MB had decreased at average rate of about 5% per year since 1998. Some developed countries have reduced consumption of MB by more than 20% of what they were consuming in the early 1990s. Fifteen of these countries plan to phase out all MB utilization between 2006 and 2009.[81] Available data on MB production in developing countries has shown China increased production of MB from 170 ODP tonnes in 1995 to 876 ODP tonnes in 1999. This was a reduction of China's 1998 MB production figure of 1,400 ODP tonnes.[82]

It was estimated in 2002 that if all MB production had been finished in 2003, the total chlorine loading in the atmosphere, relative to the goal of a reconstituted ozone layer, would have decreased by 4%. If this figure was changed to emissions, rather than production, the figure would still have been 4%.[83]

I. New Chemicals

In addition to the chemicals noted above, a number of new chemicals have been listed as a source of concern, but have not yet been listed in the Annexes to the Montreal Protocol. These include n-propyl bromide. This substance is primarily used as a solvent and for feedstock purposes. Studies in 2002 suggested that roughly 0.5% of the bromine emitted as n-propyl bromide reaches the stratosphere.[84] Emissions of n-propyl bromide were predicted to reach 40,000 tonnes by 2010. This is an increase from the 10,000 tonnes produced in 2001.[85] Additional new chemicals for concern include hexachlorobutadiene (HCBD). HCBD is used as a solvent and produced as a by-product of chlorinated chemical production.[86] Finally, 6-bromo-2-methoxyl-naphthalene, which is used in manufacture of methyl bromide, is an important new chemical to note.[87]

---

[81] Decision XII/1. Methyl Bromide Production By Non-Article 5 Parties for Basic Domestic Needs in 2001. Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 7, 35. Report of the 10th MOP of the Montreal Protocol. 17.

[82] Oberthur, S. (2001). *Production and Consumption of Ozone Depleting Substances, 1986–1999.* (Institute for Environmental Policy, Eschron). 86–87.

[83] Co-Chairs of the Assessment Panels. Ibid. 22.

[84] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 10.

[85] Decision X/8. New Substances With ODS. Decision XIII/7. N-Propyl Bromide. UNEP. (1999). *Synthesis of the Reports of the Scientific, Environmental Effects and Economic Assessment.* (UNEP, Ozone Secretariat, Nairobi). 19.

[86] Report of the Twelfth Meeting of the Parties to the Montreal Protocol. 9, 17.

[87] UNEP. (2001). 'Threats to Ozone Layer Persist'. Press Release. 01/102. (Oct 16, 2001).

J. Overlapping Climate Change Gases

A number of gases which influence other international environmental problems also contribute to ozone depletion. Although the air pollutants of aerosols,[88] sulphate particles[89] and carbon monoxide[90] all contribute to ozone depletion, the main pollutants which have a strong influence are related to climate change. Thus, as the 1985 Vienna Convention recognized, CO_2 was a chemical which, 'affects stratospheric ozone by influencing the thermal structure of the atmosphere'.[91] The influence upon the thermal structure relates to the general idea of global warming, or more specifically, 'increasing concentrations of CO_2 should decrease the temperature of the stratosphere, altering rates for several key reactions, resulting in a change in ozone'.[92] The basic theory that warming in the troposphere will result in cooling in the stratosphere has remained largely unchallenged. However, the influence that this will have upon the ozone layer has been the subject of debate. Originally, it was assumed that cooling in the stratosphere, caused by global warming, could off-set the destruction of the ozone layer. This cooling was believed to enhance natural chemical reactions which stimulate the manufacture of ozone.[93] However, by 1989, this view was challenged with the currently prevailing theory that a cooler stratosphere was not beneficial for the protection of the ozone layer as it would be catalytic for its accelerated, prolonged destruction.[94]

In addition to the above generic problems associated with a general warming, there are also two key climate change gases, CH_4 and NOx, which play additional roles in ozone destruction. The projected increases in these gases are predicted to have small chemical effects on the rate of increase of the total global column of ozone in the next fifty year. However, this could become more significant later in the 21st century.[95]

---

[88] The aerosols help attenuate UV radiation. Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 24.

[89] By providing surfaces on which ozone destroying compounds act. Charlson, R. (1994). 'Sulfate Aerosol and Climatic Change'. *Scientific American.* Feb 28–35.

[90] According to the Vienna Convention, Carbon monoxide is believed to have: "an indirect role in stratospheric photochemistry." Annex 1 (4)(i).

[91] Annex 1 (4)(ii).

[92] CCOL. (1983). List of Substances Capable of Modifying the Stratospheric Ozone: Draft Text Submitted by the USA. UNEP/CCOL/6/4/Add 2. April 5. 4.1.2.

[93] Anon. (1979). 'Ozone Weathers the Greenhouse Effect'. *New Scientist.* July 12. 87. Anon. (1987). 'Carbon Dioxide Adds Uncertainty to Ozone Debate'. *New Scientist.* Oct 22. 13.

[94] Co-Chairs of the Assessment Panels. Ibid. 12–13. Report of the 13th MOP. UNEP/OzL.Pro.13/10. 26 Oct, 2001. 27. Gribbin, J. (1989). 'Greenhouse Gases Put The Chill on Arctic Ozone'. *New Scientist.* May 13. 13. Pearce, F. (1999). 'Chill In the Air'. *New Scientist.* May 1. 29–32. Gribbin, J. (1992). 'Arctic Ozone Threatened By Greenhouse Warming'. *New Scientist.* Nov 28. 16. Hecht, J. (1999). 'Polar Alert'. *New Scientist.* June 12. 6.

[95] Co-Chairs of the Assessment Panels. Ibid. 12.

The Vienna Convention also noted that methane, 'affects both tropospheric and stratospheric ozone'.[96] Originally, it was assumed that methane made a beneficial contribution to the ozone layer because it coverted ozone-depleting chorine to hydrolic acid, which came back down to Earth in rain.[97] However, by the late 1980s, the idea that methane may be beneficial was rejected, and CH_4 was reclassified as having a negative effect due to the realisation that methane may be a precursor to reactions that destroy ozone in the stratosphere. This happens because, when CH_4 rises to the stratosphere, the molecules are broken apart. This frees hydrogen atoms, which react with oxygen to form water. Such oxidation of methane produces about half of the water in the stratosphere. Some of that high altitude water forms ice crystals and stratospheric clouds in the Polar regions. The ice crystals greatly increase the conversion of atmospheric chlorine into forms that destroy ozone during the Polar winters. The stratospheric clouds can magnify ozone depletion because they help to convert the chlorine from synthetic CFCs into the active chlorine that reacts with the ozone.[98] This process may be responsible for an increase of as much as 28% in the level of water in the stratosphere over the last 50 years, and as much as 45% over the past two centuries.[99]

The other greenhouse gas which impacts upon the ozone layer is Nitrous oxide. The Vienna Convention notes that nitrous oxide, 'is the primary source of stratospheric NOx, which plays a vital role in controlling the abundance of stratospheric ozone'.[100] Specifically, NOx has a,

> direct role in only in tropospheric photochemical processes and an indirect role in stratosphere photochemistry, whereas injection of NOx close to the troposphere may lead directly to a change in upper troposphere and stratospheric ozone.[101]

The realization that NOx may have an influence on the ozone layer began in 1970, when Paul Crutzen discovered that NOx catalyses the breakdown of stratospheric ozone into molecular oxygen. These gases are produced in the atmosphere from NOx which is released by micro-organisms in the soil. Crutzen showed that this is the main pathway for breaking down ozone naturally. This discovery began to cast suspicion over human generated NOx, and Harold Johnson, came to suggest that supersonic aircraft

[96] Annex 1 (4)(iii).
[97] MacKenzie, D. (1984). 'Anybody Want to Save the Ozone Layer?' *New Scientist.* Nov 15. 10. CCOL. (1983). Ibid. 4.1.3.
[98] Pearce, F. (1989). 'Methane: The Hidden Greenhouse Gas'. *New Scientist.* May 6. 19.
[99] Anon. (1988). 'Rising Methane Means Falling Ozone'. *New Scientist.* March 24. 31.
[100] Annex 1 (4)(b)(i).
[101] Annex 1 (4)(b)(ii).

(such as the Concorde) could destroy the stratospheric ozone by releasing NOx in the middle of the ozone layer.[102] Although this idea was challenged, it was later shown that about 25% of NOx in the stratosphere originates from aircraft. In the lower stratosphere, where the ozone destruction is concentrated, this figure may rise to 60%. Aircraft engines also discharge an estimated 80 million tonnes of water vapour into the stratosphere every year.[103] Such vapour, when combined with particulate soot and other condensable gases, such as sulphate aerosols, on the stratosphere may have a detrimental impact on the ozone layer by providing the platforms and chemical catalysts from which chlorine reactions can take place.[104]

The other source of by nitrogen is through its use as a fertilizer in agriculture. It was hypothesized in the mid 1970s that this could lead to a 20% reduction in the ozone layer within 100 years.[105] The interest in this theory was such that research into nitrogen oxides and nitric acid was directed in the two primary research collaborations of this period.[106] As research progressed over the 1980s, the role of this factor was initially downplayed[107] before coming back into the spot-light, as a result of its indirect relationships with solar considerations in the stratosphere and its build-up and concentration in the Antarctic and elsewhere.[108] By 2002, it was feared that all of the achievements of the Montreal Protocol in reducing chlorine and bromine in the stratosphere, could be offset by rapid rises in NOx, which is released by nitrogen fertilizers, some industrial processes and the burning of fossil fuels. The IPCC suggested that its concentration

102 Hecht, J. (1995). 'Ozone Prophets Reach Rarefied Heights'. *New Scientist*. Oct 21. 10. Anon. (1976). 'Washington Hearing Satisfy Neither Concorde Lobby Nor Critics'. *New Scientist*. Jan 15. 108. Gribbin, J. (1990). 'Supersonic Plans Threaten Ozone Layer'. *New Scientist*. June 9. 4. Anon. (1976). 'UN Meteorologists Accept SSTs But Still Fear Fluorocarbons'. *New Scientist*. Jan 15. 109.

103 Pearce, F. (1994). 'Saving the Ozone With a No-Go Zone'. *New Scientist*. Apr 30. 14–15.

104 Patel, T. (1993). 'Green Designs on Supersonic Flight'. *New Scientist*. Aug 14. 35. Pearce, F. (1994). 'Airlines Take Ozone Monitors on Board'. *New Scientist*. March 26. 8. Hecht, J. (1999). 'Polar Alert'. *New Scientist*. June 12. 6. Anon. (1993). 'High Speed Threat To Ozone Layer'. *New Scientist*. June 19. 17. Pearce, F. (1997). 'Aircraft Wreak Havoc On Ozone Layer'. *New Scientist*. Feb 15. 15.

105 Anon. (1976). 'Agriculture May Be Worse than Fluorocarbons'. *New Scientist*. June 24. 685. Anon. (1978). 'Nitrate Fertilisers Threaten the Ozone Layer'. *New Scientist*. Sep 26. 918.

106 Agreement Between the Governments of the United States of America, France and the United Kingdom Regarding Monitoring of the Stratosphere (1976). IPE. XVI. 8289. Article IV. See also the 1977 Ozone Plan of Action. Recommendation 2. See Roan, S. (1991). *Ozone Crisis*. (Wiley, New York). 73–80.

107 Stolarski, R. (1988). 'The Antarctic Ozone Hole'. *Scientific American*. January 20, 23.

108 Pyle, J. (1991). 'Closing In On Arctic Ozone'. *New Scientist*. Nov 9. 49–53. Gribbin, J. (1990). 'Why Arctic Ozone Has Survived So Far'. *New Scientist*. April 14. 11. Anon. (1986). 'Air Chemists Braced For Battle Over Ozone Hole'. *New Scientist*. Nov 6. 22.

in the air could increase by 45% by 2100. This increase could, after 2040, offset any recovery of the ozone layer.[109]

2. The Constituents of Climate Change

A. Carbon Dioxide

Carbon dioxide (CO_2) is an odourless and invisible molecule which is an essential component of the atmospheric budget which maintains life on Earth. If there were no CO_2 in the atmosphere, heat would escape more easily from the Earth. The surface temperature required for the balance between incoming and outgoing radiation would be lower and the oceans might be a solid mass of ice. On Venus, which has no oceans, the atmosphere consists mainly of CO_2, so that the greenhouse effect is much more severe and the surface temperature is 400c. On Mars, where the atmosphere is very thin, the effect is weaker and the surface temperature is 50 degrees centigrade. Thus, irrespective of the current debates about climatic change, there is already a so-called greenhouse effect.[110]

The total amount of CO_2 in the atmosphere is little more than 0.03% by volume. Despite its low concentration, it has important ramifications. In contrast to both oxygen and nitrogen which together make up more than 99% of the atmosphere, the trace greenhouse gases absorb infrared radiation, or radiant heat. This is a continuous process which has been in operation on Earth for millions of years. Indeed, whenever the carbon atom is released from a molecule of CO_2, it will flit back and forth between plants, soil, air and water for approximately 100,000 years, before eventually returning to the quiescent reservoir of the sediments. The average carbon atom has made the cycle from sediments through vegetation, soils, air and water some 20 times over the course of the Earth's history.[111]

Over time vast quantities of CO_2 have been emitted by volcanoes. Almost all of it has been chemically transformed into calcium carbonate and magnesium carbonate or into organic matter and has been buried in marine sediments. The amount of carbon in sedimentary carbonates is about 50

---

[109] Pearce, F. (2002). 'Another Good Reason To Fake That Suntan'. *New Scientist.* March 16. 8.

[110] Schneider, S. (1987). 'Climate Modeling'. *Scientific American.* 256(5): 3. Revelle, R. (1982). 'Carbon Dioxide and World Climate'. *Scientific American.* 247(2): 33.

[111] McElroy, M. (1988). 'The Challenge of Global Change'. *New Scientist.* July 28. 34. Graedel, T. & Crutzen, P. (1989). 'The Changing Atmosphere'. *Scientific American.* September. 28–35. Houghton, R. (1989). 'Global Climate Change'. *Scientific American.* 260(4). 18–25.

million gigatonnes of carbon (Gt C) and the amount in sedimentary organic matter is estimated to be about 20 million Gt C. The total of some 70 million Gt C is almost 2,000 times more than all the carbon in the atmosphere, the oceans and the biosphere, which amounts to about 42,000 Gt C. The atmospheric component is itself a small fraction of this amount, at roughly 700 Gt. The fact that most of the carbon in the Earth's surface layers has passed through the atmosphere and has been buried in sediments accounts for the moderate strength of the greenhouse effect in the Earth's atmosphere.

In addition to the already captured CO_2 in the Earth's ecosystems is the fact that these ecosystems, notably the atmosphere, oceans and terrestrial systems, all continue to play a part in dealing with the increasing emissions of greenhouse gases into the atmosphere. For example, of the 270 Gt (+/−30) of CO_2 emitted between 1850 and 1998 and the 136 (+/−55) resulting from land-use change (typically deforestation) resulting in a 28% increase in carbon concentration (from 285 ppm to 366 ppm), only 43% of this increase has been retained in the atmosphere. The remainder, about 260 (+/−60) Gt is estimated to have been taken up in approximately equal amounts by the oceans and the terrestrial ecosystems.[112] Due to this fact that at least half of all CO_2 emissions are not ending up in the atmosphere, it is essential to have a broad understanding of the other inter-related ecosystems.

(i) Oceans

It has been long realized that the oceans and climate are connected. In a contemporary context, a foremost example of this has been with the El-Nino phenomenon in which heat masses in the ocean change, making ocean currents change directions and associated land masses are affected with unusual weather conditions.[113] The linkage between climate change and the oceans was first made in the 1950s when it was suggested that human activities may be adding to the build-up of CO_2 in the atmosphere. These views were initially dismissed because most scientists assumed because the sea holds around 60 times as much CO_2 as the atmosphere and exchanges around 15 times as much CO_2 as all human activities, almost

[112] IPCC. (2000). *Land Use, Land Use Change, and Forestry*. (Cambridge University Press, Cambridge). 4. Groot, P. (1989). 'Balancing the Carbon Budget'. *New Scientist.* Jan 6. 9. Crane, A. (1985). 'Carbon Dioxide, Climate and the Sea'. *New Scientist.* Nov 21. 60.

[113] Note the debate about the relationship between climate change and El Nino. See Anon. (2003). 'We're Off the Hook Over El-Nino'. *New Scientist.* July 19. 22. Pearce, F. (1999). 'Can't Stand the Heat'. *New Scientist.* Dec 26. 32–33 Pearce, F. (1999). 'Weather Warning'. *New Scientist.* Oct 9. 36–39. Pearce, F. (1989). 'Blowing Hot and Cold in the Greenhouse'. *New Scientist.* Feb 11. 62.

all of the anthropogenic CO_2 would be sequestered by the oceans and thereby withdrawn from the atmosphere.[114] However, this complete negating effect was discounted by most climate scientists by the 1970s, and a much more dynamic role of the oceans in relation to climate change was realized, although debates from the impact of choppy seas, through to phytoplankton and thermohaline circulation and their relationship with climatic change have continued.[115] Nevertheless, overall, with regard to the oceans, 'considerable quantitative uncertainty remains regarding the processes'.[116] Two areas of uncertainty are of particular concern.

The first area relates to what is broadly known as thermohaline circulation. This term refers to the fact that the world's oceans are linked by a single circulation system that stirs waters from the ocean depths to the surface and back roughly every thousand years. Major ocean currents, such as the Gulf Stream, form part of this larger system. The circulation, known as the 'conveyor belt' is one of the main methods by which the planet circulates heat and removes CO_2 from the atmosphere. The system is driven by strong convection currents which are located in four small areas of the world's oceans. One occurs where the waters of the Mediterranean enter the Atlantic. The other three areas are all in the Polar regions including the Greenland and Labrador Seas of the far North Atlantic and the Wendell Sea off Antarctica. These convection currents are central concerns in the maintenance of regional climate. For example, warm surface water is drawn north throughout the Atlantic at a flow rate more than a hundred times that of the Amazon river. It then sinks to the deeps of the Greenland and Labrador Seas, and returns to the Southern Ocean at 2 to 3 km below the surface as the so-called 'North Atlantic Deep Water.' The waters release heat into the cold Northern atmosphere at a rate equivalent to 100 times the world's energy consumption. This energy warms the air over Europe by at least 5.c.[117]

It is possible that climate change may affect ocean circulation. Historical evidence suggests that previous climatic change, such as with the last Ice Age, managed to stop circulation of the oceans, and they accordingly

---

114 Williamson, P. (1991). 'How Plankton Change the Climate'. *New Scientist.* March 16. 44. Revelle, Ibid. 33–34.

115 Pearce, F. (2001). 'Choppy Seas May Take the Edge Off Global Warming'. *New Scientist.* Apr 14. 12. Pearce, F. (1997). 'Global Warming Chills Out Over Pacific'. *New Scientist.* Feb 22. 16. Gribbin, J. (1988). 'The Oceanic Key to Climate Change'. *New Scientist.* May 19. 32–33.

116 IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change.* (Cambridge University Press, Cambridge). 17.

117 Rahmstorf, S. (1997). 'Ice Cold Paris'. *New Scientist.* Feb 8. 26. Gribbin, J. (1989). 'Warmer Seas Increase Greenhouse Effect'. *New Scientist.* Jan 6. 11. Pearce, F. (1995). 'Is Broken Ocean Pump A Global Warning?' *New Scientist.* March 19. 4. Crane. Ibid. 60.

become stagnant for several thousand years. In a contemporary context, it is theorized that climate change may again affect ocean circulation.[118] The current projections using climate models do not show a complete shutdown of the thermohaline circulation by 2100. However, beyond 2100, the thermohaline circulation could completely, and possibly irreversibly, shutdown in either hemisphere if the change in radiative forcing is large enough in terms of both impact and duration.[119]

This problem may occur if the oceanic conveyor belt is disrupted by injections of either warm or fresh (less saline) water. The increase in fresh water is most likely to come from melting ice, increased precipitation, or run-off. These sources will probably interact with both the salinity and the heat of the flows. Both of these will probably affect the mechanics of the systems.[120] If these ocean mechanics are affected, it is possible that there will be, 'important feedbacks for the climate system'.[121] There is already evidence that sections of the ocean are becoming less saline and warmer.[122]

There are two clear risks if ocean circulation changes. The first is that enhanced climate change may dramatically diminish the capacity of the oceans to absorb CO_2. The presence of a warmer surface layer inhibits convection, which brings dense, saline water from the deep ocean to the surface at high latitudes, where it cools (giving up heat to the atmosphere) and sinks back to form cold, deep ocean currents. One effect of this suppression, is that the CO_2 previously taken down to the deep ocean by newly formed deep water, may not occur. Depending on the increase in CO_2, this could reduce the capacity uptake by up to 50%.[123] Moreover, if ocean circulation changes, the heat held in the top few metres of the ocean could be released. Likewise, large sources of methane, held in lattice-like geological structures called clathrates, exist on the continental shelf. These 'deposits' are physically bound to water in nodules which are kept

[118] Anon. (2005). 'Ocean Conveyor Belt Shuts Down.' *New Scientist.* Feb 12. 10. Anon. (2004). 'Plankton Point to Balmy Arctic Seas'. *New Scientist.* Dec 18. 19. Pearce, F. (2001). 'Dead In the Water'. *New Scientist.* May 19. 10.

[119] IPCC. (2001). *Climate Change 2001: The Scientific Basis.* (Cambridge University Press, Cambridge). 16.

[120] Broecker, W. (1995). 'Chaotic Climate'. *Scientific American.* Nov 44–50. Pearce, F. (1997). 'Dam The Mediterranean'. *New Scientist.* July 26. 10. MacKenzie, D. (1997). '*Sea Ice Meltdown*'. New Scientist. Sep 6. 4.

[121] IPCC. (1996) *Climate Change 1995: Impacts, Adaptations and Mitigation.* (Cambridge University Press, Cambridge). 8.

[122] IPCC. (2001) Ibid. 4. Anon. (1990). 'Growing Greenhouse'. *New Scientist.* March 3. 10. Anon. (2001). 'Sea For Yourself'. *New Scientist.* Apr 21. 23. Edwards, R. (1999). 'Freezing Future'. *New Scientist.* Nov 27. 6. Adler, R. (1999). 'Fresher Waters'. *New Scientist.* July 31. 22.

[123] Pearce, F. (1996). 'Will A Sea Change Turn Up The Heat ?' *New Scientist.* Nov 30. 16. Anon. (1998). 'Getting Warmer'. *New Scientist.* May 23. 27. Anon. (1990). 'Changes in Ocean Currents'. *New Scientist.* July 14. 19.

stable by the pressure of the water and earth above them. It is believed that changing patterns in the oceans could affect these and their captured CH_4 could be released if they were cracked, or eroded by warmer waters penetrating to the bottom of the oceans.[124] The second risk pertains to sudden changes in temperature on associated land masses. If the Gulf Stream, which keeps Western Europe several degrees warmer that it would be otherwise, were to cease circulation, temperature changes of up to 5.c. (or higher) could occur within decades, although this may be partly offset by global warming.[125]

The second area of risk with the carbon budget and the marine ecosystem relates to phytoplankton. The influence of phytoplankton on the carbon budget has been closely examined since 1990. It is studied because marine plankton takes up CO_2 during photosynthesis. Although much of the CO_2 is returned to the water when the plankton dies and decomposes, some of it reaches the seabed, where it becomes buried. Overall, it is suggested that about 100 billion tonnes of CO_2 are stored by phytoplankton each year. This process could be disrupted due to the fact that plankton populations may be vulnerable to warmer waters caused by stratification in which the warm surface layers of the ocean no longer mix with the cooler layers beneath. This may cut off the supply of nutrients from the lower layers, reducing the productivity absorption capacity of plankton. A hypothetical loss of 10% of phytoplankton would reduce the annual uptake of CO_2 by the oceans by about 5 Gt C. This is the amount equivalent to all the annual emissions of CO_2 from fossil fuel consumption.[126] In addition, less phytoplankton could also result in less absorption and scattering of light which may help cool the topmost layers of the ocean.[127] Finally, reduced phytoplankton may result in less dimethyl sulphide (the gas that gives sea air its bracing smell). Dimethyl sulphide plays a key role in helping clouds to nucleate. Exactly what the impacts on clouds, may be which have a feedback into climate change, is a matter of debate.[128]

[124] Anon. (2005). 'Methane Burps'. *New Scientist.* Feb 12. 10. Joyce, C. (1988). 'Underwater Methane Could Fuel Warming'. *New Scientist.* Dec 17. 9. Pearce, F. (1989). 'Methane: The Hidden Greenhouse Gas'. *New Scientist.* May 6. 19, 23. Brown, W. (1990). 'Flipping Oceans Could Turn Up the Heat'. *New Scientist.* Aug 25. 11

[125] Anon. (1997). 'Unlucky Irish'. *New Scientist.* Dec 6. 25. Pearce, F. (1995). 'Global Warming Jury Delivers Guilty Verdict'. *New Scientist.* Dec 9. 6.

[126] Charles, D. (1990). 'The Sea's Forgotten Carbon Enters Climate Debate'. *New Scientist.* Dec 15. 6. Pearce, F. (1995). 'Pacific Plankton Go Missing'. *New Scientist.* Apr 8. 5. Crane, A. (1985). 'Carbon Dioxide, Climate and the Sea'. New Scientist. Nov 21. 60. Anon. (2005). 'Hungry Algae Plunged Earth Into Deep Freeze'. *New Scientist.* Feb 5. 16.

[127] Williamson, P. (1991). 'How Plankton Change the Climate'. *New Scientist.* March 16. 44.

[128] Fell, N. (1993). 'Can Algae Cool The Planet?' *New Scientist.* Aug 21. 34–37. Leggett, J. (1992). 'Running Down to Rio'. *New Scientist.* May 2. 38–42.

(ii) Terrestrial Ecosystems

There is carbon uptake in both vegetation and soils in terrestrial ecosystems. Current carbon stocks are much larger in soils than in vegetation, particularly in non-forested ecosystems in middle and high latitudes. Of a estimated total of 2,477 Gt C, 2011 are within soils (down to a depth of a metre) and only 466 Gt C are in vegetation. With regard to vegetation, the top four sources are tropical forests at 212, boreal forests at 88, tropical savannas at 66, and temperate forests at 59. The next biggest source is wetlands at 15 Gt C, followed by temperate grasslands at 9, deserts and semi-deserts at 8, tundra at 6 and croplands at 3 Gt C. Conversely, with CO_2 stored in soils, the largest stocks are within boreal forests at 471 Gt C, followed by temperate grasslands at 295, tropical savannas at 264, wetlands at 225 and tropical forests at 216. Deserts and semi-deserts are at 191, tundra at 121 and finally temperate forests held 100 Gt C. In overall group terms, this means that boreal forests have the highest carbon stocks at 559 Gt C, followed by tropical forests at 428 Gt C. The smallest stock is held in tundra at 127 Gt C.[129]

From 1850 to 1998, approximately 270 (+/−30) Gt C were emitted as CO_2 into the atmosphere from fossil fuel burning and cement production. About 136 (+/−55) Gt C were emitted as a result of land-use change, predominantly in terms of forest ecosystems.[130] With particular regard to the contribution from changes in forest ecosystems it is necessary to divide this sector into two contexts. The first is historical deforestation in temperate countries and the second is modern deforestation in tropical countries.

In deeply historical terms, it is possible that the concentrations of CO_2 that started to rise about 8,000 years ago, may have begun due to early human agricultural deforestation and crop irrigation.[131] In more contemporary historical terms, it is believed that post 1850 'pioneer agriculture' across North America, Europe, South Africa, Australia and New Zealand was responsible for 10% of the carbon in the atmosphere at the end of the nineteenth century. By 1950, this source was believed to have added 120 Gt C of carbon into the atmosphere, while over the same period the increase from burning fossil fuels was only 60 Gt C.[132] Hypothetically, if all of the carbon released by historical land-use changes could be restored to the terrestrial biosphere over the course of the century (for example, by

129 IPCC. (2000). *Land Use, Land-Use Change, and Forestry*. (Cambridge University Press, Cambridge). 4.
130 IPCC. Ibid. 4.
131 See Ruddiman, W. (2005). 'How Did Humans First Alter Global Climate?' *Scientific American*. Mar. 34–41.
132 Gribbin, J. (1979). 'Woodman, Spare That Tree'. *New Scientist.* March 29. 1016. Gribbin, J. (1978). 'Fossil Fuel: Future Shock'. *New Scientist.* Aug 24. 541.

reforestation), the CO_2 concentration would be reduced by between 40 ppm to 70 ppm.[133]

In contemporary terms, tropical deforestation as a prime source of CO_2 has been apparent since the late 1970s. The recognition of the magnitude of this source increased during the 1980s and 1990s with estimates ranging from 2 to 4 billion tonnes of CO_2 being released each year.[134] Later work in the new century suggested that up to 9 billion tonnes of carbon came into the atmosphere from natural sources (typically wildfires) in the tropics, between 1982 and 1999.[135] The 1997 forest fires in South East Asia alone were estimated to have released 1.7 billion tonnes of carbon from the burning of peat bogs.[136] Halting deforestation in tropical countries could reduce CO_2 emissions by up to three billion tonnes per year.[137]

In many countries, land which was once cleared but has subsequently been reforested is now acting as a sink for CO_2. For example, temperate forests, planted in the past 40 years in the Northern Hemisphere alone, may be absorbing millions of extra, previously unaccounted, tonnes of carbon per year from the atmosphere. This is due to the large plantings that had occurred between 1920 and 1960 when boreal forests increased fourfold in size in Europe, North America and Russia.[138] Accordingly, whereas it was initially believed that the planted temperate forests were not that close (1.6 +/−1.0 Gt C/yr) to offsetting deforestation, later analysis suggested that the total (tropical and temperate) net CO_2 release was much closer to equaling each other (1.1 +/−1.2 Gt C/yr) in terms of emissions and sequestration than previously assumed.[139] By the year 2000 it was suggested that over the previous two decades planted terrestrial ecosystems might have served as a small net sink for CO_2. This appears to have

[133] IPCC. (2001). *Climate Change 2001: The Scientific Basis*. (Cambridge University Press, Cambridge). 12.

[134] Anon. (1977). 'Lost Forests Exacerbate Carbon Dioxide Threat'. *New Scientist*. Apr 14. 61. Lewin, R. (1977). 'Atmospheric Carbon Dioxide: A New Warning'. *New Scientist*. July 28. 211. Gribbin, J. (1979). 'Woodman, Spare That Tree'. *New Scientist*. March 29. 1016. Pye-Smith, C. (1998). 'Ragged Edge'. *New Scientist*. Aug 22. 12. Pearce, F. (1989). 'Felled Trees Deal Double Blow to Global Warming'. *New Scientist*. Sep 16. 7.

[135] CBD Secretariat. (2001). *Impacts of Human Caused Fires on Biodiversity and Ecosystem Functioning and Their Causes in Tropical, Temperate and Boreal Forest Biomes*. (CBD Technical Series No. 5). Singer, E. (2003). 'Space Map Plots Vanishing Forests'. *New Scientist*. July 19. 7.

[136] Pearce, F. (2002). 'Forest Fires Fuel Pollution Crisis'. *New Scientist*. Aug 17. 5, 9.

[137] Levine, J. (1996). *Biomass Burning and Global Change*. (MIT Press, London). Houghton, R. (1989). 'Climate Change'. *Scientific American*. 260(4). 18–25.

[138] Pearce, F. (2001). 'Global Green Belt'. *New Scientist*. Sep 15. 15. MacKenzie, D. (1993). 'Did Northern Forests Stave Off Global Warming?' *New Scientist*. Sep 11. 6. MacKenzie, D. (1994). 'Where Has All the Carbon Gone?' *New Scientist*. Jan 8. 30–34. Pearce, F. (1992). 'Flourishing Forests Mop Up Missing Carbon'. *New Scientist*. July 11. 10.

[139] IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change*. (Cambridge University Press, Cambridge). 18.

occurred in spite of net emissions from deforestation in the tropics.[140] There is an irony here in that many of the temperate forests which are currently sucking up carbon are built on a historical pattern which involved the destruction of previous forests in the eighteenth and nineteenth centuries which released vast amounts of CO_2 in the process.[141]

In addition to carbon being held in ecosystems such as forests, large amounts are also stored in other ecosystems. For example, about 14% of the Earth's organic carbon is tied up in the frozen peat beneath the tundra. Methane is also believed to be trapped in tundra.[142]

Peatlands (including bogs, fens, carrs, and peat swamp forest) are characterized by their unique ability to accumulate and store dead plant material under waterlogged conditions. An active peatland is one on which peat is currently forming and accumulating. The presence of peat or vegetation capable of forming peat is the key characteristic of peatlands. Peatlands are the most prevalent wetlands in the world, representing 50 to 70% of all wetlands and covering 3% of the land and freshwater surface of the planet. Peatlands can be coastal/marine or inland/fresh. Peatlands contribute to biological diversity, global water issues, wetland functions and climatic change.[143] Peatlands are particularly notable of global importance, for as the (Ramsar) Convention on Wetlands of International Importance has noted they are, 'a major storehouse of the world's carbon, exceeding that of forests.'[144] It is estimated that somewhere between 270 to 370 Gt C equivalent is currently stored in the peats of boreal and sub boreal peatlands alone. Globally, peat represents about one-third of the total soil carbon pool and contains approximately the equivalent of two thirds of all carbon in the atmosphere.[145]

It is estimated that the bogs of Europe, Siberia, and North America hold the equivalent of 70 years of global industrial emissions of organic

[140] IPCC. (2000). *Land Use, Land Use Change, and Forestry*. (Cambridge University Press, Cambridge). 4. Wofsy, S. (2004). 'The Case of the Missing Carbon'. *National Geographic*. Feb 89–116.

[141] Editor. (1998). 'Fuel's Paradise'. *New Scientist*. Oct 24. 3.

[142] Joyce, C. (1988). 'Underwater Methane Could Fuel Warming'. *New Scientist*. Dec 17. 9. Pearce, F. (1989). 'Methane Locked in Permafrost May Hold Key To Global Warming'. *New Scientist*. March 4. 28. Houghton, R. (1989). 'Global Climate Change'. *Scientific American*. 260(4). 18–25.
Edwards, R. (2001). 'Drying Bogs May Release Years of Pollution'. *New Scientist*. Jan 27. 6.

[143] Resolution 8.11. Additional Guidance for Identifying and Designating Under Represented Wetland Types as Wetlands of International Importance. (2002, Valencia). Annex. Identification and Designation of Peatlands.

[144] Resolution 8.17. Guidelines for Global Action on Peatlands. (2002, Valencia). Annex. Paragraph 14.

[145] SBSTA. (2003). *Biological Diversity and Climate Change*. UNEP/CBD/SBSTTA/9/INF/12. Sep 30. 56.

carbon in their peatlands.[146] Emissions of CO_2 from Indonesia's peat bogs in 1997 were initially believed to release more CO_2 during a six month period that all of the Western Europe's power stations and vehicle emissions over a one year period.[147] However, later research suggested that the 1997 blazes released as much as 2.6 billion tonnes of carbon into the air. This amount was equivalent of between 13 to 40% of global emissions from the burning of fossil fuels in the same year.[148] Continued burning of peatlands in the Tropics in 2004 was associated with the sudden accelerated increase in the atmospheric concentrations of CO_2.[149]

Aside the direct anthropogenic utilization or destruction of peats, it also appears that peat bogs are already releasing increased amounts of dissolved organic carbon, which ultimately contributes to climatic change. Climate change may affect these peatlands, and in doing so release either (or both) the stored carbon or methane. Exactly what will occur if such carbon or methane is released is a matter of debate, although there is a clear risk that as temperature, hydrology and composition of peatlands change and as permafrost melts, there is potential for release of large quantities of greenhouse gases.[150]

(iii) Sources and Amounts of Anthropogenic Emissions of CO_2

In terms of emissions in 1990, it was estimated that buildings (including their applicances) were emitting 1,650 Mt C. The annual growth rate of this sector in the first half of the 1990s was 1.0%. Industry was emitting 2,300 Mt C, with an annual growth rate of 0.4%. Certain sectors are particularly noticeable. For example, in 1997, cement kilns were shown to produce 7% of global CO_2 emissions, with an expectation that it would rise to 10% by the end of the decade.[151] Agricultural industries and processes produced 210 Mt C (no growth rate noted). Energy supply and conversion added 1,620 Mt C, with an annual growth rate of 1.5%.[152]

Transport was emitting 1,080 Mt C. The annual growth rate of this sector in the first half of the 1990s was 2.4%.[153] Within this bracket, road

[146] Pearce, F. (2004). 'Peat Bogs Harbour Carbon Time Bomb'. *New Scientist.* July 10. 9. Pearce, F. (1994). 'Peat Bogs Hold Bulk of Britain's Carbon'. *New Scientist.* Nov 19. 6.
[147] Pearce, F. (1997). 'Indonesia's Inferno Will Make Us All Sweat'. *New Scientist.* Oct 18. 22.
[148] Pearce, F. (2002). 'Burning Peat Sparks Warming Fears'. *New Scientist.* Nov 9. 11.
[149] Pearce, F. (2004). 'Massive Peat Burning Is Speeding Up Climate Change'. *New Scientist.* Nov 6. 11.
[150] IPCC. (2003). *Climate Change and Biodiversity*. (IPCC, Technical Paper V, Geneva). 23. IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change.* (Cambridge University Press, Cambridge). 27.
[151] Pearce, F. (1997). 'The Concrete Jungle Overheats'. *New Scientist.* July 19. 12.
[152] IPCC. (2001). *Climate Change 2001: Mitigation.* (Cambridge University Press, Cambridge). 7.
[153] IPCC. Ibid. 7.

transport is a particular concern.[154] In large part, this is due to the exponential increase in the size of the world's motor vehicle fleet, which has risen from a handful of motor vehicles at the turn of the twentieth century to 39 million cars being produced annually at the end of the 1990s. This latter figure represented more than one new car every second.[155] Although there are strong regional disparities in motor vehicle ownership, the estimated total of motor vehicles on the road in 2030 is one billion.[156]

Globally, the transport sector consumes 27% of all commercial energy. This is the fastest growing sector of CO_2 emissions. By 2020, it is estimated that emissions from transport will increase to 31% of the total greenhouse gas output.[157] About 50% of this pollution comes from cars. Within the European Union this sector increased emissions by 24% between 1990 and 2000. By 2010, it is estimated that this sector will be producing 30% of all the European Communities CO_2 emissions.[158] In the mid 1990s, per capita CO_2 emissions from transportation averaged 5.7 tonnes annually in the United States, and 1.9 tonnes in Europe and Japan.[159] The CO_2 emissions from the United States transport alone sector amount to 5% of total global CO_2 emissions.[160]

Air transport is an area of particular concern. CO_2 from aircraft contributes approximately 2 to 10% of the total anthropogenic CO_2 emissions.[161] A 10% figure would mean that aircraft emissions equal more than half the total of emissions from road transport.[162] Every seat on a plane produces 684 grammes of CO_2 or its equivalent for every kilometre traveled. On the same basis, a car produces 83 grammes, and a fast train only 31

---

154 See IEA. (1993). *Cars and Climate Change*. (IEA, London).

155 Brown, L. (2001). *Vital Signs: 2000–2001*. (Earthscan, London). 86–87. Elsom, D. (1996). *Smog Alert: Managing Urban Quality*. (Earthscan, London). 5.

156 Commission on Sustainable Development. (2001). Energy and Transport, Report of the Secretary General. E/CN.17/2001/PC/20. UNDP, UNEP, World Bank, WRI. (2000). *World Resources 2000–2001*. (Oxford University Press, Oxford). 295. Schwela, D. (1999). *Urban Traffic Pollution*. (Routledge, London). 2–3.

157 Commission on Sustainable Development. (2001). Energy and Transport, Report of the Secretary General. E/CN.17/2001/PC/20. UNEP. (2003). 'Sustainable Mobility'. *Energy & Sustainable Development*. June 1, 3. Henderson, C. (1998). 'Small Is Still Beautiful'. *New Scientist*. April 25. 18–19.

158 European Conference of Ministers of Transport. (1997). *CO_2 Emissions From Transport*. (OECD, Paris). Anon. (1998). 'Action on Transport'. *Environmental Policy and the Law*. 28(1). 29. Hamer, M. (1994). 'Royal Commission Slams Road Building Plans'. *New Scientist*. Nov 5. 6.

159 OECD. (1996). *Towards Clean Transport*. (OECD, Paris). 25.

160 UNEP. (2002). *GEO 3*. (Earthscan, London). 231. Fergusson, M. (1999). 'Greening Transportation'. *Environment*. 41(1). 24.

161 IPCC. (1999). *Aviation and the Global Atmosphere*. (Cambridge University Press, Cambridge). 4.

162 IPCC. (1999). Ibid. 6. cf. Pearce, F. (1998). 'Air Emergency'. *New Scientist* .Apr 11. 4.

grammes.[163] Aircraft also produce NOx that are converted into ozone in the upper troposphere. In the troposphere, ozone acts as a power greenhouse gas.[164] The NOx emitted by aircraft accounts for about two thirds of their overall greenhouse impact. Aircraft vapour trails could also be contributing to global warming through assisting in the formation of cirrus clouds, through the creation of water vapour, in the upper atmosphere.[165] Emissions associated with aircraft from developed countries increased by more than 40% between 1990 and 2000. In the European Union, emissions from international air travel increased by 70% between 1990 and 2002.[166] The other source of concern in the transport sector is international shipping, which accounts for about 7% of the total greenhouse emissions generated by the transport sector.[167]

Many of the above increases in emissions correspond to increases in energy consumption. From the beginning of the Industrial Revolution, dating at least from James Watt's steam engine, the demand for energy has grown exponentially. Global energy demand has grown at an average annual rate of approximately 2% for almost two centuries.[168] In the last 30 years, in many countries, the demand for the basic fuels that contribute to global warming, has increased at a rate beyond 2% per year.[169] Between 1987 and 1998, energy production (from a total derived from all energy sources) in the developing world increased by 44%. Emissions in China and India rose by 28 and 55% respectively. CO_2 emissions from industrialized nations increased by 6.7% over the same period, with the United States increasing by 10.3%, and the European Union at 0.3%. The emissions of the former Soviet Union fell by 30.3%.[170]

(iv) Two Views of Contribution: Sovereign and Per-Capita Emissions

It is possible to calculate a country's cumulative greenhouse gas emissions through its percentage share of greenhouse gas totals, in terms of national emissions (via tonnage) or in terms of per capita emissions. Each approach,

---

163 Hamer, M. (1992). 'Polluting Planes Top The Greenhouse League'. *New Scientist*. July 25. 5.

164 Pearce, F. (1998). 'Air Emergency'. *New Scientist*. Apr 11. 4.

165 Pearce, F. (1997). 'Wispy Trails Could Warm The Earth'. *New Scientist*. March 29. 5.

166 Anon. (2005). 'Fuel Tax Ahead'. *New Scientist*. Mar 26. 7. Decision 1/CP 9. National Communications From Parties Included in Annex I to the Convention.

167 See Michaelis, L. (1997). *Special Issues in Energy Taxations: Marine Bunker Fuel Charges*. (OECD, Paris, Working Paper 11). 5–6.

168 IPCC. (1996) *Climate Change 1995: Impacts, Adaptations and Mitigation*. (Cambridge University Press, Cambridge). 12.

169 Revelle, R. (1982). 'Carbon Dioxide and World Climate'. *Scientific American*. 247(2): 33, 40. Brown, L. (2001). *Vital Signs*. (Earthscan, London). 52–53.

170 Dreyfus, D. (1990). 'Fueling Our Global Future'. *Environment*. 32(4): 17–41. Lee, W. (1990). 'Energy For Our Future'. *Environment*. 32(7): 12–16.

gives a different emphasis and, accordingly, a different political view point.[171] These differences can reflect opposing philosophical and political viewpoints.[172]

In terms of sovereign emissions, with regard to developed countries, in 1990, the top five emitters of CO_2 were the United States with 36.1% of the total (4,957,022 tonnes), the Russian Federation with 17.4% (2,388,720 tonnes), Japan with 7.4% (1,173,360 tonnes), Germany with 7.4% (1,012,443 tonnes) and the UK with 4.3% (584,078 tonnes).[173] Between 1990 and 1997, OECD countries averaged a 7.8% increase in CO_2 emissions.[174] Despite these increases, the developed countries were collectively projected to be approximately 3% below 1990 levels in the year 2000 and about 8% above 1990 levels in the year 2010. Much of this reduction was due to greenhouse gas emissions from developed countries in economic transition, declining by 28% between 1990 and 1995.[175] This overall decline in greenhouse gas emissions for developed countries between 1990 and 2010 because of reductions in countries in economic transition was confirmed in 2003.[176] Despite this overall drop in emissions for developed countries (including countries in economic transition) as a whole, a number of individual developed countries have not adequately stabilized their greenhouse emissions.[177] This was made clear in 2003, when it was shown that the emissions for most developed countries, once the reductions due to countries in economic transition had been removed from the equation, the remaining developed countries had actually increased their greenhouse gas emissions by about 8.5%.[178] Accordingly, as the parties to the FCCC concluded, 'further action is needed by [developed countries] to implement policies and

---

[171] Hammond, A. et al. (1991). 'Calculating National Accountability for Climate Change'. *Environment.* 33(1): 11. Jodha, N. (1992). 'A Comment of Global Warming in an Unequal World'. *Global Environmental Change.* 97–102. Thery, D. (1992). 'Should We Drop or Replace the WRI Global Index ?' *Global Environmental Change.* 88–92. Agarwal, A. (1992). *Global Warming in an Unequal World.* (Centre for Science and Environment, New Delhi).

[172] IPCC. (1996). *Climate Change 1995: Economic and Social Dimensions.* (Cambridge University Press, Cambridge). 7–8.

[173] Annex. Total carbon dioxide emissions of Annex I Parties in 1990, for the purposes of Article 25 of the Kyoto Protocol. COP 3, Kyoto (1997). FCCC/CP/1997/7/Add.1. March 18. 1998.

[174] Anon. (1997). 'Hot Air'. *New Scientist.* July 19. 7.

[175] Decision 11/CP.4. National communications from Parties included in Annex I to the Convention. Paragraph 10(b).

[176] Decision 1/CP.9. National Communications From Parties Included in Annex I to the Convention.

[177] Decision 9/CP.2. Communications from Annex I Parties: Guidelines, Schedule and Process. Paragraph 13.a. Decision 11/CP.4. National communications from Parties included in Annex I to the Convention. Paragraph 10(c). Pearce, F. (1995). 'Climate Treaty Heads For Trouble'. *New Scientist.* March 18. 4.

[178] Report of the 9th COP (2003). Proceedings. 20.

measures that will contribute to modifying longer-term trends in atmospheric emissions'.[179]

A growth in emissions is clearly occurring in developing countries. Greenhouse gas emissions from developing countries as a whole exhibited an increase of 3.5% from 1990 to 1995.[180] These modest increases do not fully reflect the fact that some developing countries made massive increases in their CO_2 emissions. For example, China, India, Brazil, and Indonesia all increased their CO_2 emissions by more than 20% between 1990 and 1995. If such increases continue, it is expected that by 2005, the developing world will be producing more CO_2 from the burning of fossil fuels than developed countries were producing in 1988. Between 2010 and 2025 the developing world should be responsible for well over half of all global emissions.[181] Certain countries, such as China, are expected to make exponential increases in their emissions, and by 2025 (if not earlier) China is expected to be the world's largest emitter (in sovereign terms) of greenhouse gases.[182] China and India are expected to represent 58% of the global CO_2 output in 2030.[183] However, many other developing countries and regions have a minimal contribution to greenhouse gas emissions. For example, as of 2002, the entire continent of Africa was responsible for less than 3.5% of global emissions of CO_2, with South Africa being responsible for 42% of this figure.[184]

In terms of per capita emissions, by the end of the twentieth century, the global average for per capita CO_2 emissions, in kilogrammes, was 4,157. The differences from the global total ranged from 19,675 for the United States (which has actually considerably reduced, due to energy efficiencies, from its 1970s average) 949 for China, 652 for India, all the way down to two kilogrammes per capita for Somalia. Despite the broad differences between developed and developing countries, by 2010 it is estimated that certain developing countries such as Turkey, Korea and Mexico will have per-capita emissions as high as traditional European countries.

[179] Decision 1/CP 9. National Communications From Parties Included in Annex I to the Convention.

[180] Decision 11/CP.4. National communications from Parties included in Annex I to the Convention. Paragraph 10(b). IEA. (2000). *International Energy Outlook 2000*. (IEA, Washington). 167.

[181] Pearce, F. (1997). 'Countdown to Chaos'. *New Scientist*. Nov 29. 22. MacKenzie, D. (1990). 'Communication Gaps Undermine Reports on Global Warming'. *New Scientist*. June 23. 5. Pearce, F. (1988). 'Time For Politicians To Act'. *New Scientist*. Oct 15. 21. Reddy, A. (1990). 'Energy For the Developing World'. *Scientific American*. Sep 63, 69.

[182] Smil, V. (1994). 'China's Greenhouse Gas Emissions'. *Global Environmental Change*. 4(5): 325–332.

[183] Pearce, F. (2003). 'Expect a Hot Polluted Future'. *New Scientist*. May 24. 8.

[184] UNEP. (2002). *GEO 3*. (Earthscan, London). 218.

Estimations based on future growth rates of developing countries are contingent on many considerations and may themselves be subject to debate.[185]

B. Methane

By 1985, methane was being identified as an important trace gas in the climate change debate. Although, on a molecule-for-molecule basis, methane is much more effective at trapping the sun's heat than CO_2, by comparison it is much shorter lived in the atmosphere. Methane is expected to contribute 18% of the total expected global warming over the next 50 years, as opposed to 50% attributed to CO_2. In the mid 1990s, it was estimated that globally, between 1,250 and 2,800 Mt (of CO_2 equivalent) of methane was being emitted. More than half (probably somewhere between 60 to 80%) of current CH_4 emissions are anthropogenic. Of the non-anthropogenic sources, wetlands are a recognized source, with wetlands in tropical regions believed to be releasing approximately 66 million tonnes per year, as opposed to those in subtropical or temperate regions, which only release an approximate 5 million tonnes. Termites are also of particular note, although their contribution of CH_4 to the global atmosphere has been increasingly downplayed.[186]

The methane in today's atmosphere is 80% from the present and 20% from the past. Past sources of CH_4 include leaking from coal seams, melting permafrost, rocks beneath the oceans and natural gas deposits. The list of modern sources includes cattle, the world's five million square kilometres of bogs and marshes, the 1.5 million square kilometres of rice paddies, the burning of forests and grasslands and putrefying waste tips.[187]

---

185 Pearce, F. (1997). 'Countdown to Chaos'. New Scientist. Nov 29. 22. Fiekhen, E. (2003). 'Warming the Books'. TIME. March 3. 53. Anon. (1989). 'Surge In Carbon Dioxide Prompts New Greenhouse Fears'. *New Scientist.* Apr 1. 21. Pearce, F. (1993). "Carbon Dioxide's Taxing Questions'. *New Scientist.* June 26. 12. Milne, R. (1979). 'China Leads New Surge in Output of Greenhouse Gases'. *New Scientist.* July 1. 10. UNDP, UNEP, World Bank, WRI. (2000). *World Resources 2000–2001.* (Oxford University Press, Oxford). 282. Sassin, W. (1980). 'Energy'. *Scientific American.* 243(3). 107–113.

186 IPCC. (2001). *Climate Change 2001: Mitigation.* (Cambridge University Press, Cambridge). 7. IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change.* (Cambridge University Press, Cambridge). 25. Milich, L. (1999). 'The Role of Methane in Global Warming'. *Global Environmental Change.* 9: 179, 183. Pearce, F. (1989). 'Methane: The Hidden Greenhouse Gas'. *New Scientist.* May 6. 19. Anon. (1983). 'Have Termites Increased Atmospheric Methane ?' *New Scientist.* March 31. 889. Pearce, F. (1996). 'Plug A Leak And Save the World'. *New Scientist.* May 25. 6. Joyce, C. (1985). 'Trace Gases Amplify Greenhouse Effect'. *New Scientist.* May 16. 3.

187 IPCC. (2000). *Land Use, Land-Use Change, and Forestry.* (Cambridge University Press, Cambridge). 4. Anon. (2005). 'Forests Belch Greenhouse Gas'. *New Scientist.* March 26. 20.

Agriculture is the largest source of anthropogenic methane emissions. In 1990, agriculture was adding 210 Mt C, (of CO_2 equivalent).[188] There are two notable agricultural sources. The first agricultural source is domestic ruminants. Methane is produced from ruminants via the bacteria that break down cellulose in their guts. This process converts between 3 and 10% of the food that the cattle eat into methane. Cattle are conspicuous for producing 70% of overall animal emissions. As an estimate, a sheep typically burps out 25 litres of methane a day, while a cow expels 280 litres. Given approximately 1300 million cattle in the world, close to 100 million tonnes of methane each year is being put into the atmosphere from this source.[189]

The second large agricultural source comes from microbial activity in paddy fields. One study suggested that between 150 and 200 tonnes of methane per year may be coming from this source.[190] However, the exact emissions from these sources are difficult to calculate as each country may have different methods and conditions of rice cultivation, due to soil type, soil temperature, management techniques and type and mode of application of fertilizers. For example, Chinese rice paddies may emit between four to ten times as much methane as rice fields in Europe or the United States. However, even such regionalized estimates may be problematic. For example, later studies demonstrated that India's paddy fields generate only a fraction of the methane that was originally attributed to them by inaccurate field studies from other countries. Rather than emitting 37.8 million tonnes as earlier predicted, India's rice paddies were only emitting almost one tenth of that figure, at 4.3 million tonnes each year.[191]

The final anthropogenic source of methane important to note is waste sites. This source is believed to contribute about 240 Mt C (of CO_2 equivalent) per year into the atmosphere. Developed countries may be producing up to 70 million tonnes of methane per year from this source, with some countries such as the United Kingdom emiting 2.2 million tonnes annually. The world's coal mines are estimated to emit between 25 and 45 million tonnes of methane per year. This is roughly as much as leaks from the world's oil and gas fields.[192] Many of the emissions from old coal

---

188 IPCC. (2001). *Climate Change 2001: Mitigation.* (Cambridge University Press, Cambridge). 7.

189 Hadfield, P. (2002). 'No Burps, Please'. *New Scientist.* June 15. 21. EPA. (1992). *Global Methane Emissions From Livestock and Poultry Manure.* (EPA, Washington). Pearce (1989). Ibid.

190 Milich. Ibid. Pearce. (1989). Ibid.

191 Menon, S. (1994). 'Wrong Paddy Field Measurements For Methane'. *New Scientist.* Aug 27. 6. Anon. (1991). 'Belching Rice'. *New Scientist.* May 18. 13. See 'International Project to Monitor Asian Methane Emissions'. 5 *YBIEL.* (1994) 204.

192 IPCC. (2001). *Climate Change 2001: Mitigation.* (Cambridge University Press, Cambridge). 7. Pearce, F. (1999). 'A Good Scrub'. *New Scientist.* Jan 30. Milich, L. (1999). 'The Role

mines are due to slow burning fires. Underground coal fires rage at various locations all over the world. Known mine fires burn in the United States, India, China, Indonesia and Australia. In 2002, it was estimated that the fires in the Chinese coal seams could be burning up to 100 million tonnes of coal per year.[193] In 1996, the emissions from leaking gas pipelines and wellheads in Russia was put at 35 million tonnes per year.[194] Industry also adds 170 Mt C (of CO_2 equivalent) per year.[195] Methane is also produced from tropical deforestation and the destruction of grasslands, and the resultant effects on their associated soils. Apparently, 8.2 Mt C (of CO_2 equivalent) of methane are emitted from savanna burning alone each year.[196]

With regards to sinks for methane, there is considerable scientific uncertainty. Nevertheless, it has been shown that CH_4 can be removed from the atmosphere by interaction with the hydroxyl radical or through a bacterium from acidic wetlands. However, the bacterium itself is often under threat from industrial pollutants.[197] In a similar manner, in places where methane is naturally produced, like wetlands, natural processes can consume huge quantities of methane before it reaches the atmosphere. However, such natural processes may be negated, by up to 50%, by rising CO_2 concentrations.[198]

C. Nitrous Dioxide

Nitrous dioxide (N_2O) was identified an as important trace gas in the climate change mix in the mid 1980s. Natural sources are probably twice as large as anthropogenic ones. The main sources of N_2O are from agriculture (especially the development of pasture in tropical regions), biomass burning, and a number of industrial processes (such as adipic acid and nitric acid production).[199] Although N_2O only makes up only a small percentage of greenhouse gases, molecule for molecule, it is 300 times more effective

---

of Methane in Global Warming'. *Global Environmental Change*. 9: 179, 191. Pearce, F. (1989). 'Methane: The Hidden Greenhouse Gas'. *New Scientist.* May 6. 19.

193 Pearce, F. (2002). 'Fires From Hell'. *New Scientist.* Aug 31. 34–38.

194 Pearce, F. (1996). 'Plug A Leak And Save the World'. *New Scientist.* May 25. 6.

195 IPCC. (2001). Ibid. 7.

196 Nielsen, T. (1996). 'Savanna Burning in West Africa'. Collaborating Centre on Energy and Environment. (UNEP). 8: 6–7. Pearce. Ibid.

197 Klaffke, O. (1999). 'Savior From the Acid Swamps'. *New Scientist.* March 20. 13. Jones, N. (2003). 'Here Comes the Rain'. *New Scientist.* Apr 26. 24–25.

198 Anon. (2000). 'Methane Munchers'. *New Scientist.* June 10. 7. Anon. (1989). 'Fertilisers and Acid Rain Are Warming The World'. *New Scientist.*. Oct 7. 11.

199 Pearce, F. (1997). 'Lightening Sparks Pollution Rethink'. *New Scientist.* Jan 25. 15. Nielsen, T. (1996). 'Savanna Burning in West Africa'. *Collaborating Centre on Energy and Environment.* (UNEP). 8: 6–7. Pearce, F. (1989). 'Methane Locked in Permafrost May Hold Key To Global Warming'. *New Scientist.* March 4. 28.

at trapping heat than CO_2. N_2O is responsible for more than 7% of the warming effect of all US greenhouse gas.[200] N_2O is removed primarily by being slowly broken down by sunlight in the stratosphere.[201]

D. Overlapping Pollutants

(i) Aerosols

In addition to the core greenhouse gases noted above a number of chemicals involved in air pollution and ozone depletion also have to be accounted for, as they too can contribute to climatic change.

It is possible that aerosols (typically Suspended Particle Matter or SPMs) could be impacting upon climate change by helping cool the atmosphere directly and indirectly. The direct effect is primarily to scatter (and often reduce) sunlight, reducing the amount that hits the Earth.[202] The indirect effects range from affecting the greenhouse gases held in the terrestrial ecosystems, forcing down temperatures on the ground and disrupting local ecologies, through to providing the platform for condensation nuclei, which go on to make up clouds.[203] Air pollution works on a very different time scale and regional influence to global warming.[204] Whereas air pollutants typically last in the atmosphere for less than a week, before disappearing, greenhouse gases, typically have lifetimes of years. As such, aerosols, due

---

200 IPCC. (2001).*Climate Change 2001: The Scientific Basis*. (Cambridge University Press, Cambridge). 9. IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change*. (Cambridge University Press, Cambridge). 28. Pearce, F. (1998). 'Catalyst For Warming'. *New Scientist*. June 13. 20. Joyce, C. (1985). 'Trace Gases Amplify Greenhouse Effect'. *New Scientist*. May 16. 3.

201 IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change*. (Cambridge University Press, Cambridge). 28. Joyce, C. (1985). 'Trace Gases Amplify Greenhouse Effect'. *New Scientist*. May 16. 3

202 Pearce, F. (1994). 'Not Warming, But Cooling'. *New Scientist*. July 9. 37–41. Anon. (1989). 'Pollution May Worsen Greenhouse Effect'. *New Scientist*. June 10. 14. Pearce, F. (1992). 'Clean Air Will Expose Europe to Global Warming'. *New Scientist*. Jan 25. Pearce, F. (1992). 'UN Fears Pollution Curbs Could Raise Temperature'. *New Scientist*. Jan 4. 5. Charlson, R. (1994). 'Sulfate Aerosol and Climatic Change'. *Scientific American*. Feb 28–35. Copley, J. (1999). 'Smoke on the Water'. *New Scientist*. Aug 21. 7. Anon. (1996). 'Cooling Effect'. *New Scientist*. April 6. 13. Pearce, F. (1994). 'Not Warming, But Cooling'. *New Scientist*. July 9. 37–41. Pearce, F. (1997). 'Global Warming Chills Pacific'. *New Scientist*. Feb 22. 16. Pearce, F. (1997). 'Greenhouse Wars'. *New Scientist*. July 19. 38–39.

203 Note the uncertainties in this area. See Pearce, F. (2005). 'Ozone Clouds the Issue of Climate Change'. *New Scientist*. Dec 18. 9. IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change*. (Cambridge University Press, Cambridge). 30. Pearce, F. (1994). 'Not Warming, But Cooling'. *New Scientist*. July 9. 37–41. Pearce, F. (2002). 'Pollution in Plunging Us Into Darkness'. *New Scientist*. Dec 14. 6. Pearce, F. (1990). 'Whatever Happened to Acid Rain?' *New Scientist*. Sep 15. 41.

204 IPCC. (1995). Ibid. 11, 31. Pearce, F. (2001). 'Lucky Escape'. *New Scientist*. Sep 15. 13.

to their continual replacement as air pollution, may be postponing the impacts of climate change by offsetting global warming by as much as 25 to 30% in some regions. With regard to long term implications of climatic change, the evidence would suggest that if such aerosols were cleared from the air, a scenario of a 5.8c increase in temperature, may be underestimated in the range of 3%. This could translate into a temperature change of between 7 and 10c.[205]

(ii) Ozone Depleting Substances

From the outset of investigations into the ozone layer in the 1970s, it was apparent that ODS may also have an overlapping detrimental impact on the climate. Thus, as international research on the ozone layer began in 1977 under the auspice of the Ozone Plan of Action, emphasis was also placed on developing computer models on the 'effects on the earth's radiation balance and the global climate' that ozone depleting chemicals may produce.[206] The research on, 'interactions with other environmental factors such as climate change' has been ongoing.[207] This is deemed important because, as Robert Watson warned,

> the effects of these gases [nitrous dioxide (N_2O), methane, oxides of nitrogen (NOx) and carbon dioxide (CO_2) in addition to the well known chlorine species] are strongly coupled and cannot be considered in isolation . . . In conclusion, it should be noted that [humanity is conducting the] . . . equivalent of one giant experiment. Mankind is perturbing the carbon, nitrogen, hydrogen and chlorine cycles on a global scale and in an unprecedented manner. The consequences of this for the future cannot be known with any certainty.[208]

In terms of specifics, it appears that ozone depletion, and ODS may affect climate change in two ways. First, ODS have their own Global Warming Potential (GWP) and are, accordingly, involved in their own radiative

[205] IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change.* (Cambridge University Press, Cambridge). 11. Pearce, F. (1992). 'Britain Keeps Its Cool As the World Warms Up'. *New Scientist.* Apr 11. 4. Pearce, F. (1995). 'Global Warming Jury Delivers Guilty Verdict'. *New Scientist.* Dec 9. 6. Pearce, F. (2003). 'Heat Will Soar As Haze Fades'. *New Scientist.* June 7. 7. Gribbin, J. (1995). 'Smokestacks Cool Northern Oceans'. *New Scientist.* Oct 14. 18. Matthews, R. (1994). 'The Rise and Rise of Global Warming'. *New Scientist.* Nov 26. 6. Pearce, F. (1994). 'Does Polluted Air Keep the Arctic Cool?' *New Scientist.* Oct 29. 19.

[206] Ozone Plan of Action. Section 4.

[207] UNEP. (1999). *Synthesis of the Reports of the Scientific, Environmental Effects and Economic Assessment Panels.* (UNEP, Ozone Secretariat, Nairobi). 24. Decision IV/3. Recommendations of the Third Meeting of the Ozone Research Managers. Point G. 5–6.

[208] Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1984). Report of the Working Group, First Part of the Fourth Session. UNEP/WG.110/4. Page 5.

forcing irrespective of their impact on the ozone layer. Although assisting the warming in the atmosphere, the actual thinning of the ozone layer in the lower stratosphere may create a negative radiative forcing of the climate system which may be offsetting part of climatic change. However, there is large scientific uncertainty in this area.[209] Second, the impacts of ozone depletion may have potential consequences of enhanced levels of exposure of UV-B to ecosystems, which subsequently reduces their ability to sequester carbon. In this area, studies cover terrestrial and oceanic ecosystems. With regard to the latter, it appears that the negative effect of UV-B light on phytoplankton, could have a knock-on negative effect on the ability of phytoplankton to take up CO_2 in the ocean.[210]

The overlap between pollutants was recognized in the negotiations leading up to the Vienna Convention,[211] the Convention itself[212] and the Montreal Protocol.[213] This overlap led to the suggestion in 1989 that, 'control of CFCs can also be considered as a first step in dealing with the related problems of global warming'.[214] Accordingly, the climate change negotiations have often proceeded upon the realization that the control of ODS also benefits the climate system. Although the focus within the FCCC was initially on controlling, 'anthropogenic emissions of carbon dioxide and other greenhouse gases not controlled by the Montreal Protocol'[215] by the late 1990s, this was changing and some substances such as hydrofluorocarbons (HFCs), perfluorocarbons and sulphur hexafluoride (SF6), which were listed with the Montreal Protocol were also listed under the Kyoto Protocol.[216] Based on a BAU scenario, HFCs could be responsible for 1% of all the radiative forcing in 2015, and PFCs could be responsible for 0.2% of the overall radiative forcing.[217]

---

209 IPCC. (2005). *Safeguarding the Ozone Layer and the Global Climate System: Issues Related to Hydrofluorocarbons and Perfluorocarbons*. (IPCC, WMO Geneva). 4. UNEP. (1999). *Synthesis of the Reports of the Scientific, Environmental Effects and Economic Assessment Panels*. (UNEP, Ozone Secretariat, Nairobi). 13. Simpson, S. (2002). 'A Push From Above'. *Scientific American*. Aug. 9–10. Anon. (1990). 'Total CFC Ban Needed to Halt Warming'. *New Scientist*. Sep 8. 15.

210 Co-Chairs of the Assessment Panels (2003). *The Synthesis Report*. UNEP/OzL.Pro/WG.1/23/3. 6. UNEP. (1999). Ibid. 14. Sinclair, J. (1990). 'Ozone Loss Will Hit Health and Food'. *New Scientist*. Feb 3. 7.

211 Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1983). Second Revised Draft, With Additional Commentary, Prepared By UNEP. UNEP/WG.94/3/July 30. Page 6–7.

212 Article 3 (1)(c).

213 The preamble of the Protocol is: "Conscious of the potential climatic effects of emissions of these substances"

214 UNEP. (1989). First Meeting of the Parties To the Montreal Protocol, Helsinki, 2–5 May. UNEP/OzL.Pro.1/5. 6 May 1989. Paragraph 19.

215 FCCC. Article 4 (2)(b).

216 Kyoto Protocol. Annex A. See also Article 3 (8).

217 IPCC. (2005). *Safeguarding the Ozone Layer and the Global Climate System: Issues Related to*

3. The Constituents of Air Pollution

There are three broad sources of air pollution from human activities: stationary sources, mobile sources, and indoor sources. Although indoor sources of air pollution may be more detrimental to the health of many people in the developing world,[218] as this pollution tends not to be trans-boundary, I have chosen to leave it from the ambit of this work. The focus of this part of the study is on so called 'classical air pollutants'. Unlike non-classical air pollutants, which are often persistent organic pollutants, classical air pollutants do not tend to bio-accumulate, the human health effects are relatively well known, and the lung is the usual target.[219]

Note also that despite the following division of air pollutants into discrete sections, in reality, it is not always clear which pollutants are attributable to specific problems. The mix of chemicals that make air pollution are complicated, both in terms of the relationship of air pollutants to each other, as well as their relationship to other pollutants of international importance, like those that destroy the ozone layer or enhance climate change.[220]

A. Sulphur Dioxide

Fossil fuels are formed when dead animals and plants decompose and break down into liquids (oil), gases (natural gas), and solids (coal and peat). These products contain the sulphur absorbed by those animals and plants from their environment. When combusted, the sulphur may be released as sulphur dioxide (SO_2). SO_2 is a colourless pungent, irritating, water-soluble and reactive gas. Sulphur is naturally in the atmosphere. The main natural carrier of reactive sulphur is marine plankton. SO_2 also comes from volcanoes, swamps and bogs.[221] The material from which SO_2 usually originates from is coal, oil, and diesel fuel.

Hydrofluorocarbons and Perfluorocarbons. (IPCC, WMO Geneva). 4. Pearce, F. (1996). 'Pollution Detectives Add To Greenhouse Woes'. *New Scientist.* Aug 24. 6. Anon. (1995). 'Cinderella Gas Lasts Longest of All'. *New Scientist.* Apr 8. 5. Decision XIV/10. Relationship Between Efforts to Protect the Stratospheric Ozone Layer and Efforts to Safeguard the Global Climate System: Issues Relating to Hydrofluorocarbons and Perfluorocarbons.

218 According to the WHO, an estimated 1.9 million people die prematurely each year in the developing world because of indoor pollution. Conversely, only around 500,000 die from pollution in the ambient air. See WHO. (1999). *Protection of the Human Environment: Air Quality Guidelines*. (WHO, Geneva). VI:19–31.

219 WHO. Ibid. VI: 5.

220 UNEP. (1999). *Synthesis of the Reports of the Scientific, Environmental Effects and Economic Assessment.* (UNEP, Ozone Secretariat, Nairobi). 14. This overlap is noted in VOC Protocol. Article 2 (4), 2 (8), 5 (h). Gothenberg Preamble. Paragraph 8. Pearce, F. (2002). 'Smog Controls Useless Without Global Clean Up.' *New Scientist.* Oct 19. 13. Newell, J. (1977). 'Additional Hazards from Air Pollution.' *New Scientist.* July 14. 8 *YBIEL.* (1998). 176–9.

221 Charlson, R. (1994). 'Sulfate Aerosol and Climatic Change'. *Scientific American.* Feb. 28–35.

In 1990, humanity was emitting 99 million tonnes of SO_2 per year.[222] Of a 100% total of SO_2 in the atmosphere, in the Northern Hemisphere about 90% is anthropogenic, as opposed to about 33% in the Southern Hemisphere. According to the Helsinki Protocol, 'the predominant sources of air pollution contributing to acidification of the environment are the combustion of fossil fuels for energy production, and the main technological processes in various industrial sectors, as well as transport'.[223] The 1994 Protocol on Further Sulphur Reductions reiterated this.[224] Together, SO_2 and the closely related SPM (see below) make up the dominant source of air pollution in many cities.[225] In the last two decades, especially in industrialized countries, the primary causes of SO_2 and SPM pollution is road traffic. This is different to the traditional causes of SO_2 pollution, which were industry or domestic coal burning.[226] The other important source of SO_2 is from ships over 400 tonnes which burn cheap oil containing high concentrations of sulphur.[227] In 1996, such vessels were responsible for 7% of global SO_2 emissions.[228]

With regard to stationary sources, for the former ECE region 88% of total SO_2 emissions originated from combustion processes, including 20% from industrial combustion, 5% from production processes, and 7% from oil refineries. The power plant sector in many countries is the major single contributor to SO_2 emissions. In some countries, the industrial sector (including refineries) are also an important SO_2 source. Although emissions from refineries in the former ECE region were relatively small, their impact on overall SO_2 emissions was large due to the high sulphur in the oil products they consumed. Typically 60% of the sulphur intake present in the oil crudes remains in the product, 30% is recovered as elemental sulphur and 10% is emitted from refinery stacks. At the end of the twentieth century, the United States was the world's largest producer of SO_2 on a per-capita basis. Of the other nine countries that made up the 'top ten' on a per capita basis, one other was Canada, another was in Eastern Europe, and the remaining seven were in central Europe. In the European Union, Spain had the largest emissions on a per capita basis (0.055 kilogrammes per person) of SO_2 and Austria (at 0.009 kilogrammes per person) had the

222 Elsom, D. (1996). *Smog Alert: Managing Urban Air Pollution.* (Earthscan, London). 34.
223 1985 Helsinki Protocol. Preamble. Paragraph 3.
224 The 1994 Protocol on Further Sulphur Reductions. Preamble. Paragraph 6.
225 World Resources Institutes, UNEP & World Bank. (1999). *World Resources: 1998–1999.* (Oxford University Press). 63.
226 Anon. (1981). 'London Will Fail EEC Air Pollution Standards'. *New Scientist.* May 14. 398.
227 Pearce, F. (1993). 'Britain Faces Huge Bill to Cut Acid Rain'. *New Scientist.* March 13. 4.
228 Bond, M. (1996). 'Dirty Ships Evade Acid Rain Controls'. *New Scientist.* June 22. 8.

smallest. The European Union average between 1980 and 1993 was 0.038.[229]

In Northern countries, emissions of SO_2 grew with the Industrial Revolution. Between 1910 and 1950, apart from an SO_2 emission spike with World War II emissions of SO_2 were fairly constant with an average annual emission of 25 million tonnes.[230] SO_2 emissions then grew by 2% per year between 1955 and 1975. However, after a high tide mark of the early 1980s, the emissions of SO_2 in most industrialized countries began to rapidly fall.[231] For example, although about 9.1 million tonnes of SO_2 were emitted by countries that were signatories to the LRTAP and its protocols at the end of the twentieth century,[232] SO_2 emissions in Europe still declined by 61% between 1980 and 2002.[233] In Japan, by the mid 1990s, SO_2 emissions had fallen by 82% since the mid 1970s.[234] Taken as a whole, the 21 Parties of the 1985 Helsinki Protocol reduced their SO_2 emissions, from what they were in 1980, by more than 50% by 1993. Four countries not party to the Helsinki Protocol achieved a 30% reduction (or more), eleven parties achieved reductions of at least 60%, and two of these had reductions above 80%.[235] The aim is for even greater SO_2 emission reductions (62% less than what was emitted in 1980) by 2010.[236] Although most European countries have followed the trend of decreasing emissions, Greece and Portugal increased their emissions between 1990 and 1998, by 7% and 3% respectively.[237]

Despite such decreases in SO_2 emissions in the developed world, such progress has not been replicated in the developing world, where SO_2 levels often massively exceed WHO safety standards for air pollution. For example, Shenyang in China has SO_2 pollution levels 8 times above the WHO

---

229 1994 Protocol on Further Reductions of Sulphur Emissions. Annex IV. Control Technologies For Sulphur Emissions From Stationary Sources. Paragraph 8. Guidance Document on Control Techniques for Emissions of Sulphur From Stationary Sources. 2 UNEP. (2000). GEO 2000 Report. (Earthscan, London). 114. McCormick, J. (1997). *Acid Earth: The Politics of Air Pollution*. Earthscan, London). 111–112. Pearce, F. (1984). 'World Study Pinpoints Dirtiest Air'. *New Scientist.* Nov 8. 9.

230 Coghlan, A. (1999). 'The Smog of War'. *New Scientist.* July 3. 12.

231 Pearce, F. (1982). 'The Menace of Acid Rain'. *New Scientist.* August 12. 419–423. Sage, B. (1980). 'Acid from Fossil Fuels'. *New Scientist* March 6. 743.

232 EMEP. (2000). *Transboundary Acidification and Eutrophication in Europe*. (EMEP, Geneva). 11.

233 UNECE. (2004). Present State of Emission Data. EB.AIR/GE.1/2004/10. July 1. 6.

234 UNECE. Ibid. UNEP. (2002). *GEO 3*. (Earthscan, London). 230. EPA. (1995). *Human Health Benefits from Sulphate Reductions*. (EPA, Washington). Table S-2. Expert Panel on of Air Quality Standards. (1995). *Sulphur Dioxide*. (DoE, London). Table 1.

235 6 *YBIEL*. (1995). 218, 419. 5 *YBIEL*. (1994). 157. 7 *YBIEL*. (1996). 125.

236 1999 Gothenburg Protocol. Annex II. Emission Ceilings. Table 1. For earlier targets, see Protocol on Further Sulphur Reductions. Annex II. Sulphur Emission Ceilings And Percentage Emission Reductions. Available from <http://unece.org/env/lrtap/protocol/94sulp_a/annex2.htm>

237 UNEP. (2002). *GEO 3*. (Earthscan, London). 224.

recommendations. Anshan, a close-by town has the worst recorded air pollution in the world. In 2001, Tehran recorded $S0_2$ levels four times the guidelines prescribed by the WHO.[238] These problems often directly correspond to the rapid growth of SO_2 emissions in a number of developing regions. For example, in 1997, South East Asia was producing one third of the world's output of SO_2.[239] This increase is largely driven by India and China, who increased their SO_2 emissions by 50 and 53% respectively, between 1980 and 1993, and polluted their neighboring countries accordingly.[240] It was suggested that due to such trends, that by the year 2000 SO_2 pollution in Asia surpassed the combined SO_2 emissions of North America and Europe.[241] One manifestation of such emission growth is the seasonal (between October and May) 'Asian Brown Cloud' which was first identified in 1997. This cloud or 'haze' is three kilometers thick, and is composed of a mixture of pollutants including soot, sulphates, nitrates, organic particles, fly ask and mineral dust. By 2005, the cloud was reducing the sunlight reaching the tropical Indian Ocean surface, by as much as 10%, with a larger reduction over the Indian sub-continent.[242] It is projected that unless SO_2 pollution is confronted in Asia, then by 2020 the problem could be three times worse than it was in 2003.[243]

Progress in controlling SO_2 pollution is being made in some parts of the developing world. For example, Anshan's SO_2 pollution is 50% better than it was in the 1980s. This improvement reflects the fact that although extreme pockets of SO_2 pollution exist in China, in the most polluted cities annual declines of SO_2 emissions of between 1 and 10% were being recorded. Likewise, in Mexico city, the SO_2 has fallen from 100 to 140 pg/m3 in 1991 to between 32 and 37 pg/m3 in 1996.[244] Finally, the SO_2

---

238 Walsh, B. (2004). 'Choking on Growth'. *TIME*. Dec 13. 16–23. UNEP. Ibid. 221. Pearce, F. (2000). 'Hold Your Breath'. *New Scientist*. Jan 22. 16–17. WHO (1999). *Protection of the Human Environment: Air Quality Guidelines*. II:16. UNEP. (2000). *GEO 2000 Report*. (Earthscan, London). 56.

239 Hadfield, P. (1997). 'Raining Acid On Asia'. *New Scientist*. Feb 15. 15.

240 McCormick, J. (1997). *Acid Earth*. (Earthscan, London). 10. Pearce, F. (2000). 'Hold Your Breath'. *New Scientist*. Jan 22. 16–17. Anon. (1987). 'Acid Rain Catches Up With China'. *New Scientist*. July 9. 25. Holmes, B. (1999). 'A Dark Cloud Over Asia'. *New Scientist*. Feb 13. 25. Anon. (1997). 'Acid Future'. *New Scientist*. May 3. 13. Anon. (2001). 'Acid Ripples'. *New Scientist*. Oct 8. 12.

241 UNEP. (2000). Ibid. 46.

242 Hecht, J. (2005). 'Sooty Skies Blight Asia's Climate'. *New Scientist*. March 12. 15. UNEP. (2002). Ibid. 222. Pearce, F. (2002). 'Forest Fires Fuel Pollution Crisis'. *New Scientist*. Aug 17. 8.

243 Ananthaswamy, A. (2003). 'Choking Future Awaits Asia's Cities'. *New Scientist*. Jan 25. 13.

244 UNEP. (2002). *Benchmarking Urban Air Quality Management and Practice in Major and Mega Cities of Asia*. (UNEP, Nairobi). 5.

emissions in Delhi have fallen by 63% between 1996 and 2003, following strong judicial actions.[245]

B. Suspended Particle Matter

Airborne particles are referred to as suspended particulate matter (SPM), total suspended particulates (TSP) or black smoke depending on the type of measurement and terminology used. What ever the name, the source is the same. Thus, when coal and certain other fuels burn, they emit substances, including carbon particles (if combustion is inefficient) and SO_2 gas. In addition the high temperature of combustion cause nitrogen in the air to combine with oxygen, yielding NOx gases. When the gases encounter water or related molecules in the atmosphere, they form sulphuric acid (H_2SO_4) droplets and nitric acid (HNO_3) gas, both of which are dissolved in the Earth bound rain. If the atmosphere is relatively dry, nitric acid tends to remain in the gaseous state but sulphuric acid tends to form minute particles. These bits sometimes reach the Earth in rain, but they and other particles often settle out of the air on their own. These particles often consist of a mixture of substances. This makes it difficult to identify their compounds and hence their sources.[246]

Particulates in the atmosphere may be divided into two principal size groups. Fine particles up to two microns in diameter come from combustion processes and from coagulation and condensation of gases and vapours. Larger particles (SPM 10) are particles of between two to 100 microns in diameter. Particles larger than 10 microns in diameter are deposited in the vicinity of where they originated, but smaller particles may remain airborne and be transported for long distances. Smaller particles predominate in transport pollution, as opposed to larger particles in industrial pollution.[247]

Annual anthropogenic SPM emissions are estimated to be approximately 300 million tonnes, about half of which are sulphate particles from SO_2 conversion. Anthropogenic emissions probably constitute only 5 to 50% of total SPM, although in urban areas, anthropogenic SPM emissions often dominate.[248]

The largest source of fine particles is coal-fired power plants, but automobiles are also prime contributors, especially along busy transport corridors.

---

[245] Bell, R. (2004). 'Clearing the Air: How Delhi Broke the Logjam'. *Environment.* April 22–30.

[246] Shaw, R. (1987). 'Air Pollution by Particles'. Scientific American. August 84.

[247] Hamer, M. (1994). 'Number of Particles Is Key to Pollution Deaths'. *New Scientist.* Apr 8. 17.

[248] Merefield, J. (2002). 'Dust to Dust'. *New Scientist.* Sep 21. 1–4.

Cities with large numbers of diesel vehicles, especially where these are poorly maintained, can experience very high concentrations of SPMs. In the late 1990s, 86% of London's SPM10 came from road transport. Tirana (Albania) was, in 2004, identified as the most polluted capital of Europe. On an average morning, the SPM10 content is ten times higher than the WHO safety limits. This SPM10 content is attributed to the fact that Albania went from 2,000 cars in the late 1980s, to over 300,000 cars, trucks and lorries by 2003. In Tirana, these vehicles release an estimated 35,000 tons of air pollutants each year. This is the equivalent of 49 kilogrammes per person.[249] Additional sources from transport (that is, beyond those from combustion) are wear and tear on tires. It has been estimated that in Europe this source alone is responsible for 40,000 tonnes of SPM10 each year. Particulates also enter the atmosphere from unexpected anthropogenic sources, such as cigarette smoking. In Los Angles, this source contributes 1.0 to 1.3% of the fine particles polluting the air.[250]

Measuring the degree of SPM pollution has been difficult, as the basis of the evolving scientific knowledge of the problem only began to become realized in the mid 1990s. That is unlike research relating to particulates above SPM10. The research for this class of air pollutants suggests that, reductions in emissions for SPM 10 and above are being made in most industrialized countries. For example, between 1988 and 1997, average SPM10 concentrations in the United States decreased by 26%. In the United Kingdom, SPM10 concentrations decreased by 42% since between 1970 and 1999.[251] Ten of Asia's 11 mega-cities exceed the WHO guidelines by a factor of at least three. Similar problems have been recorded in a number of Middle Eastern cities. Although some decreases in of SPM 10 pollution have been recorded in a few cities in developing countries, the general trend, especially in Asia, is that SPM10 concentrations are increasing.[252]

[249] Brown, P. (2004). 'Tirana, Pollution Capital of Europe'. *Guardian Weekly*. Apr 8. 21.

[250] World Resources Institutes, UNEP & World Bank. (1999). *World Resources: 1998–1999*. (Oxford University Press). 63. UNEP/WHO. (1994). 'Air Pollution in the World's Megacities'. *Environment*. 36(2). 11. Holmes, B. (1994). 'Warning: Tobacco Seriously Causes Smog'. *New Scientist*. Aug 20. 9. Pearce, F. (1999). 'Burning Rubber'. *New Scientist*. Apr 10. 14.

[251] OECD. (1999). *Environmental Data Compendium*. (OECD, Paris). 57. EPA. (1997). *1997 National Air Quality*. (EPA, Washington). 10.

[252] UNEP. (2002). *Benchmarking Urban Air Quality Management and Practice in Major and Mega Cities of Asia*. (UNEP, Nairobi). 5. UNEP. (2002). *GEO 3*. (Earthscan, London). 228–229. UNEP. (2000). *GEO 2000 Report*. (Earthscan, London). 56, 170. Patel, T. (1997). 'Filthy Air Pushes Delhi To Crisis Point'. *New Scientist*. March 8. 9.

C. Oxides of Nitrogen

Fossil fuel combustion is the main source of non-natural nitric oxide (NO) and nitrogen dioxide (NO2) known collectively as nitrogen oxides (NOx). In international terms, it has been recognized since 1974 that, 'nitrogen oxides, especially in relation to the formation to photochemical air pollution' may be a cause of air pollution.[253]

One global inventory has estimated that about 150 million tonnes of NOx are emitted into the atmosphere each year, divided equally between natural and anthropogenic causes.[254] However, the accuracy of natural emissions is far from certain. Lightening is the largest source of natural nitrogen oxides accounting for perhaps 25% of the planet's production of NOx.[255] Between 1955 and 1975, annual emissions of NOx was put at 2 million metric tonnes in Europe with large amounts also being released by the United States.[256] In 1990, the world wide total of NOx emissions was an estimated 68 million tonnes per year.[257] With regard to NOx per capita emissions in Europe, in the mid 1990s, the highest rate of NOx emissions was Luxembourg at 0.058 kilogrammes per person. The lowest rate was 0.016 kilogrammes per person for Portugal. The average was 0.035.[258]

In the late 1980s, in terms of anthropogenic emissions of NOx, with regard to stationary sources, public power, cogeneration and district heating plans (boilers and stationary combustion turbines) commercial, institutional and residential combustion plants, industrial combustion plants and processes accounted for 85% of total emissions. Non-combustion processes, such as nitric acid production accounted for 12%, and extraction, processing and distribution of fossil fuels accounted for 3%. Road traffic was usually the largest single overall source of NOx emissions for mobile sources.[259]

On a global basis, it has been estimated that motor vehicles can account for between 25 and 50% of NOx.[260] In congested cities, traffic can be

[253] 1974 OECD *Guidelines for Action to Reduce Emissions of Sulphur Oxides and Particular Matter from Fuel Combustion in Stationary Sources*. IPE. XV. 7628.
[254] WHO (1999). Protection of the Human Environment: Air Quality Guidelines. (WHO, Geneva). II:17.
[255] IPCC. (2000). *Land Use, Land-Use Change, and Forestry*. (Cambridge University Press, Cambridge). 4.
[256] Anon. (1980). 'Soft Words on Acid Rain'. *New Scientist*. August 21. 574.
[257] Elsom. (1996). *Smog Alert*. (Earthscan, London). 34.
[258] McCormack, J. (1997). *Acid Earth*. (Earthscan, London). 111–112.
[259] 1988. Sophia Protocol. Technical Annex. Paragraphs 7 and 42.
[260] WHO. (1999). *Protection of the Human Environment: Air Quality Guidelines*. (WHO, Geneva). VI:4. Cf. Schwela, D. (1999). *Urban Traffic Pollution*. (Routledge, London). 4.

responsible for between 80 to 90% of NOx. In the mid 1980s in the United Kingdom, it was estimated that 39% of the 1.9 million tonnes of NOx in the British atmosphere came from motor vehicles. In the United States in the same period, trucks and cars contributed 36% of the NO into the atmosphere.[261] In many places, the exponential growth in road traffic has weakened any chance of substantial reductions in NOx emissions. This problem has been replicated in the developing world.

By 1995, 18 of the 25 parties to the 1988 Sophia Protocol had fully complied with the basic obligation to stabilize their NOx emissions at 1987 levels by the end of 1994. By 1995, the average overall reduction was 4% below 1987 levels. Including reductions by countries in the regions which were not parties to the Protocol, the overall reduction was 13%. The cumulative reductions in NOx emissions within Europe between 1980 and 2001 was 26%. Some countries, such as the United Kingdom reduced their NOx emissions from 4,852 Gg in 1980 to 1002 Gg in 2002. NOx emissions in Japan fell by 21% between 1975 and 1999. Such progress has not been reflected in all developed countries. For example, in the United States, NOx emissions have proved difficult to reduce, moving only from 22,121 Gg in 1980, down to 19,263 Gg in 2002.[262] Similar problems have been recorded in a number of developing countries. For example, for the period 1980 to the mid 1990s, China's emissions of NOx increased by 50% (from 4,910,000 to 5,370,000 tonnes). Likewise, India's increased 53% (from 1,670,000 to 2,560,000 tonnes).[263] The average increase of NOx emissions in Asia in 2002 was between 5 to 10% per year.[264]

D. Low-Level Ozone

Ozone in the stratosphere is necessary to protect the Earth's surface from harmful ultra-violet light. However, low-level ozone in smog, although continuing to block the harmful UV light poses a distinct human and environmental risk. Low-level ozone forms in the atmosphere when a number of substances come together. Typically, these mixes involve Volatile Organic

261 UNEP. (2002). *GEO 3*. (Earthscan, London). 227. UNEP. (2000). *GEO 2000 Report*. (Earthscan, London). 115. World Resources Institute, UNEP, World Bank. (1997). *World Resources 1996–1997*. (Oxford University Press). 86. Anon. (1984). 'How Vehicles Exhaust the Atmosphere'. *New Scientist*. December 20. 6. Anon. (1988). 'Acid Rain Blamed for Nutrient Overload Along Coasts'. *New Scientist*. May 5. 30.

262 UNECE. (2004). Present State of Emission Data. EB.AIR/GE.1/2004/10. July 1. 7–20. cf. Lomborg, B. (2001). *The Sceptical Environmentalist*. (Cambridge University Press, Cambridge). 174. 6 *YBIEL*. (1995). 218. 7 *YBIEL*. (1996). 125.

263 McCormick, J. (1997). *Acid Earth*. (Earthscan, London). 10.

264 UNEP. (2002). *Benchmarking Urban Air Quality Management and Practice in Major and Mega Cities of Asia*. (UNEP, Nairobi). 5.

Compounds (VOCs), CH_4, NOx (which oxidizes in the atmosphere to form N_2O), sunlight and heat.[265] Although, low level ozone will not accumulate when it can react rapidly with the NOx to reform N_2O and dioxygen, it may appear when organic gases are present. The oxygen atoms in these gases, which are mostly hydrocarbons, allow NOx to form N_2O with the intervention of ozone. One effect of this is that in the core of big cities, ozone can be quite low. Meanwhile, in the surrounding countryside where there is little nitric oxide left to destroy ozone, levels may rise. Thus, perversely, only addressing one pollutant, may actually increase another.[266]

Background levels of ozone in the lower atmosphere are typically 30 ppb. The WHO sets a recommended safety limit for exposure to low level ozone of 100 ppb over one hour, and 60 ppb over eight hours.[267] In the United States, the peak concentrations of low level ozone declined by about 50% in a number of large cities between 1955 and the early 1990s. In Los Angles, the number of critical health alert days due to dangerous concentrations of low level ozone reduced from 121 days in 1977 to seven days in 1996. Nevertheless, in the year 2000, it was estimated that, 'tens of millions' of people still lived in areas in the United States where the one hour low level ozone standard was exceeded.[268] The highest levels of ozone concentrations in Europe were recorded in the 1970s. Although concentrations of low level ozone generally fell in the 1990s a number of spikes have shown this to be a difficult pollutant to control in the United Kingdom and a number of other European countries.[269] Once the Gothenburg Protocol is fully implemented, the number of days with excessive ozone will should be halved.[270] The slow success of dealing with low level ozone

[265] The methane connection to low level ozone was noted in the preamble of the Gothenburg Protocol. Paragraph 23. Gribbin, J. (1989). 'Ozone in Smog Blocks Harmful Ultraviolet'. *New Scientist.* November 4. 13.

[266] Pearce, F. (1986). 'Controls on Nitrogen Could Increase Ozone Pollution'. *New Scientist.* January 16. 18. Pearce, F. (1986). 'Stalled in a Haze of Ozone'. *New Scientist.* November 20. 18.

[267] Pearce, F. (1992). 'Back to the Days of Deadly Smogs'. *New Scientist.* Dec 5. 25–26.

[268] UNEP. (2002). *GEO 3.* (Earthscan, London). 230. Anon. (1997). 'Coming Up For Air'. *New Scientist.* May 17. 13. Lents, J. (1993). 'Clearing the Air in Los Angles'. *Scientific American.* Oct 18. Anon. (1989). 'Americans Overdose on Ozone'. *New Scientist.* July 22. 5.

[269] Hecht, J. (1999). 'Ozone-Busting Fuel Proves a Damp Squib'. *New Scientist.* May 22. 20. Anon. (1995). 'French Fumes'. *New Scientist.* July 15. Day, M. (1998). 'City Dwellers Dying For A Breath of Fresh Air'. *New Scientist.* Jan 24. 16. Cf. Hamer, M. (1997). 'Lies, Damned Lies'. *New Scientist.* Nov. 29. Editor. (1995). 'Britain's Last Gasp'. *New Scientist.* May 13. 3. Boehmer, S. (1990). 'Curbing Auto Emissions in Europe'. *Environment.* July/August. 16. Pearce, F. (1986). 'Stalled in a Haze of Ozone'. *New Scientist.* November 20. 18.

[270] UN/ECE (2000). The 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground Level Ozone. <http://www.unece.org/env/lrtap/multi_h1.htm>

pollution in the wealthy countries has not been replicated in the developing world where an annual increase of between 5 and 10% in the 1990s was common.[271] In some countries this is a particular problem. For example, in Mexico city, the concentration of low level ozone level reached 398 ppb in the early 1990s, and WHO safety levels were exceeded on 310 days of the year.[272]

E. Volatile Organic Carbons

Volatile Organic Compounds (VOCs) is a collective term for a wide range of compounds containing carbon. The term is usually taken to include hydrocarbons, oxygenates such as alcohol, and CH_4. According to the 1991 VOC Protocol, VOCs are, 'all organic compounds of anthropogenic nature, other than methane, that are capable of producing photochemical oxidants by reactions with nitrogen oxides in the presence of sunlight'.[273] All VOCs need to be controlled if the objective is to confront dangerous concentrations of low level ozone.[274] VOCs all evaporate quickly. VOCs like NOx and benzene are also independent health hazards.[275] Although CH_4 is the most abundant VOC, CH_4 is not controlled under the VOC Protocol. Rather, CH_4 is dealt with under the FCCC. Accordingly, the focus of the VOC Protocol is on non-methane VOCs.

The sources of VOCs for indoor and outdoor air pollution are multiple. In many countries, the industrial use of solvents is the biggest contributor from stationary sources. This includes large scale painting, chemical and ink uses. The industries of petroleum (from refineries and distribution), food (when using alcohol and/or aliphatic hydrocarbons), iron and steel, waste (when dealing with methane emissions) and agriculture (when burning straw and stubble, organic pesticides, or allowing the anaerobic degradation of animal feed or wastes) are all notable emission sources. VOCs also come from domestic 'product' emissions, such as adhesives, some paints, household cleaning and personal care products, office products (such as correction fluid), aerosols, car maintenance products, deodorants, barbecues and starter fluid and petrol burning garden tools. A single indus-

[271] WHO (1999). *Protection of the Human Environment: Air Quality Guidelines*. (WHO, Geneva). II:13.
[272] Pearce, F. (1992). 'Back to the Days of Deadly Smogs'. *New Scientist.* Dec 5. 25–26.
[273] VOC Protocol. Article 1.
[274] VOC Protocol (1991). Preamble.
[275] Benzene is a constituent of crude oil. In Europe at the end of the 20th century it was present in petrol in a proportion of about 5%, and occasionally as high as 16%. However, in the USA, the concentration in petrol does not exceed 1.5–2%. The major source of atmospheric benzene is emissions from motor vehicles and evaporation loss during handling, distribution and storage of petrol. See Schwela, D. (1999). *Urban Traffic Pollution.* (Routledge, London). 45.

trial chainsaw operating for one hour releases as many hydrocarbons as a typical passenger car traveling at 320 km. Likewise, domestic lawn mowing for one hour can produce the equivalent amount of polycyclic aromatic hydrocarbons (PAHs) as a 150 kilometre drive in a typical passenger car.[276]

Road transport accounts for approximately 50% of global anthropogenic VOCs emissions. In the European Union, the contribution from road transport is between 35 and 45% of total anthropogenic VOC emissions.[277] The largest source of road transport VOC emissions is petrol driven vehicles. These vehicles account for 90% of total traffic emissions of VOCs, of which between 30 to 50% are evaporative emissions.[278]

By 1998, VOC emission reduction targets (30% from 1988 levels) had been achieved by most of the Parties to the VOC Protocol.[279] With the United States between 1980 and 1996, VOC emissions (in terms of 000 metric tonnes) were reduced from 23,596 to 17,315. Germany reduced VOC emissions from 3,224 to 1,877 in the same period. Similar reductions have also been recorded with countries in economic transition. For example, VOC emissions were reduced in Poland from 1,036 to 766.[280] Many of these decreases continued into the new century.[281]

F. Carbon Monoxide

Carbon monoxide (CO) is a primary and secondary pollutant. It is a primary pollutant in that CO is poisonous. CO binds strongly to the blood's hemoglobin and prevents oxygen from being carried to the tissues. Like a number of other gases, it is also a secondary pollutant which in the presence of NOx and VOCs helps in the formation of low level ozone.[282]

Although CO is not a long-lived gas, its tendency to react easily gives it a potent influence on other chemicals which do not have a global range. The most important of these is hydroxyl (OH), a free radical made up of one atom of oxygen and one of hydrogen that is produced when UV radiation bombards ozone in the atmosphere. Hydroxyl is present in the atmosphere in only minute quantities (less than 0.00001 ppb). Despite such small

[276] VOC Protocol. 1991. Annex. Paragraphs 24–71, 80. Pearce, F. (2001). 'Are You Killing Your Neighbours When You Mow the Lawn'. *New Scientist.* June 9. 8. Hecht, J. (1999). 'Cutting Edge'. *New Scientist.* Feb 20. 21. Boehmer-Christiansen, S. (1990). 'Curbing Auto Emissions in Europe'. *Environment.* July/August. 16.

[277] WHO. (1999). *Protection of the Human Environment: Air Quality Guidelines.* (WHO, Geneva). VI:4.

[278] VOC Protocol. 1991. Annex III. Paragraph 4.

[279] 9 YBIEL. (1998). 178.

[280] UNDP, UNEP, World Bank, WRI. (2000). *World Resources 2000–2001.* (Oxford University Press, Oxford). 284.

[281] UNECE. (2004). Present State of Emission Data. EB.AIR/GE.1/2004/10. July 1. 12–15.

[282] Preamble. Also, Newell, R. (1989). 'Carbon Monoxide and the Burning Earth'. *Scientific American.* Oct 58–64.

quantities, hydroxyl is the atmosphere's most important oxidising agent, removing many pollutants from the air in the lower atmosphere. The main removal process for methane is reaction with OH.[283] Evidence suggests that in some regions, there was a 25% less hydroxyl in the atmosphere in the late 1980s than in 1950. Hydroxyl is unique, in that it is both positively and negatively affected by multiple environmental factors. For example, stratospheric ozone depletion leads to an increase in the concentration of the OH in the troposphere. Conversely, OH may be destroyed by enhanced levels of CO. Thus, CO plays a crucial role in allowing methane to accumulate in the atmosphere. However, the removal of OH from the atmosphere may, cause ozone production to slump because OH takes part in the reaction between NOx and hydrocarbons which produce ozone, and ironically the problem of air pollution is enhanced at a different level.[284]

CO originates from both natural and anthropogenic sources. The amount of natural CO is difficult to estimate and suggestions range from 300 million to 1,600 million tonnes per year. This uncertainty makes overall measurements of CO difficult. CO from anthropogenic sources is formed by the incomplete combustion of carbon containing fuels and various industrial processes. On a global basis, it has been estimated that motor vehicles can account for between 60 to 70% of industrial CO. In congested cities, traffic can be responsible for between 90 to 95% of ambient concentrations of CO.[285]

Ambient levels of CO have fallen over the last two decades in a number of developed nations. For example, within the United Kingdom, emissions of CO reduced from 7,669 Gg in 1980 to 3,238 Gg in 2002. However, in other developed countries, the decreases have not been consistent, and downward trends have been reversed. For example, in the United States, emissions of CO were reduced from 101,641 Gg in 1980 to 83,993 Gg

[283] IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change*. (Cambridge University Press, Cambridge). 26. Graedel, T. & Crutzen, P. (1989). 'The Changing Atmosphere'. *Scientific American*. September. 28–35. Pearce, F. (1989). 'Methane: The Hidden Greenhouse Gas'. *New Scientist*. May 6. 19.

[284] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report*. UNEP/OzL.Pro/WG.1/23/3. 29. Pearce, F. (2003). 'Pollutants Do Part Time Cleaning Job'. *New Scientist*. Feb 22. 7. Editor. (2001). 'Bolt From the Blue'. *New Scientist*. Apr 28. 3. Pearce, F. (2001). 'Hanging In the Air'. *New Scientist*. Apr 28. 21. McElroy, M. (1988). 'The Challenge of Global Change'. *New Scientist*. July 28. 34. Anon. (2000). 'Greenhouse Shock'. *New Scientist*. Jan 8. 7.

[285] WHO. (1999). *Protection of the Human Environment: Air Quality Guidelines*. (WHO, Geneva). VI:4. Schwela, D. (1999). *Urban Traffic Pollution*. (Routledge, London). 5. World Resources Institute, UNEP, World Bank. (1997). *World Resources 1996–1997*. (Oxford University Press). 86. Pearce, F. (1996). 'Air Bubbles Burst Poisonous Gas Theory'. *New Scientist*. Aug 31. 17.

in 1995. However, CO emissions then increased to 101, 798 Gg in 2002.[286] In a more consistent manner, emissions of CO have risen in much of the developing world. Part of the rise of CO in the developing world, and in some countries in particular, can be attributed to the burning of forests. Although this source of CO is less toxic than industrial CO it was a growing problem with the forest fires in South East Asia in the late 1990s. For example, the forest fires in Indonesia between 1997 and 2000 often produced concentrations of CO of 380 ppm. This level of CO concentration was ten times higher than the normal level in this region. The CO helped produce low level ozone. The smoke over some Indonesian cities reached 7.5 milligrammes per cubic meter and lasted for several weeks. This was substantially more than the great London smog of 1952 which peaked at 4.6 milligrammes and killed over 4,000 people in five days. Thus, in some instances, biomass burning in tropical countries may be larger polluters (in terms of density of local pollution) than the motorists of Europe and North America.[287]

G. Ammonia

Ammonia (NH_3) is typically created by the huge amounts of slurry which is often sprayed onto fields by farmers. It is a by-product of animal manure and fertilizer use, and is mainly a problem where intensive agricultural methods are used. Ammonia, which has grown rapidly with the advent of factory farming is an important factor in air pollution. Ammonia may also link into the effects of air pollution on ecosystems by forcing vital nutrients in the soil, such as magnesium, potassium, and calcium, to dissipate. In addition, when NH_3 hangs in the air, it can produce ammonium sulphate. This, in turn, settles on trees and the soil. In the soil, sulphate converts to sulphuric acid and the ammonia (which is made of nitrogen and hydrogen atoms) converts to nitric acid.[288] European emissions of ammonia had dropped by 24 % between 1990 and 2002.[289]

---

286 UNECE. (2004). Present State of Emission Data. EB.AIR/GE.1/2004/10. July 1. 16–17. UNDP, UNEP, World Bank, WRI. (2000). *World Resources 2000–2001*. (Oxford University Press, Oxford). 284.

287 WHO. Ibid. VI:15. WHO. (1999). *Health Guidelines for Vegetation Fires*. (WHO, Geneva). v. Anon. (2001). 'Burning Issue'. *New Scientist*. Dec 15. 27. Pearce, F. (1996). 'Tropical Smogs Rival Big City Smogs'. *New Scientist*. May 18. 4. Newell, R. (1989). 'Carbon Monoxide and the Burning Earth'. *Scientific American*. Oct. 58–64. Hadfield, P. (2000). 'Slow Burn'. *New Scientist*. Jan 1. 16. Editor. (1997). 'The Neighbor From Hell'. *New Scientist*. Oct 4. 3.

288 Pearce, F. (1986). 'Unraveling A Century of Acid Pollution'. *New Scientist*. Sep 25. 23–24. Pearce, F. (1986). 'Are Cows Killing Britain's Trees ?' *New Scientist*. Oct 22. 20. Pearce, F. (1986). 'The Strange Death of Europe's Trees'. *New Scientist*. December 4. 44–45.

289 UNECE. Ibid. 7.

H. Lead

Lead is released into the atmosphere from both natural and human-made sources. Low level measures in glacier ice and remote locations indicate that natural sources of lead, mostly wind blown dust and volcanoes, are relatively small and of the order of 2,000 tonnes per year. Conversely, humanity currently releases approximately 450,000 tonnes annually. This is not a new problem. Lead, deposited in ice, marine and freshwater sediments and annual tree rings over the centuries via atmospheric loads due to smelting, demonstrates that Antiquity had lead levels equivalent to 15% of all the lead of the twentieth century accumulated from leaded petrol.[290] In later historical periods, lead poisoning may have contributed to the premature death of thousands of people. Half of the anthropogenic lead remaining in the European environment at the turn of the new century was generated before the Industrial Revolution.[291]

Given that lead is a product which has multiple applications in modern society, it was possible to argue that the sources of lead contamination occurred through any number of sources such as pipes, paint, crockery, food and even candles.[292] It is also possible to demonstrate that lead contamination is due to its usage in gasoline as an anti-knock agent.[293] Estimates over what extent leaded petrol was responsible for the overall lead contamination in modern cities produced heated debates from the 1970s until the 1990s, with percentage estimates ranging from 6.5% to 90%.[294] It was

[290] Emsley, J. (1994). 'Ancient World Was Poisoned By Lead'. *New Scientist.* Oct 1. 14.

[291] Anon. (2000). 'Ye Olde Pollution'. *New Scientist.* Jan 8. 12.

[292] Randerson, J. (2002). 'Candle Pollution'. *New Scientist.* June 22. 15. Anon. (1984). 'Lead in Tap Water: A Menace for Millions'. *New Scientist.* November 29. 9. Anon. (1983). 'Paint Stripping Can Harm Your Child'. *New Scientist.* September 22. 835. Patel, T. (1993). 'Lead Paint Poisons Paris Children'. *New Scientist.* Aug 21. 8. Anon. (1985). 'Lead in Your Coffee'. *New Scientist.* September 26. 21. Anon. (1983). 'Lead Report Brings New Alarm'. *New Scientist.* February 3. 291.

[293] Oil companies started putting lead in petrol in the 1920s when it was found to be an effective agent anti-knock agent. Knock occurs because the fuel/air mixture burns progressively across the combustion chamber, normally leaving some un-burnt mixture called 'end-gas'. Lead in tetraethyl and tetra-methyl form, helps the mixture to burn, reduces the amount of end-gas and delays the conditions under which it ignites. Lead also lubricates and prolongs the lives that allow fuel into, and burnt gas out of, the engine.

[294] UNEP/WMO. (1989). 'Monitoring the Global Environment: As Assessment of Urban Air Quality'. *Environment.* October. 6, 33. Anon. (1980). 'Report Sinks Like Lead Balloon'. *New Scientist.* April 3. 5. Pearce, F. (1983). 'Lead Man Deserts the Government's Camp'. *New Scientist.* March 3. 569. Lee, B. (1980). 'Lead Risk Undercuts Energy Savings'. *New Scientist.* January 31. 304. Lubinska, A. (1982). 'Turin Experiment Reveals Lead Threat'. *New Scientist.* November 4. 281. Price, D. (1983). 'Censorship Hits Turn Lead Survey'. *New Scientist.* February 17. 425. WHO. (1999). Protection of the Human Environment: Air Quality Guidelines. (WHO, Geneva). VI:4. World Resources Institute, UNEP, World Bank. (1997). World Resources 1996–1997. (Oxford University Press). 86.

only in the late 1990s that reliable international estimates concluded the global average (noting that a number of countries had by now banned lead-based petrol) of 60% of all lead in the atmosphere originated from lead based gasoline. However, in some congested cities which still had leaded gasoline, the figure was 80 to 90%.[295]

In most industrialized countries, once lead was removed from petrol, lead levels in the air of cities fell dramatically. For example, in the United States, between 1970 and 1997, petroleum based lead emissions were reduced by 98%.[296] Similar reductions of more than 90% have also been recorded in many European cities.[297] Unfortunately, this has not been the case in many developing countries. For example, in the new century, lead poisoning cases, not seen in Europe or the North America for thirty years, persist in Africa, Latin America and the Middle East. This is not surprising given that the WHO health standard for lead in the air (1 microgramme per cubic metre) is commonly exceeded because the sale of leaded petroleum continues unabated in many of these regions.[298]

I. The Transboundary Nature of Air Pollution

The possibility of air pollution going from one state to another was first suggested in 1881, when a Norwegian scientist attributed polluted snowfall to a industrial district in Britain.[299] Despite this early identification of transboundary air pollution, and subsequent studies from the 1960s to the 1980s, that indicated that, inter alia, the United States was polluting Canada, whilst Sweden and Norway were being polluted from air pollution from other countries,[300] it was not until the mid 1980s that more reliable, less contested scientific analysis of transboundary air pollution evolved. Soon after, international law, in the form of the 1991 VOC Protocol recognized

[295] WHO. (1999). *Protection of the Human Environment: Air Quality Guidelines*. (WHO, Geneva). VI:4. World Resources Institute, UNEP, World Bank. (1997). *World Resources 1996–1997*. (Oxford University Press). 86.

[296] WHO. Ibid. VI:15. UNEP. (2000). GEO *2000 Report*. (Earthscan, London). 168. Anon. (1986). 'Lead Fallout Drops'. *New Scientist*. July 10. 21.

[297] Elsom. (1996). *Smog Alert*. (Earthscan, London). 65.

[298] UNEP. (2000). *GEO 2000 Report*. (Earthscan, London). 132, 176. Motluk, A. (1996). 'Lead Blights The Future of Africa's Children'. *New Scientist*. March 23. 6. Graham-Rowe, D. (2001). 'Its Time For Africa To Clean Up Its Petrol'. *New Scientist*. Oct 29. 18. World Resources Institute, UNEP, World Bank. (1997). *World Resources 1996–1997*. (Oxford University Press). 86.

[299] Noted in McCormick, J. (1997). *Acid Earth*. (3rd End, Earthscan, London). 6.

[300] Pearce, F. (1982). 'The Menace of Acid Rain'. *New Scientist* August 12. 423. Anon. (1979). 'Acid Rain Comes Between Canada and the US'. *New Scientist*. August 23. 573. Yanchinski, S. (1978). 'Air Pollution Evidence Stacked Against Sweden'. *New Scientist*. June 15. 731. Anon. (1986). 'Britain and US Accept the Science of Acid Rain'. *New Scientist*. March 27. 11.

that, 'VOCs, nitrogen oxides and resulting ozone are transported across international boundaries, affecting air quality in neighboring states'.[301] Likewise, the Gothenburg Protocol added that air pollution could be transported, 'between continents'[302] and not just between neighboring countries.

As of the year 2000 58% of the SO_2 deposition (4.7 million tonnes) in the EMEP countries (basically Europe, as well as Canada and the United States) originated from the transboundary exchange of pollution among countries. Only in seven countries, including Turkey, Ireland, Spain and Portugal, was the SO_2 deposition from other countries below half of the total deposition. Norway got 95% of its SO_2 from other countries, whereas the United Kingdom got 25% from offshore. It has also been calculated that about 5% of the deposition on Europe comes from North America and 1% from Asia. With regards to nitrogen emissions, of the 9.8 million tons were emitted from EMEP countries in 1998, 45% of the total are transboundary in movement.[303] Foreign deposition of nitrogen contributes is below 50% of total deposition in 13 countries. The United Kingdom got 30% of its nitrogen air pollution from offshore sources, whereas Latvia got 90% from other countries. Low level ozone pollution is also transboundary. In the mid 1990s, research suggested that contributions of air pollutants from other countries to England's coastal locations were about 20% from France, 18% from Germany and 6% from the Netherlands.[304]

301 VOC Protocol (1991). Preamble.
302 Gothenburg Protocol. 1999. Preamble. Paragraph 5.
303 EMEP. (2000). *Transboundary Acidification and Eutrophication in Europe*. (EMEP, Geneva). 11.
304 EMEP. (2000). *Transboundary Acidification and Eutrophication in Europe*. (EMEP, Geneva). 11–13. Stedman, J. (1992). 'The Relationship Between Ozone and Precursor Emissions'. *Atmospheric Environment*. 26: 1271–1281.

III. NATURAL AND ANTHROPOGENIC INFLUENCES

1. Ozone Depletion

The dispute about the natural, non-human, contribution to the thinning of the ozone layer has a long history.[1] The basic argument was that any detrimental impact on the ozone layer was more likely caused by non-human natural sources than anthropogenic causes. This is not an outrageous suggestion, for as the Vienna Convention, noted, 'chemical substances of natural and anthropogenic origin . . . are thought to have potential to modify the chemical and physical properties of the ozone layer'.[2] There were two basic arguments in this debate. The first argument tried to negate the role of anthropogenic emissions at the expense of natural ones. The second argument suggested that Nature was much more resilient than commonly believed.

The first argument that attempted to negate the human contribution of damage to the ozone layer suggested that a number of chemicals, already naturally present in the atmosphere, affect the ozone layer to a much greater degree than humanity does. NASA was the first organization to use this argument in the mid 1970s, when they tried to downplay the influence of the chlorine coming from the space shuttle, as opposed to the influence of volcanoes.[3] This identification of volcanoes as a source of ozone depleting gases was correct, as later research clearly demonstrated that when Mount Pinatubo erupted in 1991, the ozone in the lower stratosphere over the tropics reduced by 30 per cent over the Antartic and 20 per cent over the Arctic. However, although volcanoes were shown to a source of ozone damaging chemicals, their impact did not eclipse the anthropogenic impact. Rather, it supplemented it.[4] Natural sources of methyl chloride, methyl bromide and chloromethane) were also identified as a

---

[1] Anon. (1986). 'Hunt for the Hole in the Ozone Layer'. *New Scientist.* July 3. 22.
[2] Annex 1. (4).
[3] Litfin, K. (1994). *Ozone Discourses.* (Columbia University Press, New York). 63.
[4] Gribbin, J. (1993). 'Hot Dust Threatens Ozone Above Tropics'. *New Scientist.* Jan 2. Mackenzie, D. (1992). 'Ozone Threat'. *New Scientist.* Feb 8. 16. Editor. (1992). 'Ozone Hole Exposes the North'. *New Scientist.* Feb 15. 13. Pearce, F. (1992). 'Europe Exposed to UV Risk As Ozone Levels Hit All-Time Low'. *New Scientist.* Apr 11. 5. Anon. (1984). 'El Chichon and the Ozone Layer'. *New Scientist.* Oct 18. 29. Anon. (1988). 'Volcanoes Poised to Blow Another Ozone Hole'. *New Scientist.* Sep 1. 42. Gribbin, J. (1992). 'Dust From Last Year's Volcanoes'. *New Scientist.* Nov 28. 16.

threat to the ozone layer. However, once more, the natural contribution of these chemicals was found to be substantially less than the anthropogenic ones.[5] Finally, solar cycles and the flux of radiation from the sun was suggested, from the mid 1970s until the late 1980s, as being the primary cause of the depleted ozone layer.[6] Later research demonstrated that although the solar cycle has an influence on the ozone layer, it does not cancel out the human contribution of ODS.[7]

The second argument originally suggested, that one of the reasons why there was no evidence of ozone depletion, was due to the possibility that a natural sink for ODS was beneficially soaking up the ODS and thus negating any detrimental effect inflicted on the ozone layer.[8] This view was quickly dismissed when it was discovered that the Polar regions that were acting as the sinks for ODS, and the impact of ODS was not being negated, but concentrated in detrimentally catalytic areas. In this instance, Nature behaved in a completely unexpected way. This unpredictability was such that even fundamental chemical equations were thrown into doubt. In this context, the unpredictability was caused by the uplifting of air currents after the Polar winter whereby ozone-poor air from lower altitudes is drawn into the stratosphere via a 'polar vortex'. This process then links into extremely cold temperatures and stable air masses. These conditions form the perfect platform for ODS destruction of the ozone layer.[9]

5 Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 14. Anon. (1987). 'Fungus Bogey Blights Ozone Layer'. *New Scientist.* Feb 5. 27. Anon. (1994). 'Fire Hazard'. *New Scientist.* March 12. 11. Gribbin, J. (1978). 'Monitoring Halocarbons'. *New Scientist.* Jan 18. 164–167.

6 Anon. (1976). 'Ozone Layer May Link the Sun With Climate Change'. *New Scientist.* June 3. 508. Callis, L. (1979). 'Solar Variability and Ozone'. *New Scientist.* Nov. 15. 532. Anon. (1984). 'Solar Influence on Ozone'. *New Scientist.* Aug 2. 36. Anon. (1986). 'Antarctic Investigators Rule Out Natural Causes of Ozone Hole'. *New Scientist.* Oct 30. 20. Anon. (1987). 'Do Solar Particles Pierce the Ozone Layer?' *New Scientist.* June 4. 30. Gribbin, J. (1988). 'Return of Sunspots Brings Radiation Fears'. *New Scientist.* July 7. 22. van Loon, H. (1988). 'When the Wind Blows'. *New Scientist.* Sep 8. 58–59. Anon. (1989). 'Changing Sun Could Influence Ozone Chemistry'. *New Scientist.* May 20. 12.

7 Gribbin, J. (1993). 'Quieter Sun Will Lead to Deeper Ozone Hole'. *New Scientist.* Feb 13. 16.

8 The 1977 World Plan of Action on the Ozone Layer, stressed importance of understanding the possibility of "sources and sinks" *World Plan of Action on the Ozone Layer*, 1977. In *IPE* XXVIII, 390. Section 1. Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1984). Report of the Working Group, First Part of the Fourth Session. UNEP/WG. 110/4. 4. Gribbin, J. (1979). 'Monitoring Halocarbons in the Atmosphere'. *New Scientist.* Jan 18. 164–167. Eggleton, A. (1976). 'Will Chlorofluorocarbons Really Affect The Ozone Shield?' *New Scientist.* May 20. 402–403. Anon. (1976). 'Upper Atmosphere Chemistry: The Arguments Continue'. *New Scientist.* June 10. 564. Anon. (1976). 'Aerosols and Ozone: Good News and Bad'. *New Scientist.* May 20. 395. Anon. (1986). 'Ozone Hole Is Normal'. *New Scientist.* Sep 4. 22.

9 Anon. (1987). 'US Spy Plane Set To Examine Origins of Ozone Hole'. *New Scientist.* July

2. Climate Change

Natural events or patterns are also at the forefront to the challenge that human's overtly influence the Earth's climate. The specific areas of concern are volcanoes, sunspots, Earth wobbles, and clouds.

Volcanoes can lead to a cooling of the atmosphere through massive emissions of SO_2 (which forms a shield, and reduce the amount of solar heating reaching the planet's surface). Such impacts may last for a number of years. Several major eruptions occurred in the periods 1880 to 1920 and 1960 to 1991. The eruptions of El Chichon and Mount Pinatubo were particularly notable.[10] Clouds as transient, ephemeral objects, surprisingly, also have an important role to play in climatic change, and may already be changing because of global warming in addition to enhancing climatic change.[11] Nevertheless, factoring clouds into climate change calculations has been very difficult, with ongoing debate over whether they create a positive or negative feedback for climate change. Factors of cloud density, height, season and location, rates of precipitation, snow, oceans and even aerosol pollution all influence the debate in this area.[12]

---

30. 22. Gribbin, J. (1987). 'An Atmosphere In Convulsions'. *New Scientist.* Nov 26. 30–31. Stolarski, R. (1988). 'The Antarctic Ozone Hole'. *Scientific American*. January. 20–25. Verma, S. (1989). 'As Antactica's Ozone Hole Grows'. *New Scientist* Oct 7. 9. Joyce, C. (1987). 'Chlorine Clears The Ozone Layer Down South'. *New Scientist.* Oct 8. 18–19. Anon. (1987). 'Lab Experiments Back Theories of Ozone Depletion'. *New Scientist.* Dec 3. 28. Hogan, J. (2003). 'Key Chemicals Face Turbulent Times'. *New Scientist.* Sep 13. 18.

[10] IPCC. (2001). *Climate Change 2001: The Scientific Basis*. (Cambridge University Press, Cambridge). 10. Penvenne, L. (1996). 'Volcanoes Take Their Cue From Changing Climate'. *New Scientist.* June 29. 16. Edwards, R. (1997). 'Volcanic Sneezes'. *New Scientist.* Aug 30. 10. Joyce, C. (1991). 'Volcanoe Clouds The Picture on Global Warming'. *New Scientist.* Aug 24. 11. Pearce, F. (1993). 'Pinatubo Points to Vulnerable Climate'. *New Scientist.* June 19. 7. Gribbin, J. (1986). 'Global Warming is Linked to Sahal Drought'. *New Scientist.* April 24. 24.

[11] Henderson-Sellers, A. (1987). 'Climate is a Cloudy Issue'. *New Scientist.* July 23. 37. Anon. (1987). 'Towards A Cold Greenhouse'. *New Scientist.* Sep 17. 31. Anon. (1989). 'Clouds Dampen Global Warming'. *New Scientist.* Sep 25. Pearce, F. (1994). 'Not Warming, But Cooling'. *New Scientist.* July 9. 37–41. 5. Ananthaswamy, A. (2003). 'Rising Clouds Leave Forests High and Dry'. *New Scientist.* March 22. 18.

[12] Hogan, J. (2004). 'Do Cosmic Rays Hold Sway Over Climate?' *New Scientist.* Aug 14. 10. Stoott, P. (2003). 'You Can't Control The Climate'. *New Scientist.* Sep 20. 25. Mason, B. (2002). 'Cosmic Rays and Newborn Clouds Explain One of the Mysteries of Global Warming'. *New Scientist.* Aug 10. 13. IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change.* (Cambridge University Press, Cambridge). 30. Adler, R. (1999). 'All Dried Up'. *New Scientist.* Oct 16. 15. Gribbin, J. (1987). 'Steamships Make the World Grow Warmer'. *New Scientist.* Sep 10. 30. Hecht, J. (1994). 'Clouds Hold Key To Global Warming Theory'. *New Scientist.* Jan 22. 16. Pearce, F. (1994). 'Not Warming, But Cooling'. *New Scientist.* July 9. 37–41. Rind, D. (1995). 'Drying Out'. *New Scientist.* May 6. 36–41. Coghlan, A. (2003). 'Hidden Cloud Layer Revealed'. *New Scientist.* Feb 22. 6. Hecht, J. (1994). 'Clouds Hold Key To Global Warming Theory'. *New Scientist.* Jan 22. 16. Schneider, S. (1987). 'Climate Modeling'. *Scientific American.* 256 (5): 3. Anon. (2000).

In 1980, Soviet researchers, demonstrated that the Sun, although primarily stable, could influence the Earth's temperature either by flaring or through spot activity, which the Sun did on a regular cycle.[13] Although it has been suggested that the Moon may also influence warming by influencing the Earth's tides and its ocean thermostat, the main body of scientific research has concentrated on changes in the Sun's energy output.[14] However, as the research has progressed it has become became apparent that although the sunspots and flares can explain a small part of some of the early warming of the Earth, the influence and timing of the sunspots does not account for the warming (which it should have offset) in the later half of the Twentieth century.[15] A similar conclusion has been reached with so called Milankovitch 'wobbles'.[16] If anything, the natural factors should have led to cooling of about 0.3c. over the last century. This means that non-human factors may not be so much contributing to global warming, as keeping the temperature cooler. The difficulty with this conclusion is that this makes the human impact larger than expected (when the offsetting considerations are removed).[17]

'Every Cloud Has A Silver Lining'. *New Scientist.* May 6. 7. Pearce, F. (1997). 'Greenhouse Wars'. *New Scientist.* July 19. 38–39. Gribbin, J. (1978). 'Fossil Fuel: Future Shock'. *New Scientist.* Aug 24. 541.

13 Gribbin, J. (1981). 'Sun and Weather: The Stratospheric Link'. *New Scientist.* Sep 10. 669–672.

14 Hoyt, D. (1997). The Role of the Sun in Climate Change. (OUP, Oxford). Byrne, G. (2003). 'Sun Fuels Debate on Climate Change'. *New Scientist.* Apr 12. 14. Hogan, J. (2003). 'Hyperactive Sun Comes Out in Spots'. *New Scientist.* Nov 1. 17. Pearce, F. (2000). 'Tidal Warming'. *New Scientist.* Apr 1. 12. Muir, H. (2004). 'Solar Cycles Drove Medieval Markets'. *New Scientist.* Jan 3. 8. Gribbin, J. (1984). 'Carbon Dioxide Controls Ice Age Rhythms'. *New Scientist.* Apr 19. 23. Gribbin, J. (1991). 'Climate Change—The Solar Connection'. *New Scientist.* Nov 23. 22. Gribbin, J. (1990). 'An Assault on Climate Consensus'. *New Scientist.* Dec 15. 22–26.

15 IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change.* (Cambridge University Press, Cambridge). 13, 32. Anon. (1992). 'Sun's Cycles Not Main Cause of Climatic Change'. *New Scientist.* Dec 7. 18. Burroughs, B. (1990). 'Frosts and Sunspots'. *New Scientist.* Dec 15. 26. Pearce, F. (1999). 'Blazing Hot'. *New Scientist.* June 5. 5. Pearce, F. (1999). 'Only Ourselves To Blame'. *New Scientist.* Nov 20. 24. Anon. (2000). 'Don't Blame The Sun'. *New Scientist.* May 6. 6.

16 IPCC. (2001). *Climate Change 2001: The Scientific Basis.* (Cambridge University Press, Cambridge). 10. Hecht, J. (2002). 'Sun Struck'. *New Scientist.* June 15. 8. Hecht, J. (1998). 'Sweltering In Siberia'. *New Scientist.* Dec 5. 4. Pearce, F. (1997). 'Blowing Hot and Cold'. *New Scientist.* Nov 22. 14. Hecht, J. (1997). 'Global Warming May Melt The Ice'. *New Scientist.* May 10. 22.

17 Anon. (2002). 'Its Hotter With Us'. *New Scientist.* July 20. 24.

3. Air Pollution

With regard to air pollution, and especially earlier forms of air pollution typically known as 'acid rain', one of the primary arguments was over how much the causes of air pollution were non-human in origin, or whether air pollution was actually beneficial for the environment. This problem was threefold. First, in moderation, sulphur, nitrogen and ammonia are good for the environment, often providing essential nutrients for life on Earth.[18] Second, many air pollutants also originate from non-human sources including plankton as a source of sulphur,[19] whilst some species of trees produce VOCs.[20] In addition, some viruses, fungi or other predators combine with some naturally acidic ecosystems to destroy vulnerable species either independently or in conjunction with human caused environmental problems, such as climatic change.[21] In time, each of these arguments have been critiqued, and suitably placed in the broader perspectives, with regard to their relative contributions to air pollution. The general conclusion is that although all of these natural sources are important, they are comparatively minor compared to anthropogenic sources of air pollution and its impacts.

---

[18] Conzelmann, C. (1986). 'Sulphur Dioxide Could Keep Plants Healthy'. *New Scientist.* July 17. 20. Pearce, F. (1985). 'When Pollution Help's Norway's Lakes'. *New Scientist.* Oct 17. 21. MacKenzie, D. (1995). 'Killing Crops With Kindness'. *New Scientist.* Sep. 23. 4. Anon. (1988). 'Primeval Acid Rain Could Have Killed Dinosaurs'. *New Scientist.* Feb 18. 32. Anon. (1984). 'Fungi Save Roots From Acid Rain'. *New Scientist.* April 5. 18. Gould, R. (1991). 'Pests and Pollution Join Forces to Destroy Trees'. *New Scientist.* Sep 14. 13. Mohnen, V. (1988). 'The Challenge of Acid Rain'. *Scientific American.* August. 14–23. Muir, H. (2000). 'Airborne Devastation'. *New Scientist.* May 27. 16. Anon. (1986). 'Acid Rain in Cornwall'. *New Scientist.* April 24. 21.

[19] Pearce, F. (1988). 'Plankton Shares the Blame for Sulphur Pollution'. *New Scientist.* February 11. 25.

[20] Anon. (2004). 'Trees Implicated In Air Pollution'. *New Scientist.* Oct 16. 18. Anon. (2003). 'A Forest of Polluters'. *New Scientist.* March 15. 26. Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 28.

[21] Mohnen, V. (1988). 'The Challenge of Acid Rain'. *Scientific American.* August. 14–23. Pearce, F. (1990). 'Whatever Happened to Acid Rain?' *New Scientist..* Sep 15. 41. Anon. (1985). 'British Trees Pass Acid Test'. *New Scientist.* March 14. 7. Pearce, F. (1994). 'Damage to Britain's Trees Is Not So Natural After All'. *New Scientist.* June 18. 5. Anon. (1995). 'Britain's Trees Pass Medical'. *New Scientist.* May 6. 7. Anon. (1985). 'German Tree Deaths Blamed on Virus'. *New Scientist.* August 15. 17. Anon. (1987). 'Acid Pollution Stalks Plans for More British Trees'. *New Scientist.* Jan 15. 18. Coghlan, A. (2000). 'Surviving Great Smokey'. *New Scientist.* July 1. 14. Hedin, L. (1996). 'Atmospheric Dust And Acid Rain'. *Scientific American.* Dec 56–60. Kiernan, V. (1997). 'Lightening Sharpens Acid Rain's Bite'. *New Scientist.* May 31. 17. Coghlan, A. (1997). 'Toxic Chemistry Turns Air Acid'. *New Scientist.* May 3. 20.

IV. THE CALCULATION OF POLLUTANTS

1. Cumulative Approaches

The earlier Protocols to the Long Range Convention on Transboundary Air Pollution were all singular with their focus on the individual pollutants of SO_2, NOx or VOCs. However, the 1999 Gothenburg Protocol was qualitatively different by being both multi-pollutant and cumulative with regard to the aggregation of pollutants for targets. Thus, although individual targets were suggested, 'as an alternative, a Party may apply different emission reduction strategies that achieve equivalent overall emission levels for all source categories together'.[1]

With the ozone regime, in the run-up to the Vienna Convention, it was suggested that a cumulative approach (although then it was labelled a net approach) be adopted for controlling ODS. Thus,

> To add flexibility, a provision should be added whereby Parties could substitute reductions in emissions from other CFC uses, providing that the net amount of emissions reduction after such substitution is at least equal to the threat that would have resulted had a complete ban on non-essential CFC aerosol use been implemented.[2]

The furtherance of a cumulative approach is evident in the Montreal Protocol, whereby it was agreed in Article 3 that with the calculation of control levels of ODS production, each Party shall, 'multiply its annual production of each controlled substance by the ozone depleting potential specified in respect of it in Annex A, Annex B, Annex C or Annex E [and] add together, for each such Group, the resulting figures'. As such, each Party would come up with a figure for the overall cumulative total of their ODS production.

Despite this cumulative total for reporting purposes, the Protocol and its subsequent amendments did not adopt a cumulative approach, whereby an overall target was given, and the Parties would have been given flexibility in choosing which ODS they wished to reduce, so long as the cumulative target of reductions was met. Rather, the Protocol and the amendments

---

1 Article 3. (2) & (3).

2 Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1983). Draft Annex Concerning Measures to Control CFCs. Summary of Comments By Governments. UNEP/WG.94/4/Add.3/Septermber 15. 2.

mandated specific reductions, different timetables and different schedules for each ODS.

The climate change regime is unique in having both a net and comprehensive approach to greenhouse gas accounting. The net approach relates primarily to additions and subtractions within the individual CO_2 budget, whereas the comprehensive approach applies to an aggregate account of all greenhouse gases, which may include the net approach.

The net approach, whereby emissions of CO_2 from anthropogenic sources may be offset by sequestrations was first suggested at the 1991 G7 summit.[3] Despite the G7 preference, the issue was only fully resolved with the Kyoto Protocol, and not the FCCC. The Kyoto Protocol was clear that, 'the net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land-use change and forestry activities'[4] were the basis for calculation of greenhouse gas totals.

A comprehensive approach is one in which all of the relevant greenhouse gases are given a Global Warming Potential (GWP) and added into a comprehensive index an overall total of global warming impact is given for all greenhouse gases together. Within this comprehensive approach, no individual gas is singled out for specific focus. Rather, the focus is on the 'basket' of overall gases. The development of this comprehensive approach to climate change gases first appeared in 1990 when the United States announced that they could not agree to any CO_2 stabilization target, unless it included other greenhouse gases such as CH_4, NOx, VOCs and CFCs. The advantage to the United States was that many of these gases were already being restricted in other forums.[5] This proposal was originally objected to by a number of countries, as all of the other greenhouse gases apart from CO_2, were poorly understood in scientific terms.[6] It was also argued that this comprehensive approach could also lead to a greater level of methodological complexity.[7] Such complexities and uncertainties could lead to 'creative accounting'.[8] In addition, it was suggested that the comprehensive approach failed to distinguish between the merits of the control of the different greenhouse gases. For example, it may be more ethical

[3] The G7 desired a convention which should encourage the domestic utilisation of strategies that "limit net emissions of greenhouse gases." G7, 1991 London Summit. Available from <http://www.g7.utoronto.ca/g7/summit/1991london/communique/environment.html>
[4] Kyoto Protocol. Article 3 (3).
[5] Charles, D. (1991). 'Petty Politics Mars Global Warming Conference'. New Scientist. Feb 23. 6. Charles, D. (1991). 'US Feels Heat On Global Warming Stance'. New Scientist. Feb 16. 8.
[6] MacKenzie, D. (1991). 'America Creates Cold Climate For Greenhouse Talks'. New Scientist. June 22. 16.
[7] Pearce, F. (1997). 'US Plan Complicates The Climate Equation'. New Scientist. Feb 1. 8.
[8] Anon. (1992). 'Don't Let Us Drown, Islanders Tell Bush'. *New Scientist.* June 13. 6.

to restrict CO_2 emissions from private motor vehicles in industrialized countries, as opposed to methane emissions of subsistence rice farmers in the developing world. Despite these concerns, the United States advocacy for a comprehensive approach was largely successful. Although the FCCC did not come to cover ODS or VOCs, it did come to encompass CO_2, CH_4 and N_2O. In doing so, the FCCC suggested that climate change policies should be, 'comprehensive, cover all relevant sources, sinks and reservoirs of greenhouse gases'.[9] Thus, developed countries should start,

> immediate action in a flexible manner . . . as a first step towards a comprehensive response strategies . . . that take into account all greenhouse gases with due consideration of their relative contributions to the enhancement of the greenhouse effect."[10]

Despite the language of the FCCC on this point, it was by no means clear following the conclusion of the FCCC whether the US comprehensive approach (also known as the 'basket' or 'aggregate') or the more European biased gas-by-gas approach would be adopted.[11] Eventually, the European position changed and they came to accept the comprehensive approach[12] Once this issue was resolved, this comprehensive approach was formalized in the Kyoto Protocol. This stipulated that, in addition to the net approach adopted with CO_2,

> The Parties included in Annex I shall . . . ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments.[13]

2. Pollution Potential

Greenhouse gases warm the Earth's surface. 'Radiative forcing' is the name given to the effect which these gases have in altering the energy balance of the Earth's atmospheric system. Using this concept, the 1990 IPCC report introduced the idea of the Global Warming Potential (GWP). GWP allows the radiative forcing of different gases go be compared.[14] The GWPs

[9] FCCC. Article 3 (3).
[10] FCCC. Preamble. Paragraph 18.
[11] Oberthur, S. (1996). 'The Second Conference of the Parties' *Environmental Policy and the Law*. 26 (5): 195–201.
[12] Ehrmann, M. (1997). 'Spring Time in Climate Negotiations ?' *Environmental Policy and the Law*. 27 (3). 192–196. 7 *YBIEL*. (1996). 132. 8 *YBIEL*. (1997). 177.
[13] Kyoto Protocol. Article 3. (1).
[14] IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change*. (Cambridge University Press, Cambridge). 11.

are recommended by the IPCC and may be amended by the COPs as necessary.[15] The GWP of all listed greenhouse gases are projected over a 100 year period. Originally, although the 100 year time frame/yardstick for GWP was highlighted 'other time horizons' were also permissible.[16] This approach was reiterated in 1997, with time frames other than 100 years (such as for 20 or 500 years) being noted for 'informational purposes only'.[17] The difficulty of choosing any one time frame such as 100 years is that it may lead to over-focusing on future considerations, as opposed to the immediate actions required to stabilize emissions in the present. Therefore, possible considerations for making reductions of gases with shorter lifetimes than CO_2, such as CH_4, tend to get downgraded.[18]

The 100 year GWP for CH_4 is 24.5 years, and 320 years for NOx.[19] In addition to the traditional greenhouse gases, GWP have also been attributed to a number of ODS, which also have an impact on climate change.[20] The GWP of the ozone chemicals is much larger than the GWP of the traditional greenhouse gases.[21] The GWP of CFC 11 is 4,500 years. For CFC 12 it is 7100.[22] With regard to HCFCs and HFCs, if a standard CFC has a GWP of 1.0 HCFCs have a GWP of 0.02, and HCFs possess a GWP of 0.7.[23]

A chemical substance's effect on the ozone layer is measured by its ozone depletion potential (ODP). ODP is a numerical estimate of the total quantity of ozone destroyed by a given mass of the substance over its entire atmospheric life. The ODP was developed in the ozone regime because the number of chemicals that were found to effect the ozone layer expanded, and it was necessary to have some way of comparing their relative influence.[24]

---

[15] Kyoto Protocol. Article 4. (3).

[16] Decision 9/CP.2. Communications from Annex I Parties: Guidelines, Schedule and Process. Annex I. Paragraph 5.

[17] Decision 2/CP.3. Methodological issues related to the Kyoto protocol. Paragraph 3.

[18] Pearce, F. (2002). 'Cap A Landfill-Save the Planet'. *New Scientist.* Feb 16. 6–7. Hammond, A. et al. (1991). 'Calculating National Accountability for Climate Change'. *Environment.* 33(1): 11. Victor, D. & Salt, J. (1994). 'Climate Change'. *Environment.* Dec 7–15.

[19] IPCC. Ibid. 33.

[20] Litfin, K. (1994). *Ozone Discourses.* (Columbia University Press, New York). 89.

[21] IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change.* (Cambridge University Press, Cambridge). 25, 33. Anon. (1995). 'Cinderella Gas Lasts Longest of All'. *New Scientist.* Apr 8. 5. Pearce, F. (1996). 'Pollution Detectives Add To Greenhouse Woes'. *New Scientist.* Aug 24. 6. Anon. (1988). 'Synthetic Gases Heat Up Greenhouse Debate'. *New Scientist.* May 26. 46.

[22] Litfin. Ibid. 160.

[23] Johnson, J. (1990). 'CFC Substitute Will Still Add to Global Warming'. *New Scientist.* April 14. 8. Anon. (1991). 'Inertia Threatens The Ozone Agreement'. *New Scientist.* June 22. 16.

[24] Final Report: Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol. UNEP/OzL.Pro.WG.1(2)/4. 2 & 5.

The lifetime of an ODS chemical refers to how long the substance will remain active in the stratosphere before it is removed by natural processes. This is an important consideration, as although emissions of ODS may be reduced, the destruction of the ozone layer may not cease immediately. Rather, the build-up of the ODS in the atmosphere may continue long after their emissions ceased, owing to the fact that many ODS have long lifetimes.[25]

The traditional CFCs are known as 'fully halo-genated' as all outside positions on the molecule are occupied by a chlorine or fluorine atom. This makes them resilient to destruction by sunlight. Accordingly, they have very long lifetimes or existences. CFCs 11 and 12 have lifetimes of 45 and 100 years respectively.[26] CFC 22 has an existence of 3 years in the stratosphere.[27] CFC 114 exists for 300 years, and CFC 115 exists for 1700 years.[28] CT has a lifetime of 26 years.[29] MC has a lifetime of 0.7 years.[30] The HCFC chemicals have lifetimes between 1.3 years (HCFC-123) through to 17.9 years (HCFC-142b). The HFC chemicals have lifetimes ranging between 1.4 years (HFC-152a) to 270 years (HFC-23). PFCs have lifetimes between 3,200 years and 50,000 years.[31] N-propyl bromide exists in the atmosphere for less than one month, although where and when it is released may alter the length of its chemical lifetime.[32] Ammonia and most hydrocarbons have atmospheric lifetimes of days or weeks.[33]

The lifetimes of ODS are key considerations in calculating each chemical's ODP. ODPs are measures relative to CFC 11, which is set at 1.0. A chemical which destroys half as much ozone per kilogramme has an ODP of 0.5, and one which destroys twice as much would be 2.0. ODPs are important because the lifetimes of the ODS are a crucial figure in the estimation of impacts. If they suddenly move, so too does extrapolations of their effects.[34] Accordingly, since the early 1980s scientific debate over the

---

[25] UNEP. (1989). First Meeting of the Parties To the Montreal Protocol, Helsinki, 2–5 May. UNEP/OzL.Pro.1/5. 6 May 1989. Paragraph 18.

[26] IPCC. (2005). *Safeguarding the Ozone Layer and the Global Climate System: Issues Related to Hydrofluorocarbons and Perfluorocarbons*. (IPCC, WMO Geneva). 7.

[27] Final Report: Second Session. Ibid. 19. MacKenzie, D. (1987). 'Chemical Giants Battle Over Ozone Holes'. *New Scientist*. Apr 23. 22.

[28] IPCC. (2005). Ibid. 7.

[29] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report*. UNEP/OzL.Pro/WG.1/23/3. 14. Original estimates suggested it had a lifetime of 50 years.

[30] IPCC. (2005). Ibid. 7.

[31] IPCC. (2005). Ibid. 7.

[32] Decision X/8. New Substances With ODS. Co-Chairs of the Assessment Panels. Ibid. 10, 15. Pearce, F. (2001). 'Ozone Unfriendly: A Quartet of Green Chemicals Face Ban'. *New Scientist*. Oct. 20. 17.

[33] IPCC. (2005). *Safeguarding the Ozone Layer and the Global Climate System: Issues Related to Hydrofluorocarbons and Perfluorocarbons*. (IPCC, WMO Geneva). 4.

[34] Allaby, M & Lovelock, J. (1980). 'Spray Cans: The Threat That Never Was'. *New Scientist*. July 17. 212.

lifetimes of exact chemicals has been strong, as changed lifetimes means reduced impacts on the ozone layer, which should necessitate a different regulatory response.[35] This debate has been reflected in the directives to the various panels to recheck and update the ODP of the various ODS if needed, and reported to the COPs for consideration.[36] In 2001, the possibility of expediting this procedure was investigated.[37] Although the base figure of 1.0 remains the same, some of the ODP estimates of the ODS have changed.

As at 2003, within Annex A Group I (the traditional CFCs) the ODP of CFCs range from 0.6 to 1.0. Most have the value of 1.0. Specifically, CFC 11, 12 and 114 all have 1.0. The ODP for CFC 113 is 0.8 and for CFC 115 the ODP is 0.6.[38] In Annex A Group II, dealing with halons, the worst ODP halon is 1301 which is rated at 10.0[39] Halon 1211 is 3.0[40] and halon 2402 is 6.0. In Annex B Group I, CFC 13, 111, and 211–217 are all rated at 1.0. In Annex B Group I, CT has an ODP of 1.0–1.2.[41] The average is 1.1. In Annex B Group III, MC has an ODP of between 0.10 and 0.16.[42] The typical average is 0.1.[43] In Annex C, Group I HCFC 21 has an ODP of 0.04, HCFC 22 is 0.055, HCFC 31 is 0.02, HCFC 124 is 0.022, HCFC 133 is 0.06, HCFC 141b is 0.11,[44] HCFC-142b is 0.065, HCFC 225 is 0.07, HCFC 225ca is 0.025, HCFC 225cb is 0.033.

[35] For example, in 1981, the Chemical Manufacturers Association were arguing that the atmospheric lifetime for CFC-11 is roughly half what's its currently calculated lifetime (75 years) was put at, due to the stratospheric removal process alone. If the lifetime was reduced by half, then "the calculated steady state ozone depletion would be reduced by 50%." CCOL. (1981). Some Recent Research Results: A Contribution By the Chemical Manufacturers Association. UNEP/CCOL/5/4. September 1. 5.

[36] Decision IV/11. Destruction Technologies. Decision IX/24. Control of New Substances With ODS. Decision X/8. New Substances With ODS. Decision XI/19. Assessment of New Substances. Decision XI/20 Procedure For New Substances. XIII/5. Procedures for Assessing the Ozone Depleting Potential of New Substances that May Be Damaging to the Ozone Layer.

[37] Decision XIII/6. Expedited Procedures for Adding New Substances to the Montreal Protocol.

[38] Annex A, Montreal Protocol (1987).

[39] MacKenzie, D. (1987). 'Chemists Unite In Call For Ozone Protection'. *New Scientist.* Apr 30. 25.

[40] UNEP. (1989). First Meeting of the Parties To the Montreal Protocol, Helsinki, 2–5 May. UNEP/OzL.Pro.1/5. 6 May 1989. Paragraph 76 & Decision 9.

[41] Final Report: Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol. See Annex B of the 1990 Revisions.

[42] Final Report: Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol.

[43] Annex B. London Revisions, 1990.

[44] Anon. (1989). 'Chemicals Firm Takes the Sting Out of CFC 113'. *New Scientist.* March 18. 31.

In Annex E, Group 1, the ODP of MB is 0.7.[45] Hexachlorobutadiene has an ODP of 0.07.[46] HFCs have the ODP of one thousandth of CFC 11.[47]

The first convention to deal with the differentiation of pollutant potentials was the VOC Protocol. All the earlier air pollution protocols had been restricted to only one pollutant, and comparisons were not possible. However, as there are many VOCs, comparisons of the different pollution potentials was necessary as, 'VOCs differ greatly from each other in their reactivity and in their potential to create tropospheric ozone and other photochemical oxidants'.[48] Accordingly, each VOC was given a 'photochemical ozone creation potential' (POCP) which referred to the potential of an individual VOC relative to that of other VOCs. Although the emphasis for the Parties was to reduce the VOCs with the 'greatest POCP',[49] owing to the presence of so many different sources, with different POCP, it was decided a cumulative approach to dealing with VOCs was in order. Accordingly, the Parties are obliged to work on detailed information of the POCP levels for individual VOCs.[50]

3. Reporting Considerations and Anomalies

Parties to the Montreal Protocol and its subsequent amendments are obliged to provide the Secretariat with information of their annual production and consumption, imports and export and destruction or reuse of ODS.[51] Calculating ODS production and consumption is not an easy exercise. This is because not everything produced or consumed is necessarily counted. Specifically, the definition of production is,

> the amount of controlled substances produced, minus the amount destroyed by technologies to be approved by the Parties and minus the amount entirely used as feedstock in the manufacture of other chemicals. The amount recycled and reused is not to be considered as 'production'.

Accordingly, ODS which are recycled are not counted for a countries total ODS production or consumption figures, although figures on recycled and reused ODS are noted for the information purposes of the Secretariat.

[45] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 14. It had earlier been identified at 0.4 and 0.6.
[46] Report of the Twelfth Meeting of the Parties to the Montreal Protocol 9.
[47] Baggott, J. (1994). 'HFCs Declared Safe For Ozone Layer'. *New Scientist.* Feb 5. 15.
[48] VOC Protocol. 1991. Preamble.
[49] VOC Protocol. 1991. Articles 1, 2(5) and Annex IV.
[50] VOC Protocol. 1991. Article 2 (7) (a). See also Article 5 (c).
[51] Montreal Protocol. Article 7.

This problem has been doubly complicated by lack of clarification of certain terminology relating to 'recycled, reclaimed and recovered'.[52] Similar problems can be seen with feed stocks where ODS are used in the production of other ODS) these too are not counted in a countries consumption of ODS.[53] Although Parties are obliged to report on how much feedstock they trade,[54] it has been clearly stated that the controlled substances produced and exported for the purpose of being used only as feedstock in the manufacture of other chemicals in importing countries should not be the subject of 'production' and 'consumption' in exporting countries.[55] With certain ODS, such as CT, this may cause difficulties. For example, although the production figure of CT as a feedstock remain relatively small, there is considerable uncertainty over the full extent of the utilization of CT.[56]

A similar exception exists for the utilization of ODS as 'process agents.' Process agents, which were the subject of a dedicated report,[57] are typically used for manufacture of products. Due to the fact that these are believed to be an insignificant amount (4,501 tons in 1997) they also are not taken into account in the production and consumption calculations. Nevertheless, the Parties are not to embark on new plants using ODS as process agents after the middle of 1999, unless necessary for 'essential uses' for which no alternatives are available.[58] The Parties went some way towards clarifying this area in 2003 when they reissued their approved list of uses of controlled substances as process agents, as well as directing the Technology and Economic Assessment Panel to report on progress made in reducing emissions of controlled substances from process uses in this area.[59] The Parties also indicated that they would re-examine this area in the future, especially with regard to the assumption that many of the process uses of ODS have only 'non-negligible' impacts.[60]

Baselines are the final area within the ozone regime in which recording anomalies may present difficulties. Baselines are the amount of production or consumption of ODS that a country was doing at a certain point in

[52] Decision XIV/3. Clarification of Certain Terminology Related to Controlled Substances.
[53] Montreal Protocol. Definitions.
[54] Annex II. Amendments to the Montreal Protocol. Second Meeting of the Parties to the Montreal Protocol. UNEP/OzL.Pro.2/3. 29 June 1990.
[55] Decision VII/30. Export and Import of Controlled Substances to be Used as Feedstock.
[56] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 33.
[57] Decision XIII/13. Request to the Technology and Economic Assessment Panel for the Final Report on Process Agents.
[58] Decision X/14. Process Agents.
[59] Decision XV/6. List of Uses of Controlled Substances as Process Agents.
[60] Decision XV/7. Process Agents.

time, by which subsequent obligations are assessed. Given that baselines are the foundation figure from which all ODS reductions are subsequently made, their importance cannot be overestimated. However, there are instances in which the data for the baselines missing,[61] as well as a number instances where baselines have been changed.[62] In 2003, the Parties agreed to start tightening this area by establishing an agreed set of methodologies from which applications for changes in baseline data could be assessed.[63]

With regards to the climate regime, the necessity to obtain internationally agreed upon methodologies for estimating sources and sinks of greenhouse gases was a clear quest in the negotiation process leading up to the formation of the FCCC.[64] The need to have such 'appropriate methodologies' was emphasized in Agenda 21[65] and when the FCCC was concluded, it was agreed that all Parties to the agreement were obliged to report on their sources and sinks of greenhouse gases by, 'using comparable methodologies to be agreed by the COP'.[66] Despite the acceptance of this goal, the conclusion of such agreed methodologies for modalities, rules and guidelines has proved difficult. Nevertheless, following work on this in 1993 and 1994, a special report of the IPCC, including Guidelines for National Greenhouse Gas Inventories was produced.[67] These Guidelines were utilized for the 1995 COP in Berlin, before being reviewed and refined[68] and recommended again for utilization in 1996[69] and 1997.[70] These were refined again, and recommended once more in 2001.[71] In 2003, specific guidance on methodologies for adjustments under Article 5 (2) of the Kyoto Protocol were agreed.[72]

Although the goal of having comparable methodologies for calculating sources and sinks was reiterated in the Kyoto Protocol,[73] this goal was not

[61] See the chapter on Compliance.
[62] Decision XIV/27. Requests for Changes In Baseline Data.
[63] Decision XV/20. Methodology For Submission of Requests For Revision of Baseline Data.
[64] 3 *YBIEL.* (1992). 228.
[65] Agenda 21. Paragraphs 9.12(b).
[66] FCCC. Article 4 (1)(a), 4 (2)(c) & 7(d).
[67] 4.*YBIEL.* (1993). 144. 5 *YBIEL.* (1994). 166, 168. Victor, D. & Salt, J. (1994). 'Climate Change'. *Environment.* Dec 7–15.
[68] Decision 4/CP.1. Methodological Issues. Paragraph 1 (d).
[69] Decision 9/CP.2. Communications from Annex I Parties: Guidelines, Schedule and Process. Annex I. Paragraph 14.
[70] Decision 2/CP.3. Methodological issues related to the Kyoto protocol. Paragraph 1.
[71] Decision 21/CP.7. Good practice guidance and adjustments under Article 5, paragraph 2, of the Kyoto Protocol. Decision 19/CP.7. Modalities for the accounting of assigned amounts under Article 7, paragraph 4, of the Kyoto Protocol.
[72] Decision 20/CP.9. Technical Guidance on Methodologies for Adjustments Under Article 5 (2) of the Kyoto Protocol.
[73] Kyoto Protocol. Article 5 (1).

finalized, and the process was continued[74] with the view that the COPs would, 'regularly review and, as appropriate, revise such methodologies and adjustments' as necessary.[75] Although the COP decided to defer a further review of the guidelines in 2001[76] it is likely that this process will be subject to continual review. The reason a continual review of methodological questions with regard to greenhouse gases is due to the fact that the measurement of each gas can be problematic. These problems may come from two sources.

The first source of problems relates to scientific uncertainty in measuring some greenhouse gas emissions and sinks. That is, although certain sectors are relatively easy to measure, such as with the energy sector, in which emissions can be estimated to within 5 per cent of accuracy, other sectors, such as those dealing with the sequestration are notoriously difficult to measure. Such difficulties have distinct implications for the robustness of the methodologies.[77]

The second set of problems relate to decisions that certain sectors are not calculated in many overall inventories. The foremost example of this is the exclusion from national inventories, of 'bunker' fuels used for aircraft and ships involved in international travel.[78] This policy, of not including bunker fuels has been endorsed by the COPs, following an IPCC recommendation not to include bunker fuels in national calculations, because there was no obvious way of allocating the emissions from international travel and commodities utilizing international trade routes to individual countries. This decision is fortuitous for some countries, as to include such fuels in national communications, could raise their greenhouse emissions by up to 5%.[79] Another example where it has been deemed politically

[74] Kyoto Protocol. Section 5.
[75] Kyoto Protocol. Article 4 (2).
[76] Decision 34/CP.7. Revision Of The Guidelines For The Preparation Of National Communications By Parties Included In Annex I To The Convention, Part I: UNFCCC Reporting Guidelines On Annual Inventories, And The Guidelines For The Technical Review Of Greenhouse Gas Inventories From Parties Included In Annex I To The Convention.
[77] IPCC. (2000). *Land Use, Land-Use Change, and Forestry*. (Cambridge University Press, Cambridge). 17. Decision 19/CP.7. Modalities for the accounting of assigned amounts under Article 7, paragraph 4, of the Kyoto Protocol. Pearce, F. (1994). 'All Gas And Guesswork'. *New Scientist*. July 30. 14–15.
[78] 'Emissions based upon fuel sold to ships or aircraft engaged in international transport should not be included in national totals, but reported separately; and urges the Subsidiary Body for Scientific and Technological Advice to further elaborate on the inclusion of these emissions in the overall greenhouse gas inventories of Parties.' Decision 2/CP.3. Methodological issues related to the Kyoto protocol. Paragraph 4.
[79] Decision 4/CP.1. Methodological Issues. Paragraph 1 (f). Decision 9/CP.2. Communications from Annex I Parties: Guidelines, Schedule and Process. Annex I. Paragraph 17. Decision 2/CP.3. Methodological issues related to the Kyoto protocol. Paragraph 4 & 5. Decision

expedient not to include certain emission sources has been with large scale 'single projects' that add more than 5% to the overall total in one year to a Parties emission sources. The possibility of an exception for this area was envisaged in the Kyoto Protocol,[80] and after being deferred,[81] was finally dealt with in 2001 when it was agreed that under specific conditions, certain large scale 'single projects' do not need to be counted in national totals.[82]

IV/3. Recommendations of the Third Meeting of the Ozone Research Managers. Point c. 5. Pearce, F. (1995). 'Planes Fly Through Climate Loophole'. *New Scientist*. Jan 7. 4. Subak, S. (1995). 'Methane Embodied In the International Trade of Commodities'. *Global Environmental Change*. 5 (5): 433–446. Pearce, F. (1995). 'Planes Fly Through Climate Loophole'. *New Scientist*. Jan 7. 4.

[80] Kyoto Protocol. Section 5.

[81] Decision 16/CP.4. Impact of single projects on emissions in the commitment period.

[82] Decision 14/CP.7. Impact of single projects on emissions in the commitment period. The conditions are, that for a single site which came into operation since 1990 (or an existing process which has been expanded) and has expanded from less than 0.05% to over 5% of total national CO_2 emissions, then that amount shall not be included in national totals if in accordance with the above considerations, it also uses renewable energy, aiming at a reduction in greenhouse gas emissions per unit of production and best environmental practice is followed. The total emissions shall not exceed 1.6 million tonnes of carbon dioxide annually on the average during the first commitment period and cannot be transferred via the Kyoto Protocol mechanisms.

V. IMPACTS

1. Air Pollution

A. Impacts Upon Humans

The detrimental effects of air pollution upon humans was first recognized in international law with the 1985 Helsinki Protocol.[1] Although the impact of air pollution on humans was not specifically acknowledged in the 1988 Sofia Protocol,[2] it was acknowledged in the 1991 VOC Protocol,[3] and the 1994 Oslo Protocol.[4] The 1999 Gothenburg Protocol was, 'aware that nitrogen oxides, sulphur, volatile organic compounds and reduced nitrogen compounds have been associated with adverse effects on human health'.[5]

Although the adverse effects of air pollution upon humans was only recognised in international law in the 1980s, the scientific linkage between the two goes back over two hundred years, when an English doctor named John Arbuthnot published an essay Concerning the Effects of Air Pollution on the Human Body.[6] Unfortunately, his thesis was strongly contested, and the effects of air pollution on humans continued to worsen over the following centuries. For example, in 1880, 2,200 Londoners died in a single incident when coal smoke from home heating and industry combined to form a lethal toxic smog.[7] A further 500 died in a similar fog in 1873.[8] The next notable smog was in 1951 when the weather conditions in early winter trapped the pollutants over the English capital. The smog extended for 30 km around London, and visibility was reduced to between one to

---

[1] Helsinki Protocol. Preamble, paragraph 2.

[2] Nevertheless, "present emissions of air pollutants are causing damage. . . ." Preamble. Protocol to the 1979 Convention on Long Range Transboundary Air Pollution Concerning the Control of Emissions of Nitrogen Oxides or Their Transboundary Effects. BH930.txt.

[3] "VOCs and the resulting secondary photochemical products are causing damage . . . under certain exposure conditions, have harmful effects on human health." VOC Protocol (1991). Preamble.

[4] Protocol on Further Reductions of Sulphur Emissions (Oslo, 1994). Preamble.

[5] Gothenburg Multi-Effects Protocol. Preamble.

[6] For a discussion of the early literature on this topic, see Sherman, J. (2004). *Gasp: The Swift and Terrible Beauty of Air*. (Shoemaker, New York). 172–80.

[7] World Resources Institutes, UNEP & World Bank. (1999). *World Resources: 1998–1999*. (Oxford University Press). 63.

[8] McCormick, J. (1997). *Acid Earth*. (Earthscan, London). 5.

five metres. The pH level[9] of the air was between 1.6 and 2.0. This level is close to the equivalent of sulphuric acid, or ten times above the level the WHO currently recommends as a safe air quality standard. The 1951 smog was linked to the deaths of 1,850 people. The following year, at the same time and under similar conditions, two further smogs killed between 4,700 to 12,000 people. In the London winter of 1962, a further 750 people were killed by the same pollutants.[10] Similar results were recorded in the Meuse Valley in Belgium in 1930 when 63 deaths were attributed to the air pollution, and Donoara in Pennsylvania in 1948 which accounted for 28 deaths.[11]

At the turn of the new century, the WHO global estimates suggest that as many as 1.4 billion (UNEP put the figure at 1.6 billion) urban residents breath air exceeding WHO guidelines. Mortality estimates due to outdoor air pollution are between 200,000 and 570,000 each year. This figure represents between 0.4 to 1.1% of total global deaths.[12] In 2004, it was estimated that close to 100,000 deaths annually in Europe were associated with long term exposure to air pollution.[13] At the end of the twentieth century, in the United States, at least 80 million people lived in cities which did not meet WHO outdoor air standards. [14]

At the end of the 1980s in Poland and Czechoslovakia, SO_2 depositions averaged 12,000 microgrammes per square metre every month.[15] In the mid 1990s, the Katowice region of Poland received more than one kilogram of industrial particle fallout per square metre per year. In this region, the incidence of circulatory diseases was 15% above the national average, and there were 30% more tumours and 47% more respiratory diseases. Life expectancy was two years less than the national average.[16] In 2004,

---

9 The pH scales measures acidity in water. The scale ranges from 0.0 to 14.0, with a value of 7.0 representing a solution which is neutral. Between 0 and 7.0 indicates greater acidity, and 7.0 and 14.0 greater alkalinity.

10 See Anon/Histories. (2002). 'Darkness At Noon'. *New Scientist.* Nov 30. 48. Pearce, F. (1992). 'Back to the Days of Deadly Smogs'. *New Scientist.* December 5. 25–26. Read, R. (1991). 'Breathing Can Be Hazardous To Your Health'. *New Scientist.* February 23. 26–29. Hamer, M. (1984). 'Ministers Opposed Action on Smog'. *New Scientist.* Jan 5. 3. Anon. (1986). 'Pea Soupers and Westland Helicopters in 1955'. *New Scientist.* Jan 2. 12.

11 Schwela, D. (1999). *Urban Traffic Pollution.* (Routledge, London). 24–26. McCormick. Ibid. 32.

12 UNEP. (2002). *GEO 3.* (Earthscan, London). 211. World Resources Institutes. Ibid. 63.

13 UNECE. (2004). *The 2004 Substantive Report on the Review and Assessment of Air Pollution Effects and Their Recorded Trends.* EB.AIR/WG.1/2004/14/Rev.1. September 21, 2004. 5.

14 World Resources Institutes. Ibid. 63.

15 Chandler, W. (1990). 'Energy for the Soviet Union, Eastern Europe and China'. *Scientific American.* September. 75.

16 McCormick, J. (1997). *Acid Earth.* (Earthscan, London). 33. Elsom, D. (1996). *Smog Alert.* (Earthscan, London). 20–24.

Tirana (Albania) was identified as the most polluted capital of Europe. On an average morning, the SPM10 content was ten times the WHO safety limit for SPM10 emissions.[17] The other area within the former Soviet influence which has an unfortunate legacy of SO_2 and other pollution is around the Arctic, and the Kola Peninsular in particular, which has suffered major degradation.[18]

In the developing world, outdoor air pollution is believed to account for between 2 to 5 per cent of all deaths in urban areas.[19] In the early 1990s, an estimated 40,000 people died from air pollution caused by SPM in the air in 36 Indian cities.[20] The World Bank has estimated that unless China begins to seriously confront its air pollution over the next 25 years, the number of premature deaths will increase from 205,000 to 850,000 by 2020. Chronic bronchitis cases may also rise from 2 million to 7.4 million, and bouts of respiratory symptoms from 6 to 22 billion.[21]

Greater specificity in understanding air pollution has come with increased knowledge about the dangerous nature of anthropogenic SPMs.[22] Fine SPMs, which are typically by-products of combustion processes, are more likely to contain carcinogens.[23] This is unlike other, natural, forms of fine particles such as dust from deserts and salt from ocean spray. The anthropogenic fine particles penetrate deep into the lungs and may cause the release of inflammatory molecules called cytokines. These can, in turn, trigger changes in the heart's blood vessels. SPMs may also cause irreversible genetic mutations in DNA.[24] Vulnerable groups include infants, the elderly and those suffering from chronic respiratory conditions, such as bronchitis, tightness in the chest, and wheezing. In some situations, the effects may be short term and reversed if air pollution levels decline. Other effects such as lung cancer and cardio-pulmonary disease may be chronic. The 1998 (American) National Acid Precipitation Assessment Programme concluded,

> Indications from epidemiological studies of an association between ambient particles with [sic] human health end points suggest decreased emissions could

---

[17] Brown, P. (2004). 'Tirana, Pollution Capital of Europe'. *Guardian Weekly*. Apr 8. 21.
[18] UNEP. Ibid. 236–237.
[19] World Resources Institute. Ibid. 63.
[20] UNEP. (2002). *Benchmarking Urban Air Quality Management and Practice in Major and Mega Cities of Asia*. (UNEP, Nairobi). 6.
[21] Holland, F. (1997). 'China Chokes'. *New Scientist*. Nov 29. 15.
[22] Hamer, M. (1996). 'Clean Air Strategy Fails to Tackle Traffic'. *New Scientist*. Aug 31. 6. Anon. (1993). 'Deadly Urban Air'. *New Scientist*. May 29. 11.
[23] Pearce, F. (1997). 'Devil in the Diesel'. *New Scientist*. Oct 25. 4.
[24] Gosline, A. (2004). 'Air Pollution Damages DNA Long Before Birth'. *New Scientist*. July 3. 14. Anon. (2004). 'Airborne Particulates Can Mutate DNA'. *New Scientist*. May 22. 19. Day, M. (1998). 'Taken to Heart'. *New Scientist*. May 9. 23. Boyce, N. (2000). 'Hold Your Breath'. *New Scientist*. Aug 5. 5. Cohen, M. (1996). 'Mother Nature Could Break US Clean Air Law'. *New Scientist*. Nov 16. 7.

> lead to reductions in premature mortality and morbidity from cardiovascular and respiratory causes.[25]

The 1999 (European) Charter on Transport, Environment and Health added,

> Long term exposure to air pollutants and levels exceeding air quality guideline values is associated with a number of adverse health effects, including effects on cardiovascular diseases and on respiratory diseases in adults and children. Such exposure may reduce life expectancy. Some pollutants such as benzene and some types of particle, increase cancer risks.[26]

Although these assertions relating to the detrimental of impact of air pollution on humans have been challenged due to scientific uncertainties,[27] SPM pollution, especially when involving toxic particles, and/or intertwined with other smog pollutants such as CO and NOx has increasingly been linked to a high number of human deaths. This is in part because epidemiological studies on large populations have been unable to identify a threshold concentration below which ambient SPM has no detrimental impact on human health. Life expectancy may be two to three years shorter in communities with high SPM than in communities with low SPM. Much of this damage appears to begin at a young age. For example, children's DNA can be damaged by compounds called polycylic aromatic hydrocarbons which are produced when fuel burns and coat SPMs. Some of this damage is done when the foetus is in the womb.[28] SPM pollution is estimated to cause approximately 135,000 premature deaths in the United States each year. This is the equivalent of 6% of total annual deaths in the United States.[29] In the early 1990s SPM10s were considered to be killing up to hundreds in Paris,[30] tens of thousands in the United Kingdom[31]

---

[25] 1998 National Acid Precipitation Assessment Programme . (1998). *Biennial Report to Congress: An Intergrated Assessment.* (Washington, DC). 3.

[26] Charter on Transport, Environment and Health. EUR/ICP/EHCO 020205/9 Rev.4. 09009–16 June, 1999. 1.2.

[27] Joyce, C. (1980). 'Foggy Future for Diesel Cars'. *New Scientist.* October 9. 79. Anon. (1995). 'Diesel Doubts'. *New Scientist.* May 6. 11. Anon. (1998). 'Breathe Easy ?' *New Scientist.* March 14. 7. Edwards, R. (1995). 'Industry Denies Dangers of Particle Pollution'. *New Scientist.* Nov 4. 5.

[28] UNECE. (2004). *The 2004 Substantive Report on the Review and Assessment of Air Pollution Effects and Their Recorded Trends.* EB.AIR/WG.1/2004/14/Rev.1. September 21, 2004. 5. WHO. (1999). *Protection of the Human Environment: Air Quality Guidelines.* (WHO, Geneva). III:39. Boyce, N. (2000). 'Hold Your Breath'. *New Scientist.* Aug 5. 5. UNEP. (2000). *GEO 2000 Report.* (Earthscan, London). 168. Cohen, P. (2002). 'Pollution Triggers Genetic Defects'. *New Scientist.* Dec 14. 8. Edwards, R. (1996). 'Smog Blights Babies In the Womb'. *New Scientist.* Oct 19. 8.

[29] Anon. (2002). 'Diesel Cancer'. *New Scientist.* Sept 14. 9.

[30] Patel, T. (1996). 'French Smog Smothers Hundreds'. *New Scientist.* Feb 17. 7.

[31] The original figure was 10,000 people in the UK each year. Hamer, M. (1994). 'Dying

and in other parts of Europe.[32] Evidence from a study encompassing France, Switzerland, and Austria suggested that long-term exposure to air pollution from cars caused an extra 21,000 premature deaths each year from respiratory or heart disease in people over the age of 30. In addition, it caused an extra 300,000 cases of bronchitis in children, 15,000 admissions to hospital for heart disease, 395,000 asthma attacks in adults and 162,000 in children.[33] Research in New Zealand suggested nearly an equal number of people die annually from SPM related illnesses (399 people over the age of 30 die prematurely), as are killed in vehicle accidents (454).[34]

Research dealing with SPM 2.5s suggests that lung cancer rises by 8% for every 10 microgramme increase in the average concentration of SPM 2.5s per cubic metre. The increased risk is comparable with the risks to long-term passive smokers. Typical SPM 2.5s in Los Angles are 20 microgrammes per cubic metre and in New York they are16 microgrammes. The limit set by the Environmental Protection Agency (EPA) is 15 microgrammes. Although British levels are similar, sites in London in 2002 recorded concentrations of up to 32 microgrammes per cubic metre.[35]

With regard to low-level ozone, it has been shown that ozone concentrations above a certain level (50ppb) are damaging to humans.[36] Hospital admissions with increase in concentrations of low level ozone also increases, to does hospital admissions. On average, a 7 to 10% increase in hospital admissions follow a 0.05 ppm increase in ozone levels. Low-level ozone has also been linked to multiple health difficulties ranging from some forms of cancer through to damage to the immune system.[37] The closely related air pollutant N_2O also has negative health impacts which range from the

From Too Much Dust'. *New Scientist.* March 12. 5. In 1998, this figure was lowered to 8,100 per year. Day, M. (1998). 'City Dwellers Dying For A Breath of Fresh Air'. *New Scientist.* Jan 24. 16. Cf. Hamer, M. (1997). 'Lies, Damned Lies'. *New Scientist.* Nov 29. Hamer, M. (1996). 'Cars Must Go To Meet Clean Air Targets'. *New Scientist.* May 18. 12. Anon. (1999). 'Not So Clean'. *New Scientist.* Jan. 23. 5. Editor. (1994). 'Smog Alert'. New Scientist. June 25. 3. Editor. (1995). 'Britain's Last Gasp'. *New Scientist.* May 13. 3. Day, M. (1998). 'City Dwellers Dying For A Breath of Fresh Air'. *New Scientist.* Jan 24. 16.

[32] The 1999 Charter on Transport, Environment and Health suggested that: "In European cities around 80,000 adult deaths a year are related to long term exposure to traffic related air pollution, using the proportion of ambient PM10 concentration due to traffic as an indicator." Charter.

[33] UNEP. (2002). *GEO 3*. (Earthscan, London). 224.

[34] NZPA. (2002). 'Vehicle Pollution Major Killer'. *New Zealand Herald.* March 22. A8.

[35] Pearce, F. (2002). 'Big City Killer'. *New Scientist.* March 9. 8.

[36] Brown, W. (1993). 'Dirty Air Not To Blame For Asthma'. *New Scientist.* Dec 18. 5. Lean, G. (1993). 'Gasping For Air'. *Independent.* Oct 10. 19. Radford, T. (1995). 'Air of Mystery'. *Guardian.* May 28. 30.

[37] World Resources Institutes, UNEP & World Bank. (1999). *World Resources: 1998–1999.*

dangerously pathological, through to irritating.[38] For example, N_2O levels of 2 ppm kill (and strongly irritate at 0.4 ppm) the microscopic hairs that line the nostrils and windpipe. This could be a major cause of hay-fever.[39] Other air pollutants like benzene have been linked to problems such as haematoxicity, immunotoxicity, neurotoxicity and carcinogenicity.[40] Air pollution caused by ammonia may also be responsible for sickness in humans.[41]

With regard to actual deaths, in the mid-1990s in France, more people died from heart and lung diseases on smoggy days or days with high ozone concentrations.[42] In the United Kingdom, low-level ozone caused by vehicle fumes was believed to kill 12,500 people per year.[43] Once the Gothenburg Protocol is implemented, within Europe there should be 47,500 fewer premature deaths resulting from low level ozone and SPM pollution.[44]

In terms of lead pollution, people have less lead in their bodies now than in the past. It is possible to assert this because as bone is very good at trapping lead that enters the body, the archaeological evidence is strong. At the end of the twentieth century, most children have less that 2 ppm in their bones. Most adults have 5 ppm. This is substantially less than the worst period of lead poisoning, was between the years of 960 AD to 1530.[45] By the eighteenth century, the average amount of lead in the bones of humans was between 48 ppm and 60 ppm.[46] Although these levels have fallen dramatically, lead poisoning remains a distinct health problem in some countries. The foremost example of this has been with over-exposure of children, to lead pollution, as they are more susceptible to lead ingestion than adults. The results of this ingestion are most probably a lowering of their intelligence with degrees of lost corresponding to degrees of exposure and other catalytic considerations.[47]

(Oxford University Press). 65. Schwela, D. (1999). *Urban Traffic Pollution*. (Routledge, London). 14–22. Edwards, R. (1995). 'Ozone Alert Follows Cancer Warning'. *New Scientist.* May 27. 4. Vaughan, C. (1990). 'Streetwise to the Dangers of Ozone'. *New Scientist.* May 26. 42–47.

38 WHO. (1977). *Oxides of Nitrogen. Environmental Health Criteria Number 4*. (WHO, Geneva). Schwela. Ibid. 10–14.

39 Webb, J. (1991). 'Car Exhausts May Cause Hay Fever'. *New Scientist.* June 22. 22.

40 WHO. (1993). *Benzene. Environmental Health Criteria Number 150*. (WHO, Geneva).

41 Renner, R. (2002). 'Sickness in the Air'. *Scientific American.* Oct 10.

42 Patel, T. (1994). 'Killer Smog Stalks the Boulevards'. *New Scientist.* Oct 5.

43 Day, M. (1998). 'City Dwellers Dying For A Breath of Fresh Air'. *New Scientist.* Jan 24. 16.

44 UN/ECE (2000). The 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground Level Ozone. <http://www.unece.org/env/lrtap/multi_h1.htm>

45 Anon. (2000). 'Ye Olde Pollution'. *New Scientist.* Jan 8. 12.

46 See Emsley, J. (1987). 'When the Empire Struck Lead'. *New Scientist.* January 1. 64–67.

47 Kleiner, K. (2003). 'Lead May Be Damaging the Intelligence of Millions. Children

B. Impacts upon the Environment

The recognition of the impacts of air pollution on the natural environment in international law, has taken time to evolve. For example, the 1979 Convention on Long Range Transboundary Air Pollution only noted that, 'a rise in the level of emission of air pollutants within the region as forecast may increase . . . adverse effects'.[48] However, by 1980s, the possibilities of environmental damage were becoming more acknowledged. Thus, the 1980 Memorandum of Intent between the United States and Canada noted, 'scientific findings . . . indicate that continued pollutant loadings will result in extensive acidification in geologically sensitive areas during the coming years, and that increased pollutant loadings will accelerate this process'.[49] Five years later the 1985 Helsinki Protocol recognized that air pollution was, 'causing widespread damage . . . to natural resources of vital environmental and economic importance, such as forests, soils and waters'.[50] This point was also noted in the 1988 Sofia Protocol,[51] the 1991 VOC Protocol,[52] the 1994 Oslo Protocol[53] and the 1999 Gothenburg Protocol which not only acknowledged the threat air pollution posed to the environment, but also that, 'critical loads of acidification, critical loads of nitrogen and critical loads of ozone . . . are still exceeded in many areas'.[54]

Although it is now accepted in international law that air pollution can detrimentally impact upon the environment, it has taken hundreds of years to get to this position. Indeed, as early as 1727 the Swedish botanist, Carl von Linne described the sulphur given off by the nearby smelter as a 'poisonous, pungent sulphur smoke, poisoning the air wide around, corroding

Worldwide'. *New Scientist.* Apr 26. 21. Motluk, A. (1997). 'Is Lead Really That Bad For You?' *New Scientist.* July 26. 12.Anon. (1981). 'More Evidence of the Dangers of Lead Pollution.' *New Scientist.* January 15. 128. Anon. (1982). 'Lead: Unknown Children at Risk.' *New Scientist.* September 23. 815. Anon. (1983). 'Asian Children Face Lead Threat.' *New Scientist.* January 6. 4. Editor. (1983). 'Leading Question.' *New Scientist.* April 14. 58. Anon. (1986). 'Lead's Threat to Children.' *New Scientist.* September 11. 16. Anon. (1986). 'Lead Threatens Children's Health.' *New Scientist.* September 18. 24. Joyce, C. (1990). 'Lead Poisoning Lasts Beyond Childhood.' *New Scientist.* January 13. 4. Wright, B. (1992). 'High Levels of Lead May Permanently Lower IQ.' *New Scientist.* February 29. 13. Pearce, F. (1997). 'Tooth Decay Linked to Persistent Lead Pollution.' *New Scientist* Jan 18. 5.

48 Convention on Long Range Trans-boundary Air Pollution. BH764.txt. Preamble.

49 Memorandum of Intent Between the Government of the United States and the Government of Canada Concerning Trans-boundary Air Pollution. 1980, August 5. In *IPE.* XXVIII. 352.

50 Preamble, paragraph 2.

51 Protocol to the 1979 Convention on Long Range Trans-boundary Air Pollution Concerning the Control of Emissions of Nitrogen Oxides or Their Trans-boundary Effects. Preamble.

52 VOC Protocol (1991). Preamble.

53 Protocol on Further Reductions of Sulphur Emissions (Oslo, 1994). Preamble.

54 1999 (Gothenburg Multi-Effects) Protocol. Preamble.

the earth so no herbs can grow'.[55] The scientific explanation of exactly how this occurs did not emerge until Robert Angus Smith, who was a chemist and Britain's first Alkali Inspector (the public official who monitored air pollution) wrote his first report in 1852. Twenty years later, after studying the chemistry of rainfall in the midlands in the 1850s and 1860s, in 1872 he wrote *Air and Rain: The Beginnings of Chemical Climatology*. This book set down many of the fundamental principles of air pollution. He argued that there was a link between the SO_2 that was released when coal was burned and what he called 'acid rain'.[56] Smith demonstrated that the chemistry of precipitation was linked to such factors as wind, proximity to the ocean, frequency of rain and snow and the amount of coal used in combustion. He also noted that this 'acid rain' had the potential to damage plants and materials. Smith's ideas became acceptable scientific and legal currency in the early twentieth century. Five decades later, notable scientists like Svante Oden began to show the basics of the so-called 'acid rain theory' and how it affected the environment.[57] By the late 1960s, the Council of Europe was sponsoring workshops on the effects on the environment.[58] Around the same period, rainstorms occurring in Scotland and Norway contained rain with a pH acidic equivalent of vinegar, whilst a rainstorm was recorded in West Virginia with the pH equivalent of lemon juice.[59]

Periodic national assessments of the deteriorating state of forests due to air pollution began in the late 1960s or soon after, in a number of countries including Sweden, Norway, Belgium, (west) Germany, the United Kingdom, the United States and Japan.[60] Many of these studies were

[55] Noted in McCormick, J. (1997). *Acid Earth.* (Earthscan, London). 6.

[56] Smith, R.A. (1872). *Air and Rain: The Beginnings of a Chemical Climatology*. (London, Longman).

[57] Carson, N. (2000). 'Flaws in the Conventional Wisdom'. *Environment.* 42 (2). 33–35. Munton, D. (1998). 'Dispelling the Myths of the Acid Rain Story'. *Environment.* 40(6): 1–10.

[58] 'Symposium on the Influences of Air Pollution on Plants and Animals' in 1970.This was noted in Council of Europe Committee of Ministers. Resolution (70) 11. March 7, 1970. On the Co-Ordination of Efforts Made in Town and Country Planning in Air Pollution Control. *IPE.* XV. 7532.

[59] Smith, G. (1979). 'Acid Rain'. *Scientific American.* Oct 39–47. Sage, B. (1980). 'Acid Drops from Fossil Fuels'. *New Scientist.* March 6. 743.

[60] Anon. (1984). 'Swiss Investigate Death of Alpine Trees'. *New Scientist.* April 5. 9. MacKenzie, D. (1986). 'Acid Rain'. *New Scientist.* Jan 2. 10. Pearce, F. (1986). 'Unraveling A Century of Acid Pollution'. *New Scientist.* Sep 25. 23–24. MacKenzie, D. (1988). 'Pollution Treaties Upstaged by German Technique'. *New Scientist.* Nov 12. 23. Anon. (1983). 'One Third of German Trees Hit By Acid Rain'. *New Scientist.* Oct 27. 250. Anon. (1987). 'Reprieve for German Trees'. *New Scientist.* Nov 12. 21. Anon. (1985). 'British Trees Pass Acid Test'. *New Scientist.* March 14. 7. Milne, R. (1985). 'Fighting Over the Corpses of Trees'. New Scientist. August 29. 21. Pearce, F. (1985). 'Foresters Cannot See The Dead Wood for the Trees'. *New Scientist.* Nov 7. 20. Also, Rose, C. (1985). 'Acid Rain Falls on British

fraught with disagreement, and it was not until the mid 1970s that regional studies largely eclipsed national ones. The first European study on this topic in 1987 concluded that air pollution was causing an 'intolerably high' impact on the region's forests.[61] Further reports on the same topic had similar conclusions throughout the 1990s.[62] The 2002 EC Report concluded more than 20% of the sample trees were rated as damaged,[63] and the 2003 Report agreed that about one fifth of more than 130,000 sample trees in Europe could be classified as moderately or severely defoliated. The causes of such defoliation were attributed to tree age, weather extremes, biotic factors and air pollution.[64] Within the overall European view, a few specific areas of destroyed forests, such as around Chomutov in the Czech Republic, continue to show the overt effects of such air pollution, and efforts to replace the damaged forests continue to be unsuccessful.[65] In 2004, the defoliation of the monitored sites was again increasing, although air pollution was only one of the factors to blame. At 45% of the 109 sites monitored nitrogen deposition was sufficient to cause nutrient imbalance, and nitrogen was still accumulating at 92% of the sites, threatening nitrogen saturation in the long term.[66]

Although sulphur and nitrogen can also act beneficially as fertilizer, and some plants can develop a tolerance to forms of air pollutions, other plants may not. Air pollution, including sulphur, nitrogen, and ammonia can damage trees, plants and crops by affecting the balance of heavy metals in the soils. This is especially so when low-level ozone is involved which can damage plants by penetrating the plant tissue through open pores to form free radicals. These initiate chain reactions that destroy or damage vital plant compounds such as proteins or enzymes, and fatty chemicals that help to form cell membranes. Damage to sensitive plants has been

Woodlands'. *New Scientist.* Nov 14. 52–56. Anon. (1985). 'New Tree Survey'. *New Scientist.* Nov 21. 21. Pearce, F. (1994). 'Damage to Britain's Trees Is Not So Natural After All'. *New Scientist.* June 18. 5. Anon. (1995). 'Britain's Trees Pass Medical'. New Scientist. May 6. 7. Stone, B. (1985). 'Japan Wakes Up To Acid Rain'. *New Scientist.* Nov 7. 20.

[61] Anon. (1987). 'Europe's Trees Sicken Further'. *New Scientist.* July 9. 19. Anon. (1989). 'Europe's Trees Still Dying'. *New Scientist.* December 2. 9.

[62] European Commission. (2001). *Forest Condition in Europe.* (UNECE, 2001). 24. Pearce, F. (1990). 'Whatever Happened to Acid Rain ?' *New Scientist.* Sep 15. Anon. (1996). 'State of Forests'. *Environmental Policy and the Law.* 26 (6). 268. Jones, N. (2000). 'Crisis Time For Europe's Ravaged Forests'. *New Scientist.* Oct 28. 6. MacKenzie, D. (1997). 'Forest Fables'. *New Scientist* May 19. 15.41.

[63] UNECE. (2002). *The Condition of Forests in Europe.* (UNECE). iii.

[64] UNECE (2003). *The Condition of Forests in Europe.* (UNECE). 8–9.

[65] UNEP. (2002). *GEO 3.* (Earthscan, London). 238.

[66] UNECE. (2004). The 2004 Substantive Report on the Review and Assessment of Air Pollution Effects and Their Recorded Trends. EB.AIR/WG.1/2004/14/Rev.1. September 21, 2004. 8.

measured at concentrations of ozone above 40 to 50 ppb. Some tree species are at risk of damage from concentrations of low-level ozone above 75 ppb.[67] In 2004, the extent of the damage caused to non-forest vegetation in Europe and North America was hard to pinpoint, owing to the strong local variances, and increasing research showing that certain crops were more vulnerable than others to the impacts of low-level ozone.[68] Once the Gothenburg Protocol is implemented, the area in Europe it is calculated that the exposure of vegetation to excessive ozone levels will be 44% down on 1990.[69]

Although air pollution may detrimentally affect salt water ecosystems,[70] its detrimental impacts are primarily associated with fresh water ecosystems are affected by an increase in concentrations of mobile anions in run off, or through the acidification of adjacent soils. One of the most damaging side effects of this process is the eutrophication of the surrounding water. This is a natural phenomenon involving an increase in the nutrient content of lakes and streams, leading to the accumulation over extended periods of time of organic matter. If the process goes far enough, there is plant overgrowth, and subsequent decomposition causes the fresh water to become de-oxygenated, and thereafter the water becomes virtually lifeless and foul smelling.[71] This process can have a detrimental impact upon certain species of fish (but not all) and birds.[72]

The linkage between air pollution and freshwater ecosystems was well recognised in a number of countries from the late 1960s onwards, including Canada, Sweden, Norway, the United States, and the United Kingdom.[73]

---

[67] UNEP. (2002). *GEO 3*. (Earthscan, London). 212. Anon. (1990). 'How Man-Made Ozone Damages Plants'. *New Scientist.* Aug 25. 15. Pearce, F. (1986). 'Stalled in a Haze of Ozone'. *New Scientist.* November 20. 18. Coghlan, A. (2000). 'Surviving Great Smokey'. *New Scientist.* July 1. 14–15. Milne, R. (1988). 'Corrosive Clouds Choke Britain's Forests'. *New Scientist.* March 17. 27. Anon. (1986). 'Calls for Ozone Curbs'. *New Scientist.* May 15. 27. Patel, T. (1997). 'Rampant Urban Pollution Blights Asia's Crops'. *New Scientist.* June 14. 11.

[68] UNECE. (2004) Ibid. 8.

[69] UN/ECE (2000). The 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground Level Ozone. <http://www.unece.org/env/lrtap/multi_h1.htm>

[70] Anon. (2004). 'We've Given Oceans Acid Indigestion'. *New Scientist.* July 24. 19. Anon. (1988). 'Acid Rain Blamed for Nutrient Overload Along Coasts'. *New Scientist.* May 5. 30. Anon. (1988). 'Algal Blooms Blamed on Acid Rain'. *New Scientist.* June 23. 27.

[71] Pearce, F. (1986). 'Unraveling A Century of Acid Pollution'. *New Scientist.* Sep 25. 30.

[72] Sage, B. (1980). 'Acid Drops from Fossil Fuels'. *New Scientist.* March 6. 743. Pearce, F. (1982). 'The Menace of Acid Rain'. *New Scientist.* August 12. 420. Hecht, J. (1993). 'Acid Rain Not Guilty of Killing Amphibians'. *New Scientist.* Aug 7. 6. Edwards, R. (1998). 'Smog Casts a Pall Over Sex Life of Birds'. *New Scientist.* Nov 7. 12. Brooke, M. (1998). 'Acid Attack'. *New Scientist.* Apr 25. 17.

[73] Pearce, F. (1982). 'The Menace of Acid Rain'. *New Scientist.* August 12. 420. Anon. (1979). 'Acid Rain Comes Between Canada and the US'. *New Scientist.* August 23. 573.

By the year 2000, although some improvements have been made, all of Europe's mountain lakes were polluted in some way, although some were in a much worse condition than others.[74] By 2004, this disparity in recoveries was more pronounced, with the fresh water ecosystems in the Scandinavian countries and Canada showing clear improvements, unlike the most acidified Central European sites. Of the 72 sites which were monitored, 51 of them still exceeded the critical load for acidity. Moreover, although there was clear evidence of environmental benefits resulting from SO_2 reductions, fewer than half the regions monitored exhibited a similar trend in decreasing nitrates from nitrogen deposition.[75] Once the Gothenburg Protocol is fully implemented, excessive levels of eutrophication should fall from 165 million hectares in 1990 to 108 million hectares in 2010.[76]

C. Impacts upon the Cultural Environment

This problem of 'widespread damage' including, damage to, 'historical monuments'[77] was noted in the 1985 Helsinki Protocol as well as the 1994 Oslo Protocol.[78] The impacts of air pollution upon the cultural environment are because although air pollution often returns to the Earth in a wet form as rain, if the conditions are dry for a prolonged period, SO_2 and SPMs may be deposited in a continuous manner upon what they settle on. Dry deposition of sulphur was put at 10 grammes of SO_2 per square metre in Central Europe in the 1970s. This was approximately four times the deposition from rain or snow. SO_2 can cause a hard surface skin on vulnerable stone, such as sandstone or limestone, which eventually flakes off. Alternatively, the sulphur may form crystals of calcium sulphate (gypsum)

Anon. (1988). 'Canada Fails to Win Deal on Acid Rain'. *New Scientist.* May 5. 30. Park, P. (1992). 'Canada, Land of Dying Lakes and Forests'. *New Scientist.* April 25. 9. Joyce, C. (1987). 'Trees and Lakes Need Fear No Acid'. *New Scientist.* Sep 24. 21. Anon. (1983). 'Sulphur from Selby'. *New Scientist.* December 8. 721. Anon. (1986). 'British Streams'. New Scientist. May 15. 29. Anon. (1983). 'Acid Rain Kills Fish'. New Scientist. May 12. 357.

[74] See ICP Waters. (2002). 'Major Results After 12 Years of the Water Programmeme'. <http://www.niva.no/ICP-waters> Coghlan, A. (2000). 'Tainted Rain'. *New Scientist.* Apr. 22. 20.

[75] UNECE. (2004). The 2004 Substantive Report on the Review and Assessment of Air Pollution Effects and Their Recorded Trends. EB.AIR/WG.1/2004/14/Rev.1. September 21, 2004. 7. EMEP. (2000). *Trans-boundary Acidification and Eutrophication in Europe.* (EMEP, Geneva). 11. Wettestad, J. (1997). 'Acid Lesson: LRTAP Implementation and Effectiveness'. *Global Environmental Change.* 7(3). 235–249.

[76] UN/ECE (2000). The 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground Level Ozone. <http://www.unece.org/env/lrtap/multi_h1.htm>

[77] Preamble, paragraph 2.

[78] Protocol on Further Reductions of Sulphur Emissions (Oslo, 1994) . . . "under certain circumstances, have harmful effects on human health."

in the pores of the stone. The crystals can slowly eat into the stone, which may then expand with the calcium carbonate in the stone, forcing the rock to fracture. This can be devastating to historical stone heritages, and has been linked to detrimental impacts on culturally important buildings and artefacts longing from the Acropolis to the Taj Mahal to the Statue of Liberty.[79] Nevertheless, reductions of corrosion rates for many materials observed in the periods between 1987 and 1995 at 39 sites in Europe and North America, were in the order of between 30 and 70%. These reductions are mainly the result of decreases in SO_2 concentrations in ambient air during the same period.[80]

2. Ozone Depletion

A depleted ozone layer lets in increased levels of UV light, and UV-B in particular, which may have adverse effects on humans and other species. Adverse effects have been defined as, 'changes in the physical environment or biota, including changes in climate, which have significant deleterious effects on human health or on the composition, resilience and productivity of natural and managed ecosystems, or on materials useful to mankind'.[81] Adverse impacts may be divided into impacts upon humans, and impacts upon other parts of Nature.

A. Impacts Upon Humans

Too little sunshine can be bad for humans, and some exposure to UV light is beneficial to some humans in some situations.[82] Conversely, too much sunshine may also be bad. With regard to the latter, the most commonly associated problem with over-exposure to sunlight is skin cancer. Skin cancer was first detected in 1775, when the English doctor, Percivall Pott, reported a prevalence of ragged sores on the bodies of chimney sweeps, and suggested they were probably caused by external factors.[83] The

[79] Pearce, F. (1985). 'Acid Eats Into Britain's Stone Heritage'. *New Scientist.* Sep 26. 26–30. Health, M. (1986). 'Polluted Rain Falls in Spain'. *New Scientist.* Sep 18. 60–62.
[80] UNECE. (2004). The 2004 Substantive Report on the Review and Assessment of Air Pollution Effects and Their Recorded Trends. EB.AIR/WG.1/2004/14/Rev.1. September 21, 2004. 10. ICP Materials. (2002). See <http://www.corrtitute.se/ICP-Materials/html/results.html>
[81] Vienna Convention. Article 1, Definitions.
[82] UNEP. (1998). *Environmental Effects of Ozone Depletion: 1998 Assessment.* (UNEP, Ozone Secretariat, Nairobi). xi. Biever, C. (2003). 'Bring Me Sunshine'. *New Scientist.* Aug 9. 30–35. Anon. (2003). 'Sunny Disposition'. *New Scientist.* Aug 16. 18.
[83] Leffell, D. (1996). 'Sunlight and Skin Cancer'. *Scientific American.* July. 38–43.

external factor was over-exposure to sunlight, and it eventually became apparent that this factor could cause various forms of skin cancer including basal-cell carcinoma, squalamous-cell carcinoma and melanoma.[84]

Two hundred years after the discovery of the causal agent of skin cancer, it was internationally acknowledged that, 'there is some evidence that increased UV-B would be associated with an increase in skin cancer'.[85] In 1978 the first official international study on the risk of enhanced UV-B on skin cancer suggested that for each 1% reduction in the ozone, there was likely to be a 4% increase in the incidence of some kinds of skin cancers in fair skinned people, who do not have the natural protection of melanin found in some darker skinned peoples.[86] Despite this recognition, other mid 1970s estimates of ozone depletion and their adverse effects upon humans in terms of skin cancer on fair skinned people were not great and tended to get downplayed against the far greater rising tide of skin cancer in industrialized countries which was attributed to, 'white collar workers who spend the week indoors and get overexposed at the weekend'.[87] Such uncertainties were quickly seized upon by those opposed to the regulation of ODS who argued in the early 1980s that, 'the present methods of estimating effects clearly over-estimate them and need considerable refinement before realistic estimates of changes in non-melanoma incidence can be made for hypothesized depletions of ozone'.[88] This debate was also muddied, and continues to be muddied, by arguments surrounding the merits of sunscreens, problems of translating measuring UV and its impacts on humans, and even debates about sunhats.[89]

Despite the debate about exactly what proportion of damage UV-B does to humans, the generally accepted hypothesis by 1980 was that, 'a decrease

[84] Wright, B. (1994). 'Sunscreens And the Protection Racket'. *New Scientist.* Jan 22. 21.
[85] Ozone Plan. Section 2.
[86] Gribbin, J. (1979). 'Fluorocarbons As A Global Environmental Case Study'. *New Scientist.* Jan 18. 164–167. Hughes, J. (1986). 'The Dark Side of Sunlight'. *New Scientist.* Aug 21. 31–35.
[87] Anon. (1976). 'US Row Over Aerosol Ban'. *New Scientist.* Nov 4. 262. Gribbin, J. (1979). 'Disappearing Threat to Ozone'. *New Scientist.* Feb 15. 474–473. Gwynne, P. (1976). 'Aerosols Lost in the Ozone'. *New Scientist.* Sep 23. 627.
[88] CCOL. (1981). The Chemical Manufacturers Association: The CFC Ozone Theory Assessment of New Science. UNEP. October 12.
[89] Thomas, P. (2004). 'Sun Scream'. *Ecologist.* July 16–17. Jones, N. (2001). 'Out of the Frying Pan' *New Scientist.* Apr 14. 5. Edwards, R. (2000). 'Sinister Side of Sun Screen'. *New Scientist.* Oct 7. 13. Concar, D. (1992). 'The Resistible Rise of Skin Cancer'. *New Scientist.* May 16. 23. Anon. (1981). 'Warning: Sunbathing Can Damage Your Health'. *New Scientist.* April 30. 268. Wright, B. (1994). 'Sunscreen And the Protection Racket'. *New Scientist* Jan 22. 21. Graham-Rowe, D. (2004). 'Warning of Bigger Burn for Sunbathers'. *New Scientist.* July 24. Hamer, M. (2002). 'Kids Hats Fail UV Test'. *New Scientist.* July 13. 10.15. Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 25.

in stratospheric ozone might be expected to increase the incidence of melanoma'.[90] Scientific reports in the 1980s estimated that a two to five per cent increase in skin cancer incidence would occur with a one per cent decrease in stratospheric ozone.[91] Reports confirmed that in the mid 1990s, the global incidence of melanoma was climbing by about 7% per year. In Queensland, Australia, melanoma became the most common cancer on record, in the early 1990s, with at least 1% of the population (140,000 people) contracting a basal-cell or squamous cell carcinoma. About one in seven cases was/is fatal. By 2002, melanoma was believed to be killing about 1,000 Australians per year, despite extensive and largely successful public education campaigns to beware of over exposure to sunlight.[92] Globally, in 2001, the WHO reported that over 2 million non-melanoma skin cancers and 200,000 malignant melanomas occurred each year. With a 10% decrease in stratospheric ozone and current trends and behaviour, an additional 300,000 non-melanoma and 4,500 melanoma skin cancers could be expected world-wide.[93] It is possible that this figure is an under-estimate.[94] With the United States alone, it has been estimated that a depleted ozone layer will lead to an additional 12 million cases of skin cancer by 2040, which would be responsible for killing at least 200,000 people.[95]

UV-B has been 'strongly implicated,' since 1977, as the primary cause in the development of age-related cortical cataracts.[96] By the late 1980s, the equation was for every one per-cent of total ozone depletion, 'in the long run' an increase of 100,000 blind people due to cataracts was expected worldwide.[97] This figure was later increased by the WHO which suggested that, of the 12 million to 15 million people who go blind each year from

[90] CCOL. (1981). An Environmental Assessment of Ozone Layer Depletion and Its Impact. UNEP/WG. 69/6. Oct 16. Annex 1. Paragraphs 9 & 10.

[91] Anon. (1982). 'Ozone: Winning on the Roundabouts, Losing on the Swings'. *New Scientist.* Apr 8. 68. Final Report: Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol. 17.

[92] Williams, D. (2002). 'Rays of Hope'. *TIME.* Nov 11.50–55. Anon. (2003). 'Sun Safe Campaign Pay Off For Aussies'. *New Scientist.* Nov 29. 15.

[93] WHO. (2001). Intersun: The Global UV Project. http://www.who.int/peh-uv/publicatioNew Scientist/index.htm

[94] UNEP. (1999). *Synthesis of the Reports of the Scientific, Environmental Effects and Technology and Economic Assessment Panels.* (UNEP, Ozone Secretariat, Nairobi). 24. Report of the 13th MOP. UNEP/OzL.Pro.13/10. 26 Oct, 2001. 27

[95] Anon. (1991). 'Ozone Cancer Risk Rises'. *New Scientist.* Apr. 13. 7. Anon. (1986). 'American's Press For End to CFCs'. *New Scientist.* Nov 27. 20.

[96] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 25. See the 1977 Ozone Plan. Section 2.

[97] Final Report: Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol. 17.

cataracts, 20% of these (approximately 3 million per year) could be due to enhanced UV exposure.[98]

The final detrimental impact of a depleted ozone layer on humans, has to do with damaged immune systems. This damage occurs because certain human cells are unusually sensitive to UV radiation, which can inhibit the natural defence systems of the immune system. In turn, this can cause an increase in the occurrence of the severity of infectious diseases such as herpes and malaria.[99]

B. Impacts Upon the Environment

It appears that the world's worst mass extinction, 250 million years ago, may have been significantly contributed to by extreme amounts of UV radiation pouring in through a greatly depleted ozone layer.[100] In more recent times, anthropogenic destruction of the ozone layer was first linked with possible detrimental impacts upon non-human nature in 1977.[101] However, as specifics were not known, a number of research projects were directed towards terrestrial, aquatic and agricultural effects.[102] By the early 1980s research was tentatively demonstrating that enhanced UV-B could reduce leaf area on some plant species by up to 50% as well as causing difficulties in cell growth and biosynthesis difficulties in other plant species.[103] However, there was considerable scientific uncertainty on this question, and some commentators argued that this problem was over emphasised.[104] This scepticism of the alleged detrimental impacts of enhanced UV-B upon

---

98 WHO. (2001). Ibid.

99 Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 6, 25. Hughes, J. (1986). 'The Dark Side of Sunlight'. *New Scientist.* Aug 21. 31–35. Concar, D. (1992). 'The Resistible Rise of Skin Cancer'. *New Scientist.* May 16. 26–27. Final Report: Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol. 17.

100 Anon. (2004). 'Sunburnt to Extinction'. *New Scientist* July 31. 15.

101 Ozone Plan. Section 2.

102 Ozone Plan. Section 3.

103 CCOL. (1981). Some Results of Ongoing Projects in the Federal Republic of Germany. UNEP/CCOL/5/4/Ad. October 12.

104 CCOL. (1981). An Environmental Assessment of Ozone Layer Depletion and Its Impact. UNEP/WG. 69/6. Oct 16. Annex 1. Paragraph 9. UNEP. (1982). Some Obstructions on the Preparation of a Global Framework for the Protection of the Ozone Layer. UNEP/WG.69/8. January 13. Paragraph 27. Also, NRC. (1980). Protection Against Depletion of the Stratospheric Ozone Layer by Chlorofluorocarbons. This is reported in Anon. (1980). 'Ozone Debate Put on Scientific Footing'. New Scientist. Jan 24. 223. CCOL. (1981). The Chemical Manufacturers Association: The CFC Ozone Theory Assessment of New Science. UNEP. October 12. CCOL. (1981). Effects of UV-B, Submitted by Chemical Manufacturers of Association. UNEP/CCOL/5/Background 3. October 12–16. Paragraph F.

Nature was increased at the end of 1992, when it was reported that in lower Chile an unusually large number of cataracts, cancers, and other eye diseases in sheep, cattle and rabbits was occurring. Although a number of eye diseases were found in the sheep, they were not going blind, and the type of cataracts detected would not lead to blindness.[105] Despite this mistake, enhanced UV-B has been documented as having possible lethal and sub-lethal effects on a number of species of non-human animals, such as frogs, and especially when at embryonic stages.[106]

With regard to flora, although some studies came to show that some species were more resilient than first assumed,[107] other studies concluded that other species were more vulnerable than expected. For example, of 80 plant varieties and 12 species investigated in the late 1980s, half were found to be sensitive to UV-B, typically having smaller leaves and reduced growth. Some soya-beans were shown to have a reduced food yield of up to 25%, for exposures simulating a 25% total ozone loss. Legumes and fruit are also more sensitive to enhanced UV-B than other species, such as wheat. UV-B also appears to have strong internal effects through altered patterns of gene activities. Such considerations may affect long-term interactions within ecosystems, and alter fragile balances by indirect means, such as, by becoming susceptible to new pathogens.[108]

Finally, it has long been realised that enhanced UV could have a 'negative effect' on a number of aquatic species, such as phytoplankton, zooplankton, larval crabs, shrimps, and juvenile fish.[109] In 2000 it was suggested that enhanced UV radiation could be killing up to 90% of Atlantic cod larvae, at depths of up to 8 metres over a ten day period.[110] However, the extent of such impacts on other aquatic species has proved scientifically contentious. For example, with regard plankton around the Antarctic, the original estimate that a depleted ozone layer was reducing the plankton

[105] Pearce, F. (1993). 'Ozone Hole Innocent of Chile's Ills'. *New Scientist.* Aug 21. 7.
[106] Withgott, J. (2001). 'Feeling the Burn'. *Natural History*. July 38–45. Pahkala, M. (2002). 'Lethal and Sub-lethal Effects of UV-B on Common Frog Embryos'. *Conservation Biology*. 16(4): 1063–1073. Broomhall, S. (2000). 'Comparative Effects of Ambient UV-B Radiation on Two Species of Australian Frogs'. *Conservation Biology*. 14(2): 420–427.
[107] George, A. (2001). 'Back From the Brink'. *New Scientist.* Sep 8. 12. Brown, J. (1994). 'Some Plants Can Survive'. *New Scientist.* Sep 10. 11. Holmes, B. (1999). 'Against the Grain'. *New Scientist.* Feb 6. 8.
[108] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 26. UNEP. (1998). *Environmental Effects of Ozone Depletion: 1998 Assessment.* (UNEP, Ozone Secretariat, Nairobi). xii. Final Report: Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol. 17.
[109] Co-Chairs of the Assessment Panels (2003). Ibid. 27. Final Report. Ibid. 17. Anon. (1989). 'Radiation Flood Through Ozone Hole Is Measured'. *New Scientist.* Apr 15. 18.
[110] Knight, J. (2000). 'Frying Fish'. *New Scientist* .Dec 16. 21.

population by between six and twelve per cent per year, has been challenged as both an over estimate and an under estimate.[111]

C. Impacts Upon Materials

Physical and mechanical properties of polymers, such as wool, cotton, paper, and wood are negatively affected by increased UV-B. These effects may be enhanced by climatic change. The exact damage depends on the product and the exposure it suffers. However, some effective photo-stabilizers, mixed into various plastics, have been developed to mitigate against types of exposure.[112]

3. Climate Change

The adverse effects of global warming are those which result in changes to the physical environment or biota which have significant deleterious effects on the composition, resilience, or productivity of natural and managed ecosystems or on the operation of socio-economic systems or on human health and welfare.[113]

Historical records indicate that many human cultures have been detrimentally affected by climatic change, which has often acted in conjunction with other factors. Some cultures have been able successfully to adapt to changing climates and have prospered.[114] However, apart from these few bright spots, history is littered with examples of civilisations that failed to adapt to changing climates. Indeed, changing climatic conditions has been attributed to part of the reasons for the collapse of a number of early civilisations, including the early Egyptian empire, the western Roman Empire, the Mayan civilisation, the Bronze Age people of Canaan, and the Norse farmers of Greenland.[115]

The future impacts of global warming upon humanity will depend on the speed and the magnitude of change. Although the possibility of adverse

---

[111] UNEP. (1998). Ibid. xiii. Pearce, F. (1998). 'Algal Bloom'. *New Scientist.* Aug 8. 24. Schrope, M. (2000). 'The Hole Story?' *New Scientist.* Feb 19. 17.

[112] Co-Chairs of the Assessment Panels (2003) Ibid. 29.UNEP. (1998). Ibid. xv.

[113] FCCC. Article 1. Definitions.

[114] Anon. (1990). 'Adapting to Climate Change Will Be Easy'. *New Scientist.* Feb 24. 12. Hecht, J. (1999). 'Born In A Storm'. *New Scientist.* May 22. 38.

[115] Mason, B. (2002). 'Egypt Felled By Famine'. *New Scientist.* Jan 26. 14. Mason, B. (2001). 'End of an Empire ? Blame it On The Weather'. *New Scientist.* Dec 22. 11. Vince, G. (2003). 'The Maya's Arid End'. *New Scientist.* Mar 22. 19. Pain, S. (1994). 'Rigid Cultures Caught Out By Climate Change'. *New Scientist.* Feb 19. Gribbin, J. (1990). 'Climate and History: The West vikings' Saga'. *New Scientist.* Jan 20. 34. 13.

effects was first noted in the 1950s[116] it was not until the late 1970s and 1980s that the possibilities of 'considerable changes'[117] of climate change that could be 'catastrophic'[118] or result in 'major effects on the quality of life for mankind in many regions'[119] become apparent. The foremost example from this period, was the statement from the 1988 Toronto Conference on the Changing Atmosphere which concluded,

> Humanity is conducting an enormous, unintended, globally pervasive experiment whose ultimate consequences could be second only to global nuclear war.[120]

The FCCC which followed four years later, took a much less alarmist approach than the Toronto Conference and only noted that, 'an additional warming of the Earth's surface and atmosphere may adversely affect natural ecosystems and humankind'.[121] This weak recognition of adverse impacts has been largely eclipsed by subsequent statements from the COPs[122] which suggest that the adverse impacts of climate change, 'will result in significant, often adverse, impacts on many ecological systems and socio-economic sectors'.[123] However, it has also been noted that, 'considerable uncertainties still persist with regard to the assessment of the adverse effects of climate change, particularly at the regional, sub-regional and national levels'.[124] Despite these uncertainties, as a generalization, it appears that countries with a diversified, industrial economy and an educated and flexible labour force are likely to have smaller impacts, as opposed to countries with a specialized and natural resource based economy, especially agriculture or forestry, and a poorly developed and physical resource dependent labour force.[125]

[116] See White, R. (1990). 'The Great Climate Debate'. *Scientific American.* July 18.
[117] Anon. (1978). 'Coal Group Calls For Climate Studies'. *New Scientist.* June 22. 804.
[118] Anon. (1983). 'Raised Temperatures Over Greenhouse Effect'. *New Scientist.* Oct 27. 247.
[119] Joyce, C. (1988). 'American Politicians Warm to Greenhouse Effect'. *New Scientist.* Sep 8. 30.
[120] Anon. (1988). 'Toronto Delegates Call for a 'Law of the Atmosphere'. *New Scientist.* July 7. 24.
[121] FCCC. Preamble. Paragraph 2.
[122] COP 6, Part One. Action Taken By The COP At The First Part Of Its Sixth Session. FCCC/CP/2000/5/Add.2. 4 April 2001. Personal Observations of the Chair.
[123] The Geneva Ministerial Declaration. Report of the Second Session of the COP, Geneva. 1996. FCCC/CP/1996/15/Add.1. 29 Oct. 1996. Annex. Paragraph 2.
[124] Decision 5/CP.4. Implementation of Article 4.8 and 4.9 of the Convention. Hadfield, P. (2000). 'Totally Tropical Tokyo'. *New Scientist.* Sep 22. 10. Adler, R. (1999). 'Born to Be Wild'. *New Scientist.* Aug 7. 6. Milne, R. (1990). 'Pressure Grows on Bush To Act on Global Warming'. *New Scientist.* June 2. 5.
[125] IPCC. (1996). *Climate Change 1995: Economic and Social Dimensions.* (CUP). 10.

A. Food

One of the biggest questions relating to the impacts of climate change is how these impacts will effect food supply. This is all the more heightened, given that food supplies must be increased within the next five decades in order to meet increasing human population needs. Despite the need to answer this question, certainty is difficult as a warmer climate may have both a beneficial and a detrimental impact on agriculture, as well as oceanic sources of food.[126]

The beneficial impact on agriculture from climate change comes from experiments that show that a higher concentration of CO_2 can create a 'fertilization effect' resulting in greater photosynthesis, depending on the CO_2 concentration, of up to 40%, and promote faster growth for some plant species.[127] Research also suggests that some plant species which are detrimentally effected by UV-B may have their negative effects offset by enhanced CO_2 concentrations.[128] When these increases are coupled with the possibilities that some regions which are currently inhospitable to agriculture may become receptive with a warmer climate and increased precipitation, then climate change has been welcomed because, 'it will increase harvests everywhere'.[129]

The detrimental view of the impact of climate change on agriculture does not take such a clear-cut view of overall benefits for all concerned. Rather, it suggests that although there may be theoretical increases in some areas, these may be offset in others. Thus, there will probably be 'winners and losers'.[130]

---

126 FAO. (2002). *The State of World Fisheries and Aquaculture*. (FAO, Rome). Chapter 3. UNEP. (1995). *The Impacts of Climate Change on Fisheries*. (UNEP, Nairobi).

127 IPCC. (2001). *Climate Change 2001: Impacts, Adaptation and Vulnerability*. (Cambridge University Press, Cambridge). 4. IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change*. (Cambridge University Press, Cambridge). 18. Anon. (2003). 'Veggie Monsters'. *New Scientist*. Oct 25. 15. Pain, S. (1988). 'No Escape From the Greenhouse'. *New Scientist*. Nov 12. 38. Pearce, F. (2003). 'Gardening Goes All Hot and Steamy'. *New Scientist*. Oct 11. 13. Fajer, E. (1992). 'Is Carbon Dioxide A Good Gas?' *Global Environmental Change*. 301–310. Pearce, F. (2001). 'Global Warning'. *New Scientist*. Nov 17. 4.

128 Co-Chairs of the Assessment Panels (2003). *The Synthesis Report*. UNEP/OzL.Pro/WG.1/23/3. 26.

129 Anon. (2003). 'Its Hot As Hell But The Bubbly's Lovely'. *New Scientist*. Nov 15. 17. Miller, J. (1989). 'Soviet Climatologist Predicts Greenhouse 'Paradise'. *New Scientist*. Aug 26. 8. West, S. (1979). 'Carbon Dioxide Induces An Air of Calm'. *New Scientist*. Apr 19. 172.

130 CBD. (2003). *Interlinkages Between Biological Diversity and Climate Change*. (CBD Technical Series No 10, Montreal). 2–3. Parry, M (1990). *Climate Change and World Agriculture*. (Earthscan, London). Bazzaz, F. (1996). *Global Climate Change and Agricultural Production*. (Willey, London). Fischer, G. (1994). 'Cliamte Change and World Food Supply, Demand and Trade'. *Global Environmental Change*. 4 (1): 7–23. Chen, R. (1994). 'Climate Change and World Food Security'. *Global Environmental Change*. 4 (1): 3–6.

The causes of the adverse effects upon agriculture for some countries due to climate change are multiple. Typically, the effects include decreases in agricultural output due to some crops being overcome by excessive heat, of more than a few degrees C above current temperatures, and drought.[131] For example, with the 2003 heat wave in Europe, France lost 20% of its grain harvest, Italy lost 13% of its wheat and the UK lost 12% of its wheat. The Ukraine saw a 75% decrease in their grain harvest from normal years.[132] Changed climate may also create infertile conditions and create complex ecosystem interactions which are negative for agricultural output, in terms of changed moisture patterns, increased weed growth, the introduction of alien pests and other unwelcome bio-invasions, altered water supplies from changes in precipitation and other water sources, and reduced nutrients in existing crops. Surpassed thresholds in CO_2 sequestration may also limit plant growth.[133]

It has been argued since the mid 1970s that such detrimental impacts may result in decreases of certain agricultural yields.[134] This view is also the broad consensus of the IPCC which believes that a general reduction

[131] IPCC. (2001). *Climate Change 2001: Impacts, Adaptation and Vulnerability*. (Cambridge University Press, Cambridge). 4. Biver, C. (2003). 'Bumper Harvests Will Wither Away if the Temperature Keeps Rising'. *New Scientist*. Feb 22. 16. Coghlan, A. (2003). 'Heatwave's Warning for the Future of Farming'. *New Scientist*. Aug 23. 7. Joyce, C. (1991). 'World's Rice Crop Vulnerable To Changing Atmosphere'. *New Scientist*. Jan 12. 16. Pain, S. (1990). 'The Days of the Kiwifruit May Be Numbered'. *New Scientist*. Feb 24. 11. Nowak, R. (2002). 'How the Rich Stole the Rain'. *New Scientist*. June 15. 6. Gribbin, J. (1986). 'Warming is Linked to Sahal Drought'. *New Scientist*. April 24. 24. Anderson, I. (1988). 'Greenhouse Warming Grips American Corn Belt'. *New Scientist*. June 30. 35.

[132] Vidal, J. (2003). 'Heatwave Devastates Europe's Crops'. *Guardian Weekly*. 169:12/Sep 17. 1.

[133] Cohen, P. (2004). 'Pine Beetles Leave No Tree Unchewed'. *New Scientist*. Dec 18. 16. Ananthaswamy, A. (2002). 'Don't Count on Plants To Save the World From Global Warming'. *New Scientist*. Dec 14. 18. Lawton, G. (2002). 'Plague of Plenty'. *New Scientist*. Nov 30. 26–29. Pearce, F. (2003). 'Gardening Goes All Hot and Steamy'. *New Scientist*. Oct 11. 13. Holmes, B. (1996). 'Weeds Won't Save Us From A Greenhouse Fate'. *New Scientist*. Dec 14. 16. O'Rourke, K. (1999). 'Will Global Warming Spawn the Superweed ?' *New Scientist*. Aug 7. 11. SBSTTA. (2000). The Global Strategy on Invasive Alien Species. UNEP/CBD/SBSTTA/6/INF/9. Coviella, C. (1999). 10–11. 'Effects of Elevated Atmospheric Carbon Dioxide On Insect-Plant Interactions'. *Conservation Biology*. 700–712. Mulvaney, K. (1998). 'Eaten Alive'. *New Scientist*. July 18. 12. Holmes, B. (1998). 'Unwelcome Guests'. *New Scientist*. Apr 18. 15. Copley, J. (1999). 'Off Their Food'. *New Scientist*. Apr 3. 23. Kleiner, K. (1998). 'Dying For A Change'. New Scientist. Sep 5. 8. IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change*. (Cambridge University Press, Cambridge). 18. Pearce, F. (1990). 'High and Dry in the Global Greenhouse'. *New Scientist*. Nov 10. 26–29. Bazzar, F. (1992). 'Plant Life In A CO_2 Rich World'. *Scientific American*. Jan. 18–24. Gribbin, J. (1995). 'Plants Issue Their Own Global Warming'. *New Scientist*. Sep 30. 21. Fajer, E. (1992). 'Is Carbon Dioxide A Good Gas?' *Global Environmental Change*. 301–310.

[134] Anon. (1976). 'A Weatherman's Eye on Climatic Stability'. *New Scientist*. Dec 2. 511. Pearce, F. (2003). 'Did Warming Seas Suck Africa Dry?' *New Scientist*. Oct 15. Hulme, M. (2001). 'Climatic Perspectives on the Sahelian Desiccation: 1973–1998'. *Global Environmental Change*. 11: 19–29.

in potential crop yields in most tropical and sub-tropical regions for most projected increases in temperature is likely.[135] Typically, the losses will be in developing countries,[136] although some industrialized countries may also be affected.[137] In 2001, UNEP suggested that harvests of vital crops like rice, wheat and corn could plummet by over a third, with a 10% drop for every single degree increase in temperature, in some regions over the next 100 years, causing mass starvation.[138] Other studies suggest that additional millions could be added to the numbers which are expected to be nutritionally deficient in the future.[139] However, this area is rife with uncertainty, especially when additional macro-economic considerations like future trade flows in food stuffs are added.[140]

In terms of overall global output of agricultural yields, in 1990 the IPCC suggested that 'global food production can be maintained at essentially the same level' although the cost of achieving this is 'unclear'.[141] In 1996 the IPCC added,

> On the whole, global agricultural production could be maintained relative to baseline production in the face of climate change but regional effects would vary widely. This conclusion takes into account the beneficial effects of CO_2 fertilisation, but does not allow for changes in agricultural pests and possible effects of changing climatic stability.[142]

The IPCC added in 1998 that where agriculture is well adapted to current climate variability and/or where market and institutional factors are in place to redistribute agricultural surpluses to make up for shortfalls, vulnerability to changes in climate is generally low. However, in regions where agriculture is unable to cope with existing extremes, where markets and institutions are weak and redistribution deficits and surpluses are not in place, and/or where adaptation resources are limited, the vulnerability of the agricultural sector should be considered high.[143]

---

135 IPCC. (2001). Impacts. Ibid. 4. Jones, P. (2003). 'Potential Impacts of Climate Change on Maize Production in 2055'. *Global Environmental Change*. 13: 51–59.

136 UNEP. (1988). *The Impact of Climate Variations on Agriculture*. (UNEP, Nairobi). Anon. (1988). 'Gluts From Global Warming'. *New Scientist*. Nov 12. 22.

137 Pearce, F. (1992). 'Grain Yields Tumble In Greenhouse World'. *New Scientist*. Apr 18. 4.

138 Pearce, F. (2001). 'Global Warning'. *New Scientist*. Nov 17. 4.

139 Rind, D. (1995). 'Drying Out'. *New Scientist*. May 6. 36–41.

140 IPCC. (2001). *Climate Change 2001: Impacts, Adaptation and Vulnerability*. (Cambridge University Press, Cambridge). 9. Reilly, J. et al. (1994). 'Climate Change and Agricultural Trade'. *Global Environmental Change*. 4 (1): 24–36.

141 See MacKenzie, D. (1990). 'Communication Gaps Undermine Reports on Global Warming'. *New Scientist*. June 23. 5.

142 IPCC. (1996) *Climate Change 1995: Impacts, Adaptations and Mitigation*. (Cambridge University Press, Cambridge). 9.

143 IPCC. (1998). *The Regional Impacts of Climate Change: An Assessment of Vulnerability*. (Cambridge University Press, Cambridge). 6.

B. Fresh Water

Water stress was a clearly recognised by the IPCC, as detrimental consequence of climate change in 1995,[144] 1998[145] and 2001. In 1995, the IPCC concluded that, 'experts disagree over whether water systems will evolve substantially enough to compensate for the negative impacts of climate change on water resources and for potential increases in demand'.[146] By 2001, the IPCC emphasis was much more on detrimental impacts of climate change on fresh water resources. This was especially so with 1.7 billion people already existing in water-stressed regions.[147] The number of people living in water stressed areas is projected to increase to around 5 billion by 2025. The projected climate change could further decrease the stream flow and groundwater recharge in many of these water-stressed countries and regions, including central Asia, southern Africa, and countries around the Mediterranean Sea.[148]

C. Increases in Sea Level and Coastal Stress

The Earth's oceans can rise or fall in relation to the warming or cooling of their waters and melting Polar icecaps. These influences have long effected the Earth's sea levels. For example, for much of the last interglacial period, the sea level was 2.5 metres higher than it is today. It rose briefly by another 3.5 metres at the end of the warm interglacial period, possibly due to the glaciers dumping a vast amount of ice into the oceans. However, at the end of the last interglacial period 118,000 years ago, the sea level dropped 15 metres in less than a century.[149] The oceans last rose quickly between 12,000 and 6,000 years ago in response to the disappearance of global ice sheets.[150] The oceans have been rising ever since, with clear rises throughout the twentieth century, although certainty with exact levels is difficult due to moving land masses and regional weather

[144] IPCC. (1996) Ibid. 8.
[145] IPCC. (1998). Ibid. 5.
[146] IPCC. (1996) Ibid. 9.
[147] IPCC. (2001). Ibid. 4.
[148] IPCC. (2001). Ibid. 4, 8. Ravillious, K. (2004). 'Ice Melt May Dry Out US West Coast'. *New Scientist.* Apr 10. 17. Pearce, F. (2004). 'Climate Change Heralds Thirsty Times Ahead for Most'. *New Scientist.* May 22. 16–17. Poff, L. (2002). *Aquatic Ecosystems and Global Climate Change.* (Pew Centre, Florida). Hecht, J. (1994). 'California's Climate Poised on Knife Edge'. *New Scientist.* June 25. 10.
[149] Ravilious, K. (2002). 'Deep Secrets'. *New Scientist.* Apr 20. 38–42.Anon. (1993). 'Bahamas Backs Theory Of Sudden Change'. *New Scientist.* Dec 18. 14.
[150] Davidson, G. (1992). 'Icy Prospects For A Warmer World'. *New Scientist.* Aug 8. 23–24.

patterns such as El-Nino.[151] The key point is that the seas are rising regardless of climate change. Most of the predictions of future climate change recognize this, and the low-end of the sea level rise scenarios are what could be expected with a continuation of the natural rise in sea level. However, the high-end of sea level rise predictions represent a substantial acceleration of the natural process.

Despite the difficulties noted above, it is possible to show, with tide gauge data that over the last 100 years, that global average sea level rose between 0.1 and 0.2 metres.[152] Between 1993 and 2002, the global average sea level rose by 2.8 millimetres, although this rate was greater (3.7 millimetres) if within 100 kilometres of a coastline.[153] It is very likely that the twentieth century warming contributed significantly to the observed sea level rise. If the current climate change continues, it is expected that sea levels will rise even further.

Although it is difficult to predict exactly how much sea levels will change in the future, due to uncertainties about how key ecosystems such as the Polar regions and the oceans, will respond to enhanced climatic change,[154] it is expected that sea levels will rise in the future, because of climatic change. Generally, the increases in the rise of sea levels are much greater the further the time frame is cast.[155] For example, in 500 years, an eventual rise of seven to 13 metres is likely.[156] However, the typical time frame is 100, and not 500, years. Thus, between 2000 and 2100 global mean sea level is projected to rise by 0.09 to 0.88 metres. This is due primarily to thermal expansion and loss of mass from glaciers and ice caps.[157] This projected rise is less than earlier IPCC,[158] and

---

151 Schneider, D. (1997). 'The Rising Seas'. *Scientific American*. March. 96–101. A Hecht, J. (1995). 'Cash Cuts Could Sink Poseidon'. *New Scientist*. May 13. 7. non. (1990). 'Greenhouse Makes Greenland Ice Grow'. *New Scientist*. Feb 3. 16. Wells, S. (1989). 'Gone With The Waves'. *New Scientist*. Nov 11. 29. Anderson, I. (1989). 'Australia Prepares To Measure the Rise and Rise of the Pacific'. *New Scientist*. July 22. 10.

152 IPCC. (2001).*Climate Change 2001: The Scientific Basis*.(Cambridge University Press, Cambridge).4, 10. Hecht, J. (2004). 'Rome's Ancient Fisheries Confirm Sea Level Fears'. *New Scientist*. Aug 14. 14.

153 Hogan, J. (2004). 'Why Oceans Behave Like Water In A Bathtub'. *New Scientist*. Apr 24. 16.

154 Pearce, F. (1999). 'Going Under'. *New Scientist*. Oct 30. 5. Revelle, R. (1982). 'Carbon Dioxide and World Climate'. *Scientific American*. 247 (2): 33, 38. Anon. (1990). 'Greenhouse Makes Greenland Ice Grow'. *New Scientist*. Feb 3. 16.

155 IPCC. (2001).*Climate Change 2001: The Scientific Basis*.(Cambridge University Press, Cambridge).16.

156 Pearce, F. (2000). 'Washed Off the Map'. *New Scientist*. Nov 25. 5.

157 IPCC. (2001).*Climate Change 2001: The Scientific Basis*.(Cambridge University Press, Cambridge). 16.

158 In 1990, the IPCC suggested that sea levels would be 20 centimetres higher by 2030, and 65 centimetres by 2100. Jager, E. (ed). *Climate Change: Science, Impacts and Policy:*

other,[159] predictions. This lowering is primarily due to the use of improved models, which give a smaller contribution from glaciers and ice sheets.[160]

The threat to coastal habitats comes from both rising sea levels and possibly worsening weather patterns. With regard to the first consideration, the threat of, 'possible adverse effects of sea level rise on . . . coastal areas, particularly low-lying coastal areas'[161] which were, 'particularly vulnerable to the adverse effects of climate change'[162] was noted in the FCCC. This statement was justified by the scenario that, apart from the obvious sea level rises, storm surges could result in the erosion of shores and associated habitats, increased salinity of estuaries and freshwater aquifers, altered tidal ranges in rivers and bays, changes in sediment and nutrient transport, and a change in the pattern of chemical and microbiological contamination in coastal areas, as well as increased coastal flooding. Some coastal ecosystems are particularly at risk, including saltwater marshes, sea-grasses mangrove ecosystems, coral reefs, coral atolls, and river deltas. By the year 2080 about 20% of coastal wetlands could be lost due to sea level rise.[163] Globally, in the mid-1990s, some 46 million people were at risk each year from flooding due to storm surges. With projected sea level rises of 50 centimetres, this could increase to 92 million people at risk, and a 1 metre increase to 118 million.[164]

Such threats may detrimentally impact upon a number of industrialized countries such, inter alia, the United Kingdom, the Netherlands, and parts of the United States.[165] Despite these impacts, it is expected that the adverse

Proceedings of the Second World Climate Conference. (Cambridge University Press, Cambridge). 23. The IPCC Second Assessment Report put the sea level rise at between 15 and 95 cm, with 50 cm being the average. This was endorsed by the COP at its second session in 1996. The Geneva Ministerial Declaration. Report of the Second Session of the COP, Geneva. 1996. FCCC/CP/1996/15/Add.1. 29 Oct. 1996. Annex. Paragraph 2.

159 For example, the 1988 Toronto Conference on the Changing Atmosphere, suggested that in conjunction with the increase in temperatures, sea levels could rise by as much as 1.5 metres by the year 2050. Anon. (1988). 'Toronto Delegates Call for a 'Law of the Atmosphere'. *New Scientist.* July 7. 24. See also, Anon. (1995). 'Sea Change'. *New Scientist.* Nov 4. 12. MacKenzie, D. (1990). 'US and Europe Could Fall Out Over Climate Change'. *New Scientist.* Sep 1. 5. Gavaghan, H. (1989). 'Effect of Global Warming on Sea Levels 'Over-Estimated'. *New Scientist.* Dec 16. 5. Wells, S. (1989). 'Gone With The Waves'. *New Scientist.* Nov 11. 29.

160 IPCC. (2001). Ibid. 16.

161 FCCC. Preamble. Paragraph 12.

162 FCCC. Preamble. Paragraph 19.

163 IPCC. (2003). *Climate Change and Biodiversity*. (IPCC, Technical Paper V, Geneva). 1, 21. IPCC. (1996) *Climate Change 1995: Impacts, Adaptations and Mitigation.* (Cambridge University Press, Cambridge). 8. Eisma, D. (1995). *Climate Change: Impact of Coastal Habitation*. (Lewis, London).

164 IPCC. (2001). *Climate Change 2001: Impacts, Adaptation and Vulnerability*. (Cambridge University Press, Cambridge). 3, 4, 8. Jones, N. (2003). 'Here Comes the Rain'. *New Scientist.* Apr 26. 24–25.

165 Pearce, F. (2005). 'Cities May Be Abandoned as Salt Water Invades'. *New Scientist.* Apr

effects of this problem will be greater on a number of developing countries. For example, Bangladesh could lose between 15 and 17.5% of its land to a one metre rise, affecting an additional ten million people, over the existing millions who are already vulnerable to flooding. For the same level, 0.05% of Uruguay, and 1% of Egypt could be submerged. In India, 7.1 million people could be displaced by coastal flooding, as could 6.9 million in Vietnam.[166]

Small Island Developing States (SIDS) are at the forefront of the extreme risks posed by climatic change. The threat of, 'possible adverse effects of sea level rise on islands'[167] was recognised in the FCCC. It was added that such 'small island countries' are, amongst others, 'particularly vulnerable to the adverse effects of climate change'.[168] The 'deep concern' for small island states was reiterated at the 7th COP in 2001.[169] This concern, which is continually reiterated by groups such as the South Pacific Forum,[170] is due to their specific situation, which according to the 1994 UN Global Conference for the Sustainable Development of Small Island Developing States is,

> While small island developing states are among those that contribute least to global climate change and sea level rise, they are among those that would suffer most from the adverse effects of such phenomena and could in some cases become uninhabitable.[171]

This forecast is due to the fact that many SIDs rarely exceed 3 to 4 metres above present mean sea level. A one metre rise could result in an 80% land loss for the Majuro Atoll in the Marshall islands. Other island groups notably affected include the Maldives (consisting of some 1300 tiny islands,

---

16. 9. Brown, P. (2004). 'Melting Ice Could Submerge London'. *Guardian Weekly*. July 23. 9. Simon, P. (1992). 'Why Global Warming Could Take Britain By Storm'. *New Scientist*. Nov 7. 35–37. Anon. (2002). 'Big Apple Under Water'. *New Scientist*. Jan 19. 16. IPCC. (1996). Ibid. 11.

166 IPCC. (1998). *The Regional Impacts of Climate Change: An Assessment of Vulnerability*. (Cambridge University Press, Cambridge). 7. IPCC. (1996) *Climate Change 1995: Impacts, Adaptation and Mitigation*. (Cambridge University Press, Cambridge). 11. Brown, L. (2004). 'Hundreds of Millions To Be Made Homeless By Rising Sea Levels'. *Ecologist*. March. 8. Warrick, R. (1996). *The Implications of Climate Sea Level Change for Bangladesh*. (Kluwer, the Netherlands). Sinclair, J. (1990). 'Rising Sea Levels Could Effect 300 Million'. *New Scientist*. Jan 20. 9. Kleiner, K. (1994). 'Climate Threatens Southern Asia'. New Scientist. Aug 27. 6.

167 FCCC. Preamble. Paragraph 12.

168 FCCC. Preamble. Paragraph 19.

169 The Marrakesh Ministerial Declaration. COP 7 (Marrakesh). FCCC/CP/2001/13/Add.1. 21 January 2002. Part II. Action Taken. Decision 1/CP. 7.3.

170 For example: "global warming and sea level rise were among the most serious threats to the Pacific region and the survival of some island states." South Pacific Forum Communique. Paragraph 29. Available from <http://www.forumsec.org.fj/docs/fc93.htm>

171 Report of the Global Conference on the Sustainable Development of Small Island Developing States. A/CONF.167/9. October, 1994. Annex I, Section III.

with an average size of only one to two square kilometres in width and an average one to 1.5 metres above mean sea level), Tuvalu (five atolls and four separate reef islands, a total land mass of only 23 square kilometres, virtually all beneath 2 metres above sea level) and Kiribati (700 square kilometres on 33 islands, with most less than 2 metres high).[172]

The overt threats to SIDS is due to the fact that the adaptive capacity of the communities in these areas is generally low, while their vulnerability is very high. The 2001 projected sea-level rise will most probably cause increased coastal erosion, loss of land and property, dislocation of people and the threat of 'environmental refugees'.[173] Islands with very limited water supplies are highly vulnerable to the impacts of climate change on the water balance. Tourism, an important source of income and foreign exchange for many islands, may face severe disruption from climate change and sea-level rise. Limited arable land makes agriculture of SIDS, both for domestic food production and cash crop exports, highly vulnerable to climate change. It is likely coral reefs; mangroves, sea grass beds and other coastal ecosystems and the associated biodiversity may be adversely affected by rising temperatures and accelerated sea-level rise. Declines in coastal ecosystems may also negatively impact reef fisheries.[174]

D. Storms, Cyclones and Tornadoes

One of the most commonly associated changes in climate linked to global warming is storms, tornadoes and cyclones.[175] Although this link was not made in the FCCC, it has been noted in separate COP resolutions in 1998, with regard to Hurricane Mitch in Central America, and in 2000, with regard to Cyclone Eline which affected southern Africa. The 1998 Resolution stipulated that, 'global warming may be contributing to the worsening of weather'[176] and the 2000 Resolution added that, 'global warm-

[172] IPCC. (2003). *Climate Change and Biodiversity*. (IPCC, Technical Paper V, Geneva). 34. Leatherman, S. (1997). *Island States at Risk: Global Climate Change, Development and Population*. (Coastal Research Foundation, Florida). Anon. (1992). 'Don't Let Us Drown, Islanders Tell Bush'. *New Scientist*. June 13. 6. Wells, S. (1989). 'Gone With The Waves'. *New Scientist*. Nov 11. 29. Anon. (2004). 'Sinking Feeling'. New Scientist. Feb 21. 5. Anon. (1989). 'Toddleoo Tuvalu'. *New Scientist*. March 25. 22. Pearce, F. (2000). 'Turning Back the Tide'. *New Scientist*. Feb 12. 44–46.

[173] Beston, A. (2000). 'Climate Refugees Forecast'. *NZ Herald*. Feb 15. A5. Pearce, F. (1992). 'Yields Tumble In Greenhouse World'. *New Scientist*. Apr 18. 4.

[174] IPCC. (2001). *Climate Change 2001: Impacts, Adaptation and Vulnerability*. (Cambridge University Press, Cambridge). 17.

[175] Pearce, F. (2002). 'Europe's Wake Up Call'. *New Scientist*. Aug 24. 4. Adler, R. (2001). 'Here Comes the Rain'. *New Scientist*. Dec 22. 11. Simon, P. (1992). 'Why Global Warming Could Take Britain By Storm'. *New Scientist*. Nov 7. 35–37.

[176] Resolution 1/CP.4. Solidarity with Central America.

ing may contribute to the increasing frequency and severity of extreme weather events'.[177]

The difficulty with the COP resolutions is that although economic losses from weather related damage were clearly increasing over the last fifth of the twentieth century, with the number of large weather disasters increasing fourfold since 1960,[178] the linkage between climate change and extreme weather events is uncertain. With regard to precipitation although there is already evidence that rainfall is becoming more intense, and it is predicted that by the second half of the twenty-first century, that precipitation will increase further over northern mid- to high latitudes and Antarctica in winter. At low latitudes there are likely to be both regional increases and decreases over land areas. Larger year to year variations in precipitation are very likely over most areas where an increase in mean precipitation is projected.[179]

Although it has been suggested that the rise in violent weather incidents cannot be definitely blamed on the greenhouse effect, it is possible that current examples of extreme weather are harbingers of what could be expected in the future.[180] However, this assertion is contested on two grounds. First, with regard to global changes in tropical and extra-tropical storm intensity and frequency, there were no significant trends evident over the twentieth century. In addition, conflicting analyses made it difficult to draw definitive conclusions about changes in storm activity. Moreover, no systematic changes in the frequency of tornadoes, thunder days, or hail events were evident in the limited areas analysed.[181] Accordingly, there is insufficient information to assess recent trends, and climate models currently lack the spatial detail required to make confident projections. For example, very small-scale phenomena, such as thunderstorms, tornadoes, hail, and lightning, are not simulated in many climate models and regional differences with regard to the impacts of such incidents are hard to predict. Despite these caveats, it is likely that warming associated with increasing greenhouse gas concentrations will cause an increase of Asian summer monsoon precipitation variability. Changes in the monsoon mean duration and strength depend on the details of the emission scenario. Current projections show little change or a small increase in amplitude for El Niño

[177] Resolution 1/CP.6. Solidarity with southern African countries, particularly with Mozambique.
[178] Pearce, F. (2002). 'Count the Cost of Global Warming'. *New Scientist*. July 27. 7.
[179] IPCC. (2001) Ibid. 13. Walker, G. (2000). 'Wild Weather'. *New Scientist*. Sep 16. 26–29.
[180] Anon. (2004). 'Warmer World Mean Fiercer Hurricanes Will Blow Our Way'. *New Scientist*. Oct 9. 10. Gribbin, J. (1990). 'Did the Greenhouse Effect Cause the Storm?' *New Scientist*. Feb 3. 5. Pearce, F. (1993). 'Is Global Warming To Blame?' *New Scientist*. Jan 16. 4.
[181] IPCC. (2001) Ibid. 5. Ananthaswamy, A. (2003). 'Historic Storms Live Again'. *New Scientist*. Sep 27. 14.

events over the next 100 years. It is possible the intensity of individual cyclones, but not their overall numbers, may increase.[182]

E. Heat waves and Disease

Increased heat may have a distinct impact on some human populations. With regard to developed countries, it is likely that heat-waves will have a direct impact on some urban populations, affecting particularly the elderly, sick, and those without access to air-conditioning.[183] For example, the 2003 heat wave in Europe was believed to have killed at least 35,000 people, with some 14,800 deaths from heat-related diseases alone in France.[184] Research suggested that the summer death toll in Japan could increase by 600, for people over 65, if temperatures rise by just one degree. If the temperatures increased by two degrees, there would be an extra 65 deaths per day, and 162 per day with a three degree increase.[185] However, other evidence indicates that in some temperate countries, reduced winter deaths (from cold) could occur.[186]

Global warming may lead to a worldwide resurgence, in association with other factors such as population increase, deforestation, new agricultural practices, and increased flooding, of a number of diseases such as dengue fever, the West Nile virus and malaria. It is estimated that malaria could increase between 50 to 80 million additional cases to the existing background of 500 million cases per year, if the temperature increases by between 3 and 5 degrees.[187] Climate change may also lead to an increase of some allergies.[188]

---

[182] IPCC. (2001).*Climate Change 2001: The Scientific Basis*.(Cambridge University Press, Cambridge). 15–16. Walker, G. (2000). 'Wild Weather'. *New Scientist*. Sep 16. 26–29. Karl, T. et al. (1997). 'The Coming Climate'. *Scientific American*. May. 54, 57–58. Anon. (1997). 'Storm Warning'. *New Scientist*. Apr 19. 13.

[183] Anon. (2004). 'Heatwaves Are Here To Stay'. *New Scientist*. Aug 21. 17. Pearce, F. (2004). 'Cities Will Swelter on Summer Nights'. *New Scientist*. June 19. 15. WRI, UNDP & World Bank. (1999). *World Resources 1998–1999*. (Oxford University Press, Oxford). 67–69. McMichael, M. (1996). *Climate Change and Human Health*. (WHO, WMO& UNEP, Geneva).

[184] Anon. (2003). 'Heat Shock'. *New Scientist*. Oct 18. 7.

[185] Hadfield, P. (1997). 'Stay Out of the Greenhouse'. *New Scientist*. Aug 16. 20.

[186] IPCC. (2001). Ibid. 4.

[187] WHO. (2004). *Climate Change and Human Health*. (WHO, Geneva). IPCC. (2001). *Climate Change 2001: Impacts, Adaptation and Vulnerability*. (Cambridge University Press, Cambridge). 7. Peiter, P. (2000). 'Biting Back'. *New Scientist*. Sep 23. 41–44. Randerson, J. (2004). 'Climate Blamed for Upsurge In Disease'. *New Scientist*. June 19. 8. Ananthaswamy, A. (2003). 'Death in the Sun'. *New Scientist*. July 16. 12–13. Schrope, M. (2002). 'Global Warming, Global Fever'. *New Scientist*. June 29. 22. Epstein, P. (2000). 'Is Global Warming Harmful To Health ?' *Scientific American*. Aug 36–43. Pearce, F. (1998). 'On The March'. *New Scientist*. Apr 18. 20.

[188] Smith, M. (1996). 'Sneezing While the Earth Warms'. *New Scientist*. Aug 24. 5. Anon. (2000). 'Gesundeit'. *New Scientist*. May 6. 23.

F. The Impact Upon Specific Ecosystems

Natural systems can be especially vulnerable to climate change because of limited adaptive capacity, and some of these systems may undergo significant and irreversible damage. Natural systems at particular risk include icecaps, glaciers, coral reefs and atolls, mangroves, boreal and tropical forests, Polar and alpine ecosystems, wetlands and grasslands.

(i) The Poles

One of the foremost concerns with projected levels of climate change, has been to do with its impact upon the Polar regions. These areas are important because the largest masses of glacial ice on Earth are on Antarctica (85%) and Greenland (10%) frozen. If this water is released, sea levels will probably increase and the currents of the oceans, with subsequent impacts on climate, may be impacted upon. Additional feedbacks from the Poles into climatic change include changing solar heat and reflective rates associated with ice.[189] These are all problematic risks as the icecaps are by no means eternal. At the end of the previous interglacial period, which ended a little over 100,000 years ago, sea level reached a peak about six metres higher than today. The extra six metres of water could have come from melting the ice sheets covering either Greenland or West Antarctica.[190] During the inter-glacial period of 400,000 years ago, sea levels were 20 metres higher than today. This has also been attributed to the melting of both the Greenland and Antarctic ice sheets).[191] The melting of the Greenland ice sheet could raise ocean levels across the world by some 23 feet.[192]

Despite the past geological records, trying to estimate future projections is difficult. This is especially so the further the projections are cast, due to the slow response and distinctive nature of the Polar areas.[193] For example, while the Polar areas remain cold enough, and snow continues to fall, the potential for ice to build up increases.[194] Although snow and precipitation is believed to be offsetting melting in the Antarctic, it is unlikely to

---

[189] Maslin, M. (1993). 'Waiting For the Polar Meltdown'. *New Scientist.* Sep 4. 36–41. Pearce, F. (1997). 'Blowing Hot and Cold'. *New Scientist.* Nov 22. 14.

[190] Anon. (1989). 'West Antarctic Ice Won't Melt Quickly'. *New Scientist.* Jun 17. 15.

[191] Hecht, J. (1999). 'The Big Thaw'. *New Scientist.* Apr 17. 5.

[192] Anon. 'Melting of Greenland Ice Sheet Forecast'. *Ecologist.* June 6.

[193] Kiernan, V. (1997). 'Arctic Vigil To Fill the Climate Gap'. *New Scientist.* March 1. 13. Pearce, F. (1997). 'Ice Watch'. *New Scientist.* Sep 27. 16. Maslin, M. (1993). 'Waiting For the Polar Meltdown'. *New Scientist.* Sep 4. 36–41. Redfern, M. (1993). 'Global Warming Cuts No Ice'. *New Scientist.* Sep 25. 16. Hecht, J. (1999). 'Mighty Melt'. *New Scientist.* Oct 16. 14.

[194] Davidson, G. (1992). 'Icy Prospects For A Warmer World'. *New Scientist.* Aug 8. 23–24.

do the same for the Greenland ice sheet[195] Climate models indicate that in the future the warming of 5.5 degrees over Greenland is likely to be one to three times the global average. If this temperature increase is sustained for 1,000 years, it is likely that it will result in a contribution from Greenland of about three metres to sea level rise. In the year 2000, it was suggested that the currently melting Greenland ice shelf could be eroding more than 50 billion tons of water per year into the ocean.[196]

The thinning of the Arctic ice cap became a prominent concern as research and evidence has confirmed that the effects of a warming climate on the Arctic are more dramatic and dynamic than expected. Northern Hemisphere spring and summer sea-ice extent has decreased by between 10% and 15% since the 1950s. It is likely that there has been about a 40% overall decline in Arctic sea-ice thickness during late summer to early autumn in recent decades and a considerably slower decline in winter sea-ice thickness. In 2002, it was shown that some 686,000 square kilometres of ice melted during the year. This was 9% more than the previous record, leaving the Arctic sea ice at its lowest level since records began in the 1950s. This melting has coincided with a warming of vast stretches of the Arctic Ocean and warming over the land. In all, the Arctic appears to have warmed by twice as much as the rest of the planet over the past 150 years (1.5c since 1840, compared with a global average of 0.6) although, most of this increase occurred before 1940. Average temperatures over Alaska have risen by one degree since the late 1960s.[197]

In terms of historical geological periods, the Antarctic ice-sheet appears to have more stable than that of Greenland. In 2001, although some areas

---

195 IPCC. (2001).*Climate Change 2001: The Scientific Basis*. (Cambridge University Press, Cambridge). 16. Gribbin, J. (1995). 'Global Warming Cuts No Ice in Greenland'. *New Scientist.* Nov 11. 18.

196 IPCC. (2001). Ibid. 17. Pearce, F. (1999). 'Only Ourselves To Blame'. *New Scientist.* Nov 20. 24.

197 Hassol, S. (2004). *Arctic Climate Impact Assessment: Impacts of a Warming Arctic*. (Cambridge University Press, Cambridge). 10–14. Anon. (2004). 'Overheating Arctic'. *New Scientist.* May 29. 5.Sturm, M. (2003). 'Meltdown in the North'. *Scientific American.* Oct 42–49. Pearce, F. (2003). 'Longer Summers Shrink Arctic Ice Cap'. *New Scientist.* Nov 1. 12. McCarthy, J. (2000). 'How Earth's Ice is Changing'. *Environment.* 42 (10): 8–18. IPCC. (2001).*Climate Change 2001: The Scientific Basis*. (Cambridge University Press, Cambridge). 2. Anon. (2002). 'Slip Sliding Away'. *New Scientist.* June 15. 24. MacKenzie, D. (2002). 'Arctic Meltdown'. *New Scientist.* March 2. 5. Armstrong, S. (2001). 'Ask The Experts'. *New Scientist.* Nov 3. 37–40. MacKenzie, D. (1995). 'Polar Meltdown Fulfils Worst Predictions'. *New Scientist.* Aug 12. 4. Anon. (1999). 'Going, Going . . ." *New Scientist.* Aug 7. 5. Coghlan, A. (1989). 'American Navy Witholds Greenhouse Data'. *New Scientist.* Sep 9. 4. Anon. (2001). 'Gambling On Thin Ice'. *New Scientist.* Nov 3. 29. Anon. (2002). 'Arctic Ice Retreats'. *New Scientist.* Dec 21. 9. Kiernan, V. (1997). 'The Frozen North In Hot Water' *New Scientist.* Feb 8. 12. Hecht, J. (1997). 'Baked Alaska'. *New Scientist.* Oct 11. 12.

of the Earth had warmed, Antarctica was not one of them. Nevertheless, some of the surrounding oceans may have increased in temperature. The warming oceans may be problematic due to the fact the west Antarctic ice sheet rests on land, which is below sea level. If the west Atlantic ice sheet slid off the Continental Shelf, iceberg by iceberg, global sea levels would rise by five metres, regardless of whether the ice melted or not.[198] Despite sections of the ocean warming, earlier suggestions that the Antarctic sea-ice is melting, and some spectacular icebergs breaking off Antarctica or the melting of glaciers (in 1995, 2000, 2002 and 2004)[199] no significant trends in diminishing Antarctic sea-ice extent have been apparent since 1978, when reliable satellite measurements began.[200] In fact, the actual amount of sea-ice in the area appears to be increasing. Ironically, this increase in sea-ice is consistent with the theory of the greenhouse effect that raised levels of precipitation, in areas which maintain below freezing temperatures, may actually increase ice and snow.[201] However, if a substantial disruption of the West Antarctic ice-sheet did occur, a sea level increase of three metres over the next 1,000 years could occur.[202]

(ii) The Cryosphere

The FCCC recognizes that, 'developing countries with fragile mountainous ecosystems are particularly vulnerable to the adverse effects of climate change'.[203] This statement is supported by IPCC predictions that glaciers and ice covered mountain regions are projected to continue their widespread retreat during the twenty-first century.[204] This problem will follow a pattern which was already well established at the end of the twentieth

---

198 IPCC. (2001). *Climate Change 2001: The Scientific Basis.* (Cambridge University Press, Cambridge). 5. Anon. 'Sleeping Giants'. *New Scientist.* Feb 12. 9. Goddard, A. (1995). 'Antarctic Glaciers Keep Their Cool'. *New Scientist.* Aug 5. 16. Anon. (1989). 'Antarctic Ice Won't Melt Quickly'. *New Scientist.* Jun 17. 15. Joyce, C. (1991). 'Antarctic Icy Evidence of Global Warming'. *New Scientist.* July 27. 13. Mullins, J. (2002). 'In Hot Water'. *New Scientist.* Feb 23. 15. Anon. (1994). 'Antarctic Warming'. *New Scientist.* June 25. 11. Pearce, F. (2000). 'Washed Off the Map'. *New Scientist.* Nov 25. 5.

199 Anon. (2004). 'Meltdown'. *New Scientist.* Jan 1. 25. Anon. (2002). 'Big Berg Breaks Off'. *New* Scientist. May 18. 7. Meek, J. (2000). 'Antarctica About to Spawn Vast Iceberg'. Guardian Weekly. March 30. 12. Walker, G. (1999). 'Southern Exposure'. New Scientist. Aug 14. 42–44. MacKenzie, D. (1997). 'Sea Ice Meltdown'. *New Scientist.* Sep 6. 4. MacKenzie, D. (1995). 'Polar Meltdown Fulfils Worst Predictions'. *New Scientist.* Aug 12. 4. Holmes, B. (2004). 'Melting Ice, Global Warning'. *New Scientist.* Oct 2. 8.

200 IPCC. (2001) Ibid. 5, 16

201 IPCC. (2001) Ibid. 16. Gavaghan, H. (1989). 'Effect of Global Warming on Sea Levels 'Over-Estimated'. *New Scientist.* Dec 16. 5. Pearce, F. (2002). 'The Icehouse Effect'. *New Scientist.* June 1. 6. Bindschadler, R. (2002). 'On Thin Ice'. *Scientific American.* Dec 66–73.

202 IPCC. (2001) Ibid. 16.

203 FCCC. Preamble. Paragraph 19.

204 IPCC. (2001). *Climate Change 2001: The Scientific Basis.* (Cambridge University Press, Cambridge). 16.

century. For example, one third of the ice on Mount Kilimanjaro disappeared between 1990 and 2001. The glacier that Edmond Hillary climbed to conquer Mount Everest had retreated by five kilometres within 49 years of the event. Alpine glaciers have retreated 25% since 1900, and the Himalayan glaciers are retreating at a rate which suggests that they will be gone by 2040. Glaciers in the mountains off Chile and Argentina are melting at a rate that had doubled from 1975 averages by 2003. 90% of Alaska's glaciers are melting more in summer than they are gaining in winter, averaging a reduction of about one metre per year. The largest glacier in the French Alps (Mer de Glace) was thinning at a rate of 4.1. metres per year between 2000 and 2003 (up from a one metre loss per year between 1979 and 1994). Such retreats are consistent with satellite data which show that there are very likely to have been decreases of about 10% in the extent of snow cover since the late 1960s, and ground-based observations show that there is very likely to have been a reduction of about two weeks in the annual duration of lake and river ice cover in the mid and high latitudes of the Northern Hemisphere, over the twentieth century. In total, models project that between one third and one half of existing mountain glacier mass could disappear by 2100.[205]

The projected decreases in mountain glaciers and snow cover will probably affect hydro systems, including rivers, lakes, waterfalls and floods, soil stability and related socio-economic systems.[206] Mountain resources, such as food and fuel, not to mention safety, through to the detrimental impact on recreational industries and tourism, especially areas including ski fields, could be large.[207]

---

[205] IPCC. (2001) Ibid. 2. IPCC. (1996) *Climate Change 1995: Impacts and Mitigation*. (Cambridge University Press, Cambridge). 6. Anon. (2004). 'Satellites Spot Glacier Meltdown'. *New Scientist*. Sep 18. 14. Samuel, E. (2001). 'Total Meltdown'. *New Scientist*. June 9. 13. Pearce, F. (2002). 'Meltdown'. *New Scientist*. Nov 2. 45–48. Anon. (2001). 'Africa On Ice'. *New Scientist*. May 26. 13. Anon. (2002). 'Everest Meltdown'. *New Scientist*. July 13. 8. Anon. (2004). 'Glaciers'. *Ecologist*. March. 9. Pearce, F. (1999). 'Flooded Out'. *New Scientist*. June 5. 18. Anon. (2003). 'Patagonian Meltdown'. *New Scientist*. Oct 25. 5. Gosline, A. (2004). 'Alaska Rattled By Melting Ice'. *New Scientist*. Aug 14. Monastersky, R. (2001). 'The Long Goodbye'. *New Scientist*. Apr 14. 30–34.

[206] Anon. (2001). 'Melting Mountains On The Skids'. *New Scientist*. Jan 13. 23. Pearce, F. (1999). 'Flooded Out'. *New Scientist*. June 5. 18. Falk, D. (1999). 'High and Dry'. *New Scientist*. June 5. 10. Ravilious, K. (2004). 'Warmer Lakes Will Face Trouble'. *New Scientist*. Nov 27. 10.

[207] IPCC. (1996) Ibid. 6. Ravilious, K. (2004). 'Mountains Face Meltdown'. *New Scientist*. July 24. 6. Edwards, R. (1995). 'Not Yodelling But Drowning'. *New Scientist*. Nov 11. 5. Anon. (2003). 'Dry Ski Slopes'. *New Scientist*. Dec 6. 7. Wilson, J. (1999). 'Global Warming: Tourist Spots Too Hot To Handle'. *Guardian Weekly*. Sep 2. 5.

(iii) Forests, Coral Reefs and Deserts

In 1995, the IPCC warned that models projected that a sustained increase of 1.c. in global mean temperature is sufficient to cause changes in regional climates that would affect the growth and regeneration capacity of forests in many regions. In several instances, this could significantly alter the composition of forests. In some areas, this may already be occurring.[208] As a consequence of possible changes in temperature and water availability under a doubling of CO_2 conditions, a substantial fraction (a global average of one third, varying by region from one seventh to two thirds) of the existing forested areas of the planet might undergo major changes in broad vegetation types. Depending on the temperature increases, even key forests, such as those in the tropics, might not be immune to sustained higher temperatures. These findings reflect later work in this area which suggest that on a broad scale, the climatic zones suitable for temperate and boreal plant species may be displaced by between 200 and 1,200 kilometres northward by the year 2100. Paleoecological evidence suggests that in the past most plant species migrated by only between 20 and 200 kilometres per century although this may have been limited by the rates of climate change at that time. It is questionable whether such movements are possible in the future, given both ecological and social constraints, such as human competition for ecological space.[209]

Coral reefs require highly stable environments, and temperature fluctuations of just one or two degrees above normal can have a devastating impact upon them.[210] Already, episodes of coral bleaching over the past 20 years have been associated with several causes, including increased ocean temperatures. Thus, as the fifth COP of the Convention on Biological Diversity noted,

---

[208] See for example, Holmes, B. (2004). 'Canopy Trees Taking Over'. *New Scientist.* Mar 13. 12.

[209] IPCC. (2003). *Climate Change and Biodiversity*. (IPCC, Technical Paper V, Geneva). 17. 209 IPCC. (1998). *The Regional Impacts of Climate Change: An Assessment of Vulnerability*. (Cambridge University Press, Cambridge). 5. IPCC. (1996) *Climate Change 1995: Impacts, Adaptations and Mitigation.* (Cambridge University Press, Cambridge). 5–6. Anon. (2000). 'Forests Turn to Dust'. *New Scientist.* May 6. 7. Rind, D. (1995). 'Drying Out'. *New Scientist.* May 6. 36–41. Hecht, J. (1990). 'A Climate of Change Sweeps The Tropics'. *New Scientist.* Dec 22. 13. Anon. (1997). 'A Rotten Prospect For the Tropics'. *New Scientist.* Dec 13. 7. Pearce, F. (1999). 'Going Under'. *New Scientist.* Oct 30. 5.

[210] IPCC. (2003). Ibid. 20. Pearce, F. (2002). 'Grief on the Reef'. *New Scientist.* Apr 20. 11. Schrope, M. (2000). 'Corals Face Catastrophe'. *New Scientist.* May 27. 8. Wilkins, C. (1994). *Global Climate Change and Coral Reefs: Implications for Peoples and Reefs.* (UNEP/IUCN, Geneva). Anon. (1999). 'The World's Coral Reefs In Hot Water'. *Ecologist.* 29 (3): 1.

> There is significant evidence that climate change is a primary cause of the recent and severe extensive coral bleaching, and that this evidence is sufficient to warrant remedial measures being taken in line with the precautionary approach.[211]

In 2004, an estimated 20% of the world's coral reefs had been destroyed. Many of the world's currently damaged coral reefs were impacted upon with the, one in a thousands year, bleaching associated with El Nino in 1998.[212] It is likely that future sea surface warming will further increase stress on coral reefs and result in increased frequency of marine diseases, and the massive bleaching experienced in 1998 could become a regular event.[213]

Finally, deserts are likely to become more extreme, and with few exceptions, they are projected to become hotter, but not significantly wetter.[214] Evidence in 2005 suggested that the fraction of the Earth's land area suffering drought had more than doubled in the previous 30 years.[215] However, as with many environmental problems, it is important to note that there is no singular cause of desertification, but rather, a host of factors combining into a detrimental impact. Within this combination, climatic change is expected to add a further layer of difficulties.[216] This threat has been clearly recognized within the 1994 Convention to Combat Desertification.[217]

(iv) Wildlife

Historically, climate change may have been responsible for the extinction of thousands of species.[218] In the contemporary context, while some species may increase in abundance or range with climate change, more vulnerable

---

211 Decision V/3. Progress Report on the Implementation of the Work Plan on Coastal Biological Diversity. UNEP/CBD/COP/5/23. p. 74.

212 Global Coral Reef Monitoring Network. (2004). Status of the Coral Reefs of the World. (Australian Government, Canberra). 6–9. earce, F. (2002). 'Its Started'. *New Scientist.* March 30. 11.

213 IPCC. (2001). *Climate Change 2001: Impacts, Adaptation and Vulnerability*. (Cambridge University Press, Cambridge). 12. Dicks, L. (2003). 'Worm Brings Death to Coral'. *New Scientist.* Apr 12. 16. Pearce, F. (2003). 'Extinction Looms for Caribbean Rainforest of the Ocean'. *New Scientist.* July 26. 9. Anon. (2004). 'World Set To Lose Half of Its Coral Reefs'. *Ecologist.* Apr 6. Hecht, J. (2004). 'Corals Change Partners To Cope With the Heat'. *New Scientist.* Aug 14. 9.

214 IPCC. (1996) Ibid. 6.

215 Anon. (2005). 'Earth Dries Up As Temperatures Rise's. *New Scientist.* Jan 22.

216 Kimble, J. (1998). 'Alteration of Soil Properties Caused by Climate Change'. In Blume, H. (ed). *Towards Sustainable Land Use.* (International Soil Conservation Society, Bonn). 175–184.

217 Decision 2/COP 4. Interim Report of the Ad Hoc Working Group for the In Depth Review and Anaylsis of Reports Submitted to the Third and Fourth Sessions of the COP. Annex. Interim Report. ICCD/COP (4) /11/Add 1. p. 6.

218 Anon. (2004). 'Iced to Death'. *New Scientist.* Dec 4. 20.

species face increasing risks of extinction.[219] It is well established that the geographical extent of the damage or loss, and the number of ecosystems and species within them affected, will increase with the magnitude and rate of climate change. The speed of ecosystem change could leave some species stranded in unsuitable environments, such as within the boundaries of protected areas, as the conditions the animals have evolved to live in alter faster than they can. Extinctions may be inevitable as plants and animals, which may already be under stress from other anthropogenic causes, fail to keep up with their changing habitats, or adapt too slowly to new conditions. Accordingly, the world could become, 'biologically less rich and less stable'.[220] Species at existing in or around the Polar regions, (especially bears, birdlife, and marine mammals)[221] as well as a number of migratory species are particularly at risk.[222]

G. Climatic Surprise

It is possible that the Earth may respond in unanticipated ways to forced climate change. In the literature on climate change, this is known as 'surprise'.[223] Climatic surprise includes significant slowing of the ocean circulation that transports warm water to the North Atlantic, large reductions

219 CBD. (2003). *Interlinkages Between Biological Diversity and Climate Change*. (CBD Technical Series No 10, Montreal). 3.

220 IPCC. (2003). *Climate Change and Biodiversity*. (IPCC Technical Paper V, Geneva). 1. IPCC. (2001). *Climate Change 2001: Impacts, Adaptation and Vulnerability*. (Cambridge University Press, Cambridge). 4. Anon. (2004). 'Climate Change Hits Base of Food Chain'. *New Scientist*. Aug 21. 18. Anon. (1998). 'Short In The Tooth'. *New Scientist*. Aug 15. 11. Pain, S. (1988). 'No Escape From the Greenhouse'. *New Scientist*. Nov 12. 38. Eatherley, D. (2002). 'Nature Steps On the Gas'. *New Scientist*. June 22. 13. Pearce, F. (2002). 'Nasty Neighbours'. *New Scientist*. Apr 13. 9. Brown, P. (2004). 'Global Warming Threatens to Kill Off a Million Species'. *Guardian International*. Jan 15. 3.Brown, K. (2000). 'Homeless'. *New Scientist*. May 13. 28–32. Joyce, C. (1988). 'Global Warming Could Wipe Out Wildlife'. *New Scientist*. Feb 4. 29. Anon. (2003). 'Extinctions Hot Up'. *New Scientist*. Aug 9. Holmes, B. (1999). 'Heads In the Clouds'. *New Scientist*. May 8. 32–35. Pain, S. (1988). 'How the Heat Trap Will Wreak Ecological Havoc'. *New Scientist*. Oct 15. 22. Ananthaswamy, A. (2002). 'The Last Straw'. *New Scientist*. June 1. 19. Sohn, E. (2002). 'Now Mammals Are Feeling the Heat'. *New Scientist*. Oct 5. 9. Peters, R. et al. (1992). *Global Warming and Biological Diversity*. (Yale UP, Massachusetts). Pernetta, E. (1995). *Impacts of Climate Change on Ecosystems and Species*. (IUCN, Geneva).

221 Pearce, F. (1998). 'Too Darn Hot'. *New Scientist*. Aug 8. 40–42. Mulvaney, K. (1998). 'Can't Take the Heat'. *New Scientist*. Sep 26. 12.

222 Ravilious, K. (2003). 'Global Warming Puts Freeze on Reindeer'. *New Scientist*. March 8. 24. Biever, C. (2003). 'Squirrels Evolve as the World Heats Up'. *New Scientist*. Feb 22. 18. Anon. (2000). 'Sink or Swim'. *New Scientist*. Aug 5. 16. Joyce, C. (1988). 'Warming Could Wipe Out Wildlife'. *New Scientist*. Feb 4. 29.

223 Bunyard, P. (2004). 'Crossing the Threshold'. *Ecologist*. Feb. 55–58. Streets, D. (2000). 'Exploring the Concept of Climate Surprise'. *Global Environmental Change*. 10: 97–107. Pain, S. (1992). 'Runaway Greenhouse Warming Cannot Be Ruled Out'. *New Scientist*.

in the Greenland and west Antarctic ice sheets, accelerated global warming due to carbon cycle feedbacks in the terrestrial biosphere, and releases of terrestrial carbon from permafrost regions and methane from hydrates in coastal sediments. These risks may be more pronounced if the carbon more than doubles (above pre-industrial levels) in the longer term. The end result could be a dramatic catapulting of the climatic system to a new, rapid and unpleasant method of operating.[224] Within the official documents, the IPCC warned in 1990 that despite their predictions, 'The complexity of the system means that we cannot rule out surprises'.[225] The IPCC 1996 Report also emphasised the possibility of, 'surprises and unanticipated rapid change'.[226] The Third Assessment Report in 2001 by the IPCC added that the potential for large-scale and possibly irreversible impacts poses risks that have yet to be reliably quantified. These possibilities are very climate scenario-dependent and a full range of plausible scenarios has not yet been evaluated. Conflicting analysis suggested that rapid climatic change, when judged from the examples of the past, was either possible or unlikely.[227]

Feb 15. 19. Leggett, J. (1992). 'Running Down to Rio'. *New Scientist.* May 2. 37–42. Kates, R. (1996). 'Expecting the Unexpected'. *Environment.* 38(2): 6–7.

224 IPCC. (2001). *Climate Change 2001: Impacts, Adaptation and Vulnerability*. (Cambridge University Press, Cambridge). 7. Sinclair, J. (1990). 'Global Warming May Distort Climate Cycle'. *New Scientist.* May 26. 9. Pearce, F. (2003). 'Doomsday Scenario'. *New Scientist.* Nov 22. 40–43. Hecht, J. (2002). 'Earth's Ancient Heat Wave Gives A Taste of Things to Come'. *New Scientist.* Dec 7. 21. IPCC. (1996) *Climate Change 1995: Impacts, Adaptations and Mitigation.* (Cambridge University Press, Cambridge). 4. Anon. (2005). 'Soils Give Up Their Carbon Stores'. *New Scientist.* Feb 12. 9. Anon. (2004). 'Methane Burps'. *New Scientist.* Feb 12. 10. Anon. (2005). 'Ocean Conveyor Belt Shuts Down'. *New Scientist.* Feb 12. 10.

225 Milne, R. (1990). 'Pressure Grows on Bush To Act on Global Warming'. *New Scientist.* June 2. 5.

226 IPCC. Noted in Pearce, F. (1995). 'Global Warming Jury Delivers Guilty Verdict'. *New Scientist.* Dec 9. 6.

227 Alley, R. (2004). 'Abrupt Climate Change'. *Scientific American.* Nov 40–48. cf. Nielson, R. (2004). 'Not Quite The Day After Tomorrow'. *New Scientist.* Sep 11. 6.

VI. ECOLOGICAL SAFETY LIMITS

1. Critical Loads for Air Pollution

In the mid 1980s the United Kingdom argued that there was no scientific justification for making the same reductions of pollutants for all countries, as each situation was different, or as the 1988 Sophia Protocol recognized, 'the adverse environmental effects of emissions [of air pollutants] vary among countries'. The same realization was noted in the 1991 VOC Protocol,

> Conscious that VOCs differ greatly from each other in their reactivity and in their potential to create tropospheric ozone and other photochemical oxidants and that, for any individual compounds, potential may vary from time to time and from place to place depending on meteorological and other factors . . . such differences and variations should be taken into consideration.[1]

The 1994 Protocol on Further Sulphur Reductions was conscious of the need for a Protocol, 'to combat air pollution that takes account of the variations in effects and abatement costs between countries'.[2] The 1999 Gothenburg Protocol concurred.[3] Accordingly, it was suggested that the best way forward would be to work out the ecological limit for each ecosystem, before it would become irreversibly damaged by air pollutants, and make the necessary reductions accordingly within an effect-orientated scientific equation. This flexible approach meant that, instead of requiring set percentage reduction in emissions, policy makers should set reduction targets based on the effects of pollutants on different environments, or the critical loads (CL) that they could cope with. Critical loads would provide policymakers with a more precise idea of the relationship between the largest sources of pollution and the most sensitive environments, thereby allowing them to focus on making emission reductions which are based on an ecological bottom line.[4] The definition of a CL, as given in the 1988 Sophia Protocol and the 1994 Protocol, was, 'a quantitative estimate of the exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge'.[5] The VOC Protocol, and the 1994 Protocol

---

[1] VOC Protocol. Preamble.
[2] 1994 Protocol on Further Sulphur Reductions. Preamble. Paragraph 7.
[3] Gothenburg Protocol. Preamble. Paragraph 13.
[4] UNECE. (1991). *Report of the Working Group on Abatement Strategies.* (Geneva).
[5] Article 1, definitions.

defined 'critical levels' as, 'concentrations of pollutants in the atmosphere for a specified exposure time below which direct effects on receptors, such as human beings, plants, ecosystems or materials do not occur according to present knowledge'.[6] The 1994 Protocol utilizes the language of both critical loads, and critical levels.[7] The 1994 Protocol also added the term 'critical sulphur deposition'. This is a,

> quantitative estimate of the exposure to oxidised sulphur compound, taking into account the effects of base citation uptake and base citation deposition, below which significant harmful effects on specified sensitive elements of the environment do not occur, according to present knowledge.[8]

A CL may be described as the highest deposition load that a receptor can withstand without long term-damage occurring, or as the 1982 Stockholm Conference on the Acidification of the Environment suggested, the threshold that an ecosystem could stand before it became damaged.[9] The Sophia Protocol, and the VOC Protocol,[10] explained the utility of CLs and the overall idea. Thus,

> the elaboration of an approach based on critical loads is aimed at the establishment of an effect-orientated scientific basis to be taken into account when reviewing the operation of this Protocol and at deciding on further internationally agreed measures to limit and reduce emissions of nitrogen oxides of their transboundary fluxes.[11]

To achieve this goal, the Parties were obliged to establish the; internationally accepted critical loads and then to make reductions in national emissions of nitrogen oxides, as required to achieve agreed objectives based on critical loads.[12] To this end, the Parties had to determine the geographical distribution of sensitive areas[13] and; develop in the context of an approach based on critical loads, methods to investigate, technical and economic data in order to determine appropriate control strategies.[14]

---

6 VOC Protocol. Article 1.
7 1994 Protocol on Further Sulphur Reductions. Preamble. Paragraph 15.
8 1994 Protocol on Further Sulphur Reductions. Article 1.
9 Metcalfe, S. (1994). 'Modeling Future Acid Deposition: A Critical Loads Approach'. *Global Environmental Change*. 4(2). 125–139. McCormick, J. (1997). *Acid Earth*. (Earthscan, London). 64. Pearce, F. (1986). 'Unraveling A Century of Acid Pollution'. *New Scientist*. Sep 25. 23–24.
10 1991 VOC Protocol. Preamble.
11 1988 Sophia Protocol. Preamble.
12 Sophia Protocol. Article 2 (3) (a)–(c).
13 Sophia Protocol. Article 6 (b) & 8 (f).
14 Sophia Protocol. Article 6 (e).

This ideal of reducing air pollutants through the CL was originally much easier to state than implement. Indeed, although the UNECE developed methodologies for calculating critical loads in 1988, five years later debates continued over how the calculations and representation of CLs was utilized.[15] Questions such as how many ecosystems were threatened, and at what level, as well as what amount of damage was 'acceptable' were all problematic. Nevertheless, it soon became apparent, that if the CL of the ecosystems was the benchmark, then reductions far above what had been agreed, were needed. This was especially so if a CL had already been reached for an ecosystem. The initial CLs resulted in Europe as a whole, having to make overall reductions of SO_2 between 58 and 63%.[16] However, in some European areas such as Greece, due to the greater resilience of some Greek ecosystems to air pollution, no CLs were theoretically necessary.[17] The critical SO_2 deposition rates were set out in Annex I to the 1994 Oslo Protocol. However, given that these would have necessitated massive cuts in some instances, the signatories decided to achieve less than complete reductions to meet the CL targets immediately.[18] Accordingly, the 1994 Oslo Protocol required States to reduce the gap between existing deposition loads and the corresponding critical loads by 60% by 2000.[19] This became known as the 60% gap closure. To reach this goal, European countries had to achieve differentiated emission reduction targets. The ultimate goal is 100% gap closure in the long term.[20] The reduction for this 'gap closure' was calculated on the following factors,

1. The level of total SO_2 emissions of a country in 1980.
2. Overall reductions necessary to arrive at critical levels in areas effected by countries whose emissions contribute to acid deposition above the CLs for those areas, and
3. calculated contribution of that given country to the present level of acid deposition.

[15] Pearce, F. (1993). 'How Britain Hides Its Acid Soils'. *New Scientist.* Feb 27. 29.
[16] Pearce, F. (1995). 'League Table Names the Filthy Few'. *New Scientist.* Nov 25. 4. Pearce, F. (1993). 'Come Clean on Acid Rain'. *New Scientist.* Sep 25. 7. Pearce, F. (1993). 'Britain Faces Huge Bill To Cut Acid Rains'. *New Scientist.* March 13. 4. Anon. (1990). 'Sulphur Cuts Too Small for Britain's Lakes'. *New Scientist.* March 31. 5. Pearce, F. (1992). 'Will Britain Fail the Acid Test ?' *New Scientist.* Dec 5. 11. Anon. (1993). 'Acid Bogs'. *New Scientist.* May 15. 10. Anon. (1993). 'Risk From Rain'. *New Scientist.* Jan 16. 11.
[17] See Pearce, F. (1993). 'How Britain Hides Its Acid Soils'. *New Scientist.* Feb 27. 29.
[18] Pearce, F. (1993). 'Worst Hit Areas Lose Out In Plan To Cut Acid Rain'. *New Scientist.* June 12. 5.
[19] 4 *YBIEL.* (1993). 136–137.
[20] McCormack, J. (1998). 'Acid Pollution: The International Communities Continuing Struggle'. *Environment.* 40(3): 17, 43–44.

The final equation is 60% of (a − b/100 × c).[21]

It is these CLs which make up the core of the air pollutant emission reduction targets. The Gothenburg Protocol followed the CL approach, with the overall objective of reducing the areas with excessive acidification in Europe from 93 million hectares in 1990 to 15 million hectares in 2010.[22]

2. Chlorine Loading in the Ozone Layer

In the late 1980s, as the earlier models were clearly proving inadequate in predicting the extent of ozone depletion, a new approach was adopted. The new mechanism was known as chlorine loading potential ('CLP'). CLP is a conservative measure of the amount of stratospheric chlorine that is needed to destroy ozone in the stratosphere. Earlier approaches had been based on rather simplistic calculations of atmospheric abundance of chlorine within various emission scenarios. This began to change when it was shown that the ozone thinning over Antarctica correlated with chlorine concentrations exceeded two PPB, and pre-industrial levels were 0.6 ppb.[23] The CLP was the basis of the ecological bottom line in the ozone negotiations, from which it was suggested that 85% reduction in ODS emissions were required to stabilize atmospheric concentrations of chlorine at existing levels. If the Montreal Protocol and the CLP model had not been adopted, the chlorine content in the stratosphere over Antarctica may have reached 9 ppb.

3. Ecological Limits and Climatic Change

The 1992 FCCC states clearly,

> The ultimate objective of this Convention and any related legal instruments the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.[24]

---

[21] 4 *YBIEL*. (1993). 136–137.

[22] Protocol to Abate Acidification, Eutrophication and Ground Level Ozone. UNECE. <http://www.unece.org/env/lrtap/multi_h1.htm>

[23] Litfin, K. (1994). *Ozone Discourses*. (Columbia University Press, New York). 131.

[24] FCCC. Article 2.

The utility of this statement is that it is impossible to disagree with. Accordingly, both it and similar statements are common in official pronouncements. For example, in 1997 the G8 stated that, 'Our ultimate goal must be to stabilize atmospheric concentrations of greenhouse gases at an acceptable level'.[25] Despite the clarity of such statements, exact determination of where the level for, 'dangerous anthropogenic interference with the climate system' is, has proved difficult.[26] The first time a safety limit for greenhouse gases in the atmosphere was suggested was in 1985, with the Villach Conference, which recommended a target of limiting the rate of global mean temperature change to a maximum of 0.1 c per decade.[27] The IPCC reiterated the 0.1 c target in 1990, along with a total increase of no more than between one to two degrees Celsius above the pre-industrial level.[28] The overall 2.0 c target was later adopted by European nations as a ceiling limit.[29] The 2.0 c target, when translated into CO_2 concentration, would suggest that the goal is to prevent the concentration from going over 550 ppm. 550 ppm is an effective doubling of the CO_2 concentration from the pre-industrial level, as well as being a substantive increase on the 360 ppm CO_2 concentration at the end of the twentieth century.[30] The 550 ppm ceiling was informally reiterated in 2004.[31]

To achieve this goal, eventually global emissions of greenhouse gases must be less than 50% of current levels of what they were in the late 1990s.[32] If such a goal was accepted, then the absolute limit of what is tolerable in the atmosphere, acts as the baseline for discussions on what greenhouse gas reductions are actually required to protect the ecology.[33]

Despite the worth of such an approach, and the advocacy of this limit by some countries since 1989, the IPCC, despite looking at the idea of an overall ecological limit, has refused to specify exactly where such a limit may be.[34] The unwillingness of the IPCC to stipulate exactly what a dangerous

[25] G8 Summit Communique. (Denver). Available from <http://www.g7.utoronto.ca/g7/summit/1997denver/98final.htm>

[26] Parry, M. et al. (1996). 'What Is A Dangerous Climate Change ?' *Global Environmental Change*. 6 (1):1–6.

[27] WMO (1986). *Report of the International Conference on the Assessment of CO_2 and Other Greenhouse Gases in Climate Vibrations and Associated Impacts*. (WMO No 661, Geneva). xxi.

[28] Bowler, S. (1990). 'The Reality and the Rhetoric'. *New Scientist*. Oct 27. 12–13. Gribbin, J. (1990). 'Why Caution Is Wrong on Global Warming'. *New Scientist*. July 28. 2.

[29] Pearce, F. (1999). 'Going Under'. *New Scientist*. Oct 30. 5. Pearce, F. (1996). 'Carbon Targets Up In the Air'. *New Scientist*. July 6. 9.

[30] Pearce, F. (1996). 'Carbon Targets Up In the Air'. *New Scientist*. July 6. 9.

[31] Pearce, F. (2004). 'Kyoto Won't Stop Climate Change'. *New Scientist*. Oct 9. 6–7.

[32] The Geneva Ministerial Declaration. Annex. Paragraph 2. Pearce, F. (1996). 'Governments Agree Greenhouse Curbs'. *New Scientist*. July 27. 5.

[33] Editor. (2001). 'Give Us A Plan'. *New Scientist*. March 10. 3.

[34] Milne, R. (1989). 'Industrialized Countries Must Make Deepest Carbon Cuts'. *New Scientist*.

level is in large part because of its concern that this is a political, as opposed to a scientific decision.[35] Although this refusal should not be a justification for inaction, it has implicitly been utilized by some politicians as such. Thus, in 2000, George Bush (jnr) suggested that, 'our approach must be consistent with the long term goal of stabilizing greenhouse gas concentrations in the atmosphere . . . [but] . . . no one can say with any certainty what a dangerous level is'.[36] This problem became all the more pressing in 2003 when calls began to appear for scientific and political debate on what 'dangerous' meant in scientific terms, from which a bottom line on the negotiations could proceed afresh.[37] Tony Blair went towards answering this problem in 2004, when he called for a special scientific conference to determine an upper limit on how much the temperature can rise before the world faces, 'catastrophic consequences of climate change'.[38] Although no formal ppb target was adopted at the conference, most researchers agreed that the world should not be allowed to warm more than two degrees Celsius (or 550 ppb) above pre-industrial levels.[39]

In terms of reductions required to stabilize the build-up of greenhouse gases in the atmosphere, in 1990, the IPCC suggested that a 70% reduction of global emissions of CO_2, from what was being emitted in 1990, was required to stabilize the build-up of greenhouse gases in the atmosphere. To take greenhouse gas levels back to the pre-industrial concentrations, steeper reductions were required.[40] The figure to stabilize CO_2 concentrations in the atmosphere was later reduced to 60%.[41] In addition, CH_4 emissions would need a reduction between 15% and 20%.[42] The 60% (CO_2) target was reiterated in 1993,[43] and the CH_4 figure was lowered to 10% (to stabilize).[44] In 1994, rather than giving a figure, the IPCC only suggested that to stabilize the concentration of CO_2 in the atmosphere would require, 'anthropogenic emissions that eventually drop to substan-

Dec 2. 8. 5 *YBIEL*. (1994). 168. Pearce, F. (1995). 'Climate Treaty Heads For Trouble'. *New Scientist*. March 18. 4.

35 Editor. (2001). 'Just Get On With It'. *New Scientist*. July 21. 3. Hulme, M. (2000). 'Choice is All'. *New Scientist*. Nov 4. 56–58.

36 Bush. In Editor (2000). 'Getting Warmer'. *New Scientist*. June 16. 3.

37 Pearce, F. (2003). 'Saving the World, Plan B'. *New Scientist*. Dec 13. 6–7.

38 Brown, P. (2004). 'Blair Sets Climate Challenge'. *Guardian Weekly*. Sept 24. 11.

39 Pearce, F. (2005). 'Act Now Before Its Too Late.' *New Scientist*. Feb 12. 8.

40 Gavaghan, H. (1990). 'European Nations Want Action Now On Global Warming'. *New Scientist*. Feb 17. 6.

41 MacKenzie, D. (1990). 'Scientists Clash With Politicians Over CO_2 Emissions'. *New Scientist*. Nov 10. 5.

42 Milne, R. (1990). 'Pressure Grows on Bush To Act on Global Warming'. *New Scientist*. June 2. 5.

43 Pearce, F. (1993). "Carbon Dioxide's Taxing Questions'. *New Scientist*. June 26. 12.

44 MacKenzie, D. (1994). 'Carbon Targets Not Tough Enough'. *New Scientist*. Sep 17. 5.

tially below 1990 levels'.[45] In 2001, the IPCC added that in the longer term, if the objective is to keep concentrations below 450 ppm, 'eventually CO_2 emissions would need to decline to a very small fraction of current emissions'.[46]

[45] IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change.* (Cambridge University Press, Cambridge). 11.

[46] IPCC. (2001). *Climate Change 2001: The Scientific Basis*. (Cambridge University Press, Cambridge). 12.

VII. SCIENTIFIC INVESTIGATION

1. Air Pollution

Scientific debate on both the cause and impacts of air pollution in the 1970s was a heated debate both within and between countries. These difficulties increased when science was utilized on a partisan basis.[1] The difficulties became so entrenched that even bilateral scientific missions, such as those between the United States and Canada,[2] and between Norway and the United Kingdom, failed to reach scientific consensus.[3] It was not until after the mid 1980s, that an international scientific consensus on air pollution began to emerge.[4]

---

[1] Sage, B. (1980). 'Acid Drops from Fossil Fuels'. *New Scientist* March 6. 743. Pearce, F. (1982). 'Science and Politics Don't Mix At Acid Rain Debate'. *New Scientist.* July 1.3. Caufield, C. (1983). 'Treasury Vetoes Action on Acid Rain'. *New Scientist.* Sep 15. 747. Zell, R. (1983). 'Germany's Acid Rain Laws Go Up in Smoke'. *New Scientist.* Sep 29. 915. Milne, R. (1985). 'Bonn Summit Measures Up To Pollution'. *New Scientist.* May 2. 3. Anon. (1981). 'Acid Rain Spreads Its Tentacles'. *New Scientist.* Oct 15. 149. Pearce, F. (1982). 'The Menace of Acid Rain'. *New Scientist.* August 12. 423. Pearce, F. (1982). 'Warning Cones Hoisted As Acid Rain clouds Gather'. *New Scientist.* June 24. 828. Roberts, L. (1984). 'Washington Defers Action on Acid Rain'. *New Scientist.* February 9. 9. Milne, R. (1988). 'Europe's Worst Polluter is Tamed'. *New Scientist.* June 23. 29. Mohnen, V. (1988). 'The Challenge of Acid Rain'. *Scientific American.* August. 14–23. Boehmer-Christiansen, S. & Skea, J. (1991). *Acid Politics.* (Belhaven, London). 50–51, 146–147, 154, 207–210. Editor. (1988). 'Coal Comfort'. *New Scientist.* May 5. 22. Mayer, M. (1982). 'Britain Slashes Research on Air Pollution'. *New Scientist.* April 29. 271. Anon. (1982). 'Research Cuts Corrode Britain's Acid Rain Strategy'. *New Scientist.* July 15. 141. Milne, R. (1991). 'Electricity Giant Axes Studies on Acid Rain'. *New Scientist.* July 13. 15. Mason, D. (1984). 'Call for National Survey of Acid Rain'. *New Scientist.* Jan 12. 4. Anon. (1983). 'Britain Funds Independent Research on Acid Rain'. *New Scientist.* Sep 8. 671. Dear, D. (1984). 'In Pursuit of Acid Rain'. *New Scientist.* Nov 22. 30–35. Pearce, F. (1986). 'Norwegians Protest Over Gag On Research'. *New Scientist.* March 20. 24. Anon. (1985). 'Norway Is Angry About Film on Acid Rain'. *New Scientist.* Oct 31. 13. Anon. (1985). 'Norway Protests to Thatcher'. *New Scientist.* December 12. 13. Anon. (1986). 'Whitehall Condemn Acid Video'. *New Scientist.* Jan 16. 20.

[2] Memorandum of Intent Between the Government of the United States and the Government of Canada Concerning Transboundary Air Pollution. 1980, August 5. In *IPE.* XXVIII. 352.

[3] National Acid Precipitation Program. (1987). *Interim Assessment: The Causes and Effects of Acid Deposition.* (Washington). Joyce, C. (1987). 'Trees and Lakes Need Fear No Acid'. *New Scientist.* Sep 24. 21. National Acid Precipitation Program. (1990). *Assessment Highlights.* (Washington). 7–8. Caufield, C. (1983). 'Reagan Accused of Wrecking Acid Rain Talks'. *New Scientist.* February 3. 291. Joyce, C. (1987). 'Trees and Lakes Need Fear No Acid'. *New Scientist.* Sep 24. 21. Also, Anon. (1988). 'Canada Fails to Win Deal on Acid Rain'. *New Scientist.* May 5. 30. 7 *YBIEL.* (1996). 272.

[4] Anon. (1986). 'Britain and US Accept the Science of Acid Rain'. *New Scientist.* March 27. 1986. 11.

It is surprising that the scientific consensus took so long to develop, given that the investigation of air pollution in Europe began in the 1950s with the European Atmospheric Chemistry Network, which began collecting data on rainfall from 175 stations. The international scientific network was enhanced following the 1972 Stockholm Conference on the Human Environment, from which it was recommended that the WHO, assist governments in monitoring air pollution in terms of risk to health. In addition, the WMO, which had been operating an international Air Pollution Monitoring Network since 1969, was asked to establish over 100 stations to monitor long term global trends in atmospheric pollution.[5] Scientific research into air pollution was further by a number of European agreements,[6] UNEP monitoring and oversight,[7] and OECD studies,[8] as well as a number of bilateral agreements for scientific cooperation, such as that between the United States and the former Soviet Union.[9]

Despite this growing body of scientific research into air pollution, by 1979, the LRTAP nevertheless recognized the, 'need to study the implications of the long-range transport of air pollutants and the need to seek solutions for the problems identified'.[10] The initial methods to help this study was for the Parties of the LRTAP to exchange information about air pollution and share their research on the matter, under the auspice of the governing body of the LRTAP, the UNECE.[11] Protocols to the LRTAP

---

[5] Recommendations 77 and 79.

[6] Agreement on the Implementation of a European Project on Pollution on the Topic of 'Research into SO_2 in the Atmosphere'. In *IPE.* XV 7510. Council of Europe. Committee of Ministers. Resolution (71) 6. ECC Council Decision, 24 June 1975. 75/441/EEC. Establishing A Common Procedure for the Exchange of Information Between the Surveillance and Monitoring Networks Related to Air Pollution. *IPE.* XV. 7634. EEC. Agreement on Research on Sulphur Dioxide in the Atmosphere. Reprinted in *IPE.* XVIII. 8863. The EMEP was assisted with the LRTAP under which the EEC which chose to recognize the authority of the UNECE on this matter, Economic Commission for Europe. Resolution on Long-Range Transport. In *IPE*, XXVIII. 455.

[7] UNEP began trying to co-ordinate much of this research from the period, through its Global Environment Monitoring System (GEMs, which began in 1974) and the Urban Air Quality Monitoring Programme, which collects data from nearly 80 cities.

[8] The OECD study of Long-Range Transport of Air Pollutants, Measurements and Findings, done from 67 stations between 1973–75 confirmed that the precipitation of Europe was becoming more acidic, and the areas of high acidity were spreading.

[9] In 1972, the USA and former USSR agreed to Co-operate on the modeling of air pollution, and common methodologies of the problem. Memorandum of Implementation of Agreement Between the USA and the USSR in the Field of Environmental Cooperation. May 23, 1972. Reprinted in *IPE.* I. 53. Limitation of Pollutants Emitted in the Atmosphere by Motor Vehicles. Memorandum of Implementation of Agreement Between the United States of America and the USSR in the Field of Environmental Cooperation. May 23, 1972. Reprinted in *IPE.* I. 53.

[10] LRTAP, Preamble.

[11] LRTAP, Articles 3, 4, 8 & 9.

in 1988,[12] 1991,[13] 1994[14] and 1999[15] all reiterated the importance of scientific investigation of air pollution as the basis for further action in controlling the pollutants.

Much of the scientific knowledge for the LRTAP and its subsequent Protocols comes from the Programme for the Evaluation and Monitoring of Long Range Pollutants in Europe (EMEP). EMEP is the central body for research into air pollution within the UNECE region. EMEP was established in 1977 under the auspice of the UNECE. This was so successful, that by 1984 it was clear that, 'the positive results achieved so far in the implementation of EMEP'[16] necessitated a specific Protocol which guaranteed ongoing independent funding. This funding arrangement is discussed in chapter 12.

The EMEP Programme covers the international centres co-operating within EMEP on the activities appearing in the work programme of the EMEP Steering Body.[17] EMEP has three main components. The components are the collection of emission data for SO_2, NOx, VOCs and other air pollutants, measurement of air and precipitation quality, and modeling of atmospheric dispersion. In 2002, over 100 monitoring stations in 24 UNECE countries were participating in the programme.[18]

The obligations of EMEP are to provide agreed upon tables and calculations showing annual trans-boundary transmissions of pollutants. These are all based on internationally agreed methodology.[19] These obligations are often specified in Protocols. For example, the 1985 Helsinki Protocol stipulated,

> EMEP shall in good time before the annual meetings of the Executive Body provide to the Executive Body calculations on sulphur budgets and also [information on] transboundary fluxes and depositions of sulphur compounds for each previous year within the geographical scope of EMEP, utilising appropriate models. In areas outside the geographical scope of EMEP, models appropriate to the particular circumstances of Parties therein shall be used.[20]

---

12 1988 Sophia Protocol Concerning the Control of Emissions of Nitrogen Oxides or Their Transboundary Fluxes. Preamble.

13 1991 Protocol to the 1979 Convention on LTTAP Concerning the Control of Emissions of Volatile Organic Compounds or Their Transboundary Fluxes. Preamble.

14 1994 Protocol to the 1979 Convention on LRTAP on Further Reduction of Sulphur Emissions. Preamble.

15 1999 Protocol to the LRTAP To Abate Acidification, Eutrophication and Ground Level Ozone. Preamble.

16 Preamble, Protocol on Long-Term Financing of Co-Operative Programme for Monitoring and Evaluation of the Long Term Transmission of Air Pollutants in Europe. BH856.txt.

17 Article 2. 1984 Protocol on Long Term Financing.

18 UNECE (2002). *EMEP Protocol.* <http://www.unece.org/env/lrtap/emep_h1.htm>

19 See EMEP Report. EB.AIR/GE.1/16.

20 1985 Helsinki Protocol. Article 5.

A similar obligation was imposed upon EMEP by the 1988 Sophia Protocol with regard to, 'calculations of nitrogen budgets and also of transboundary fluxes and deposition of nitrogen oxides'.[21] Scientific research on the effects of such air pollutants was also mandated,[22] and directed with the assistance of a number of agreed goals, specifying what scientific areas need to be focused upon.[23] The 1991,[24] 1994,[25] and 1999[26] Protocols all contained similar obligations, with regard to their respective air pollutants. The EMEP research is complimented by national research programmes, which are directed to examine, inter alia, the basic scientific understandings, identification, distribution, and quantity of various air pollutants.[27] All of the domestic scientific research is meant to be scientifically harmonized, and shared with EMEP.[28]

Outside the UNECE geographical area, the other locations of note where there has been regional scientific collaboration on air pollution has been with the United States and Mexico,[29] and the United States and Canada.[30]

Despite the establishment of such research programmes noted above, it was recognized in Agenda 21 at the 1992 Earth Summit that, 'the lack of reliable emissions data outside Europe and North America is a major constraint to measuring trans-boundary air pollution. There is also insufficient information on the environmental and health effects of air pollution in other regions'.[31] It was hoped that the LRTAP experiences would be, 'shared with other regions of the world'.[32] The broadening of the scientific study of air pollution was reiterated at the 2002 World Summit on Sustainable Development where it was agreed to,

> Strengthen capacities of developing countries and countries with economies in transition to measure, reduce and access the impacts of air pollution, includ-

---

[21] 1988 Sophia Protocol. Article 9.
[22] 1988 Sophia Protocol. Article 6 (a) & (c).
[23] 1999 Gothenburg Protocol. Article 8.
[24] 1991 VOC Protocol, Article 9.
[25] Protocol to the 1979 Convention on Long Range Transboundary Air Pollution on Further Reduction of Sulphur Emissions. Article 5 (3).
[26] 1999 Protocol to the LRTAP To Abate Acidification, Eutrophication and Ground Level Ozone. Article 7 (3).
[27] See for example, the 1988 Sophia Protocol. Article 6., 1991 VOC Protocol, Article 5.
[28] 1999 Gothenburg Protocol. Article 7 (b) and 8 (a). 1994 Protocol, Article 5 (2) and 6 (a).
[29] Annex IV to the Agreement Between the Untied States of America and the United Mexican States on Co-Operation for Protection of the Environment in the Border Region, Regarding Transboundary Air Pollution Caused By Copper Smelting Along Their Common Border. 26 *ILM* (1987). 33. Articles 2–5.
[30] Agreement Between the Governments of the United States of America and the Government of Canada on Air Quality. 30 *ILM*. (1991). 676. Articles V–IX.
[31] Agenda 21. Paragraph 9.25.
[32] Agenda 21 Paragraph 9.26.

ing health impacts, and provide financial and technical support for these activities.[33]

In some respects, attempts to achieve this goal have been continuing since the early 1990s. This process began in 1991, when the World Bank gave $1 (US) million to begin studying air pollution over Asia.[34] American and European researchers joined this effort in 1994.[35] The conceptual design of the Acid Deposition Monitoring Network in East Asia, for China, Indonesia, Japan, Malaysia, Mongolia, Philippines, Singapore, South Korea, Thailand and Vietnam) was finalized in 1994. The East Asia Network is modeled on EMEP.[36] It was incorporated into the 1995 ASEAN Co-operation Plan on Trans-boundary Pollution. The Co-operation Plan consists of assessing the origin, causes, nature and extent of both national and regional pollution. The research is conducted through the ASEAN Specialized Meteorological Centre (ASMC). This ASMC research is complimented by common, harmonized inventories, air quality indexes, danger rating systems and shared and disseminated information.[37] This system was supplemented by the 2002 ASEAN Agreement on Transboundary Haze Pollution.[38] Despite these initiatives, the systematic monitoring of air pollution over Asia remains in need of greater co-ordination and depth.[39]

2. Ozone Depletion

When CFCs were first made commercially available in 1930, few would have imagined the substance might damage the ozone layer. Indeed, it was not until the middle of the 1950s that measurements of the thickness of the ozone layer even began, and only in the late 1960s did measurements of CFCs in the atmosphere begin with James Lovelock.[40] Although

[33] WSSD. Plan of Implementation of the World Summit on Sustainable Development. A/CONF.199/L.1. Paragraph 37 (a).

[34] Hunt, P. (1991). 'Putting Asian Acid Rain on the Map'. *New Scientist.* December 12. 6.

[35] 5 *YBIEL.* 1994. 158.

[36] 6 *YBIEL.* (1995). 219.

[37] 8 *YBIEL.* (1997). 407–408.

[38] Editor. (2002). 'Agreement on Forest Fire Haze'. *Environmental Policy and the Law.* 32 (5): 214–215.

[39] UNEP. (2002). *Benchmarking Urban Air Quality Management and Practice in Major and Mega Cities of Asia.* (UNEP, Nairobi). 2.

[40] In 1969, when James Lovelock devised a way of detecting measurable concentrations of CFC 11 in the atmosphere, as a way to track the movement of air masses around the globe (rather than for their biological impact). Although these appeared to be accumulating, his research did not suggest that they represented any overt environmental threat. Gribbin, J. (1989). 'Centenary Unlocks the History of the Ozone Hole'. *New Scientist.* Feb 4. 24.

measurements of the ozone layer and the build-up of CFCs were being monitored by the late 1960s, few had thought that the two might be connected. The one recorded dip in ozone levels in the mid-1960s was attributed to nuclear tests and the solar cycle.[41]

In 1970 Paul Crutzen discovered that NOx catalyze the breakdown of stratospheric ozone into molecular oxygen. This work led to research by Harold Johnson, who suggested that supersonic aircraft could destroy the stratospheric ozone by releasing NOx during flight.[42] This suggestion coincided with European plans to expand the supersonic airlines. Soon after, the first debate about possible direct anthropogenic destruction of the ozone layer began. No sooner had the Johnson thesis been dismissed by the WMO in 1976,[43] than another threat to the ozone layer, identified two years earlier, began to gain scientific credibility. The first was proposed by Richard Stolarski and Ralph Cicerone, who theorized that the chlorine from the space shuttle might affect the ozone layer.[44] The second, and much more prominent theory, was proposed by Mario Molina and Sherwood Rowland. The genesis of Molina and Rowland's thesis was found in the work of James Lovelock, who Rowland heard talk in 1972 about his invention which measured trace levels of CFCs in the atmosphere. Rowland was intrigued by the fate of these CFCs. The answer to this question was framed in 1974 when they hypothesized:

> Chlorofluoromethanes are being added to the environment in steadily increasing amounts. These compounds are chemically inert and may remain in the atmosphere for 40–150 years, and concentrations can be expected to reach 10–30 times present levels. Photo-dissociation of the chlorofluoromethanes in the stratosphere produces significant amounts of chlorine atoms, and leads to the destruction of the atmospheric ozone.[45]

---

[41] See Glasgow, L. (1990). 'The History of the Ozone Layer'. *New Scientist.* Nov 24. 14.

[42] Roan, S. (1991). *Ozone Crisis.* (Wiley, New York). 11–12, 13–15. Hecht, J. (1995). 'Ozone Prophets Reach Rarefied Heights'. *New Scientist.* Oct 21. 10.

[43] Anon. (1976). 'Washington Hearing Satisfy Neither Concorde Lobby Nor Critics'. *New Scientist.* Jan 15. 108. 44 Gribbin, J. (1990). 'Supersonic Plans Threaten Ozone Layer'. *New Scientist.* June 9. 4. Anon. (1976). 'UN Meteorologists Accept SSTs But Still Fear Fluorocarbons'. *New Scientist.* Jan 15. 109. According to the 1977 World Plan of Action on the Ozone Layer, "there is a large measure of agreement on the model predictions that current aircraft emissions have minimal effects on the ozone layer." World Plan of Action on the Ozone Layer, 1977. In *IPE* XXVIII, 390.

[44] Stolarski, R & Cicerone, R. (1974). 'Stratospheric Chlorine: A Possible Sink for Ozone'. *Canadian Journal of Chemistry.* 52: 1610–15.

[45] Molina & Rowlind. (1974). 'A Stratospheric Sink for Chlorofluoromethanes'. 249 *NATURE.* 810.

Rowland and Molina estimated that if CFC production continued to increase at the then present rate of 10% per year until 1990, and remain at a steady state thereafter, the chemicals would cause an ozone loss between 5 and 7% by 1995 and a loss of between 30 and 50% by 2050.[46] At this point in time, the thinning ozone layer over Antarctica had not been discovered. Accordingly, the Molina-Rowland thesis was strongly contested by notable skeptics such as James Lovelock and Fred Singer. The idea that CFCs may damage the ozone layer was argued against, and it was suggested that even if the thesis was correct, that not only was UV necessary for the evolution of life, but that the Earth was self-healing.[47] The rapid expansion of scientific inquiry into the Rowland-Molina thesis did not lead to a resolution of these debates, and it was not until the late 1980s that a near scientific consensus, that the Molina-Rowland thesis was correct, began to emerge and it was largely agreed that, 'the ozone changes coupled with other atmospheric data were strongly suggestive of a chlorine induced effect'.[48] This consensus has been a necessary condition for the successful ongoing negotiations under the Montreal Protocol.

A. The International Scientific Endeavour

The first agreement to facilitate co-operation on the scientific investigation into anthropogenic threats to the ozone layer was between the United States, France, and the United Kingdom. This agreement requested UNEP,

---

[46] See Roan, S. (1991). Ozone Crisis. (Wiley, New York). Chapter 2.

[47] Pearce, F. (1994). 'Ozone Meter Gets It Wrong.' *New Scientist.* July 2. 7. When Crutzen, Rowland and Molina were given the Nobel Prize for Chemistry in 1995, Singer accused the Swedish Academy (who chose the recipients) as making a "political statement" rather than one based on scientific merit. Hecht, J. (1995). 'Ozone Prophets Reach Rarefied Heights.' *New Scientist.* Oct 21. 10. Editor. (1995). 'A Mission to Deny, Do Little or Delay?' *New Scientist.* Sep 30. 3. Holmes, B. (1995). 'Arizona Fights For the Right to Stay Cool.' *New Scientist.* Apr 29. 7. Kiernan, V. (1995). 'Leave Ozone Hole to Nature, Say Republicans.' *New Scientist.* Sep 30. 8. Elizabeth Dowdeswell, the former Executive Director of UNEP, referred to these as "small pockets of political backlash." Seventh Meeting of the Parties to the Montreal Protocol. Vienna, 5–7 December. 1995. UNEP/OzL.Pro. 7/12. 27 December 1995. 2. For some of the earlier skepticism, see Allaby, M & Lovelock, J. (1980). 'Spray Cans: The Threat That Never Was.' *New Scientist.* July 17. 212. Gribbin, J. (1978). 'Ozone Passion Cooled By the Breath of Sweet Reason.' *New Scientist.* Oct 12. 94. Gribbin, J. (1979). 'Disappearing Threat to Ozone Layer.' *New Scientist.* Feb 15. 474–473. Gribbin, J. (1987). 'An Atmosphere In Convulsions.' *New Scientist.* Nov 26. 30–31. Anon. (1979). 'All At Sea Over Ozone'. *New Scientist.* Nov 15. 502.

[48] Proceedings of the Third MOP to the Montreal Protocol. Nairobi, 19–21 June 1991. UNEP/OzL.Pro.3/11. 21 June 1991. 9. MacKenzie, D. (1987). 'Chemists Unite In Call For Ozone Protection'. *New Scientist.* Apr 30. 25. MacKenzie, D. (1987). 'High Noon For Ozone in Montreal'. *New Scientist.* Sep 3. 24.

'to catalyze and co-ordinate on a worldwide basis work on the problems of protection of the stratosphere'. The WMO, WHO, and FAO, operating under a UNEP umbrella, were to co-operate, 'towards the establishment of a strengthened global stratospheric ozone monitoring capability'.[49] The global ozone monitoring system was operational by the end of 1976.[50] The above agreement was supplemented in 1977 with the World Plan of Action on the Ozone. The World Plan recognized,

> There are many known gaps in our knowledge of the factors affecting the ozone layer, and there may be factors that are as yet unrecognized. An intensive and well-coordinated monitoring and research programme related to the occurrence of trace substances in the atmosphere, to test the model predictions and narrow their range of uncertainty, is particularly important.[51]

Despite such co-operative objectives, early attempts to reach consensus on the issue of anthropogenic damage to the ozone layer, such as the 1977 international 'Meeting of Experts' were elusive.[52] This process of uncertainty actually increased over the following years despite the fact that the research was supplemented by a bewildering array of scientific investigation from space, including NASA's space shuttles from the mid 1980s, satellites utilizing Total Ozone Mappings Spectrometer (TOMS) from 1979, specially adapted balloons, and an expanding network of ground monitoring stations.[53] Unfortunately, much of this early information was of limited utility. For example, the ground ozone stations were not only disproportionately over represented in the Northern Hemisphere, they were also often calibrated differently, and it was not until the Vienna Convention was signed that a comprehensive, ozone maintaining robust global monitoring system of ground stations began.[54]

---

[49] Agreement Between the Governments of the United States of America, France and the United Kingdom Regarding Monitoring of the Stratosphere (1976). *IPE*. XVI. 8289.

[50] Anon. (1976). 'Ozone Monitoring Takes Off'. *New Scientist*. Nov 18. 374.

[51] World Plan of Action on the Ozone Layer, 1977. In *IPE* XXVIII, 390.

[52] Anon. (1977). 'US Ban Nearer For Aerosol Cans'. *New Scientist*. May 5. 254.

[53] Gribbin, J. (1988). 'Satellite Failure Threatens Ozone Probe'. *New Scientist*. July14. 32. Anon. (1979). 'Ozone Wisdom From SAGE'. *New Scientist*. March 1. 652. Anon. (1985). 'Spacelab Probes the Ozone Layer'. *New Scientist*. Aug 8. 19. Dayton, L. (1989). 'Data From Canadian Balloons Signal Destruction of Ozone'. *New Scientist*. Feb 25. 32.

[54] The Vienna Convention when it was noted that particular emphasis should be given to the inter-calibration of observational instrumentation and methods with a view to generating comparable standardized scientific data sets. Annex 1. (3). See also, Litfin, K. (1994). *Ozone Discourses*. (Columbia University Press, New York). 68–69. Gribbin, J. (1979). 'Monitoring Halocarbons'. *New Scientist*. Jan 18. 164–167. CCOL. (1981). Some Recent Research Results: A Contribution by the United Kingdom. UNEP/CCOL/5/3/Add.4. October 12–16. Gribbin, J. (1988). 'Ozone Depletion Spreads Around the Globe'. *New Scientist*. Dec 10. 16.

The lack of scientific consensus was a clear problem in the negotiations for an international instrument to control ODS. Accordingly, the necessity of scientific work being facilitated, 'through or in collaboration' with competent international bodies was clearly articulated in proposed draft articles,[55] as well as the final Vienna Convention which emphasized the importance of, 'international co-operation and action based on relevant scientific and technical considerations' carried out 'through competent international bodies' such as the WMO.[56] The areas of required research were recorded in the Convention and its associated Annex. The international research was, and has remained, closely co-ordinated with national research programmes.[57]

This framework for scientific research was clearly useful, as no sooner had the Vienna Convention been concluded, that the thinning of the ozone layer over the Antarctica was revealed. This thinning spurred NASA in collaboration with other United States Agencies, the WMO and UNEP to establish an international body of 150 scientists from 11 countries. This body presented the Ozone Trends Panel Report in 1988.[58] Notably, for the first time, the scientists were coming to, 'strikingly similar conclusions'.[59] Further co-operative research with the United States, countries of the European Union, the former Soviet Union, and a number of developing countries followed.[60]

[55] Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1983). Second Revised Draft, With Additional Commentary, Prepared By UNEP. UNEP/WG.94/3/ July 30. See Draft Articles 6,7 & 8. Page 6–7. Annex II. UNEP. (1982). Some Obstructions on the Preparation of a Global Framework for the Protection of the Ozone Layer. UNEP/WG.69/8. January 13. Paragraph 35. UNEP Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1981). A Look At Some Issues: A Contribution by the UNEP Secretariat. UNEP/WG.69/5. December 31. Paragraph 21.

[56] Preamble, Section 6 and Article 3 of the Vienna Convention. See also Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1984). Statement By the WMO. EC-XXXVI/Doc. 77. Appendix. UNEP/WG.94/CRP/18. January 18 .

[57] Decision IV/3. Recommendations of the Third Meeting of the Ozone Research Managers. Decision V/3. Recommendation of the Fourth Meeting of the Ozone Research Managers.

[58] Benedict, R. (1991). *Ozone Diplomacy*. (Harvard University Press, Cambridge). 110.

[59] MacKenzie, D. (1987). 'Chemists Unite In Call For Ozone Protection'. *New Scientist.* Apr 30. 25.

[60] Anon. (1988). 'European Accord on Ozone'. *New Scientist.* Feb 11. 23. Milne, R. (1988). 'Europeans Seek A Lift Through the Arctic's Ozone Hole'. *New Scientist.* June 23. 28. Anon. (1988). 'Europeans Compare Notes on Ozone Research'. *New Scientist.* Aug 18. 23. MacKenzie, D. (1988). 'Scientists Set To Track Ozone in the Arctic'. *New Scientist.* Jan 14. 30. Anderson, I. (1988). 'First Footers to Seek Arctic Ozone Hole'. *New Scientist.* Dec 24. 4. Gribbin, J. (1988). 'Satellite Failure Threatens Ozone Probe'. *New Scientist.* July 14. 32.

The scientific consensus following the Vienna Convention had a positive influence on the organization of science within the Montreal Protocol. Although there is a distinction between the science pursued under the Convention and the Protocol,[61] the Protocol nevertheless, reiterated the importance of working, 'directly or through competent international bodies' in the promotion of consistently updated and relevant research.[62] Article 6 of the Montreal Protocol stipulated,

> Beginning in 1990, and at least every four years thereafter, the Parties shall assess the control measures provided for in Article 2 on the basis of available scientific, technical and economic information. At least one year before each assessment, the Parties shall convene appropriate panels of experts qualified in the fields mentioned and determine the composition and terms of references of any such panels. Within one year of being convened, the panels will report their conclusions, through the Secretariat, to the Parties.

In accordance with this provision, at the first MOP in 1989, a review panel for scientific assessment was established.[63] The scientific assessment was updated in 1994, 1998 and 2002. It will be updated again in 2006.[64] The scientific assessments are designed to be highly inclusive. For example, the 1998 assessment was prepared by more than 304 scientists from 35 countries. The report was peer-reviewed by 125 scientists and was further discussed by 75 scientists at a panel review meeting. [65]

3. Climatic Change

Proving that anthropogenic climate change has started, and that it will have a detrimental impact upon the Earth has been a long and difficult debate. Although scientific consensus is more cohesive in this area, in the twenty-first century, this was not always the case.[66] This was especially so in

---

61 Decision I/3. the Vienna Convention is the most appropriate instrument for harmonizing the policies and strategies on research [and] the Montreal Protocol is the appropriate instrument for achieving the harmonization of policies, strategies and measures for minimizing the release of substances likely to cause modifications of the ozone layer.

62 Article 9.

63 Decision I/2. The Scientific Assessment of the Ozone Layer. The terms of references for the Panels were contained in Annex VI.

64 Decision XV/53. Terms of Reference for the Scientific Assessment Panel.

65 UNEP. (1999). *Synthesis of the Reports of the Scientific, Environmental Effects and Technology and Economic Assessment Panels of the Montreal Protocol.* (UNEP, Ozone Secretariat, Nairobi). 11. Report of the 11th MOP. UNEP/OzL.11/10. 7 Dec 1999. 17.

66 Revelle, R. (1982). 'Carbon Dioxide and World Climate'. *Scientific American.* 247 (2): 33, 35. Pearce, F. (1989). 'Politics in the Greenhouse'. *New Scientist.* Apr 22. 11. Schneider, S. (1990). 'Prudent Planning For A Warmer Planet'. *New Scientist.* Nov 17. 39–41.

the 1970s, and early 1980s,[67] when the international conferences on climate change were forced to conclude that, 'uncertainty dominated every aspect of the greenhouse gas question'.[68] From this body of uncertainty, a number of sceptics (and associated institutes such as the Competitive Enterprise Institute, the American Enterprise Institute and the International Policy Network), including, inter alia, Sherwood Idso, George Keyworth, Frederick Seitz, Richard Lindzen and Patrick Michaels, stand out. Some of these individuals, but not all, have links with the fossil fuel industries.[69] Accordingly, in 1996, Timothy Wirth, the Under-Secretary of State in the United States, suggested that the sceptics represented, 'special interests bent on belittling, attacking and obfuscating climate change science'.[70] A contra charge, that a number of scientists have vested interests in promoting the idea of climate change, has been leveled against the IPCC.[71] When George Bush (jr) gained the Whitehouse, the sceptical view of climate change initially reasserted itself. This reassertion coincided with legal action in the United States courts over the validity of a number of climate change predictions.[72]

---

[67] Lewin, R. (1977). 'Atmospheric Carbon Dioxide: A New Warning'. *New Scientist.* July 28. 211. Paltridge, G. (1979). 'The Problem With Climate Prediction'. *New Scientist.* Apr 19. 194–198. Anon. (1976). 'A Weatherman's Eye on Climatic Stability'. *New Scientist.* Dec 2. 511. Gribbin, J. (1978). 'Fossil Fuel: Future Shock'. *New Scientist.* Aug 24. 541.

[68] WMO. (1986). *Report of the International Conference on the Assessment of CO_2 and Other Greenhouse Gases in Climate Vibrations and Associated Impacts.* (WMO No 661, Geneva). 24.

[69] For some useful general sceptical views, see Moore, T. (1998). *Climate of Fear: Why We Should Not Worry About Global Warming.* (Cato Institute, Washington). Philander, S. (1998). *Is the Temperature Rising? The Uncertain Science of Global Warming.* (Princeton UP, New Jersey). For some general comment on the sceptics see Pearce, F. (2005). 'Climate Change: Menace or Myth?' *New Scientist.* Feb 12. 38–42. Anon. (1981). 'Greenhouse Theorists Blow Hot and Cold'. *New Scientist.* Nov 12. 432. Anon. (1982). 'The Science and Politics of Atmospheric Carbon Dioxide'. *New Scientist.* Sep 2. 622. Anon. (1983). 'Raised Temperatures Over Greenhouse Effect'. *New Scientist.* Oct 27. 247. White, R. (1990). 'The Great Climate Debate'. *Scientific American.* July 18–25. Editor. (1990). 'The Burning Bush'. *New Scientist.* Apr 28. 3. Joyce, C. (1990). 'US Fails In Bid To Play Down Global Warming Threat'. *New Scientist.* Apr 28. 6. Bush, G. (1990). 'Two World Leaders on Global Environmental Policy'. *Environment.* April 12–15. MacKenzie, D. (1990). 'Scientists Clash With Politicians Over CO_2 Emissions'. *New Scientist.* July 28. 5. Skolnikoff, E. (1999). 'The Role of Science In Policy: The Climate Change Debate in the United States'. *Environment.* 41 (5): 15–22. Gribbin, J. (1990). 'Why Caution is Wrong on Global Warming'. *New Scientist.* July 28. 2. Gribbin, J. (1990). 'An Assault on Climate Consensus'. *New Scientist.* Dec 15. 22–26. Pearce, F. (1991). 'US Industry Attacks Greenhouse Predictions'. *New Scientist.* Nov 2. 10. Pearce, F. (1998). '*Warring Over Warming'.* New Scientist. July 25. 22. Marshall, G. (2004). 'More Hot Air on the BBC'. *Ecologist.* June 8. Pearce, F. (1992). 'American Sceptic Plays Down Global Warming Fears'. *New Scientist.* Dec 19. 6. Pearce, F. (1995). 'Fiddling While Earth Warms'. *New Scientist.* March 25. 14.

[70] Wirth. Noted in Pearce, F. (1996). 'Governments Agree Greenhouse Curbs'. *New Scientist.* July 27. 5. Pearce, F. (1997). 'Greenhouse Wars'. *New Scientist.* July 19. 38–39.

[71] Shckley, S. (1995). 'IPCC Gazing and the Interpretative Social Sciences'. *Global Environmental Change.* 5 (3). 175–180.

[72] Cornwell, R. (2003). 'Bush Accused of Censorship Over Global Warming Risk'. *Independent.*

However, by late 2004, the Bush Administration appeared to be changing its approach on this question, as it conceded that human induced influences were in part responsible for the climatic changes over the last three decades.[73]

In many ways, the turn-around of the Bush administration can be attributed to the slow build-up to scientific consensus in this area, as represented by the IPCC. Indeed, when the IPCC released their first report in 1990, unlike the confidence expressed by some of the prominent commentators at the time, that climate change was already underway, the IPCC only noted that some of the changes they recognized were, 'of the same magnitude as natural climate variability' and unambiguous detection of climate induced changes may take a number of decades. Despite the clear uncertainties that they recognized, the IPCC maintained their confidence that human activities were substantially increasing the atmospheric concentrations of the greenhouse gases, which should result in an additional warming of the Earth's surface.[74] The 1992 IPCC (Supplementary) Report added that the new research did not justify alteration of the major conclusions of the 1990 Report. However, uncertainties were still foremost. These initial uncertainties, 'particularly with regard to the timing, magnitude and regional patterns' of climate change were reflected in the FCCC.[75] As such, it was only noted that human induced climate change, 'may adversely natural ecosystems and humankind'.[76]

The extent of the scientific uncertainties of climate change that the FCCC reflected were not repeated in the Second Assessment Report of the IPCC in 1995 which concluded, that although uncertainties remained, 'the balance of evidence suggests a discernible human influence on global climate'. This balance of evidence was deemed sufficient by the IPCC to, 'provide the basis for governments to develop and pursue a global policy'.[77] Despite internal IPCC debate about the 'balance of evidence' statement,[78] this view was endorsed by the 2nd COP in 1996.[79] Moreover, the views

---

June 20. Pearce, F. (2003). 'US Court Case Challenges Climate Change Warning'. *New Scientist.* Oct 11. 12.

[73] Editor. (2004). 'Bush's U-Turn'. *New Scientist.* Sep 4. 3, 5.

[74] See Harrison, J. (1990). 'Global Warming'. *New Scientist.* Sep 1. 2. Anon. (1990). 'Growing Greenhouse'. *New Scientist.* March 3. 10. Editor. (1990). 'Changing the Climate'. *New Scientist.* Dec 22. 3. IPCC. (1996) *Climate Change 1995: Impacts, Adaptations and Mitigation.* (Cambridge University Press, Cambridge). 4.

[75] FCCC. Preamble. Paragraph 5.

[76] FCCC. Preamble. Paragraph 2.

[77] Report of the COP, Berlin, 1995. Proceedings. Page 45.

[78] Pearce, F. (1995). 'Experts Blow Cold On Climate Claims'. *New Scientist.* Nov 11. 5. Anon. (1996). 'Greenhouse Row'. *New Scientist.* Aug 24. 13. Pearce, F. (1995). 'Global Warming Jury Delivers Guilty Verdict'. *New Scientist.* Dec 9. 6.

[79] Geneva Ministerial Declaration. Paragraph 2.

of the sceptics were discounted following, 'careful scientific and technical analysis because of [their] inadequate scientific basis'.[80]

In the following five years, the confidence of the IPCC in the ability of models to project future climate increased, as did overall knowledge about the climate system. Although a few uncertainties remain there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.[81] The G8 have also come to accept the scientific position that there is, 'overwhelming scientific evidence' for the build up of greenhouse gases in the atmosphere.[82]

One example for which increasing scientific confidence can be shown is with the accuracy of data measurements suggesting that the Earth's atmosphere is getting warmer. When it was first being suggested that CO_2 might be causing climatic change in the 1940s and 1950s, the idea was challenged due to the fact that measurements of CO_2 in samples of air taken at different times and places varied so much that it was impossible to determine total amounts in the atmosphere.[83] Variations on this theme of the accuracy of data have continued since then. Most of these themes were increasingly discounted during the 1980s as data from high altitude balloons, data taken from aircraft, data taken from underground and measurements involving the retention of radiation within the atmosphere came to corroborate the information obtained from land stations.[84] Despite this increasing consensus, the scientific confidence was challenged in 1990 when NASA data revealing temperature measurements from satellites did not show an increase in temperature in the lower atmosphere during the first ten years of satellite measurement since 1980. This failure to show an increase in temperature,

[80] Report of the 2nd COP, Geneva, 1996. Proceedings. FCCC/CP/1996/15. 29 October 1996. 31.

[81] IPCC. (2001). *Climate Change 2001: The Scientific Basis*. (Cambridge University Press, Cambridge). 7, 9, 10, 17. Moss, R. (1995). 'The IPCC: Policy Relevant (not Driven) Scientific Assessment'. *Global Environmental Change.* 5 (3). 171–174. Editor. (1999). 'Writing On the Wall'. *New Scientist.* Nov 27. 5. Anon. (1998). 'The Human Factor'. *New Scientist.* Nov 21. 17. Also, Anon. (1998). 'Better Late Than Never'. *New Scientist.* March 28. 5. Karl, T. (1999). 'The Human Impact on Climate Change'. *Scientific American.* Dec 63–68. Matthews, R. (1994). 'The Rise and Rise of Global Warming'. *New Scientist.* Nov 26. 6. Anon. (2000). 'Hotting Up In The Hague'. *Economist.* Nov 18. 97. Trenbeth, K. (2001). 'Stronger Evidence of Human Influence on Climate Change'. *Environment.* 43 (4): 8–19. Pearce, F. (1999). 'Only Ourselves to Blame'. *New Scientist.* Nov 20. 24. Hogan, J. (2003). 'Global Warming: The New Battle'. *New Scientist.* Sep 13. 6–7.

[82] G8 Summit Communique. (Denver). Available from <http://www.g7.utoronto.ca/g7/summit/1997denver/98final.htm> G8 Environment Minister's Communique. Available From http://www.g7.utoronto.ca/g7/environment/2001trieste/communique.html Paragraph 3.

[83] Revelle, R. (1982). 'Carbon Dioxide and World Climate'. *Scientific American.* 247 (2): 33.

[84] Anon. (1985). 'A Greenhouse in the Stratosphere'. *New Scientist.* Sep. 26. 30. Gribbin, J. (1988). 'Britain Shivers In the Global Greenhouse'. New Scientist. June 9. 42. Anon. (1992). 'Global Warming From Underground'. *New Scientist.* May 15. 17. Dayton, S. (1987). 'Radiation Measurements Prove The Greenhouse Effect'. *New Scientist.* Sep 10. 30.

became a central argument of the sceptics case.[85] However, this later became discounted when it was shown that the supposed cooling of the lower atmosphere recorded from satellites was actually due to the gradual slippage of the satellites from their orbits over time. When this was factored in, what was shown that the atmosphere was warming (0.07% per decade) in accordance with the global warming models.[86]

A. The International Scientific Study into Climate Change

Climate change, as a scientific consideration, first appeared as a topic at an international environmental forum at the 1972 Stockholm Conference on the Human Environment. At this Conference it was recommended,

> That approximately 10 baseline stations be set up, . . . in areas remote from all sources of pollution in order to monitor long-term global trends in atmospheric constituents and properties which may cause changes in meteorological properties, including climatic changes. . . .
>
> That these programmes be guided and co-ordinated by the WMO.
>
> That the WMO, in co-operation with the International Council of Scientific Unions (ICSU), continues to carry out the Global Atmospheric Research Programme, and if necessary establish new programmes to understand better the general circulation of the atmosphere and the causes of climate changes whether these causes are natural or the result of man's activities.[87]

Two years later in 1974, the WMO established its first panel to examine human induced climatic change.[88] Similar examinations were conducted by the ICSU, the OECD, and independent research programmes in both the United States and Europe.[89] In 1978 the United States suggested,

> One of the goals in any US program must be the involvement of the international scientific community probably through one or more of the existing international scientific programs. No single country can or should bear the entire research burden. International co-operation will be crucial if both scientific and policy problems are to be solved.[90]

---

85 Editor. (1990). 'Too Much Hot Air'. *New Scientist.* Apr 21. 3. Pearce, F. (1997). 'Greenhouse Wars'. *New Scientist.* July 19. 38–39.

86 Hecht, J. (1998). 'The Heat Is On'. *New Scientist.* Aug 15. 4.

87 Recommendation 79 from the 1972 Stockholm Declaration on the Human Environment.

88 See Boehmer-Christiansen, S. (1995). 'Global Climate Protection Policy: The Limits of Scientific Advice'. *Global Environmental Change.* 4 (2): 140, 154.

89 Anon. (1976). "EEC's Changing Climate'. *New Scientist.* Dec 16. 639. Anon. (1977). 'Climate Changes For Weather Research'. *New Scientist.* Aug 25. 459. Anon. (1978). 'EEC to Study Climatic Change'. *New Scientist.* Sep 21. 831. Anon. (1978). 'US Warms To CO_2 Research'. *New Scientist.* Aug 24. 531 White, R. (1991). 'Our Climatic Future'. *Environment.* March 204–208.

90 Anon. (1978). 'US Warms to CO_2 Research'. *New Scientist.* Aug 24. 531.

The importance of international co-operation in the scientific study of climatic change was reiterated by the EEC[91] and a number of American Science reports including the National Research Council and the National Academy of Science reports. The following year, in 1979, the WMO organized the first International Climate Conference, involving more than 300 scientists from 50 countries.[92] Although this Conference drew attention to climate as a research issue, the question of policy responses was inconclusive. Nevertheless, the Conference did lead to the establishment of the World Climate Programme, which was run under the auspice of the WMO, UNEP and the ICSU. The following conference was in Villach in 1985, and once more, the need for greater scientific research was highlighted. This coincided with strong domestic scientific interest in climate change in the United States, Europe and the former Soviet Union.[93] The following year, the WMO and UNEP agreed to establish an international body to examine the knowledge and uncertainties regarding climate change. This plan was endorsed at the 1988 Toronto Conference and the IPCC was created by 33 nations, which sought to review programmes and models with regard to the scientific literature on climate change, its impacts, costs and possible policy responses. This decision to establish the IPCC was welcomed and supported by the G7.[94] The IPCC was divided into three Working Groups (WGs). Initially, these were scientific processes (WGI), impacts (WGII) and responses (WGIII). After 1992, WGII absorbed the responses portfolio, and WGIII took on cross-cutting issues, such as economic considerations. Following the release of their first reports in 1990 (coinciding with the Second World Climate Conference in 1990) it was suggested that the forthcoming convention on climate change should include a technical annex to provide for international cooperation in research, systematic observation and exchange of related information, as well as adjustments based on updated scientific information.[95] These views were largely incorporated into the FCCC, which came to reflect the importance of

[91] Hans, U. (1978). 'Climatological Research: An Interdisciplinary Study'. *New Scientist.* Nov 30. 691.
[92] WMO. (1979). *Proceedings of the World Climate Conference.* (WMO No 537, Geneva).
[93] Anon. (1989). 'Bush Sets Priorities For Climate Research'. *New Scientist.* Sep 9. 4. Anon. (1987). 'Political Thaw Leads to Cooperation on Climate'. *New Scientist.* Dec 17. 4. Anon. (1988). 'Greenhouse Scientists Seek A Breather-To Build Up Steam'. *New Scientist.* Nov 5. 25. Also, Editor. (1988). 'A Changing Climate'. *New Scientist.* Dec 24. 2. Pearce, F. (1989). 'Greenhouse Scientists To Model Regional Changes'. *New Scientist.* Feb 4. 25.
[94] G7 Summit, Communique, Toronto, 1988. Available from http://www.g7.utoronto.ca/g7/summit/1988/toronoto/communique/environment.html> G7 Paris Summit (1989). Summit Communique, available from<http://www.g7.utoronto.ca/g7/summit/1989/paris/communique/energy.html>
[95] 1 *YBIEL.* (1990). 101.

international scientific research into climate change. This recognition began with the point that the signatories were,

> conscious of the valuable analytical work being conducted by many States on climate change and of the important contributions of the World Meteorological Organization, the United Nations Environment Program and other organs, organizations and bodies of the United Nations system, as well as other international and intergovernmental bodies, to the exchange of results of scientific research and the co-ordination of research.[96]

With regard to the pursuit of science related to climatic change, all Parties (within the confines of common but differentiated responsibilities) agreed to,

> promote and co-operate in scientific, technological, technical, socio-economic and other research, systematic observation and development of data archives related to the climate system and intended to further the understanding and to reduce or eliminate the remaining uncertainties regarding the causes, effects, magnitude and timing of climate change and the economic and social consequences of various response strategies.[97]

In addition, Article 5, on Research and Systematic Observation, added that, in carrying out the above obligations, the Parties shall,

> (a). Support and further develop, as appropriate, international and intergovernmental programmes and networks or organisations aimed at defining, conducting, assessing and financing research, data collection and systematic observation, taking into account the need to minimize duplication of effort,
> (b). Support international and intergovernmental efforts to strengthen systematic observation and national scientific and technical research capabilities, particularly in developing countries, and to promote access to, and the exchange of, data and analyses thereof obtained from areas beyond national jurisdiction; and
> (c). Take into account the particular concerns and needs of developing countries and co-operate in improving their endogenous capacities and capabilities to participate in the efforts referred to . . . above.[98]

The importance of training scientific, technical and managerial personnel, in particular for developing countries, for climate change related issues was added to in Article 6.[99] The 1997 Kyoto Protocol, added that all Parties shall,

> Co-operate in scientific and technical research and promote the maintenance and the development of systematic observation systems and development of

[96] FCCC. Preamble. Paragraph 15.
[97] FCCC. Articles 4 (1) (g) and 4 (1) (h).
[98] FCCC. Article 5.
[99] FCCC. Article 6. a. (iv) & b. (ii).

> data archives to reduce uncertainties related to the climate system, the adverse impacts of climate change and the economic and social consequences of various response strategies, and promote the development and strengthening of endogenous capacities and capabilities to participate in international and intergovernmental efforts, programmes and networks on research and systematic observation, taking into account Article 5 of the Convention.[100]

In addition, the Parties shall,

> Co-operate in and promote at the international level, and, where appropriate, using existing bodies, the development and implementation of education and training programmes, including the strengthening of national capacity building, in particular human and institutional capacities and the exchange or secondment of personnel to train experts in this field, in particular for developing countries, and facilitate at the national level public awareness of, and public access to information on climate change. Suitable modalities should be developed to implement these activities through the relevant bodies of the Convention, taking into account Article 6 of the Convention.[101]

The importance of enhanced research and systematic observation, based on the information developed by the Global Climate Observing Systems and domestic partner programmes was reiterated by the COPs in 1998[102] and 1999.[103] In 2003, a type of code of practice for the Global Climate Observing Systems emerged, to help co-ordinate, facilitate and synthesize the information evolving from the system.[104]

The goals of enhanced research and systematic observation of climate change were furthered at the 2002 World Summit on Sustainable Development, which called for increased scientific research and endeavour in this area, especially with the enhanced co-operation of developing countries, as well as specific research on the impacts of climate change on the Arctic and the Antarctic.[105] Soon after, in 2003, the Parties to the FCCC called upon the GEF to give appropriate consideration from developing countries in assisting their regional action plans relating to global observing systems for climate.[106] Support for the implementation of this system was reiterated in 2004.[107]

Interestingly, the role of the IPCC was not specified in either the FCCC or the Kyoto Protocol. Although it was expected that the IPCC would

---

[100] Kyoto Protocol. Article 10 (d).
[101] Kyoto Protocol. Article 10 (e).
[102] Decision 14/CP.4. Research and systematic observation.
[103] Decision 5/CP.5. Research and Systematic Observation.
[104] Decision 11/CP.9. Global Observing Systems for Climate.
[105] WSSD. Plan of Implementation of the World Summit on Sustainable Development. A/CONF.199/L.1. Paragraph 36.
[106] Decision 4/CP.9. Additional Guidance to an Operating Entity of the Financial Mechanisms.
[107] Decision 5/CP.10. Implementation of the Global Observing System for Climate.

play a strong role in the FCCC exactly how this would fit in with the specific FCCC bodies of the SBSTA (the Subsidiary Body for Scientific and Technical Advice) and the SBI (the Subsidiary Body on Implementation) which were given specific roles within the FCCC[108] was not initially clear.[109] This was especially so as the FCCC specified (in addition to setting up the SBSTA and the SBI) that as an interim arrangement,

> The head of the interim secretariat . . . will cooperate closely with the Intergovernmental Panel on Climate Change to ensure that the Panel can respond to the need for objective scientific and technical advice. Other relevant scientific bodies could also be consulted.[110]

As the climate regime evolved, the clear appreciation of the work of the IPCC by a number of COPs,[111] and the supporting role of the SBI to the IPCC was spelt out.[112] The division of labour between the SBI, SBSTA and IPCC was refined in 1995, [113] 1996,[114] with the Kyoto Protocol[115] and the decisions from the 1997 COPs[116] and 1998.[117]

A large amount of the praise of the IPCC's work from the FCCC COPs is because of the rigorous research processes it undergoes. That is, the chapters of the main reports are compiled by between one to ten authors, nearly all of whom are well-known research scientists. Although the lead authors are formally nominated by governments, the selection of leading authors is heavily influenced by the coterie of scientists which constitute the active core of the IPCC. All of the chapters are reviewed by a large number of scientific peers as well as governments, NGOs, and industrial lobbies. The IPCC thus intends that nearly all the key experts in a particular field of inquiry are involved in the preparation or review of its reports. The documents that emerge are typically robust products of negotiation between the principal scientists, the chair of the group, govern-

[108] The role of the SBSTA is specified in Article 9, and the SBI in Article 10.
[109] See Victor, D. & Salt, J. (1994). 'Climate Change'. *Environment.* Dec 7–15. 6 *YBIEL.* (1995). 229.
[110] FCCC. Article 21 (2).
[111] Decision 6/CP.2. Second Assessment Report of the IPCC. Decision 7/CP.3 Co-operation with the Intergovernmental Panel on Climate Change. Decision. 19/CP.5. Cooperation with the Intergovernmental Panel on Climate Change. Decision 25/CP.7. Third Assessment Report of the Intergovernmental Panel on Climate Change.
[112] Decision 6/CP.2. Second Assessment Report of the IPCC. Paragraph b.
[113] Decision 6/CP.1. The Subsidiary Bodies Established By the Convention.
[114] Decision 2/CP.2. Programme of Work for the SBI.
[115] Kyoto Protocol. Article 15.
[116] Decision 13/CP.3. Division of labour between the SBI & the SBSTA.
[117] Decision 8/CP.4. Preparations for the first session of the COP. Serving as the MOP to the Kyoto Protocol: Matters related to Decision 1/CP.3, paragraph 6.

mental representatives, NGOs and industry representatives. As such, the IPCC seeks to be as wide and as inconclusive as possible.[118] The 1990 IPCC reports involved over 300 prominent climate scientists, from 40 countries.[119] The 1994 IPCC (science) report, had 25 main authors. It drew on draft text from 120 authors, whose work was reviewed by more than 230 other people from 31 countries.[120] The Second Assessment Report, comprising of three reports, contained over 2,000 pages and 10,000 references. and involved around 2,000 scientists and experts.[121] The Third Science Assessment in 2001 included 123 lead authors, 516 contributors, 21 review editors, and more than 700 reviewers. [122] With each of these reports, or more specifically, each reports Executive Summary, the wording is, 'agreed upon after an extensive discussion and very careful consideration by governments, in view of the importance of the key findings for policy makers'.[123] For example, with the 2001 Science Summary, agreement of the final document was achieved, line by line by over 100 national delegations, 10 NGOs and 42 independent scientists.[124]

Despite this careful process, the IPCC has not been without controversy. Aside a number of complaints pertaining to the timing of reports[125] the predominance of Western scientists within the IPCC,[126] and the general debates over the scientific evidence, there have been broader political debates as various countries have tried to discredit the IPCC conclusions. This process was noticeable with the 1990, 1995 and 2001 IPCC reports.[127]

---

[118] O'Riordan, T. (1997). 'The Intergovernmental Panel On Climate Change: Consensual Knowledge and Global Politics'. *Global Environmental Change*. 7 (1): 77–79. MacKenzie, D. (1988). 'Britain Agrees to Co-Ordinate UN's Greenhouse Study'. *New Scientist.* Nov 19. 25.

[119] Milne, R. (1990). 'Pressure Grows on Bush To Act on Global Warming'. *New Scientist.* June 2. 5. Editor. (1990). 'Climate of Reason'. *New Scientist.* Sep 8. 3.

[120] Pearce, F. (1995). 'Fiddling While Earth Warms'. *New Scientist.* March 25. 14.

[121] Anon. (1995). 'IPCC Rome Plenary Finalises Second Assessment Report'. *Climate Change Bulletin*. 9 (4): 1–2.

[122] Trenbeth, K. (2001). 'Stronger Evidence of Human Influence on Climate Change'. *Environment.* 43 (4): 8–19. Connor, S. (2001). 'Two Years and 1,057 Scientists'. *Independent.* July 12. 9.

[123] Report of the 2nd COP, Geneva, 1996. Proceedings. FCCC/CP/1996/15. 29 October 1996. 31.

[124] Trenbeth, K. (2001). 'Stronger Evidence of Human Influence on Climate Change'. *Environment.* 43 (4): 8–19.

[125] Pearce, F. (1994). 'Frankenstein Syndrome Hits Climate Treaty'. *New Scientist.* June 11. 5.

[126] Pearce, F. (1995). 'Fiddling While Earth Warms'. *New Scientist.* March 25. 14.

[127] Editor. (1990). 'Global Warning'. *New Scientist.* Nov. 17. Oberthur, S. (1996). 'The Second COP' *Environmental Policy and the Law*. 26 (5): 195–201. Oberthur, S. (1996). 'Signs of Progress'. *Environmental Policy and Law*. 26 (4): 156–158. Trenbeth, K. (2001). 'Stronger Evidence of Human Influence on Climate Change'. *Environment.* 43 (4): 8–19. Pittock, B. (2002). 'What Next for the IPCC?' *Environment.* 44 (10): 21–36.

The final area where politics and the IPCC have met was in 2002, when Robert Watson, the former head of the IPCC had his leadership challenged, allegedly, for being critical of the United States and its decision not to ratify the Kyoto Protocol.[128]

[128] MacKenzie, D. (2002). 'Too Hot For Head of Climate Panel'. *New Scientist.* Apr 20. 16. Hecht, J. (2003). 'US Answer to Climate Change'. *New Scientist.* Aug 2. 6. Editor. (2003). 'Weather of Mass Destruction'. *New Scientist.* Aug 2. 3.

VIII. THE PRECAUTIONARY PRINCIPLE

1. The Air Pollution and Climate Change Regimes

By the end of the twentieth century, in the respective regimes of air pollution and climate change, the importance of taking a precautionary approach was well established. According to Principle 15 of the Rio Declaration from the 1992 Earth Summit, a precautionary approach is, where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation. This principle has been replicated in both the air pollution and climate regimes. For example, the 1999 Gothenburg Protocol[1] and the 1994 Oslo Protocol stipulate,

> Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking into account that such precautionary measures to deal with emissions of air pollutants should be cost effective.[2]

In the context of the climate change debate, as early as 1978, it was being argued that it was important not to proceed on the assumption of 'innocent until proven guilty'[3] as to wait until the evidence is conclusive, that anthropogenic emissions of greenhouse gases damage the climate, then it may be too late to avert the problem. This argument persisted during the 1980s, especially after the ozone experience had become apparent.[4] Accordingly, in 1990 the G7 stipulated, in the build-up to the negotiation process for the FCCC, 'lack of full scientific certainty is no excuse to postpone actions which are justified in their own right'.[5] Soon after, when the FCCC was concluded, it was agreed,

> The Parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing such measures, taking

---

[1] 1999 Gothenburg Multi-Effects Protocol. Preamble, Paragraph 11.

[2] 1994 Protocol on Further Reductions of Sulphur Emissions. Preamble. Paragraphs 3 & 4.

[3] Gribbin, J. (1978). 'Fossil Fuel: Future Shock'. *New Scientist.* Aug 24. 541.

[4] See Gribbin, J. (1990). 'Why Caution is Wrong on Global Warming'. *New Scientist.* July 28. 2.

[5] G7 Houston Summit (1990). Summit Communique, available from <http://www.g7.utoronto.ca/g7/summit/1990/houston/communique/energy.html>

> into account that policies and measures to deal with climate change should be cost effective so as to ensure global benefits at the lowest possible costs.[6]

Since this point, although scientific uncertainties have remained, it has been clearly argued that the remaining uncertainties, are not sufficient to justify inaction.[7] The important point with the 1994 and 1999 air pollution protocols and the FCCC is that the need to work on a precautionary basis in formulating policy responses evolved only after the example of the ozone negotiations showed that to wait until the scientific evidence is conclusive, may be to wait too long.

2. The Ozone Regime and the Precautionary Approach

Between 1975 and 1985, one of the central justifications for not taking the Rowland and Molina thesis seriously, was that there was no evidence of ozone depletion that could not be attributed to natural causes.[8] This was especially so since indications showed that ozone in the Northern Hemisphere had increased between 1979 and 1981.[9] UNEP described the situation in 1982 as one whereby,

> The limited accuracy of equipment and methods of ozone measurement and the relatively large natural variability in total ozone makes the detection of man-induced changes in the ozone layer extremely difficult even by sophisticated statistical techniques.[10]

The situation was well summed up in 1984, by Robert Watson who informed the Working Group on the draft convention, that although there were many remaining uncertainties, 'the consistency between theory and observations does not validate the theoretical description of atmospheric processes controlling ozone'.[11] The influence of having, inter alia, no proof

[6] FCCC. Article 3 (3).

[7] Editor. (2000). 'Steamed Up'. *New Scientist.* Aug 24. 3.

[8] CCOL. (1981). Some Recent Research Results: A Contribution By the Chemical Manufacturers Association. UNEP/CCOL/5/4. September 1. 3. UNEP Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1981). A Look At Some Issues: A Contribution by the UNEP Secretariat. UNEP/WG.69/5. December 31. Paragraphs 25–27. Anon. (1977). 'Aerosols Can Continue'. *New Scientist.* Sep 15. 655. Anon. (1978). 'Verdict Still Open on Fluorocarbons'. *New Scientist.* Sep 21. 12.

[9] CCOL. (1981). An Environmental Assessment of Ozone Layer Depletion and Its Impact. UNEP/WG. 69/6. Oct 16. Annex 1. Paragraph 4.

[10] UNEP. (1982). Some Obstructions on the Preparation of a Global Framework for the Protection of the Ozone Layer. UNEP/WG.69/8. January 13. Paragraph 27.

[11] Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1984). Report of the Working Group, First Part of the Fourth Session. UNEP/WG.110/4. Page 3.

of damage resulted in a continual downgrading of the predictions of ozone loss caused by ODS. For example, the initial predictions of total ozone loss, assuming a BAU scenario of ODS emissions from a base year of 1977, projected over 100 years into the future, estimated a total ozone loss of between 10% and 20%. Later studies in the early 1980s placed the figure between 5 and 10%.[12]

The down-grading of the risk of ODS to the ozone layer stopped suddenly with the revelation of the so called 'Antarctic ozone hole' in 1985. The Antarctic, like the Arctic, was a natural place to look for ozone depletion, because it was known by 1980 that ozone was variable both seasonally and geographically.[13] However, at this point, despite the fact that measurements of the ozone layer from the Antarctic had been occurring since 1957, no detection of ozone depletion had been located. This situation changed radically in the middle of 1985, when the British Antarctic Survey, led by Joe Farman, revealed that between 1980 and 1984, the ozone present over the Antarctica, on both an all seasons basis, but most spectacularly, in spring was thinning by up to 50%. In addition, retrospectively, the scientific understanding of what might be causing the problem, and what the implications were for the future, were repeatedly wrong. The thinning ozone layer represented a problem that was unexpected in both causation and location, that confounded earlier predictions.[14]

---

[12] Anon. (1976). 'UN Meteorologists Accept SSTs But Still Fear Fluorocarbons'. *New Scientist.* Jan 15. 109. Anon. (1976). 'The Official View on CFCs and the Ozone Layer'. *New Scientist.* Apr. 29. 213. Gwynne, P. (1976). 'Aerosols Lost in the Ozone'. *New Scientist.* Sep 23. 627. Anon. (1979). 'All At Sea Over Ozone'. *New Scientist.* Nov. 15. 502. Gribbin, J. (1979). 'Disappearing Threat to Ozone Layer'. *New Scientist.* Feb 15. 474–473. Anon. (1980). 'Ozone Debate Put on Scientific Footing'. *New Scientist.* Jan 24. 223. CCOL. (1981). An Environmental Assessment of Ozone Layer Depletion and Its Impact. UNEP/ WG. 69/6. Oct 16. Annex 1. Paragraph 2. Anon. (1982). 'Aerosol Reprieve'. *New Scientist.* Feb 25. 486. Anon. (1982). 'Ozone: Winning on the Roundabouts, Losing on the Swings'. *New Scientist.* Apr 8.

[13] Allaby, M. & Lovelock, J. (1980). 'Spray Cans: The Threat That Never Was'. *New Scientist.* July 17. 212.

[14] First Meeting of the Parties To the Montreal Protocol, Helsinki, 2–5 May. UNEP/ OzL.Pro.1/5. 6 May 1989. Paragraph 14. Final Report: Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol. UNEP/OzL.Pro.WG.1(2)/4. 15. Warr, K. (1990). 'Ozone: The Burden of Proof'. *New Scientist.* Oct 27. 28–34. Gribbin, J. (1985). ' Stratosphere Is Losing Ozone'. *New Scientist.* May 23. 7. Gribbin, J. (1987). 'An Atmosphere In Convulsions'. *New Scientist.* Nov 26. 30–31. Anon. (1988). 'Farman Calls For Tighter Controls on CFCs'. *New Scientist.* March 24. 23. Toon, O. (1991). 'Polar Stratospheric Clouds and Ozone Depletion'. *Scientific American.* June 40–47. Pearce, F. (1997). 'Nature Fuels Loss of Arctic Ozone'. *New Scientist.* June 7. 11. Editor. (1996). 'Disaster in the Stratosphere'. *New Scientist.* March 16. 3. Anon. (1996). 'Hole Over Britain'. *New Scientist.* Nov 16. 11. Hecht, J. (1999). 'Polar Alert'. *New Scientist.* June 12. 6. Editor. (1987). 'The Ozone Zone'. *New Scientist.* Nov 12. 18. Farman, J. (1987). 'What Hope for the Ozone Layer Now?' *New Scientist.* Nov 12. 50–54. UNEP. (1989). MacKenzie, D. (1988). 'Coming Soon: The Next Ozone Hole'.

The above situation demonstrated two lessons to the international community. First, science cannot always predict the ways in which ecosystems will react. Second, waiting for actual 'proof' may involve taking unjustified risks with the Earth's ecology. This situation reflected an overall change in ethos, in which the burden of proof was originally on those suggesting the risk, not the other way around, was reversed into what we now know as the precautionary principle.

From the outset when the CFC depletion thesis was unveiled in 1974, it was, as a Du Pont executive explained, 'purely speculative, with no concrete evidence to support it'.[15] Indeed, as the UNEP Governing Council recognized in 1976, scientists were looking at the, 'potential impact that stratospheric pollution and a reduction in the ozone layer may have on mankind'.[16] Scientists were looking at, what the European Union Action Programme on the Environment categorized as, 'possibilities' that were 'difficult to assess'[17] but nevertheless, to quote the WMO they had, 'no scientific basis to reject'.[18] These difficulties meant that initial international attempts to assess the threat, could not reach a consensus on what policy route to pursue.[19] The differences were primarily over, 'the degree of confidence that can be attached to the predicted future depletion models'.[20] Philosophically, and ultimately politically, this led to the question should the international community respond on precautionary basis? As UNEP explained in 1981:

> There are those who argue against taking regulatory action until scientists are more certain and the 'theory is proven.' They caution that man should wait until there is evidence of the depletion of the ozone layer.[21]

New Scientist. Sep 1. 38. Editor. (1996). 'Disaster in the Stratosphere'. *New Scientist.* March 16. 3. Anon. (1996). 'Hole Over Britain'. *New Scientist.* Nov 16. 11. Hecht, J. (1999). 'Polar Alert'. *New Scientist.* June 12. 6.

15 Du Point Executive, noted in Benedict, R. (1991). *Ozone Diplomacy.* (Harvard University Press, Cambridge). 12.

16 UNEP. Governing Council. 1976. Reprinted in *IPE.* XXIII. 9193, 9194.

17 European Union Action Programme on the Environment. *IPE.* XVIII. 9297, 9307.

18 CCOL. (1981). Ongoing and Planned Activities Relevant to the Ozone Layer: A Contribution by the WMO. UNEP/CCOL/5/3. September 1. Paragraph 21.

19 Anon. (1977). 'US Ban Nearer For Aerosol Cans'. *New Scientist.* May 5. 254.

20 CCOL. (1981). Report of the Fourth Session of the Co-Ordinating Committee on the Ozone Layer. UNEP/CCOL/5/Background 1. Annex 3. Paragraph 44.

21 UNEP Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1981). A Look At Some Issues: A Contribution by the UNEP Secretariat. UNEP/WG.69/5. December 31. Paragraph 25.

Certain sectors within the ODS industry argued that their chemicals were, 'innocent until proven guilty', and that the burden of proof, of showing that they were unsafe fell upon those challenging them. Others took the opposite view, and suggested that,

> We cannot afford to give chemicals the same constitutional rights that we enjoy under the law. Chemicals are not innocent until proven guilty. The public interest demands precautionary environmental regulations, based on the best available data, early enough to ensure that no 'body counts' are ever needed.[22]

Within the United States, the anticipatory approach won the day, with regard to initial restrictions of CFCs in aerosols. This was confirmed in the amendments to its Clean Air Act in 1977, which allowed the administrator of the EPA to regulate, 'any substance which in his judgment may reasonably be anticipated to affect the stratosphere . . . [and] . . . endanger public health or welfare'.[23] However, such an anticipatory or precautionary approach was not followed in the initial international negotiations leading up to the Vienna Convention. This was surprising, as originally, a number of countries in the international negotiations advocated for an anticipatory approach. For example, although the 1978 Munich meeting on the Ozone Layer could not agree on any target reductions of ODS, the 14 countries present nevertheless concluded that, 'as a precautionary measure, there should be a worldwide reduction in the release of fluorocarbons'.[24] A precautionary approach was also echoed by the Parliamentary Assembly of the Council of Europe in 1980, which suggested,

> There is a strong case for limiting and controlling the use of CFCs as a preventative measure, even through available scientific data on the effects of CFCs on the ozone layer, and consequently on living creatures, plant life, climate and the ecosystem, are as yet inconclusive.[25]

This precautionary approach, whereby ODS reductions would be mandated before conclusive proof, was advocated by Norway, Finland and Sweden in the negotiations for the Vienna Convention.[26] However, as the

---

[22] The quote is from Russel Peterson, and is noted in Roan, S. (1991). *Ozone Crisis*. (Wiley, New York). 83. See also Chapter 4.

[23] 1977 Clean Air Act Amendment. Noted in Benedict, R. (1991). *Ozone Diplomacy*. (Harvard University Press, Cambridge). 23.

[24] 1978 Munich Meeting. Noted in Gribbin, J. (1978). 'Monitoring Halocarbons in the Atmosphere'. *New Scientist*. Jan 18. 164–167.

[25] Parliamentary Assembly of the Council of Europe. Resolution 733 (1980). On the Prohibition of Use of CFCs. Paragraph 6. In *IPE*. XXVIII. 460.

[26] UNEP. (1982). Some Obstructions on the Preparation of a Global Framework for the Protection of the Ozone Layer. UNEP/WG.69/8. January 13. Paragraph 38.

scientific analysis between the late 1970s and mid 1980s continually downgraded the possible damage to the ozone layer by ODS, strong precautionary approaches were avoided. This lack of conclusive evidence caused many to argue that, 'there is no need for a panic reduction'.[27] Moreover, to act in a precautionary manner that could mandate ODS reductions, was deemed an almost 'metaphysical' decision as 'evidence cannot be produced' to support it.[28] Accordingly, when the Vienna Convention was finally concluded, the basic commitment was for Parties to 'take appropriate measures' in reducing ODS, would only follow through if the adverse effects were proved, 'or likely to result from human activities which modify or are likely to modify the ozone layer'.[29] As such, although the final version of the Vienna Convention, was, 'mindful of the precautionary measures . . . which have already been taken'[30] and the Parties were, 'aware of the potentially harmful impact on human health and the environment through modification of the ozone layer'[31] the Convention went only so far as to suggest that in the absence of proof, restrictions on ODS would only be seriously considered if the ODS were 'likely' to result in modification of the ozone layer.[32] The problem was that a response cannot be precautionary and the burden of proof reversed, if the prerequisite that the impacts that have not yet been located, must first be 'likely' before they can act. Despite this limitation on the anticipatory results, Mostafa Tolba described the Convention as, 'the essence of anticipatory response'.[33] Exactly how an anticipatory response can be gauged in the absence of targeted reductions is not entirely clear, although it is notable in the sense that the international community did begin formally to deal with a problem before it fully appeared. However, by the time that the thinning of the ozone layer over the Antarctic had been discovered, although scientific uncertainties remained, the direction taken in the face of scientific uncertainty to, quote Richard Benedict, to 'err on the side of caution'.[34] This meant not only

[27] Gribbin, J. (1979). 'Disappearing Threat to Ozone Layer'. *New Scientist.* Feb 15. 474–473. Gribbin, J. (1979). 'Monitoring Halocarbons in the Atmosphere'. *New Scientist.* Jan 18. 164–167.
[28] Allaby, M. & Lovelock, J. (1980). 'Spray Cans: The Threat That Never Was'. *New Scientist.* July 17. 212.
[29] Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1983). Third Revised Draft. UNEP/WG.94/8. 18 November.
[30] Preamble. Section 5.
[31] Preamble, Paragraph 1.
[32] Article 2 (1).
[33] Tolba, noted in Roan, S. (1991). *Ozone Crisis*. (Wiley, New York). 117.
[34] Benedict, R. (1991). *Ozone Diplomacy*. (Harvard University Press, Cambridge). 4.

that the Parties to the Montreal Protocol were, 'determined to protect the ozone layer by taking precautionary measures'[35] but also, they agreed actual reductions, despite remaining scientific uncertainties, after, a damaged ozone layer had been detected.[36]

[35] Preamble, Montreal Protocol.
[36] Litfin, K. (1994). *Ozone Discourses*. (Columbia University Press, New York). 101–104. cf. Duong, M. (2003). 'A Pro-Active Stratospheric Ozone Protection Scenario'. *Global Environmental Change*. 13: 43–49.

II

Law

IX. RESTRICTIONS IN POLLUTANTS

1. Ozone Depleting Substances

A. The International Response to Ozone Depletion

The initial responses to the suspected depletion of the ozone layer, was by way of unilateral actions, in which individual countries, notably the United States, restricted or stabilized the emission rates of the non-essential utilization of ODS. Despite these unilateral efforts, the necessity for international co-operation was clear from the outset, as no-one nation had a clear monopoly on the production and/or utilization of ODS. Thus, as the EPA warned, the United States, 'alone cannot deter worldwide output by cutting back drastically at home. It has to be an international solution'.[1] Moreover, as UNEP added, 'further unilateral action would seem unlikely because of the competitive disadvantage suffered by a country that reduces CFC usage'.[2]

International co-operation on the ozone layer began with the 1976 agreement between the United Kingdom, the United States, and France on Monitoring the Stratosphere. This agreement suggested that consideration should be given to, 'facilitate the development of appropriate standards and, in turn, the establishment of regulatory measures, if deemed necessary'.[3] Steps towards international regulatory measures were furthered in 1978 in Munich, when the first international conference, involving 14 countries, on the ozone layer, agreed that, 'as a precautionary measure, there should be a worldwide reduction in the release of fluorocarbons'.[4] The ninth UNEP Governing Council meeting built on this suggestion, by deciding to initiate work on a, 'global framework convention for the protection of the ozone

---

[1] EPA, noted in Joyce, C. (1980). 'America Clamps Down on Freons'. *New Scientist*. Oct. 16. 142.

[2] UNEP Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1981). A Look At Some Issues: A Contribution by the UNEP Secretariat. UNEP/WG.69/5. December 31. Paragraphs 48 & 49.

[3] Agreement Between the Governments of the United States of America, France and the United Kingdom Regarding Monitoring of the Stratosphere (1976). *IPE*. XVI. 8289. Article VI.

[4] 1978 Munich Meeting. Noted in Gribbin, J. (1978). 'Monitoring Halocarbons in the Atmosphere'. *New Scientist*. Jan 18. 164–167.

layer'.[5] The G7 explicitly supported these negotiations.[6] Soon afterwards, from the middle of 1981, draft texts for a possible Convention on the ozone layer began being submitted.[7] Four years later in 1985, the Vienna Convention on the Protection of the Ozone Layer[8] was concluded. Two years later, the Vienna Convention was supplemented with the Montreal Protocol on Substances that Deplete the Ozone Layer.[9]

B. Targeted Restrictions on Ozone Depleting Substances

During the negotiations for the Vienna Convention, Finland, Sweden, Denmark and the United States all wanted a 'fundamental obligation' for Parties to the future convention to 'limit, reduce and prevent activities under their jurisdiction or control those which have or are likely to have adverse effects upon the stratospheric ozone layer.'[10] Importantly, the proposed convention was to be linked to a specific Annex or Protocol which mandated specific ODS reductions. The broad obligation was eventually stipulated in the Vienna Convention for Parties to,

> Adopt appropriate legislative or administrative measures and co-operate in harmonising appropriate policies to control, limit, reduce or prevent human activities under their jurisdiction or control should it be found that these activities have or are likely to have adverse effects resulting from modification or likely modification of the ozone layer.[11]

However, unlike the proposals during the negotiations for the Vienna Convention, the final document did not contain an attached Protocol or Annex which mandated specific controls on ODS. Rather, specific reductions had to wait until the Montreal Protocols. Accordingly, all controls on ODS come from the Montreal Protocol, not the Vienna Convention.

[5] UNEP. Governing Council. Ninth Session. Decision 9/13.
[6] G7 Ottawa Summit (1981). Summit Communique, available from <http://www.g7.utoronto.ca/g7/summit/1981ottawa/communique/energy.html> G7 Summit, Communique, Ottawa/1985. Available from http://www.g7.utoronto.ca/g7/summit/1985/ottawa/communique/environment.html>
[7] CCOL. (1981). Discussion Paper on Technical Aspects of a Draft Convention to Protect the Ozone Layer. UNEP/CCOL/5/7. September 1.
[8] Vienna Convention for the Protection of the Ozone Layer. TIAS11097.txt
[9] Montreal Protocol on Substances that Deplete the Ozone Layer. UKTS 19 (1990); 26 *ILM* (1987) 1550.
[10] UNEP. (1982). Text Submitted By the Delegations of Finland and Sweden. UNEP/WG.69/3. January 1. This followed through in the Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1983). Third Revised Draft. UNEP/WG.94/8. 18 November.
[11] Vienna Convention. Article 2 (b).

(i) Chlorofluorocarbons

Prior to the Montreal Protocol, reductions of chlorofluorocarbons (CFCs) came about through the unilateral actions of countries, such as the United States, or regions, such as the European Union. The United States, which began this process, banned CFCs for all non-essential products and processes (typically recognized as fluorocarbon propellants in aerosols) in 1977, and maintained this position throughout the build-up to the Protocol. Norway, Finland and Sweden, followed the American example.[12] Conversely, the European Union preferred to first 'encourage' manufacturers to voluntarily control their CFC emissions, before calling for the stabilization of these emissions at 1978 levels. Finally, the European Union mandated a 30% reduction in CFC emissions, from 1976 emission levels, by 1980.[13]

This difference between the countries which wanted a ban on non-essential CFC production and utilisation, and the countries which only wanted only a modest reduction, if any, was the basis of the debate in the formation of the Vienna Convention between 1980 and 1985.[14] By 1985, the direct control of CFCs was not supported by the majority of countries in the negotiations, due to a general belief that such actions were, as the United Kingdom argued, 'unnecessary and unsound'.[15] Accordingly, the Vienna Convention only obliged its signatories to 'take appropriate measures' if human activities were found to detrimentally affect the ozone layer.[16]

---

[12] Anon. (1976). 'US Row Over Aerosol Ban'. *New Scientist.* Nov 4. 262. See Roan, S. (1991). *Ozone Crisis.* (Wiley, New York). 82–86. Anon. (1980). 'Ozone Debate Put on Scientific Footing'. *New Scientist.* Jan 24. 223. Anon. (1977). 'Mixed Response to Aerosol Propellants'. *New Scientist.* Dec 15. 685.

[13] EC Council Resolution. (1978). Council Resolution on Fluorocarbons in the Environment. May 30. In IPE XXX. 128. Paragraph 3. EC Council Resolution. (1978). EC Council Resolution on Fluorocarbons in the Environment. May 30. In IPE XXX. 128. Paragraph 4. EC Council Resolution Concerning Chlorofluorocarbons in the Environment. 1980, March 26. 80/372/EEC. Reprinted in *IPE* XXVIII. 460. Kenward, M. (1979). 'Ozone: Cautious Inaction Needed'. *New Scientist.* Oct 25. 252. Anon. (1977). 'US Ban Nearer For Aerosol Cans'. *New Scientist.* May 5. 254.

[14] The US (and its like minded supporters) put forward one alternative clause for the draft protocol (known as the 'multi-optional format) and the EC put forward an alterative 'single option'. The difference between the two was that the US draft focused upon set reductions (leading to substantial reductions between 60–80% from what the signatories were producing at the time of the proposed draft protocol) for CFC's in aerosols only. UNEP. (1982). Text Submitted By the Delegations of Finland and Sweden. UNEP/WG.69/3. January 1. Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1984). Report of the Working Group, First Part of the Fourth Session. UNEP/WG.110/4. Pages 7–9.

[15] Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1983). Draft Annex Concerning Measures to Control . . . CFCs. Summary of Comments By Governments. UNEP/WG.94/4/Add.1/September 15. Page 6.

[16] Vienna Convention. Article 2.

Soon after the Vienna Convention was signed, the Antarctic ozone depletion was revealed. The following year in 1986, the United States argued that the necessary 'appropriate measures' were direct controls on non-essential emissions of CFCs from developed countries.[17] Specifically, the United States wanted a 50% reduction of CFCs (CFC 11,12, 113, 114 and 115) in two stages. Although the European Union, and France and the United Kingdom in particular) were reticent about the depth of the reduction, they eventually agreed to the United States demands, and the core of the Montreal Protocol was formed.[18] Accordingly, the Protocol stipulated that that emissions from developed countries of CFCs (11, 12, 113, 114 and 115) would be reduced by 50% below what emission rates were in 1986, by 1999. Interim steps towards the final target were stabilization of non-essential CFC emissions from developed countries by 1989, and 20% reductions by 1994.[19]

No sooner had the Montreal Protocol been agreed, than it was scientifically shown that further reductions in CFCs were essential to stop the rapidly growing concentration of chlorine in the atmosphere.[20] These views were reiterated by a number of countries throughout 1988 and in special meetings in the Hague and London leading up to the first MOP of the Montreal Protocol in Helsinki in 1989.[21] At the Helsinki meeting, the debate was between whether to obtain an 85% or 100% reduction in the use and production of all CFCs in developed countries by 1997, 2000 or 2005.[22] The second MOP settled this debate, although a number of countries argued the cuts were insufficient,[23] by agreeing that the five established

[17] Anon. (1986). 'Americans Press For End to Chlorofluorocarbons'. New Scientist. Nov 27. 20. For the strong American position at this time, see Benedict, R. (1991). *Ozone Diplomacy*. (Harvard University Press, Cambridge). 66–67.

[18] Benedict. Ibid. 78. MacKenzie, D. (1987). 'Small Comfort For the Ozone Layer'. *New Scientist*. May 7. 20. Anon. (1987). 'Ozone Deal'. *New Scientist*. July 9. 19. MacKenzie, D. (1987). 'Environment Ministers Sidestep the Ozone Issue'. *New Scientist*. May 28. 22.

[19] Montreal Protocol. 1987. Article 2 & Annex A.

[20] Editor. (1987). 'The Ozone Zone'. New Scientist. Nov 12. 18. Farman, J. (1987). 'What Hope for the Ozone Layer Now?' *New Scientist*. Nov 12. 50–54.

[21] Milne, R. (1988). 'Europeans Seek A Lift Through the Arctic's Ozone Hole'. *New Scientist*. June 23. 28. Anon. (1988). 'Farman Calls For Tighter Controls on CFCs'. *New Scientist*. March 24. 23. Anon. (1988). 'Lords Life For Ozone Pact'. *New Scientist*. Aug 14. 25. Pearce, F. (1988). 'A Hole In British Ozone Research'. *New Scientist*. Oct 8. 16. MacKenzie, D. (1988). 'Now It Makes Business Sense to Save the Ozone Layer'. *New Scientist*. Oct 29. 25. MacKenzie, D. (1988). 'Now It Makes Business Sense to Save the Ozone Layer'. *New Scientist*. Oct 29. 25. MacKenzie, D. (1988). 'Industry Develops Ozone-Friendly Processes'. *New Scientist*. Nov 19. 30.

[22] UNEP. (1989). First MOP To the Montreal Protocol. Paragraph 11, 24. MacKenzie, D. (1989). 'More Help For Ozone Layer'. *New Scientist*. May 6. 7.

[23] At the 1990 meeting, a number of industrialized countries (but not the US, UK or Japan) issued a Declaration expressing their "firm determination to take all appropriate measures to phase-out the production and consumption of all fully halogenated CFCs

CFCs (11, 12, 113, 114 and 115) and 10 other CFCs (13, 111, 112, 211 and 217) would be fully eliminated by 2000 (with a 50% reduction by 1995, and 85% reduction by 1997).[24] Finally, following further debate for an even greater accelerated reduction of CFCs by developed countries, and unilateral reductions far in advance of the 2000 deadline,[25] the date for all non-essential use of CFCs by developed countries was moved forward at the fourth MOP, to 1996, with an interim set of a 75% reduction by 1994.[26]

The developing countries (also known as 'Article 5' countries) which are signatories to the Vienna Convention and the Montreal Protocol have a different set of obligations with regard to the control of ODS. Most notably, developing countries were allowed to initially increase their consumption of ODS, for a period of ten years before they would be subject to CFC restrictions. Specifically, article 5 of the Montreal Protocol stipulated,

> Any Party that is a developing country and whose annual calculated level of consumption of the controlled substances of less than 0.3 kilograms per capita on the date of the entry into force of the Protocol for it, or any time thereafter within ten years of the date of entry into force of the Protocol shall, in order to meet its basic domestic needs, be entitled to delay its compliance with the control measures set out in . . . [Article 2] . . . by ten years after that specified in those paragraphs. However, such a Party shall not exceed an annual calculated level of consumption of 0.3 kilograms per capita. Any such Party shall be entitled to use either the average of its annual calculated level of consumption for the period 1995 to 1997 inclusive or a calculated level of consumption of 0.3 kilograms per capita, whichever is the lower, as the basis for its compliance with the control measures.

This provision meant that the controls in CFC production and consumption agreed for the developed countries were not applicable to developing countries. Rather, under each ODS control, a caveat was listed which read,

> In order to satisfy the basic domestic needs of the Parties operating under paragraph 1 of Article 5, its calculated level of production may exceed that limit by up to 15% of its calculated level of production in 1986.[27]

---

controlled by the Montreal Protocol as soon as possible, but not later than 1997." Declarations and Resolutions. Second MOP to the Montreal Protocol. 20.

[24] Annex II. Amendments to the Montreal Protocol. Second MOP to the Montreal Protocol. MacKenzie, D. (1990). 'Montreal Nations Agree Tougher Rules on CFCs'. *New Scientist.* March 24. 8.

[25] See the Statement (from the Nordic countries) at the 3rd MOP, which called for CFCs, out by 1997. Other Matters. Third MOP to the Montreal Protocol. 22. Anon. (1992). 'Europe Bans CFCs'. *New Scientist.* Feb 29. 12.

[26] Report of the Fourth MOP to the Montreal Protocol. Annex 1. 32.

[27] Article 2A (5). London Revisions, 1990.

The obvious question that this raises is what exactly are basic domestic needs? Despite a number of attempts to answer this question, the only guidance offered is couched in negative terms. That is, basic domestic needs do not include the production of ODS for export purposes.[28]

The CFC reductions for developing countries began, after a ten year grace period, in 1996. The base-year for developing countries was the average level of their consumption between 1995 and 1997. From this baseline, their emissions had to be stabilized, although there was a small leeway on this, to this level by 1999.[29] Stabilization is to be followed by the total elimination of all non-essential CFC production and consumption by 2010. This final target is assisted by a series of interim steps of 80% reduction and consumption of non-essential CFC uses by 2003, 50% by 2005, and 15% by 2007.[30]

(ii) Halons

Between 1985 and 1987, the United States began to lobby to have halons included in any forthcoming Protocol. This was a difficult objective, as the United Kindgom, Japan and the former Soviet Union did not wish to incur cuts in halon production.[31] The result of this difference of objectives was that the only target agreed within the Montreal Protocol was a stabilization in the emission of non-essential halons for developed countries, at their 1986 emission levels, by 1989.[32] As the ozone situation worsened, controls on all ODS, including halons were clearly needed. Although the developed countries at the first MOP in 1989 promised to, 'phase out halons as soon as feasible',[33] no specific dates for reductions of non-essential halon emissions were agreed.[34] However, the following year in 1990, the developed countries agreed to have zero emissions of non-essential halons, by the year 2000. This was supplemented by a 50% reduction by the year

[28] Decision VI/14. B. Basic Domestic Needs. UNEP. (1989). First MOP To the Montreal Protocol. 11. Benedict, R. (1991). *Ozone Diplomacy*. (Harvard University Press, Cambridge). 94.

[29] Beijing Declaration on Renewed Commitment to the Protection of the Ozone Layer. Annex 1, Report of the 11th MOP. UNEP/OzL.11/10. 7 Dec 1999. 36. 1 *YBIEL*. (1990). 96. Anon. (1996). 'The Vienna Meeting'. *Environmental Policy and the Law*. (26:2/3). 66–71.

[30] Annex II. Adjustments to the Montreal Protocol. UNEP/OzL.11/10. 7 Dec 1999. 37.

[31] MacKenzie, D. (1987). 'High Noon For Ozone in Montreal'. *New Scientist*. Sep 3. 24. Joyce, C. (1987). 'Hot Air Threatens Ozone In Montreal'. *New Scientist*. Sep 11. 30. Editor. (1987). 'Found in the Ozone'. *New Scientist*. Sep 24. 18.

[32] Montreal Protocol. Article 2 (2).

[33] Helsinki Declaration on the Protection of the Ozone Layer. UNEP/OzL.Pro.1/5. Appendix 1.

[34] MacKenzie, D. (1990). 'Montreal Nations Agree Tougher Rules on CFCs'. *New Scientist*. March 24. 8.

1995.[35] The adequacy of this commitment was challenged at the following meeting in 1991,[36] before being accelerated to having zero emissions of non-essential halons by 1994.[37]

The same initial exceptions which applied to developing countries for CFCs, were also applied to halons.[39] In 1999 after the ten year grace period, developing countries were obliged to reduce their non-essential use emissions of halons to 50% by 2005 and completely, by 2010.[39]

(iii) Methyl Chloroform and Carbon Tetrachloride

In 1989, the Open-Ended Working Group on ODS recommended that MC and CT should be included in the Annex to the Montreal Protocol and be given specific phase out dates.[40] Despite this recommendation, specific reductions for MC were not agreed until 1990, when it was agreed that developed countries would stabilize their non-essential production and consumption of MC, at 1989 levels, before completely eliminating MC by 2005. Interim steps were for a 30% reduction of MC by 1995 and a 70% reduction by 2000.[41] The final phase out date of non-essential consumption and production of MC was accelerated at the fourth MOP to 1996. This was supplemented with an interim step of a 50% reduction by 1993.[42]

Progress in reducing the non-essential consumption and production of CT was slightly faster than MC. It was originally agreed in 1990 that the developed countries would have a complete elimination of the non-essential consumption and production of CT by the year 2000. This was supplemented with a 50% reduction of CT by 1995 and an 85% reduction by 1997.[43] Following unilateral reductions, and calls for an accelerated rate of reduction for CT,[44] it was agreed in 1992 that all non-essential consumption and production of CT by developed countries would cease by 1996. This target was supplemented with an 85% reduction by 1995.[45]

---

[35] London Revisions. 1990. Article 2B.
[36] Other Matters. Third MOP to the Montreal Protocol. 22.
[37] Annex 1. Report of the Fourth MOP to the Montreal Protocol.
[38] London Revisions. 1990. Article 2B.
[39] Annex II. Adjustments to the Montreal Protocol. UNEP/OzL.11/10. 7 Dec. 1999. 37.
[40] Final Report: Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol. UNEP/OzL.Pro.WG.1(2)/4. 2.
[41] Annex II. Amendments to the Montreal Protocol. Second MOP to the Montreal Protocol. Article 2.E.
[42] Annex II. Report of the Fourth MOP to the Montreal Protocol. 34.
[43] Annex II. Amendments to the Montreal Protocol. Second MOP to the Montreal Protocol. Article 2.D. MacKenzie, D. (1990). 'Montreal Nations Agree Tougher Rules on CFCs'. *New Scientist*. March 24. 8.
[44] See the Statement (from the Nordic countries) at the 3rd MOP. Other Matters. Third MOP to the Montreal Protocol. 22.
[45] Annex II. Report of the Fourth MOP to the Montreal Protocol. 34.

(iv) Other Fully Halogenated Ozone Depleting Substances
In 1992, limits for fully halogenated ODS, other than those noted above, were established. The final phase out date for all non-essential consumption and production for industrialized countries was the year 1996. This was supplemented by an interim step of 75% reduction by 1994.[46]

(v) Methyl Bromide
In the early 1990s, a number of countries, and the United States most notably, wanted the non-essential consumption and production of MB phased out as soon as possible. This proposal was strongly objected to by the European Union and the developing world, which were not convinced of either MBs impact on the ozone layer, nor the adequate availability of alternatives to MB.[47] The compromise agreed at the fourth MOP in 1992 was for the stabilization of non-essential MB consumption and production by 1995, with 1991 as the base year.[48] The adequacy of this commitment was strongly debated the following year, along with a number of countries declaring their intention to reduce their consumption of MB, by at least 25% by the year 2000.[49] This pressure was clearly effective, as in 1995 it was agreed that developed countries would have zero emissions of non-essential use and production of MB by 2010. This was to be supplemented with a 25% reduction by 2001 and 50% reduction by 2005. Despite this improvement, another declaration by disappointed countries was recorded, suggesting greater reductions of MB were needed.[50] Due to such remaining concerns, the issue of further MB controls was revisited in 1997, and the final phase out date for the non-essential consumption and production of MB by developed countries was accelerated to 2005. This was supplemented by interim steps of a 25% reduction of MB by 1999, a 50% reduction by 2001 and a 70% reduction by 2003.[51] However, once more, another declaration was passed urging greater action.[52] The need for further action

[46] Annex II. Report of the Fourth MOP to the Montreal Protocol. See also Decision VIII/18.
[47] Report of the Fourth MOP to the Montreal Protocol. 28–29. MacKenzie, D. (1992). 'Large Hole in the Ozone Layer'. *New Scientist.* Nov 28. 5.
[48] Annex III. Report of the Fourth MOP to the Montreal Protocol. 38. 8 *YBIEL.* (1997). 172.
[49] Report of the Fifth MOP to the Montreal Protocol. 19 November 1993. 8 and Annex VII. Declaration on Methyl Bromide. MacKenzie, D. (1993). 'Clinton Faces Both Ways on Ozone Treaty'. *New Scientist.* Nov 27. 10. Pearce, F. (1995). 'Introducing The Ozone Friendly Bacteria'. *New Scientist.* Oct 28. 10.
[50] Annex X. Declaration on Methyl Bromide. UNEP/OzL.Pro.7/12. 81. Anon. (1996). 'The Vienna Meeting'. *Environmental Policy and the Law.* (26:2/3). 66–71.
[51] Report of the Ninth MOP Of the Montreal Protocol. 52–53 and Annex III. Adjustments to Annex E. Miller, D. (1997). 'Open-Ended Working Group of the Parties'. *Environmental Policy and the Law.* 27 (5): 396–397.
[52] Annex XI. Declaration Regarding Methyl Bromide. Report of the Ninth MOP Of the Montreal Protocol. 92.

in this area was highlighted in 2004, when the signatories to the Montreal Protocol expressed their commitment to reduce their MB utilizations in the future,[53] and created extra reporting requirements for MB utilization, along with greater research and examination of alternatives.[54]

In 1995 the developing countries agreed only to freeze their non-essential consumption and production of MB levels in 2002, at the average level they used between 1995 and 1998.[55] Two years later, the developing countries agreed to targets of a complete phase-out of non-essential consumption and production of MB by 2015. The final target date for complete elimination was later lowered to 2010, with an interim step of 85% reduction of non-essential MB by 2007.[56] In 2004 the Parties to the Montreal Protocol agreed to consider, in the future, an acceleration of this timetable.[57]

(vi) Hydro-Chloro-Fluoro-Carbons and other Transitional Substances

No sooner had the first generation of alternatives to traditional ODS, such as HCFCs, become commercially available, than the Parties to the Montreal Protocol were forced to realise that although the alternative substances did not damage the ozone layer as much as the original ODS, they still had a detrimental impact. Accordingly, 'particular attention should be paid to potential substitutes for the presently controlled substances particularly HCFCs'.[58] The following year it was agreed that the alternatives to traditional ODS would be known as 'transitional substances' that should only have limited applications and strict time periods, until more suitable alternatives became available. The Parties concluded that 'if possible', transitional substances should be phased out by 2020 if possible and 2040 at the latest.[59] The final phase out date for transitional substances was later accelerated to 2030,[60] and then 2020, with a ten year exception for the servicing of existing equipment.[61] Despite successive declarations by

---

53 Decision Ex.I/3. Critical Use Exemptions For Methyl Bromide. Anon. (2004). 'Methyl Bromide: Compromise'. *Environmental Policy and Law*. 34 (3): 118–121.
54 Decision Ex.I/4. Conditions for Granting and Reporting Critical Use Exemptions for Methyl Bromide. Annex I. 21–29.
55 Miller, D. (1995). 'Open Ended Working Group'. Environmental Policy and the Law. (25:4/5): 181–183. MacKenzie, D. 'Ozone Deal Could Backfire'. *New Scientist*. Dec 16. 7.
56 Annex III. Adjustments to the Montreal Protocol. UNEP/OzL.11/10. 7 Dec 1999. 39. 39–40. Annex IV. Adjustments to the Montreal Protocol. UNEP/OzL.11/10. 7 Dec 1999. 39–40. 8 *YBIEL*. (1997). 172.
57 Decision Ex.I/1. Further Adjustments Relating to the Controlled Substance in Annex E.
58 UNEP. (1989). First Meeting of the Parties To the Montreal Protocol. Decision 10.
59 Annex VII. Resolution by Governments at the 2nd COP of the Montreal Protocol. Other Matters. Third MOP to the Montreal Protocol. 22.
60 Annex III. Report of the Fourth MOP to the Montreal Protocol. 37.
61 6 *YBIEL*. (1995). 222. MacKenzie, D. 'Ozone Deal Could Backfire'. *New Scientist*. Dec 16. 7.

disappointed governments urging greater reductions of transitional substances within shorter time periods,[62] further attempts to achieve such goals within the Montreal Protocol failed.[63]

With regard to developing countries, it was agreed in 1995 that their consumption and production of transitional substances would be stabilized by 2015, and completely phased out by 2040.[64] Further attempts to accelerate this target have been unsuccessful.

(vi) New Chemicals

By the year 2000 a number of 'new' chemicals with ODP were becoming a concern within the ozone regime. The first of these chemicals to come under active consideration, in terms of controls was n-propyl bromide. As of 2001, although there were no targeted restrictions on this, Parties were requested to urge their industries to,

> Consider limiting the use of n-propyl bromide to applications where more economically feasible and environmentally friendly alternatives are not available and to urge them also to take care to minimize exposure and emissions during use and disposal.[65]

C. Exceptions for Essential Uses of ODS

It is incorrect to assume that the above restrictions on ODS have resulted in complete reductions leading to the absolute prohibitions of either the production or consumption of the identified ODS. Rather, clear 'loopholes' exist through which production and consumption of ODS, under the auspice of 'essential uses' may continue. For example, essential uses of CFCs in 2003 were 6,321.5 ODP tonnes.[66]

---

[62] Annex V. Memorandum By Germany, Austria, Switzerland & Liechtenstein on HCFCs. Annex VI. Declaration on HCFCs. Report of the Fifth MOP to the Montreal Protocol. 60 & 61. Annex IX. Declaration on HCFCs. UNEP/OzL.Pro.7/12. 80. Decision IV/30. HCFCs. Report of the Fourth MOP to the Montreal Protocol. 27–28. Decision VI/13. Assessment Panels. Report of the Sixth MOP to the Montreal Protocol. 21. Decision VIII/13. Uses and Possible Applications of HCFCs. 21. Annex XI. Declaration on HCFCs. Report of the Ninth MOP Of the Montreal Protocol. 91. Oberthur, S. (1997). 'Montreal Protocol: 10 Years After'. *Environmental Policy and the Law*. 27 (6): 432, 434–35. Anon. (1996). 'The Vienna Meeting'. *Environmental Policy and the Law*. (26:2/3). 66–71.

[63] Oberthur, S. (2000). 'Ozone Layer Protection at the Turn of the Century: The 11th Meeting of the Parties'. *Environmental Policy and the Law*. 30 (1/2): 34.

[64] Decision XI/28. Supply of HCFCs to Parties Operating Under Article 5. Report of the 11th MOP. UNEP/OzL.11/10. 7 Dec. 1999. 34. Annex III. Adjustments To the Montreal Protocol Relating to Controlled Substances in Annex E. UNEP/OzL.Pro.7/12. 60–61. MacKenzie, D. (1995). 'Ozone Deal Could Backfire'. New Scientist. Dec 16. 7. 12 *YBIEL*. (2001): 210.

[65] Decision XIII/7. N-Propyl Bromide. Report of the 13th MOP of the Montreal Protocol.

[66] Annex I. Essential Use Nominations for 2002–2004. Report of the 13th MOP. 56.

The idea that not all ODS would be prohibited, because they remain vital for certain 'essential uses' began in 1976, when the United States was contemplating unilateral restrictions on ODS. At this point, it was made clear that CFCs, necessary for, 'essential uses' would not be encompassed in proposed restrictions. This idea, which the United States maintained[67] flowed into the negotiations for the Vienna Convention because, as UNEP recognized, 'different uses have different priorities, and the feasibility of a shift to substitutes varies'.[68]

The need to have an ability to retain 'essential usages' of ODS was reiterated throughout the negotiations, although the scope of the exception could not be resolved with countries going as far as arguing that CFCs as propellants for cooking oil were 'essential' to them while others later argued consumer air-conditioning was 'essential.'[69] Owing to the obvious difficulties of trying to define what the 'essential uses' were at the outset, the Protocol simple noted the possibility that there might be exceptions to the general restrictions on each ODS. These broad exceptions, which are in addition to the basic domestic needs exceptions of developing countries,[70] were built into all of the operative paragraphs of the Montreal Protocol. The language, which is the same in each ODS restriction paragraph states,

> This paragraph will apply save to the extent that the Parties decide to permit the level of production or consumption that is necessary to satisfy uses agreed by them to be essential.[71]

The guiding principles of whether an application of an ODS is essential or not is that,

[67] Anon. (1977). 'US Ban Nearer For Aerosol Cans'. *New Scientist.* May 5. 254. Vandevelde, K. (1977). 'International Regulation of Fluorocarbons'. 2 *Harvard Environmental Law Review.* 17. Anon. (1980). 'Ozone Debate Put on Scientific Footing'. *New Scientist.* Jan 24. 223.

[68] UNEP Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1981). A Look At Some Issues: A Contribution by the UNEP Secretariat. UNEP/WG.69/5. December 31. Paragraph 46.

[69] At the 4th MOP, it was stressed that "sustainable development meant changes in the behavior of producers and, in particular, of consumers. Air conditioning might be an essential use for controlled substances in one context and a mere luxury in another. Luxury, and indeed comfort, that entailed damage to the environment, would have to be renounced." Report of the Fourth MOP to the Montreal Protocol. 25 November 1992. 10. Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1983). Draft Annex Concerning Measures to Control CFCs. Summary of Comments By Governments. UNEP/WG.94/4/Add.1/Septermber 15. 2.

[70] Decision IV/25. Essential Uses. Report of the Fourth MOP to the Montreal Protocol. 25.

[71] Paragraph 2A of the updated Montreal Protocol.

> It is necessary for the health, safety or is critical for the functioning of society (encompassing cultural and intellectual aspects) and there is no available technically and economically feasible alternatives or substitutes that are acceptable from the standpoint of environment and health.

Finally, essential uses should only be permitted once, 'all economically feasible steps have been taken to minimize the essential use' and the controlled substance is not available from 'existing stocks of banked or recycled controlled substances.'[72]

(i) Exceptions for CFCs

In 1993, a number of countries began drawing up lists covering 'essential' uses for CFCs for which there was no alternative, which were forwarded to the Technology and Assessment Panel for consideration. The list included 22 suggestions, ranging from use for fingerprinting through to safety tests for children's toys.[73] The Panel concluded that for all CFCs only three exceptions should apply. These were for Metered Dose Inhalers (MDIs), the Space Shuttle, and laboratory and analytical uses. For all other suggestions, either alternatives and substitutes were available, or the needs could be satisfied by existing ODS supplies. This conclusion was adopted by the Parties at the sixth MOP, together with the condition, that even when an an exception is granted, all steps to minimize emissions should still be pursued.[74] These essential uses, were reconfirmed the following year, with the expressed hope that the list of exceptions might be further refined.[75]

Developed countries seeking to nominate other CFC uses as 'essential' have faced strong resistance to expand the list. For example, applications from countries in economic transition, arguing that CFCs were essential for their refrigeration needs have been rejected, as have applications for nasal and anti-anginal needs.[76] Conversely, projects like torpedo maintenance, have been accepted.[77]

---

[72] Decision IV/25. Essential Uses. Report of the Fourth MOP to the Montrese Protocol. 24–26.

[73] Hamer, M. (1994). 'Dabs Dilate the Ozone Hole'. *New Scientist.* Oct 29. 5. Milne, R. (1993). 'Britain Bids to Use Essential Ozone Eaters'. *New Scientist.* Aug 28. 6. Hadfield, P. (1994). 'Japan Seeks Last Minute Opt Out From Ban'. *New Scientist.* March 19. 6.

[74] Decision VI/9. Essential Use Nominations for Controlled Substances Other Than Halons for 1996 and Beyond. Report of the Sixth MOP. 7, 18.

[75] Decision VII/28. Essential Use Nominations. Seventh MOP to the Montrese Protocol. 40–41.

[76] Decision XI/14. Essential Use Nominations for Non-Article 5 Parties for Controlled Substances for 2000–2001. Report of the 11th MOP. 27. Miller, D. (1995). 'Open Ended Working Group'. *Environmental Policy and the Law.* 25:4: 181–183.

[77] Decision X/6/ Essential Use Nominations for Controlled Substances for 1999 & 2000. Report of the 10th MOP of the Montreal Protocol. 19–20. Decision XIII/8. Essential Use Nominations for Non-Article 5 Parties For Controlled Substances for the Year 2002 and Beyond. Report of the 13th MOP.

One of the foremost exceptions for the continued utilization of CFCs is MDIs.[78] The amount of CFCs required for MDIs has fallen from approximately 10,000 ODP tonnes in 1997 down to 2,583 for 2004, and 3,268 for 2005.[79] As such, considerably less CFCs were being used for MDIs than the mid 1990s.[80] Although this figure is clearly decreasing, CFCs remain essential for use in MDIs for asthma and chronic obstructive pulmonary disease. Despite this remaining essential use of CFCs for MDIs, successive MOPs have tried to increasingly tighten restrictions and facilitate non-CFC alternatives in this area.[81] For example in 2001, it was decided that all Parties were to start creating plans for non-CFC based MDIs.[82] In a desire to avoid unnecessary production of new CFCs, it was also agreed that a Party may allow a MDI company to transfer all or part of its essential use authorization to another existing MDI company provided that compliance with national or regional authorization requirements were met.[83] Other measures to create efficiencies included examining options of avoiding stockpiling CFCs for MDI purposes.[84] This process was furthered in 2002, with the creation of a Global Database and Assessment, to determine appropriate measures to complete the transition from CFC based MDIs to non-CFC based MDIs. The database required each Party to submit information on their production, consumption and plans for expanding their markets for non-CFC based MDIs.[85] Finally, in 2003 the Parties called for greater specifics in the information provided by those seeking an essential use exception for MDIs, including information on ingredients used, markets for sale, and domestic plans of action for the phased out (including an end-by date) use and production of CFC used MDIs, where the sole active ingredient is salbutamol.[86]

---

[78] Decision VII/34. Assessment Panels. 44. Miller, D. (1997). 'Open-Ended Working Group of the Parties'. *Environmental Policy and the Law*. 27 (5): 396–397.

[79] Decision XV/4. Essential Use Nominations for Non-Article 5 Parties in 2004–2005. Report of the 15th MOP to the Montrese Protocol. Annex I. 80.

[80] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 31. Report of the 13th MOP. 27.

[81] Decision VIII/10 was designed to facilitate industry's participation and efficient transition from CFC based Meter Dosed Inhalers, and Decision VIII/11 was designed to help the Transition from CFC Based MDIs. See also Report of the 10th MOP to the Montrese Protocol. 8.

[82] Decision XII/2/ Measures to Facilitate the Transition to CFC Free MDIs. Report of the Twelfth MOP to the Montrese Protocol. 25–26.

[83] Decision XII/2/ Measures to Facilitate the Transition to CFC Free MDIs. Report of the Twelfth MOP to the Montreal Protocol. 25–26. See also the earlier Decision IX/20 which authorized the essential use transfers for CFCs for MDIs between Parties.

[84] Decision XIII/9. Metered Dose Inhaler (MDI) Production. Report of the 13th MOP. 45.

[85] Decision XIV/5. Global Database and Assessment to Determine Appropriate Measures to Complete the Transition from CFC Based MDIs.

[86] Decision XV/5. Promoting the Closure of Essential Use Nominations For Metered Dose Inhalers. Report of the 15th MOP to the Montreal Protocol. 46.

The second major recognised essential use of CFCs involves laboratory and analytical uses. These have been considered an essential use, worthy of exemption, since the 1980s. In 2004, 1.025 tons of CFC-113 was approved for laboratory and analytical use.[87] This exception was supplemented by 'emergency exemptions' for laboratory and analytical uses of 2.05 tons of CFC-113 for 2003, and 0.025 ODP tons of hydrobromofluorocarbons and bromocholomethane for 2003 and 2004 for the EC.[88]

To ensure that the laboratory and analytical section has not been exploited, the Parties have continually refined the possible exceptions within this essential use. This process began in 1995, when exactly what were, and were not, laboratory and analytical uses were first defined.[89] This list was refined in 1997,[90] 1998[91] and 1999, and is set for further review in 2005.[92] This continuing process is built on a system in which earlier exceptions for CFC usage for laboratory and analytical work have been removed from the list. For example, in 1999, three usages were taken from the exception list, including forensic finger printing.[93] The result of the tightening of this category was that between 1997 and 2001 there was a 71% reduction of CFCs usage, from 14,700 ODP tonne per year, down to 4,300 ODP tonnes.[94]

(ii) Exceptions for Halons

In 1990 when the initial reduction targets for halons were being negotiated, it was agreed that the reductions would not cover the production and consumption of halons that was necessary to satisfy essential uses such as fire-fighting, for which no adequate alternatives are available.[95] Accordingly, it was agreed that, 'the Parties shall adopt a decision identifying essential uses, if any, for the purposes of [halons]. Such a decision shall be reviewed

[87] Decision XV/4. Essential Use Nominations for Non-Article 5 Parties for Controlled Substances in 2004–2005. Report of the 15th MOP. Annex I. 80.

[88] Decision XV/. Ibid. 46.

[89] Decision VII/11. Laboratory and Analytical Uses. Annex IV, Categories and Examples of Laboratory Uses. Seventh MOP to the Montreal Protocol. 28–29, 63.

[90] Decision IX/17. Essential Use Exemption for Laboratory and Analytical Uses of Substances. Report of the Ninth MOP Of the Montreal Protocol. 35.

[91] Decision X/19. Exemption for Laboratory and Analytical Uses. Report of the 10th MOP of the Montreal Protocol. 32–33.

[92] Decision XV/8 Laboratory and Analytical Uses. Report of the 15th MOP to the Montreal Protocol. 50.

[93] Decision XI/15. Global Exemption for Laboratory and Analytical Uses. Report of the 11th MOP. 27.

[94] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 33.

[95] London Revisions. 1990. Article 2B. Annex VII. Resolution by Governments at the 2nd COP of the Montreal Protocol. 67. Milne, R. (1990). 'CFC Clampdown Eases Pressure on the Ozone Layer'. *New Scientist.* July 7. 9.

at their subsequent meetings'.[96] Until this was formalised, the list of essential uses was put forward by the MOP and recommended to the Parties was, 'on a voluntary basis'.[97]

As a way of reducing the essential uses of halons, in 1992 an 'International Recycled Halon Bank Management' scheme was established.[98] It was hoped that this scheme would assist all Parties in meeting their essential halon needs by the recycling, reclamation and recovery of existing halons, rather than having to manufacture new ones.[99] In the following decade, the importance of having incentives linked to this recycling scheme were reiterated over the following years.[100] The possibilities of recycling, reclamation and recycling led the majority of Parties (but not Russia) to suggest that no new production of halons was necessary to satisfy essential needs for developed countries as the Halon Bank and greater efficiencies in utilisation, or alterative substances could meet the demand for essential use halons.[101] The effectiveness of the Halon Bank was enhanced over the following years, with recommendations for the de-commissioning and recycling of non-essential halons being strongly encouraged.[102] This policy was expanded upon in 1998, with general Halon Management Strategies, through which dates for decommissioning non-critical halon installations and equipment were set.[103] The information made available from the Halon Management Strategy meant that information from Parties on their relative surplus and deficit of halons was collected and analysed. This information resulted in the reiterated conclusion that the future essential needs for halons could be satisfied from halon banking, without the need to manufacture new halons.[104]

---

[96] London Revisions. 1990. Article 2B, Also, Seventh MOP to the Montreal Protocol. 7.

[97] Essential Use classifications. Decision IV/25.

[98] Decision V/15 International Halon Bank Management. Report of the Fifth MOP to the Montreal Protocol. 15.

[99] Decision IV/26. International Recycled Halon Bank Management. Report of the Fourth MOP to the Montreal Protocol. 26.

[100] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 35.

[101] Decision VI/8. Essential Use Nominations for Halons For 1995. Report of the Sixth MOP to the Montreal Protocol. 18. Decision V/14. Essential Use of Halons. Decision V/16. Supply of Halons. Report of the Fifth MOP to the Montreal Protocol. 15–16, 21. Decision VII/12. Control Measures For . . . Halons. Seventh MOP to the Montreal Protocol. 30. UNEP. (1999). *Synthesis of the Reports of the Scientific, Environmental Effects and Technology and Economic Assessment Panels of the Montreal Protocol.* (UNEP, Ozone Secretariat, Nairobi). 17.

[102] Decision IX/21. De-Commissioning of Non-Essential Halon Systems in Non-Article 5 Parties. Report of the Ninth MOP Of the Montreal Protocol. 37–38.

[103] Decision X/7. Halon Management Strategies. Report of the 10th MOP of the Montreal Protocol. 20.

[104] For the posing of the question, see Decision VIII/17. Availability of Halons for Critical

(iii) Exceptions for Methyl Bromide

Critical use exemptions for MB were first agreed in 1997. The exceptions are only permissible if there is no alternatives to the required use of MB, and if failure to allow the exception would cause a, 'significant market disruption'. Moreover, production and consumption of MB for essential uses is only permissible, if all steps to minimize emissions from the critical use are made, and attempts are made to secure already existing MB from banked or recycled stocks.[105] Revised nomination forms for MB essential uses exceptions[106] were designed to help evaluate whether an 'appropriate effort' was being made with these prerequisites. This was especially so with regard to the evaluation and pursuit of alternatives to MB.[107] Despite the relative clarity of the objectives in this area, the debate about the extent of alternatives to MB for essential uses led to the first extra meeting, between the normal sequence of MOPs, of the Montreal Protocol in 2004.[108]

The first essential use exception for MB relates to quarantine and pre-shipment applications. In 1992 when controls on MB were first agreed, it was clear that these controls would not apply to utilization of MB for quarantine and pre-shipment applications.[109] The definitions, and thus the scope for the exception, for quarantine and pre-shipment were defined in 1994[110] and 1999.[111] Parties using MB for quarantine and pre-shipment applications are also obliged to monitor its utilisation in this area,[112] whilst seeking general efficiencies in its usage, and encouraging alternatives to MB for quarantine and pre-shipment uses, and using recycled MB wherever possible.[113]

The second essential use of MB relates to agricultural applications. When the original controls on MB were being negotiated, it was clear that although the Parties utilizing MB would 'endeavour' to reduce MB by adopting, 'good agricultural practices and improved application techniques'[114]

Uses. Report of the 8th MOP to the Montreal Protocol. 22. Report of the 11th MOP to the Montreal Protocol. 18.

105 Decision IX/6. Critical Use Exemptions for Methyl Bromide.

106 Decision XIII/11. Procedures for Applying for a Critical Use Exemption for Methyl Bromide.

107 Decision XV/54. Categories of Assessment to Be Used By the Technology and Economic Assessment Panel When Assessing Critical Uses of Methyl Bromide.

108 Report of the First Extraordinary Meeting of the Parties to the Montreal Protocol on Substances That Deplete the Ozone Layer.

109 Annex III. Report of the Fourth MOP to the Montreal Protocol. 38.

110 Decision VI/11. Clarification of Quarantine and Pre-Shipment.

111 Decision XI/12. Definition of Pre-Shipment Applications of Methyl Bromide. See also Decision XI/13. Quarantine and Pre-Shipment. Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 37.

112 Decision XI/12. Definition of Pre-Shipment Applications of Methyl Bromide.

113 Decision XI/13. Quarantine and Pre-Shipment. Decision VII/5. Definition of Quarantine.

114 Decision VII/6. Reduction in Methyl Bromide Emissions. Seventh Meeting of the Parties to the Montreal Protocol. 26.

the overall emission targets would only, 'apply save to the extent that the Parties decide to permit the level of production or consumption that is necessary to satisfy uses agreed by them to be critical agricultural uses'.[115] At the time, 'critical agricultural uses' was an undefined term. Although this term was later defined,[116] some countries, such as South Africa, were, 'loath to accept the carrot of exemption for critical agricultural uses'.[117] In 2003 certain countries, such as the United States, wanted this exception expanded.[118] The reluctance to be too restricted in this sub-category was accepted by the MOP in 2004 when it was agreed that if the Parties had not met a reduction step specified in their phase-out agreements of MB, 'as a result of a specified circumstance not envisaged' then the Executive Committee was directed to deal with them in a 'flexible' manner.[119] The Parties went on to define such exceptional circumstances as,

> Unforeseen de-registration of an approved methyl bromide alternative when no other feasible alternatives are available, or where pest and pathogens build resistance to the alternative, or where the use-reduction [alternatives do not] satisfy the critical uses . . . of that Party.[120]

In a similar manner of a general loosening of restrictions in this area, in 2003 the MOP agreed, after prompting by Algeria and Tunisia, that for the Parties that use over 80% of their MB consumption for the treatment of high-moisture dates, assuming they did not actually increase their MB emissions, that they should not be deemed in non-compliance of their reduction obligations of MB. This finding will last until two years after the Technology and Economic Assessment Panel formally concludes their study into alternatives to MB in this area.[121]

The third, and final, critical use exception which allows the utilization of MB is for emergency situations. In such circumstances, MB use, of up to 20 tons, upon notification to the Secretariat may be acceptable.[122]

---

[115] Annex III. Adjustments To the Montreal Protocol Relating to Controlled Substances in Annex E. UNEP/OzL.Pro.7/12. 60–61.

[116] Decision VII/29. Assessment of the Possible Need for and Modalities and Criteria for A Critical Agricultural Use Exemption for Methyl Bromide. Decision VIII/16. Critical Agricultural Uses of Methyl Bromide.

[117] UNEP/OzL.Pro.7/12. 48. 7 *YBIEL*. (1996). 130.

[118] See Anon. (2003). '60 Seconds Environment: The United States'. *New Scientist*. Feb 8. 13.

[119] Decision Ex.I/2. Accelerated Phase Out of Methyl Bromide.

[120] Decision Ex.I/3. Critical Use Exemptions For Methyl Bromide for 2005.

[121] Decision XV/12. Use of Methyl Bromide for the Treatment of High Moisture Dates.

[122] Decision IX/7. Emergency Methyl Bromide Use. Report of the Ninth MOP Of the Montreal Protocol. 30.

D. Targets Within Overlapping International Organisations

In addition to the Montreal Protocol, some other international organisations also control the utilization of ODS. For example, in 1991 the International Maritime Organization (IMO), after earlier calling for voluntary restrictions on ODS on all international vessels,[123] agreed to ban the use of ODS in refrigerants and air conditioning systems, and the use of halons in new fire extinguishers on board all international vessels. However, new vessels are allowed to utilize HCFCs until 2020. Ships are required to dispose of ODS at suitable ports in accordance with the requirements of the Montreal Protocol.[124]

With regard to the International Civil Aviation Organisation (ICAO), the primary difficulty with regard to ODS is the continued use of ODS in civilian aircraft. This is particularly problematic given that potential alternatives, as opposed to halons, exist for both engines and cargo bays of commercial aircraft. However, new airframes are still being designed and certified with halons as the required fire extinguisher due to regulatory requirements.[125] In 2003, the ozone Secretariat was directed to engage in discussions with the ICAO, with regards to the possible development of a plan of action to consider modification of the regulatory requirement that mandates the use of halons in the industry.[126]

E. Promoting Technological Change within the Ozone Regime

As discussed in chapter nineteen, the pursuit of alternatives to traditional forms of ODS has been a central concern of the ozone regime. This pursuit, was a clear message coming out of the domestic and international responses to the ozone debates leading up to the formation of the Vienna Convention.[127] The Convention echoed these suggestions and emphasized

[123] See IMO Resolution A 655 (16). October 18, 1989. The Use of Halons as Fire Extinguishing Media on Ships.

[124] See Annex VI of the 1973 International Convention for the Prevention of Pollution from Ships (MARPOL). Regulation 12. This is reprinted in IMO (2003). MARPOL 73/78. (IMO, London). 408. See also 8 *YBIEL*. (1997). 496. Anon. (1991). 'Cleaner Ships'. *New Scientist*. Nov 16. 10.

[125] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report*. UNEP/OzL.Pro/WG.1/23/3. 34.

[126] Decision XV/11. Plan of Action to Modify Regulatory Requirements That Mandate the Use of Halons on New Airframes.

[127] Anon. (1976). 'The Official View on CFCs and the Ozone Layer.' *New Scientist*. Apr. 29. 213. EC Council Resolution. (1978). Council Resolution on Fluorocarbons in the Environment. May 30. In *IPE* XXX. 128. Paragraph 2. Parliamentary Assembly of the Council of Europe. Resolution 733 (1980). On the Prohibition of Use of CFCs. Paragraph 6. In *IPE*. XXVIII. 460. UNEP. Governing Council. Eighth Session. Decision 8/7.

the importance of individual, joint and shared research between countries to assist in the development of alternatives,[128] and even included a specific Annex on Information Exchange.[129] The preamble of the Montreal Protocol reiterated the same goals, and Article 9 of the Protocol added,

> The Parties shall co-operate, consistent with their national laws, regulations and practices and taking into account in particular the needs of developing countries, in promoting, directly or through competent international bodies, research, development and exchange of information on:
>
> (a) Best technologies for improving the containment, recovery, recycling or destruction of controlled substances or otherwise reducing their emissions;
> (b) Possible alternatives to controlled substances, to products containing such substances, and to products manufactured with them.

In addition, the industrialized Parties promised, 'to facilitate access to environmentally safe alternative substances and technology for Parties that are developing countries and assist them to make expeditious use of such alternatives'.[130] To further these objectives, specific review panels were designated under both the Vienna Convention,[131] and the Montreal Protocol, to consider issues related to alternative ODS technologies.[132] The Parties to the ozone regime, and even the WSSD,[133] have continued to reiterate the importance of the individual and shared pursuit of, and access to, alternatives to ODS.[134]

2. Reductions in Greenhouse Gases

A. The International Response to Climate Change

The first suggestion of an international convention on climate change arose in 1977, when the National Academy of Sciences suggested that due to the possible impacts that climate change may have in the future, that

[128] Vienna Convention. Article 3 (f) and article 4.
[129] Vienna Convention. Annex II.
[130] Article 5 (2). Montreal Protocol.
[131] Decision 4. Research, Observations and the Transfer of Technology. Report of the First COP to the Vienna Convention. 8.
[132] Decision 2/13. Assessment Panels. Report of the First MOP to the Montreal Protocol. 14. The terms of references for the Panels were contained in Annex VI.
[133] The WSSD reiterated the general agreement to, 'Improve access by developing countries to affordable, accessible, cost effective safe and environmentally sound alternatives to ozone depleting substances by 2010. Plan of Implementation of the WSSD. A/CONF.199/L.1. Paragraph 37 (d).
[134] Helsinki Declaration on the Protection of the Ozone Layer. Appendix 1. Decision XI/16. CFC Management Strategies in Non-Article 5 Parties. Report of the 11th MOP to the Montreal Protocol. 27–28.

'important international decisions' will have to made.[135] Although the G7 promised in 1981 and 1985 to 'address'concerns such as climate change,[136] it was not until the World Commission on Environment and Development in 1987, that a clear call for an international convention on the protection of the atmosphere from greenhouse gas emissions was made.[137] This call was reiterated the following year at the Toronto Conference on the Changing Atmosphere,[138] and in 1989 the United Nations General Assembly, with clear G7 support,[139] listed climate change as a major environmental issue for the forthcoming Earth Summit in 1992, and directed UNEP and the WMO to form a task force and advise on elements pertaining to a climate convention. An Intergovernmental Negotiation Committee (INC) was added to this process, and six meetings, beginning in the middle of 1991 and ending just before the Earth Summit, concluded the United Nations Framework Convention on Climate Change (FCCC).[140]

The first discussion of 'qualified emissions limitations and reduction objectives' (QELROs) in greenhouse gases came from the 1988 (non-governmental) Toronto Conference, which called for CO_2 reductions by developed countries of 50% by 2015.[141] Although a number of other non-governmental conferences and prominent individuals reiterated this 50% call,[142] the most commonly advocated reduction target of CO_2 for developed countries was 20% by 2005.[143] However, such suggestions of a 20% reduction were strongly rejected by most of the large developed countries

135 See Lewin, R. (1977). 'Atmospheric Carbon Dioxide: A New Warning'. *New Scientist.* July 28. 211.

136 G7 Ottawa Summit (1981). Summit Communique, available from <http://www.g7.utoronto.ca/g7/summit/1981ottawa/communique/energy.html> G7 Summit, Communique, Ottawa/1985. Available from http://www.g7.utoronto.ca/g7/summit/1985/ottawa/communique/environment.html>

137 World Commission on Environment and Development. (1987). *Our Common Future.* (Oxford University Press, Oxford). 5.

138 Anon. (1988). 'Toronto Delegates Call for a 'Law of the Atmosphere'. *New Scientist.* July 7. 24.

139 The G7 called for, 'a framework or umbrella convention on climate change to set out general principles or guidelines' and 'specific protocols containing concrete commitments" should be added as necessary'. G7 Paris Summit (1989). Summit Communique, available from <http://www.g7.utoronto.ca/g7/summit/1989/paris/communique/energy.html>

140 UNGA. Res 44/26. Paragraph I,12(a). UNGA Res 45/212. 2 *YBIEL.* (1991). 111. Charles, D. (1991). 'Petty Politics Mars Global Warming Conference'. *New Scientist.* Feb 23. 6. 1 *YBIEL.* (1990). 102, 377.

141 MacKenzie, D. (1988). 'Britain Agrees to Co-Ordinate UN's Greenhouse Study'. *New Scientist.* Nov 19. 25. Joyce, C. (1988). 'American Politicians Warm to Greenhouse Effect'. *New Scientist.* Sep 8. 30.

142 MacKenzie, D. (1990). 'Europe Pushes Hard Line in Greenhouse Talks'. *New Scientist.* May 19. 8. MacKenzie, D. (1990). 'Scientists Clash With Politicians Over CO_2 Emissions'. *New Scientist.* July 28. 5.

143 Milne, R. (1989). 'Industrialised Countries Must Make Deepest Carbon Cuts'. *New Scientist.* Dec 2. 8.

and the G7[144] who only wanted an umbrella convention which could be supplemented with, 'specific protocols containing concrete commitments, as scientific evidence requires' at a later date.[145] Although some key members of the G7, like the United Kingdom and Japan were ambiguous in their reactions to such suggested targets, the United States was forthright in its refusal to accept any legally binding restrictions on CO_2 emissions.[146] By 1991, following gridlock over this issue, the EC suggested a compromise between no reductions at all, or specific reduction targets, with the proposal that all developed countries should stabilize their greenhouse gas emissions at their 1990 emission levels.[147] Although this proposal was originally rejected by the United States, the American administration changed its position, and agreed to sign the FCCC, if it was clear that the stabilization objective was not a legally enforceable target. Further tinkering with the wording of the FCCC assured this American objective, and the United States duly agreed to sign the Convention.[148]

B. The United Nations Framework Convention on Climate Change

The commitment for developed countries to control their greenhouse gas emissions follows the two general principles that one state may not knowingly pollute another State or the commons,[149] and that the goal of controlling greenhouse gas emissions is to prevent dangerous change to the atmospheric system.[150] The specific commitment for developed countries in Article 4 (2) (a) stipulated,

---

[144] Spinks, P. (1989). 'Nations Fail to Agree On Measures to Limit Greenhouse Effect'. *New Scientist.* Nov 18. 7.

[145] G7 Paris Summit (1989). Summit Communique, available from<http://www.g7.utoronto.ca/g7/summit/1989/paris/communique/energy.html> G7 Houston Summit (1990). Summit Communique, available from <http://www.g7.utoronto.ca/g7/summit/1990/houston/communique/energy.html>2 *YBIEL.* (1991). 111. Editor. (1990). 'Global Warning'. *New Scientist.* Nov. 17. MacKenzie, D. (1990). 'Climate Conference Ends in Disarray'. *New Scientist.* Nov 17. 5. 1 *YBIEL.* (1990). 101.

[146] Gavaghan, H. (1990). 'Bush Rejects Scientists Call For Action on Global Warming'. *New Scientist.* Feb 10. 5. Milne, R. (1990). 'Pressure Grows on Bush To Act on Global Warming'. *New Scientist.* June 2. 5. Cross, M. (1990). 'Japan In Two Minds Over Greenhouse Gases'. *New Scientist.* Oct 27. 5.

[147] Bower, S. (1990). 'The Politics of Climate: A Long Haul Ahead'. *New Scientist.* Oct 27. 12–13. 1 YBIEL. (1990). 103.

[148] MacKenzie, D. (1991). 'Storms Cloud Gather Over Climate Talks'. *New Scientist.* Sep 21. 5. Pearce, F. (1992). 'US Forces Earth Summit To Cut Carbon Commitment'. *New Scientist.* May 9. 6. 3 YBIEL. (1992). 228. Gavaghan, H. (1990). 'European Nations Want Action Now On Global Warming'. *New Scientist.* Feb 17. 6. MacKenzie, D. (1990). 'US and Europe Could Fall Out Over Climate Change'. *New Scientist.* Sep 1. 5. Pearce, F. (1992). 'Draft Treaty Fails to Put Limits on Emissions'. *New Scientist.* May 16. 5. Editor. (1991). 'Must We Agree on Carbon Cuts'. *New Scientist.* Aug 24. 9.

[149] FCCC. Preamble. Paragraphs 7–8.

[150] FCCC. Article 2. For discussion, see chapter six of this book.

> Each of these Parties shall adopt national policies and take corresponding measures on the mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs. These policies and measures will demonstrate that developed countries are taking the lead in modifying longer-term trends in anthropogenic emissions consistent with the objective of the Convention, recognizing that the return by the end of the present decade to earlier levels of anthropogenic emissions of carbon dioxide and other greenhouse gases not controlled by the Montreal Protocol would contribute to such modification, and taking into account the differences in these Parties' starting points and approaches, economic structures and resource bases, the need to maintain strong and sustainable economic growth, available technologies and other individual circumstances, as well as the need for equitable and appropriate contributions by each of these Parties to the global effort regarding that objective.

As soon as the FCCC was concluded, attempts were made to move beyond the emission stabilization reduction target of greenhouse gas emissions for developed countries. This was done because it was becoming increasingly apparent that the FCCC commitments were inadequate for the long term, if the objective was to stop dangerous anthropogenic interference with the atmosphere. Accordingly further action, by developed countries to reduce their greenhouse gas emissions to their 1990 levels by 2000 was required.[151] The G7, including the United States, agreed.[152]

Following on from the agreed need to make substantive reductions in greenhouse gas emissions from developed countries, the Alliance of Small Island States (AOSIS) proposed that a protocol be added to the FCCC at the forthcoming COP in Berlin in 1995. The core of the proposed protocol was a reduction of CO_2 emissions by developed countries of 20 to 25% by 2005.[153] However, the proposed protocol by AOSIS was not discussed in Berlin.[154] However, the Berlin COP, with the support of the G7,[155] did decide to undertake a,

[151] Decision 9/CP.2. Communications from Annex I Parties: Guidelines, Schedule and Process. Paragraph 13.a. INC 9. A/AC/WG.1/L.17/Rev.1. Pearce, F. (1995). 'Climate Treaty Heads For Trouble'. *New Scientist.* March 18. 4. Anon. (1995). 'Governments Act on Treaty Commitments: A First Review'. *Climate Change Bulletin.* 6 (1): 4. MacKenzie, D. (1994). 'Carbon Targets Not Tough Enough'. *New Scientist.* Sep 17. 5. 5 *YBIEL.* (1994). 164.

[152] G7 Naples Summit (1994). Summit Communique, available from <http://www.g7.utoronto.ca/g7/summit/1994/naples/communique/energy.html>. G8 Summit Communique. (Denver). Available from <http://www.g7.utoronto.ca/g7/summit/1997denver/98final.htm> YBIEL. (1993). 144. 5 *YBIEL.* (1994). 169. Pearce, F. (1994). 'Targets Beyond 2000'. *New Scientist.* Sep 3. 7. Brown, D. (2002). *American Heat.* (Rowman, New York).

[153] AOSIS Protocol. Noted in 5 *YBIEL.* (1994). 164. MacKenzie, D. (1994). 'No Advance In Sight On Greenhouse Treaty'. *New Scientist.* Sep 10. 6. Editor. (1995). 'Hot Air In Berlin'. *New Scientist.* March 25. 3. 3 *YBIEL.* (1992). 228.

[154] Report of the COP, Berlin, 1995. FCCC/CP/1995/7. 24 May 1995. Part One, Proceedings. Paragraph 57 & 58. Oberthur, S. (1995). 'The First COP'. *Environmental Policy and the Law.* 25 (4): 144.

[155] G7 Halifax Summit (1995). Summit Communique, available from<http://www.g7.utoronto.ca/g7/summit/1995/halifax/communique/energy.html>

> process to enable it [the FCCC] to take appropriate action for the period beyond 2000, including the strengthening of the commitments of the [developed] Parties to the Convention through the adoption of a protocol or another instrument.[156]

Moreover, this process would 'aim' to, inter alia,

> Set quantified limitation and reduction objectives within specified time-frames, such as 2005, 2010 and 2020, for their anthropocentric emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol.[157]

Accordingly, strong legal restrictions on greenhouse gas emissions were clearly on the table with the international negotiations following the Berlin Mandate. For example, the protocol proposed by AOSIS was 'included for consideration' as was a later proposal by Germany (later to become an EU proposal) for a 15% reduction in CO_2 for developed countries by 2010,[158] and a Japanese proposal of 2.5% reduction in CO_2 for developed countries.[159] Conversely, the United States was acting ambiguously,[160] and Australia was clearly unreceptive to any specific reductions of greenhouse gas emissions by developed countries.[161] Due to such an impasse, by the time of the second COP in 1996 in Geneva, there was no consensus on necessary reductions in greenhouse gas emissions. Nevertheless, the majority of the COP agreed[162] that 'substantive negotiations' going towards the third FCCC COP at Kyoto should conclude a, 'protocol or other legal instrument' which contained,

> Qualified legally binding objectives for emission limitations and significant overall reductions within specified time frames, such as 2005, 2010, 2020,

[156] Decision 1/CP.1. The Berlin Mandate.

[157] Decision 1/CP.1. The Berlin Mandate. Paragraph II. 2 (a). Anon. (1995). 'Back on Target'. *New Scientist.* Nov 11. 13. Editor. (1995). 'Sweating It Out Together'. *New Scientist.* Apr 15. 3.

[158] Decision 1/CP.1. The Berlin Mandate. Paragraph III. 5. 7 *YBIEL.* (1996). 132. Oberthur, S. (1996). 'Signs of Progress'. *Environmental Policy and the Law.* 26 (4): 158–160. Subak, S. (1995). 'The Adequacy Debate: Make the Toronto Targets the Next Commitment'. *Climate Change Bulletin.* 9 (1): 5. 8 *YBIEL.* (1997). 175. Pearce, F. (1997). 'Nations Squabble In the Greenhouse'. *New Scientist.* Mar 15. 10.

[159] Anon. (1997). 'Just Hot Air?' *New Scientist.* Oct 11. 5. Hadfield, P. (1997). 'Japan Fiddles While the World Warms'. *New Scientist.* May 31. 10.

[160] Oberthur, S. (1996). 'The Second COP ' *Environmental Policy and the Law.* 26 (5): 195–201. Pearce, F. (1997). 'The Heat Is On'. *New Scientist.* Nov 1. 5. Pearce, F. (1998). 'Warring Over Warming'. *New Scientist.* July 25. 22.

[161] Pearce, F. (1996). 'Governments Agree Greenhouse Curbs'. *New Scientist.* July 27. 5. Anon. (1995). 'US Left Behind As Europe Backs Cuts'. *New Scientist.* Apr 8. 4. Pearce, F. (1996). 'Carbon Targets Up In The Air'. *New Scientist.* July 6. 9.

[162] Note the reservations by Australia and a number of OPEC countries. Report of the 2nd COP, Geneva, 1996. Proceedings. Annex IV.

> with respect to their anthropogenic emissions by sources and removals by sinks of greenhouse gases not controlled by the Montreal Protocol.[163]

C. The 1997 Kyoto Protocol to the United Nations Framework Convention on Climate Change

The eventual agreement which came out of the third COP in 1997 was the so-called Kyoto Protocol. The Protocol was predicated on the recognition that the existing obligations imposed under Article 4 of the FCCC to 'aim' to stabilize the emissions of greenhouse gas from developed countries, at their 1990 levels, were, 'not adequate' to meet the overall goals of the FCCC.[164] Accordingly, strong reduction targets for developed countries were required.[165] Thus,

> The [developed] Parties . . . shall, individually or jointly, ensure that their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts, calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of this Article, with a view to reducing their overall emissions of such gases by at least 5 per cent below 1990 levels in the commitment period 2008 to 2012.[166]

The above paragraph reflected the conclusion of extensive negotiations between 1994 and 1997. The final agreement amounted to an overall reduction for industrialized countries of only 5% below what the overall emission rate of greenhouse gases from them was in 1990.[167] This 5% cut was not a uniform obligation on all developed countries.[168] Rather, it was an aggregate amount as each industrialized country received a different target. Thus, some developed countries were permitted to increase their greenhouse gas emissions above their 1990 levels. For example, Australia could increase their emissions by 8%, Iceland by 10% and Norway by 1%. Another group of countries, such as New Zealand, the Ukraine and the Russian Federation, were obliged to maintain their emissions of green-

[163] The Geneva Ministerial Declaration. Paragraph 8. Pearce, F. (1996). 'Governments Agree Greenhouse Curbs'. *New Scientist.* July 27. 5. Pearce, F. (1997). 'Countdown to Chaos'. *New Scientist.* Nov 29. 22.

[164] Kyoto Protocol. Preamble, Paragraph 1.

[165] "Each [developed] Party shall, by 2005, have made demonstrable progress in achieving its commitments under this Protocol." Kyoto Protocol. Article 3. (2).

[166] Kyoto Protocol. Article 3. (1).

[167] Parry, M. et al. (1998). 'Buenos Aires and Kyoto Targets Do Little To Reduce Climate Change Impacts'. *Global Environmental Change.* 8 (4): 285–288.

[168] Kyoto Protocol. Annex B. Quantified Emission Limitation or Reduction Commitments.

house gases at what they were in 1990 level. The final group of developed countries had to reduce their greenhouse gas emissions below what they were emitting in 1990. For example, Canada had to make 6% reductions, the United States had to make 7% reductions, and the European Union had to make 8% reductions. Note however, that the European Union operates under the Kyoto Protocol as an aggregate total.[169] Accordingly, whilst some countries are making reductions, such as Germany with a 21% reduction, or the UK with a 12.5% reduction, other countries within the Union are allowed to increase their emissions above what they were in 1990. For example, Portugal is permitted to allow a 27% increase, Greece a 25% increase, and Spain a 15% increase.

As soon as the Kyoto Protocol was agreed, its became apparent, that many developed countries would not achieve their FCCC obligations to return their greenhouse gas emissions to 1990 levels by the year 2000,[170] let alone their new Kyoto commitments. Difficulties were also enhanced because of deep uncertainties relating to how the Kyoto Protocol would work in practice. Finally, the new American administration, began to unveil policies which appeared to contradict the goals of the Kyoto Protocol. This collection of difficulties combined to force the sixth COP to collapse.[171] This collapse forced a six month suspension of the COP in the hope that all Parties would, 'intensify political consultations among themselves and explore areas of common ground that would enable the successful conclusion of negotiations at a resumed session'.[172]

Although the G7 expressed their intention to work, 'intensively together to meet our common hopes'[173] with regard to climate change policies, following the collapse of the first part of the sixth COP, the Bush Administration refused to ratify the Kyoto Protocol, due to it being, 'fatally flawed'.[174] At

---

[169] See Agreement Between The European Union And Its Member States. Under Article 4 Of The Kyoto Protocol. Note By The Secretariat. FCCC/COP/2002/2. Annex X. Table of quantified emission limitation or reduction commitments for the purpose of determining the respective emission levels allocated to the European Union and its member states in accordance with article 4 of the Kyoto protocol.

[170] Decision 11/CP.4. National communications from Parties included in Annex I to the Convention. Paragraph 10 (c).

[171] Brown, P. (2000). 'US Seeks Pollution Reprieve'. Guardian Weekly. July 27. 2. Editor (2000). 'Getting Warmer'. New Scientist. June 16. 3. Editor. (2000). 'Time To Come Clean'. *New Scientist.* Dec 2. 3

[172] Decision 1/CP.6. Implementation of the Buenos Aires Plan of Action. Paragraph 5.

[173] G8, 2001 Communique (Genova). Paragraph 24. Available from <http://www.g7.utoronto.ca/g7/summit/2001genoa/finalcommunique.html>

[174] Brown, P. (2001). 'US Isolated By Treat to Arrest Climate Change'. *Guardian Weekly.* July 26. 1. Note, some individual states within the American union have set their own Kyoto targets. McKee, M. (2004). 'Lawsuit Could Force Limits on US Carbon Emissions'. *New Scientist.* July 31. 12. Chandler, D. (2003). 'Bush Defied Over Greenhouse Cuts'.

the same time, the United States unveiled its own greenhouse gas control strategies including a regional emissions trading system, and a number of domestic voluntary agreements with industries.[175] Although these domestic strategies may slow the rise of American greenhouse gas emissions, the emissions will still be increasing. As such, it is very unlikely that the domestic strategy will reduce American emissions to the levels set out in the Kyoto Protocol, nor stabilize them, as required by the FCCC.[176] The American Congress has consistently refused to accept further attempts to move closer to the Kyoto objectives.[177] This is despite both the World Summit on Sustainable Development (WSSD) and subsequent FCCC COPs,[178] urging States which had not already done so to ratify the Kyoto Protocol in a timely manner.[179] Despite the American refusal to ratify, the FCCC process survived and Kyoto Protocol eventually came into force in 2005.[180] Although the Kyoto Protocol came into existence, it is likely that further reductions in greenhouse gas emissions by developed countries, will be required in the future, if the goal remains preventing dangerous anthropogenic interference with the climate system.[181]

D. Commitments for Developing Countries under the Kyoto Protocol

Despite early proposals that developing countries should be involved in the reduction of greenhouse gases, developing countries, as a group, have been strongly reluctant to commit themselves to any greenhouse gas emission targets. The difficulty that this refusal presents is that in the near future, the majority of anthropogenic greenhouse gas emissions will be coming from developing, not developed, countries.[182] As such, the eventual involve-

New Scientist. Jan 25. 4. Mukerjee, M. (2003). 'Greenhouse Suits' *Scientific American.* Feb 8–10. Anon. (2003). 'Pollution Fight'. *New Scientist.* March 1. 8.

175 Gardiner, D. (2002). 'Will Voluntary Programs Be Sufficient to Reduce US Greenhouse Gas Emissions?' *Environment.* 44 (8): 18–33. Whitman, C. (2003). 'Going It Alone'. *New Scientist.* Aug 16. Dunne, N. (2001). 'North America Ponders Kyoto Alternative'. *Financial Times*. Dec 14. A5.

176 Hecht, J. 'Proposals Under Fire'. *New Scientist.* March 8. 9. Pearce, F. (2002). 'Grim Outlook'. *New Scientist.* Feb 23. 7. Pearce, F. (2001). 'An Ill Wind'. *New Scientist.* Jan 20. 16. Pearce, F. (2001). 'A Real Roasting'. *New Scientist.* Apr 7. 3 & 11. Kleiner, K. (2001). 'Power Hungry'. *New Scientist.* May 26. 17.

177 Anon. (2003). 'Kyoto Lite Fails'. *New Scientist.* Nov 8. 4.

178 Decision 1/CP.8. Delhi Ministerial Declaration on Climate Change and Sustainable Development.

179 WSSD. Plan of Implementation of the World Summit on Sustainable Development. A/CONF.199/L.1. Paragraph 36.

180 Editor. (2001). 'Bonn's Global Achievement'. *Guardian Weekly*. July 26. 14. Pearce, F. (2001). 'Kyoto Lives'. *New Scientist.* July 28. 13.

181 FCCC. Provisional Agenda to the 8th COP. FCCC/CP/2002/1/Add.1. 12 August. 2002. Paragraphs 60–61.

182 Milne, R. (1989). 'Industrialised Countries Must Make Deepest Carbon Cuts'. *New*

ment of developing countries in the reduction process, at some meaningful level, is essential because as the FCCC noted,

> The global nature of climate change calls for the widest possible cooperation by all countries and their participation in an effective and appropriate international response.[183]

To date, the response of the FCCC and the Kyoto Protocol to the need 'for the widest possible co-operation by all countries' with regard to developing countries is that although developing countries have a role to play with regard to the 'common' problem of climate change that all countries share, developing countries have, 'differentiated responsibilities' due to their 'respective capabilities and their social and economic conditions'.[184] Thus, 'developed countries Parties should take the lead in combating climate change and the adverse effects thereof'.[185] Conversely, 'the specific needs and special circumstances of developing country Parties [means they should not] bear a disproportionate or abnormal burden under the Convention'.[186]

Despite this conclusion in both the FCCC and the Kyoto Protocol, a number of industrialized countries from the JUSCANZ group (Japan, New Zealand, Canada, the United States and Australia) began arguing in 1994 that some developing countries should be bound by greenhouse gas controls. The focus was on the more prosperous developing countries, such as Mexico, South Korea, and Singapore. Likewise, attempts by Turkey, as a member of the OECD, to avoid having reduction targets were challenged before Turkey was removed from the Annex[187] which classifies countries as developed.[188] The early attempts to include greenhouse gas stabilization or reduction targets on developing countries were strongly objected to by the developing countries.[189] The developing country objection was so successful that the Berlin Mandate was explicit in stating that the process designed to set targets for developed Parties, shall, 'not introduce any commitments for Parties not included in Annex I'.[190]

Scientist. Dec 2. 8. Gribbin J. (1981). 'The Politics of Carbon Dioxide'. *New Scientist.* Apr 9. 82–83.

[183] FCCC. Preamble. Paragraph 6.

[184] FCCC. Preamble. Paragraph 6.

[185] FCCC. Article 3 (1).

[186] FCCC. Article 3 (2).

[187] Decision 26/CP.7. Amendment to the list in Annex II to the Convention. This process of changing from the Annexes is detailed in Article 4 (2) (f) & (g) of the FCCC.

[188] Other Action Taken By The COP. Report of the Fifth COP to the FCCC. Anon. (1999). 'Climate Change: Plan of Action Adopted'. *Environmental Policy and the Law.* 29 (1): 3. Pearce, F. (1994). 'Greenhouse Targets Beyond 2000'. *New Scientist.* Sep 3. 7. Pearce, F. (1997). 'Chill Winds At the Summit'. *New Scientist.* March 1. 12–13.

[189] Oberthur, S. (1995). 'The First COP'. *Environmental Policy and the Law.* 25 (4): 144.

[190] Decision 1/CP.1. The Berlin Mandate. Paragraph II. 2 (b).

Although the Berlin Mandate explicitly excluded greenhouse gas reduction obligations for developing countries, a number of developed countries, notably, the United States and Australia, continued to argue that 'key' developing countries should adopt, at a minimum, voluntary reduction targets.[191] The G8 added in 1997, prior to the Kyoto Protocol, that,

> Action by developed countries alone will not be sufficient to meet this goal [the stabilization of atmospheric concentrations of greenhouse gases at an acceptable level]. Developing countries must also take measurable steps, recognising that their obligations will increase as their economies grow.[192]

Accordingly, attempts were made to persuade developing countries to 'voluntarily' consider reduction targets (during the final Kyoto negotiations). However, this attempt was again criticized and blocked,[193] and the Kyoto Protocol came to stipulate in its preamble that, 'the process will not introduce any new commitments for Parties not included in Annex I'.[194] Although there was no specified reduction target for developing countries, they still had the general obligation to formulate, implement, publish and regularly update national and, where appropriate, regional programmes containing measures to mitigate climate change and measures to facilitate adequate adaptation to climate change.[195] Unwilling to accept such limited obligations for developing countries, the G8 continued to express their intention to,

> Look at ways of working with all countries to increase global participation in establishing targets to limit or reduce greenhouse gas emissions. We look forward to increasing participation from developing countries, which are likely to be most affected by climate change and whose share of emissions is growing. We will work together with developing countries to achieve voluntary efforts and commitments.[196]

This approach was successful as at the fourth COP in 1998, Argentina and Kazakhstan both indicated they might be willing to undertake greenhouse gas controls.[197] These pledges of intention were expressly welcomed

---

[191] Pearce, F. (1997). 'It's a Deal, But Can It Work?' *New Scientist.* Dec 13. 6. Pearce, F. (1997). 'Rich Nations Squabble In the Greenhouse'. *New Scientist.* March 15. 10. Editor. (1997). 'Mission Improbable'. *New Scientist.* Nov 29. 3. 7 *YBIEL.* (1996). 132. Ott, H. (1998). 'The Kyoto Protocol: Unfinished Business'. *Environment.* 40 (6): 18–34. Pearce, F. (1998). 'The Fog Descends'. *New Scientist.* Nov 7. 14.

[192] G8 Summit Communique. (Denver). Available from <http://www.g7.utoronto.ca/g7/summit/1997denver/98final.htm>

[193] Ehrmann, M. (1997). 'Spring Time in the Climate Negotiations?' *Environmental Policy and the Law.* 27 (3). 192–196. 8 *YBIEL.* (1997). 177.

[194] Kyoto Protocol. Preamble. Paragraph 4.

[195] Kyoto Protocol. Article 10.

[196] G8 Summit Communique. (Birmingham). Available from <http://www.g7.utoronto.ca/g7/summit/1998birmingham/finalcom.htm>

[197] See Depledge, J. (1999). 'Coming Of Age At Buenos Aires'. *Environment.* 41 (7). 15, 18.

by the G8 in 1999.[198] At the fifth COP in 1999, Kazakhstan requested to be put on Annex I of the FCCC, and thereby classified as a developed country for FCCC and Kyoto Protocol purposes.[199] Although the G8 welcomed such developments they warned that, 'the ultimate objective of the Convention will require much greater efforts in developed, and developing countries'.[200] Despite the G8 push, the Delhi Declaration from the eighth COP was notable for its failure to include reference to a 'wider participation' with regard to greenhouse gas reduction targets for the post 2012 period.[201]

E. Targets for Substances with Ozone Depleting and Global Warming Potential

There is a strong overlap between the substances that deplete the ozone layer and also add to climatic change. Despite this overlap, the FCCC focus was initially on controlling, 'anthropogenic emissions of carbon dioxide and other greenhouse gases not controlled by the Montreal Protocol'.[202] Although this separation of substances was followed in the Kyoto Protocol,[203] the two regimes have come to overlap, and both have sought complementary synergies with each other, so as to achieve shared environmental objectives.[204] These synergies are necessary as some substances, such as hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) are listed for control under both the Kyoto Protocol and the Montreal Protocol.[205] Although the respective COPs have agreed to work with each other on these overlapping

---

Tangen, K. (1999). 'The Climate Change Negotiations: Buenos Aires and Beyond'. *Global Environmental Change*. 9: 175–178. Desai, B. (1999). 'Institutionalising the Kyoto Accord'. *Environmental Policy and the Law*. 29 (4): 159. Argentina had ambitious plans for expanding into renewable technologies and Kazakhstan had emissions 45% below their 1990 level.

198 G8 Summit Communique. (Koln). Available from <http://www.g7.utoronto.ca/g7/summit/1999koln/finalcom.htm>

199 The Kazakhstan process was concluded in 2001. Pearce, F. (1999). 'A Carbon Fix?' *New Scientist*. June 12. 22.

200 G8 Environment Minister's Communique. Available From http://www.g7.utoronto.ca/g7/environment/2001trieste/communique.html Paragraph 8.

201 Anon. (2003). 'Less Than Satisfactory Results'. *Environmental Policy and the Law*. 33 (1): 18–22.

202 FCCC. Article 4 (2) (b).

203 Kyoto Protocol. Article 2 (a) (vii).

204 Decision X/16. Implementation of the Montreal Protocol in Light of the Kyoto Protocol. Decision XIII/29. Recognizing the Preparations for the World Summit on Sustainable Development 2002. Point 3.

205 Decision 13/CP.4. Relationship between efforts to protect the stratospheric ozone layer and efforts to safeguard the global climate system: issues related to hydrofluorocarbons and perfluorocarbons. Paragraph 1. Decision X/16. Implementation of the Montreal Protocol in Light of the Kyoto Protocol.

substances, and reports on the issue have been called for,[206] the identification of which international organisation has primary responsibility for controlling these substances, has not been settled.

F. Overlapping International Organizations

With regard to the control of greenhouse gases which fall outside strictly national emissions, such as those caused by international maritime and air transport, the Kyoto Protocol stipulated,

> The Parties included in Annex I shall pursue limitation or reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organization and the International Maritime Organization, respectively.[207]

Despite this point, although the IMO has undertaken discussions and investigations with regard to the contribution from international maritime transport to climate change, no targeted restrictions on this source have appeared.[208]

With regard to the ICAO, although it has been suggested that the greenhouse gas emissions from commercial aircraft involved in international travel should be controlled, the ICAO has refused to endorse such a suggestion.[209] Rather, the ICAO has sought to promote further scientific research into the area of greenhouse gas emissions from civilian aircraft, and has only recommended that States pursue limited voluntary measures in this area. That is, the ICAO has recommended that even voluntary greenhouse gas reduction levies should not be pursued until this matter is further discussed within the ICAO in 2007.[210]

---

[206] Decision 17/CP.5. Relationship between efforts to protect the stratospheric ozone layer and efforts to safeguard the global climate system. Decision XIV/10. Relationship Between Efforts to Protect the Stratospheric Ozone Layer and Efforts to Safeguard the Global Climate System: Issues Relating to Hydrofluorocarbons and Perfluorocarbons. Decision 12/CP.8. Relationship between efforts to protect the stratospheric ozone layer and efforts to safeguard the global climate system: issues relating to hydrofluorocarbons and perfluorocarbons.

[207] Kyoto Protocol. Article 2. 2.

[208] 9 *YBIEL*. (1998). 579. 8 *YBIEL*. (1997). 496.

[209] Abeyratne, R. (2003). 'Air Transport and Sustainable Development'. *Environmental Policy and the Law*. 33 (3): 138–142. 10 *YBIEL*. (1999). 229. Anon. (1998). 'Action on Transport'. *Environmental Policy and the Law*. 28 (1). 29. Report of the 2nd COP, Geneva, 1996. Proceedings. FCCC/CP/1996/15. 29 October 1996. 33.

[210] ICAO. Resolutions from the 2004 Assembly of the 35th Session of the ICAO. See Resolution A35–5. A Consolidated Statement of Continuing ICAO Policies and Practices Related to Environmental Protection. Appendix H. Environmental Impact of Civil Aviation on the Atmosphere.

3. Reductions in Air Pollutants

A. Controlling Air Pollution

Before air pollution was an international problem, it was a national one, and before it was a national problem, it was a local one that was resolved in civil law. It was not until the nineteenth century that a number of countries began to develop their own national policies on air pollution. The United Kingdom has the first legislation with the Alkali Act of 1863, and Cincinnati, passed the first smoke ordinances in the United States in 1871.[211] Air pollution first became an international issue at the end of the nineteenth century with the Trail Smelter arbitration between Canada and the United States in which a tribunal awarded damages to the USA and prescribed a regime, which became a cornerstone of international environmental law, that attempted to control further emissions from the Canadian smelter. The tribunal eventually concluded in 1941,

> No state has the right to use or permit the use of its territory in such a manner as to cause injury by fumes in or to the territory of another.[212]

In 1961, the Council of Europe's Parliamentary Assembly, took up the problem of air pollution, and recommended that the Committee of Ministers, 'convene a European Convention on Air Pollution'.[213] The Conference, which took place in 1965, set up a Committee of Experts to examine the problem, which in turn, led to the 1968 Declaration of Principles of Air Pollution.[214] Two year later, the Council of Europe in 1970 declared that it was, 'desirable to limit the concentration of sources of emissions' of air pollutants, irrespective of their source.[215] However, this issue could not be resolved within Europe, and accordingly, Sweden placed the issue of

---

[211] For a detailed discussion of the early legislation see Ashby, E. & Anderson, M. (1981). *The Politics of Clean Air*. (Oxford University Press, Oxford). Chapter 9. Sherman, J. (2004). *Gasp: The Swift and Terrible Beauty of Air*. (Shoemaker, New York). 167–219.

[212] Trail Smelter Arbitration. 35 *AJIL*. (1941). 716.

[213] Recommendation 290.

[214] This included liability of those causing the pollution, legislation to reflect technical and scientific needs, pollution control in frontier areas, and town and country planning measures for supervision and implementation. See Resolution 68: 4 For a discussion of this period, see 1 *YBIEL*. (1990). 359.

[215] Council of Europe Committee of Ministers. Resolution (70) 11. March 7, 1970. On the Co-Ordination of Efforts Made in Town and Country Planning in Air Pollution Control. *IPE*. XV. 7532. The following year, the Council of Europe passed a resolution which recognized that: "it is in the common interest to prevent as far as possible the occurrence of problems caused by transfrontier air pollution." Council of Europe. Committee of Ministers. Resolution (71) 5. Air Pollution in Frontier Areas. Reprinted in *IPE*. XV. 7560.

transboundary air pollution on the agenda at the 1972 Stockholm Conference on the Human Environment. One of the most notable conclusions of the Conference was Principle 21 of the Stockholm Declaration. This principle, which is recognised as a cornerstone of international environmental law,[216] declared,

> States have . . . the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other states or of areas beyond the limits of national jurisdiction.

Principle 21 was incorporated into matters of air pollution through the 1974 OECD Guidelines for Action to Reduce Emissions of Sulphur Oxides and Particular Matter from Fuel Combustion in Stationary Sources.[217] Despite the unanimous agreement on this incorporation within the OECD, the Guidelines were not a legally binding document. The G7 acted in a similar way, in that although they were simultaneously expressing their intention to double their coal production in the 1970s, they also promised to, 'do everything in our power to ensure that increased use of fossil fuels, especially coal, does not damage the environment'.[218] The interest of the G7 and the OECD in this area, was also supplemented by work of the International Labour Organization (ILO)[219] and prominent international NGOs such as the IUCN which argued that, 'international agreements to control air pollution', were required.[220] The eventual agreement which culminated in 1979 was the Convention on Long Range Trans-boundary Air Pollution[221] (LRTAP). The LRTAP has been supplemented by Protocols in 1984, 1985, 1988, 1991, 1994 and 1999.

The other region which has similar agreements is the Americas. Specific agreements were reached between the United States and Mexico in 1986. The core of this agreement was that smelters on both sides of the border would not exceed transboundary SO_2 emissions of a set percentage over set time periods.[222] The other agreement of note is the 1991 Agreement

[216] Principle 2, Rio Declaration on the Environment and Development
[217] These Guidelines suggested: "states have a responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States." 1974 OECD Guidelines for Action to Reduce Emissions of Sulphur Oxides and Particular Matter from Fuel Combustion in Stationary Sources. *IPE*. XV. 7628. Preamble.
[218] G7 Venice Summit (1980). Summit Communique, available from <http://www.g7.utoronto.ca/g7/summit/1980venice/communique/energy.html>
[219] 1977 Convention Concerning the Protection of Workers Against Occupational Hazards in the Work Environment Due to Air Pollution. Reprinted in *IPE* XXIII. 335.
[220] IUCN, 14th Session. 1978. *IPE*. XXIII. 313, 314.
[221] Convention on Long Range Transboundary Air Pollution. BH764.txt.
[222] See Annex IV to the Agreement Between the Untied States of America and the United Mexican States on Co-Operation for Protection of the Environment in the Border Region, Regarding Transboundary Air Pollution Caused By Copper Smelting Along Their Common Border. 26 *International Legal Materials* (1987). 33.

between the United States and Canada on Air Quality. This Agreement set down specific air quality objectives in terms of emission limitations or reductions of SO_2 and NOx.[223] Many of the Canadian and United States commitments have been incorporated into the LRTAP regime.

The final region which has similar agreements is South East Asia. Within this region, in 2002, the Agreement on Transboundary Haze Pollution was signed. This Agreement was predicated upon the idea of co-operation in confronting the sources of air pollution, rather than by establishing overall limits of air pollutant emissions. As such, no specific air pollutant emission targets are within the agreement.[224]

B. The LRTAP Regime

The way that the targets have been achieved within the LRTAP and its Protocols has been unique. This process began with the LRTAP, which although recognising Principle 21 of the Stockholm Declaration, did not contain any emission restriction targets. Rather, the signatories to the LRTAP only had to, 'endeavour to limit, and as far as possible, gradually reduce and prevent air pollution'.[225] This approach was negated in the Protocols that followed and came to focus on specific air pollutants. Thereafter, the pollutants have been controlled by either direct restrictions on how much can be emitted, or by requiring that the constituents of various fuels, such as restricting the amount of sulphur that can be included in a fuel mix, be changed. Such changes can make quick and effective reductions in emissions of either air pollutants,[226] or climate change gases.[227]

---

[223] Agreement Between the Governments of the United States of America and the Government of Canada on Air Quality. 30 International Legal Materials. (1991). 676. Article IV & Annex 1. For the United States, this involved a commitment to reduce annual sulphur dioxide emissions to approximately 10 million tons below 1980 levels by 2000, with a permanent cap on national emissions of 8.95 million tons for electric utilities by 2010. The Canadian reduction was for 2.3 million tons by 1994, and a total cap of 3.2 million tons by 2000. For nitrogen oxides, the United States had to make a total reduction by approximately 2 million tons from 1980 levels by 2000 (made up of commitments on both stationary and mobile sources). Conversely, Canada had no overall target, but rather commitments in terms of its stationary sources (670,000 total emissions by 2005) and like the United States, multiple obligations in terms of new limits for the mobile sources.

[224] Editor. (2002). 'Agreement on Forest Fire Haze'. *Environmental Policy and the Law.* 32 (5): 214–215.

[225] Article 2.

[226] 1994 Protocol on Further Sulphur Reductions. Article 2 (4). 1994 Protocol on Further Reductions of Sulphur Emissions. Annex IV. Control Technologies For Sulphur Emissions From Stationary Sources. Paragraph 9 (ii) (b). 1988. Sophia Protocol. Technical Annex. Paragraph 15.

[227] The FCCC COPs have noted the importance of assisting developing countries in utilizing, 'less greenhouse gas-emitting, environmentally sound, energy sources, including

The first LRTAP instrument to adopt direct restrictions and air pollutants was the 1985 Protocol on the Reduction of Sulphur Emissions or their Transboundary Fluxes by at Least 30 per cent (the Helsinki Protocol).[228] This protocol contained the legal obligation that,

> The Parties shall reduce their national annual sulphur emissions or their transboundary fluxes by at least 30% as soon as possible and at the latest by 1993, using 1980 levels as the basis for calculation of reductions.[229]

The 1988 Protocol Concerning the Control of Emissions of Nitrogen Oxides or Their Transboundary Fluxes (the Sophia Protocol) legally obliged Parties to,

> Control and/or reduce their national annual emissions of nitrogen oxides or their trans-boundary fluxes so that these, at the latest by 31 December 1994, do not exceed their national annual emissions of nitrogen oxides or transboundary fluxes of such emissions for the calendar year 1987.[230]

The specific legal obligation of the 1991 Protocol Concerning the Control of Emissions of Volatile Organic Compounds or their Transboundary Fluxes (the VOC Protocol)[231] is that its signatories shall, take effective measures to reduce national emissions of VOCs by 30% by 1999.[232] Note however, that the Parties to VOC Protocol also agreed to single out certain areas which require extra stringent management[233] due to their sensitivity to VOC air pollution. Under the 1991 VOC Protocol, listed Tropospheric Ozone Management Areas (TOMA) included the Lower Fraser Valley in the Province of British Columbia and the Windsor-Quebec Corridor in

---

natural gas, according to the national circumstances of each of these Parties'. Decision 5/CP.7 Implementation of Article 4, paragraphs 8 and 9, of the Convention. Likewise, the 2002 World Summit on Sustainable Development, agreed that, 'the transition to the cleaner use of liquid and gaseous fossil fuels, where considered more environmentally sound, socially acceptable and cost-effective'. WSSD. Plan of Implementation of the World Summit on Sustainable Development. A/CONF.199/L.1. Paragraph 8 (d).

228 1985 Protocol to the 1979 Convention On Long-Range Transboundary Air Pollution on the Reduction Of Sulphur Emissions Or Their Transboundary Fluxes by at Least 30 Per Cent (the Helsinki Protocol) BH868.txt.

229 Article 2.

230 Protocol to the 1979 Convention on Long Range Transboundary Air Pollution Concerning the Control of Emissions of Nitrogen Oxides or Their Transboundary Fluxes. 28 *International Legal Materials*. (1989). 212. BH930.txt Article 2.

231 Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution Concerning the Control Of Emissions of Volatile Organic Compounds or their Transboundary Fluxes (1991). BH994.txt.

232 1991 VOC Protocol. Article 2 (1) and (2) (a).

233 Special obligation, when one Parties VOCs effect a TOMA of another, the offending country shall reduce its VOCs by 30% (same reduction as before) and its national emissions of VOCs by 1999 do not exceed the 1988 level). 1991 VOC Protocol. Article 2 (2) (b).

the Provinces of Ontario and Quebec. The Norwegian mainland was also listed.[234]

The tradition of blanket reductions by which all the Parties make the same reductions was not incorporated into the 1994 Protocol on Further Reductions of Sulphur Emissions (the Oslo Protocol).[235] The Oslo Protocol was the first to use differentiated targets for SO_2 reductions, based on the idea that restrictions of SO_2 should be based on the tolerance of ecosystems to SO_2 emissions.[236] Accordingly, because all ecosystems are different, in both type and location, mandated SO_2 reductions ranged from 80% for the United Kingdom, through to 3% for Portugal.[237] Note also, that although the Oslo Protocol had differentiated emission controls, it retained the idea that certain areas which require extra stringent management due to their sensitivity to SO_2 air pollution. These are known as Sulphur Oxide Management Areas (SOMA)[238] and South East Canada was listed as one such SOMA.[239]

Although the Oslo Protocol broke with tradition and introduced differentiated targets for SO_2 controls, the 1999 Gothenburg Protocol, which entered force in 2005, went even further, in trying to establish differentiated targets for a NOx, VOCs, ammonia and SO_2.[240] The result of this is that all the earlier blanket responses under the 1985, 1988 and 1991 Protocols, and the differentiated target under the 1994 Protocol, were eclipsed by differentiated goals, based on the critical limit theory. In addition to the general critical limit theory, some areas could be singled out due to their sensitivity to the respective air pollutants. These are known as Pollutant Emission Management Areas (PEMAs). However, unlike the earlier LRTAP protocols on special management areas, the Gothenburg Protocol restricted such areas to only large countries (greater than 2 million square kilometres) where the pollutants are primarily internally generated.[241] The only PEMA recognised under the Gothenburg Protocol is the Russian Federation.[242]

Under the Gothenburg Protocol, with regard to VOCs, differentiated reduction targets ranged from a 69% reductions for Germany (from 3,195

---

234 1991 VOC Protocol. Annex 1.

235 Protocol on Further Reduction of Sulphur Emissions. 33 *International Legal Materials* (1994). 1542.

236 1994 Protocol on Further Sulphur Reductions. Article 2. See chapter six of this book.

237 1994 Protocol on Further Sulphur Reductions. Annex II. Sulphur Emission Ceilings And Percentage Emission Reductions. Available from <http://unece.org/env/lrtap/protocol/94sulp_a/annex2.htm>

238 1994 Protocol. Article 1.

239 1994 Oslo Protocol. Article 2 (3) (c).

240 Gothenberg Protocol. Article 3. Annex II. Emission Ceilings.

241 1999 Gothenberg Protocol. Article 3 (9).

242 1999 Gothenberg Protocol. Annex III. Designated Pollution Emissions Management Area.

tonnes of VOCs in 1990 to 995 tons in 2010) to 0% reductions for Armenia (which had the lowest emissions in the region of 81 tons in 1990). The overall reductions for the European Union as a whole are projected to be 57%, in terms of reductions of VOC emissions from 15,353 tonnes in 1990 to 6600 tonnes in 2010.[243]

In terms of reductions of NOx, the 1999 Gothenburg Protocol, established a series of differentiated reductions which ranged from a 60% reduction for Germany (from 2,693 tonnes in 1990 to 1,081 in 2010) through to 0% reductions for Greece and Armenia. The United Kingdom reduction is 56% from 2,673 tonnes in 1990 to 1,181 tonnes in 2010. The European Union average is a 49% reduction (from 13,161 tonnes in 1990 to 6,671 tonnes in 2010).[244] With regard to ammonia,[245] reductions aim for a 15% reduction within the European Union area by 2010 (3,129 tonnes), from 1990 figures (3,671 tonnes). The differentiated reductions range from Norway having to reduce their ammonia emissions by 23 tons, through to a 43% reduction for the Netherlands from 226 tonnes reduced to 128 tonnes.[246]

In terms of SO_2 emissions, the 1999 Gothenburg Protocol set differentiated reductions, from a 90% SO_2 reduction for Germany (from 5,313 tonnes in 1990 to 550 in 2010), 83% for the United Kingdom (from 3,731 tonnes in 1990 to 625 in 2010) through to a 7% increase for Greece (from 509 to 546). The EC reduction as a whole is 75% (from 16,436 tonnes in 1990 to 4,059 tonnes in 2010).[247]

Finally, the Gothenburg Protocol contained Annex IV which suggested limit values for sulphur content of fuel utilized for stationary sources, and emission limits for VOCs from industrial and commercial stationary sources.

C. Outside of the LRTAP Regime

The long running dispute over transboundary air pollution between the United States and Canada was first confronted in a Memorandum of Intent. This memorandum acknowledged the LRTAP, and recorded their joint determination to confront the problem at hand.[248] Despite these good faith intentions, the problem of transboundary air pollution was an irritant

[243] Gothenburg Protocol. Annex II. Emission Ceilings. Table 4.
[244] Gothenburg Protocol. Annex II. Emission Ceilings. Table 2.
[245] Gothenburg Protocol. Preamble. Paragraph 19.
[246] Gothenburg Protocol. Annex II. Emission Ceilings. Table 3.
[247] Annex II. Emission Ceilings. Table 1.
[248] Memorandum of Intent Between the Government of the United States and the Government of Canada Concerning Transboundary Air Pollution. 1980, August 5. In *IPE*. XXVIII. 352.

between the two countries[249] until an Agreement on Air Quality[250] was signed by the two countries in 1991. This agreement obliges each Party to control their own air pollution and its transboundary impact. It also established a series of good-faith mechanisms, such as environmental impact assessments, and prior informed activities, in conjunction with the International Joint Commission with a bilateral Air Quality Committee.[251] This Agreement, which was later updated[252] contains a number of annexes with specific air pollution reduction commitments, which form the basis of the Canadian and American commitments under the LRTAP Protocols.[253]

In addition to dealing with Canada, the United States has also dealt with Mexico over trans-boundary air pollution. This process began in 1987, after being identified as a problem in 1985,[254] when both countries agreed to stop polluting each other with transboundary air pollution.[255] This was later subsumed within their joint Bi-National Environmental Program (the Border XXI Program).[256]

Attempts to 'harmonise transboundary air pollution prevention and abatement practices' in Asia beginning in 1990, and took five years to evolve, before the ASEAN Co-operation Plan on Transboundary Pollution was agreed.[257] The Co-Operation Plan consists of assessing the origin, causes, nature and extent of both national and regional pollution, run through the ASEAN Specialised Meteorological Centre. This is complimented by common, harmonised inventories, air quality indexes, danger rating systems and shared and disseminated information. Early detection warning systems, and the prohibition of burning biomass during haze periods, as well as minimizing the generation of all other contributing pollution from local sources are also broad objectives. The long term goal is the development

249 Anon. (1979). 'Acid Rain Comes Between Canada and the US'. *New Scientist.* August 23. 573. Anon. (1981). 'Ontario Takes the US to Court Over Acid Rain'. *New Scientist.* March 19. 725. Anon. (1981). 'Acid Rain Clouds Relations Between Canada and the United States'. *New Scientist.* Jan 8. 51. Anon. (1983). 'Acid Talks Go Sour'. *New Scientist.* March 3. 570. Joyce, C. (1986). 'Pollution and the 49th Parallel'. *New Scientist.* Jan 16. 20. Anon. (1988). 'Canada Fails to Win Deal on Acid Rain'. *New Scientist.*. May 5. 30.

250 Agreement Between The Government of the United States of America and the Government of Canada on Air Quality. Available from <http://www.epa.gov/airmarkets/usca/agreement.html> 3 *YBIEL.* (1992). 224.

251 Articles III, V, VI & VII and IX.

252 10 *YBIEL.* (1999). 385. 11 *YBIEL.* (2000). 352–353.

253 See the 1994 Oslo Protocol. Article 2 (5). 1999 Gothenburg Protocol. Article 3 (11).

254 Anon. (1985). 'Mexican Smelters Pollute the Rockies'. *New Scientist.* April 4. 5.

255 Anon. (1987). 'Acid Pact Angers Canada'. *New Scientist.* Jan 15. 22.

256 EPA. (2000). About the Border XXI Program. <http://www.epa.gov/usmexicoborder/ef-about.htm>

257 8 *YBIEL.* (1997). 406–408.

of zero-burning practices and technologies. Tii-lateral agreements also operate in this area, such as the 1995 Agreements between Singapore, Indonesia and Malaysia on this matter. Indonesia and Malaysia both promised to take measures to limit the burning of biomass, share firefighters as necessary, and engage in educational efforts to reduce emissions of transboundary air pollution. Singapore also agreed to provide early detection assistance with the assistance of satellite technology.[258] In 1998, an Asian framework convention on transboundary air pollution was called for, and UNEP began work, trying to assist the project.[259]

D. Air Quality Standards

Air Quality Standards (AQS) often accompany international control strategies to combat air pollution. AQS are typically domestically based, and not internationally mandated. The only exception to this is the AQS Guidelines, which are offered by the WHO.[260] The Gothenburg Protocol adopted a series of the WHO guidelines.

AQS for SO_2 have been progressively raised in most countries. The WHO AQS guideline for SO_2 is 500 μg/m3 over a ten minute period, 125 μg/m3 over a 24 hour period, and 50 μg/m3 if averaged out annually. Nitrogen oxide levels are 200 μg/m3 for a one hour period, or 40 μg/m3 if averaged out annually. Lead only has an annual average of 0.5 μg/m3.[261] The WHO and the Gothenburg Protocol recommend AQS for low level ozone of 120 μg/m3 over an eight hour period.[262] Some countries, have stricter AQS for low level ozone than the WHO.[263] However, this is often countered by the fact that many of the constituents of low level ozone, especially VOCs, are subject to individual controls, which have been progressively raised over the last few decades.[264] The best example of this is benzene, which has been subject to international controls since

[258] 8 *YBIEL.* (1997). 167, 405–408. 5 *YBIEL.* 1994. 158.

[259] 9 *YBIEL.* (1998). 641–642, 735.

[260] See WHO. (2000). *Air Quality Guidelines.* (WHO, Geneva, 2nd Edition). 3:2.

[261] WHO. (1999). *Protection of the Human Environment: Air Quality Guidelines.* (WHO, Geneva). III:16.

[262] Gothenburg Protocol. Annex 1, III.

[263] For example, the UK target is 50 ppb. UNEP. (2002). *GEO 3.* (Earthscan, London). 230. Vaughan, C. (1990). 'Streetwise to the Dangers of Ozone'. *New Scientist.* May 26. 42. Pearce, F. (1992). 'Back to the Days of Deadly Smogs'. *New Scientist.* Dec 5. 25–26. Editor. (1994). 'Noxious Fumes'. *New Scientist.* July 23. 3. Anon. (1994). 'Tough Target For Britain's Ozone'. *New Scientist.* May 28. 7.

[264] Stansell, J. (1983). 'Clean Cars Reach Crossroads'. *New Scientist.* November 24. 564–567. Gould, R. (1989). 'The Exhausting Options of Modern Vehicles'. *New Scientist.* May 13. 20–25. Anon. (1989). 'Bush Clears the Air'. *New Scientist.* July 29. 5.

1971,[265] and ever increasing domestic restrictions.[266] The 1999 WHO Recommendations on benzene are 5.0–20.0 μg/m3.[267] WHO AQS for carbon monoxide are based upon microgrammes per cubic metre (mg/m3). The values are 100 mg/m3 over a fifteen minute period, 60 mg/m3 over a thirty minute period, 30 mg/m3 over a hour period, and 10 mg/m3 over an eight hour period.[268] AQS for SPM are more difficult to ascertain, as the identification of SPMs are a relatively new occurrence. Indeed, as late as 1987, the WHO was treating SO_2 and SPM jointly. The first specific standards for SPM 10s originated in Europe in 1980. By the mid 1990s, the AQS for SPM 10s in the European Union was 50 mg/m3 over any 24 hour period.[269] AQS for SPM smaller than SPM 10, were first established in 1997 in both Europe and the United States. The American standard for SPM 2.5s is 15 mg/m3 for an annual target, and 65 mg/m3 over a 24 hour period.[270]

E. Overlapping International Organisations

All commercial aircraft of an international nature, are required to meet the engine certification standards adopted by the Council of ICAO.[271] These were originally designed to respond to concerns regarding air quality in the vicinity of airports. As a consequence, they establish limits for emissions of NOx, CO and unburned hydrocarbons, for a reference landing and take-off cycle. There are also provisions regarding smoke and vented fuel. While these standards are based on an aircraft's landing and take-off cycle, they also help to limit emissions at altitude. Of particular relevance is the standard for NOx. The standard for NOx was first adopted in 1981, then made more stringent in 1993, when the ICAO reduced the permitted

[265] In 1971, the International Labor Organisation passed a Recommendation which suggested that benzene should not exceed a ceiling of 25 parts per million. ILO. Recommendation Concerning Benzene. 1971, June 2. Recorded in *IPE*. XXVIII. 374.
[266] Anon. (1987). 'Clampdown on Benzene'. *New Scientist*. September 10. 25. Hamer, M. (1997). 'Fighting for Air'. *New Scientist*. Apr 19. 14–15. See also 7 *YBIEL*. (1996). 386–387.
[267] WHO. (1999). *Protection of the Human Environment: Air Quality Guidelines*. (WHO, Geneva). III:39.
[268] WHO. (1999). Ibid. III:16.
[269] Hamer, M. (1995). 'Brussels Blocks Britain's Clean Air Plan'. *New Scientist*. Nov 18. 6. Hamer, M. (1996). 'Cars Must Go To Meet Clean Air Targets'. *New Scientist*. May 18. 12. Anon. (1999). 'Not So Clean'. *New Scientist*. Jan 23. 5.
[270] Kleiner, K. (1997). 'Clean Air Plan Steeped in Confusion'. *New Scientist*. Feb 15. 4. Pearce, F. (2002). 'Big City Killer'. *New Scientist*. March 9. 8. Hamer, M. (1997). 'Clearing the Air'. *New Scientist*. Nov 15. 12. Cohen, M. (1996). 'Mother Nature Could Break US Clean Air Law'. *New Scientist*. Nov 16. 7.
[271] These provisions are contained in Annex 16—Environmental Protection, Volume II, Aircraft Engine Emissions to the Convention on International Civil Aviation.

levels by 20 per cent for newly certificated engines, with a production cut-off at the end of 1999. In 1999, the Council further tightened the standard by about 16 per cent on average for engines newly certificated from the end 2003. The emissions standards do not encompass CO_2.

International law also controls emissions of air pollution from ocean vessels of a commercial nature, over 400 tonnes in weight. NOx emissions are controlled by the IMO through the technical code for NOx emissions from marine diesel engines. This code is part of Annex VI to the MARPOL Convention. Accordingly, NOx emissions must be kept below levels which are tagged to the amount of revolutions per minute of different engine sizes.[272] Levels of VOC emissions are also regulated, although not as strictly as emissions of NOx.[273] Unlike emission levels for NOx and VOCs, SO_2 is dealt with by restricting the type of fuel oil that may be used on board ships. Specifically, the sulphur content of any fuel used on board ships shall not exceed 4.5% of its total volume.[274] The 4.5% figure was the source of disappointment to many countries, who wanted a target of 3.0% or lower. This was especially so as the average sulphur content in fuel used in international shipping by the year 2000 was 2.7%.[275] However, special coastal areas can be designated in which SO_2 fuel content or SO_2 emission controls are more stringent than the IMO standards.[276]

F. Domestically Mobile Sources of Air Pollution

International controls on pollution from motor vehicles began in 1949. Although Conventions on Motor Traffic date back to 1926,[277] it was not until 1949 that pollution as such became an international topic with the Convention on Road Traffic which required exhaust silences for all vehicles.[278] By the late 1950s, international agreements on the Uniform Conditions for Motor Vehicles were being concluded, which contained internationally

---

272 See Regulation 13 of Annex VI of the 1973 International Convention for the Prevention of Pollution from Ships (MARPOL). This is reprinted in IMO (2003). *MARPOL 73/78*. (IMO, London). 408.

273 See Regulation 15 of Annex VI. Ibid. 411–412.

274 See Regulation 14 of Annex VI. Ibid. 410.

275 10 *YBIEL*. (1999). 698. 11 *YBIEL*. (2000). 658. 8 *YBIEL*. (1997). 495–496. Bond, M. (1996). 'Ships Evade Acid Rain Controls'. *New Scientist*. June 22. 8.

276 See Appendix III of Annex VI of the 1973 International Convention for the Prevention of Pollution from Ships (MARPOL). Ibid., 429–431.

277 The initial obligations related to considerations such as the installment of suitable steering columns, brakes and registration plates. Convention on Motor Traffic (1926). British TS. No 11 (1930). Cmd. 3510. Reprinted in Hudson, R. (ed.). *International Legislation*. (Oceana, New York, 1950). Volume III: 1925–27.1858–1875. This was updated in 1930 with the Convention on the Regulation of Automotive Traffic Also in Hudson. Volume V: 1929–31. 786.

278 Convention on Road Traffic, 1949. Reprinted in *IPE* Volume XV. 7399.

agreed limits for CO, with different limits applied to different size engines.[279] Over the following decades, the only furtherance of controls of air pollutants from motor vehicles beyond domestic controls, came from the European Union, which began to mandate air pollution limits from mobile sources as early as 1970.[280] Thus, outside of some recognition that mobile sources of air pollution are a serious concern that need to be confronted, by the G7,[281] Agenda 21[282] the European Charter on Transport, Environment and Health,[283] and the WSSD,[284] there is no specific convention on Transport and the Environment. This is despite the fact that the idea has been mooted since 1990, and it may be relatively easy to achieve, as fourteen companies produce more than four-fifths of the world's automobiles.[285] The only exception to this area is the protocols to the LRTAP regime which have come to recognise the problem of air pollution from domestically mobile sources,[286] and encompass a number of restrictions to control it. These restrictions have been achieved by emission limits for different types of vehicles, limits for different types of fuels and mandated types of technology.

[279] Agreement Concerning the Adoption of Uniform Conditions of Approval and Reciprocal Recognition of Approval for Motor Vehicle Equipment and Parts. 1958. In IPE, XV, 7401. Article 5.2.1.1.4.

[280] See for example, Council of Europe Committee of Ministers. Resolution (70) 11. March 7, 1970. On the Co-Ordination of Efforts Made in Town and Country Planning in Air Pollution Control. *IPE*. XV. 7532. Council of Europe Committee of Ministers. Council Directive on the Approximation of the Laws for Air Pollution [from] Motor Vehicles. Reprinted in *IPE*. XV. 7565. Directive No 70/220/EEC. Council of Europe Committee of Ministers. Resolution (70) 11. March 7, 1970. On the Co-Ordination of Efforts Made in Town and Country Planning in Air Pollution Control. *IPE*. XV. 7532. Commission Directive. 78/665/EEC. Reprinted in *IPE* XXIII. 406. Consultative Assembly of the Council of Europe. Resolution 510 (1972). On the Reduction of Air Pollution from Motor Vehicle Exhaust Gases. Reprinted in *IPE*. XV. 7581. Anon. (2001). 'White Paper on Transport'. *Environmental Policy and the Law*. 31 (6): 299–300.

[281] G7 Summit, Communique, Bonn, 1985. Available from http://www.g7.utoronto.ca/g7/summit/1985bonn/communique/environment.html>

[282] Agenda 21 recognised, "the transport sector is also a source of atmospheric emissions." Accordingly, the objective is: "to promote cost effective policies or programmes, as appropriate, to limit, reduce or control, as appropriate, harmful emissions into the atmosphere . . . taking into account development priorities as well as local and national circumstances." Paragraph 9.14.

[283] Charter on Transport, Environment and Health. EUR/ICP/EHCO 020205/9 Rev.4. 09009–16 June, 1999. Declaration of the Third Ministerial Conference on Environment and Health. (1999). Paragraph 12. Available from http://www.who.dk/london99/english.htm added to this with the recognition that: "the current patterns of transport in the European region, dominated by road motor vehicles, are not suitable and have significant adverse impacts on health and the environment, and that the potential health risks benefits of sustainable transport have not been adequately explored."

[284] WSSD. Plan of Implementation of the World Summit on Sustainable Development. A/CONF.199/L.1. Paragraphs 20 (a) & (b).

[285] Pearce, F. (1994). 'Greenhouse Targets Beyond 2000'. *New Scientist*. Sep 3. 7. Anon. (1989). 'Britain Seeks Global Action to Halt Global Warming'. *New Scientist*. May 20. 4.

[286] 1988 Sophia Protocol. Preamble. Gothenburg Protocol. Article 6 (1) (e).

In terms of emission limits for various types of vehicles, the 1991 VOC Protocol was the first to recommend a series of emission limits of VOCs for domestically mobile sources, as well as associated systems, such as petrol stations.[287] Many of the VOC obligations were repeated in the 1999 Gothenburg Protocol which established air pollution emission limits for CO, NOx and SPM for new mobile sources for passenger cars, light-duty vehicles, heavy duty vehicles, motorcycles and mopeds and non-road vehicles and machines.[288] The standards for NOx, which were first utilized in the United States in 1968 and were set at 3.6 grammes per mile for the average passenger car,[289] were with the Gothenburg Protocol, depending on vehicle size and fuel usage, set between 0.08 to 0.21 grammes per kilometre (for all classes of petrol vehicles) and 0.25–0.78 (for diesel vehicles). For SPM pollution, the Gothenburg standards for diesel passenger vehicles and light weight transport, depending on engine size and phase in dates, range from 0.025 to 0.10 grammes per kilometre. VOC standards, depending on engine size but not fuel type, as they only apply to petrol, not diesel engines, range between 0.10 and 0.29 grammes per kilometre.[290] CO emission levels, which originally began in 1967 in the United States at 87.0 grammes per mile for the average passenger car, were in the Gothenburg Protocol, depending on the engine size and fuel type as low as 1.0 grammes per kilometre.[291]

In terms of setting limits for the constituents of different types of fuels, as a method to control air pollution, the most notable LRTAP instrument was the 1988 Sophia Protocol, which was unique in its time, for recommending that lead-free petrol be made available in the territory of each signatory to the Protocol.[292] Outside of the Sophia Protocol, the only recommendation of note to phase-out lead based petrol came from the WSSD.[293] In all other instances, restrictions on the lead based content of petrol have been domestically driven. This is especially so in many developed countries from the early 1980s and a number of developing countries including China, and parts of the Middle East and Africa.[294]

---

[287] VOC Protocol. 1991. Articles 2 (b) (iii); 10. and Annex III. Paragraph 12.

[288] 1999 Gothenberg Protocol. Annex VIII. Limit Values for New Mobile Sources.

[289] Stansell, J. (1983). 'Clean Cars Reach Crossroads'. *New Scientist*. November 24. 564–567.

[290] Gothenberg Protocol. (1999). Annex VIII. Table 1.

[291] Gothenberg Protocol. (1999). Annex VIII. Table 1.

[292] 1988 Sophia Protocol. Article 4. Note this did not represent a regional or international call for a prohibition of unleaded fuel. Indeed, the attempt to achieve this in the mid 1990s was squarely blocked (by Australia and Canada). Patel, T. (1995). 'Industry Blocks International Ban'. *New Scientist*. July 15. 10.

[293] WSSD. Plan of Implementation of the World Summit on Sustainable Development. A/CONF.199/L.1. Paragraph 49 (b) & (c). See also paragraph 8.

[294] UNEP. (2002). *GEO 3*. (Earthscan, London). 233. Hodes, G. (2003). 'A Strategy to Phase Out Lead in African Gasoline'. *Renewable Energy for Development*. 16 (3): 1–4. 9 *YBIEL*. (1998). 478.

The LRTAP regime established limits for the amounts of other constituents in fuel utilized for domestically mobile sources. This began with the 1991 VOC Protocol,[295] and was followed with the 1999 Gothenburg Protocol, which specified permissible limits for sulphur content, oxygenates and hydrocarbons.[296] These processes have also been mirrored in a number of countries which have increasingly raised standards.[297] For example, the permissible sulphur content for vehicle fuels in the European Union has fallen from 350 ppm in 1980 to zero by 2009.[298] Likewise, specific restrictions on certain hydrocarbon content within fuels, such as with benzene, have been progressively increased in a number of countries, falling from over 5% by volume to less than 1%.

The final way air pollution from domestically mobile sources can be controlled is through the adoption of key types of certain types of technology. This process can be seen on three levels. The first level deals with catalytic converters. Here, despite the fact that catalytic converters have been mandated domestically in some countries since 1973, and have become prescribed technology in a number of developed and developing countries since then,[299] such technologies are not mandatory under the LRTAP regimes, although their benefits are clearly noted in the 1991[300] and 1988 protocols.[301] Second, under the 1991 Protocol, the utilization of specific technology was directed, but not mandated, to help in to controlling the emission of VOCs which are generated when fuel is put into a mobile source. Although these technologies were not mandatory under the VOC, due to their adoption in a number of countries, by the turn of the century, appropriate technological measures at petrol stations to capture VOCs were well established in most developed countries.[302] Finally, the same successful

295 VOC Protocol. 1991. Article 2 (b) (ii).

296 Gothenberg Protocol. Annex 8. Limit Values for New Mobile Sources. Tables 8–10.

297 Anon. (2003). 'Go With the Grain.' *New Scientist.* Oct 25. 5. Kintisch, E. (2001). 'Spirit of the Road.' *New Scientist.* Jan 20. 12–13. MacKenzie, D. (1995). 'Summer Petrol Cleans Up Viennese Smog.' *New Scientist.* Aug 19. 10.

298 Anon. (2003). 'Sulphur Fumes'. *New Scientist.* Nov 22. 5. Anon. (1997). 'Cleaning Diesel'. *New Scientist.* June 28. 11. Anon. (1998). 'Clean Break'. *New Scientist.* Jan 14. 12. 7 *YBIEL.* (1996). 386–387.

299 Boehmer-Christiansen, S. (1990). 'Curbing Auto Emissions in Europe'. *Environment.* August. 16. Pearce, F. (1986). 'Stalled in a Haze of Ozone'. *New Scientist.* November 20. 18. Hunt, P. (1992). 'Catalysts Make Converts in Far East' *New Scientist.* July 11. 9. MacKenzie, D. (1988). 'Dutch Lead Drive to Banish Car Pollution'. *New Scientist.* December 24. 4. Anon. (1989). 'Dutch Courage Curbs Pollution'. *New Scientist.* March 18. 29. MacKenzie, D. (1988). 'French Torpedo Pact to Limit Car Pollution'. *New Scientist.* July 28. 31. MacKenzie, D. (1988). 'Pollution Accord Creates Technical Dilemma'. *New Scientist* December 3. 29. Anon. (1989). 'Ministers Discover That Cleaner Cars Are Possible After All'. *New Scientist.* June 17. 10.

300 VOC Protocol. 1991. Annex III. Paragraph 18.

301 1988 Sophia Protocol. Article 4.

302 VOC Protocol. 1991. Annex III. Paragraph 33. Jones, N. (2001). 'Breath of Fresh Air.' *New Scientist.* Apr 7. 22. Anon. (1994). 'Petrol Pact.' *New Scientist.* Nov 19. 14.

conclusion for other forms of technological change, such as public transport, although approvingly noted in both the 1988[303] and 1991[304] and regional initiatives such as the European Transport, Health and Environment Plan,[305] remain substantially underdeveloped.

4. The Provision of Renewable, Efficient and Cleaner Energy

A. Technological Choice

The international direction for the adoption of certain advanced technological solutions for air pollution, such as those which remove the sulphur from coal, as discussed in chapter nineteen, began in 1974, with the OECD Guidelines on Air Pollution. These Guidelines suggested, in certain situations, 'advanced particulate arrestment facilities, and/or, whenever appropriate, desulphurization facilities' may be useful to combat air pollution.[306] The LRTAP convention, and the 1985 Protocol,[307] followed the caution of the OECD on this technological question, in that although it obliged its signatories to adopt the, 'best available technology' the caveat was that the technology must be 'economically feasible'.[308] Although the 1988 Protocol reiterated the importance of, 'best available technologies which are economically feasible',[309] and clearly noted that what technological options were suitable for one country, may not be suitable for another,[310] the

---

303 Measures to reduce NOx emissions and other air pollutants may include enforcement of speed limits and efficient traffic management. Key measures for traffic management aim at changing the modal split of public and long range transport especially in sensitive areas like cities . . . by transferring transport from road to rail through tactical, structural, financial and restrictive elements and also be optimising the logistics of delivery systems. Sophia Protocol. Technical Annex. Paragraph 51.

304 This stipulated the signatories shall, 'foster public participation in emission control programmes, through public announcements, encouraging the best use of all modes of transportation and promoting traffic management schemes'. 1991 VOC Protocol. Article 2 (iv).

305 See UNECE. (2002). Transport, Health and the Environment: A Pan-European Programme. ECE/AC.21/2002/9/ Aug 21.

306 1974 OECD Guidelines for Action to Reduce Emissions of Sulphur Oxides and Particular Matter from Fuel Combustion in Stationary Sources. *IPE*. XV. 7628. I. (d). The OECD added the caveat that: "only a few countries consider that they are technically and economically feasible at this time." Annex 9.

307 1985 Helsinki Protocol. Article 6.

308 LRTAP. Article 6.

309 1988 Sophia Protocol. Article 2 (2) (a).

310 As such, although the Technical Annex should be taken into account, 'the characteristics of the plant, its age and its rate of utilization and the need to avoid undue operational disruption'. 1988 Sophia Protocol. Article 2 (2) (c). In addition, 'the choice of pollution control measures for any particular case will depend on a number of factors, including

Protocol nevertheless contained a, 'recommendatory' Technical Annex of various technological options to 'provide guidance'.[311] The same pattern of calling upon Parties to be guided by a recommendatory Annex which sets out technological possibilities, whilst the Parties adopt the best available technological options for reducing air pollutants from existing stationary sources of pollution, which are economically feasible and suit local conditions, was replicated in the 1991,[312] 1994[313] and 1999 protocols. Following the European developments in this area such as the 1988 Large Plants Directive, and mandatory directives in key countries such as the United States, in which clear choices in large scale technology for new stationary sources were restricted, the LRTAP protocols of 1988[314] and 1991[315] adopted a more directive approach, as opposed to recommendatory, for new technologies. The more directive approach, was followed by the protocols of 1994[316] and 1999 which set limit values for specific forms of new or refitted technology.[317] For example, Annex V of the 1999 Protocol set limit values for emissions of NOx from stationary sources including boilers and heaters (exceeding 50 MW), combustion turbines, cement production, iron and steel production, nitric acid production and new stationary engines.[318]

B. Renewable Energy

Renewable energy sources are beneficial for both climate change and air pollution, in that renewable energy sources generate only minimal pollutants for either problem.[319] Given the large importance of the possibilities

---

the relevant legislative and regulatory provisions, primary energy pattern, industrial infrastructure and economic circumstances of the Party concerned and, in the case of stationary sources, the specific circumstances of the plant'. 1988. Sophia Protocol. Technical Annex. Paragraph 4.313.

311 Sophia Protocol. Article 10. Technical Annex. Paragraph 1.

312 VOC Protocol. 1991. Articles 2 (i) and 10. See also paragraphs 1, 3 and 4 of the Annex.

313 1994 Protocol on Further Sulphur Reductions. Articles 2. (4) and 10. See also Annex IV. Control Technologies For Sulfur Emissions From Stationary Sources. Paragraph 4.

314 With application for, 'major new stationary sources [with a thermal input which is over 50 MW] and the retrofitting of existing major stationary sources[a thermal input which is at least 100 MW]' 1988 Sophia Protocol. Preamble.

315 The VOC Protocol applied to new sources, and existing ones if the agreed low-level ozone standards were not met within five years (from the entry date of the Protocol). VOC Protocol. 1991. Article 2 (b) (ii).

316 The 1994 Protocol set values for all new stationary sources, and by 2004 to all major existing stationary sources above above 50 MW (with a special focus on those above 500 MW). 1994 Protocol on Further Sulphur Reductions. Article 4 (5) (a) & (b).

317 1999 Gothenburg Protocol. Article 3 (4). Note the exception for countries in economic transition in Article 3 (3).

318 1999 Gothenberg Protocol. Article 12. Also, Annex V. Limit Values for Emissions of Nitrogen Oxides from Stationary Sources. See also Guidance Document on Control Techniques for Emissions of Sulphur From Stationary Sources. 1.

319 1994 Protocol on Further Sulphur Reductions. Preamble. Paragraph 13.

of renewable energy in both regimes, it is not surprising that the development and support for renewable sources has been strongly iterated in both domestic and international settings. In some domestic settings, the support for renewable energy, as a method to combat climate change has become so pronounced, that official targets have been established in relation to how much national energy markets must be sourced from renewable sources in the future. For example, both China and the United Kingdom, share the same goal of seeking to achieve 10% of all their domestic energy from renewable sources by 2010.[320]

Within international environmental law, the importance of promoting and facilitating renewable energy sources has been evident since 1975.[321] Since this point, promises of facilitation and promotion of renewable energy have been repeated continually by the G7/G8 in every decade since the 1970s.[322] Similar commitments can also be found in the LRTAP protocols of 1988,[323] 1994,[324] and 1999;[325] within the FCCC,[326] the Kyoto Protocol[327] and the respective FCCC COPs;[328] Agenda 21;[329] and the two United Nations conferences on the topic in 1981 (the New and Renewable Sources

---

320 Note, although there was strong advocacy in the UK for the target to be 20%, in 1997 the figure was only 2%. Ottinger, R. (2004). 'Renewable 2004 Conference'. *Environmental Policy and Law*. 34 (4): 169–170. Ottinger, R. (2000). 'Legal Structures in Use for Climate Change Mitigation'. *Environmental Policy and the Law*. 30 (4): 184, 186. Sykes, L. (1997). 'The Power To Choose'. *New Scientist*. Sep 6. 18–19. Edwards, R. (2001). 'Death Knell For Nuclear Energy'. *New Scientist*. Dec 15. 5. Editor. (2000). 'Off Target'. *New Scientist*. 3. Edwards, R. (2003). 'Britain's Global Energy Vision'. *New Scientist*. March 1. 12. 8 YBIEL. (1997). 227.

321 Council of Europe. Resolution 592 (1975). On the Economic Consequences of the Limits to Growth. Reprinted in *IPE*. XVIII. 9098.

322 G7 Venice Summit (1980). Summit Communique, available from <http://www.g7.utoronto.ca/g7/summit/1980venice/communique/energy.html> G7 Houston Summit. Summit Communique. Available from <http://www.g7.utoronot.ca/g7/summit/1990/houston/communique/energy.html> G8 Ottawa Summit. (2001). Paragraph 66. Available from <http://indonesia-ottawa.org/economy/G8/commu_g8.html> G8 Science and Technology for Sustainable Development. (2003, Evian). Available from <http://www.g7.utoronto.ca/summit/2003evian/sustainable_development_en.html> G8 Genoa Summit. (2001). Paragraph 27. Available from <http://www.g7.utoronto.ca/g7/summit/2001genoa/finalcommunique.html> G7 Ottawa Summit (1981). Summit Communique, available from <http://www.g7.utoronto.ca/g7/summit/1981ottawa/communique/energy.html>

323 1988. Sophia Protocol. Technical Annex. Paragraph 12.

324 1994 Protocol on Further Reductions of Sulphur Emissions. Article 2 (4). Annex IV. Control Technologies For Sulphur Emissions From Stationary Sources. Paragraph 9.

325 Gothenburg Protocol. Article 6 (1) (c).

326 FCCC. Preamble. Paragraph 22.

327 Kyoto Protocol. Article 2 (a) (iv).

328 Decision 5/CP.7 Implementation of Article 4, paragraphs 8 and 9, of the Convention. Decision 4/CP.4. Development and transfer of technologies. Paragraph 2 (a). Decision 9/CP.7. Matters relating to Article 3, paragraph 14, of the Kyoto Protocol. Decision 9/CP.3. Development and transfer of technologies. Paragraph 5 (a). Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Decision 1/CP.8. Delhi Ministerial Declaration on Climate Change and Sustainable Development. Paragraph 1.

329 Agenda 21. Paragraphs 9.12. (i) and 18. (f).

of Energy Conference)[330] and 1996 (the World Solar Summit).[331] A number of international agencies, most notably the GEF, and the World Bank, have substantial projects designed to fulfil the commitments to facilitate and promote renewable energy.[332]

The only attempts to break this cycle and have actual targets for percentage amounts of how much renewable energy should constitute energy markets were made at the WSSD in 2002, and the Bonn Summit on Renewable Energy in 2004. However, with regard to the WSSD, attempts to establish a target of 15% of total global energy supply from renewable sources by 2010,[333] were defeated by the United States and a number of oil producing nations, and the final language was changed to seek, (with at any associated target) a 'substantial increase' in the use of renewable energy.[334] In a very similar manner, the Bonn Summit on Renewable Energy, despite a political declaration and useful policy recommendations, omitted any targets for renewable energy.[335]

C. Energy Efficiency

As discussed in chapter nineteen, the pursuit of more efficient uses of energy is an important method to reduce emissions of substances which cause both air pollution and/or climate change. In many instances, such efficiencies also make sound economic sense, irrespective of their environmental benefits. Accordingly, the pursuit of methods to enhance efficient ways to utilize energy have been notable in international settings since 1970.[336] Since this point, the pursuit and facilitation of energy efficiency has been repeatedly emphasised by the G7/G8.[337] The goal is also identifiable

[330] Coyne, P. (1980). 'Secret Memo Reveals Energy Conservation Collapse'. *New Scientist.* March 27. 987. Anon. (1982). 'An Alternative Energy Authority for Britain?' *New Scientist.* July 1. 4. Anon. (1982). 'Energy Secrets Are Renewable'. *New Scientist.* July 8. 78. Anon. (1982). 'Energy Advisors Torpedo Renewable Energy Research'. *New Scientist.* May 6. 337. Stansell, J. (1981). 'More Light Than Heat'. *New Scientist.* Aug 20. 460–461. Stansell, J. (1981). 'Britain Warns Third World: Avoid Energy Politics'. *New Scientist.* July 23. 205.

[331] Editor. (1996). 'Energy Crisis In the Third World'. *New Scientist.* Sep 29.

[332] Ottinger, Ibid. 170. 4 *YBIEL.* (1993). 196. Kozloff, K. (1995). 'Rethinking Development Assistance for Renewable Electricity Sources'. *Environment* 37 (9): 7–15. 6 *YBIEL.* (1995). 231. Mandishona, G. (1996). 'Technology Transfer Realised in GEF Solar Project'. *Renewable Energy for Development.* 9 (1) 6.

[333] WSSD. Draft (Bali) Plan of Implementation of the World Summit on Sustainable Development. A/CONF.199/L.1. Paragraph 19 (e).

[334] See Edwards, R. (2002). 'Green Energy Targets Blown Away'. *New Scientist.* Sep 3, 7.

[335] Ottinger, R. (2004). 'Renewable 2004 Conference'. *Environmental Policy and Law.* 34 (4): 169–170.

[336] Council of Europe Committee of Ministers. Resolution (70) 11. March 7, 1970. On the Co-Ordination of Efforts Made in Town and Country Planning in Air Pollution Control. *IPE.* XV. 7532.

[337] G7 Venice Summit (1980). Summit Communique, available from<http://www.g7.utoronto.ca/g7/summit/1980venice/communique/energy.html> G7 Paris Summit (1989).

within the LRTAP protocols of 1988,[338] 1994[339] and 1999;[340] Agenda 21;[341] the FCCC;[342] the Kyoto Protocol;[343] respective FCCC COPs,[344] and the IPCC.[345] The 1996 Energy Charter Protocol on Energy Efficiency and Related Environmental Aspects, reiterated the importance of the domestic facilitation and promotion of energy efficiency, but did not contain any targets to be achieved by energy efficiency.[346] The WSSD reiterated all of these goals in 2002,[347] and the GEF and the World Bank financially supports their fulfilment.[348]

The promotion and facilitation of energy efficiency is an equally well recorded goal in most domestic jurisdictions. The difference from the international language in this area is the various methods to achieve the goals of facilitation and promotion. For example, although no country has adopted actual national targets of energy savings to be achieved by energy efficiency,[349] a few countries have mandated strict energy efficiency standards which have to be met for certain products or processes. The American National Energy Policy Act, which set federal efficiency standards for lighting, heating, cooling equipment and electric motors,[350] and the American Corporate Average Fuel Economy regulations, which set federal efficiency standards

Summit Communique, available from <http://www.g7.utoronto.ca/g7/summit/1989/paris/communique/energy.html> G7 Naples Summit (1994). Summit Communique, available from <http://www.g7.utoronto.ca/g7/summit/1994/naples/communique/energy.html> G8 Summit Communique. (Koln). Available from http://www.g7.utoronto.ca/g7/summit/1999koln/finalcom.htm Paragraph 33. G8 Genoa Summit. (2001). Paragraph 27. Available from <http://www.g7.utoronto.ca/g7/summit/2001genoa/finalcommunique.html>

338 1988. Sophia Protocol. Technical Annex. Paragraph 11.

339 1994 Protocol on Further Sulphur Reductions. Article 2 (4). Annex IV. Control Technologies For Sulphur Emissions From Stationary Sources. Paragraph 9.

340 Gothenburg Protocol. Article 6 (1) (c).

341 Agenda 21. Paragraphs 9.9; 9:12 (h)–(j), 9:18 (b) and (f).

342 FCCC. Preamble. Paragraph 22.

343 Kyoto Protocol. Article 2 (a) (i).

344 Decision 4/CP.4. Development and transfer of technologies. Paragraph 2. Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Decision 5/CP.7 Implementation of Article 4, paragraphs 8 and 9, of the Convention. *Decision* 9/CP.7. *Matters relating to Article 3, paragraph 14, of the Kyoto Protocol.*

345 *IPCC. (1996). Climate* Change 1995: Economic and Social Dimensions. (CUP). 6.

346 Availabl.e from http://www.unescap.org/enrd/energy/compend/ceccpart5chapter1.htm See also 7 *YBIEL.* (1996). 173–174. See Article 1, 8 and 9.

347 WSSD. Plan of Implementation of the WSSD. A/CONF.199.L.1. 10. Paragraph 19 (b) and 19 (h).

348 4 *YBIEL.* (1993). 196. 6 *YBIEL.* (1995). 231.

349 Edwards, R. (2001). 'Death Knell For Nuclear Energy'. *New Scientist.* Dec 15. 5. Anon. (1989). 'Efficient Europe'. *New Scientist.* May 20. 5. Boyle, S. (1989). 'More Work For Less Energy'. *New Scientist.* Aug 5. 19–25.

350 3 *YBIEL.* (1992). 273.

for motor vehicles of various classes,[351] are particularly notable in this instance, as was the Californian legislature decision that a certain percentage of cars on the roads of California by 1998 had to be totally free of emissions of air or climate pollution.[352] However, such mandatory measures to achieve energy efficiency are relatively rare in other countries, and are completely absent in international environmental law. The more common approach in a number of different countries, is for the voluntary labelling of products, so that consumers can voluntarily choose for themselves the most energy efficient products or processes they want to purchase.[353] The voluntary SAVE scheme of the European Union which provides consumer information relating to energy efficiency of specific consumer products is most notable in this setting.[354] Although the utility of such consumer information was recognised in Agenda 21,[355] and by the G8,[356] there have been few attempts to make such labelling mandatory domestically, let alone internationally.[357]

D. Fuel Switching

As discussed in chapter nineteen, changing the type of fuel utilized, for either natural gas or one which contains less sulphur, is a very effective way to reduce emissions that produce either air pollution or climatic change. This idea was first utilized in the reign of Edward I of England (1272–1307) when a Royal Proclamation was issued, which prohibited the use of sea coal (coal washed ashore from exposed coal deposits) because of the smoke it produced. Since this point, dozens of countries have, since the 1960s, progressively reduced the permissibility of fuels above a certain sulphur content.[358] However, outside of the actions of international organisations,

[351] See Harrington, W. (2003). 'A Lighter Tread: Policy and Technology Options for Motor Vehicles'. *Environment.* Nov 22–35. Henderson, C. (1998). 'Small Is Still Beautiful'. *New Scientist.* April 25. 18–19. Anon. (2002). '3 YBIEL. (1992). 273. Ottinger, R. (2000). 'Legal Structures in Use for Climate Change Mitigation'. *Environmental Policy and the Law.* 30 (4): 184, 186.

[352] Anon. (2002). 'Soundbites'. *New Scientist.* July 20. 9. 5 *YBIEL.* (1994). 204.

[353] 6 *YBIEL.* (1995). 201.

[354] 4. *YBIEL.* (1993). 144. MacKenzie, D. (1992). 'Europe Weakens Carbon Tax'. *New Scientist.* May 16. 5. 6 *YBIEL.* (1995). 201. Anon. (1995). 'A Carbon Tax in Waiting'. *New Scientist.* May 20. 9.

[355] Agenda 21. Paragraphs 9.12(l).

[356] See G8 Science and Technology for Sustainable Development. (2003, Evian). Available from <http://www.g7.utoronto.ca/summit/2003evian/sustainable_development_en.html>

[357] 11 *YBIEL.* (2000). 622.

[358] McCormick, J. (1997). *Acid Earth.* (3rd End, Earthscan, London). 4. Pearce, F. (1982). 'The Menace of Acid Rain.' *New Scientist.* August 12. 420. Cross, M. (1984). 'Technology

such as the IMO noted above, there is little international recognition of the value of fuel switching, beyond recommendations from the OECD,[359] and some regional standards established within the European Community.[360] Nevertheless, some of the LRTAP protocols do recognise the utility of fuel cleaning, or 'desulphurisation'.[361]

5. Base Years

Before concluding this chapter, it is necessary to understand the points at which all of the above the restrictions start and finish. The beginning point, from which emissions are measured, is known as the 'base year,' and the end point, from which the goal must be achieved, is known as the 'target year.' Although this may sound quite straight forward, the reality is somewhat different as each regime utilizes different approaches to base and target years.

The 1988[362] and 1991[363] protocols of the LRTAP regime utilize a floating base year, or an average or selected date within a set of years, by which a signatories obligations are gauged against. This is a useful tool when difficulties arise between countries, all trying to find a common year from which they all wish to start counting. Conversely, the 1994 and 1999 protocols use the same base year for all the signatories. However, although the 1994 and 1999 protocols have different base years, the required emis-

for Cleaner Air.' *New Scientist.* Sep 13. 10. Milne, R. (1990). 'Britain Risks Row Over Emissions.' *New Scientist* March 24. 6. Anon. (1990). 'Thatcher Says Don't Jump To Conclusions.' New Scientist.. March 24. 6. Edwards, R. (1996). 'Greens Attack Plans to Import Dirty Fuel.' New Scientist. July 13. Pearce, F. (2000). 'Hold Your Breath.' *New Scientist.* Jan 22. 16–17. Pearce, F. (1982). 'The Menace of Acid Rain.' *New Scientist* August 12. 420. Cross, M. (1984). 'Technology for Cleaner Air.' *New Scientist* Sep 13. 10.

359 1974 OECD Guidelines for Action to Reduce Emissions of SO_2 and Particular Matter in Stationary Sources. *IPE.* XV. 7628. I (a) and Annex 8.

360 This process began with the 1972 Directive 72/116, which limited the sulphur content of gas oil used for heating and cooking. EEC Council Directive. 24 Nov, 1975. Law Relating to the Sulphur Content of Certain Liquid Fuels. *IPE.* XV. 7641. EEC Proposal for a Council Directive on the Use of Fuel Oils with the Aim of Decreasing Sulphurous Emissions. Reprinted in *IPE.* XV. 7671.

361 1994 Protocol on Further Reductions of Sulfur Emissions. Annex IV. Control Technologies For Sulfur Emissions From Stationary Sources. Paragraph 9 (ii) (b).

362 Article 2 of the Sophia Protocol, obliges signatories to hold emissions, to 1987, "or any previous year to be specified upon signature or accession, to the Protocol" provided any other year does not exceed the 1987 levels.

363 With the VOC Protocol, the obligation on major emitters of VOCs to make a 30% reduction, by 1999 or any other nominated year between 1984 and 1990. 1991 VOC Protocol. Article 2. (2) (a) & (b). Most countries chose 1988 as a base year, but the US and Switzerland opted for 1989.

sion controls are different for each Party. In addition, the targets, for the 1994 Protocol, had a series of interim steps to be achieved, of reduction goals to be achieved by the year 2000 and 2005, before the final target to be achieved by the year 2010.

With the ozone regime, 1986 was the overall base year for the mandated reductions for developed countries. The exception to this was with regard to the then Soviet Union, which was granted a 'grandfather clause' whereby a country could add to its 1986 total, if the ODS production facility was already under construction prior to the beginning of 1987.[364] With regard to developing countries, their base years, for CFC controls started at a point which followed a permitted period of growth in CFC consumption and production, before an average from the growth period was obtained, from which future reductions of ODS, would be based. With regard to other ODS, such as halons, CT, MC, MB and transitional substances, different base years were applied to each substance as international attempts to restrict them came into existence, with different, but established at the outset, base and target years for developed and developing countries.

With the FCCC, the obligation for developed countries to return their emissions of their greenhouse gases to their 1990 levels was clear, in terms of the base year. The 1990 base year was also adopted in the Kyoto Protocol with regard to the traditional greenhouse gases, but not the newly listed hydrofluorocarbons, perfluorocarbons and sulphur hexafluoride, which work from a base year of 1995.[365]

Although the FCCC has been strong in defending this base year and has not permitted most developed countries to change their base year,[366] the regime has, however, shown 'flexibility' to five countries in economic transition. This was necessary as it became apparent that some of these countries, had gaps with their own historical records, which meant base years could not be established. For example, 1988 was the last year for Poland for which figures on emissions existed.[367] Due to such difficulties, five countries in economic transition were permitted to use different base years, as opposed to the 1990 base year for all other developed countries, for their FCCC obligation. Thus, Bulgaria and Romania were given 1989 as a base year, Poland was given 1988, Hungary had the average of the

---

[364] This became article 2 (6). For discussion of this, see Benedict, R. (1991). *Ozone Diplomacy.* (Harvard University Press, Cambridge). 82–83.
[365] Kyoto Protocol. Article 3 (8).
[366] Pearce, F. (1997). 'Dishonest Brokers'. *New Scientist.* Dec 6. 4.
[367] See Victor, D. & Salt, J. (1994). 'Climate Change'. *Environment.* Dec 7–15.

years between 1985 and 1987,[368] and Slovenia was given 1986 as their base year from which to measure its FCCC obligations.[369] The same flexibility towards countries in economic transition, was replicated in the Kyoto Protocol,[370] and confirmed by subsequent agreement.[371]

6. Banking

'Banking' is the process by which target years can be a little fudged within the climate regime. Banking was introduced by the United States, New Zealand and Canada, as a way to allow national emissions levels, which come in below their commitment period targets, to be offset against future commitment period targets. Banking also allows Parties to borrow against their emission targets for a subsequent period in order to emit more in a current period. This is very unlike the ozone or air pollution regime, in which reduction targets are typically tied to a specific date. Although banking was opposed by the European Community and most developing countries due to fears about individual countries building up 'debts' in one period and then later disowning them,[372] two versions of banking found their way into the climate regime. First, with the Kyoto Protocol, the target period for the first commitment period for industrialized countries was set for 2008 to 2012.[373] The average from these four years, is the final sum for each country.[374] As such, a country may ultimately be above target one year, and below it the next, and not be in actual breach of the

[368] Decision 9/CP.2. Communications from Annex I Parties: Guidelines, Schedule and Process. Report of the Second Session of the COP, Geneva. 1996. 15. Paragraph 4 & 7.
[369] Decision 11/CP.4. National communications from Parties included in Annex I to the Convention. Paragraph 13.
[370] Kyoto Protocol. Article 3 (5).
[371] Decision 19/CP.7. Modalities for the accounting of assigned amounts under Article 7, paragraph 4, of the Kyoto Protocol.
[372] See Pearce, F. (1997). 'Chill Winds At the Summit'. *New Scientist.* March 1. 12–13. 8 *YBIEL.* (1997). 175. Ehrmann, M. (1997). 'Spring Time in the Climate Negotiations?' *Environmental Policy and the Law.* 27 (3). 192–196. Ehrmann, M. (1997). 'Meeting of the Subsidiary Bodies'. *Environmental Policy and the Law.* 27 (2). 84–85.
[373] Kyoto Protocol. Article 3 (3).
[374] Kyoto Protocol. Article 3 (7).

Protocol as it is the average for the period which counts. Second, if a Party reduces more greenhouse gas emissions than it is actually obliged to do within one commitment period, it can carry-over part of that surplus to be offset for future commitment periods. Accordingly,

> If the emissions of a Party included in Annex I in a commitment period are less than its assigned amount under this Article, this difference shall, on request of that Party, be added to the assigned amount for that Party for subsequent commitment periods.[375]

It was later agreed that, subject to various considerations, a, 'carry-over' to the subsequent commitment period' of up to 2.5% was permissible.[376]

[375] Kyoto Protocol. Article 3 (13).
[376] Decision 19/CP.7. Modalities for the accounting of assigned amounts. Article 7, paragraph 4, of the Kyoto Protocol.. Section F. Carry-over. Report of the Seventh COP 57. Note, AAUs may be carried over, but not RMUs. Also, the section is contingent on Article 3 (7) of the Kyoto Protocol (dealing with LUCF).

X. COMPLIANCE

1. The Ozone Regime

The drafting process for the Vienna Convention clearly envisaged that a dispute resolution mechanism, for serious disputes between the signatories would be included in the final document.[1] Accordingly, the Vienna Convention concluded that with inter-state disputes related to the Convention, if negotiations fail, then the good offices of, or mediation by, a third Party should be utilized. Arbitration is noted as a dispute resolution option, as is submission of the dispute to the International Court of Justice (ICJ).[2] The fact that ICJ involvement was not compulsory, was due to the sensitive nature of the United States' relationship with the ICJ at that time.[3] The Arbitration procedure was elaborated upon in a separate Annex at the first COP of the convention in 1989, under which special arbitral commissions could be established to examine issues in dispute.[4] However, this somewhat more formal approach within the Vienna Convention, was not replicated within the Montreal Protocol. Rather, the signatories to the Montreal Protocol developed an internal mechanism which deals directly with compliance issues relating to the objectives of the Protocol, and its attempts to control ODS. Specifically, article 8 of the Montreal Protocol stipulated,

> The Parties, at their first meeting, shall consider and approve procedures and institutional mechanisms for determining non-compliance with the provisions of this Protocol and for treatment of Parties found to be in non-compliance.

In furtherance of this article, an Implementation Committee (IC) was established at the first MOP in 1989, to deal with issues of non-compliance

---

[1] Draft Article 13, listed a series of alternative mechanisms, including third Parties offering good offices, the International Court of Justice, or replicating Article 10 of the MARPOL Convention. See the Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1983). Second Revised Draft, With Additional Commentary, Prepared By UNEP. UNEP/WG.94/3/ July 30. Article 13.

[2] Article 11.

[3] Litfin, K. (1994). *Ozone Discourses*. (Columbia University Press, New York). 74. Litfin is referring to the American abrogation of international commitments to the ICJ, following the 1984 Nicaragua case.

[4] Report of the first COP of the Vienna Convention. Annex II.

with the Protocol.[5] Non-compliance was defined as breach of obligations in relation to the ozone regime.[6] Interim procedures and mechanisms for determining non-compliance were adopted in 1990.[7] This was a radical step in international environmental law, which was recognized at the outset as being possibly precedent setting.[8]

Despite uncertainties about the relationship between the IC and the dispute resolution mechanism of the Vienna Convention, it was initially suggested that dealing with non-compliance could, 'in practical terms' be the first step of the arbitration process.[9] However, at the second IC meeting, the relationship was redefined as, 'distinct and separate and providing an option for simultaneous application'.[10] To date, no resolution of disputes have been taken under the formal procedures of the Vienna Convention, and the compliance model of the Montreal Protocol, which has stressed the goal of, 'amicable resolutions'[11] has been the clear preference for Parties within the ozone regime. Accordingly, the importance of, 'resolving problems amicably and obviating the need for recourse to formal arbitration or the ICJ' has been emphasized.[12] Thus, the ozone regime has been seen as encompassing more a system of 'peer review' which is the first step towards assessing objectively the performance of the Parties, than a system of formal judicial review.[13] The signatories to the Protocol are clearly content with this approach, for as they noted in their 1997 Review of the Non- Compliance Procedure, bar some streamlining procedural issues the, procedure has functioned satisfactorily'.[14]

---

[5] Decision I/8. Non Compliance.
[6] At the second IC meeting, the Committee was of the view that it would be useful to define non-compliance. Draft Report of the Second Meeting of the Implementation Committee Under the Non-Compliance Procedure for the Montreal Protocol. UNEP/OzL.Pro/ImpCom/2/3. April 12, 1991. 3. The MOP agreed to this request. Decision III/2. Non-Compliance Procedure. Much of this was done in negative, with countries stipulating what could not be considered non-compliance, such as non-payment of contributions, See 2 *YBIEL.* (1991). 109. Other aspects are dealt with inside the convention, where the obligatory obligations, and exceptions (such as for some obligations with developing countries) are spelt out. See 1 *YBIEL.* (1990). 97.
[7] Decision II/5. Non-Compliance.
[8] 1 *YBIEL.* (1990). 98.
[9] Report of the First Meeting of the Implementation Committee Under the Non-Compliance Procedure. UNEP/OzL.Pro/ImpC0m/1/2. December 11. 1990. 3. 2 *YBIEL.* (1991). 110.
[10] Draft Report of the Second Meeting of the Implementation Committee Under the Non-Compliance Procedure for the Montreal Protocol. UNEP/OzL.Pro/ImpCom/2/3. April 12, 1991. 3.
[11] Report of the First Meeting of the Implementation Committee Under the Non-Compliance Procedure. UNEP/OzL.Pro/ImpC0m/1/2. December 11. 1990. 3.
[12] Third MOP of the Montreal Protocol. 9.
[13] 3 *YBIEL.* (1992). 229.
[14] Decision IX/35. Review of the Non-Compliance Procedure. Decision X/10. Review of the Non-Compliance Procedure.

A. The Committee

The IC has an 'equitable geographical distribution'.[15] There are 10 members of the IC who work on a two year roster. Every second year, new countries are nominated to the MOP, for vacant positions within the IC. The MOP must reach consensus decisions on which countries are placed on the IC.[16] The IC meet twice yearly, once when the annual data comes into the Secretariat, and again, prior to the MOPs.[17]

B. The Process of the Investigation

The starting point for assertions of non-compliance with the Montreal Protocol is that one country informs the Secretariat that it has, 'reservations about another Parties implementation of its obligations under the Protocol'.[18] The Secretariat then forwards the complaint to the IC, and the challenged Party, which is given a 'reasonable opportunity to reply'. The IC is obliged to consider the matter as soon as practicable.[19] Although the possibility of charges of non-compliance by NGOs to the IC was initially considered, this proposal was not adopted.[20] Nevertheless, the IC has periodically 'drawn attention' to comments made by 'observers' about non-compliance.[21] The other way the IC can come to examine a compliance question is if a Party itself concludes that it is unable to comply with its obligations, and informs the Secretariat of its difficulties.[22]

The IC is obliged to, 'receive, consider and report' on submissions sent to it.[23] The IC is charged to bring about, 'full compliance with the Protocol . . . and to further the Protocol's objectives'.[24] The Role of the IC is also, 'to identify the facts and possible causes relating to individual cases of non-compliance and make appropriate recommendations to the MOP.[25] In 1998, the MOP added,

---

15 Annex III. Non-Compliance Procedure. 1990 COP. Annex IV, Non-Compliance Procedure. Point 5.
16 Decision XV/13. Membership of the Implementation Committee.
17 Report of the First Meeting of the Implementation Committee Under the Non-Compliance Procedure. UNEP/OzL.Pro/ImpC0m/1/2. December 11. 1990. 3. Annex IV, Non-Compliance Procedure. Point 6.
18 Annex III. Non-Compliance Procedure. 1990 COP.
19 Annex IV. Non-Compliance Procedure. Points 1 & 2.
20 2 *YBIEL.* (1991). 108.
21 Report of the Twelfth MOP to the Montreal Protocol12.
22 Annex IV. Non-Compliance Procedure. MOP 4. Point 4.
23 Annex IV. Non-Compliance Procedure. Point 7.
24 Annex III. Non-Compliance Procedure. 1990 MOP. 1 *YBIEL.* (1990). 98.
25 Annex IV. Non-Compliance Procedure. MOP 4. Points 12–14. Point D, Annex II. MOP 10. 46–47.

> Consideration should be given to progress made by a Party towards achieving compliance and measures taken to help the non-compliant Party to return to compliance.[26]

Direct contacts with the Parties regarding matters of compliance, is important for the functioning of the IC.[27] The direct contact may involve invited visits to the territories of the disputed Party, for the purposes of information gathering.[28]

C. Penalties

At the second IC meeting, it was decided that it would be useful to develop a list of possible actions that could be taken when non-compliance was recognized.[29] The three options listed the following year in 1992 were,

1. Appropriate assistance, including assistance for the collection and reporting of data, technical assistance, technology transfer and financial assistance, information transfer and training.
2. Issuing cautions.
3. Suspension, in accordance with the applicable rules of international law concerning the suspension of the operation of a treaty, of specific rights and privileges under the Protocol, whether or not subject to time limits, including those concerned with industrial rationalization, production, consumption, trade, transfer of technology, financial mechanism and institutional arrangements.[30]

Threatening to withhold financial assistance and/or trade restrictions related to ODS, is the most powerful option that the IC possesses.[31] These options can only be utilized if the Party in question is found to have lost its 'good standing' status. The force of these options is such, that the MOP has issued instructions to make sure that decisions to stop funding due to non-compliance are handled correctly by the respective bodies to the Protocol.[32]

---

[26] Point 3.
[27] Report of the First Meeting of the Implementation Committee Under the Non-Compliance Procedure. UNEP/OzL.Pro/ImpCom/1/2. December 11. 1990. 3.
[28] Annex IV, Non-Compliance Procedure. MOP 4. Point 7.d. 2 *YBIEL*. (1991). 107.
[29] Draft Report of the Second Meeting of the Implementation Committee Under the Non-Compliance Procedure for the Montreal Protocol. UNEP/OzL.Pro/ImpCom/2/3. April 12, 1991. 3.
[30] Annex V. Indicative List of Measures. MOP 4. See also Decision III/2. Non-Compliance Procedure.
[31] See Oberthur, S. (1997). 'Montreal Protocol: 10 Years After.' *Environmental Policy and the Law*. 27(6): 432, 434–35.
[32] Decision XIV/37. Interaction Between the Executive Committee and the Implementation Committee.

D. Minor Difficulties

The possibility of disputes between Parties due to insufficient data on country production and consumption of ODS was identified as a potential source of non-compliance concerns before the Convention was even signed.[33] The necessity to transfer various types of information to the Secretariat was incorporated into the Draft Convention[34] and then into Article 5 of the final text. Accordingly, the Parties shall,

> transmit through the Secretariat, to the COP, . . . information on the measures adopted by them in implementation of this Convention and of Protocols to which they are Party in such form and at such intervals as the meeting of the Parties to the relevant instruments may determine.

Despite the clarity of Article 5 of the Vienna Convention, problems related to requests for information continued. For example, in 1986, UNEP sent out 170 requests for data but received only 18 responses.[35] Due to such difficulties, Article 7 of the Montreal Protocol was created to clearly establish the obligation on all signatories of the reporting of required ODS information. Such information, ranging from basic data from which the baselines for all subsequent commitments are measured,[36] through to annual information on the production and consumption of ODS,[37] is essential if compliance with the Montreal Protocol is to be achieved.[38] Nevertheless,

[33] Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1984). Report of the Working Group, First Part of the Fourth Session. UNEP/WG.110/4. Page 9. Benedict, R. (1991). *Ozone Diplomacy*. (Harvard University Press, Cambridge). 181. Roan, S. (1991). *Ozone Crisis*. (Wiley, New York). 154–156.

[34] See Draft Article 8. UNEP. (1982). Some Obstructions on the Preparation of a Global Framework for the Protection of the Ozone Layer. UNEP/WG.69/8. January 13. Paragraph 35. Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1983). Second Revised Draft, With Additional Commentary, Prepared By UNEP. UNEP/WG.94/3/ July 30. Annex II.

[35] Litfin, K. (1994). *Ozone Discourses*. (Columbia University Press, New York). 87.

[36] Decision XV/18. Non-Compliance With Data Reporting For the Purposes of Establishing Baselines. Decision XV/16. Non-Compliance With Data Reporting Under Article 7. Report of the 15th MOP to the Montreal Protocol. 52. Decision XIII/15. Data and Information Provided by the Parties in Accordance with Article 7 of the Montreal Protocol.. Decision XII/6. Data and Information Provided By the Parties in Accordance with Articles 7 & 9.

[37] Decision XV/21. Potential Non-Compliance With Consumption of Annex A ODS By Article 5 Parties for 2002.

[38] Decision III/9. Formats For Reporting Data Under the Amended Protocol. (Annex V). Decisions V/5 & V/6. Revised Format for Reporting & Data and Information Reporting. Revised data forms for reporting in 1996 via Decision VIII/21 & again in 1997. Decision IX/28.

despite the clarity of Article 7, repeated appeals from the MOP to its signatories to supply the required information on time,[39] and additional MOP decisions on what to report and when,[40] the problem of developed and developing Parties (at time up to three quarters of the total) failing to report ODS information continued during the late 1980s and most of the 1990s.[41] This problem began to improve in the new century, and by 2003 160 Parties out of 183, were reporting their Article 7 information on time.[42]

The difficulties with regard to data reporting have been confronted by the following actions. First, the formats for ODS reporting have been changed (a number of times) and some ODS such as MB, have specific reporting requirements.[43] Second, other issues such as joint reporting,[44] confidential information,[45] and accounting questions relating to what to report, and what not to report[46] have all been dealt with.

If the above actions by the MOP have not resolved the compliance issue, the operation of the IC has come into play, but with a substantively soft approach. That is, following direction by the MOP, the IC has addressed the issue with a view to securing an 'amicable solution' to the problem and utilizing measures such as reduction schedules, technical and financial assistance.[47] In 2001, 2002 and 2003 this process was furthered, when a number of countries were listed as being presumed to be in non-compliance due to their failure to provide required ODS data. In some instances, such as with Azerbaijan[48] and Qatar,[49] clarifications of their ODS data has been called for. However, rather than penalize such countries, the IC recommended that they continue to be treated as members 'in good standing'

[39] Decision III/3. Implementation Committee. 16. Decision IV/9 Data and Information Reporting. Decisions V/5 & V/6. Revised Format for Reporting & Data and Information Reporting. Decision XIV/13. Data and Information Provided By Parties in Accordance With Article 7 of the Montreal Protocol.

[40] Decision XV/15. Earlier Reporting of Consumption and Production Data.

[41] Decision VIII.2. Data and Information. Decision IX/11. Data and Information Provided by the Parties. Decision X/2/ Data and Information Provided. Decision XIV/13. Data and Information Provided By Parties in Accordance With Article 7 of the Montreal Protocol. Report of the 10th MOP of the Montreal Protocol. 16. Anon. (1994). 'Budgets Approved.' *Environmental Policy and the Law*. (24:2/3): 67. Benedict. Ibid. 180–183.

[42] Decision XV/14. Data and Information Provided By the Parties in Accordance with Article 7 of the Montreal Protocol.

[43] Decision Ex.I/4. Conditions for Granting and Reporting Critical Use Exemptions for Methyl Bromide.

[44] First Meeting of the Implementation Committee Under the Non-Compliance Procedure. UNEP/OzL.Pro/ImpC0m/1/2. December 11. 1990. 4.

[45] Decision I/11. Reporting and Confidentiality of Data.

[46] Report of the Twelfth MOP to the Montreal Protocol. 12. Seventh MOP to the Montreal Protocol. 11. 19.

[47] Decision IV/15. Situation Whereby Parties Operating Under Article 5 Exceed the Consumption Limits Set in that Article.

[48] Decision XV/28. Non-Compliance With the Montreal Protocol by Azerbaijan.

[49] Decision XV/68. Non-Compliance With the Montreal Protocol by Qatar.

and continue to receive international financial assistance, with a view to working towards meeting their reporting obligations, as soon as possible. Close monitoring of the situation by the IC is maintained, and the Parties are required to produce plans of action to show how they will meet their reporting commitments.[50]

The final area that may be classified as a lesser concern for the IC, is potential non-compliance with the Montreal Protocol. When potential non-compliance is identified, the problem is dealt with by pre-empire calls for explanation of a Parties actions. Such calls have been clearly made for identified developing countries with regard to reductions of halons,[51] and hydro-bromo-fluorocarbons.[52] The same approach has been followed with both developing[53] and developed[54] countries over issues relating to MB. In all of these instances, the situation is 'monitored closely' and plans of action (from the State in question) are called for.

E. Substantial Difficulties

Substantial non-compliance within the Montreal Protocol is when a country does not reduce or control its ODS consumption and/or production in accordance with its commitments. Substantial difficulties deal with instances of proven, not potential, non-compliance. In most instances, substantive non-compliance is dealt with in a strict and uniform manner. However, a degree of flexibility is exercised by the IC for substantial non-compliance of MB by developing countries.[55]

The first instance of actual, substantive non-compliance was in 1992 when the Russian Federation announced that it was, 'experiencing extraordinary political, economic and social difficulties and did not have the capacity to assume the additional obligations under the Montreal Protocol'. Accordingly, the Russian Federation would not object to further restric-

[50] Decision XIII/16. Potential Non-Compliance With the Freeze on CFC Consumption in Article 5 Countries. Decision XIV/14. Non-Compliance With Data Reporting Under Article 7 of the Montreal Protocol. 47. Decision XV/21. Potential Non-Compliance With Consumption of Annex A ODS By Article 5 Countries and Requests for Plans of Action.

[51] Decision XV/22. Potential Non-Compliance With Consumption of . . . Halons by Article 5 Parties in 2002 and Requests for Plans of Action. 55.

[52] Decision XV/23. Potential Non-Compliance With Consumption of Hydrobromofluorocarbons By Morocco in 2002 and Request for a Plan of Action.

[53] Decision XV/23. Potential Non-Compliance With Consumption of Methyl Bromide By Article 5 Parties in 2002 and Request for a Plan of Action.

[54] Decision XV/24. Potential Non-Compliance With Consumption of Methyl Bromide By Non-Article 5 Parties in 2002 and Request for a Plan of Action. Notably, Latvia and Israel.

[55] Decision Ex.I/2. Accelerated Phase Out of Methyl Bromide. Anon. (2004). 'Methyl Bromide: Compromise.' *Environmental Policy and Law.* 34(3): 118–121.

tions on ODS within the protocol, 'if-and only if- it was granted a specific preferential regime in the Protocol's implementation'.[56] Although the Russian Federation got its exception, within three years, Russia (along with Belarus, Bulgaria, Poland and the Ukraine) was threatening non-compliance with their obligations to control their ODS emissions. At this point, the IC concluded an agreement with each Party.[57] Each agreement contained the following elements,

1. Clear statements regarding the situation by the Party and IC.
2. A clear statement by the Party regarding its intention to achieve compliance.
3. Identification of what steps were necessary to achieve compliance.
4. An agreement between the Party in non-compliance and the MOP, on what assistance was necessary for the Party in non-compliance to implement the agreed steps necessary to achieve compliance.[58]

The most notable situation from this period involved the Russian Federation, which had informed the Secretariat, that due to ongoing economic difficulties it could not possibly comply with the Montreal Protocol. Accordingly, Russia requested a deferment of its ODS reduction obligations and financial assistance. They also asked the MOP to refrain from the discriminatory measures (that is, ODS related trade restrictions that would prohibit all exports of recycled or recovered ODS from Russia) that the IC had recommended. Despite this request, and to the clear annoyance of the Russian Federation,[59] although the MOP facilitated financial assistance for Russia to meet its ODS reduction obligations, the MOP still set limited discriminatory measures against Russia. That is, unlike the total trade restrictions in ODS imposed on Belarus and the Ukraine,[60] Russia was allowed to continue to trade ODS, but only with other members of the Commonwealth of Independent States.[61] By the following year, although further questions about the trade in new and recycled ODS involving the Russian Federation remained unanswered, due to the fact that the Russian Federation was making progress in meeting its authorized ODS consumption needs by

[56] Fourth MOP to the Montreal Protocol. 31.
[57] Decision VII/15. Non Compliance By Poland. VII/16. Non Compliance By Bulgaria.
[58] Seventh MOP to the Montreal Protocol. 12–13.
[59] Russia still considered that this limitation was 'unacceptable' and they, 'reserved the right to study the consequences of such a decision and to draw the appropriate conclusions for the conduct of its policy with regard to the further implementation of the Montreal Protocol by the Russian Federation'. Seventh MOP to the Montreal Protocol. 12, 20–21, 52–53. Anon. (1996). 'The Vienna Meeting.' *Environmental Policy and the Law*. (26:2/3). 66–71.
[60] Decision VII/19. Non Compliance By the Ukraine. VII/17 Non Compliance By Belarus. Seventh MOP to the Montreal Protocol. 32 & 34.
[61] Decision VII/18. Compliance by the Russian Federation. Seventh MOP to the Montreal Protocol. 33–34.

recycled or reclaimed ODS, and was cutting back on new production of ODS, greater financial assistance was offered.[62] This progress continued into 1997, with internal demand for ODS being increasingly satisfied by recycled and reclaimed sources, and Russia agreeing to honor the request not to be involved in any trade or exchange of ODS outside of the Commonwealth of Independent States.[63] Accordingly, the financial assistance was continued.[64] Although the IC reiterated in 2001, 'serious concern that the Russian Federation had not complied with its commitments'[65] in terms of meeting its ODS phase-out benchmarks which it had earlier agreed, the serious concern was short lived, and the Federation, which was clearly trying to improve the situation, continued to be treated as in 'good standing' and thus eligible for financial assistance. This approach proved successful, and in 2002 Russia was commended for finally being on track to the meeting of all their ODS commitments.[66]

The other decisions of note from the IC in the mid 1990s involved Latvia and Lithuania. In both instances, each of the countries was designated as being in 'good standing' and thus eligible for continued financial assistance. However, the assistance was clearly linked to demonstrated good faith efforts to meet their ODS commitments, such as having renewed national plans to control their ODS, and promises by the Parties to ratify the necessary amendments to the Montreal Protocol.[67]

Following these decisions, by the late 1990s, the IC had settled into a clearly established pattern. Accordingly, compliance decisions in 1998, for Azerbaijan,[68] Belarus,[69] the Czech Republic,[70] Estonia,[71] Latvia,[72] Lithuania,[73] the Russian Federation,[74] Ukraine[75] and Uzbekistan,[76] and in 1999 for

---

[62] Report of the Eighth MOP Of the Montreal Protocol. 14. Pearce, F. (1996). 'Smugglers Outwit the CFC Cops.' *New Scientist*. Oct 26. 4. 7 *YBIEL*. (1996). 130.
[63] Report of the Ninth MOP Of the Montreal Protocol. 24–25.
[64] Decision IX/31. Compliance with the Montreal Protocol by the Russian Federation. Report of the Ninth MOP Of the Montreal Protocol. 43–44.
[65] Decision XIII/17. Compliance With the Montreal Protocol by the Russian Federation. Report of the 13th MOP. 45.
[66] Decision XIV/35. Compliance With the Montreal Protocol by Russia. Report of the 14th MOP. 59.
[67] Decision VIII/22 and IV/29. Compliance By Latvia. Decision VIII/23 and IX/30. Compliance by Lithuania. Report of the Ninth MOP. 42–43.
[68] Decision X/20 Compliance By Azerbaijan.
[69] Decision X/21. Compliance By Belarus.
[70] Decision X/22. Compliance By Czech Republic.
[71] Decision X/23. Compliance By Estonia.
[72] Decision X/24. Compliance By Latvia.
[73] Decision X/25. Compliance By Lithuania.
[74] Decision X/26. Compliance By the Russian Federation.
[75] Decision X/27. Compliance By the Ukraine.
[76] Decision X/28. Compliance By Uzbekistan.

Bulgaria and Turkmenistan,[77] all contained the following elements. First, a detailed explanation of the non-compliance was recorded. Second, a clear warning of the consequences of persistent non-compliance was issued. Thus,

> If the country fails to meet the commitments noted above in the times specified, the Parties shall consider measures [that] could include the possibility of actions available under Article 4, designed to ensure that the supply of CFCs and halons that [are] the subject of non-compliance is ceased, and that exporting Parties are not contributing to a continuing situation of non-compliance.

Third, if progress was being made in countries not complying with its ODS obligation, the country would continue to be treated as being a 'member of good standing' which was therefore eligible for financial assistance. 'Progress' was tied to clear plans of action with distinct benchmarks to confront the problem, within specific time frames.

The list of non-complying was added to in 2001 with Armenia,[78] Kazakhstan,[79] Tajikistan,[80] Argentina,[81] Cameroon,[82] Ethiopia,[83] and Peru.[84] In 2001, the precedents were not all the same. That is, the non-compliance issue for Armenia was non-ratification of the London Amendment of the Montreal Protocol. In other instances, traditional substantive non-compliance whereby Parties failed to reduce their ODS consumption ranged from being 0.2 of a tonne over the limit (for Ethiopia) through to between 250 and 300 tonnes (for Argentina). Despite the differences in consumption, each country received the three step approach outlined above.

Non-compliance with the Montreal Protocol in 2002 involved Albania,[85] the Bahamas,[86] Bolivia,[87] Bosnia and Herzegovina,[88] Namibia,[89] Nepal,[90]

[77] Decision XI/24. Compliance By Bulgaria, and Decision XI/25 Compliance By Turkmenistan. Report of the 11th MOP. 31 and 32.
[78] Decision XIII/19. Compliance by Armenia. Report of the 13th MOP. 46.
[79] Decision XIII/19. Compliance with the Montreal Protocol by Kazakhstan.
[80] Decision XIII/20. Compliance with the Montreal Protocol by Tajikistan.
[81] Decision XIII/21. Compliance with the Montreal Protocol by Argentina.
[82] Decision XIII/23. Compliance with the Montreal Protocol by Cameroon.
[83] Decision XIII/24. Compliance with the Montreal Protocol by Ethiopia.
[84] Decision XIII/25. Compliance with the Montreal Protocol by Peru.
[85] Decision XIV/18. Non-Compliance With the Montreal Protocol by Albania. Report of the 14th MOP. 48.
[86] Decision XIV/19. Non-Compliance With the Montreal Protocol by the Bahamas. Report of the 14th MOP. 49.
[87] Decision XIV/20. Non-Compliance With the Montreal Protocol by Bolivia. Report of the 14th MOP. 50.
[88] Decision XIV/21. Non-Compliance With the Montreal Protocol by Bosnia and Herzegovina. Report of the 14th MOP. 50.
[89] Decision XIV/22. Non-Compliance With the Montreal Protocol by Namibia. Report of the 14th MOP. 51.
[90] Decision XIV/23. Non-Compliance With the Montreal Protocol by Nepal. Report of the 14th MOP. 51.

Saint Vincent and the Grenadines,[91] Libya,[92] and the Maldives.[93] In each of these cases, the determination for non-compliance was the same as the three steps outlined above, with the addition, that now the amount of financial assistance already received by the country was also recorded. The traditional non-compliance of a substantial nature involved ODS consumption ranging from Libya at 268 tonnes over their target, through to Namibia being 1 tonne over target. Variations on non-compliance in 2002 included Bangladesh,[94] Nigeria,[95] Cameroon,[96] Belize[97] and Ethiopia.[98] In all of these instances, the countries were determined to be in 'good standing' as they had already submitted plans of action detailing how they would resolve the situation and ultimately achieve their final reduction targets. The cases of non-compliance from 2002 which did not fit this pattern involved Belarus and Latvia who reported data which suggested that their ODS consumption was above their earlier resubmitted national plans, which had been provided due to earlier non-compliance. Both were called to account to explain their non-compliance, 'as a matter of urgency'.[99] Finally, Armenia escaped direct censure for over-consuming ODS by applying to change its status as a developing country. Nevertheless, Armenia was still directed to ratify the amendments to the Montreal Protocol, if it wished to continue to be eligible for financial assistance.[100–101]

In 2003, findings of substantive non-compliance were recorded for the Democratic Republic of the Congo[102] and Vietnam.[103] The process of

---

91 Decision XIV/24. Non-Compliance With the Montreal Protocol by Saint Vincent and the Grenadines. Report of the 14th MOP. 52.
92 Decision XIV/25. Non-Compliance With the Montreal Protocol by Libyan Arab Jamahirya. Report of the 14th MOP. 53.
93 Decision XIV/26. Non-Compliance With the Montreal Protocol by the Maldives. Report of the 14th MOP. 53.
94 Decision XIV/29. Non-Compliance With the Montreal Protocol by Bagladesh. Report of the 14th MOP. 55.
95 Decision XIV/30. Non-Compliance With the Montreal Protocol by Nigeria. Report of the 14th MOP. 55.
96 Decision XIV/18. Non-Compliance With the Montreal Protocol by Cameroon. Report of the 14th MOP. 56.
97 Decision XIV/33. Non-Compliance With the Montreal Protocol by Belize. Report of the 14th MOP. 57.
98 Decision XIV/34. Non-Compliance With the Montreal Protocol by Ethiopia. Report of the 14th MOP. 58.
99 Decision XIV/28. Non-Compliance With Consumption Phase-Out By Parties Not Operating Under Article 5 in 2000. Report of the 14th MOP. 54.
100 Decision XV/27. Non-Compliance With the Montreal Protocol by Armenia. UNEP/OzL.Pro.15/9. Nov 11, 2003. 58.
101 Decision XIV/31. Non-Compliance With the Montreal Protocol by Armenia. Report of the 14th MOP. 56.
102 Decision XV/33. Non-Compliance With the Montreal Protocol by The Democratic Republic of the Congo. Report of the 15th MOP. 62–63.
103 Decision XV/45. Non-Compliance With the Montreal Protocol by Vietnam. Report of the 15th MOP. 45.

dealing with the problem, whilst retaining their 'good standing' in accordance with the three steps set out above. The other development of note in 2003 involved the IC examining plans of action, as earlier requested, for the countries found to be in non-compliance. Successful plans of actions were approved by the IC for Albania,[104] Bolivia,[105] Bosnia and Herzegovina,[106] Boswana,[107] Cameroon,[108] Guatemala,[109] Honduras,[110] Libya,[111] the Maldives,[112] Namibia,[113] Papua New Guinea,[114] Uganda,[115] Uruguay.[116] Only Saint Vincent and the Grenadines[117] were recognized as not responding to earlier IC demands for a plan of action. They were requested to address this issue 'urgently'.

2. The Air Pollution Regime

Originally, the protocols to the LRTAP regime did not directly address the problem of formal dispute resolution. Rather, in 1984 it was agreed,

> If a dispute arises between two or more contracting Parties to the present protocol as to its interpretation or application, they may seek a solution by negotiation or by any other method of dispute settlement acceptable to the Parties in the dispute.[118]

[104] Decision XV/26. Non-Compliance With the Montreal Protocol by Albania. Report of the 15th MOP. 57.
[105] Decision XV/29. Non-Compliance With the Montreal Protocol by Bolivia. Report of the 15th MOP. 59.
[106] Decision XV/30. Non-Compliance With the Montreal Protocol by Bosnia and Herzegovina Report of the 15th MOP. 59.
[107] Decision XV/31. Non-Compliance With the Montreal Protocol by Botswana. Report of the 15th MOP. 60.
[108] Decision XV/32. Non-Compliance With the Montreal Protocol by Cameroon. Report of the 15th MOP. 61.
[109] Decision XV/34. Non-Compliance With the Montreal Protocol by Guatemala. Report of the 15th MOP. 63.
[110] Decision XV/35. Non-Compliance With the Montreal Protocol by Honduras. Report of the 15th MOP. 64.
[111] Decision XV/36. Non-Compliance With the Montreal Protocol by the Libyan Arab Jamahiriya. Report of the 15th MOP. 65.
[112] Decision XV/37. Non-Compliance With the Montreal Protocol by the Maldives. Report of the 15th MOP. 65.
[113] Decision XV/38. Non-Compliance With the Montreal Protocol by Namibia. Report of the 15th MOP. 66.
[114] Decision XV/40. Non-Compliance With the Montreal Protocol by Papua New Guinea. Report of the 15th MOP. 67.
[115] Decision XV/43. Non-Compliance With the Montreal Protocol by Uganda. Report of the 15th MOP. 70.
[116] Decision XV/44. Non-Compliance With the Montreal Protocol by Uruguay. Report of the 15th MOP. 71.
[117] Decision XV/42. Non-Compliance With the Montreal Protocol by Saint Vincent and the Grenadines. Report of the 15th MOP. 69.
[118] Article 7. 1984 EMEP Protocol.

Although this approach was followed in the protocols of 1985,[119] 1988,[120] and 1991,[121] the later protocols of 1994[122] and 1999[123] contained a formal dispute resolution mechanism with the options of the ICJ, arbitration or conciliation. To date, the formal dispute resolution options have not been implemented, and its relationship to the IC is unclear. The only principle that is clear, is that compliance procedures within the LRTAP regime, are without prejudice to the dispute settlement provisions in the LRTAP protocols.[124]

A. The Implementation Committee of the LRTAP Regime

With regard to compliance concerns within the actual air pollution regime, the 1991 protocol was the first LRTAP protocol to establish 'a mechanism for monitoring compliance with the present Protocol.' Specifically, the Parties to the protocol agreed,

> As a first step based on information provided pursuant to article 8 or other information, any Party which has reason to believe that another Party is acting or has acted in a manner inconsistent with its obligations under this Protocol may inform the Executive Body to that effect and, simultaneously, the Parties concerned. At the request of any Party, the matter may be taken up at the next meeting of the Executive Body.
>
> The formal establishment of the IC occurred with the adoption of the 1994 protocol, Article 7 stipulated, an Implementation Committee is hereby established to review the implementation of the present Protocol and compliance by the Parties with their obligations. It shall report to the Parties at sessions of the Executive Body and may make such recommendations to them as it considers appropriate.
>
> Upon consideration of a report, and any recommendations, of the Implementation Committee, the Parties, taking into account the circumstances of a matter and in accordance with Convention practice, may decide upon and call for action to bring about full compliance with the present Protocol, including measures to assist a Party's compliance with the Protocol, and to further the objectives of the Protocol.
>
> The Parties shall, at the first session of the Executive Body after the entry into force of the present Protocol, adopt a decision that sets out the structure and functions of the Implementation Committee as well as procedures for its review of compliance.

---

119 Article 8. 1985 Helsinki Protocol.
120 Article 12.1988 Sofia Protocol.
121 Article 12. VOC Protocol.
122 Article 5. 1994 Oslo Protocol.
123 Article 11. Gothenberg Protocol.
124 Article 12, of the Oslo Protocol. See also Annex III. Decision 1997/2 Structure and Function of the IC. Point 12.

Accordingly, the Executive Body established an entrenched[125] IC to, 'review compliance by the Parties with their obligations under the protocols to the Convention'.[126] The protocols covered by the IC are those from 1991,[127] 1994,[128] and 1999.[129] The IC was modeled, to a limited degree, on the IC of the Montreal Protocol. The five members of the IC are elected through the Executive Body, for two year periods and all of the IC's decisions are made by consensus.[130]

The IC of the air pollution regime is underlined with the principles of simplicity, transparency, facilitating technical and financial assistance, and being non-confrontational.[131] In terms of penalties, it was made clear from the outset that, unlike with the ozone regime, the measures recommended by the IC to bring about compliance, shall not be discriminatory, that is, trade based.[132] The emphasis with the IC of the LRTAP regime, is clearly upon encouraging compliance, not punishing non-compliance.[133]

The IC can examine a situation of alleged non-compliance by one of three means. First, Parties 'that have reservations about another Parties compliance with its obligations under that instrument' may inform the Secretariat. Second, submission by a Parties that has failed to comply with its own obligations. Finally, the Secretariat, when it becomes aware of alleged non-compliance, and the matter is not resolved between the Secretariat and the allegedly non-complying Party, may inform the IC of the situation.[134]

---

[125] The IC can only be altered with the consensus of all the Parties. Report of the Working Group on Strategies, 25th Session (EB.AIR/WG.5/52). Annex III. Decision 1998/3 on the Procedure For Amending Decisions Pertaining to the Implementation Committee.

[126] Annex III. Decision 1997/2 Concerning the IC. Its Structure, Functions and Procedure for Review of Compliance.

[127] Annex IV. Decision 1997/3. Compliance Monitoring For the VOC Protocol.

[128] Annex II. Decision 1998/6. Concerning the Application of the Compliance Procedure to the Oslo Protocol. See also Annex III. Decision 1997/2 Concerning the IC. Its Structure, Functions and Procedure for Review of Compliance. Points 3 & 4. of preamble. Annex IV. Decision 1997/3 on Compliance Monitoring for the VOC Protocol. Report of the 15th Session of the Executive Body. Also, 8 *YBIEL*. (1997). 167.

[129] Article 9 of the Gothenberg Protocol stipulates, 'Compliance by each Party with its obligations under the present Protocol shall be reviewed regularly. The Implementation Committee established by decision 1997/2 of the Executive Body at its fifteenth session shall carry our such reviews and report to the Parties at a session of the Executive Body in accordance with the terms of the annex to that decision, including any amendments thereto'.

[130] 9 *YBIEL*. (1998). 176.

[131] Anon. (1994). 'Supervision of Non-Compliance.' *Environmental Policy and the Law*. 24 (2). 57. 4 *YBIEL*. (1993). 136–137. 6 *YBIEL*. (1995). 218. 7 *YBIEL*. (1996). 126.

[132] Annex III. Decision 1997/2. Ibid. Point 11.

[133] The Executive Body must 'assist a Party's compliance with the Protocol'. Article 7, Oslo.

[134] Annex III. Decision 1997/2 Structure and Function of the IC. Points 4 & 5.

The IC may request information on matters under its consideration through the Secretariat, and, 'undertake, at the invitation of the Party concerned, information gathering in the territory of that Party'.[135] Information provided in confidence shall be respected.[136] Finally, Parties under investigation are entitled to participate in the IC's proceedings, but not in the final recommendations of the IC.[137]

B. Non-Compliance with the LRTAP Regime

One of the core obligations under the air pollution regime is the provision of information to the Executive Body on national emissions of the pollutants, and how they are being dealt with in accordance with the various obligations assumed under the respective protocols. This obligation can be found in the protocols of 1985,[138] 1988,[139] 1991,[140] the 1994,[141] and 1999.[142] The IC regards the failure to provide the correct reporting of information to the Executive Committee, as outlined in these protocols, as a 'serious' case of non-compliance. To facilitate compliance in this area, the IC has advised on ways to improve the reporting of required information,[143] and has created standardized guidelines.[144] Nevertheless, in 2000, France, Liechtenstein, Greece, Luxembourg and the European Union were in breach of this obligation.[145] Spain and the Russian Federation joined this list in 2001,[146] as did Luxembourg and the Ukraine in 2002.[147] Luxembourg and the European Union were specifically reminded of the importance of reporting specific data, as required by the respective Protocols, in 2003.[148]

The second area of non-compliance under the LRTAP regime involves instances where countries have failed to meet their overall reduction of air

---

[135] Annex III. Decision 1997/2. Ibid. Point 6.
[136] Annex III. Decision 1997/2. Ibid. Point 7.
[137] Annex III. Decision 1997/2. Ibid. Point 8.
[138] Article 4. 1985 Helsinki.
[139] Article 8. 1988 Sofia Protocol.
[140] Article 8. VOC Protocol.
[141] Article 5. 1994 Oslo Protocol.
[142] Articles 4 & 7. 1999 Gothenberg Protocol.
[143] 9 *YBIEL*. (1998). 176. 10 *YBIEL*. (1999). 219.
[144] Annex XI. Decision 2002/10 on Emission Data Reporting.
[145] Decision 2000/2. Compliance By the Parties With their Reporting Obligations. Report of the 18th Session of the Executive Body.
[146] Decision 2001/4. Compliance By the Parties With their Reporting Obligations. Report of the 19th Session of the Executive Body.
[147] Annex X. Decision 2002/9. Concerning Compliance by the Parties With Regard to Their Reporting Obligations.
[148] Decision 2003/9. Concerning Compliance With Reporting Obligations.

pollutant commitments. With such problems, the situation is noted and the countries are instructed to report on their progress in rectifying their non-compliance along with a timetable of how long they think it will take. The situation is then monitored, on an ongoing basis, by the IC. This process has been applied with Slovenia (with the 1994 Oslo Protocol),[149] Italy (and the VOC Protocol),[150] Finland for a short time (with the VOC Protocol),[151] repeatedly with Norway (with the VOC Protocol),[152] Sweden for a short time, (with the VOC Protocol),[153] repeatedly with Greece (with the NOx Protocol),[154] repeatedly with Ireland (with the NOx Protocol)[155] and repeatedly with Spain with the NOx Protocol[156] as well as the VOC Protocol.[157] Where even this approach fails and progress is not achieved in controlling the air pollutant in question, as with Norway[158] and Italy,[159] the Executive Body express their disappointment and reiterate their urging towards compliance. Conversely, where progress is made, such as with Finland, they welcome it, but retain the role of the IC to monitor progress until compliance is fully achieved.[160]

[149] Decision 2000/1. On the Compliance of Slovenia with the 1994 Oslo Protocol.
[150] Decision 2001/3 On the Compliance of Italy with the VOC Protocol.
[151] Decision 2003/2. Concerning Compliance By Finland With Its Obligations Under the VOC Protocol. Decision 2001/2 On the Compliance of Finland with the VOC Protocol.
[152] Decision 2003/1. Concerning Compliance By Norway With Its Obligations Under the VOC Protocol. Decision 2001/1 On the Compliance of Norway with the VOC Protocol.
[153] Decision 2003/4. Concerning Compliance By Sweden With Its Obligations Under the VOC Protocol. Annex VI.
[154] Decision 2003/5. Concerning Compliance By Greece With Its Obligations Under the 1988 NOX Protocol. Annex VII. Decision 2002/6 Concerning Compliance by Greece With Its Obligations Under the NOx Protocol.
[155] Decision 2003/6. Concerning Compliance By Ireland With Its Obligations Under the 1988 NOx Protocol. Annex VIII. Decision 2002/7 Concerning Compliance by Ireland With Its Obligations Under the NOx Protocol.
[156] Decision 2003/7. Concerning Compliance By Spain With Its Obligations Under the VOC Protocol. Annex IX. Decision 2002/2 Concerning Compliance by Spain With Its Obligations Under the NOx Protocol.
[157] Decision 2003/8. Concerning Compliance By Spain With Its Obligations Under the VOC Protocol.
[158] Annex III. Decision 2002/2 Concerning Compliance by Norway With Its Obligations Under the VOC Protocol.
[159] Decision 2003/3. Concerning Compliance By Italy With Its Obligations Under the VOC Protocol. Annex V. Decision 2002/4 Concerning Compliance by Italy With Its Obligations Under the VOC Protocol.
[160] Annex IV. Decision 2002/3 Concerning Compliance by Finland With Its Obligations Under the VOC Protocol.

3. The Climate Change Regime

In the same manner as both the air pollution and ozone regimes, the climate change regime contains a mechanism for dealing with formal settlement of disputes between signatories to the Convention and its Protocol. Specifically, Article 14 of the FCCC contains the possibilities of sending disputes related to the interpretation or application of the Convention between two or more Parties, to the ICJ, international arbitration or through a conciliation commission.[161] Article 14 was also carried over into the Kyoto Protocol.[162] The formal dispute resolution mechanisms are separate from the internal non-compliance mechanisms of the climate regime.[163]

A. Reporting Commitments

Clear and comprehensive reporting and sharing of information related to climate change policies, is recognized as a clear gesture of good faith[164] in the climate regime, as this allows Parties to learn[165] from each other, and help evaluate the overall success and failure of the regime both generally,[166] and specifically with problems of non-compliance.[167] Due to such importance, the reporting requirements of the climate regime are extensive, and the Secretariat goes to great lengths to promote national reports.[168] The obligation for all Parties, subject to 'common but differentiated' responsibilities, to report on their national greenhouse gas inventories,[169] includes the increasingly complicated sector of additional (voluntary) reporting for Land Use, Land Use Change and Forestry (LULUCF).[170] The reporting obligations for all Parties were also reiterated in the Kyoto Protocol, which also added additional reporting requirements relating to the flexibility mechanisms.[171]

---

161 FCCC. Article 14.
162 Kyoto Protocol. Article 19.
163 Kyoto Protocol. Article 16.
164 Decision 13/CP.7. 'Good practices' in policies and measures among Parties included in Annex I to the Convention.
165 Kyoto Protocol. Article 2 (b).
166 Decision 11/CP.4. National communications from Parties included in Annex I to the Convention. Paragraph 8 (b).
167 Kyoto Protocol. Article 7 (1).
168 Decision 12/CP.4. Initial national communications from Parties not included in Annex I to the Convention. Paragraph 1. Decision 7/CP.5. First compilation and synthesis of initial communications from Parties not included in Annex I to the Convention. Decision 6/CP.3. Communications from Parties included in Annex I to the Convention. Paragraph 3 (b). Decision 33/CP.7. National communications from Parties included in Annex I to the Convention.
169 FCCC. Article 4 (1)(a)–(c).
170 Decision 15/CP.10. Good Practice Guidance for Land Use, Land Use Change and Forestry Activities Under Article 3, Paragraphs 3 and 4 of the Kyoto Protocol.
171 Kyoto Protocol. Article 10 (a). Decision 17/CP.10. Standard Electronic Format For

Apart from some common reporting consideration and certain common methodological similarities, the reporting requirements for developed and developing countries are different, both in terms of content required, and submission dates. As a rule, the reports from developed countries are more detailed than those of developing countries.[172] The content of the reports for developed countries has been elaborated upon in, 1996, 1997, 1999, 2001 and 2002.[173] The submission dates of the reports for developed countries began sixth months after entry into force of the FCCC, and was followed by reports due in 1997, 2001 and 2004/2005.[174] Although the problem of some developed countries not complying with their submission dates,[175] the standard, as a whole, for the reporting of information in national communications is considered to be improving.[176] The exception to the improvements in reporting for developed countries, is with some countries in economic transition. These countries are treated with some 'flexibility' on their reporting requirements.[177]

Developing countries have different submission times[178] and despite the fact that their reporting requirements have evolved,[179] their reporting requirements are less onerous than those imposed on developed countries. Financial and/or technical assistance is available to help developing countries meet

Reporting Kyoto Protocol Units. This decision was linked to draft decision -/CMP.1. Standard Electronic Format for Reporting Kyoto Protocol Units, which created a Standard Electronic Format (SEF) with six tables, detailing the required information

172 FCCC. Article 12. 2.

173 Decision 9/CP.2. Communications from Annex I Parties: Guidelines, Schedule and Process. Kyoto Protocol. Article 7 (1), (2)-(4). Decision 3/CP.5 and Decision 4/CP.5 Guidelines for the preparation of national communications by Parties included in Annex I to the Convention, Part I: UNFCCC reporting guidelines on annual inventories & Part II National Communications. Paragraphs 1 & 2. Decision 18/CP.8. Guidelines For The Preparation Of National Communications By Parties Included In Annex I To The Convention, Part I: UNFCCC Reporting Guidelines On Annual Inventories. Decision 20/CP.7. Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol.

174 FCCC. Article 12. 5. Decision 3/CP.1. Preparation and Submission of National Communications. Decision 11/CP.4. National communications from Parties included in Annex I to the Convention. Paragraph 2 (a).

175 Decision 3/CP.1. Preparation and Submission of National Communications. Decision 11/CP.4. National communications from Parties included in Annex I to the Convention. Paragraph 2 (a). Decision 4/CP.8. National communications from Parties included in Annex I to the Convention. Decision 1/CP 9. National Communications From Parties Included in Annex I to the Convention. 5 *YBIEL*. (1994). 166.

176 Decision 11/CP.4. National communications from Parties included in Annex I to the Convention. Paragraph 8 (b). Decision 4/CP.8. National communications from Parties included in Annex I to the Convention.

177 Report of the First COP to the FCCC. Proceedings. Para. 47.

178 Developing countries had three years extra before they had to start the reporting cycle. LDC's could make their initial report, 'at their discretion'. FCCC. Art. 12. 5.

179 Decision 8/CP.1. First Communications From Parties Not Included In Annex I to the Convention. Decision 10/CP.2. Communications from Parties Not Included in Annex I: Guidelines, Schedule and Process.

their reporting obligations.[180] Apart from a slowness in meeting some submissions dates for developing countries, (but not LDCs, which have no set submission dates)[181] as a generalisation, at the turn of the century, although developing countries were, overall, fulfilling their reporting commitments, there was, 'a varied level of detail across the different communications'.[182] Attempts to rectify this problem began in 1999 when a, 'consultative group of experts' was created for the purpose of improving national communications from developing Parties.[183] The consultative group of experts was continued,[184] as new guidelines, designed to encourage the presentation of information in a consistent, transparent, comparable and flexible manner. This encouragement is meant to assist the Secretariat's compilation and synthesis of initial national communications from developing countries.[185] The compilation and synthesis is due to be completed in 2005.[186]

B. Review

Although semi-official teams of experts had already been assisting countries with various climate related issues since the early 1990s, the assistance of

---

[180] FCCC. Article 12. 7. See chapter XV of this book.

[181] Decision 7/CP.5. First compilation and synthesis of initial communications from Parties not included in Annex I to the Convention.

[182] Decision 7/CP.5. First compilation and synthesis of initial communications from Parties not included in Annex I to the Convention. Para. 3 (a) and (b). Decision 3/CP.6 Second compilation and synthesis of initial national communications from Parties not included in Annex I to the Convention. Paragraph 3.(a) & (b). Decision 30/CP.7. Third compilation and synthesis of initial national communications from Parties not included in Annex I to the Convention.

[183] Decision 8/CP.5. Other matters related to communications from Parties not included in Annex I to the Convention. Decision 7/CP.5. Paragraph 3. See also the attached Annex Terms Of Reference Of The Consultative Group Of Experts On National Communications From Parties Not Included In Annex I To The Convention. The Group is made up, primarily, from developing country members. See the Terms of Reference of the Consultative Group of Experts. Their mandate was to exchange experience and information on the preparation of national communications, including consideration of sub-regional experience, consider, as appropriate, the needs for and availability of financial resources and technical support, and the identification of barriers to and gaps in this support; identifying gaps and making recommendations to better coordinate these activities and programs in order to enhance the preparation of national communications, including with regard to methodological issues, with a view to enhancing the quality of future inventories. See Paragraph 5 of the Terms of Reference.

[184] Decision 31/CP.7. Consultative Group of Experts on National Communications from non-Annex I Parties. 19. Decision 3/CP.8. Consultative Group of Experts on National Communications from Parties not included in Annex I to the Convention.

[185] Decision 17/CP.8. Guidelines for the preparation of national communications from Parties not included in Annex I to the Convention. Decision 2/CP.8. Fourth compilation and synthesis of initial national communications from Parties not included in Annex I to the Convention.

[186] Decision 2/CP 9. Compilation and Synthesis of Initial National Communications.

official experts was not finalized until the FCCC was concluded. To further this assistance, the FCCC and the Kyoto Protocol,[187] created a mechanism to achieve a fast and efficient review of the required information provided by the Parties to the climate regime.[188] Notably, what began with a review of national reports, developed with the Kyoto Protocol to also focus on, 'a thorough and comprehensive technical assessment of all aspects of the implementation by a Party of this Protocol',[189] including, 'identifying any potential problems in, and factors influencing, the fulfillment of commitments'.[190] The purpose of the review process is to ensure that the COP and the Compliance Committee have adequate information, in accordance with the necessary guidelines, with regards to the Parties assigned reduction amounts. Effectively, this means that all aspects of the implementation by a Party and factors influencing its fulfillment of commitments is to be available for review. To do this a, 'thorough, objective and comprehensive technical assessment of the capacity of [each] national registry'[191] as well as national communications and obligations under FCCC and the Protocol is undertaken. Review of a Parties use of the various flexibility regimes may also be undertaken,[192] independently of the other review processes within some of the flexibility regimes, such as the CDM.[193]

The majority of the Expert Review Teams (ERTs) are politically neutral experts nominated by the Parties, and individuals from intergovernmental organizations, as appropriate.[194] In 2001 the Expert Review Process was

187 Kyoto Protocol. Article 8 (1). The Guidelines may be periodically reviewed by the COP. See Article 8 (4).

188 FCCC. Article 4 (2)(b) and 12. 6. For the earlier process, see Victor, D. & Salt, J. (1994). 'Climate Change.' *Environment.* Dec. 7–15.

189 Kyoto Protocol. Article 8 (3).

190 Kyoto Protocol. Article 8 (3).

191 Decision 23/CP.7. Guidelines for review under Article 8 of the Kyoto Protocol. Ibid. Appendix I. Part V: Review Of National Registries. See also Part I: General Approach To Review. B. Objectives 2. (a) & C. Also, Part II: Review Of Annual Inventories.

192 Decision 23/CP.7. Guidelines for review under Article 8 of the Kyoto Protocol. Ibid. Appendix II. Review for Reinstatement of eligibility to use mechanisms. Decision 13/CP.10. Incorporation of the Modalities and Procedures for Afforestation and Reforestation Project Activities Under the Clean Development Mechanism Into the Guidelines Under Articles 7 and 8 of the Kyoto Protocol. Annex III and IV.

193 Decision 18/CP.9. Guidance to the Executive Board of the Clean Development Mechanism. Annex II. The procedures for review of the CDM mechanism, which are limited to issues of fraud, malfeasance or incompetence, were refined in 2004. See Annex II of the Draft Decision attached to Decision 12/CP.10. Guidance Relating to the Clean Development Mechanism. The Request, Scope, Modalities, Review, and Review Decision options are all clearly set out.

194 Kyoto Protocol. Article 8 (2). For the earlier organization, which involved a representative from the Secretariat, see Decision 2/CP.1. Review of the First Communications From the Parties Included in Annex I. Paragraphs 1 & 2.d. For the lead up to this decision, see Cutajar, M. (1994). 'INC To Review National Efforts to Implement Treaty.' *Climate Change Bulletin.* 4 (3): 2–3. Expert review teams shall be coordinated by the secretariat and shall be composed of experts selected on an ad hoc basis from the UNFCCC

concluded,[195] and specific training programmes for the ERTs, as well as selection criteria for the lead reviewer, were agreed in 2003.[196] The reviews are designed to include invited visits to the country under examination.[197] The review teams are directed to produce, in an open, transparent, non-confrontational and flexible[198] way, a report on the Parties' commitments, which is then forwarded to the Party concerned in good time, to allow alterations.[199] The ERTs are obliged to identify, investigate and help solve problems where possible. Remaining problems of a serious nature relating to mandatory commitments should be listed as a question of implementation in the final review reports. The ERTs are to refrain from making any political judgments, and confidentiality shall be protected where necessary.[200] The Reports are then forwarded to the Secretariat, and then to the COP, which, after taking any necessary advice, 'shall take decisions on any matter required for the implementation of this Protocol'.[201]

The review of national reports began in 1995, and technical reviews of the greenhouse gas inventories of a number of countries which volunteered to be reviewed, began in 1999.[202] The formal review of the inventories of developed Parties (8 reviews per year) began in 2003.[203] Revised Guidelines for the technical reviews were concluded in 2002,[204] and operational guidelines for Technical Review Teams, including a Code of Practice for

roster of experts and will include lead reviewers. Participating experts shall serve in their personal capacity. The objective is to have a a balance between Annex I & II Parties in the overall composition, geographical balance. Decision 23/CP.7. Guidelines for review under Article 8 of the Kyoto Protocol. Ibid. Appendix II. E. Expert review teams and institutional arrangements.

[195] Decision 23/CP.7. Guidelines for review under Article 8 of the Kyoto Protocol. Appendix I. Part I: Review Of Information On Assigned Amounts Pursuant To Article 3, Paragraphs 7 And 8, Emission Reduction Units, Certified Emission Reductions, Assigned Amount Units And Removal Units.

[196] Decision 21/CP 9. Issues Relating to the Implementation of Article 8 of the Kyoto Protocol. 34–39.

[197] Decision 6/CP.3. Communications from Parties included in Annex I to the Convention. Paragraph 3 (a).

[198] Flexibility is only important when dealing with countries in economic transition. Report of the Sixth COP to the FCCC. Personal Observations of the Chair.

[199] Decision 2/CP.1. Review of the First Communications From the Parties Included in Annex I. Annex I (Purpose of Reviews). The tasks of the review are then set down (Annex II) along with the outline for review reports (Annex III). Decision 12/CP.4. Initial national communications from Parties not included in Annex I to the Convention. Paragraph 1. Decision 32/CP.7. Other Matters Relating To Communications From Parties Not Included In Annex I To The Convention. 10 *YBIEL.* (1999). 229.

[200] FCCC. Article 12. 8 & 9.

[201] Kyoto Protocol. Article 8 (6).

[202] Decision 6/CP.5. Guidelines for the Technical Review of greenhouse gas inventories from Parties included in Annex I to the Convention. Paragraph 4 (a) & (b).

[203] Decision 6/CP.5. Guidelines for the Technical Review. Ibid. Paragraph 11.

[204] Decision 19/CP.8. UNFCCC guidelines for the technical review of greenhouse gas inventories from Parties included in Annex I to the Convention.

confidential information, were concluded in 2003,[205] and further refined in 2004. Most notably, it was decided that a Parties decision not to release confidential information on demand to a Technical Review Team, was not to be treated as an inconsistency with reporting requirements, provided the confidential information was later examined by an Expert Review Team. Moreover, the latter review could lead to the retroactive application of an adjustment for the relevant years of the commitment period.[206]

C. Implementation

Article 13 of the FCCC, and the Kyoto Protocol reiterated,[207] that a multilateral process for the resolution of questions regarding the implementation of the Convention should be created. To facilitate this objective, the COP, aside agreeing that that reports on implementation shall be, as much as possible, publicly available,[208] agreed that an Ad Hoc Group on Article 13 be established.[209] The Ad Hoc Group eventually concluded the Multilateral Consultative Process (MCP) in 1998.[210] The objective of the MCP was agreed as resolving, 'questions regarding the implementation of the Convention'[211] by providing advice to overcome difficulties encountered in their implementation, promoting understanding of the climate regime, and preventing disputes. The process was to be conducted in a facilitative, cooperative, non-confrontational, non-judicial, transparent and timely manner. Parties are entitled to participate fully in the MCP deliberations.[212]

[205] Decision 12/CP 9. Issues Relating to the Technical Review of Greenhouse Gas Inventories From Parties Included in Annex I to the Convention.

[206] Decision 18/CP.10. Issues Relating to the Technical Review of Greenhouse Gas Inventories of Parties Included in Annex I of the Convention and the Implementation of Article 8 of the Kyoto Protocol. The point about the retroactive application was contained in Draft decision -/CMP.1. Issues Relating to the Implementation of Article 8 of the Kyoto Protocol, which will come into force with the first MOP of the Protocol.

[207] Kyoto Protocol. Article 16.

[208] Decision 7/CP.1. The Report on Implementation.

[209] Decision 4/CP.2. Future Work of the Ad-Hoc Group on Article 13. Note, in 1996 the discussion was widened to link compliance issues with reduction targets. Decision 5/CP.2. Linkage Between the Ad-Hoc Group on Article 13 and the Ad-Hoc Group on the Berlin Mandate. Report of the Second Session of the COP, Geneva. 8. Decision 14/CP.3 Future work of the Ad Hoc Group on Article 13

[210] Decision 10/CP.4. Multilateral Consultative Process. The exception was the failure to solve the constitution of the Committee, which remained in square brackets. The constitution of the Committee was not fully settled in 1998, with the exact numbers (10,15 or 25) upon the Committee being underdetermined. Likewise, the principles of rotation, and considerations of 'equitable geographical distribution' were not settled. Decision 10/CP.4. Multilateral Consultative Process. Annex. Paragraphs 8 & 9.

[211] Decision 10/CP.4. Multilateral Consultative Process. Ibid. Paragraph 2.

[212] Decision 10/CP.4. Multilateral Consultative Process. Ibid. Paragraphs 2 (a)-(c), and 3.

Questions regarding the implementation of the Convention may be raised, with supporting information, by an individual or groups of Parties with respect to their own implementation, or the implementation by another individual or group of Parties.[213] From these investigations, the Committee is obliged to report to the Parties concerned,[214] prior to forwarding the report to the COP.[215] The Committee may recommend cooperation between the Party or Parties concerned and other Parties to further the objective of the Convention, as well as measures necessary for the effective implementation of the Convention.[216]

D. Substantive Non-Compliance

Article 18 of the Kyoto Protocol stated a new mechanism would be created which would,

> Approve appropriate and effective procedures and mechanisms to determine and to address cases of non-compliance with the provisions of this Protocol, including through the development of an indicative list of consequences, taking into account the cause, type, degree and frequency of non-compliance. Any procedures and mechanisms under this Article entailing binding consequences shall be adopted by means of an amendment to this Protocol.[217]

Following strong support for a mechanism to deal with substantive non-compliance by the G7[218] and dedicated working groups within the FCCC,[219] the modalities of the Compliance Committee (CC) were finally settled in 2001.[220] Moreover, acceptance of the CC by the Parties, was linked to

---

213 Decision 10/CP.4. Multilateral Consultative Process. Ibid. Paragraph 5.

214 Decision 10/CP.4. Multilateral Consultative Process. Ibid. Paragraph 12.

215 Decision 10/CP.4. Multilateral Consultative Process. Ibid. Paragraph 13.

216 Decision 10/CP.4. Multilateral Consultative Process. Ibid. Paragraph 12 (a) & (b).

217 Kyoto Protocol. Article 18.

218 G8 Summit Communique. (Denver). Available from http://www.g7.utoronto.ca/g7/summit/1997denver/98final.htm G8 Summit Communique. (Birmingham). Available from http://www.g7.utoronto.ca/g7/summit/1998birmingham/finalcom.htm Paragraph 11. G8 Summit Communique. (Koln). Available from http://www.g7.utoronto.ca/g7/summit/1999koln/finalcom.htm Paragraph 33. G8 Environment Minister's Communique. Available From http://www.g7.utoronto.ca/g7/environment/2001trieste/communique.html Paragraph 9.

219 Decision 15/CP.5. Future work of the Joint Working Group on Compliance. 10 *YBIEL*. (1999). 229.

220 Decision 24/CP.7. Procedures And Mechanisms Relating To Compliance Under The Kyoto Protocol. For the lead up to this decision, see COP 6, Part One. Action Taken By The COP At The First Part Of Its Sixth Session. Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action, Annex. Section VIII. Procedures And Mechanisms Relating To Compliance Under the Kyoto Protocol. For the debate on this in the run-up to COP6, see Anon. (2000). 'Disappointment At Meagre Progress.' *Environmental Policy and the Law*. 30(5): 217.

eligibility to perform in some of nationally beneficial mechanisms of the Kyoto Protocol.[221]

The objective of the CC is to, 'facilitate, promote and enforce compliance with the commitments under the Protocol'. The Committee has a facilitative branch and an enforcement branch. A plenary can be formed when the two branches are brought together. The Committee consists of 20 elected members, based on rotating and equitable geographical distribution. The CC is equally divided between the facilitative and enforcement branches. The members of the CC serve in their individual capacities. Decisions by the CC shall, wherever possible, be made by consensus. If consensus is not possible, a three quarters majority is required. Submissions may be made to the CC, by either a Party about its own compliance, or by a Party about the compliance of another Party. Such allegations must be supported by corroborating information.

Both branches are aware of the common but differentiated responsibilities of the Parties. A special flexibility is also shown to countries in economic transition. The difference in examining Party responsibilities is especially important for the facilitative branch[222] which deals with issues of more common concern, as opposed to the Enforcement Branch which deals strictly with developed country obligations.

All claims are subject to a preliminary examination, which shall establish that the questions raised have a sufficient basis for examination, in terms of being well founded, and in accordance with the climate regime.[223] If the claims are established as being well founded, the Party concerned may elect people to represent it to the relevant branch, for all stages of the deliberations, except when the final decision is being made. The Party under investigation also has the opportunity to comment in writing on all submitted information.[224] In addition, the branch shall consider all pertinent information from the reports of the ERTs, information submitted by the respective Parties, reports of the COPs, and information from the other branch as well as competent IGOs and NGOs. Subject to any rules relating to confidentiality, the information examined and decision reached should be public.

The Facilitative Branch[225] is responsible for providing advice and facilitation to Parties in implementing the Protocol, and for promoting compliance by Parties with their commitments under the Protocol. It is, in

[221] Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action, Annex. Section VI. Mechanisms Pursuant To Articles 6, 12 And 17 of the Kyoto Protocol.
[222] Decision 24/CP.7. Ibid. Annex. XIV. Consequences Applied By The Facilitative Branch..
[223] Decision 24/CP.7. Ibid. Annex. VII. Allocation And Preliminary Examination.
[224] Decision 24/CP.7. Ibid. Annex. VIII. General Procedures.
[225] Decision 24/CP.7. Procedures And Mechanisms Relating To Compliance Under The Kyoto Protocol. Ibid. Annex. IV. The Facilitative Branch.

essence, the 'early warning' prior to formal challenges on non-compliance. The Facilitative branch has the option of providing advice and facilitation of assistance, including recommendations of financial assistance and assistance including capacity building and even technology transfer. Conversely, the Enforcement Branch[226] is responsible for determining whether a developed country is in compliance with its reduction targets, its reporting requirements, and its greenhouse gas inventories.

The Enforcement Branch,[227] has more formal, and more streamlined, procedures than the Facilitative Branch. An expedited procedure exists for questions of implementation pertaining to the flexibility mechanisms.[228] A Party may appeal to the COP, if it feels it has been denied due process.[229] The COP can over-ride the decision of the Enforcement Branch and refer the issue back to them, if three quarters of the Parties agree to do so.

When the Enforcement Branch is examining non-compliance related to inventory or communication issues, then depending on the cause, type, degree and frequency of the non-compliance of that Party, the Enforcement Branch may declare them to be in non-compliance, and provide them with a plan of action, to remedy the problems within a set time frame.[230] Where it has been determined that a developed Party does not meet one or more of the eligibility requirements with regards to the flexibility mechanisms it shall suspend the eligibility of that Party in accordance with relevant provisions under those articles. Where it has been determined that the greenhouse gas emissions of a Party have exceeded their assigned reduction amount, then the objective for the Enforcement Branch is the restoration of compliance. Accordingly, the following consequences shall apply. First, deduction from the Party's assigned amount for the second commitment period of a number of tonnes equal to 1.3 times the amount in tonnes of excess emissions. Second, suspension of trading ability under Article 17 of the Protocol, until a Compliance Action Plan (which recognizes the problem and sets out to solve it within a specific time frame) is agreed between the Enforcement Branch and the Party in non-compliance. A Party may also be offered an additional period to fulfill their commitments, by which the Party can attempt to acquire the necessary credits through the flexibility mechanisms.[231]

---

226 Decision 24/CP.7. Ibid.
227 Decision 24/CP.7. Ibid. Annex. IX. Procedures For The Enforcement Branch.
228 Decision 24/CP.7. Ibid. Annex. X. Expedited Procedures For The Enforcement Branch.
229 Decision 24/CP.7. Ibid. Annex. XI. Appeals.
230 Decision 24/CP.7. Ibid. Annex. XV. Consequences Applied By The Enforcement Branch.
231 Decision 24/CP.7. Procedures And Mechanisms Relating To Compliance Under The Kyoto Protocol. Ibid. Annex. XIII. Additional Period For Fulfilling Commitments. 12 *YBIEL.* (2001): 216–217.

XI. EVOLVING LEGAL INSTRUMENTS

1. The LRTAP and its Protocols

The LRTAP and its supplementary protocols of 1984,[1] 1985,[2] 1988,[3] 1991,[4] 1994,[5] and 1999,[6] is recognized by its signatories as, 'an outstanding example of intergovernmental cooperation'.[7] A large part of this success is due to the fact that the air pollution regime has continually evolved to confront changing problems. One of the driving factors of this evolution has been a continuing stream of national and regional initiatives to confront transboundary air pollution.[8] This continual stream has been assisted by the fundamental design of the LRTAP, as a framework convention, that was intended to be built upon, as needed. Within the regime itself, the evolution has been facilitated by continual reviews of the operation of the instrument in terms of meeting its overall objectives (to stop transboundary air pollution) by the Executive Body.[9] In addition, each protocol has an

---

[1] Protocol on Long-Term Financing of Co-Operative Programme for Monitoring and Evaluation of the Long Term Transmission of Air Pollutants in Europe. BH856.txt.

[2] The 1985 Helsinki Protocol to the LRTAP on the Reduction of Sulphur Emissions or Their Transboundary Fluxes by at Least 30%. BH868.txt.

[3] Protocol to the 1979 Convention on Long Range Transboundary Air Pollution Concerning the Control of Emissions of Nitrogen Oxides or Their Transboundary Fluxes. 28 *International Legal Materials*. (1989). 212. BH930.txt

[4] Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution Concerning the Control Of Emissions of Volatile Organic Compounds or their Transboundary Fluxes (1991). BH994.txt

[5] Protocol on Further Reduction of Sulphur Emissions. 33 *International Legal Materials* (1994). 1542.

[6] The Gothenburg Multi-Effects Protocol. Available from <http://www.unece.org/env/lrtap/protocol/99multi.htm>

[7] Annex II. Gothenburg Ministerial Declaration. December 1. 1999. Report of the Seventeenth Session of the Executive Body. ECE/EB.AIR/68, 27 December 1999.

[8] See especially the Large Plants Directive of the EC and subsequent General Directives on Ambient Air Quality Assessment and Management. Anon. (1994). 'Air and Water Quality.' *Environmental Policy and the Law*. 24 (6). 321–322. 7 *YBIEL*. (1996). 386. Anon. (1997). 'Directive on Air Quality.' *Environmental Policy and the Law*. 27(1). 47. Boehmer-Christiansen, S. (1991). *Acid Politics*. (Belhaven, London). Chapter 12. For notes on these processes within the Protocols, see the Helsinki Protocol, see Decision A (I), ECE/EB AIR/1. p4. For the recognition of this, see Preamble. Helsinki Protocol. 1988 Protocol. Preamble. the 1991 VOC Protocol. Preamble. See also, 5 *YBIEL*. 1994. 158. 6 *YBIEL*. 1995. 217.

[9] Article 10. Decision 1999/2. Concerning the Structure and Organisation of Work. Report of the 17th Session of the Executive Body. ECE/EB.AIR/68. Levy, M. (1993). 'European Acid Rain: The Power of Tote-Board Diplomacy.' In Hass, P.M. et al. (eds). *Institutions for the Earth*. (Cambridge, Mass. MIT Press)

institutional process designed to create an internal momentum towards continual improvements in meeting its overall objectives. For example, regular scientific and policy reviews of the success of the protocols, buttressed against the idea that further controls on air pollutants may be required to meet the overall goals of the LRTAP regime, if the controls of the instruments are not be adequate, was built into the protocols of 1985,[10] 1988,[11] 1991,[12] 1994,[13] and 1999.[14]

Despite the institutional processes within each protocol designed to create an internal momentum towards continual improvements, the actual legal mechanisms within the 1984,[15] 1985,[16] 1988,[17] 1991,[18] 1994[19] and 1999[20] protocols that have to be utilized to achieve amendments and/or adjustments are very conservative. That is, changes to existing instruments can only be done by consensus of all those present at the Executive Meetings.

In 2004, 48 of the 55 ECE members were Parties to the LRTAP. The European Union is also Party as a regional economic integration organization. Of the six that are not members, three are in Central Asia. These are Tajikistan, Turkmenistan and Uzbekistan. There are 41 signatories to the 1984 Protocol. The Protocol of 1985 had only limited signatories. The 1988 Protocol had almost 90% of the LRTAP Parties signing it. The 1991 Protocol took nearly 6 years to come into force. The 1994 Protocol has been signed by 28 Parties. All of these earlier protocols will be eclipsed by the 1999 Gothenburg Protocol. In 2004, there were only 11 signatories to the Gothenburg Protocol and it was not yet in force.[21]

2. The Ozone Instruments

Like the LRTAP on which it was modeled, the Vienna Convention, is also a framework convention,[22] without any definitive controls on the tar-

[10] Articles 3, 4, 5 & 6.
[11] 1988 Sophia Protocol. Articles 2(3) and 5.
[12] 1991 VOC Protocol. Article 6.
[13] 1994 Protocol on Further Sulphur Reductions. Preamble. Paragraph 8, Articles 2 (8) and 8. (1) & (2).
[14] 1999 Gothenberg Protocol. Articles 3 (7) and 10.
[15] 1984 EMEP Protocol. Article 6.
[16] 1985 Helsinki Protocol. Article 7.
[17] 1988 Sofia Protocol. Article 11.
[18] 1991 VOC Protocol. Article 11.
[19] 1994 Protocol on Further Reductions of Sulphur Emissions. Article 11.
[20] 1999 Gothenberg Protocol. Article 13.
[21] UNECE. (2004). Ratification of the Convention and Its Protocols. EB.AIR/2004/4. September 16.
[22] UNEP Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of

getted pollutants. However, it was envisaged that as controls may be necessary in the future, an internal mechanism would be created to examine such needs. The core of this mechanism within the Vienna Convention was in Article 6, which provided for Conferences of the Parties (COPs) at regular intervals in the future. Each COP, in addition to reviewing the overall adequacy of the Convention in terms of scientific, regulatory and administrative considerations, was also obliged to consider and undertake any additional action that may be required, including the possible adoption of protocols,[23] and/or amendment of the primary instrument,[24] necessary for the overall achievement of the purposes of this convention.[25]

Two years after the conclusion of the Vienna Convention, the additional action that was required, and concluded, was the Montreal Protocol on Substances that Deplete the Ozone Layer. The Montreal Protocol, which has co-ordinated mechanisms with the Vienna Convention,[26] utilizes regular Meetings of the Parties (MOPs),[27] as well as specific amendments to the Protocol (in 1990, 1992, 1997 and 1999) to achieve its objectives. The regular meetings and amendments of the Montreal Protocol are designed to consider any additional action that may be required for the achievement of the purposes of the Protocol in light of the best available scientific, technical and economic information.[28]

The evolution of the Vienna Convention, like that of the Montreal Protocol has also been facilitated by its voting mechanisms. In terms of amending the Vienna Convention, if consensus cannot be achieved, amendments to the Convention can be passed by a majority of three quarters of those present and voting.[29] In terms of amending the Montreal Protocol, if consensus cannot be achieved, a two-thirds majority of those present and voting may amend the instrument.[30] Originally, the two-thirds majority only had to include at least 50% of the total ODS consuming nations. However, with the amendments to the Protocol in 1990, the two-thirds

a Global Framework Convention for the Protection of the Ozone Layer. (1981). A Look At Some Issues: A Contribution by the UNEP Secretariat. UNEP/WG.69/5. December 31. Paragraphs 53 & 54. UNEP. (1982). Some Obstructions on the Preparation of a Global Framework for the Protection of the Ozone Layer. UNEP/WG.69/8. January 13. Paragraph 35.

[23] Article 8.

[24] Article 9.

[25] Article 7 (4)k.

[26] By 1996, the increased linkage between the Vienna and Montreal instruments was such that when the meetings were being held, they were designed to largely co-ordinate the timings of the meetings. 7 *YBIEL*. (1996). 127.

[27] Montreal Protocol. Article 11.

[28] Montreal Protocol. Article 11(4). j.

[29] Vienna Convention. Article 9(3).

[30] See Article 2 (9)(c–d). See also 1 *YBIEL*. (1990). 47.

majority was changed to have to encompass a majority of developing countries, and a majority of industrialized countries.[31] Although this two-thirds majority may be difficult to achieve, the result is desirable, as once the decisions are concluded, they are binding on all Parties, including those who objected.[32] This results of these voting processes are reinforced by the fact that neither the Vienna Convention nor the Montreal Protocol allow reservations.[33] However, the limitation remains that any formal amendment to the Protocol effectively creates a new legal instrument, which requires formal ratification by the signatory. Until such amendments are ratified, the Parties cannot be considered to be bound by the amendments. The result of the requirement of ratification for each individual amendment to the Protocol is that there is an ad-hoc collection of signatories for each instrument, which makes implementation considerations increasingly difficult.[34] At the end of 2003, 166 Parties had ratified the 1990 London Amendment to the Montreal Protocol and 154 Parties had ratified the 1992 Copenhagen Amendment, while only 107 Parties had ratified the 1997 Montreal Amendment. Only 57 Parties had ratified the 1999 Beijing Amendment.[35]

One proposal put forward by the European Union to confront this problem called for an 'expedited procedure' for suggesting that updates to the ODS list, could be added, and binding, on Parties through the voting mechanism, rather than having to be separate amendments requiring ratification. If adopted, this would have sorted out many of the differences in ratification, as the binding nature of the article 2(9) would have imposed the same obligations across the board, doing away with the effective veto by requiring ratification. However, this proposal was not supported by a majority of the Parties, due to a fear of 'giving too much power' to the two-thirds majority.[36]

3. The Climate Change Regime

Before negotiations even began, the G7 stipulated that any future convention on climate should be a 'framework or umbrella convention' which

[31] 3 *YBIEL.* (1992). 225.
[32] Montreal Protocol. Article 2(9)(d).
[33] See Article 18 in both documents.
[34] 11 *YBIEL.* (2000). 164.
[35] Decision XV/1. Ratification of the Vienna Convention, the Montreal Protocol, and the London, Copenhagen, Montreal and Beijing Amendments. For earlier figures, see Decisions XIV/1, XIII/14.
[36] 10 *YBIEL.* (1999). 221. Oberthur, S. (2000). 'Ozone Layer Protection at the Turn of the Century: The 11th Meeting of the Parties.' *Environmental Policy and the Law.* 30(1/2): 34.

should be built on with, 'specific protocols containing concrete commitments could be fitted into the framework as scientific evidence requires and permits'.[37] The G7 argument was persuasive, and the eventual instrument was clearly labeled as the Framework Convention on Climate Change. Nevertheless, it was recognized that,

> The steps required to address climate change will be most effective if they are based on relevant scientific, technical and economic considerations and continually re-evaluated in the light of new findings in these areas.[38]

Building on this general recognition, COPs were obliged to, 'review the adequacy' of or assess, the implementation of the FCCC,[39] its greenhouse gas control commitments, (in light of the best available scientific, technical, social and economic information)[40] and the environmental, economic and social effects of the FCCC greenhouse gas policies.[41]Based on such reviews and assessments, the COP shall take appropriate action, which may include the adoption of amendments to the commitments.

The necessity for a mechanism, within any future protocol to the FCCC, which would allow for the regular review of the implementation of the instrument and strengthening of its commitments as necessary, was envisaged from the outset of the negotiations of the Kyoto Protocol,[42] and was concluded in the final agreement.[43] Finally, a clear intention to preserve the integrity of the FCCC[44] and the Kyoto Protocol[45] was established by stipulating that no reservations were permissible to either agreement.

Despite the clear intention that there would be additional protocols to the FCCC, a clear barrier against the easy introduction of a new protocol was placed within the text of the final agreement. Unlike the FCCC which only required the ratifications of 50 countries before coming into force,[46] the Kyoto Protocol was designed to enter force, only after,

> Not less than 55 Parties to the Convention, incorporating Parties included in Annex I which accounted in total for at least 55 per cent of the total carbon

---

[37] G7 Paris Summit (1989). Summit Communique, available from<http://www.g7.utoronto.ca/g7/summit/1989/paris/communique/energy.html> G7 Houston Summit (1990). Summit Communique, available from<http://www.g7.utoronto.ca/g7/summit/1990/houston/communique/energy.html>
[38] FCCC. Preamble. Paragraph 16.
[39] FCCC. Article 7.
[40] FCCC. Article 4.2.(d).
[41] FCCC. Article 17.
[42] The Geneva Ministerial Declaration. Report of the Second COP to the FCCC. Paragraph 8.
[43] Kyoto Protocol. Articles 9 and 13.
[44] FCCC. Article 24.
[45] Kyoto Protocol. Article 26.
[46] Anon. (1994). 'Climate Change Convention Enters Force.' *Climate Change Bulletin*. 3(2): 1–3.

> dioxide emissions for 1990 of the Parties included in Annex I, have deposited their instruments of ratification, acceptance, approval or accession.[47]

This threshold employed a 'double trigger' in that it not only required ratification by 55 Parties of the FCCC, but also, of countries representing at least 55% of the total of greenhouse gas emissions for developed countries in 1990. This conferred upon the United States a near de-facto veto since it comprised no less than 35% of developed country emissions in 1990.[48] Thus, as the United States and Australia refused to ratify the Kyoto Protocol, it became necessary for virtually all the other developed countries to ratify the Protocol for it to enter force.[49] Accordingly, the future of the Kyoto Protocol was clearly in doubt between 2001 and the end of 2003, before the Russian Federation finally committed itself to ratifying it, thus bringing it into force on the 16th of February, 2005.[50]

The other area of difficulty within the climate change regime has been with its voting procedures. The typical way of voting within international conventions, is through either majorities, entrenched majorities (such as two thirds or three quarters) or consensus. The more progressive regimes have a simple majority for matters of lesser importance and entrenched majorities for matters of greater importance. With regard to the FCCC[51] and the Kyoto Protocol,[52] aside the areas relating to amendment to the instruments or their annexes, which both require at least a three-quarters majority, the question of voting on normal matters of business was not settled in original or subsequent instrument and was left to be resolved by future COPS.[53] The decision on how to deal with this question, typically within detailed Rules of Procedure, is usually adopted by consensus.[54] However, when this matter arose at the COP in 1995, the option of deciding all decisions by entrenched majorities or by consensus was strongly contested, as some countries wanted the consensus approach, as this method

[47] Kyoto Protocol. Article 25. (1).
[48] Report of the Eighth COP of of the FCCC. Paragraphs 15–16.
[49] 8 *YBIEL*. (1997). 184–185. Pearce, F. (1999). 'US Gives Kyoto The Cold Shoulder.' New Scientist. Nov 13. 12.
[50] Anon. (2004). 'Kyoto's Big Day'. *New Scientist*. Nov 27. 4. Webster, P. (2003). 'Last Chance for Kyoto.' *New Scientist*. Oct. 44–45. Walsh, N. (2004). 'Putin Throws Lifeline to Kyoto Treaty.' *Guardian Weekly*. May 28. 8. Anon. (2004). 'Putin Commits Russia to the Kyoto Protocol.' *Ecologist*. July. 12. Anon. (2004). 'Kyoto in Force.' *New Scientist*. Mar 20. 7. Note, the FCCC COP had already began planning for the operation of the Kyoto Protocol, before Russia finally ratified the agreement. Decision 17/CP.9. Arrangements for the First Session of the COP Serving as a MOP to the Kyoto Protocol. Decision-/CMP.1. Arrangements for the First Session of the MOP to the Kyoto Protocol.
[51] FCCC. Articles 15 & 16.
[52] Kyoto Protocol. Articles 20(3) & 21(4).
[53] FCCC. 7(k) & 7(3).
[54] Kyoto Protocol. Article 13(5).

would have given them (or anyone else) a veto with regards to the adoption of major decisions.[55] This matter was not resolved in 1995, or thereafter.[56] Accordingly, although the Rules of Procedure are broadly followed they have not been formally adopted, and the question of entrenched majorities or consensus remains unanswered.[57]

[55] Oberthur, S. (1996). 'The Second Conference of the Parties' *Environmental Policy and the Law*. 26 (5): 195–201. Oberthur, S. (1995). 'The First Conference of the Parties.' *Environmental Policy and the Law*. 25 (4): 144.
[56] Report of the 2nd COP to the FCCC. 8. 7 *YBIEL*. (1996). 132.
[57] Report of the Eighth COP to the FCCC. Paragraphs 17–18. Report of the 9th COP of FCCC. 10.

XII. FINANCING THE REGIMES

1. Core Costs

Questions of which countries should contribute financially to the running of the new ozone regime, whether such funding should be voluntary or obligatory, and what the finance should be used for, were all subject to strong discussion as early as 1982.[1] The primary discussion was the nature of the 'generating mechanism'. The three options suggested were the UN Scale of Assessment, costs divided equally amongst all signatories to the convention, or a type of polluter pays arrangement whereby countries which produce and/or consume ODS contribute in proportion to their ODS emissions.[2] Although this conclusion was not concluded in the Vienna Convention,[3] the Parties agreed to the UN Scale of Assessments.[4] In a similar way, although the Montreal Protocol, which is operated under a separate Trust Fund to the Vienna Convention, did not conclude its contributions regime,[5] the Parties later agreed, that the UN Scale of Assessment was the most appropriate mechanism.[6] The 2005 budget for the Trust Fund for the Montreal Protocol was 3,746,861 (USD)[7]

The financial procedures for the FCCC were agreed at the first COP in 1995.[8] The FCCC also utilizes the the UN Scale of Assessments[9] (which

---

1 UNEP. (1982). Some Obstructions on the Preparation of a Global Framework for the Protection of the Ozone Layer. UNEP/WG.69/8. January 13. Paragraph 38. UNEP. (1982). Financial Implications of the Implementation of the Convention of the Ozone Layer. UNEP/WG.78/7. 23 November. Paragraphs 5–7, 9.

2 UNEP. (1982). Financial Implications of the Implementation of the Convention for the Protection of the Ozone Layer. UNEP/WG.78/7. 23 November. Paragraph 10. Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1984). Financial Implications of Convention: A Paper By the UNEP Secretariat. UNEP/WG.94/13. July 27. Page 3.

3 Vienna Convention. Article 6 (3).

4 Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1984). Report of the Working Group, First Part of the Fourth Session. UNEP/WG.110/4. Pages 11–12.

5 See Article 13 of the Montreal Protocol.

6 Decision 14 Funding Arrangements for the Montreal Protocol. Annex II. Terms of Reference for the Administration of the Trust Fund for the Montreal Protocol.

7 Decision XV/52. Financial Matters: Financial Reports and Budgets. Report of the 15th MOP to the Montreal Protocol. 75.

8 Decision 15/CP.1. Financial Procedures.

9 Decision 15/CP.1. Financial Procedures, Annex I. Paragraph 7.

was revised for FCCC purposes in 2001).[10] The core budget for the FCCC has risen from 18,664,200 (USD) in 1996/1997[11] to 34,807,326 for 2004 to 2005.[12] An interim allocation for the anticipated entry into force of the Kyoto Protocol was set aside from 2003.[13]

In addition to the obligatory payments towards the core budget, voluntary contributions for the three special Trust Funds of the FCCC are also solicited.[14] These Trust Funds relate to Participation in the FCCC Process by Developing Countries,[15] Supplementary Activities (that is, related to the flexible mechanisms),[16] and the 'Bonn Fund' (related to the Secretariat and its operation in Germany).[17] The Trust Funds have all been continually plagued by late payment and insufficient funding.[18]

Unlike the ozone and climate regimes, the LRTAP and its subsequent protocols (with the exception of the EMEP Protocol) did not contain provision for the funding of core activities.[19] However, this oversight was later rectified by the adoption of UN Assessment rate to help fund the (non-science) core costs of the regime.[20] The core costs for 2002, 2003 and 2004

[10] Decision 39/CP.7. Income and budget performance in the biennium 2000–2001 and arrangements for administrative support to the Convention.

[11] Decision 17/CP.1. Adoption of the Convention Budget for 1996–1997. For other budgets, see Decision 15/CP.3. Decision 20/CP.5 and Decision 38/CP.7.

[12] Decision 16/CP 9. Programme Budget for the Biennium: 2004–05.

[13] Decision 11/CP.10. Administrative and Financial Measures. Paragraph 14.

[14] Decision 15/CP.1. Financial Procedures. Annex 1. Paragraph 15. See Decision 18/CP.1. Other Voluntary Funding.

[15] Decision 23CP.2. Secretariat Activities Relating to Technical and Financial Support to Parties. 1 *YBIEL*. (1990). 378.

[16] Decision 17/CP.7. Modalities And Procedures For A Clean Development Mechanism As Defined In Article 12 of the Kyoto Protocol. Annex. Modalities and Procedures for a Clean Development Mechanism. C. Executive board.

[17] Decision 16/CP.3 Financial performance of the Convention in the biennium 1996–1997. Paragraph 2.

[18] Decision 9/CP.10. Administrative and Financial Matters. Paragraphs 7 and 8. Decision 21/CP.5. Income and budget performance in the biennium 1998–1999 and arrangements for administrative support to the Convention. Decision 39/CP.7. Income and budget performance in the biennium 2000–2001 and arrangements for administrative support to the Convention. Paragraphs 4 & 6. Decision 16/CP.8. Administrative and financial matters. Decision 16/CP.9. Programme Budget for the Biennium: 2004–05.

[19] The Core Activities, not covered by the EMEP Protocol include the programmes for the Monitoring and Assessment of Air Pollution on Forests; Rivers and Lakes; on Historical and Cultural Monuments; on Ecosystems; Health Effects; and Critical Loading. Annex 1. Decision 2002/1 on the Financing of Core Activities. Decision 2000/3. Recommendation on the Funding of Core Activities in 2001–2003. Report of the 18th Session of the Executive Body. Appendix 2.

[20] Decision 2001/5. Recommendation on the Funding of Core Activities: Appendix: Recommended Scale of Contributions. Report of the 19th Session of the Executive Body. ECE/EB.AIR/75.

was 1,920,950 (USD) per year.[21–22] Finally, in 2003 the Parties created a Trust Fund to facilitate the participation of countries with economies in transition, in the work of the regime.[23]

2. Scientific Costs

Once UNEP's financial support for the scientific research under the air pollution regime ended (in 1984) and voluntary contributions were insufficient to meet all of the scientific costs involved, it was recognized that a specialized protocol would have to be concluded to resolve the matter.[24] The instrument that was concluded has a cost-sharing arrangement for the scientific programme of EMEP based on, 'mandatory contributions, supplemented by voluntary contributions'.[25] The mandatory contributions, as set out in an Annex to the Protocol, are based on the UN Scale of Assessments.[26] The mandatory assessments are paid by the countries within the geographical scope of EMEP, and the voluntary ones are by those outside the geographical scope, such as Canada and the United States.[27] In some instances the mandatory contributions are supplemented by additional voluntary contributions for specific scientific projects.[28] This is particularly so when the bases of the scientific investigation are located within individual countries. For example, although the Assessment and Monitoring of Rivers and Lakes utilizes over 40 laboratories in 27 countries, the base of the scientific research is in Norway, and Norway underwrites the costs of all of this research.[29] The study into air pollution and forests is based in Germany, the scientific study of the impacts upon cultural materials is based in Sweden and impacts on non-forest vegetation is based in the United Kingdom.

[21] Decision 2001/5. Recommendation on the Funding of Core Activities.
[22] Decision 2000/3. Recommendation on the Funding of Core Activities in 2001–2003.
[23] Decision 2003/11. On The Facilitation of Countries With Economies in Economic Transition.
[24] Preamble, Protocol on Long-Term Financing of Co-Operative Programme for Monitoring and Evaluation of the Long Term Transmission of Air Pollutants in Europe. BH856.txt.
[25] Article 3. 1984 Protocol on Long Term Financing.
[26] Article 4. 1984 Protocol on Long Term Financing.
[27] Executive Body for the Convention on LRTAP. Report of the 17th Session. Paragraph 73. EMEP budgets set at US $2,040, 495 (for the period 2001–2003).
[28] UNECE. Financial Budgetary Matters of EMEP. EB.AIR/GE.1/2001/8. 22 June 2001. UNECE. Steering Body to EMEP. EB.AIR/GE.1/2004/2. Sep 30. 15–18.
[29] International Co-Operative Programme on Assessment and Monitoring of Acidification of Rivers and Lakes. See <http://www.niva.no/ICP-waters>

The funding of international scientific research into the ozone layer has come from a number of sources. First, assistance comes from the Trust Fund for the Vienna Convention, which is based on the UN Scale of Assessment.[30] This Fund had a targeted budget of 1,233,169 (USD) for 2005.[31] Second, special funds exist for unique projects, such as the establishment of global ozone observing systems in developing countries.[32] Third, with regard to the specialized panel or subsidiary body reports, the Parties make ad-hoc voluntary contributions,[33] which are channeled into an extra-budgetary fund.[34] Finally, the GEF has financially supplemented scientific work under both the Vienna Convention and the Montreal Protocol.[35]

The funding of the core scientific work of the climate regime, as represented by the IPCC, is met through annual contributions from governments which are determined in accordance with the UN Scale of Assessments.[36] However, this has often not been enough, and the COPs have commonly made appeals for additional financial resources for the IPCC.[37] The GEF has also been involved in supporting science related within the FCCC,[38] although when this work overlaps with more national, as opposed to international scientific programmes, the support is not always clear cut.[39]

[30] Annex 1. Report of the Third COP of the Vienna Convention. Decision V/4. Financial Report and Budget & Annex II. Report of the 5th COP of the Parties to the Vienna Convention. 4, 8–14.

[31] Decision VC VI/2. Financial Matters.

[32] Decision I/4. Ozone Research Managers. Decision IV/3. Recommendations of the Third Meeting of the Ozone Research Managers. Decision III/5. Recommendation of the Second Meeting of the Ozone Research Managers. Report of the Third COP of the Vienna Convention.

[33] Decision XIII/30. Financial Matters: Financial Reports and Budgets. Point 8.

[34] Decision VC VI/1. Ozone Related Monitoring and Research Activities for the Vienna Convention.

[35] Decision V/3. Recommendation of the Fourth Meeting of the Ozone Research Managers. Decision III/5. Recommendation of the Second Meeting of the Ozone Research Managers. point 3. Anon. (1994). 'Budgets Approved'. *Environmental Policy and the Law*. (24:2/3): 67. Decision IV/4. Funding Matters.

[36] See IPCC. (1998). Principles Governing the IPCC. Appendix B, Financial Procedures. <http://www.ipcc.ch/about/about.htm>

[37] Decision 20/CP.5. Programme budget for the biennium 2000–2001. Paragraph 14. Decision 19/CP.5. Cooperation with the Intergovernmental Panel on Climate Change. Paragraph 4. Decision 25/CP.7. Third Assessment Report of the Intergovernmental Panel on Climate Change.

[38] Decision 19/CP.5. Cooperation with the Intergovernmental Panel on Climate Change. Paragraph 4.

[39] Decision 5/CP.5. Research and Systematic Observation.

XIII. COUNTRY GROUPINGS AND CLASSIFICATIONS

1. The Ozone Regime

A. Developing Countries

A 'developing' country, for the purpose of the ozone regime, is, according to paragraph 1 of Article 5 of the Montreal Protocol, a country which has an annual level of consumption of ODS which is, 'less than 0.3 kilograms per capita on the date of entry of the Montreal Protocol, or at any time thereafter within ten years of the date of entry into force of the Protocol'. Countries which fulfill this requirement are known as 'Article 5 countries'. Countries which do not fulfill the criteria of Article 5, are known as 'non-Article 5' countries' or Article 2 countries, as Article 2 of the Montreal Protocol contains ODS controls that are not applicable to Article 5 countries. Although this is a strict categorization within the ozone regime, within this book, I shall use the term developing (for Article 5 countries) and developed or industrialized (for non-Article 5/Article 2 countries). Although these terms are broadly interchangeable, some countries do not fit easily within the stereotypes. For example, Cyprus, Saudi Arabia, United Arab Emirates and the Republic of Korea all consumed more than 0.3 kilograms on a per-capita basis at the date of entry of the Montreal Protocol.[1] Also, despite the MOPs steadfast refuse to alter the core of Article 5 criteria,[2,3] a number of countries, including Turkey,[4] Malta, Bahrain,[5] Slovenia,[6] Kuwait,[7] Moldova, Kyrgyzstan, Armenia[8] and South Africa have applied to the MOPs to have their national classification changed, arguing that they fit the Article 5 criteria, and are accordingly eligible for financial and technical assistance in meeting their ODS obligations.[9]

---

[1] Decision V/4. Classification of Certain Developing Countries.
[2] Decisions IX/26 & 27. Report of the Ninth MOP Of the Montreal Protocol. 40.
[3] Decision III/5. Definition of Developing Country. Report of the Third MOP to the Montreal Protocol.
[4] Third MOP to the Montreal Protocol. 14.
[5] Decision V/4. Classification of Certain Developing Countries. Report of the Fifth MOP to the Montreal Protocol. 11.
[6] Report of the Twelfth MOP to the Montreal Protocol. 9–10. Decisions XII/11 & XII/12. At 30–31.
[7] Report of the Seventh MOP to the Montreal Protocol. 11.
[8] Decision XIV/2. Application by Armenia for Developing Country Status Under the Montreal Protocol. Report of the 14th MOP. 42.
[9] Decision IV/7. Definition of Developing Country. Decision VI/5. Status of Certain Parties.

B. Countries in Economic Transition

In the early 1990s, a new category of countries emerged within the ozone regime. These countries, typically known as those with their 'economies in transition' do not fulfill the Article 5 requirements, in terms of per-capita consumption, yet due to the nature of their economic transition, were often in dire need of financial assistance to meet their commitments under the Montreal Protocol. This issue arose in 1992 when Hungary, Bulgaria and Poland defaulted in their contributions to the Multilateral Fund.[10] The following year, their situation worsened, as a number of countries in economic transition fell into substantive non-compliance with the Protocol. At this point, Belarus, Romania, the Ukraine and the Russian Federation asked the MOP to,

> Decide on the special status of countries with economies in transition, which would provide for concessions and a certain flexibility in the fulfillment of their obligations under the Montreal Protocol.[11]

Although an awareness of the difficulties of countries in economic transition was recognized by the MOP in 1993[12] no substantial changes in classification within the Protocol, and subsequent access to financial assistance from the Multilateral Fund occurred. However, although the Multilateral Fund was unable to financially assist them in meeting their ODS obligations, the GEF was able, to and has continued to assist countries in economic transition.[13] By 2003, the GEF had directly assisted 18 countries in economic transition, to the sum of 167 million (USD), and had leveraged an additional 173 million (USD), to help this group of countries meet their ODS obligations.[14]

C. Developing Countries within the Vienna Convention and the Montreal Protocol

The inclusion of developing countries in the ozone regime was (and has remained)[15] a clear goal within the negotiating process. As early as 1981,

5 *YBIEL*. (1994). 161. Decision XV/49. Application for Technical and Financial Assistance from the Global Environment Facility by South Africa. Report of the 15th MOP to the Montreal Protocol. 74.

[10] Decision IV/21. Temporary Difficulties Encountered By Hungary, Bulgaria & Poland. Report of the Fourth MOP to the Montreal Protocol. 22.

[11] Annex VIII. Declaration By Belarus, Bulgaria, Romania, Ukraine & Russia. Report of the Fifth MOP to the Montreal Protocol. 63.

[12] Decision V/10. Temporary Difficulties Encountered By Hungary, Bulgaria and Poland. Report of the Fifth MOP to the Montreal Protocol. 14.

[13] Decision XV/50. Continued Assistance from the GEF to Countries in Economic Transition. Report of the 15th MOP to the Montreal Protocol. 74.

[14] Report of the 15th MOP to the Montreal Protocol. 37.

[15] See Decision IV/8. Participation of Developing Countries. Report of the Fourth MOP to the Montreal Protocol. 15.

a number of large developing countries, such as India, Kenya, Argentina and Brazil were participants, on an ad-hoc basis in the formation of the Vienna Convention[16] and the Convention came to recognize that, 'the circumstances and particular requirements of developing countries', especially in terms of scientific, legal and technical co-operation, including technology transfer,[17] needed to be taken 'into account'.[18] Despite this consideration of developing countries within the Convention, it was clearly warned by developing countries, that the considerations listed in the Vienna Convention were too broad, vague, and possibly inadequate for the tasks at hand.[19] In addition, the more divisive issue of possible ODS controls for developing countries was avoided, as the Convention contained no ODS controls for either developed or developing countries. This failure to include controls meant that thorny issue of seeking ODS controls for developing countries, which the United States wanted, but the European Union did not, was avoided when the Vienna Convention was concluded.[20] However, when the Montreal Protocol was concluded, and the necessity to control all ODS meant that developing countries, whose consumption and production of ODS was set to exponentially expand, needed to be curtailed if the Protocol was to succeed in its objectives over the long term.[21] However, politically, it was not possible to seek the same ODS controls for developing countries as were imposed on developed countries, as the developing countries sought to have an exception, whereby they would be allowed to consume and produce ODS for a limited period, before they too, would have to strictly control their ODS emissions. In addition, the developing countries demanded that if they had to forgo the

[16] UNEP Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1981). A Look At Some Issues: A Contribution by the UNEP Secretariat. UNEP/WG.69/5. December 31. Paragraphs 7 and 33. Conference of Plenipotentiaries on the Protection of the Ozone Layer. (1985). Final Report of the Ad-Hoc Working Group. UNEP/IG-53/4. January 28. Paragraph 11.

[17] Vienna Convention. Article 4.

[18] Preamble, Third section.

[19] Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1983). Draft Annex to Control CFCS: Summary of Comments By Governments. UNEP/WG/94/4/Add 2. October 14. Page 6.

[20] Conference of Plenipotentiaries on the Protection of the Ozone Layer. (1985). Final Report of the Ad-Hoc Working Group. UNEP/IG-53/4. January 28. The alternate texts can be seen in Annex III. Discussion of the debate can be seen in paragraphs 14–32. For debate in the media of this, see Anon. (2985). 'Ozone Agreement Is Up In the Air'. *New Scientist.* Feb 7. Anon. (1985). 'Ozone Deal is Paper Thin'. *New Scientist.* March 28. 5.

[21] MacKenzie, D. (1995). 'Ozone's Future Up In The Air'. *New Scientist.* Dec 16. 14. MacKenzie, D. (1987). 'Chemists Unite In Call For Ozone Protection'. *New Scientist.* Apr 30. 25. Miller, J. (1989). 'Chinese Bring a Chill to Backers of Ozone Protocol'. *New Scientist.* Feb 11. 28. Glenny, M. (1987). 'America Attacks Europe Over Stratospheric Ozone'. *New Scientist.* March 5. 17.

utilization of ODS, they needed assistance to achieve the goal. Following these demands from the developing countries, the Montreal Protocol included two novel clauses. The first was Article 5 which not only effectively classified countries as being developed or developing on account of whether their population consumed more or less than 0.3 kilogrammes of ODS per-capita ODS. As a follow on, the protocol accepted that if a country was consuming less than 0.3 kilogrammes per capita, then that country was allowed to increase its ODS consumption, to meet their 'basic domestic needs', over the following ten years, up to the 0.3 kilogramme per-capita level.[22] This was agreed despite the theoretical, but unlikely, risk that this possibility of expansion represented.[23]

The Montreal Protocol also recognized that, 'special attention to the needs and circumstances of the developing countries'[24] was required, and accordingly, the Parties agreed to, 'co-operate in promoting technical assistance to facilitate participation in and implementation of this Protocol'.[25] Finally, the Parties also agreed to,

> Undertake to facilitate bilaterally or multilaterally the provisions of subsidies, aid, credits, guarantees or insurance programs to Parties that are developing countries for the use of alternative technology and for substitute products.[26]

The progressive intentions towards developing countries recorded in the Montreal Protocol did not satisfy the demands of key developing countries such as China and India, which reiterated they had not caused the problem, yet if the problem was to be solved, they would be denied the technologies that the developed world had already utilized. The solution to the problem, in the view of such developing countries, was the creation of a Multilateral Fund (see Chapter XV) to assist developing countries in finding alternatives to conventional ODS, as well as assisting in minimizing economic costs to developing countries from such changes.[27]

2. The Air Pollution Regime

The idea that countries which are economically weaker than others may have exceptions in meeting air pollution reduction obligations, first appeared

---

[22] See paragraphs 2, 3 and 4 of article 2 & article 5 of the Montreal Protocol..
[23] MacKenzie, D. (1990). 'Montreal Nations Agree Tougher Rules on CFCs'. *New Scientist.* March 24. 8. Cf. Benedict, R. (1991). *Ozone Diplomacy.* (HUP). 150.
[24] Article 10(3). Montreal Protocol.
[25] Article 10 Montreal Protocol.
[26] Article 5(3). Montreal Protocol.
[27] Anon. (1989). 'China Attacks Unfair Ozone Protocol'. *New Scientist.* March 11. 26. Miller, J. (1989). 'Chinese Bring a Chill to Backers of Ozone Protocol'. *New Scientist.* Feb 11. 28.

in Europe in the early 1980s.[28] Special arrangements were also made to facilitate former Soviet countries, such as East Germany, Czechoslovakia, and Poland, in making reductions in transboundary air pollution.[29] Following the end of the Cold War, special assistance for countries in 'transition to market economies' through bilateral relationships, such as between Finland, Estonia and Russia, and Germany and Bulgaria, Hungary, Poland, Romania, Slovakia and the Czech Republic has continued both in Europe and Asia (between Japan and China).[30] In addition, the idea that special arrangements for countries in economic transition shall be made, has also been reflected in the LRTAP protocols and high level Declarations,[31] because of the, 'relatively heavy economic burden on countries with economies that are in transition to a market economy'.[32] The specific flexibility that this reflection has resulted in within the LRTAP regime, is that countries in economic transition have different air pollution reduction timetables, as opposed to countries which are not in economic transition and accordingly, have to control their transboundary air pollution quicker than countries in economic transition.[33]

With regard to general assistance, in 1997, the Executive Body of the LRTAP agreed to facilitate the participation of countries with their economies in transition, 'which would not otherwise be in a position to take part' through the creation of a Trust Fund to help assist such countries attend meetings.[34] In 2001, a large number of countries in economic transition were formally identified for the purpose of utilizing this Trust Fund.[35]

---

[28] Time delays for Greece & Ireland from EEC Large Plants directive, before having to comply, were accepted. See Milne, R. (1988). 'Europe's Worst Polluter is Tamed'. *New Scientist.*. June 23. 29. Also, McCormack (1997). *Acid Earth.* (Earthscan, London). 102.

[29] Anon. (1989). 'Pollution Technology Crosses From West Germany to the East'. *New Scientist.* July 15. 6. Anon. (1991). 'A Breath of Fresh Air for Czechs'. *New Scientist.* Jan 26. 6. Lofstedt, R. (1998). 'Transboundary Environmental Problems: The Burning of Coal in Poland'. *Global Environmental Change.* 8(4): 329–340.

[30] 4 *YBIEL.* (1993). 136–137. 5 *YBIEL.* 1994. 158. Hadfield, P. (1997). 'Raining Acid On Asia'. *New Scientist.* Feb 15. 15. Pearce, F. (2000). 'Hold Your Breath'. *New Scientist.* Jan 22. 16–17.

[31] The Gothenburg Ministerial Declaration recognized that, 'international financial institutions to support its implementation through bilateral and multilateral assistance to Parties with economies in transition" was necessary as may be an additional "stable, long terms funding arrangement'. Annex II. Gothenburg Ministerial Declaration. December 1. 1999. Report of the Seventeenth Session of the Executive Body. ECE/EB.AIR/68, 27 December 1999.

[32] 1994 Protocol on Further Sulphur Reductions. Preamble. Paragraph 9.

[33] 1999 Gothenberg Protocol. Annex VII. Timescales Under Article III. 5 *YBIEL.* (1994). 157.

[34] Annex VII. Report of the 15th Session of the Executive Body. Decision 1997/4 on the Facilitation of Participation of Countries With Economies in Transition.

[35] These were Albania, Armenia, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Georgia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Republic of Macedonia,

3. The Climate Change Regime

A. Countries with Obligations to Control their Greenhouse Gas Emissions

There is a bewildering collection of country groupings within the FCCC. In broad terms, there is a developed and developing group. 'Developed' is defined in Annex 1 as synonymous with membership of the OECD, but the term 'OECD' does not appear in the FCCC. Rather, within the FCCC, the group of countries obliged to control their greenhouse gas emissions is known as 'Annex I' countries.[36] Those without specific climate targets are known as 'non-Annex I countries'. Conversely, with the Kyoto Protocol, the countries with emission limitations or commitments are listed in Annex B.[37] Due to such confusion, for the majority of this book, although Annex I for the FCCC, or Annex B for the Kyoto Protocol are the correct legal titles for countries with greenhouse gas emission control obligations, I utilize the terms 'developed' or industrialized for countries with greenhouse gas control obligations, as opposed to 'developing countries' which do not have the same obligations.

In terms of the industrialized countries, the grouping may be divided into the JUSCANZ group, and the broader like-minded group. The original JUSCANZ group included Japan, the United States, Canada, Australia and New Zealand. This group was often joined by the 'Umbrella Group' which added Russia, the Ukraine, Kazakhstan, Norway and Iceland. The broader like-minded group, were those other countries with commitments, with the core being the European Union.[38] Note however, that the JUSCANZ group is not as cohesive as it was originally, with the decision of

Ukraine and Yugoslavia. Conversely, OECD countries are, 'in principle, expected to fund their own participation'. Decision 2001/6. On the Facilitation of Participation of Countries With Economies in Transition. Report of the 19th Session of the Executive Body. ECE/EB.AIR/75.

[36] This list, as of 1998 (with the additions of Decision 4/CP3) include Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, European Union, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland, United States of America.

[37] Australia, Austria, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, European Union, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, United Kingdom of Great Britain and Northern Ireland, & the United States of America.

[38] For a discussion of the groupings originally, see Nilsson, S. (1994). *Protecting the Atmosphere.* (Earthscan, London). 55–60.

the United States and Australia not to ratify the Kyoto Protocol, whereas other countries within JUSCANZ, such as Japan and New Zealand decided to ratify the Protocol.

B. Countries in Economic Transition

As a group, some countries in economic transition have greenhouse emission control targets, and some do not have targets as they are not formally recognized as developed countries. This problem is complicated by some countries in economic transition, requesting to be added to (such as Kazakhstan) or removed from (such as the countries of the CACAM group)[39] the FCCC and Kyoto Annexes which list the countries which are obliged to control their greenhouse gas emissions. Where the countries in economic transition are listed on the Annexes of the FCCC or the Kyoto Protocol, 'a certain degree of flexibility' shall be allowed to them by the COP.[40] Once the necessity for flexibility is demonstrated[41] then a number of options, for these countries are considered. There include changing the base years for their greenhouse gas controls,[42] less stringent reporting requirements,[43] overall compliance commitments,[44] and assistance for capacity building in relation to their FCCC and Kyoto Protocol obligations.[45]

C. Developing Countries

As discussed in chapter IX, developing countries have no obligations to restrict their emissions of greenhouse gases. There are four reasons that

[39] Decision 35/CP.7. Request from a group of countries of Central Asia and the Caucasus, Albania and Moldova regarding their status under the Convention. FCCC. Report of the Eighth COP of the FCCC. Paragraphs 107–08. For earlier successful attempts to be removed from the Annexes, see Decision 4/CP.3. Annex I of the Convention was amended, by deleting the name of Czechoslovakia; and including the names of Croatia, the Czech Republic, Liechtenstein, Slovakia and Slovenia.

[40] FCCC. Article 4 (6). Kyoto Protocol. Article 3 (5) & 3 (6).

[41] At COP 2, the COP requested that such countries, invoking article 4.6. 'explicitly indicat[e] the nature of this flexibility . . . and should state clearly the special consideration they are seeking and provide an adequate explanation of their circumstances'. Decision 9/CP.2. Communications from Annex I Parties: Guidelines, Schedule and Process. Paragraph 7.

[42] Decision 9/CP.2. Communications from Annex I Parties: Guidelines, Schedule and Process. Paragraph 7. Kyoto Protocol. 3 (5).

[43] Report of the First COP of the FCCC. Paragraph 47. Report of the Sixth COP, Session One. Personal Observations of the Chair.

[44] The Compliance Committee shall take into account any degree of flexibility for ". . . the Parties included in Annex I undergoing the process of transition to a market economy." Decision 24/CP.7. Procedures And Mechanisms Relating To Compliance Under The Kyoto Protocol. For further discussion, see chapter X.

[45] Report of the Sixth COP, Session One. Personal Observations of the Chair. See also Chapter XV of this book.

developing countries do not have greenhouse emission control targets like developed countries.[46] First, developing countries did not cause the problem of climate change, as the largest share of historical global emissions of greenhouse gases originated from developed countries.[47] Second, there are contemporary discrepancies between countries in terms of emissions. This is especially so when viewed from differences in per-capita emissions from developed as opposed to developing countries, with the latter group still having, 'relatively low' levels.[48] Third, many developing countries require substantial improvements in their overall 'development.' As such, they cannot afford, in material terms, to make reductions in their greenhouse gas emissions, which is often seen as a luxury that can only be pursued after a certain level of development has been achieved.[49] Thus, for developing countries in particular, 'economic development', as opposed to reductions in greenhouse gas emissions, is their priority.[50] Accordingly, the greenhouse gas policies of the developed countries may be, inappropriate for developing countries.[51] Finally, developing countries have waited for developed countries to take the lead in confronting climatic change, and are waiting to see the adequacy of the response by developed countries first, before committing themselves to any such greenhouse gas reductions.[52]

D. The Least Developed Countries

The Least Developed Countries (LDCs) are unique within the climate regime due to the enhanced assistance which is designed to help them through the LDC Fund. LDCs also have an exemption from contributions to the funding regime associated with the flexibility mechanisms, if a CDM

[46] For some useful discussions of the area of equity within climate change, see Toth, F. (1999). *Fair Weather: Equity Concerns in Climate Change.* (Earthscan, London). See in particular Shukla's chapter, 'Justice, Equity and Efficiency in Climate Change: A Developing Countries Perspective'. 145–160.

[47] FCCC. Preamble. Paragraph 3.

[48] FCCC. Preamble. Paragraph 3. This per-capita difference has been continually pointed out in the negotiations. For example, in 1995, the Indian environment minister Kamal Nath said that the emissions from industrialized countries during the past five years of climate negotiations alone "would suffice India's development needs for the next 50 years'. Nath. Noted in Pearce, F. (1995). 'Don't Stop Talking About Tomorrow'. *New Scientist.* Apr 15. 4. See also 7 *YBIEL.* (1996). 323.

[49] Anon. (1983). 'Raised Temperatures Over Greenhouse Effect'. *New Scientist.* Oct 27. 247.

[50] FCCC. Preamble. Paragraph 21 and Articles 3 (4) and 4 (7).

[51] Thus, 'Policies and measures to protect the climate system . . . should be appropriate for the specific conditions of each Party and should be integrated with national development programmes'. FCCC. Article 3 (4). FCCC. Preamble. Paragraph 3, 10 and 22.

[52] 2 YBIEL. (1991). 112. Pearce, F. (1994). 'Greenhouse Targets Beyond 2000'. *New Scientist.* Sep 3. 7.

project is within their country.[53] Finally, LDCs are entitled to special assistance with their climate related national action plans.[54]

E. Small Island States

At the fourth meeting in the negotiations leading to the conclusion of the FCCC, the Alliance of Small Island States (AOSIS) emerged, as a group independent of either the developed or developing country groupings.[55] Their independent status evolved because of their unique position in the debate, in that of all countries, AOSIS countries are probably the most threatened by climatic change.[56] Recognition of this vulnerability within the FCCC has meant that small island states have received special attention within the FCCC[57] and its workings,[58] as well as specific financial assistance to meet the adverse effects of climatic change.[59]

F. Countries with a Dependence on the Sale of Fossil Fuels

As soon as negotiations began on possible reductions of greenhouse gases, it became apparent that a number of nations which were economically dependent on the sale of fossil fuels felt very threatened by any such objectives. This was made apparent in 1992, when the United Arab Emirates warned the European Union that they would view the carbon tax proposed by the EC as a 'declaration of a trade war.'[60] Acknowledgement of such vulnerabilities worked themselves into the preamble[61] and substantive text of the FCCC, which considered the possibility of funding assistance to meet the specific needs of, inter alia, 'Countries whose economies are

[53] A primary reason for this exemption was due to the lack of CDM projects in Africa and small island developing States. Report of the Sixth COP. Firs Session.. Personal Observations of the Chair. Decision 17/CP.7. Modalities And Procedures For A Clean Development Mechanism As Defined In Article 12 of the Kyoto Protocol. Paragraph 15. Decision 13/CP.5. Activities implemented jointly under the pilot phase.

[54] Decision 29/CP.7. Establishment of a Least Developed Countries Expert Group.

[55] 2 *YBIEL.* (1991). 112.

[56] See Chapter V of this text. See also the Report of the Conference on the Sustainable Development of Small Island Developing States. A/CONF.167/9. October, 1994. Annex I, Section III. Paragraph 19. WSSD. Plan of Implementation of the World Summit on Sustainable Development. A/CONF.199/L.1. Section VII. Paragraphs 52–55.

[57] FCCC. Article 4 (8)(a).

[58] Anon. (1992). 'Don't Let Us Drown, Islanders Tell Bush'. *New Scientist.* June 13. 6.

[59] FCCC. Article 4 (8)(a).

[60] 3 *YBIEL.* (1992). 273. For the possible economic impacts involved, and various ways to mitigate them, see IPCC. (2001). *Climate Change 2001: Mitigation.* (Cambridge University Press, Cambridge). 10.

[61] "the special difficulties of those countries, especially developing countries, whose economies are particularly dependent on fossil fuel production, use and exploration, as a consequence taken on limiting greenhouse gas emissions." FCCC. Preamble. Paragraph 20.

highly dependent on income generated from the production, processing and export, and/or on consumption of fossil fuels and associated energy-intensive products'.[62]

The advocacy of such a 'compensation fund' became increasingly vocal in the lead up to the Kyoto Protocol,[63] and the subsequent COPs following the Protocol.[64] At the sixth COP, it was agreed that to minimize the impact of their implementation of the Kyoto Protocol, Parties should report on how they were, inter alia, assisting developing country Parties which are highly dependent on the export and consumption of fossil fuels in diversifying their economies.[65] Assisting these countries was deemed a 'priority area' in 2001[66] and the possibility for assistance for them, under the newly created Special Climate Change Fund was clearly mooted.[67]

With regard to the actions of such countries within the FCCC and Kyoto process, it must be noted that a number of OPEC countries, and Kuwait, Saudi Arabia and occasionally Iran, in particular, have repeatedly played very obstructive roles in the negotiations for the FCCC, and its subsequent operation.[68] A foremost example of these difficulties can be seen with the voting procedures under the FCCC and Kyoto Protocol, under which the OPEC countries have long argued for consensus on all decisions of importance, even though amendments of the actual FCCC or the Kyoto Protocol only require three quarter majorities. If this was agreed (it is currently unresolved) then the OPEC countries (and all others) would have an effective veto over all matters that need to be voted upon within the climate regime.

[62] FCCC. Article 4.8. (h).

[63] Ehrmann, M. (1997). 'Spring Time in the Climate Negotiations ?' *Environmental Policy and the Law*. 27 (3). 192–196. Brown, P. (1997). 'Oil Nations Seek Cash For Green Cuts'. *Guardian Weekly*. March 2. 5.

[64] 9 *YBIEL*. (1998). 186. Anon. (1999). 'Climate Change: Plan of Action Adopted'. *Environmental Policy and the Law*. 29 (1): 3. Report of the Sixth COP. First Session. Personal Observations of the Chair.

[65] Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action.

[66] Decision 9/CP.7. Matters relating to Article 3, paragraph 14, of the Kyoto Protocol. 48. paragraph f.

[67] Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Report of the Sixth COP to the FCCC. Second Session. Annex. Section I: Funding the Convention. I. Funding Under the Convention.

[68] Anon. (1992). 'Oil Producers Campaign Against Carbon Cuts'. *New Scientist*. June 20. 7. Oberthur, S. (1995). 'The First COP'. *Environmental Policy and the Law*. 25 (4): 144. Oberthur, S. (1996). 'Signs of Progress'. *Environmental Policy and the Law*. 26 (4): 158–160. Pearce, F. (1995). 'Don't Stop Talking About Tomorrow'. *New Scientist*. Apr 15. 4.

XIV. NON-GOVERNMENTAL ORGANIZATIONS

1. NGOs in the Ozone Regime

Ten years before the Vienna Convention was concluded, UNEP proposed that appropriate Non-Governmental Organizations (NGOs), of both the environmental and industry based types, be involved in the negotiation process.[1] This recommendation was followed, and NGOs came to have a strong input into the formation of the Vienna Convention[2] and its subsequent operation. The typical number of NGOs at a COP or MOP of the ozone regime, usually roughly balanced between industry and environmental backgrounds, is around 40. At the 2004 extraordinary meeting there were 46 NGOs.[3]

The inclusion of environmental NGOs followed their relative success in two areas. First, they successfully brought to the public attention the dangers of ODS.[4] The value of this particular work, and its need for the promotion of public awareness by NGOs to continue, was subsequently recognized in the Montreal Protocol.[5] Second, NGOs were successful in recognizing and influencing the fact that a certain amount of ODS utilization could be linked to consumer behavior. This link was especially strong with purchasing products containing ODS involved in aerosols, packaging, and refrigeration. Consumer pressure, when assisted with national or regional labeling schemes which informed consumers of what ODS where included in products such as aerosols, despite opposition from some ODS manufacturers,[6] was particularly successful, with such markets being reduced by

---

[1] UNEP. Governing Council. 1976. Fourth Session. Reprinted in *IPE*. XXIII. 9193, 9194.

[2] CCOL. (1981). Report of the Fourth Session of the Co-Ordinating Committee on the Ozone Layer. UNEP/CCOL/5/Background 1. Annex 2. Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1984). Report of the Working Group, First Part of the Fourth Session. UNEP/WG.110/4. Conference of Plenipotentiaries on the Protection of the Ozone Layer. (1985). Final Report of the Ad-Hoc Working Group. UNEP/IG-53/4. January 28. Paragraph 12.

[3] Report of the First Extraordinary MOP to the Montreal Protocol on Substances That Deplete the Ozone Layer. 27. For some earlier NGO considerations, see Benedict, R. (1991). Ozone Diplomacy. (Harvard University Press, Cambridge). 165–169.

[4] Benedict, R. (1991). *Ozone Diplomacy*. (Harvard University Press, Cambridge). 28. Roan, S. (1991). *Ozone Crisis*. (Wiley, New York). 113. Litfin, K. (1994). *Ozone Discourses*. (Columbia University Press, New York). 72.

[5] Article 9, Montreal Protocol.

[6] Anon. (1976). 'US Row Over Aerosol Ban'. *New Scientist*. Nov 4. 262. Gwynne, P. (1976).

between 70 to 80% in some developed countries, from the mid 1970s to the mid 1980s, before the Vienna Convention and Montreal Protocol effectively took such choices away from consumers, by directly controlling ODS.[7] However, as discussed in chapter IX, not all ODS, such as MB, is strictly controlled. With such remaining ODS which is accessible to consumers, the importance of clear labeling schemes so that discerning consumers can make informed choices remains pertinent.[8]

The co-operation of industry based NGOs has been recognized as 'essential'[9] for the success of the regime,[10] and their co-operation has been continually welcomed by the COPs and MOPs of the ozone regime.[11] This appreciation is despite the fact that although some industries, such as Johnson Wax, McDonalds and a few others,[12] withdrew ODS from their products, other companies involved in the utilization of ODS refused to replicate such actions, arguing that the science was not sufficient to make such restrictions, and the economic costs were too high. The 'Alliance for Responsible CFC Policy,' a consortium of 500 companies involved in ODS utilization, formed in 1980, was the exemplar of the latter position, but following the lead of Du Pont, they too, later softened their position once the scientific evidence became more conclusive.[13]

'More Trouble for US Aerosol Makers'. *New Scientist.* Dec 2. 510. Anon. (1977). 'US Ban Nearer For Aerosol Cans'. *New Scientist.* May 5. 254. Parliamentary Assembly of the Council of Europe. Resolution 733 (1980). On the Prohibition of Use of CFCs. Paragraph 8. In *IPE.* XXVIII. 460. MacKenzie, D. (1988). 'Scientists Set To Track Ozone in the Arctic'. *New Scientist.* Jan 14. 30.

[7] See Roan. Ibid. 31, 58. Benedict. Ibid. 28, 103–104. Kenward, M. (1979). 'Ozone: Cautious Inaction Needed'. *New Scientist.* Oct. 25. 252.

[8] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 7.

[9] Conference of Plenipotentiaries on the Protection of the Ozone Layer. (1985). Final Report of the Ad-Hoc Working Group. UNEP/IG-53/4. January 28. Annex II.

[10] Second MOP to the Montreal Protocol. 9. Report of the Fourth MOP to the Montreal Protocol. 10.

[11] Beijing Declaration on Renewed Commitment to the Protection of the Ozone Layer. Annex 1, Report of the 11th MOP of the Montreal Protocol. 36. Ouagadougou Declaration. Report of the Twelfth MOP to the Montreal Protocol. 48.

[12] Gavaghan, H. (1990). 'Ozone Culprits Named By American Pressure Group'. *New Scientist.* Jan 27. 10. Litfin, K. (1994). *Ozone Discourses.* (Columbia University Press, New York). 61. Roan, S. (1991). *Ozone Crisis.* (Wiley, New York). 59. Anon. (1987). 'Burger Chain Takes the Poison From Its Packaging'. *New Scientist.* Sep 3. 24. Anon. (1989). 'Chip Firms Promise to Banish CFCs'. *New Scientist.* March 25. 22. Anon. (1989). 'Chip Firms Promise to Banish CFCs'. *New Scientist.* March 25. 22. Hunt, P. (1992). 'Multinationals In Thailand Agree to Limit CFCs'. *New Scientist.* March 14. 14.

[13] Litfin. Ibid. 61, 64, 70. Anon. (1978). 'Verdict Still Open On Fluorocarbons'. *New Scientist.* Sep 21. 12. Gribbin, J. (1978). 'Ozone Passion Cooled by the Breath of Sweet Reason'. *New Scientist.* Oct 12. 94. Joyce, C. (1980). 'America Clamps Down on Freons'. *New Scientist.* Oct. 16. 142. Roan, S. (1991). *Ozone Crisis.* (Wiley, New York). 191. Benedict, R. (1991). *Ozone Diplomacy.* 30–31, 102–103, 112, 135–137, 165. MacKenzie, D. (1988). 'Now It Makes Business Sense to Save the Ozone Layer'. *New Scientist.* Oct 29. 25.

In order to facilitate the work of NGOs in the ozone regime, it was agreed in the Vienna Convention and the Montreal Protocol[14] that,

> Any body or agency, whether national or international, governmental or non-governmental, qualified in fields relating to the protection of the ozone layer which has informed the Secretariat of its wish to be represented at a COP as an observer may be admitted unless at least one-third of the Parties present object. The admission and participation of observers shall be subject to the rules of procedure adopted by the COP.[15]

In terms of specific institutional rights within the ozone regime, the Rules of Procedure[16] stipulate that, if there is no objection from the Parties present, by at least one third of the Parties, NGOs may attend and participate without the right to vote in any meetings of the regime. Participation includes some of the more controversial meeting areas, such as those related to the Multilateral Fund,[17] if the meetings are not private or involve matters which require particular sensitivity.[18]

With regard to speaking at meetings, the general practice has been for a limited number of NGOs (typically four) to state their views.[19] It was specified that in this area, a type of equity should be aimed at in that; 'NGOs should include observers from developing and developed countries'.[20]

2. NGOs in the Climate Regime

Since the outset of NGO involvement in the formation of negotiations for an international instrument on climate change in 1990,[21] and its subsequent

Steven, H. (1990). 'The Race to Heal the Ozone Layer'. *New Scientist.* June 16. 30–34. Be Purvis, M. et al. (1997). 'Fragmenting Uncertainties: Some British Business Responses to Stratospheric Ozone Depletion'. *Global Environmental Change.* 7: 93–111. MacKenzie, D. (1987). 'Chemical Giants Battle Over Ozone Holes'. *New Scientist.* Apr 23. 22. MacKenzie, D. (1988). 'Now It Makes Business Sense to Save the Ozone Layer'. *New Scientist.* Oct 29. 25. Doyle, J. (1992). 'Hold the Applause: A Case Study of Corporate Environmentalism'. *Ecologist.* 22(3): 84–91.

14 Montreal Protocol. Article 11 (5).

15 Vienna Convention. Article 6 (5).

16 Report of the First COP of the Vienna. Annex 1.

17 Rule 7 (2). Although the general goal is to limit the total number 'as far as possible'.

18 Rules of Procedure for the Executive Committee of the Interim Multilateral Fund. Third MOP to the Montreal Protocol. Annex VI. Rule 7 (1). Rules of Procedure for the Montreal Protocol. Annex 1, UNEP/OzL.Pro.1/5. Rule 7 and Rule 29.

19 See for example: Second MOP to the Montreal Protocol. 10. Report of the Fourth MOP to the Montreal Protocol. 9, 12. Report of the 10th MOP of the Montreal Protocol. 10. Report of the Twelfth MOP to the Montreal Protocol. 6.

20 Rules of Procedure for the Executive Committee of the Interim Multilateral Fund. Third MOP to the Montreal Protocol. Annex VI. Rule 7 (1).

21 1 *YBIEL.* (1990). 102. 2 *YBIEL.* (1991). 111.

operation, NGOs have had a discernable influence in this regime,[22] as their numbers have climbed from over 177 NGOs at the first COP in 1995,[23] to 267 at the ninth COP in 2003.[24] Apart from the fact that there is a concentration (of over 90%) of NGOs from developed countries, very little can be generalized about a very divergent collection of NGO, where the divisions within the groupings of environmental and industry NGOs, may be just as wide as the divisions between environmental and industry NGOs in general.[25] For example, the industry related NGOs range from the insurance industry who are direct advocates for greater controls on greenhouse gas emissions,[26] through to the Global Climate Coalition, which has actively campaigned against the work of the FCCC and the Kyoto Protocol.[27] However, even within the Global Climate Coalition, a number of prominent industries, such as British Petroleum, Texaco, Shell and Ford have all divorced themselves from the Coalition and adopted their own, relatively progressive policies on greenhouse gas reductions. [28]

Irrespective of the merits of individual NGOs in this area, the climate regime has embraced the idea that NGOs have an important role to play in this area.[29] This is especially so with regard to the promotion of public awareness and public participation in issues relating to climatic change.[30] Special assistance for LDCs to promote public awareness is available.[31] The specific programme (public awareness) within the climate regime designed to facilitate this area is known as the New Delhi Work Programme on Article 6 of the Convention, and support for this work programme is con-

---

22 See Arts, B. (1998). The Political Influence of NGOs: Case Studies on the Climate and Biodiversity Conventions. (International Books, Netherlands). 98–156.

23 Report of the 1st COP, Berlin, 1995. Part One, Proceedings. Paragraphs 21 & 22.

24 Report of the 9th COP. Proceedings. 14 & Annex II.

25 Paoleto, G. (1997). *Enhancing Participation of NGOs in the UNFCCC Process*. (UN University, Japan).4

26 IPCC. (2001). *Climate Change 2001: Impacts, Adaptation and Vulnerability*. (Cambridge University Press, Cambridge). 13. Goldsmith, Z. (2004). 'Could the Insurance Industry Save Us?' *Ecologist*. Feb 4. Reuters. (2003). 'Climate Catastrophes Cost $92 billion'. *NZ Herald*. Dec 12. B1.

27 See Ott, H. (1998). 'The Kyoto Protocol: Unfinished Business'. *Environment*. 40 (6): 18. A useful book exploring the impact of this group is Jeremy Leggett's *The Carbon War*. (1999, Penguin, London).

28 Pearce, F. (1999). 'Can't Stand the Heat'. *New Scientist*. Dec 26. 32–33. Adam, D. (2004). 'Oil Chief: My Fear For Planet'. *Guardian Weekly*. June 25. 3. Editor. (1998). 'The Global View: Are the Corporate Players Running Away With The Green Ball?" *New Scientist*. Nov 7. 3. Editor. (2000). 'Time To Come Clean'. *New Scientist*. Dec 2. 3. Skodvin, T. (2001). 'Shell Houston, We Have A Climate Problem'. *Global Environmental Change*. 11: 103–106. Rowell, A. (1997). *Green Backlash*. (Routledge, London). 85–88, 130.

29 Kyoto Protocol. Article 14. (4)(i).

30 FCCC. Article 4(1)(i) & 6 (i) & (ii). Article 6.a. and 6 b. (i). Decision 11/CP.8. New Delhi work programme on Article 6 of the Convention. Paragraph 18.

31 Decision 11/CP.8. New Delhi work programme on Article 6 of the Convention.

tinually iterated.[32] In addition to promoting public awareness, the Parties to the FCCC also agreed to, 'encourage the widest participation' of NGOs in the FCCC processes,[33] including the SBI and SBSTA,[34] but not necessarily to the same extent with the more specialized bodies like the CDM.[35] Accordingly, the FCCC and the Kyoto Protocol[36] agreed that,

> Any body or agency, whether national or international, governmental or non-governmental, which is qualified in matters covered by the Convention, and which has informed the secretariat of its wish to be represented at a session of the Conference of the Parties as an observer, may be so admitted unless at least one third of the Parties present object. The admission and participation of observers shall be subject to the rules of procedure adopted by the Conference of the Parties.[37]

The only other condition, in addition to being, 'qualified in matters covered by the Convention', is that the NGOs must be non-profit or have a tax-exempt status. Evidence of this must be presented to the Secretariat when applying. The practice is that once the Secretariat has compiled their list, the list is put to the COP and it is adopted in one collective movement. Moreover, once an NGO is accepted, they are invited to all subsequent COPs, unless an objection is raised in accordance with the Rules of Procedure.[38] Moreover, the practice has developed, that even NGOs which argue directly against the objectives of the climate regime will not be expelled, although there was an earlier attempt which failed, for NGOs to sign 'an oath of allegiance' to the goals of the climate regime.[39]

In terms of the general meetings, the custom is for a small number of NGOs to make spoken statements to the end of the formal sessions.[40] Their physical access to the floor during negotiations is the subject of the Chair's discretion.

---

[32] Decision 7/CP.10. Status of, and Ways to Enhance, Implementation of the New Delhi Work Programme on Article 6 of the Convention.
[33] FCCC. Article 4 (1)(i) and 7. (l).
[34] Decision 18/CP.4. Attendance of intergovernmental and non-governmental organizations at contact groups.
[35] First Report Of The Executive Board Of The Clean Development Mechanism (2002). FCCC/CP/2002/3. Add 1. Annex 1. Rules of Procedure. Rules 26 & 27.
[36] Kyoto Protocol. Article 13 (8). Also, Decision 17/CP.9. Arrangements for the First Session of the COP Serving as a MOP to the Kyoto Protocol. Decision-/CMP.1. Arrangements for the First Session of the COP Serving as a MOP to the Kyoto Protocol. 9th COP to the FCCC (Milan). Part Two, Action Taken. 3–4.
[37] FCCC.7 (6).
[38] Report of the 1st COP to the FCCC. Proceedings. Paragraphs 21 & 22.
[39] Paoleto, G. (1997). *Enhancing Participation of NGOs in the UNFCCC Process*. (UN University, Japan). 2–3.
[40] See for example, COP 7. Proceedings. 40.

3. NGOs in the Air Pollution Regime

NGOs had a strong influence in the formation of international responses to air pollution,[41] and their, 'important contribution' was acknowledged in the 1999 Gothenburg Protocol.[42] The 1999 Protocol also emphasized the importance of 'public awareness' with regard to air pollution,[43] from information about the impacts of air pollution, through to the labeling of products which may contain certain air pollutants, such as VOCs, so that concerned consumers can respond accordingly, and personally reduce their own emissions of air pollutants.[44]

In terms of procedural considerations, within the LRTAP regime, all UN accredited NGOs are granted observer status at all intergovernmental meetings of the LRTAP and its Protocols, and their attendance at meetings has been welcomed by governments. At the higher level meetings, NGOs act more as observers, although they have always been given the opportunity to speak and/or present documents if they wish. At Task Force meetings, expert groups and workshops, NGOs play a much more active role in the work of the Convention (though technically they still have observer status). They have the opportunity to speak, present papers and discuss results. Because of the good relationships with NGOs, the Executive Body for the Convention has not found it necessary to develop its own rules for including NGOs in its work. As such, the Convention still uses the ECE Rules of Procedure which the Executive Body for the Convention agreed to use at its first session in 1983. While these may appear to be limiting, they are interpreted with flexibility.[45]

[41] Boehmer-Christiansen, S. & Skea, J. (1991). *Acid Politics*. (Belhaven, London). 49, 70–71, 90–92, 189–199, 210–211.
[42] Preamble.
[43] Article 5 (1).
[44] Gothenburg Protocol. Article 5 (2)(c) and 5 (2)(f). See also the VOC Protocol. 1991. Article 2 (ii), Annex. Paragraphs 71, 76 & 80.
[45] Personal communication, from the UNECE Secretariat, August, 2002.

XV. FUNDING ASSISTANCE

1. Ozone Funding Considerations

A. Financial Assistance under the Auspice of the Montreal Protocol

The funding arrangements under the ozone regime have been a crucial success to the Montreal Protocol.[1] The success is demonstrated by two examples. First, in terms of the degree with which it has assisted developing countries in phasing out ODS. Specifically, by 1998, the financial mechanism (the 'Fund') of the Montreal Protocol had enabled a total of over 2,500 projects and activities in over 100 countries, which had eliminated approximately 117,000 tonnes of ODS.[2] Second, the Fund has been continually reviewed, refined, and perfected so as to continually meet the needs of the Parties in both procedural and substantive terms.[3]

Although the Fund is currently recognized as a success, the journey to this point, was a long one.[4] The journey really started in 1989 (not in 1987 when the Montreal Protocol was concluded) when a number of developed countries agreed there was an, 'urgent need to establish international financial and other mechanisms' to enable developing countries to meet the requirements of Montreal Protocol, whilst also fulfilling the promises that the developed countries had made to developing countries when enticing them into the ozone regime, of financial and technical assistance.[5] Specifically, as the former Prime Minister of the United Kingdom, Margaret Thatcher, explained,

---

[1] Decision V/7. Review of the Functioning of the Financial Mechanism. Report of the Fifth MOP to the Montreal Protocol. 12.

[2] Report of the 7th MOP to the Montreal Protocol. 3, 13. Report of the 10th MOP of the Montreal Protocol.. 3. Report of the 11th MOP to the Montreal Protocol. 21.

[3] Decision V/11. Review Under Paragraph 8 of Article 5. Report of the Fifth MOP to the Montreal Protocol. 19 November 1993. 14. Also, Decision VI/6. Annex V. Actions to Improve the Financial Mechanism. Decision XII/16. Organization of Ozone Secretariat and Multilateral Fund Meeting. Report of the Twelfth MOP to the Montreal Protocol. 33. Report of the Eighth MOP Of the Montreal Protocol. 12. Anon. (1995). 'Ozone Obstacles'. *New Scientist.* Feb 18. 11.

[4] For a general discussion of the fund, see Jordan, A. (1998). 'The Multilateral Ozone Fund of the Ozone Protocol'. *Global Environmental Change.* 8(2). 171–175.

[5] Decision I/13. Assistance Under the Montreal Protocol. First MOP To the Montreal Protocol. Helsinki Declaration on the Protection of the Ozone Layer. Appendix 1 of MOP 1. MacKenzie, D. (1989). 'Countries Agree More Help For the Ozone Layer'. *New Scientist.* May 6. 7.

> Countries at any early stage of industrial development had understandable concerns about adverse effects on their economic growth. It was the duty of industrialized countries to help them with substitute technologies and with financing the additional costs involved.[6]

The financial assistance that was necessary to achieve the objectives that Margaret Thatcher identified, was conditional for the participation of India and China in the ozone regime.[7] This leverage, whereby clear continued reductions in the utilization or production of ODS by developing countries, has remained apparent over the following decades.[8]

The Funding Mechanism was finally set down in 1990. Article 10 of the London Revisions, which replaced the earlier Article 10 of the Montreal Protocol, stipulated,

> The Parties shall establish a mechanism for the purposes of providing financial and technical co-operation including the transfer of technologies, to Parties operating under paragraph 1 of Article 5 of this Protocol to enable their compliance with the control measures set out in Articles 2A to 2E of the Protocol.[9]

Although there was broad agreement in principle, since 1989, to the idea of enhanced financial resources to secure developing country participation, and this was the, 'major task facing the Parties',[10] the exact ways a mechanism to achieve this goal would work was uncertain. Accordingly, a Working Group was established to, 'develop modalities for such mechanisms'.[11] Although the Working Group made their report by mid 1989, five issues were unresolved, and have only been clarified over successive meetings.

B. The Size of the Fund

The first question was whether the finances for the implementation of the Montreal Protocol were to be additional to existing financial commitments? The United States was originally unwilling to tolerate the idea of new and additional funds, beyond what they were already giving to the World Bank.[12] However, this view was soon overcome, and the 1990 London Revisions came to stipulate that the, 'contributions shall be additional'

---

6 Second MOP to the Montreal Protocol. 2.

7 Comments Made at the Time of Adoption of the Decisions. Second MOP to the Montreal Protocol. 18. 1 *YBIEL*. (1990). 253–254. Third MOP to the Montreal Protocol. 7. Anon. (1991). 'Ozone Friends'. *New Scientist*. July 13. 19.

8 Co-Chairs of the Assessment Panels (2003). *The Synthesis Report*. (UNEP, Nairobi). 7. Anon. (1999). 'UN Fumes, China Fumigates'. *New Scientist*. Dec 11. 7.

9 London Revisions. 1990. Article 10.(1).

10 Second MOP to the Montreal Protocol. 1.

11 Helsinki Declaration. Ibid. Decision 13.

12 Milne, R. (1990). 'US Agrees Extra Funds to Safeguard Ozone Layer'. *New Scientist*. June 23. 8.

to existing financial support to developing countries, on this matter.[13]

The second question, was what was the size of the additional contributions likely to be? In order to answer this, the Secretariat began collecting estimates of what the possible costs, in reducing ODS utilization in developing countries would be. The answers, which were conditional on the speed and scope of the operation required were high.[14] India and China both suggested that to achieve the objective of the Montreal Protocol would cost them each just over 100 million (USD). These figures were identified as the conditions that must be met, if both China and India were to participate in the ozone regime.[15] Since this point, the progress of developing countries in making continued reductions in ODS utilization and consumption of ODS, has often been posited as conditional on continued access to adequate financial assistance.[16] In terms of actual amounts of money involved, the size of the Fund for the first period (1991 to 1993) was 200 million (USD),[17] for the second period (1994 to 1996) it was 510 million,[18] for the third period (1997 to 1999) it was 540 million,[19] for the fourth period (2000–2002) it was 440 million,[20–21] for the fifth period (2003–2005), following prolonged debate, including at the World Summit on Sustainable Development,[22] it was 573 million.[23]

---

[13] London Revisions, Article 10 (1).

[14] UNEP. (1989). Open Ended Working Group of the Parties to the Montreal Protocol. UWU/OzL.Pro.WG.I.(1)/3. August 25. 2. Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol. UNEP/OzL.Pro. WG.1(2)/4. 25. of the Second Session of the Second Meeting on the Open Ended Working Group. UNEP/OzL.Pro.WG.11 (2)/7. March 5, 1990. 5. 1 *YBIEL.* (1990) 260–263.

[15] Anon. (1991). 'Ozone Friends'. *New Scientist.* July 13. 19.

[16] Report of the Fifth MOP to the Montreal Protocol. 1. MacKenzie, D. (1995). 'Rich and Poor Split Over Ozone'. *New Scientist.* Dec 9. 5.

[17] Decision III/22. Executive Committee of the Multilateral Fund. Third MOP to the Montreal Protocol. 3 & 21. Milne, R. (1990). 'Nations Approach Unity On Measures to Protect Ozone'. *New Scientist.* June 30. 7.

[18] Decision V/9. Executive Committee of the Multilateral Fund. Report of the Fifth MOP to the Montreal Protocol. 7, 13.

[19] Decision VIII/4. Replenishment of Multilateral Fund for 1997–99. Report of the Eighth MOP Of the Montreal Protocol. 16.

[20] Decision XI/7. Replenishment of the Multilateral Fund for the Period 2000–2002. Report of the 11th MOP to the Montreal Protocol. 25 Decision XII/15. Financial Matters. Report of the Twelfth MOP to the Montreal Protocol. 31–32.

[21] Anon. (1999). 'Easy Way Out'. *New Scientist.* Dec 11. 7.

[22] Decision XIII/4. Review of the Implementation of the Fixed Exchange Rate Mechanism of the Multilateral Fund. Decision XIII/1. Terms of Reference for the Study on the 2003–2005 Replenishment of the Multilateral Fund. Report of the 13th MOP of the Montreal Protocol. 39–40. Decision XIII/2 Ad-Hoc Working Group on the Replenishment of the Multilateral Fund. WSSD. Plan of Implementation of the World Summit on Sustainable Development. A/CONF.199/L.1. Paragraph 37 (b) UNEP. (2002). *Supplement to the April 2002 TEAP Replenishment Report: Assessment for the Funding Requirement of the Multilateral Fund for the Period 2003–2005.* (Available from the Secretariat). 19.

[23] Decision XIV/39. The 2003–2005 Replenishment of the Multilateral Fund.

C. The Generating Mechanism

Once the size of the Fund had been ascertained, the question arose as to how these funds would be generated. The options included an international tax on ODS, voluntary pledges to an international trust fund, an international environmental facility designed to match funding and projects and an independent financial corporation providing commercial or subsidized loans. The debate came down to a choice between a 'polluter pays' approach, which the developing world supported, a UN Scale of Assessment regime, which the United Kingdom advocated for.[24] Eventually, the United Kingdom proposal was accepted and included in the 1990 revisions to the Montreal Protocol.[25] Since this point, alterations to the mechanism have been minimal, aside the incorporation of some improved management practices,[26] and expedited collection processes.[27] Attempts to alter the UN Scale, so as to generate greater amounts of money, have met with strong resistance by the donors.[28]

D. Incremental Costs and the Choice of Projects for Funding

The final agreement which created the Fund concluded that, inter alia, 'all' incremental costs related to the ODS commitments of developing Parties would be met by the Fund.[29] Following some interim analysis,[30] the Indicative List of Categories of Incremental Costs was concluded in 1992. Although non-exclusive, it was suggested these costs could be,

[24] UNEP. (1989). Open Ended Working Group to the Montreal Protocol. 7. First MOP To the Montreal Protocol. Paragraphs 26, 35 & 36. Second MOP to the Montreal Protocol. 8. Report of the Second Session of the Second Meeting on the Open Ended Working Group. 10–13. Report of the Second Session of the Second Meeting on the Open Ended Working Group. 15. Oberthur, S. (2000). 'Ozone Layer Protection at the Turn of the Century: The 11th MOP'. *Environmental Policy and the Law.* 30(1/2): 34.

[25] 'The Multilateral Fund shall be financed by contributions from [developed] Parties . . . on the basis of the United Nations scale of assessments'. London Revisions. 1990. Article 10.(6).

[26] Report of the 11th MOP to the Montreal Protocol. 7 Dec 1999. 7–8. Decision XI/6. Fixed Exchange Rate Mechanism for the Fund. At 24–25.

[27] Decision XII/15. Financial Matters. Report of the Twelfth MOP to the Montreal Protocol. 31–32. Anon. (1992). 'Ozone Treaty in Jeopardy'. *New Scientist.* Nov 21. 8. Anon. (1994). 'Broken Promise'. *New Scientist.* Oct 22. 13.

[28] 7 *YBIEL.* (1996). 129.

[29] Decision II/8. Financial Mechanism. Paragraph 6. Second MOP to the Montreal Protocol. 12.

[30] The costs covered the supply of substitutes, costs arising from premature retirement for existing plants, and the establishment of new production facilities. Net operational costs, and costs of importing substitutes were also part of the equation. Annex IV of the 2nd COP in 1990. Decision III/19. Financial Mechanism. Report of the Third MOP to the Montreal Protocol. 20.

1. In the supply of substitutes, for the cost of conversion of existing production facilities (covering patents, capital costs of conversion and retraining), costs arising from premature retirement (for lost production capacity) and the costs of establishing new production facilities (patents, capital and training), net operational costs, including raw materials, costs of imported substitutes,
2. Use in manufacturing as an intermediate good, covering patents, capital, retraining, research and operational cost.
3. End use, in terms of premature modification, cost of collection, management and recycling or disposal, and cost of technical assistance to reduce ODS.[31]

This list was slightly revisited in the mid 1990s, following accusations by a number of developing countries that it was being interpreted too restrictively.[32] Despite, solving such procedural problems, substantive difficulties over the choice of what ODS to provide financial assistance for have remained problematic. For example, the Fund has been directed to finance hundreds of 'essential' projects involving the controversial ODS of MB[33] and HCFCs[34] in developing countries and countries in economic transition.

E. Composition of the Executive and the Role of Other International Organizations

Given that such large sums of finance were involved, the debate quickly turned to the make-up of the Executive Committee. The Executive Committee, which is hosted by Canada[35] has specific objectives. According to

[31] Annex VIII. Incremental Costs. Report of the Fourth MOP to the Montreal Protocol. 52.

[32] Decision VI/18. Modification of the Indicative List of Categories of Incremental Costs. Report of the Sixth MOP. 11–13, 23. 5 *YBIEL.* (1994). 160.

[33] Since 1993, when the Fund supported only a 'limited number' of methyl bromide projects its role had fully expanded (as the control of methyl bromide was brought fully within the Protocol) to cover "all incremental costs" for "all methyl bromide projects, irrespective of their relative cost-effectiveness" was agreed in 1997. At the 9th MOP, immediate priority was placed within the Fund for Methyl Bromide alternatives, $25 million was dedicated specifically to the task. "New and Additional" finance was to be provided for this. By the end of 2002 the Fund had approved a total of 232 MB projects which consisted of 44 demonstration projects, 38 phasing out projects, 150 information exchange projects in more than 63 countries. See Decision IX/5. Conditions For Control Measures on Annex E. Report of the Ninth MOP Of the Montreal Protocol. 27–28. 34 Decision V/23. Funding for Methyl Bromide Projects. Report of the Fifth MOP to the Montreal Protocol. 18. Decision IX/5. Conditions for Control Measures on Annex E Substances. Guidelines for this funding were developed in 1998. Report of the 10th MOP of the Montreal Protocol. 18. Co-Chairs of the Assessment Panels (2003). The Synthesis Report. UNEP/OzL.Pro/WG.1/23/3. 36. Decision Ex.I/1. Further Adjustments Relating to the Controlled Substance in Annex E. Report of the First Extraordinary Meeting of the Parties to the Montreal.

[34] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* Ibid., 181.

[35] Decision II/8.B. Acceptance of Offer By Canada. Second MOP to the Montreal Protocol. 15.

the 1990 London Amendments, the Executive Committee has to develop and monitor the implementation of specific operational policies, guidelines and administrative arrangements, including the utilization of resources, for the purposes of achieving the objectives of the Multilateral Fund.[36] Additional considerations later included budgeting for the Fund, supervision and guidance of its administration, developing project eligibility criteria, performance review, evaluation and general monitoring of the Fund's implementation.[37]

As the Fund has such important responsibilities, unsurprisingly, both the donors and the recipients wanted to control the way in which the body would be directed.[38] This debate fell into two parts. The first part of the debate related to make-up and modalities of operation for the Executive Committee. Eventually, an Executive, which can only make decisions based on a two thirds majority,[39] and established on the basis of a balanced and rotating, representation between developed and developing countries (seven countries each), under the guidance of Chief Officer who has their own selection process, was agreed.[40]

The second part of the debate related to the role that other international organizations would play in the administration of the mechanism.[41] Key countries in the developed world, such as the United States and the United Kingdom, wanted the World Bank (over which they exercise greater

---

[36] London Revisions. 1990. Article 10.(5).

[37] Annex X. Terms of Reference for Executive Committee. Point 10. Decision IV/18. Financial Mechanism. Report of the Fourth MOP. 19–20. Decision XV/47. Terms of Reference for a Study on the Management of the Financial Mechanism of the Montreal Protocol. Report of the 15th MOP to the Montreal Protocol. 73, and Annex V. 89–92. Decision XIII/3. Evaluation Study on the Managing and Implementing Bodies of the Financial Mechanisms. Report of the 13th MOP. 40.

[38] Milne, R. (1990). 'Nations Approach Unity On Measures to Protect Ozone'. *New Scientist*. June 30. 7.

[39] Appendix II. Terms of Reference for the Executive Committee. 2nd COP. See also the London Revisions. 1990. Article 10.(9): "Decisions by the Parties under this Article shall be by consensus wherever possible. . . . If not possible, decisions shall be adopted by a two-thirds majority vote of the Parties present and voting, representing a majority of the Parties operating under paragraph 1 of Article 5 present and voting and a majority of the Parties not so operating present and voting."

[40] Report of the Second Session of the Second Meeting on the Open Ended Working Group. 13. The Executive Committee: "shall be selected on the basis of a balanced representation of the Parties operating under paragraph 1 of Article 5 and of the Parties not so operating, shall be endorsed by the Parties." London Revisions. 1990. Article 10.(5). Appendix II. Terms of Reference for the Executive Committee. 2nd COP. Paragraph 6. Decision IV/20. Executive Committee of the Multilateral Fund. Report of the Fourth MOP to the Montreal Protocol. 21. Decision XIII/27. Membership of the Executive Committee of the Multilateral Fund. Report of the 13th MOP. 51. Decision XV/48. Decision on the Report of the Executive Committee of the Multilateral Fund. Report of the 15th MOP. 73.

[41] UNEP. (1989). Open Ended Working Group of the Parties to the Montreal Protocol. 9.

control) to play a pivotal role in the Fund. However, this view was not shared by the majority of other Parties, who decided that the, 'co-operation and assistance' required, would be equally split between the UNDP, UNEP and the World Bank depending on their 'respective areas of expertise'. Theoretically, the World Bank was allocated the 'paramount' role, acting in an administrative and managerial function, with UNEP pursuing the 'political promotion of the objectives of the Protocol' as well as research, data collection and clearing house functions. The UNDP was charged with feasibility studies and other technical assistance issues.[42]

As soon as this arrangement was agreed, the question arose over what role the newly formed Global Environment Facility (GEF), which was also focused on, inter alia, financing solutions to ozone depletion, would play. Following a few years of uncertainty in the early to mid 1990s, it was eventually clarified, after the GEF was restructured, that the GEF would be primarily involved in assisting countries in economic transition which were not covered by the Fund, as opposed to the Fund which would be primarily involved in assisting developing countries.[43] Between 1991 and 1999, the GEF allocated more than 155 million (USD) to projects phasing out more than 35 million tonnes of ODS in 15 countries.[44] This role for the GEF, through which the GEF has formally pledged itself to work closely with the Fund and the other institutions of the ozone regime, in assisting countries in economic transition meet their ODS commitments, has been clearly appreciated by the Parties to the Montreal Protocol, who have continually called upon the GEF to continue this work.[45]

---

[42] This was a debate with long roots. See UNEP. (1982). Financial Implications of the Implementation of the Convention for the Protection of the Ozone Layer. UNEP/WG.78/7. 23 November. Paragraph 10. For the conclusion, see London Revisions. 1990. Article 10.(5). Appendix IV. Terms of Reference for the Interim Multilateral Fund. 2nd COP, 1990. 1 *YBIEL*. (1990). 330. Decision IV/18. Financial Mechanism. Report of the Fourth MOP to the Montreal Protocol. 19–20. Point 4 of Decision IV/18. Interim Fund. Paragraph 6, ibid. Point 16 of Decision IV/18. Report of the Second Session of the Second Meeting on the Open Ended Working Group. 9, 14–15. Benedict, R. (1991). *Ozone Diplomacy*. (Harvard University Press, Cambridge). 186–187.

[43] I *YBIEL*. (1990). 212. Report of the Fourth MOP to the Montreal Protocol. 11. Report of the Third MOP to the Montreal Protocol12. Report of the Sixth MOP to the Montreal Protocol. 12–13. Report of the Sventh MOP to the Montreal Protocol. 14–15. Report of the 10th MOP of the Montreal Protocol. 3. Report of the 13th MOP. 31. Pearce, F. (1996). 'Smart Smugglers Outwit the CFC Cops'. *New Scientist*. Oct 26. 4. Pearce, F. (1997). 'The Hole That Will Not Mend'. *New Scientist*. Aug 30. 16–17.

[44] Report of the 10th MOP of the Montreal Protocol. 10.

[45] Decision XI/22. Global Environment Facility. Report of the 11th MOP. 31. Report of the Ninth MOP Of the Montreal Protocol. 12. Decision XII/14. Continued Assistance by the GEF to Countries With Economies In Transition. Report of the Twelfth MOP to the Montreal Protocol. 31. Decision XV/51. Institutional Strengthening Assistance to Countries With Economies in Transition. Report of the 15th MOP to the Montreal Protocol. 74.

2. Climate Funding

A. Precedents and Evolution

Following the success of the funding arrangement within the ozone regime, there was a clear inference that a similar regime would be created for the climate regime.[46] However, the United States were strongly antagonist against the precedent value of the Multilateral Fund, and they were successful in getting the 1990 London Amendments to the Montreal Protocol to record that, the financial mechanism was without prejudice to any future arrangements that may be developed with respect to other environmental issues.[47] Although this may have been the intention of the Parties to the Montreal Protocol, the necessity to have some kind of funding arrangement to help assist developing countries meet the costs of abating climatic change, was repeated at the Second World Climate Conference and other international semi-official conferences at Toronto, Noordwijk and Bergen.[48]

With such a build up of interest in the idea of financial assistance to help developing countries confront climatic change, and the success of the Multilateral Fund of the Montreal Protocol (despite attempts to limit its precedent value) the ideas ultimately flowed into the FCCC. Specifically, it was recognized that, 'developing countries, need access to resources required to achieve sustainable social and economic development'.[49] This need for resources was linked to sections of the FCCC, in which developing countries were invited to, inter alia, propose projects for financing with a view to reducing greenhouse gases.[50] Linked to these broad ideas was the statement that,

> The extent to which developing country Parties will effectively implement their commitments under the Convention will depend on the effective imple-

[46] UNEP. (1989). Open Ended Working Group of the Parties to the Montreal Protocol. 5–6. Second MOP to the Montreal Protocol. 3, 6. MacKenzie, D. (1990). 'Montreal Nations Agree Tougher Rules on CFCs'. *New Scientist.* March 24. 8. Third MOP to the Montreal Protocol. 8. Benedict, R. (1991). *Ozone Diplomacy*. (Harvard University Press, Cambridge). 7.

[47] London Revisions. 1990. Article 10.(10). Milne, R. (1990). 'CFC Clampdown Eases Pressure on the Ozone Layer'. *New Scientist.* July 7. 9. Benedict, R. (1991). *Ozone Diplomacy.* (Harvard University Press, Cambridge). 84–185.

[48] Anon. (1988). 'Toronto Delegates Call for a 'Law of the Atmosphere'. *New Scientist.* July 7. 24. Spinks, P. (1989). 'Nations Fail to Agree On Measures to Limit Greenhouse Effect'. *New Scientist.* Nov 18. 7. MacKenzie, D. (1990). 'Europe Pushes Hard Line in Greenhouse Talks'. *New Scientist.* May 19. 8.

[49] FCCC. Preamble. Paragraph 22.

[50] FCCC. Article 12. 4.

mentation by developed country Parties of their commitments under the Convention related to [inter alia] financial resources.[51]

Therefore, the FCCC created a financial mechanism, under the guidance of the Parties, under Article 11 of the Convention. The financial mechanism was created for the provision of financial resources by concession or grant. However, although the principle of the financial mechanism was broadly agreed, the specific modalities of how to operate it were far from certain, and were set aside for resolution and review at future COPs.[52]

B. Size of the Various Funds and Generating Mechanisms

In the initial years before the FCCC was agreed, it was common to hear suggestions of hundreds of millions of dollars, being necessary each year, to help developing countries control their greenhouse gas emissions.[53] However, as the FCCC evolved, overall funding expectations were reduced, as initial assessments, modalities for the operation of the mechanism, and a tightly controlled ambit of what may be considered for assistance, reigned the earlier figures in.[54] In addition, financial assistance from the GEF started to become available and between 1991 and 2002, the GEF directly provided over 1.5 billion (USD), in addition to over 5 billion in leveraged funds, for climate change projects.[55] Such alternative sources of finance, meant that the scope of the financial objectives of the FCCC could be more restricted. Nevertheless, when the COP of the FCCC finally concluded its guidance to the operating entity of its financial mechanism in 2001, the sums they pledged were considerable. Specifically, the developed countries promised to collectively provide 410 million (USD) annually by 2005 for FCCC related purposes.[56] Further guidance on funding assistance required

[51] FCCC. 4 (7).

[52] FCCC. Article 11. (3) & (4).

[53] Mostafa Tolba suggested in 1990 that the initial fund should amount to $230 million. MacKenzie, D. (1990). 'Europe Pushes Hard Line in Greenhouse Talks'. *New Scientist.* May 19. 8.

[54] Decision 12/CP.2. Memorandum of Agreement Between the GEF and the COP. Report of the Second COP of the FCCC. 55. Annex I. Paragraph 9. See also Decision 13/CP.2. Annex On the Determination of Funding Necessary for the Implementation of the Convention. 60. Decision 12/CP.3 Annex to the Memorandum of Understanding on the determination of funding necessary and available for the implementation of the Convention. Report of the 3rd COP to the FCCC. 43. Decision 7/CP.7. Funding under the Convention. Report of the 7th COP to the FCCC. 43. 4. *YBIEL.* (1993). 143.

[55] Review Of The Implementation Of Commitments And Of Other Provisions Of The Convention Financial Mechanism Report Of The Global Environment Facility. FCCC/CP/2002/4. Report of the 1st COP of the FCCC. Paragraph 47. Report of the 2nd COP to the FCCC. 32. 6 *YBIEL.* (1995). 231.

[56] 12 *YBIEL.* (2001): 218–219. http://unfccc.int/issues/financemech.html. Visited, August, 2002.

for developing countries in fulfilling their commitments to the FCCC were guided by specific reports that helped identify the levels of funding required in the future.[57]

As it is likely that the financial needs of the funding arrangements that are evolving under the FCCC could be quite high, it was suggested that beyond a certain level, innovative financing arrangements, beyond traditional UN Scale of Assessment or polluter pays approaches, may be necessary.[58] This idea was built into the Kyoto Protocol, which recognized, within the Clean Development Mechanism provisions,

> That a share of the proceeds from certified project activities is used to cover administrative expenses as well as to assist developing country Parties that are particularly vulnerable to the adverse effects of climate change to meet the costs of adaptation.[59]

As such, the CDM provides a facilitative role in generating finance for one branch (the Adaptation Fund) of the FCCC financial mechanism. This arrangement was confirmed in 2001 with agreement that two per cent of the value of certified emission reductions issued for a CDM project activity would be credited to this area, unless the CDM was operating in a LDC.[60] This provision represented a major breakthrough in international environmental law, in general, as this was the first time that a levy was placed on business transactions for the financing of environment and development activities. Building on the idea of novel funding arrangements, it has also been suggested, but not concluded, that insurance schemes to cover costs associated with the impacts of climate change should be considered.[61]

C. Management of the Funds

As negotiations for the FCCC proceeded, the developed countries expressed a clear preference that any future financial mechanism in this area, should

[57] Decision 9/CP.10. Assessment of Funding to Assist Developing Countries in Fulfilling Their Commitments to the Convention.

[58] The President of the first COP 6, in his capacity as Chair, noted with the Adaptation Fund agree that the sum total should reach the level of one billion US$ on an annual basis, as soon as possible, but not later than in the year 2005. If resources in 2005 would be less than one billion US$, Parties agree to apply a levy on article 6 (Joint Implementation) and/or article 17 (emission trading). Report of the 6th COP to the FCCC. Personal Observations of the Chair.

[59] Kyoto Protocol. Article 12 (8).

[60] Decision 17/CP.7. Modalities And Procedures For A Clean Development Mechanism. Annex. Modalities and Procedures for a Clean Development Mechanism. C. Executive board. FCCC/CP/2001/13/Add.2. 20. Paragraph 15. McGivern, B. (1999). 'COP to the FCCC'. *ILM*. 37: 22.

[61] Kyoto Protocol. Article 3 (14). Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Decision 5/CP.7 Implementation of Article 4, paragraphs 8 and 9, of the Convention. Report of the 7th COP to the FCCC.

be run by international organizations that they had ultimate control over, such as the World Bank, or the GEF (as it was before it was restructured). However, most developing countries opposed either of these choices, opting for the creation of a new, independent and equitable body to govern any future financial mechanism.[62] This issue was not finally resolved by the time the FCCC was concluded. Accordingly, the FCCC only stipulated that the financial operation would be entrusted, 'to one or more existing international entities'[63] and that the mechanism would, 'have an equitable and balanced representation of all Parties within a transparent system of governance'.[64] Due to the lack of conclusion, an Interim Arrangement was agreed, with the GEF, UNEP and UNDP jointly entrusted with the operation of the financial mechanism, and subject to short term review.[65] The Interim Arrangement, after a certain clarity of roles of the different organizations, along with its regular review, continued into the new century.[66] A large part of its continuation, had to do with the GEFs relationship with the FCCC becoming clarified, streamlined, formalized, and ultimately the responsiveness of the GEF to the FCCC demands becoming satisfactory, and the primacy of the FCCC over the GEF in climate related questions being made clear.[67] Despite the solidified relationship between the

---

[62] Spinks, P. (1989). 'Nations Fail to Agree On Measures to Limit Greenhouse Effect'. *New Scientist.* Nov 18. 7. 2 *YBIEL.* (1991). 113. Victor, D. & Salt, J. (1994). 'Climate Change'. *Environment.* Dec 7–15.

[63] FCCC. Article 11. 1.

[64] FCCC. Article 11. 2.

[65] FCCC. Articles 11. 4 and 21. 3.

[66] Decision 9/CP.1. Maintenance of the Interim Arrangements. Decision 3/CP.4. Review of the Financial Mechanism. Paragraph 1 and 2. Annex: Guidelines for the Review of the Financial Mechanism. Low, P. (1997). 'UNEPs Role in Climate Change Enabling Activities'. Collaborating Centre on Energy and Environment. (UNEP). 9: 3–5. Hosier, R. (1997). 'UNDP, GEF and Climate Change Enabling Activities'. In the same volume, 6–7. In 2000, a Climate Resources Committee was discussed to give policy advice to existing financing channels and institutions such as the GEF, Regional Development banks, the World Bank, UNDP and other multilateral institutions. The advice focused on increasing climate funding, mainstreaming & monitoring and assessment. Report of the Sixth COP to the FCCC. Personal Observations of the Chair. 27–29. 4. *YBIEL.* (1993). 143.

[67] Decision 12/CP.1. Report of the GEF To The COP. Report. Decision 10/CP.1. Arrangements Between the COP and the Operating Entity of the Financial Mechanism. Decision 12/CP.2. Memorandum of Agreement Between the GEF and the COP. Report of the Second COP to the FCCC. Annex. Paragraph 9. Decision 11/CP.2. Guidance to GEF. Report of the Second COP to the FCCC. 52. Decision 2/CP.4. Additional guidance to the operating entity of the financial mechanism. Paragraph 3. Decision 3/CP.6. Other Actions Taken . . . In Relation to the GEF. Decision 6/CP.7. Additional guidance to an operating entity of the financial mechanism. Decision 5/CP.8. Review of the financial mechanism. 1(c). Decision 3/CP 9. Report of the Global Environment Facility to the COP. Report of the Ninth COP to the FCCC. 7–8. Decision 3/CP 9. Report of the Global Environment Facility to the COP. Report of the Ninth COP to the FCCC. 7–8.

FCCC and the GEF, a number of the new funds being created within the climate regime, are not directly linked to the GEF, but to either the financial mechanism (the LDCF and the Adaptation Fund), or through the GEF (the SCCF) but filtered through a new entity, directly answerable to the COP.[68]

D. Funding Objectives

In an exact replication of the debate about funding under the ozone regime, the same questions about whether the funds for developing countries meeting the costs of confronting climate would be additional to existing funds from other financial sources, and whether the funding would cover all of the incremental costs, were repeated.[69] Eventually, the view of the developing world were successful, and the importance of appropriate burden sharing between the developed and developing Parties, by way of reliable, 'new and additional' financial assistance for developing countries, made its way into the FCCC[70] and the Kyoto Protocol.[71] It was also agreed that the funding would, 'meet the agreed full incremental costs of implementing measures' for the wide ranging objectives in Article 4 of the FCCC.

Despite the agreement of the wording, exactly how to interpret key phrases, such as 'agreed full incremental costs' was, 'complex and difficult and further discussion' was required. Until that discussion was concluded, it was recommended that, 'the application of the concept of agreed full incremental costs should be flexible, pragmatic and on a case-by-case basis'.[72] This was especially so for, 'the initial and subsequent preparations of national communications' from developing Parties.[73] Given that the areas where funding could be facilitated were initially curtailed to only a few

---

[68] Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section I: Funding the Convention. I. Funding Under the Convention. Paragraph 35. Decision 10/CP.7. Funding under the Kyoto Protocol. Section 4. Decision 5/CP.7 Implementation of Article 4, paragraphs 8 and 9, of the Convention. Decision 7/CP.8. Initial guidance to an entity entrusted with the operation of the financial mechanism of the Convention, for the operation of the Special Climate Change Fund.

[69] See MacKenzie, D. (1990). 'Climate Conference Ends in Disarray'. *New Scientist.* Nov 17. 5. 71 MacKenzie, D. (1990). 'Europe Pushes Hard Line in Greenhouse Talks'. *New Scientist.* May 19. 8. 2 *YBIEL.* (1991). 113.

[70] FCCC. Article 4 (1) and (3).

[71] Kyoto Protocol. Article 11. (2)(a) and 11. (2)(c).

[72] Decision 11/CP.1. Initial Guidance on Policies, Programme Priorities and Eligibility Criteria to the Operating Entity/s of the Financial Mechanism. Paragraph 1.e. 3 *YBIEL.* (1992). 230. 4. *YBIEL.* (1993). 143. 5 *YBIEL.* (1994). 167. For discussion of this concept with the GEF, see Ahuja, D. (1994). The Incremental Cost of Climate Change Mitigation Projects. (GEF, Washington, Working Paper No. 9). Mintzer, I. (1993). *Implementing the FCCC: Incremental Costs and the GEF.* (GEF, Washington, Working Paper No. 4).

[73] Decision 11/CP.2. Guidance to GEF. Paragraphs 1–3.

very specific areas, such as national communications, it was possible to keep the idea of 'incremental costs' within tight boundaries. Once the various funding arrangements began to expand after the sixth COP, the debate about incremental costs then became determined with regard to the debates surrounding each specific area.

(i). Article 4(1) and Capacity Building

The primary guidance for funding considerations comes from Article 4(3) of the FCCC. This stipulated that developed countries would, 'provide such financial resources needed by the developing country Parties to meet the agreed full incremental costs of implementing measures that are covered by paragraph 1 of this Article'.[74] The Kyoto Protocol built on this obligation by stipulating the developed countries would,

> Provide such financial resources . . . needed by the developing country Parties to meet the agreed full incremental costs of advancing the implementation of existing commitments under Article 4, paragraph 1, of the Convention that are covered by Article 10 and that are agreed between a developing country Party and the international entity or entities referred to in Article 11 of the Convention, in accordance with that Article.[75]

Article 10 of the Kyoto Protocol reiterated many of the objectives of Article 4(1) of the FCCC, with obligations for all Parties, including national inventories and reports, programmes for adaptation, sequestration programmes, technology transfer, capacity building, co-operation in scientific and technical research and full consideration of Article 4 (8) of the FCCC relating to adverse effects. The importance of financially supporting capacity building has been repeatedly approved by the FCCC COPs.[76]

The difficulty with both the FCCC and the Kyoto Protocol is that the multiple sections in this area are very wide-ranging. Due to the vast range of possibilities for funding, the COP originally narrowed down the focus,[77]

---

[74] Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section I: Funding the Convention. I. Funding Under the Convention. Decision 7/CP.7. Funding under the Convention.

[75] Kyoto Protocol. Article 11. (2)(b).

[76] Decision 10/CP.5 Capacity-building in developing countries (non-Annex I Parties). For further elaboration of these, see the attached Annex: List Of Capacity-Building Needs Of Developing Country Parties. Decision 2/CP.7. Capacity building in developing countries (non-Annex I Parties). Action Taken. 5. Decision 6/CP.8. Additional guidance to an operating entity of the financial mechanism. 1(b).

[77] In the initial period, emphasis should be placed on enabling activities undertaken by developing country Parties, such as planning and endogenous capacity building, including institutional strengthening, training, research and education, that will facilitate implementation, in accordance with the Convention, of effective response measures. Decision 11/CP.1. Initial Guidance on Policies, Programme Priorities and Eligibility Criteria to the Operating Entity/s of the Financial Mechanism. Paragraph 1. b. (i) & (ii).

before specifically focusing on Article 4(1) of the FCCC and Article 10 of the Kyoto Protocol.[78] The core of these articles are activities aimed at strengthening research and technological capabilities for the implementation of the Convention in developing countries, through support for networking, the training of experts and, as appropriate, institutional development.[79] These objectives also overlap with the climate regime goals of public participation (the New Delhi Work Programme)[80] and adaptation (the Buenos Aires Action Plan).[81]

Support for many of these goals has become subsumed beneath the ambit of the term 'capacity building'. Capacity building, which has almost become a thematic issue running through the climate change regime is clearly articulated in Article 4 (1) of the FCCC and Article 10 of the Kyoto Protocol.[82] Capacity building is a 'priority area' designed to enhance the participation of countries in economic transition, developing countries and LDCs in particular, in the work of the climate regime and implementation of its objectives.[83] This may involve the establishment or enhancements, as appropriate, of national climate change secretariats or national focal points; enhancement and/or creation of an enabling environment; national communications; national climate change programs; greenhouse gas inventories; emission database management and systems for collecting, managing and utilizing activity data and emission factors; vulnerability and adaptation assessment; capacity building for implementation of adaptation measures; assessment for implementation of mitigation options; research and systematic observation; improved decision-making processes, including assistance for participation in international negotiations; education, training and public awareness.[84] Although wider interpretations of capacity building may

[78] See sections B, I, G & H of Article 4 (1), and sections B, D & E in Article 10 of the Kyoto Protocol.

[79] Decision 11/CP.1. Initial Guidance on Policies, Programme Priorities and Eligibility Criteria to the Operating Entity/s of the Financial Mechanism. Paragraph 1. b. (i) & (ii).

[80] Decision 7/CP.10. Status of, and Ways to Enhance, Implementation of the New Delhi Work Programme on Article 6 of the Convention. Paragraphs 3 and 4. Decision 11/CP.8. New Delhi work programme on Article 6 of the Convention.

[81] Decision 2/CP.4. Additional guidance to the operating entity of the financial mechanism. Decision 8/CP 10. Additional Guidance to an Operating Entity of the Financial Mechanism. Paragraph 3. Decision 6/CP.8. Additional guidance to an operating entity of the financial mechanism. 1 (c).

[82] In 2003, the Secretariat was directed to prepare a study on multiple aspects (from needs to best practice) of capacity building within the UNFCCC. See Decision 9/CP 9. Capacity Building. Report of the Ninth COP to the FCCC. 17.

[83] Decision 2/CP.10. Capacity Building for Developing Countries (Non-Annex I Parties). Paragraph 1 (a).

[84] This list is taken from Decision 10/CP.5 Capacity-Building in Developing Countries (non-Annex I Parties). Paragraph 1. A refined version of the list appeared in Decision 2/CP.10. Capacity Building for Developing Countries (Non-Annex I Parties). Paragraph 1.

include aspects such as technology transfer, the COPs of the FCCC have not adopted this wider interpretation.

Although all developing countries and countries in economic transition are deemed to need assistance for capacity building, the priority is clearly for those that are particularly vulnerable, that is, the LDCs and the SIDs, whose needs should be 'urgently' addressed.[85] Capacity building programmes for countries in economic transition have also been agreed and reiterated.[86] The 10th COP in 2004 identified six elements for the capacity building of countries in economic transition. All of these elements relate to the enhancement of enabling environments to promote capacity building activities relating to the implementation of the FCCC. Specifically, the elements are improvement of information sharing, enhancement of training, education and public awareness of climate change, co-operation in capacity building between countries in economic transition, enhancement of national capacities and expertise within government departments on FCCC related matters, effective participation in the climate negotiations, and participation by all stakeholders, including civil society and the private sector, in capacity building activities.[87] To further assistance in this area, the GEF was requested to provide information regarding opportunities of technical and financial support in these areas. This was to be supplemented by national reports including self assessment of what capacity building requirements are needed by countries in economic transition, with a view to reviewing this area in 2007.[88]

[85] Decision 2/CP.7. Capacity building in developing countries (non-Annex I Parties). Action Taken. 5. Decision 10/CP.5 Capacity-building in developing countries (non-Annex I Parties). Paragraph 1.

[86] Decision 4/CP 9. Additional Guidance to an Operating Entity of the Financial Mechanisms. Decision 3/CP.7. Capacity building in countries with economies in transition. Action Taken. 15. Decision 11/CP.5. Capacity-building in countries with economies in transition. Paragraph 1 (a).General priority areas for capacity-building identified by EIT Parties are to be identified in their national action plan for capacity building, and include: national greenhouse gas (GHG) inventories; projections of GHG emissions; policies and measures, and the estimation of their effects; impact assessment and adaptation; research and systematic observation; education, training and public awareness; transfer of environmentally sound technologies; national communications and national climate action plans; national systems for estimation of GHG emissions; modalities for accounting relating to targets, timetables and national registries; reporting obligations; joint implementation projects and emissions trading.

[87] Decision 3/CP.10. Capacity Building for Countries with Economies in Transition. Paragraph 1.

[88] Decision 3/CP.10. Capacity Building for Countries with Economies in Transition. Paragraphs 3 and 7

(ii). National Communications

One of the most uncontroversial areas with financial assistance in the climate change regime is with assistance for developing countries with their reporting and communication obligations. Following previous bilateral support from developed to developing countries for national analysis of greenhouse emissions,[89] and clearly articulated views that without such support, the provision of climate related information from developing countries may be less than satisfactory,[90] the FCCC and the Kyoto Protocol,[91] both came to stipulate that, the developed country Parties would provide new and additional financial resources to meet the agreed full costs incurred by developing country Parties, and LDCs in particular, in complying with their communication and reporting obligations.[92] Commitment to this area has been continually reiterated by the COPs in 1995,[93] 1996,[94] 1998,[95] 2002,[96] 2003[97] and 2004.[98]

(iii). Adaptation to Climate Change

Adaptation to climatic change, as opposed to mitigation of climatic change, has been largely overlooked in the climate negotiations. However, given that a certain degree of global warming is inevitable, there are powerful reasons to give it much more serious consideration.[99] This need is recognized in article 4(1)(e) of the FCCC.[100] Given that the possibilities for funding adaptation measures are particularly large, this area was curtailed by the division of the adaptation possibilities into Stage I to Stage III. Stage I covered eligibility for planning considerations relating to adaptation. Stage II measures, were related to, 'further capacity building'. Stage III measures

[89] Victor, D. & Salt, J. (1994). 'Climate Change'. *Environment.* Dec 7–15. Dixon, R. (1997). 'US Country Studies Program'. Collaborating Centre on Energy and Environment. (UNEP). 9: 8–9. Chatterjee, P. (1992). 'US Offers Cash For Carbon Cuts'. *New Scientist.* March 7. 9.

[90] The Geneva Ministerial Declaration. Paragraph 8.

[91] Kyoto Protocol. Article 11. (2)(a).

[92] FCCC. Article 4. 3.

[93] Decision 11/CP.1. some Initial Guidance on Policies, Programme Priorities and Eligibility Criteria to the Operating Entity/s of the Financial Mechanism. Paragraph 1.c.(i).

[94] Decision 11/CP.2. Guidance to GEF. Paragraphs 1–3.

[95] Decision 2/CP.4. Additional guidance to the operating entity of the financial mechanism. Paragraph 1 (d).

[96] Decision 6/CP.8. Additional guidance to an operating entity of the financial mechanism. 1 (a)(ii).

[97] Decision 4/CP 9. Additional Guidance to an Operating Entity of the Financial Mechanisms.

[98] Decision 8/CP 10. Additional Guidance to an Operating Entity of the Financial Mechanism. Paragraph 5.

[99] Pielke, R. (1998). 'Rethinking The Role of Adaptation in Climate Policy'. *Global Environmental Change.* 8 (2): 159–170.

[100] 'Co-operat[ion] in preparing for adaptation to the impacts of climate change'.

include the facilitation of, 'adequate adaptation' including insurance and other measures envisaged in Article 4.1.(b). The funding to be provided by the GEF for Adaptation concerns, was clearly upon Stage I measures, unless, 'emerging evidence' suggested that it was necessary to start funding Stages II and III measures.[101] Although funding Stage I measures is a priority for all developing countries, only LDCs and SIDs are within the ambit of consideration for measures beyond Stage I.[102]

The funding of Adaptation considerations was advanced in 2001, when the Kyoto Protocol Adaptation Fund (KPAF), was concluded, following strong support from the G8.[103] The KPAF was designed to, 'finance concrete adaptation projects and programs in developing country Parties'.[104] The primary source of funding for the Adaptation Fund is from a share of the proceeds from the CDM.[105] Although future work is needed in this area it was originally suggested that combating deforestation, land degradation and desertification could all be included in the category of adaptation activities.[106]

The KPAF appears to have an overlap with the Special Climate Change Fund (SCCF), which has, 'adaptation activities to address the adverse impacts of climate change' as a 'top priority for funding'.[107] Implementation of adaptation activities is meant to cover areas where sufficient information is available to warrant such activities, relating to management of water, land, agriculture, health, infrastructure development, fragile ecosystems, including mountainous ecosystems, and integrated coastal zone management. The SCCF is also meant to help improve the monitoring of climate related diseases and vectors, and support capacity building, including institutional capacity, for preventive measures, planning, preparedness and management of disasters relating to climate change.[108] Technology transfer to the least

[101] Decision 11/CP.1. Initial Guidance on Policies, Programme Priorities and Eligibility Criteria to the Operating Entity/s of the Financial Mechanism. Para.1.d. (iii) and (iv).

[102] Decision 2/CP.4. Additional guidance to the operating entity of the financial mechanism. Paragraph 1 (a). Report of the Sixth COP to the FCCC. Personal Observations of the Chair. 35.

[103] Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section I: Funding the Convention. I. Funding Under the Convention. G8 Environment Minister's Communique. Available From http://www.g7.utoronto.ca/g7/environment/2001trieste/communique.html Paragraph 9.

[104] Decision 10/CP.7. Funding under the Kyoto Protocol.

[105] Decision 10/CP.7. Funding under the Kyoto Protocol.. Sections 2 & 3.

[106] Report of the Sixth COP to the FCCC. Personal Observations From the Chair. 45.

[107] Decision 7/CP.8. Initial guidance to an entity entrusted with the operation of the financial mechanism, for the operation of the Special Climate Change Fund. Decision 5/CP 9. Further Guidance to an Entity Entrusted With the Operation of the Financial Mechanism of the Convention, for the Operation of the Special Climate Change Fund.

[108] Decision 5/CP 9. Further Guidance to an Entity Entrusted With the Operation of the Financial Mechanism of the Convention, for the Operation of the Special Climate

developed countries may also fall under this fund.[109] This is particularly in terms of implementation of the results of technology needs assessments, technology information, capacity building for technology transfer and enabling environments.[110]

(iv). Vulnerable Countries: The Least Developed Countries and Small Island States

To date, adaptation considerations have been primarily focused upon the most vulnerable of countries. Although LDCs within Africa were a clear focus within the FCCC,[111] and the WSSD,[112] the climate regime has come to encompass a wider range of developing countries that are 'particularly vulnerable to the adverse effects of climate change' which are entitled to assistance in meeting the costs of adaptation to those adverse effects.[113] Specifically, the FCCC recognizes SIDs, countries with low-lying coastal areas; arid and semi-arid areas, forested areas and areas liable to forest decay; prone to natural disasters; liable to drought and desertification; high urban atmospheric pollution; fragile ecosystems, including mountainous ecosystems; or land-locked and transit countries.[114]

The FCCC also recognizes, 'the specific needs and special situations of the least developed countries in their actions with regard to funding'[115] as an area to be taken into full account. The importance of honoring this obligation can be seen in a number of COP resolutions,[116] as well as the creation of the Least Developed Countries Fund (LDCF),[117] which is specifically designed to support a work programme for the LDCs.[118] The

Change Fund. Report of the Ninth COP to the FCCC. 11–12. Many of these principles were earlier articulated in Decision 5/CP.7 Implementation of Article 4, paragraphs 8 and 9, of the Convention.

109 Decision 6/CP.8. Additional guidance to an operating entity of the financial mechanism. 1 (c).

110 Decision 5/CP 9. Further Guidance to an Entity Entrusted With the Operation of the Financial Mechanism of the Convention, for the Operation of the Special Climate Change Fund. Report of the Ninth COP to the FCCC. 11–12.

111 FCCC. Article 4(1)(e).

112 See World Summit on Sustainable Development. Plan of Implementation. Paragraph 56 (k).

113 FCCC. Article 3 (2) and 4 (4).

114 FCCC. Article 4. 8.

115 FCCC. Article 4. 9.

116 Resolution 2/CP.6. The Third UN Conference on the LDCs. Decision 5/CP.7 Implementation of Article 4(8) and (9) , of the FCCC. 10 YBIEL. (1999). 229.

117 Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section I: Funding the Convention. I. Funding Under the Convention. Decision 5/CP.7 Implementation of Article 4, paragraphs 8 and 9, of the Convention. Decision 6/CP.7. Additional guidance to an operating entity of the financial mechanism.

118 Decision 27/CP.7. Guidance to an entity entrusted with the operation of the financial mechanism of the Convention, for the operation of the LDCF.

LDCF supports capacity building in LDCs (including for preparedness for climate related disasters by contingency planning and early warning systems), and meets the agreed full cost of preparing the National Adaptation Plans of Action (NAPAs). The creation of NAPAs are assisted by the LDC Expert Group.[119] The LDCF is also mandated to build on Stage I activities for the LDCs, and also strengthen the implementation of country-driven Stage II adaptation activities, including NAPAs with pilot or demonstration projects to show how adaptation planning and assessment can practically be translated into projects that will provide real benefits.[120] Full-cost support activities may be agreed, depending upon, inter alia, the, 'urgency and immediacy of adapting to the adverse effects of climate change'.[121] The 10th COP reiterated their support for adaptation and response measures,[122] especially through the SCCF, as seen in light of the Buenos Aires Programme of Work on Adaptation and Response measures, largely as noted above. However, in addition to reiterating support for the pilot and demonstration projects and promotion of technologies for adaptation on an urgent basis in priority areas, the COP also identified support for information and methodologies for enhanced assessment of vulnerabilities to climate change, modeling and reporting. Much of the later work was to be utilized in two pre-sessional meetings, which were designed to examine mitigation and adaptation options, so as to assist Parties in their deliberations on these matters.[123]

[119] Decisions 4/CP.10. Work of the Least Developed Countries Expert Group Decision 28/CP.7. Guidelines for the Preparation of National Adaptation Programmes of Action (NAPAs). These were clearly going well as in 2002, the COP decided they did not need to be reviewed. Decision 29/CP.7. Establishment of a LDC Expert Group. This group was granted an extended mandate in 2003 and 2004. See Decisions 4/CP.10. Work of the Least Developed Countries Expert Group, and Decisions 7/CP 9. Extension of the Mandate of the LDC Group. Decision 9/CP.8. Review of the guidelines for the preparation of NAPAs. The 9th COP reiterated that it was not necessary to review the guidelines for the preparation of NAPAs. See Decision 8/CP 9. Review of the Guidelines for the Preparation of NAPAs For its operation within GEF, see Review Of The Implementation Of Commitments And Of Other Provisions Of The Convention Financial Mechanism Report Of The GEF. FCCC/CP/2002/4. 14.

[120] Decision 8/CP.8. Guidance to an entity entrusted with the operation of the financial mechanism of the Convention, for the operation of the LDCF. Decision 6/CP 9. Further Guidance to an Entity Entrusted With the Operation of the LDCF. Decision 6/CP.7. Additional Guidance to The Financial Mechanism.

[121] Decision 6/CP 9. Ibid. Paragraph 3 (a).

[122] Decision 8/CP.10. Additional Guidance to an Operating Entity of the Financial Mechanism. Paragraph 3.

[123] Decision 1/CP.10. The Buenos Aires Programme of Work on Adaptation and Response Measures. Paragraph 5. The workshops are set down in Part II of the Decision. For commentary, see Anon. (2005). 'Preparing for Climate Change'. *Environmental Policy and the Law*. 35 (1): 33.

XVI. TECHNOLOGY TRANSFER

The ideal of technology being transferred to developing from developed countries dates back to the first UN Conference on Science and Technology for the benefit of LDCs in 1963. This ideal later became entrenched within the broad programmes such as the UN's Development Decades and the New International Economic Order. It also became a specific topic at the ill-fated UN Conferences on Science and Technology for Development (in 1979) and New and Renewable Sources of Energy (in 1981), where the ideal of technology transfer became ensnared in unresolved debates about costs, management, suitability and ownership.[1] Despite the unresolved political debates about technology transfer, the ideal continued to appear in a number of generic international environmental documents, such as those from the 1972 at the Stockholm Conference on the Human Environment, [2] the 1992 Earth Summit,[3] and the 2002 World Summit on Sustainable Development.[4] The general principle to facilitate technology transfer has also been supplemented by specific agreements, such as the United Nations Convention on the Law of the Sea,[5] the Basel Convention on the Trade in Toxic Wastes,[6] the Convention on Biological Diversity,[7] the Energy Charter Treaty[8] and the Protocol on Energy Efficiency.[9] However, despite

---

1 Agarwal, A. (1979). 'UNCSTD: Not A Non Event.' *New Scientist.* July 5. 15–18. Sardar, Z. (1981). 'Last Chance for World Unity.' *New Scientist.* Aug 6. 334–340. Sardar, Z. (1981). 'Brandt Summit: High Hopes, Deep Dispair.' *New Scientist.* Oct 29. 299–303. Editor. (1981). 'The Road From Cancun.' *New Scientist.* Oct 29. 290. Yanchinski, S. (1979). 'UNCSTD and After.' *New Scientist.* Sep 6. 724–26. Yanchinski, S. (1979). 'The Battles Begin At UNCSTD.' *New Scientist.* Aug 30. 643. Yangchinski, S. (1979). 'Third World Wins at UNCSTD—But Not Much.' *New Scientist.* Sep 6. 712. Yanchinski, S. (1979). 'The West Undermines UNCSTD.' *New Scientist.* Dec 13. 851. Yanchinski, S. (1979). 'The Battles Begin At UNCSTD.' *New Scientist.* Aug 30. 643. King, A. (1978). 'UNCSTD: Will Politics Obscure Realities?' *New Scientist.* Aug 24. 538. Sardar, Z. (1981). 'Last Chance for World Unity.' *New Scientist.* Aug 6. 334–340. Agarwal, A. (1978). 'Developing Attitudes to Technology Transfer.' *New Scientist.* Nov 23. 589. New International Economic Order. Article 4, (p).

2 Principle 20 of the 1972 Stockholm Declaration.

3 Rio Declaration, Principle 9. Agenda 21. Paragraphs 9.12(c), (d), 9.18 (c) & Chapter 34.

4 WSSD. Plan of Implementation of the World Summit on Sustainable Development. A/CONF.199/L.1. Paragraph 89–90.

5 UNCLOS, article 266–274, the hotly contested part, article 202.

6 Basel Convention on the International Trade in Toxic Waste. Article 10.

7 Convention on Biological Diversity. Article 16 & 20.

8 Energy Charter Treaty. Article 19. (1)(h).

9 Protocol on Energy Efficiency. Article 3 (e).

the continual reiteration of the idea of technology transfer, the ideal remains without certainty or specifics within the larger international arena.[10] It is against this background, that technology transfer within the air pollution, climate and ozone regimes needs to be assessed.

1. The LRTAP Regime

As discussed in chapter XIX of this book, technological change can result in impressive improvements in air pollution. Accordingly, the adoption of new technologies that reduce air pollutants has become recognized as a primary method to address the pollution problems in this area. In 1988, the importance of this approach within the LRTAP regime began to overlap with the ideal of helping other countries. Specifically, the Parties to the 1988 Sophia Protocol were obliged to consider (and report on) measures to facilitate the exchange of such new technologies.[11] The emphasis on exchange was predicated on the recognition that the, 'expeditious consideration of procedures to create more favorable conditions for the exchange of technology will contribute to the effective reduction of emissions of NOx'.[12] Accordingly, the Protocols of 1988, 1991,[13] 1994,[14] and 1999[15] suggested that the Parties would, by creating, 'favorable conditions in the public and private sectors',[16] facilitate the exchange of technology to reduce air pollution emissions, by commercial exchange of available technology, direct industrial contacts and co-operation, information exchange and the provision of technical assistance.[17] Despite these clear objectives, the actual workings of the Protocols on technology transfer is relatively elusive.

[10] Commission on Sustainable Development. (2001). Transfer of Environmentally Sound Technologies. E/CN.17/2001/PC/11. Paragraph 13. See IEA. (2001). *Technology Without Borders: Case Studies of Successful Technology Transfer*. (IEA, London). Verhoosel, G. (1997). 'International Transfer of Environmentally Sound Techology.' *Environmental Policy and the Law*. 27 (6): 477.
[11] 1991 VOC Protocol. Article 8 (c). 1988 Sophia Protocol. Article 6 (d) and 8 (e).
[12] 1988 Sophia Protocol. Preamble.
[13] Article 4 of the 1991 VOC Protocol.
[14] 1994 Protocol on Further Sulfur Emission Reductions. Article 3.
[15] 1999 Gothenberg Protocol. Article 4.
[16] The "Parties shall create favorable conditions by facilitating contracts and co-operation among appropriate organizations and individuals in the private and public sectors that are capable of providing technology, design and engineering services, equipment or finance." 1988 Sophia Protocol. Article 3 (2) and 3 (3).
[17] 1988 Sophia Protocol. Article 3 (1).

2. The Ozone Regime

The transfer of new technologies that resulted in reduced emissions of ODS, was a matter of principle for many developing countries in the ozone negotiations, as they feared that the 'clean' new technologies being developed in the industrialized countries could quickly become monopolies, which leave the developing world economically vulnerable.[18] As India explained,

> The technology for substitutes, conservation, recycling and equipment modification will be almost wholly the monopoly of a few companies in the developed world . . . the question that haunts us is the extent of the resources required to get the technology as well as the products from the companies in the developed world.[19]

Despite this concern, the Vienna Convention was largely silent on the question of technology transfer, and only obliged its Parties to, 'take into account' the needs of developing countries with regard to the transfer of technology and knowledge.[20] This objective was considerably strengthened in the 1987 Montreal Protocol, under which the Parties undertook to, 'facilitate access to environmentally safe alternative substances and technology for Parties that are developing countries'.[21] A specific article on Technical Assistance was also added, by which the Parties promised to develop work plans to facilitate technical assistance to developing countries.[22] At the following meeting in London, they added Article 10A to the Protocol. This stated,

> Each Party shall take every practicable step, consistent with the programmes supported by the financial mechanism, to ensure, that the best available, environmentally safe substitutes and related technologies are expeditiously transferred to [developing] Parties [and] the transfers occur under fair and most favorable conditions.

The importance of technology transfer was reiterated in 1995,[23] and the following years in 1996 and 1997, when the financial mechanism was directed to facilitate technology transfer.[24] Despite this direction, technology

---

[18] UNEP. (1982). Some Obstructions on the Preparation of a Global Framework for the Protection of the Ozone Layer. UNEP/WG.69/8. January 13. Paragraph 38.

[19] Anon. (1989). 'China Attacks Unfair Ozone Protocol.' *New Scientist.* March 11. 26.

[20] Vienna Convention. Article 4 (2).

[21] Montreal Protocol. Article 5 (2).

[22] Montreal Protocol. Article 10.

[23] Decision VII/4. Provision of Financial Support and Technology Transfer. Decision VII/26. Technology Transfer. Seventh MOP to the Montreal Protocol. 25, 39.

[24] Decision VIII/7. Measures to Improve the Multilateral Fund and Technology Transfer. Report of the Eighth MOP to the Montreal Protocol. 17. Decision IX/14. Measures Taken To Improve the Financial Mechanism and Technology Transfer. Report of the Ninth MOP Of the Montreal Protocol. 33–34.

transfer considerations have been restricted to facilitating transfers which do not have a proprietary basis, and have thus avoided technology transfer considerations where copyright is held by private individuals or companies.[25]

3. Climate Change

The idea that the new technologies which reduce greenhouse gas emissions, should be transferred from developed to developing countries, was a commonly articulated principle in the negotiations leading up to the FCCC.[26] Key international negotiators, such as Mostafa Tolba, even suggested that any future climate regime should utilize 'unconventional' methods, such as the United Nations purchasing patents on environmentally sound 'greenhouse friendly' technology, before giving them to developing countries.[27]

When the FCCC was concluded, technology transfer was, and has remained, an important topic for consideration for the Parties, featuring on the work agenda of the COPs,[28] and clearly within the vision statements of the Parties. For example, at the 8th COP in 2002, the Delhi Ministerial Declaration on Climate Change and Sustainable Development[29] stated,

> International cooperation should be promoted in developing and disseminating innovative technologies in respect of key sectors of development, particularly energy, and of investment in this regard, including through private sector involvement and market-oriented approaches, as well as supportive public policies.
>
> Technology transfer should be strengthened, including through concrete projects and capacity-building in all relevant sectors such as energy, transport, industry, health, agriculture, biodiversity, forestry and waste management.[30]

---

[25] Benedict, R. (1991). *Ozone Diplomacy*. (Harvard University Press, Cambridge). 157–158.

[26] Anon. (1988). 'Toronto Delegates Call for a 'Law of the Atmosphere.' *New Scientist*. July 7. 24. MacKenzie, D. (1990). 'Climate Conference Ends in Disarray.' *New Scientist*. Nov 17. 5. MacKenzie, D. (1990). 'Europe Pushes Hard Line in Greenhouse Talks.' *New Scientist*. May 19. 8. 2 *YBIEL*. (1991). 111. Charles, D. (1991). 'Petty Politics Mars Global Warming Conference.' *New Scientist*. Feb 23. 6. For some of the options in this area, see generally Wilkins, G. (2002). *Technology Transfer for Renewable Energy*. (Earthscan, London). Forsyth, T. (1997). *Positive Measures for Technology Transfer Under the Climate Change Convention*. (Earthscan, London).

[27] MacKenzie, D. (1990). 'Europe Pushes Hard Line in Greenhouse Talks.' *New Scientist*. May 19. 8.

[28] With specific regard to the impacts of reduction policies on developing countries, "Among the issues to be considered shall be . . . transfer of technology." Kyoto Protocol. Article 3 (14).

[29] Delhi Ministerial Declaration on Climate Change and Sustainable Development. Decision 1/CP.8.

[30] The Delhi Ministerial Declaration. Ibid. Paragraphs I to J.

To facilitate such goals, the FCCC and the Kyoto Protocol have developed three principles. First, all Parties, subject to common but differentiated responsibilities, are obliged to, 'Promote and co-operate in the development, application and diffusion, including transfer of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases'.[31] The Kyoto Protocol contained a similar provision, in that all Parties, subject to common but differentiated responsibilities, shall,

> Cooperate in the promotion of effective modalities for the development, application and diffusion of, and take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of technologies, know-how, practices and processes pertinent to climate change, in particular to developing countries, including the formulation of policies and programmes for the effective transfer of environmentally sound technologies that are publicly owned or in the public domain and the creation of an enabling environment for the private sector, to promote and enhance the transfer of, and access to, environmentally sound technologies.[32]

Second, despite the fact that technology transfer is something for all Parties to engage in, it is with developing countries, and LDCs in particular, that the transfer of new technologies on terms which are, 'economically and socially beneficial'[33] is most clear. This need for new technologies for developing countries, was because it was made clear that the extent to which developing country Parties would effectively implement their commitments under the FCCC was directly linked to developed countries commitments under the FCCC related to, inter alia, transfer of technology.[34] Accordingly, the FCCC obliged all developed Parties to,

> Take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention. In this process, the developed country Parties shall support the development and enhancement of endogenous capacities and technologies of developing country Parties. Other Parties and organizations in a position to do so may also assist in facilitating the transfer of such technologies.[35]

[31] FCCC. Article 4 (1)(c).
[32] Kyoto Protocol. Article 10 (c).
[33] FCCC. Preamble. Paragraph 22 and FCCC. 4 (9). The importance of technology transfer to the least developed countries was reiterated in Decision 5/CP.7 Implementation of Article 4, paragraphs 8 and 9, of the Convention. Report of the Seventh COP to the FCCC. 32.
[34] FCCC. 4 (7).
[35] FCCC. Article 4.(5).

Finally, as a way to give impetus to the above objectives, the financial mechanism created under the FCCC, and the Kyoto Protocol,[36] has been directed to provide financial resources on a grant or concessional basis, for, the transfer of technology, as relating to agreed areas of FCCC objectives.[37] In 2001, when the SCCF was created, technology transfer was one of the areas singled out for coverage.[38] However, the financial support related to technology transfer for developing countries is limited to assessments, and support for measures and mechanisms to create 'enabling environments' conducive to technology transfer, and capacity building for investigating the area.[39] Thus, the basic consideration of the actual purchase of technology to help transfer it, is not directly addressed.[40] This conclusion was largely reiterated in 2003 when some of the finer details of the SCCF restricted financial assistance to LDCs on technology transfer issues to assessments, information provision, capacity building and enabling environments.[41]

Despite the above principles, and a special IPCC report on the transfer of technology,[42] progress in achieving concrete results has been slow, with the initial work of the Parties in this area being restricted to refining the operational modalities for the effective transfer of technology and information collection exercises.[43] For example, the Secretariat was first instructed to draw up a report, including an inventory and assessment of environmentally sound and economically viable technologies conducive to mitigating and adapting to climate change, which would include, 'an elaboration of the terms under which transfers of such technologies and know-how could take place'.[44] Support from the GEF was also directed to developing countries, to help them identify and report on their own technology needs.[45]

---

[36] Kyoto Protocol. Article 11. (2)(b).
[37] FCCC. Articles 4. (3) and 11.
[38] Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section I: Funding the Convention. I. Funding Under the Convention.
[39] Decision 4/CP.7. Development and transfer of technologies. Decision 5/CP.7 Implementation of Article 4, paragraphs 8 and 9, of the Convention. Report of the Seventh COP to the FCCC. 22, 32.
[40] Review Of The Implementation Of Commitments And Of Other Provisions Of The Convention Financial Mechanism Report Of The Global Environment Facility. FCCC/CP/2002/4. 14.
[41] Decision 5/CP 9. Further Guidance to an Entity Entrusted With the Operation of the Financial Mechanism of the Convention, for the Operation of the Special Climate Change Fund. Report of the Ninth COP to the FCCC. 11–12. Decision 6/CP.8. Additional guidance to an operating entity of the financial mechanism. 1 (c).
[42] IPCC. (1999). *Methodological and Technological Issues in Technology Transfer*. (Cambridge University Press, Cambridge).
[43] Decision 13/CP.1. Transfer of Technology. Paragraph 4.
[44] Decision 13/CP.1. Transfer of Technology. Paragraph 1.b. Decision 7/CP.2. Development and Transfer of Technologies. Paragraph 3 (c).
[45] Decision 9/CP.3. Development and transfer of technologies. Paragraph 1 (b). Report of

The reports from the developing countries on their technology needs in this area were later examined in specialist workshops that were supposed to create, 'a framework for meaningful and effective' transfer of technology as envisaged in the FCCC.[46] In the year 2000, this process evolved further with the formation of an Expert Group on Technology Transfer, which was tasked with identifying ways to facilitate and advance technology transfer.[47] In 2004, the Expert Group was requested to make recommendations for enhancing the implementation of the technology transfer obligations within the FCCC.[48]

The emerging conclusions from this (and other) work, was that the private sector has a role in technology transfer, which should be supported,[49] with facilitative tools such as the identification and removal of market imperfections,[50] including, strengthening environmental regulatory frameworks, enhancing legal systems, ensuring fair trade policies, utilizing tax preferences, protecting intellectual property rights and improving access to publicly funded technologies. Positive incentives, such as preferential government procurement and transparent and efficient approval procedures, as well as bilateral or multilateral joint research programmes, for technology transfer projects, were also encouraged.[51] These conclusions were all reiterated in 2004, along with the encouragement to the Secretariat to continue its work on a pilot project on networking between national and regional technology information centres, that would provide the Parties with a clear understanding on the technical feasibilities and cost implications of the strengthening of technology centres in developing countries.[52]

Finally, with regard to the private sector in this issue, it is notable that the flexible mechanisms of the Kyoto Protocol (Article 6, 12 and 17) may be where the real progress may be made in this area in the future. That is, by utilizing the flexible mechanisms, many of the current concerns about transferring valuable technology to developing countries, may be overcome. This may be especially so with the CDM, when private companies, which

---

the Third COP to the FCCC. 39. Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section III. Development and Transfer of Technologies. Paragraph 2. Annex to Decision 4/CP.4.

[46] Decision 9/CP.5 Development and transfer of technologies. Paragraphs 2 and 5. Decision 4/CP.4. Development and transfer of technologies.

[47] Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section III. Development and Transfer of Technologies. Paragraph 2. Decision 10/CP.8. Development and transfer of technologies.

[48] Decision 6/CP.10. Development and Transfer of Technologies. Paragraph 2.

[49] Decision 4/CP.4. Development and transfer of technologies. Paragraph 7 (d).

[50] Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section. Matters Relating Article 3.14 of the Kyoto Protocol.

[51] Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. See the Annex to the Decision. Paragraph 14(a)

[52] Decision 6/CP.10. Development and Transfer of Technologies. Paragraph 4.

have a vastly superior investment potential as opposed to official state owned projects, gain access to developing countries for greenhouse gas reduction purposes and bring all of their advanced climate friendly technologies with them, thus avoiding ownership and transfer questions.[53]

[53] Forsyth, T. (1999). *International Investment in Climate Change: Energy Technologies for Developing Countries*. (Earthscan, London). Forsyth, T. (1998). 'Technology Transfer and the Climate Change Debate.' *Environment.* Nov 16–42.

XVII. FLEXIBILITY MECHANISMS

1. Joint Implementation

A. The Air Pollution Regime

Within the air pollution regime, one possibility by which countries in economic transition may be assisted in reducing their emissions, is through Joint Implementation (JI). The possibility of countries working together to achieve reductions was already an established through bilateral assistance, before it was recognized in the LRTAP protocols. However, JI is fundamentally different to bilateral assistance, as effectively two nations claim the reduced emissions, to further their own implementation objectives, as opposed to bilateral assistance where only one country can 'claim' the amount of pollutants reduced. The possibilities of JI were noted in the 1991,[1] 1994[2] and 1999 protocols.[3] The rules for JI (for SO_2 reductions) were set out in 1997 by the Executive Body. JI was defined as, 'an agreement between two or more Parties to co-operate to implement their emission reduction obligations'. The specific agreements must reduce SO_2 impacts within the EMEP area, and not detrimentally impact upon any third Party, beyond the existing emissions levels for the third Party, in the process.[4] All JI proposals have to be adopted by consensus of the Parties present at the Executive Body.[5]

B. The Ozone Regime

As soon as negotiations for a convention to control ODS began, questions over the exact mechanisms by which to achieve any possible reduction

---

[1] 1991 VOC Protocol. Article 4. Note the different terminology.
[2] 1994 Protocol on Further Reductions From Sulphur Emissions. Article 2. (7). 4 *YBIEL*. (1993). 136–7.
[3] Article 4. (1)(d).
[4] As a minimum, each proposal needs, specification of each reduction obligation (expressed as kilotons of SO_2), 'which one Party will implement through reductions carried out by another Party'. In addition, it is necessary to specify the emission reduction (expressed as kilotons of SO_2) which the other Party will undertake in addition to its emissions reduction obligation in accordance with the Protocol & the duration of the Agreement. Contain an assessment of the deposition impact of the agreement, detailing the changes of total national depositions, using the EMEP ecosystem protection schemes.
[5] Annex I. Decision 1997/1 on Rules and Conditions for Joint Implementation Under the Oslo Protocol. Report of the 15th Session of the Executive Body.

targets arose. This interest coincided with the sudden growth in 'flexible market options' being developed for environmental purposes, in the United States in the early 1980s. Accordingly, the United States suggested that 'market mechanisms' may also have some utility in this area.[6] As such, during the Second Revised Draft, it was suggested that any ODS reductions could be made, 'either individually or jointly'.[7] However, this proposal did not appear in the Vienna Convention, as no mandated reduction targets were set. With the Montreal Protocol, the possibility of limited transfers between countries which produced low levels of ODS, so as to achieve various regime objectives, was agreed in principle.[8] This policy was also later formalized in 1997, following an earlier authorized transfer between New Zealand and Australia, to allow for, 'a Party, in an emergency situation, to transfer some or all of its authorized levels of CFCs for essential uses in MDIs to another Party', provided that the transfer does not exceed the Party's individual allowance, does not create a net increase in ODS consumption or production as a result of the transfer, and the transfer is reported by both Parties.[9]

The other area in which joint implementation, with the objective of making collective overall reductions in ODS has been recognized was in Article 2 (8) of the Montreal Protocol. This Article, which has been subsequently updated to cover all ODS stipulated,

> (a) Any Parties which are Member States of a regional economic integration organization as defined in Article 1 (6) of the Convention may agree that they shall jointly fulfill their obligations respecting consumption under this Article and Articles 2A to 2I provided that their total combined calculated level of consumption does not exceed the levels required by this Article and Articles 2A to 2I.
> (b) The Parties to any such agreement shall inform the Secretariat of the terms of the agreement before the date of the reduction in consumption with which the agreement is concerned.
> (c) Such agreement will become operative only if all Member States of the regional economic integration organization and the organization concerned are Parties to the Protocol and have notified the Secretariat of their manner of implementation.

[6] This focused upon the possibility of auctioning the rights to produce the limited numbers of CFC production in the USA. Joyce, C. (1980). 'America Clamps Down on Freons'. *New Scientist.* Oct 16. 142. Anon. (1988). 'US Clamps Down on CFCs'. *New Scientist.* Aug 11. 23.

[7] Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1983). Second Revised Draft, With Additional Commentary, Prepared By UNEP. UNEP/WG.94/3/ July 30. Page 5.

[8] See Article 2(5) of the Montreal Protocol, and 2(5) bis. Annex III. Report of the Fourth MOP to the Montreal Protocol. 36.

[9] Decision IX/20. Transfer of Essential Use Authorizations for CFCs for MDIs. Report of the Ninth MOP Of the Montreal Protocol. 36–37.

The importance of this article was that it allowed the European Union to be treated as a single unit for the purposes of consumption, but not production, of ODS. This concession was only given with the assurance that all members of the European Union became Parties to the Protocol. The exact meanings of this section became clear in 1988 and 1989, when various countries within the European Union argued that they could make their reductions within a joint bubble. However, this proposal was not accepted within the European Union or the ozone regime. Accordingly, no member may, individually, have higher ODS consumption figures than those allocated by the regime, even if these could be submerged within a larger European Union generic total of ODS controls. Even the reporting requirements for individual countries, which specify the production and consumption of ODS, must be reported individually, and cannot be submerged in generic European Union totals.[10]

C. The Climate Regime

The flexibility mechanisms within the climate regime,[11] and JI in particular, have generated a large amount of scholarly interest.[12] This interest has been evident since the outset of climate negotiations, when a number of countries, particularly OECD countries, as well as some developing countries such as Mexico, argued that JI should be part of the climate regime. This was important to them, as they sought to achieve JI reduction goals, in which Emissions Reduction Units (ERUs) made in one country, could ultimately be claimed by another country.[13] This was especially so when the cost differences for reducing greenhouse gas emissions in developing countries (starting from 20 cents per tonne), as opposed to developed countries (up to 50 (USD) per tonne), became apparent. In addition, from the perspective of the science of the climate change debate, it makes little difference where the reductions of greenhouse gas emissions are geographically based. Thus, it was proposed that a developed country, should be able to claim a reduction in greenhouse gas emissions in a developing country (if the developed country in responsible for this reduction), and

---

[10] Benedict, R. (1991). *Ozone Diplomacy*. (Harvard University Press, Cambridge). 96–97, 105–106, 113, 126–127.

[11] Jackson, T. (2001). *Flexibility in Climate Policy: Making the Kyoto Mechanisms Work*. (Earthscan, London).

[12] See Kuik, O. et al. (1994). *Joint Implementation to Curb Climate Change*. (Kluwer, the Netherlands). Jepma, C. (1995). *The Feasibility of Joint Implementation.* (Kluwer, the Netherlands). Ridley, M. (1998). *Lowering the Cost of Emission Reduction: Joint Implementation in the Framework Convention on Climate Change*. (Kluwer, the Netherlands).

[13] Editor. (1991). 'Double Standards on Carbon Emissions'. *New Scientist.* Sep 28. 11. 2 *YBIEL.* (1991). 114. 4. *YBIEL.* (1993). 143.

then claim all or part of this reduction, as part of their own greenhouse gas controls, as a form of JI.[14]

The FCCC endorsed this argument, when in setting the aim for industrialized countries of stabilizing their greenhouse emissions, stated that, 'these Parties may implement such policies and measures jointly with other Parties and may assist other Parties in contributing to the achievement of the objective of the Convention and, in particular, that of this subparagraph'.[15] In addition, the FCCC recognized that, 'efforts to address climate change may be carried out co-operatively by the Parties', including possibly in a joint fashion.[16] Although such broad possibilities for JI were recorded, and the signatories to the FCCC were obliged to report about their proposed policies on JI,[17] the creation of concrete frameworks for JI and its final go-ahead were deferred until later date.[18]

The deferral was necessary as many of the key elements of JI were not resolved at the time the FCCC was concluded. The unconcluded areas included amounts of emissions that could be claimed within a JI regime; whether one country could seek to meet all of their greenhouse targets through JI; the role of developing countries; and the role of JI in overall sustainable development strategies. Broadly, the United States sought an unrestricted JI regime, by which countries could meet their full FCCC obligations through greenhouse gas controls in any country they wanted. Conversely, the developing world wanted JI restricted to deals between developed countries, with clear limits on how much could be claimed and when.[19] Finally, the baseline problem needed specific attention. The baseline problem is that before JI projects can be conducted, it must be shown that the claimed greenhouse gas emission reduction represents a true improvement over what reductions may have happened, irrespective of JI. This problem is complicated by an in-built incentive for countries to overestimate the benefits of JI, as they can claim greater reductions. To avoid

---

[14] 2 *YBIEL.* (1991). 113. Chandler, W. (1990). 'Energy for the Soviet Union, Eastern Europe and China'. *Scientific American.* September. 75. Pearce, F. (1994). 'All Gas And Guesswork'. *New Scientist.* July 30. 14–15.

[15] FCCC. Article 4 (2) (a).

[16] FCCC. Article 3 (3). Article 12. 8. Provided that such a communication includes information on the fulfillment by each of these Parties to its individual obligations under the Convention FCCC.

[17] FCCC. Article 4.2. (b) & 12. 8.

[18] FCCC. Article 4.2. (d)

[19] Oberthur, S. (1995). 'The First Conference of the Parties'. *Environmental Policy and the Law.* 25 (4): 144. Mintzer, I. (1994). 'JI Survey'. *Climate Change Bulletin.* 4 (3): 3–5. Pearce, F. (1994). 'Frankenstein Syndrome Hits Climate Treaty'. *New Scientist.* June 11. 5. Bush, E. (1997). 'Joint Implementation and the Ultimate Objective of the UNFCCC'. *Global Environmental Change.* 7 (3): 265–283. 3 *YBIEL.* (1992). 229. 4. *YBIEL.* (1993). 143. 5 *YBIEL.* (1994). 166–167. 6 *YBIEL.* (1995). 224.

this problem, it becomes necessary to define the emission that would have occurred without the JI. This definition of the projected non-JI emission level is known as the baseline.[20]

Against such a background it was agreed to establish an initial ('pilot phase') regime (which has been repeatedly extended from 1995 post 2000),[21] for Activities Jointly Implemented (AJI) in which developed and developing countries could work together on a voluntary basis.[22] Although the debate on final modalities was ongoing, a number of clear parameters were set. First, it was agreed that JI between developed and developing countries would not be seen as fulfillment of the initial commitments for developed countries under the FCCC. Thus, 'no credits shall accrue to any Party as a result of greenhouse gas emissions reduced or sequestered during the pilot phase from activities jointly implemented'.[23] Second, AJI reductions were supplemental, and could only be treated as a subsidiary means of achieving the objectives of the FCCC. Thus, each developed country had to make their primary greenhouse gas emission reductions domestically. Third, in no way could AJI be interpreted as changing the commitments of each Party under the Convention.[24] With these ground-rules established, it was decided that AJI could be comprehensive in covering all greenhouse gases (and not just CO_2) and their sources (including sequestration); that all projects required governmental approval and that the financial costs should be additional to the other commitments of the developed Parties.[25] Finally, it was agreed that the JI activities should achieve, 'real, measurable and long-term environmental benefits related to the mitigation of climate change that would not have occurred in the absence of such activities'.[26]

Two years later, the Kyoto Protocol reiterated the FCCC principle, that developed countries could meet their greenhouse targets individually or

---

[20] Michaelowa, A. (1998). 'Joint Implementation: The Baseline Problem'. *Global Environmental Change*. 8 (1): 81–92. Ott, H. (1998). 'Operationalising Joint Implementation'. *Global Environmental Change*. 8 (1): 11–47. Usher, P. (1996). 'A Frank Exchange on AIJ'. *Climate Change Bulletin*. 13 (4): 3–4. Pearce, F. (1997). 'US Plan Complicates The Climate Equation'. *New Scientist*. Feb 1. 8.

[21] Decision 10/CP.10. Continuation of Activities Implemented Jointly Under the Pilot Phase. Paragraph 1. Decision 14/CP.5. Mechanisms pursuant to Articles 6, 12 and 17 of the Kyoto Protocol. Decision 5/CP.1. Activities Jointly Implemented Under the Pilot Phase. Para 3. Decision 8/CP.2. Activities Implemented Jointly Under the Pilot Phase. Para 2.

[22] Decision 5/CP.1. Activities Jointly Implemented Under the Pilot Phase. Paragraph 1 (a).

[23] Decision 5/CP.1. Activities Jointly Implemented Under the Pilot Phase. Paragraph 1 (f). To further this, the JI was to be reported in a transparent, well-defined and credible manner, and listed as distinct from the national communications of the Parties. See paragraphs 2 a & b. 7 *YBIEL*. (1996). 132.

[24] Decision 5/CP.1. Activities Jointly Implemented Under the Pilot Phase. Paragraph d.

[25] Decision 5/CP.1. Activities Jointly Implemented Under the Pilot Phase. Paragraph 1 (b), (c) and (f).

[26] Decision 5/CP.1. Activities Jointly Implemented Under the Pilot Phase. Paragraph 1 (d).

jointly.[27] The Kyoto Protocol then formalized the key rules of JI, such as the necessity for JI projects to be government approved, and the permissibility of a comprehensive, but supplementary approach, producing real additional greenhouse gas emission reductions.[28] 'Supplementary' was later defined as meaning, 'supplemental to domestic action and that domestic action shall thus constitute a significant element of the effort made by each Party included in Annex I to meet its . . . commitments'.[29] Despite this wording, attempts to set a cap on the amount of emission reductions that may be claimed from one country and transferred to another, have failed.[30] The Kyoto Protocol added that, ERUs must be in congruence with the agreed methodologies and reporting requirements.[31] These reporting requirements were concluded in 2004.[32] Finally, it was agreed in the Protocol that JI was restricted to deals between developed countries. Thus,

> For the purpose of meeting its commitments under Article 3, any Party included in Annex I [of the FCCC] may transfer to, or acquire from, any other such Party emission reduction units resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks.[33]

Guidelines relating to verification were initially deferred until a future date.[34] In the interim it was agreed that if a, 'question of implementation' was raised with regard to the implementation of obligations under the Protocol, then that ERU, 'may not be used by a Party to meet its commitments . . . until any issue of compliance is resolved'.[35] It was later added that only Parties that had accepted the Kyoto compliance procedures, would be entitled to transfer or acquire credits generated by the use of the flexibility mechanisms.[36]

---

[27] Kyoto Protocol. Article 3. (1), (10)&(11).
[28] Kyoto Protocol. Article 6 (1)(a)–(d).
[29] Decision 15/CP.7. Principles, Nature and Scope of the Mechanisms Pursuant to Articles 6, 12 and 17 of the Kyoto Protocol. Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section VI. Mechanisms Pursuant To Articles 6, 12 And 17 of the Kyoto Protocol.
[30] 12 YBIEL. (2001): 214.
[31] Kyoto Protocol. Article 6 (1)(c).
[32] Decision 17/CP.10. Standard Electronic Format For Reporting Kyoto Protocol Units. This decision was linked to draft decision -/CMP.1. Standard Electronic Format for Reporting Kyoto Protocol Units, which created a Standard Electronic Format (SEF) with six tables, detailing the required information. Also, Decision 13/CP.10. Incorporation of the Modalities and Procedures for Afforestation and Reforestation Project Activities Under the Clean Development Mechanism Into the Guidelines Under Articles 7 and 8 of the Kyoto Protocol. Annex I. Supplementary Information under Article 7 (1).
[33] Kyoto Protocol. Article 6 (1).
[34] Kyoto Protocol. Preamble. Section 5 (c), Article 6 (2).
[35] Kyoto Protocol. Article 6 (4).
[36] Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section VI. Mechanisms Pursuant To Articles 6, 12 And 17 of the Kyoto Protocol.

Following the Kyoto Protocol, a full review of the AJI was undertaken, and concluded in 1999.[37] The interim result of the review, was enhanced reporting requirements for activities jointly implemented (which have been continually updated)[38] and an increased awareness of the importance of verification of AJI activities.[39] The substantive result of the review was the Guidelines for the Implementation of Article 6 agreed in 2001.[40] The Guidelines established an, 'Article 6 Supervisory Committee' to supervise, inter alia, the verification of ERUs generated by Article 6 projects.[41] Finally, if a Party met certain criteria,[42] then ERUs, could begin accumulating from the year 2000 but could only be issued for a crediting period starting after the end of 2007.

The key points for the verification procedure under Article 6 of the Supervisory Committee is that all project participants must submit to an accredited Independent Entity a project design document, approved by the governments involved, that contains information,[43] confirmation that the reductions are additional to any that would otherwise occur and that appropriate baselines, as specified in a dedicated Appendix,[44] and suitable

[37] Decision 6/CP.4. Activities implemented jointly under the pilot phase. Decision 7/CP.4. Work programme on mechanisms of the Kyoto Protocol. Report of the Fourth COP To the FCCC. 2, 22.

[38] Decision 10/CP.3. Activities implemented jointly under the pilot phase. Decision 14/CP.8. Activities implemented jointly under the pilot phase. Decision 14/CP.5. Mechanisms pursuant to Articles 6, 12 and 17 of the Kyoto Protocol. Decision 20/CP.8. Revised uniform reporting format for activities implemented jointly under the pilot phase.

[39] Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section VI. Mechanisms Pursuant To Articles 6, 12 And 17 of the Kyoto Protocol: Article 6. Decision 8/CP.7. Activities implemented jointly under the pilot phase. The G8 suggested in 1998, that: "we aim to draw up rules and principles that will ensure an enforceable, accountable, verifiable, open and transparent trading system and an effective compliance regime." G8 Summit Communique. (Birmingham). Available from http://www.g7.utoronto.ca/g7/summit/1998birmingham/finalcom.htm Paragraph 11.

[40] Decision 16/CP.7. Guidelines for the implementation of Article 6 of the Kyoto Protocol.. Report of the 7th COP to the FCCC. 6.

[41] Decision 16/CP.7. Guidelines for the implementation of Article 6 of the Kyoto Protocol. Annex: Guidelines for the implementation of Article 6 of the Kyoto Protocol A. Definitions. Section C. Supervisory Committee. The panel, made up of 10 members based on the FCCC composition to secure geographical and economic equity, (paragraphs 4–19, also has the weighted voting and secure majority requirements (paragraph 14 & 16) of the FCCC.

[42] Decision 16/CP.7. Ibid. Annex: Guidelines. D. Participation requirements. That the Party to the Kyoto Protocol, (which is ultimately responsible for all JI operations) has calculated and recorded all of its ERUs correctly, that it has met all of its reporting requirements, that the ERUs are in accordance with their national inventory, and that a focal point for approving projects and national guidelines and procedures for JI are established. Finally, there must be no compliance issues.

[43] And generally expected principles of good corporate character and full knowledge of the Convention and the Protocol, Decision 16/CP.7. Ibid. Annex: Guidelines. E. Verification procedure under the Article 6 supervisory committee. Appendix A.

[44] Decision 16/CP.7. Ibid. Annex: Guidelines. E. Verification procedure under the Article 6

monitoring is achieved. If a dispute arises with the review by the Independent Entity, then the matter is referred to the Supervisory Committee, which shall make a final decision on the matter, and may effectively cancel JI projects if necessary.[45]

Despite the apparent clarity of these Guidelines, debate over what type of measures may be claimed under JI has been ongoing. The largest debate, relating to the utilization of nuclear power was settled in 2001, when the Guidelines, began by reminding developed countries that they were to refrain from using ERUs generated from nuclear facilities to meet their greenhouse reduction commitments in a JI context.[46] The second debate arose in 2002 when Canada expressed its desire to claim credits for 'cleaner energy exports' for exporting natural gas and hydroelectric power to the United States, which replaced American coal production, and thus lowered American greenhouse gas emissions. However, this proposal received little support from the COP, due to a believe that Canada was reopening the understandings struck in 2001 when the Guidelines were concluded, and also, because if allowed, other countries (such as Russia) may seek to lodge similar requests for their export of natural gas.[47]

2. Bubbling

One of the variations on JI is what is known as 'Bubbling'. Bubbling, or bubbles are when a collective target is given for a group of countries. Bubbles are slightly different to JI, in that with bubbles, a joint target is binding on the countries that share that target. Conversely, JI is not tied to a joint shared sovereign reduction target, but rather, a percentage target with some shared project which makes up part of the respective overall

supervisory committee. Appendix B: Criteria for Baseline Setting. The basic considerations are the importance of transparency (from reporting to methodological issues), are project-specific basis and/or using a multi-project emission factor; take into account relevant national and/or sectoral policies and circumstances, such as sectoral reform initiatives, local fuel availability, power sector expansion plans, and the economic situation in the project sector; are in such a way that ERUs cannot be earned for decreases in activity levels outside the project activity or due to force majeure; and take into account of uncertainties and using conservative assumptions.

45 Decision 16/CP.7. Ibid. Annex: Guidelines. E. Verification procedure under the Article 6 supervisory committee. See especially paragraphs 34–45.

46 Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section VI. Mechanisms Pursuant To Articles 6 of the Kyoto Protocol.

47 Pearce, F. (2002). 'Canada Plays Dirty'. *New Scientist.* May 18. 16. Anon. (2002). 'In Preparation for COP 8'. *Environmental Policy and the Law.* 32(5): 203. FCCC. Provisional Agenda to the 8th COP. FCCC/CP/2002/1/Add.1. 12 August 2002. Paragraph 70. Note, Canada claimed the export under Article 7(4).

totals. The European Union were the prime movers in seeking to achieve their own bubble, broadly under a 'joint' response.[48] The European Union's bubble for the first commitment period was finalized in 2002.[49]

When the bubble approach was eventually accepted at the first COP in 1995, it was also agreed that all areas outside of Europe should also be able to make regional bubbles.[50] Thus, if the Secretariat is notified, specific reporting requirements are met,[51] and the bubble is for the entire commitment period, then,

> Any Parties included in Annex I that have reached an agreement to fulfill their commitments under Article 3 jointly, shall be deemed to have met those commitments provided that their total combined aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases listed in Annex A do not exceed their assigned amounts calculated pursuant to their quantified emission limitation and reduction commitments inscribed in Annex B and in accordance with the provisions of Article 3. The respective emission level allocated to each of the Parties to the agreement shall be set out in that agreement.[52]

There are three possible limitations in this area. First, 'any alteration in the composition of the organization after adoption of this Protocol shall not affect existing commitments under this Protocol'.[53] Second, 'in the event of failure by the Parties to such an agreement to achieve their total combined level of emission reductions, each Party to that agreement shall be responsible for its own level of emissions set out in the agreement'.[54] Finally,

> If Parties acting jointly do so in the framework of, and together with, a regional economic integration organization which is itself a Party to this

[48] Europe argued for a joint approach, but only for Europe, in which they could be treated as a single unit. This joint approach allowed some countries to increase emissions (such as Spain, Portugal and Ireland) whereas others (such as Germany) made greater offsetting reductions. However, the plan foundered when the 12 could not agree on a workable formula for burden sharing. It was especially hard to accommodate Spain's insistence that it needed to increase its emissions by 25%. In the end, the UK broke ranks and announced it would ratify the Convention alone. However, within two years the EU had worked out their joint implementation scheme (including Spain increasing its emissions by 25%). Pearce, F. (1995). 'The Costa del Carbon Dioxide'. *New Scientist.* May 6. 14. MacKenzie, D. (1993). 'Germany Unveils Plans To Cut Greenhouse Gases'. *New Scientist.* Aug 28. 6. MacKenzie, D. (1993). 'Last Try for Europe-Wide Climate Agreement'. *New Scientist.* Dec 18. 8.

[49] See Agreement Between The European Union And Its Member States. Under Article 4 Of The Kyoto Protocol. Note By The Secretariat. FCCC/COP/2002/2.

[50] Pearce, F. (1997). 'Rich Nations Squabble In the Greenhouse'. *New Scientist.* March 15. 10. Pearce, F. (1997). 'Countdown to Chaos'. *New Scientist.* Nov 29. 22.

[51] COP 7. Decision 19/CP.7. Modalities for the accounting of assigned amounts under Article 7, paragraph 4, of the Kyoto Protocol. Section 6. Annex.

[52] Kyoto Protocol. Article 4(1).

[53] Kyoto Protocol. Article 4(4).

[54] Kyoto Protocol. Article 4(5).

> Protocol, each member State of that regional economic integration organization individually, and together with the regional economic integration organization acting in accordance with Article 24, shall, in the event of failure to achieve the total combined level of emission reductions, be responsible for its level of emissions as notified in accordance with this Article.[55]

Therefore, if the collective bubble is not met, then individual countries may find themselves in non-compliance due to failures caused by other countries.[56]

3. The Clean Development Mechanism

In 1996 the United States and a number of other developed countries began arguing for a new type of flexibility regime that, unlike JI, allowed implementation agreements jointly between developed and developing countries.[57] This idea, which evolved into the Clean Development Mechanism (CDM) allowed for certified emission reductions from one Party to be acquired from another Party and counted towards their respective totals, found its way into the Protocol.[58] The objective of the CDM, as specified in Article 12 of the Kyoto Protocol is to assist,

> Parties not included in Annex I in achieving sustainable development and in contributing to the ultimate objective of the Convention, and to assist Parties included in Annex I in achieving compliance with their quantified emission limitation and reduction commitments under Article 3.[59]

Thus, Non-Annex I countries obtain the benefit of the projects, while,

> Parties included in Annex I may use the certified emission reductions [for the first commitment period][60] accruing from such project activities [in non-Annex I countries] to contribute to compliance with part of their quantified emission limitation and reduction commitments under Article 3.[61]

All of the savings have to be certified by a designated authority, on the basis of many of the same concerns that are associated with JI. Accordingly,

---

[55] Kyoto Protocol. Article 4(6).
[56] Michaelowa, A. (1998). 'Joint Implementation: The Baseline Problem'. *Global Environmental Change*. 8 (1): 81–92.
[57] Oberthur, S. (1996). 'The Second Conference of the Parties' *Environmental Policy and the Law*. 26 (5): 195–201. 8 *YBIEL*. (1997). 181. In 1998, it was projected that the CDM could eventually generate upto $17 billion per year. Pearce, F. (1998). 'Green Futures'. *New Scientist*. Nov 16. 18.
[58] Kyoto Protocol. Article 3. (12).
[59] Kyoto Protocol. Article 12. (2).
[60] Kyoto Protocol. Article 12. (10).
[61] Kyoto Protocol. Article 12. (3) (b).

the reductions in greenhouse gas emissions must be real, measurable and additional to any that would occur in the absence of the CDM activity.[62] Although the modalities of the CDM were to be worked out at a future period,[63] it was agreed, in a clear offering to developing countries, that,

> A share of the proceeds from certified project activities is used to cover administrative expenses as well as to assist developing country Parties that are particularly vulnerable to the adverse effects of climate change to meet the costs of adaptation.[64]

Attempts to establish the modalities ongoing during the late 1990s, and were subject to prolonged debate.[65] The basic problem was that in addition to debates about additionality, baselines and overall governance that were applicable to the other flexibility regimes, since developing countries were to be included, much greater detail in the types of projects that could be utilized between countries (from nuclear power, to large scale hydro dams, clean coal projects, energy efficiency, renewable technologies and even debt relief) had to be resolved.[66]

Despite these ongoing debates, part of the answer to these questions could be found in what Article 12 omitted. That is, the CDM was different to the JI in that, the Kyoto Protocol did not contain the limitations with Articles 6 or 17 that the benefits were to be, 'supplementary to domestic actions'.[67] However, this initial omission was later rectified by subsequent COPs which decided that the use of this CDM, shall also, 'be supplemental to domestic action and that domestic action shall thus constitute a significant element of the effort' made by each developed Party to meet its commitments.[68]

---

[62] Kyoto Protocol. Article 12. (5) (a)–(c).
[63] Kyoto Protocol. Article 12. (7).
[64] Kyoto Protocol. Article 12 (8).
[65] Decision 7/CP.4. Work programme on mechanisms of the Kyoto Protocol. Report of the 4th COP to the FCCC. 22. Decision 14/CP.5. Mechanisms pursuant to Articles 6, 12 and 17 of the Kyoto Protocol.
[66] Banuri, T. et al. (2000). *Climate Change and Clean Development Mechanism Issues*. (UNDP, NY). 25–33. OECD. (2000). *Emission Baselines: Estimating the Unknown*. (OECD, Paris). 10 *YBIEL*. (1999). 229. Pearce, F. (1999). 'Dirty Dealing'. *New Scientist*. Nov 13. 12. Anon. (2000). 'Disappointment At Meagre Progress'. *Environmental Policy and the Law*. 30(5): 217. Anon. (1999). 'Climate Change: Plan of Action Adopted'. *Environmental Policy and the Law*. 29 (1): 7. 10 *YBIEL*. (1999). 229. Lanchbery, J. (1998). 'Expectations For the Climate Talks In Buenos Aires'. *Environment*. 40 (8): 18, 19. Haites, E. (2000). 'The Clean Development Mechanism: Proposals For Its Operation and Governance'. *Global Environmental Change*. 10: 27–45.
[67] Michaelowa, A. (1998). 'Joint Implementation: The Baseline Problem'. *Global Environmental Change*. 8 (1): 81–92.
[68] Decision 15/CP.7. Principles, Nature and Scope of the Mechanisms Pursuant to Articles 6, 12 and 17 of the Kyoto Protocol. Decision 5/CP.6. Implementation of the Buenos

Many of the issues that remained unsolved with the CDM following the Kyoto Protocol were resolved in the following years. First, the modalities and procedures for the CDM were concluded.[69] These modalities specified that a CDM Executive Board[70] (whose Rules of Procedure were settled in 2003 and refined in 2004)[71] would accredit operational entities,[72] and the first four entities were accredited in 2004.[73] The CDM Executive also designates[74] or reviews[75] CDM applications as necessary, and approves CERs to be used within the CDM mechanism. The necessary modalities relating to the CDM national registries, and specifically their international transaction logs, were settled in 2004.[76]

Aires Plan of Action. Annex. Section VI. Mechanisms Pursuant To Articles 6, 12 And 17 of the Kyoto Protocol.

[69] Decision 17/CP.7. Modalities And Procedures For A Clean Development Mechanism As Defined In Article 12 of the Kyoto Protocol. Report of the 7th COP to the FCCC. 20. Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section VI. Mechanisms Pursuant To Articles 6, 12 And 17 of the Kyoto Protocol: Article 12.

[70] The executive board, made up with the usual FCCC equitable considerations shall supervise the CDM, under the authority and guidance of the COP/MOP and shall with regard to CDM, inter alia, make recommendations; approve new methodologies; review provisions; be responsible for the accreditation of operational entities (including re-accreditation, suspension and withdrawal of accreditation); operationalization of accreditation procedures and standards. Make as much information on CDM publicly available as possible, including a CDM registry. Decision 17/CP.7. Modalities And Procedures For A Clean Development Mechanism As Defined In Article 12 of the Kyoto Protocol. COP 7. Annex. Modalities and Procedures for a Clean Development Mechanism. C. Executive board. Appendix D; CDM Registry Requirements.

[71] Decision 18/CP.9. Guidance to the Executive Board of the Clean Development Mechanism. Annex 1. First Report Of The Executive Board Of The Clean Development Mechanism (2001, 2002). FCCC/CP/2002/3. Add 1. Annex 1. Decision 12/CP.10. Guidance to the Clean Development Mechanism. Annex II of the Draft Decision.

[72] Decision 17/CP.7. Modalities And Procedures For A CDM. Annex. Ibid. D. Accreditation and designation of operational entities. Note, in addition to making recommendations, reviewing compliance, and holding the ability to make spot-checks of CDM activities, the Executive Board may recommend suspension of an operational entity if compliance problems avail. With CDM projects that are already registered, suspension shall only take place if: 'significant deficiencies' are identified. For considerations on the specific entities, see Appendix A of the Decision, Standards for the Accreditation of Operational Entities.

[73] Decision 12/CP.10. Guidance Relating to the Clean Development Mechanism. Paragraph 5.

[74] Decision 17/CP.7. Modalities And Procedures For A Clean Development Mechanism. Ibid. Annex. E. Designated operational entities. For the particulars on project design. See Appendix B of the Annex.

[75] Decision 18/CP.9. Guidance to the Executive Board of the Clean Development Mechanism. Annex II. The procedures for review of the CDM mechanism, which are limited to issues of fraud, malfeasance or incompetence, were refined in 2004. See Annex II of the Draft Decision attached to Decision 12/CP.10. Guidance Relating to the Clean Development Mechanism. The Request, Scope, Modalities, Review, and Review Decision options are all clearly set out.

[76] Decision 16/CP.10. Issues Relating to Registry Systems Under Article 7, paragraph 4 of the Kyoto Protocol.

It was also agreed, on a provisional basis, that the following small-scale CDMs project activities would be eligible for inclusion,

(i) Renewable energy project activities with a maximum output capacity equivalent of up to 15 megawatts (or an appropriate equivalent).
(ii) Energy efficiency improvement project activities which reduce energy consumption, on the supply and/or demand side, by up to the equivalent of 15 gigawatt/hours per year.
(iii) Other project activities that both reduce anthropogenic emissions by sources and directly emit less than 15 kilo-tonnes of carbon dioxide equivalent annually.

With regard to the eligibility of LULUCF projects for the first commitment period, it was originally decided that claimable projects would be limited to afforestation and reforestation, and that the amount possible to claim under this area should not exceed 1 percent of the base year emissions of that Party, multiplied by five. In 2003, specific modalities and procedures for small scale (less than 8 kilotonnes of CO_2 per year) afforestation and reforestation projects under the CDM were agreed for the first commitment period. These modalities set out accreditation and participation requirements, requirements for validation, certification, registration and reporting, as well as detailed information on methodologies, baselines and monitoring.[77] In an effort to reduce transaction costs in this area, simplified modalities and procedures for small scale afforestation and reforestation projects under the CDM were agreed in 2004,[78] in addition to a number of other modalities and procedures for the full incorporation of the LULUCF activities into the CDM.[79]

With regard to the question of utilizing nuclear power within the CDM, it was agreed at the sixth COP after strong debate,[80] that although each Party should determine which activities help it achieve its own sustainable development, developed countries were, 'to refrain from using certified emission reductions generated from nuclear facilities to meet their commitments

[77] Decision 19/CP.9. Modalities and Procedures for Afforestation and Reforestation Project Activities Under the CDM in the First Commitment Period of the Kyoto Protocol. Report of the 9th COP to the FCCC. 13–32.

[78] Decision 14/CP.10. Simplified Modalities and Procedures for Small Scale Afforestation and Deforestation Under the CDM in the First Commitment Period of the Kyoto Protocol.

[79] Decision 13/CP.10. Incorporation of the Modalities and Procedures for Afforestation and Reforestation Project Activities Under the Clean Development Mechanism Into the Guidelines Under Articles 7 and 8 of the Kyoto Protocol.

[80] China, India, Canada, France, Britain and the US wanted nuclear power included in the CDM, whereas Germany, Austria, Sweden, Denmark, Saudi Arabia and Indonesia did not. See Edwards, R. (2000). 'Power Struggle.' *New Scientist.* May 13. 14. Editor. (2000). 'Groundhog Day.' *New Scientist.* May 13. 3. Anon. (2000). 'Inside the Greenhouse Debate.' *IAEA Bulletin.* 42(2): 2–6.

under Article 3.1'.[81] Although the explicit linking of nuclear power restrictions to the CDM (or JI) was not carried over to the 2001 Guidelines, the fact that the CDM was restricted to small scale operations, effectively ruled it out of contention.[82]

The verification procedures of the CDM are very similar to those of the JI regime.[83] Validation of CDM operations require independent evaluations, which monitor and verify CDM projects for the Executive Board in a transparent way, and demonstrate that the project creates real and verifiable benefits in terms of greenhouse emission reductions, and that the project is in accordance with baseline considerations and is methodologically robust. The project should also take into account relevant national and/or sectoral policies and circumstances, such as sectoral reform initiatives, local fuel availability, power sector expansion plans, and the economic situation in the project sector. For evaluative comparison purposes, historical emissions and emissions from the most economically attractive type of technology are also considered, as are average emission scenarios from other successful projects undertaken in the previous five years, in similar (social, economic, environmental and technological) circumstances.[84]

Finally, it was agreed that 2 percent of the value of certified emission reductions issued for a CDM project activity would be directed to assist developing country Parties that were particularly vulnerable to the adverse effects of climate change to meet the costs of adaptation. The only exception to this contribution was if the CDM was in a LDC.[85]

By 2002, the CDM was operational and reporting to the FCCC COPs.[86] By 2003 the CDM Executive that it had 36 proposals before it, of which

[81] Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section VI. Mechanisms Pursuant To Articles 6, 12 And 17 of the Kyoto Protocol: Article 12.

[82] 12 *YBIEL.* (2001): 214.

[83] Decision 17/CP.7. Modalities And Procedures For A Clean Development Mechanism. Ibid. Annex. F. Participation requirements. These include, that participation is voluntary; a national authority for the CDM is designated; they are Parties to the Kyoto Protocol, amounts are assigned correctly, national inventories are in place and up to date with the Secretariat, and the CDM transfers are in accordance with it and the Parties are not in breach with either branch of the compliance committee.

[84] Decision 17/CP.7. Modalities And Procedures For A Clean Development Mechanism. Ibid. Annex. G. Validation and registration. See also Appendix C: Terms of reference for Establishing Guidelines on Baselines and Monitoring Methodologies. Successful id determined by the other projects performance being among the top 20 per cent of their category.

[85] Decision 17/CP.7. Modalities And Procedures For A Clean Development Mechanism As Defined In Article 12 of the Kyoto Protocol. Annex. Modalities and Procedures for a Clean Development Mechanism. C. Executive board. Paragraph 15. Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section VI. Mechanisms Pursuant To Articles 6, 12 And 17 of the Kyoto Protocol.

[86] First Report Of The Executive Board Of The Clean Development Mechanism. FCCC/CP/2002/3. Add 1.

9 had been approved (with the rest under review) for operation once the Kyoto Protocol came into force.[87]

4. Emission Trading

A. The Precedents of Domestic Air Pollution

Although emissions trading has not been utilized for international air pollution, it has been extensively used within the United States with the problem of air pollution of SO_2, NOx and a Regional Clean Air Incentives Market.[88] Emissions trading for ammonia emissions has been trialed in the Netherlands, and emissions trading from mobile sources (in terms of NOx, SO_2 and VOCs) for urban areas in Poland and Singapore. Basically, each polluting source is granted a quota for how much they can pollute. This quota is part of an overall 'bubble' which is set by the national regulatory authority for the air pollutant in question. If the entity exceeds its quota, rather than facing stiff penalties for non-compliance with the domestic law, it has the ability to purchase or trade for underused emissions from other entities holding quota. Given market considerations of supply and demand, these may become quite valuable commodities,[89] and their value may create a double incentive to foster further reductions, typically via technological innovation or greater efficiencies, so as to create more quota to trade within the overall 'bubble' of permissible pollution levels. In addition, there may be strong economic benefits in the flexibility to achieve targets that emissions trading offers. The magnitude of savings in the United States of this method, compared to traditional command and control type approaches, was in the region of 10 billion (USD) for the decade of 1990 to 2000.[90]

Despite these clear benefits, there have been risks as well. The Executive Committee of the LRTAP regime noted these as being distributional questions (that is, the political basis in which the quotas are distributed), market imperfection, market dominance by one or two large polluting firms.[91] Finally, there is the risk of 'hot spots' being created, if some areas buy

[87] Report of the 9th COP. Proceedings, pp. 24–25. See 'Implementing the Clean Development Mechanism'. E+ (Energy & Sustainable Development). (UNEP & UCCEE). Sep 2002. 3.

[88] EPA. (2004). *The Clean Air Market Programme.* <http://www.epa.gov/airmarkets.>

[89] It was originally estimated that the cost per ton of traded sulfur would be 800–1200 per tonne. In fact, it has been much less than this, with one ton of emissions selling for as little as $68 in 1996, and only around $100 in 1995. Carson, N. (2000). 'Flaws in the Conventional Wisdom on Acid Deposition'. *Environment.* 42(2). 33, 34.

[90] Exec. Committee. 1999/1. VI. Guidance Document On Economic Instruments To Reduce NOx, SO_2, VOCs And Ammonia.

[91] See Gillespie, A. (2001). *The Illusion of Progress: Unsustainable Development in International Law and Policy.* (Earthscan, London). Chapter 3.

more quota from elsewhere, and increase their output. This may be a particular problem if some areas are more ecologically sensitive than others. As such, although emissions trading can often reduce overall pollutant levels, in some instances a few trades to the wrong places can substantially worsen pollution levels in some individual instances.[92]

B. Emissions Trading in Climate Change

In 1990, Allan Bromley, a science advisor to George Bush (snr) suggested that countries should be able to trade pollution credits with regard to climate change, much like the United States did domestically with SO_2. The United States was in such favor of this idea, that a pilot program for emissions trading between Canada, Mexico and the United States was established in 1995. The United States and many other developed countries also argued that emissions trading should be included in the Kyoto Protocol.[93]

Emissions trading was vigorously pursued because not only would it allow countries which failed to meet their greenhouse reduction targets achieve their goals by trading with other nations which possessed excess greenhouse gas emissions to exchange, it could also do so at a much cheaper economic cost.[94] For example, in the absence of emissions trading between developed countries the majority of global studies show the Kyoto targets costing reductions in projected GDP, per country, of about 0.2% to 2% in 2010. With full emissions trading between developed countries, the estimated reductions in 2010 are between 0.1% and 1.1% of projected GDP. The estimated economic costs for developed countries in meeting their Kyoto targets range from about $20/tC (USD) up to $600/tC without trading, but range from about US$15/tC up to US$150/tC with trading with other developed countries.[95] These figures were very persuasive, and the Kyoto Protocol came to endorse emissions trading.[96] Specifically, Article 17 stipulated,

---

[92] Exec. Committee. 1999/1. VI. Guidance Document On Economic Instruments To Reduce Nitrogen Oxides, Sulphur, Volatile Organic Compounds And Ammonia. McCormack, J. (1998). 'Acid Pollution: The International Communities Continuing Struggle'. *Environment.* 40(3): 17–45. For example, in Texas, one in ten trading scenarios created a quarter more ozone pollution than if the same cuts were spread equally across all the power plants. A few trades in the wrong direction resulted in worse pollution than if there had been no emission reductions at all. On the other hand, some trades virtually doubled the reduction of ozone. Jones, N. (2001). 'Dirty Dealing'. *New Scientist.* Nov 10. 11.

[93] Anon. (1990). 'Dirty Dealing'. *New Scientist.* Nov 3. 11. Pearce, F. (1997). 'Warming Goes To Market'. *New Scientist.* Jan 21. 4. 8 *YBIEL.* (1997). 227.

[94] Kosobud, R. (2000). *Emissions Trading.* (Wiley, NY). IEA. (2001). International Emission Trading: From Concept to Reality. (IEA, London).

[95] IPCC. (2001). *Climate Change 2001: Mitigation.* (Cambridge University Press, Cambridge). 10.

[96] Kyoto Protocol. Article 3 (10)&(11).

> The Conference of the Parties shall define the relevant principles, modalities, rules and guidelines, in particular for verification, reporting and accountability for emissions trading.[97]

and,

> The Parties included in Annex B may participate in emissions trading for the purposes of fulfilling their commitments under Article 3. Any such trading shall be supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments under that Article.[98]

Although the emissions trading regime was largely agreed to in principle, the modalities of the scheme were postponed for later COPS to resolve.[99] This was a drawn out process because of the layers of political and legal complexity involved. The easier questions to deal with (because they were being dealt with simultaneously in debates with the JI and the CDM) involved the starting date for the scheme,[100] compliance[101] and which institution would manage any new emissions trading regime.[102] More difficult questions involved whether there should be a 'ceiling' on how many emissions could be traded. Specifically, although the Protocol had stated that, 'any such trading shall be supplemental to domestic actions', the signatories argued strongly on exactly what was 'supplemental'. For example, the United States argued that the term meant very little, whereas a number of developing countries argued that the term meant that developed countries had to meet all of their emission reductions domestically, before they could start trade. A middle ground position was that a percentage (or a 'cap') of how much could be traded would be set, allowing developed countries to trade some emissions from offshore to meet their domestic targets. However, even this middle-ground proposal became problematic, when it became apparent that some countries in the former Soviet Union, due to their initial economic collapse, were easily going to meet their greenhouse emission targets, with vast amounts of 'hot air' (the emissions they were projected to reach, but failed to because of economic restructuring) left to trade. The question was, should there be a limit on much a country may sell, or purchase of this 'hot air'?[103]

---

97 Kyoto Protocol. Article 17.
98 Kyoto Protocol. Article 17.
99 Kyoto Protocol. Preamble. Section 5 (b). Decision 7/CP.4. Work programme on mechanisms of the Kyoto Protocol. Decision 14/CP.5. Mechanisms pursuant to Articles 6, 12 and 17 of the Kyoto Protocol.
100 8 *YBIEL*. (1997). 177.
101 Anon. (1997). 'Trading Places'. *New Scientist*. Dec 13. 7.
102 Brown, P. (1998). 'World Bank Eyes Trade in Carbon Credits'. *The Guardian*. Nov 13. Anon. (2000). 'Success of Carbon Trading Scheme'. *Environmental Policy and the Law*. 30(4): 191.
103 Webster, P. (2003). 'Last Chance for Kyoto'. *New Scientist*. Oct 44–45. Brown, P. (1999).

The most difficult questions on emissions trading, which go to the heart of the debate about equity in the climate debate, pertain to the basis on which any permits would be calculated.[104] Specifically, should the international regime which sets the initial allocations of permissible emissions for countries to make, do so on a per-capita basis (what the developing world wanted), or a sovereign basis (which most of the developed countries wanted) and if on a sovereign basis, how would factors of historical causation or 'grand-fathering' be factored in (which the developing world objected to, as to create standards on the basis of historical emissions, effectively rewarded those who polluted the most). Needless to say, each perspective gave a very different distributional result within the planned emissions trading regime.[105]

The answers to these questions were delivered at the seventh COP in 2001. First, the broad ability to trade in emission units, followed the same requirements for countries with the CDM and JI regimes.[106] Second, with regard to ceilings or caps and the broad debate about 'supplemental' actions, it was decided that emissions trading, 'shall be supplemental to domestic action and that domestic action shall thus constitute a significant element of the effort made by each Party included in Annex I to meet its commitments'.[107] Aside from an exception for Russia and the Ukraine, limitations on the amount of trading were imposed via agreement that:

'US To Exploit Soviet Hot Air'. *Guardian Weekly*. Apr 18. 4. Pearce, F. (1997). 'Dirty Dealings'. *New Scientist*. Dec 20/27. 11. Lanchbery, J. (1998). 'Expectations For the Climate Talks In Buenos Aires'. *Environment*. 40 (8): 18, 19. 8 *YBIEL*. (1997). 180–181. 9 *YBIEL*. (1998). 185. Anon. (1998). 'Talking While the World Warms'. *New Scientist*. Nov 14. 15. 9. Pearce, F. (1998). 'Just Hot Air'. *New Scientist*. May 9. 22 Pearce, F. (1998). 'The Fog Descends'. *New Scientist*. Nov 7. 14.

[104] See Gillespie, A. (2001). *The Illusion of Progress: Unsustainable Development in International Law*. (Earthscan, London). Chapter 3.

[105] Yohe, G. et al. (2000). 'Equity and the Kyoto Protocol: Measuring the Distributional Effects of Alternative Emissions Trading Regimes'. *Global Environmental Change*. 19: 121–132. Lanchbery, J. (1998). 'Expectations For the Climate Talks In Buenos Aires'. *Environment*. 40 (8): 18, 19. 9 *YBIEL*. (1998). 186. Pearce, F. (1996). 'Can The Market Cool The World?' *New Scientist*. Dec 14. 5. Pearce, F. (1997). 'Chill Winds At the Summit'. *New Scientist*. March 1. 12–13. Beckerman, W & Pasek, J. (1995). 'The Equitable International Allocation of Tradable Carbon Emission Permits'. *Global Environmental Change*. 5 (5): 405–413. Harvey, L. (1995). 'Creating A Global Warming Implementation Regime'. *Global Environmental Change*. 5 (5). 415–432.

[106] Broadly, that is that it is a Party to the Kyoto Protocol, the amounts to trade calculated correctly, they are based on a robust national system, which has a standing and robust inventory, and the country's most recent reports have been forwarded to the Secretariat, and there are no issues of compliance. Decision 18/CP.7. Modalities, Rules And Guidelines For Emissions Trading Under Article 17 of the Kyoto Protocol. Annex: Modalities, rules and guidelines for Emissions Trading. Report of the Seventh COP to the FCCC. 50.

[107] Decision 15/CP.7. Principles, Nature and Scope of the Mechanisms Pursuant to Articles 6, 12 and 17 of the Kyoto Protocol. Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section VI. Mechanisms Pursuant To Articles 6, 12 And 17 of the Kyoto Protocol.

> Each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90 per cent of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7 and 8, of the Kyoto Protocol, or 100 per cent of five times its most recently reviewed inventory, whichever is lowest.[108]

The final question pertaining to the basis of distributing permits was answered by its ultimate avoidance. This was surprising, as in 2000 and 2001, the COPs recognised the importance of per-capita considerations. Specifically, it was accepted[109] that part of the purpose of the flexibility mechanisms was,

> To reduc[e] emissions in a manner conducive to narrowing per capita differences between developed and developing country Parties while working towards achievement of the ultimate objective of the Convention.[110]

Despite this recognition, countries only have the ability to trade on the basis of emissions targets that have already been established, which are ultimately sovereign, not per-capita based.

The first emissions trading regime opened in Europe in 2005. The European Union programme applied to 25 countries, including the 10 accession countries. The first phase will run from 2005 through to 2007. The second phase will begin in 2008 and continue through to 2012, coinciding with the five year Kyoto commitment period. Initially, the scheme will only cover the CO_2 emissions generated from five energy intensive industrial sectors. The sectors, incorporating over 12,000 stationary installations include cement, glass, paper and pulp, electricity generation and steel and iron. These sectors represent about half of all the CO_2 emissions within Europe. Most of the other CO_2 emissions are produced by motor vehicles, which are currently outside of the scheme. The distribution of credits was in accordance with the already established, sovereign, Kyoto targets. Parties are only allowed to auction up to 5% of their allocation in the first phase, and 10% in the second phase. Compliance costs are currently set at 40 Euro for every excess tonne emitted in the first phase, and 100 Euro for the second phase.[111]

---

108 Decision 18/CP.7. Modalities, Rules And Guidelines For Emissions Trading Under Article 17 of the Kyoto Protocol. Annex: Modalities, rules and guidelines for Emissions Trading. Report of the Seventh COP to the FCCC. 50. McCarthy, M. (2001). 'Climate Deal Reached'. *The Independent.* July 24. 6.

109 Decision 15/CP.7. Principles, nature and scope of the mechanisms pursuant to Articles 6, 12 and 17 of the Kyoto Protocol. Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section VI. Mechanisms Pursuant To Articles 6, 12 And 17.

110 Decision 5/CP.6. Ibid.

111 Pearce, F. (2005). 'A Most Precious Commodity'. *New Scientist.* Jan 8. 6. Kruger, J. (2004). 'Greenhouse Gas Trading in Europe'. *Environment.* Oct. 8–25. Anon. (2002). 'Emissions Trading Scheme'. *Environmental Policy and the Law.* 32(6): 263. Buchan, D. (2002). 'Companies Agree First Swap'. *Financial Times.* May 7. 5.

XVIII. TRADE RELATED ISSUES

1. Air Pollution and Climate Concerns

The air pollution protocols clearly stipulate that measures taken to reduce air pollutants, should not constitute an arbitrary or unjustifiable discrimination or a disguised restriction on international competition and trade.[1] As such, possible trade related restrictions related to air pollution, such as the exclusion of imported fuels or vehicles that fail to meet prescribed pollutant levels, need to be very carefully crafted so as not to breach international trade rules. Specifically, although such acts are permissible under international trade law, they must not be applied in a discriminatory way that effectively treats domestic industries that also produce cars or fuels, in a different, discriminatory, manner.[2]

Very similar issues are apparent with the climate regime, as multiple variations exist whereby the products or processes of one country could be restricted by another, in an attempt to control greenhouse gas emissions. Although there have been murmurings of disputes in this area, unlike with the air pollution regime, there have been no formal complaints. Also like the air pollution regime, the climate regime shares that same principle that an, 'open international economic system'[3] should be supported and that, 'measures taken to combat climate change, including unilateral ones, should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade'.[4] The Kyoto Protocol added that actions taken by developed Parties, should strive to avoid adverse effects on, inter alia, international trade.[5]

---

1 1994 Protocol on Further Sulphur Reductions. Preamble. Paragraph 10. 1999 Gothenburg Protocol. Preamble. Paragraph 15.

2 In particular, see the GATT ruling on the US Gasoline Case. For commentary, see 5 *YBIEL.* (1994). 204. 8 *YBIEL.* (1997). 591–593. For further discussion see Brack, D. (1999). *International Trade and Climate Change Policies.* (Earthscan, London). 40–43. Boehmer-Christiansen, S. (1991). *Acid Politics.* (Belhaven, London). 19–25.

3 FCCC. Article 3 (5).

4 FCCC. Article 3 (5).

5 Kyoto Protocol. Article 2 (3).

2. The Ozone Experience

The ozone experience on trade related issues has been very different to the regimes noted above. In the initial stages of negotiation for the Vienna Convention, the issue of trade related restrictions was particularly sensitive, as unlike the United States which primarily produced ODS for internal consumption, the European Union was actively exporting ODS. Accordingly, the European Union argued that any reductions in ODS should only be achieved whilst ensuring that, 'the steps taken do not prevent any barriers to trade' and in particular, that any country which elected not to sign the Convention (a 'non-Party') should not be retaliated against through trade mechanisms.[6] The problem with this position was that a number of commercial entities which produced ODS appeared willing to move to countries without ODS restrictions, thereby bypassing the Convention, and making its objectives redundant.[7] Although this problem was clearly set out, it was not resolved within the Vienna Convention, which did not need to consider trade related restrictions on ODS, as there were no restrictions on ODS at any level. The approach of the Vienna Convention on this question was very different to that of the Montreal Protocol, of which trade related questions were, and have remained, a central concern.[8] The primary obligation relating to the detrimental[9] trade in ODS is in Article 4 of the Protocol which prohibited the export of ODS to non-Parties, and the import of ODS from non-Parties.[10]

To further the Article 4 goals, an annex was created for the listing of products containing ODS, of which the importation would be prohibited.[11] Second, an annex for, 'products produced with, but not containing, controlled substances' was constructed with a view to, 'if feasible' restricting

[6] Kenward, M. (1979). 'Ozone: Cautious Inaction Needed'. *New Scientist*. Oct 25. 252. Glenny, M. (1987). 'America Attacks Europe Over Stratospheric Ozone'. *New Scientist*. March 5. 17. MacKenzie, D. (1987). 'Small Comfort For the Ozone Layer'. *New Scientist*. May 7. 20. Litfin, K. (1994). *Ozone Discourses*. (Columbia University Press, NY). 61.

[7] Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1984). Report of the Working Group, First Part of the Fourth Session. UNEP/WG.110/4. Page 9–10. Paragraph 47.

[8] For a full discussion of this issue, see Brack, D. (1996). *International Trade and the Montreal Protocol*. (Earthscan, London).

[9] This obligation, which was not related to products or processes that 'improve the containment, recovery, recycling or destruction or controlled substances, promote the development of alternative substances, or otherwise contribute to the reduction of emissions of controlled substances.' Montreal Protocol. Article 4 (7).

[10] Montreal Protocol. Article 4 (1) and 4 (2).

[11] Montreal Protocol. Article 4 (3).

imports of such products.[12] In addition, by way of an enticement to join the Protocol, each Party was to discourage the export of ODS related technology to non-Parties, and refrain from any financial support (in kind or like) that would facilitate the production of controlled substances.[13] It was later agreed that countries which had met their own ODS targets, could not export ODS to other countries in need of ODS to meet their own basic domestic needs.[14] Although these objectives were relatively clear, a large amount of uncertainty surrounded the objectives, and Article 4 was rewritten at the 1990 London meeting.[15] The most notable difference of the revised Article 4 was that although trade restrictions on ODS were reiterated, support from the financial mechanism of the ozone regime to help developing countries meet their ODS commitments was possible.[16] Since this point, a number of trade related practices have become clear.

A. Products Containing ODS

The first practice to become clear is that it is permissible to restrict the trade in products containing ODS. The debate about this practice began immediately after the conclusion of the Montreal Protocol, and questions arose over how exports of products containing ODS in them, such as refrigerators, or vehicles air conditioning, would be treated.[17] This was

[12] Montreal Protocol. Article 4 (4).
[13] Montreal Protocol. Article 4 (5) & (6).
[14] 'Where, after the phase-out date applicable to it for a controlled substance, a Party is unable, despite having taken all practicable steps to comply with its obligation under the Protocol, to cease production of that substance for domestic consumption, other than for uses agreed by the Parties to be essential, it shall ban the export of used, recycled and reclaimed quantities of that substance, other than for the purpose of destruction'. Reformulated Article 4.a. Noted from the Secretariat website, in 2002. An exception for exporting to helping developing countries meet its basic domestic needs originally applied. At the 10th MOP, it was suggested that Article 5 countries, which must start limiting Annex A & B substances, should not have their reductions, 'offset by any unnecessary increase in exports of controlled substances from non-Article 5 Parties.' As such, they requested the Technology and Assessment Panel to assess the amount of ODS (Annex A & B) that the Article 5 countries need for 1999–2010, and the amount of this that needs to be exported by non-Article 5 countries to Article 5 countries, to satisfy basic domestic needs. Decision X/15. Exports of Controlled Substances in Annex A & B From Non-Article 5 Countries to Article 5 Countries. Report of the 10th MOP of the Montreal Protocol. 30.
[15] 1 *YBIEL*. (1990). 98. 21–22.
[16] The COP rewrote Article 4, to largely prohibit trade with non-Parties for products produced with ODS, or products containing ODS. Annex II. Amendments to the Montreal Protocol. Second MOP to the Montreal Protocol.. In 1992 it was specified that the export ban on Annex B substances only applies from the middle of 1993, Decision IV/17 A. Trade Issues. Report of the Fourth MOP to the Montreal Protocol. 18.
[17] Anon. (1987). 'Historic Ozone Treaty Signed At Last'. *New Scientist*. Sep 24. 22.

relatively easy to resolve, with import and export restrictions applying to the ODS listed in the A, B, C and E annexes. In addition, Annex D of Products and Equipment containing ODS, that needed to be controlled for import and export purposes, was created.[18] Annex D provided clear information which shared the products which were prohibited. This process helped countries from not purchasing products or equipment which were, or soon be, redundant.[19] The list in Annex D is updated and distributed annually.[20]

B. Products Produced with, but not Containing ODS

The second practice to become clear is with regard to products produced with, but not containing ODS. Here, despite the initial intentions of the Parties to consider trade restrictions on such products,[21] in 1993, the MOP was direct in its conclusion that it was 'not feasible to impose a ban or restriction on the import of products produced with, but not containing ODS' at that stage.[22] The approval of this decision was followed at the next meeting, with the recognition that developing countries should, 'not suffer loss of export earnings' for phasing out ODS, and should not be discriminated against by the, 'ODS free [export] products'[23] of developed countries.

C. Non-Parties

The third practice, which is not clear, is how to deal with non-Parties. The general practice is that a flexibility of trade with non-Parties, which are nevertheless complying with the Montreal Protocol, was possible if the non-Party was, in essence, in compliance with the Protocol and relevant

---

[18] Decision VII/32. Control of Export and Import of Products and Equipment Containing Substances Listed. Items listed in 2002 are: (i) automobile and truck air-conditioning units (whether incorporated in vehicles or not); (ii) domestic and commercial refrigeration and air-conditioning/heat pump equipment, e.g., refrigerators, freezers, dehumidifiers, water coolers, ice machines, and air-conditioning and heat pump units; (iii) aerosol products, except medical aerosols; (iv) portable fire extinguishers; (v) insulation boards, panels and pipe covers; and (vi) pre-polymers.

[19] Decision IX/9. Control of Export of Products and Equipment Whose Continuing Function Relies on Annex A & B Substances. Report of the Ninth MOP. 31–32.

[20] Decision X/9. Establishment of a List of Countries That Do Not Manufacture for Domestic Use and Do Not Wish to Import Products and Equipment Whose Continuing Function Relies on Annex A & B Substances.

[21] Benedict, R. (1991). *Ozone Diplomacy*. (Harvard University Press, Cambridge). 92.

[22] Decision V/17. Feasibility of Banning Or Restricting Products Produced With, But Not Containing ODS. Report of the Fifth MOP to the Montreal Protocol. 16.

[23] Annex V. Declaration by Key Developing Counties. Report of the Sixth MOP to the Montreal Protocol. 44–45.

amendments.[24] This exception, which was reiterated in 1990[25] and 1992,[26] was the subject of discussion for the Open Ended Working Group.[27] This process has resulted in a number of countries seeking extensions, or displaying compliance so as to avoid trade related restrictions.[28] Nevertheless, the general rule remains that signatories to the Montreal Protocol should not import or export ODS with non-Parties.[29] However, the legality of such restrictions, despite being a clear concern since the late 1980s, is uncertain.[30] The uncertainty continued unabated into the new century, when the Secretariat was instructed to monitor developments in the WTO, and if asked by the WTO to give interpretations of the Protocol's trade provisions, not to answer until the matter had first been referred to the Parties for discussion.[31]

D. The Trade In Recycled ODS

The situation with regard to the trade in reclaimed or recycled ODS originated from the fourth MOP, when the Parties decided to reverse their earlier decision whereby recycled or reclaimed ODS, were treated as virgin ODS, which could not be traded in any way.[32] The new position changed this, by deciding that the import and export of recycled or reused ODS, although clearly recorded and labeled as being in trade,[33] would not be counted, and thus, not lead to changes in a country's overall consumption figures.[34]

---

[24] Montreal Protocol. Article 4 (8).
[25] London Amendments. Article 4 (8).
[26] Decision IV/17 C. Application of Trade Measures. Report of the Fourth Meeting of the Parties to the Montreal Protocol. 19.
[27] Decision IV/27. Implementation of Paragraph 4 of Article 4 of the Protocol. Report of the Fourth Meeting of the Parties to the Montreal Protocol. 26–27.
[28] Decision V/3. Application of Trade Measures Under Article 4. Report of the Fifth Meeting of the Parties to the Montreal Protocol. 11. Decision VI/4. Application of Trade Measures Under Article 4 to Non Parties. Report of the Sixth Meeting of the Parties to the Montreal Protocol. 16.
[29] See Decision XV/3. Obligations of the Parties to the Beijing Amendment With Respect to HCFCs. Report of the 15th MOP to the Montreal Protocol. 45.
[30] Decision II/15. Extension of the Mandate of the Working Group. Second Meeting of the Parties to the Montreal Protocol. 17. Third MOP to the Montreal Protocol. 13, 20. Decision III/16. Trade Issues. Decision VIII/26. Exports of ODS & Products Containing ODS. Report of the Eighth MOP. 25. 2 *YBIEL*. (1991). 108.
[31] Decision XIV/11. The Relationship Between the Montreal Protocol and the World Trade Organization. Report of the 14th MOP to the Montreal Protocol. 46.
[32] Decision I/12 H.
[33] Decision VI/19. Trade in previously used ozone-depleting substances. 3. Exporting Parties should make best efforts to require their companies to include in documentation accompanying such exports, the name of the source firm of the used controlled substance and whether it was recovered, recycled or reclaimed and any further information available to allow for verification of the nature of the substance.
[34] Decision IV/24. Recovery, Reclamation and Recycling of Controlled Substances. In

The importance of an adequate labeling scheme for recycled ODS in trade became more important, once the problem of illegally manufactured ODS in trade became apparent. Accordingly, the right for Parties to trade in recycled ODS, became dependent on an adequate verification system for validation and approval of imports of any used, recycled or reclaimed ODS.[35] Finally, at the ninth MOP in 1997, a new section was added to the Protocol, which had strong implications for the trade in recycled ODS. This read,

> Where, after the phase-out date applicable to it for a controlled substance, a Party is unable, despite having taken all practicable steps to comply with its obligation under the Protocol, to cease production of that substance for domestic consumption, other than for uses agreed by the Parties to be essential, it shall ban the export of used, recycled and reclaimed quantities of that substance, other than for the purpose of destruction."[36]

E. Illegally Traded ODS & The Licensing Solution

In 2002, at the World Summit on Sustainable Development, the assembled governments committed themselves to take measures to address the illegal traffic in ODS.[37] This commitment followed the evolution of an 'urgent' problem which evolved nearly a decade earlier, when evidence of an illegal trade in ODS became apparent.[38] This trade was/is driven by the financial value of ODS. For example, in the mid 1990s, one tonne of Halon 1301 outside the European Union was worth 2,000 (USD). Inside the European Union it was worth 7,000. Even higher prices were involved for the United States. Thus, a 15 kilogramme cylinder of CFCs bought in Europe for 70 (USD), would sell for 242 in the United States. At this time, the first significant cases of CFC smuggling in the USA was uncov-

making this decision, the Parties were urged to 'adopt appropriate policies for export of the recycled and used substances to Parties operating under paragraph 1 of Article 5 of the Protocol.' Exactly how to do this was not clear, as they were to try to 'avoid any adverse impact on the industries of the importing Parties' (via an inadequate supply) while simultaneously trying not to maintain an excessive supply at low prices which might introduce unnecessary new uses.' Decision VI/19. Trade in previously used ozone-depleting substances.

[35] Decision VIII/20. Illegal imports and exports of controlled substances. Decision IX/8. Licensing system.

[36] Article 4a, adopted at ninth meeting.

[37] WSSD. Plan of Implementation of the World Summit on Sustainable Development. Paragraph 37 (e).

[38] Report of the Eighth MOP Of the Montreal Protocol. 2. Seventh MOP to the Montreal Protocol. 3. The Beijing Declaration recorded an 'appeal to the relevant Parties to take all appropriate measures to address illegal trade in ODS and to safeguard the achievements to date.' Beijing Declaration on Renewed Commitment to the Protection of the Ozone Layer. Annex.

ered. The black market value of ODS in the mid 1990s, in the United States alone, was estimated at 2.5 million (USD). It was estimated that the black market value of ODS in the mid 1990s was over 30,000 tonnes per year. The exact sources of where these illegal ODS comes from is often difficult to ascertain, as the primary producer, (typically believed to Russia in the 1990s) would often be involved in exporting to a second Party which was often a developing country with a special exemption granted to it. For example, shipping records showed more than 2,300 tonnes of CFCs imported into the Lesser Antilles in 1995, even though the islands were only allocated 90 tonnes per year in the mid 1990s. Once in a developing country, the theory was that they would be smuggled into a third country, under a falsely labeled scheme, such as by mixing recycled and virgin ODS.[39]

The response of the MOP to the problem of the illegal trade in ODS, in conjunction with studies of the problem by the Secretariat in operation with the World Customs Union, UNEP and the WTO,[40] was the creation of a system for the validation and approval of imports of any used, recycled or reclaimed ODS.[41] The (national) 'Licensing Systems' which were approved by the MOP in 1997 and 1999,[42] had the objectives of providing information and data to help determine compliance, and assist in the prevention of the illegal traffic of controlled substances.[43] The obligation was formalized in the new Article 4B at the ninth MOP.[44] This stipulated that,

> Each Party shall, by 1 January 2000 or within three months of the date of entry into force of this Article for it, whichever is the later, establish and implement a system for licensing the import and export of new, used, recycled and reclaimed controlled substances in Annexes A, B, C, and E.[45]

---

[39] Anon. (2003). 'Pst, Got Any CFCs ?' *New Scientist.* Nov 15. 4. See Environmental Investigation Agency. (1996). *Chilling Facts About a Burning Issue: CFC Smuggling in the European Union.* (EIA, London). MacKenzie, D. (1994). 'Loophole Opens Up Black Market in CFCs'. *New Scientist.* March 19. 6–7. Kiernan, V. (1995). 'CFC Smugglers Risk the Earth For A Few Dollars'. *New Scientist.* Jan 28. 7. Pearce, F. (1996). 'Smart Smugglers Outwit the CFC Cops'. *New Scientist.* Oct 26. 4. Kiernan, V. (1995). 'CFCs Chase Coke As Miami's Latest Vice'. *New Scientist.* Sep 30. 8.

[40] Decision XIII/12. Monitoring of International Trade and Prevention of the Illegal Trade in Ozone Depleting Substances, Mixtures and Products Containing ODS. Decision VII/33. Illegal Imports and Exports of Controlled Substances.

[41] Decision VIII/20. Illegal Imports and Exports of Controlled Substances. Report of the Eighth MOP Of the Montreal Protocol. Points 2 and 5.

[42] Decision XI/23. Data Reporting. Report of the 11th MOP to the Montreal Protocol. 31.

[43] Decision IX/8. Licensing System. Report of the Ninth MOP Of the Montreal Protocol. 30–31.

[44] Annex IV. Report of the Ninth MOP Of the Montreal Protocol. 55.

[45] Note, Article 5 countries may delay implementation of the licensing requirement for transitional substances until 2005, and methyl bromide until 2002.

The viability of this objective has been frustrated at a number of levels. First, not all the Parties to the Montreal Protocol have obliged in the establishment of such systems. Accordingly, in 2003 the MOP agreed to keep a watching eye on the establishment of the licensing systems as required by Article 4B, for at that point, only 73 Parties to the Montreal Protocol had established such systems.[46]

Second, earlier attempts to control the illegal trade of ODS were ad-hoc. The solution to this problem was the creation of a 'harmonized system' with the licensing of ODS in trade.[47] This process began in 2001, with the adoption of the development of standardized nomenclature to help track ODS.[48] In addition, the World Customs Organization,[49] helped establish the Harmonized Systems customs nomenclature of ODS and products containing ODS.[50] Despite progress being made, clear difficulties remained due to, 'the complexity of relevant customs codes, the lack of an internationally accepted common labeling scheme and the lack of specially trained customs officers'.[51] Accordingly, a group was created to examine options with regard to customs codes, national labeling schemes and the need for, scope of and cost of implementation of a universal labeling and/or classification scheme for ODS in their various forms.[52]

This system to stop the illegal trade was also reinforced with the obligation being placed upon Parties to closely monitor the trade in ODS under their auspice. This was furthered by a request to the Multilateral Fund to provide financial and technical assistance to developing Parties to introduce, develop and apply inspection technologies and equipment in customs to help monitor legal and prevent the illegal trade in ODS.[53] If a Party does stop an illegal trade in ODS, it cannot, itself, utilise the illegal product domestically.[54]

---

[46] Decision XV/20. Report on the Establishment of Licensing Systems Under Article 4B of the Montreal Protocol. Decision XIV/36. Report on the Establishment of Licensing Systems Under Article 4B of the Montreal Protocol. Report of the 14th MOP. 59.

[47] Decision X/18. Customs Codes. Report of the 10th MOP of the Montreal Protocol.

[48] Annex II. Recommendation of the Customs Co-Operation Council on . . . Nomenclatures. Report of the 13th MOP. 59.

[49] Decision X/18. Customs Codes. Report of the 10th MOP of the Montreal Protocol. Decision IX/22. Customs Codes. Report of the Ninth MOP. 38.

[50] Decision XI/26. Recommendations and Clarification of the World Customs Organization. Report of the 11th MOP. 33.

[51] Decision XII/10. Monitoring of International Trade and Prevention of Illegal Trade in ODS and Products Containing ODS. Report of the Twelfth MOP. 29–30.

[52] Decision XIV/8. Consideration of the Use of the Globally Harmonized System for the Classification and Labeling of ODS. Report of the 14th MOP. 45. Decision XII/10. Monitoring of International Trade and Prevention of Illegal Trade in ODS and Products Containing ODS. Report of the Twelfth MOP. 29–30.

[53] Decision XIV/7. Monitoring of Trade in ODS and Preventing Illegal Trade in ODS. Report of the 14th MOP. 44–45.

[54] Decision XV/39. Non-Compliance With the Montreal Protocol by Nepal.

III

Options

XIX. TECHNOLOGICAL EFFICIENCY AND CHANGE

1. Technological Change

Before going into the details of this chapter on technological options, it is necessary to note two things. First, technological change is part of the evolution of human society, and as with biological evolution, there is no predetermined outcome guaranteeing positive results, and it is rare that one technological solution will solve all of the problems before it.[1] Second, discussions on technologies in the areas of ozone depletion, air pollution or climate change, are often linked to the so called 'alternative technology' debates. While the discussion and examples of the next two chapters go beyond some of the typically smaller scale alternative technologies traditionally proffered, there is often merit in the paradigm of thinking which surrounds alternative technology debates, in that technological choices are not value free, and are often clouded in sociological, political and philosophical debates about the suitability of technology, which can often determine the ultimate success or failure of any technological option.[2] Despite the value in these considerations, I do not intend to address them here. Rather, the focus of the next two chapters is upon technological options, largely from the point of view of the immediate environmental problem, not necessarily the political or philosophical considerations connected to each technological choice.

---

[1] IPCC. (2001). *Climate Change 2001: Mitigation.* (Cambridge University Press, Cambridge). 3, 8. Nef, J. (1977). 'An Early Energy Crisis And Its Consequences.' *Scientific American.* 237 (5): 140–46.

[2] See for example, Rennie, J. (1997). '13 Vehicles That Went Nowhere.' *Scientific American.* Oct. 40–43. Hamer, M. (1995). 'A Growing Desire for Streetcars.' *New Scientist.* Jan 28. 14–15. Pearce, F. (1996). 'Sit Tight For 30 Years.' *New Scientist.* Jan 20. 7. Cohen, D. (1990). 'Enabling Technology.' *New Scientist.* June 9. 29–34. Douglas, J. (1980). 'Hidden Agendas In the Energy Debate.' *New Scientist.* July 17. 208. Roy, D. (1976). 'Myths About Technological Change.' *New Scientist.* May 6. 281–283. Anon. (1977). 'Intermediate Technology.' *New Scientist.* July 14. 71. Rao, R. (1980). 'When Alternatives Are Inappropriate.' *New Scientist.* Apr 30. 28. Anon. (1977). 'Ideologically Appropriate Technology.' *New Scientist.* March 5. Cross, M. (1985). 'High Technology Becomes Appropriate Technology.' *New Scientist.* Dec 5. 23. 500. Harrison, P. (1980). 'Appropriate Technology: How Can It Reach the Villages?' *New Scientist.* Nov 20. 521. Harrison, P. (1987). 'A Tale of Two Stoves.' *New Scientist.* May 28. 40–45. Charnock, A. (1985). 'Appropriate Technology Goes To Market.' *New Scientist.* May 9. 10–11.

2. Efficiency

Improving energy efficiency means acting to maintain the same unit of output, of a good or a service, without reducing the quality or performance of the output, while simultaneously reducing the amount of energy required to produce that output.[3] Such efficiencies can reduce the pollutants which impact on both air pollution and climatic change while also reducing economic costs, as less energy is used. In many instances, it makes greater economic sense to find efficiencies to reduce demand, rather than increase the supply of the energy. Thus, energy efficiencies are often a 'no regrets' policy that should often be pursued, irrespective of the environmental benefits, as they have been in many countries since the first oil crisis in the 1970s. Since that point, many countries have continually devised ways to use reduce their energy consumption, while increasing their output and their GDP.[4] At the same time, they have reduced their emissions of pollutants. For example, if the United States was operating at the efficiency levels it had in 1973 at the end of the 1980s, it would have pumped an additional 50% of CO_2 into the atmosphere by the time the FCCC was signed.[5]

The scope for future efficiencies in the utilization of energy in the future is large. The IPCC estimates that efficiency gains of between 10 to 30% above current baseline trends over the next two to three decades can be realized at negative to zero economic cost.[6] The general figure of possible efficiencies in developed countries is 20%.[7] Conversely, it is believed that the scope for energy efficiency in developing countries or countries in eco-

[3] Energy Charter Protocol on Energy Efficiency and Related Environmental Aspects. Article 2, definitions. Available from http://www.unescap.org/enrd/energy/compend/cecc-part5chapter1.htm

[4] Wilbanks, T. (1994). 'Improving Energy Efficiency: Making A No Regrets Policy Work'. *Environment.* 36 (9): 16–20. Hirst, E. (1991). 'Boosting Energy Efficiency'. *Environment.* 33 (2): 7–15. MacKenzie, D. (1991). 'Energy Answers For North and South'. *New Scientist.* Feb 16. 40–43. Boyle, S. (1989). 'More Work For Less Energy'. *New Scientist.* Aug 5. 19–25.

[5] Boyle, S. (1990). 'Lessons From the Past: What People Do When Energy Costs More'. *New Scientist.* Nov 3. 32. Fickett, A. (1990). 'Efficient Use of Electricity'. *Scientific American.* Sep. 29–36. Pearce, F. (1993). 'Carbon Dioxide's Taxing Questions'. *New Scientist.* June 26. 12.

[6] IPCC. (1996). *Climate Change 1995: Economic and Social Dimensions.* (Cambridge University Press). 6, 11, 12. Negative cost means an economic benefit. IPCC. (1996) *Climate Change 1995: Impacts, Adaptations and Mitigation.* (Cambridge University Press, Cambridge). 13.

[7] Boyle, S. (1989). 'More Work, Less Energy'. New Scientist. Aug 5. 19–25. Kenward, M. (1977). 'Energy Up the Garden Path'. *New Scientist.* July 28. 212. 8 Fickett, A. (1990). 'Efficient Use of Electricity'. *Scientific American.* Sep 29–36. Anon. (1984). 'Lost Energy'. *New Scientist.* Oct 4. 5. Anon. (1989). 'Parliamentarians Look To Energy Conservation to Combat Global Warming'. *New Scientist.* July 22. 4.

nomic transition is much greater, as many practices which utilize energy in developing countries or countries in economic transition are very inefficient, when compared with the same practices in developed countries.[8]

3. Alternatives to Ozone Depleting Substances

Aside some rather ambitious, somewhat science-fiction, plans to actually repair the ozone layer[9] most of the work in this area has revolved around the goal of finding alternative substances to traditional ODS, which do not deplete the ozone layer to the same extent. In this context, alternative substances are defined as, 'substances which reduce, eliminate or avoid adverse effects on the ozone layer'.[10] Alternative technologies are those which can reduce or effectively eliminate emissions of substances which have or are likely to have adverse effects on the ozone layer.[11] Both alternative substances and the technologies that produce them have been, and remain, essential ingredients in the saving of the ozone layer. Indeed, of the reductions in the release of ODS between 1987 and 1998, 50% of the reduction was attributed to the introduction of non-fluorocarbon substitutes, including non-chemical options such as no-clean soldering and chemical options such as hydrocarbon propellants, cleaning agents and blowing agents. A further 20% was attributed to the introduction of so called 'transitional' alternative substances of HCFCs (13%) and HFCs (7%).[12]

The search for alternatives to ODS began in 1975 with aerosols.[13] However, as the perceived threat of ozone depletion faded, so too did the active search for alternatives to ODS. This search was already slow, due

[8] IPCC. (2001). *Climate Change 2001: Mitigation.* (Cambridge University Press, Cambridge). 10. Chandler, W. (1990). 'Energy for the Soviet Union, Eastern Europe and China'. *Scientific American.* September. 75. Pachauri, R. (1996). 'Promoting Energy Efficiency in Developing Countries'. *Climate Change Bulletin.* 12 (3): 4–5. Pearce, F. (1999). 'Dirty Dealing'. *New Scientist.* Nov 13. 12. Pearce, F. (1999). 'A Carbon Fix?' *New Scientist.* June 12. 22. Parikh, J. (1993). 'Climate Change and India's Energy Policy Options'. *Global Environmental Change.* 276–285.

[9] Such as 'giant electronic curtains' that would generate electric charges into the stratosphere, which could convert the chlorine atoms into harmless ions. Mestel, R. (1994). 'Is It Curtain for the Ozone Hole?' *New Scientist.* May 21. 9. 'Ozone generators' attached to millions of balloons has also been proposed. Anon. (1989). 'Ozone Patch.' *New Scientist.* April 29. 5. Large scale releases of propane, which could capture chlorine and turn it into hydrogen was also proposed. Holmes, B. (1994). 'No Quick Fix For Climate.' *New Scientist.* Feb 26.

[10] Vienna Convention. Article 1.4. Definitions.

[11] Vienna Convention. Article 1.3. Definitions.

[12] The 30% was attributed to efficiencies and recycling. UNEP. (1999). *Synthesis of the Reports of the Scientific, Environmental Effects and Technology and Economic Assessment Panels of the Montreal Protocol.* (UNEP, Ozone Secretariat, Nairobi). 22–23.

[13] See Roan, S. (1991). Ozone Crisis. (Wiley, New York). 59–62.

to suggestions that many ODS were 'crucial' for which no financially affordable alternatives could be found.[14] However, once the necessity to find alternatives increased with the Montreal Protocol, and research into this area was strengthened, it soon became apparent that not only were alternatives possible, but also these alternatives were not as financially prohibitive as first assumed. In addition, the alternatives represented valuable market opportunities, as the traditional ODS were being increasingly regulated.[15][16] For example, it was assumed at the end of the 1980s that HCFCs production could increase to 800,000 tonnes per year, and could capture 30% of the CFC market by the year 2000.[17] Such considerations meant that by the late 1980s, a number of chemical companies were actively investing in researching 'alternatives' to traditional ODS.[18] The overall situation was best summed up by the 1991 Technology and Economic Assessment Panel, which suggested, 'technological optimism' was justified because, 'problems which were regarded as big and difficult not so long ago have been successfully dealt with much more quickly and at a lower cost than expected'.[19]

The first generation of transitional substances were CFCs 22, 123 and 134a. These were designed to replace the original CFCs 11 and 12, and CFC 13 was designed to replace MC. These were all initially pursued due to their slightly different chemical makeup, resulting in shorter lifetimes in the atmosphere.[20] The second generation of transitional substances were

[14] Milne, R. (1990). 'US Agrees Extra Funds to Safeguard Ozone Layer.' *New Scientist.* June 23. 8. Anon. (1988). 'Commercial Vacuum Halted Work on CFC Substitute.' *New Scientist.* March 17. 26. MacKenzie, D. (1987). 'Chemical Giants Battle Over Ozone Holes.' *New Scientist.* Apr 23. 22. Anon. (1986). 'Ozone Hole Found Over Europe.' *New Scientist.* Oct 16. 21.Anon. (1977). 'US Ban Nearer For Aerosol Cans.' *New Scientist.* May 5. 254. Benedict, R. (1991). *Ozone Diplomacy.* (Harvard University Press, Cambridge). 32–33. Litfin, K. (1994). *Ozone Discourses.* (Columbia University Press, New York). 70–71, 94–95.

[15] Litfin, K. (1994). Ozone Discourses. (Columbia University Press, New York). 61.

[16] Joyce, C. (1988). 'Search For Safer Propellants.' *New Scientist.* Jan 21. 24. Tickell, O. (1990). 'Up In the Air.' *New Scientist.* Oct 20. 33–35.

[17] Final Report: Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol. 20. MacKenzie, D. (1992). 'Agreement Reduces Damage to Ozone Layer.' *New Scientist.* Dec 5. 10.

[18] See Steven, H. (1990). 'The Race to Heal the Ozone Layer.' *New Scientist.* June 16. 30–34. Miller, G. (2001). 'Squeaky Clean.' *New Scientist.* Sep. 15. 13. Jones, M. (1988). 'In Search of the Safe CFC.' *New Scientist.* May 26. 56–60. Anon. (1988). 'Cold Comfort for Ozone Layer.' *New Scientist.* Nov 26. 17. Pearce, F. (1988). 'A Hole In British Ozone Research.' *New Scientist.* Oct 8. 16. Seventh MOP to the Montreal Protocol. 9.

[19] UNEP. (1991). *Report of the Economic Options Committee.* (UNEP, Nairobi). 13.

[20] Anon. (1988). 'Hitch Over CFC Substitute.' *New Scientist.* March 10. 24. Jones, M. (1988). 'In Search of the Safe CFC.' *New Scientist.* May 26. 56–60. Gribbin, J. (1981). 'New Chlorofluorocarbons May Threaten The Ozone Layer.' *New Scientist.* Sep 3. 596. MacKenzie, D. (1988). 'Scientists Set To Track Ozone in the Arctic.' *New Scientist.* Jan 14. 30. Jones, M. (1988). 'In Search of the Safe CFC.' *New Scientist.* May 26. 56–60. Anon. (1988). 'Electronics Brought to Book Over Ozone Damage.' *New Scientist.* Apr 21. 37.

HCFCs and the third generation were HFCs, which were designed to replace HCFCs. HCFCs and HFCs are different to traditional ODS because they have, comparatively, a weak chemical inertness. Thus, unlike the traditional CFC which contained the complete halogenation of their molecules with strong bonds between carbon and halogen atoms of chlorine or fluorine (which replaces the links in hydrocarbons between carbon and hydrogen atoms) HFCs and HCFCs have at least one hydrogen atom in each molecule that can be displaced easily by reactive chemicals in the troposphere, known as hydroxyl free radicals. The end result, is a much lower impact of ODP and subsequently, a much lower damage upon the ozone layer. Due to such clear benefits to the ozone layer, HCFCs came largely to eclipse traditional ODS, and in turn, HFCs are expected to eventually eclipse most remaining traditional ODS and HCFC usage.[21]

The first area in which alternatives to traditional ODS became available and widely adopted was with aerosols. The ODS powered aerosols were quickly eclipsed by mechanical pumps and chemical pumps powered by hydrocarbons, CO_2, NOx, demethlether and/or acetone.[22] The exception to the phase-out in this area has been with MDIs, although alternatives have increasingly narrowed the need for traditional ODS in MDI applications.[23] The second area was with cooling systems including refrigeration, air-conditioning and heat pump. This sector has seen highly successful, 'unprecedented transitions'[24] despite a number of corporations in this sector originally dismissing the possibilities of alternatives, due to cost, practicality and risk.[25] Research quickly identified a number of options which suggested otherwise.[26]

---

[21] HFCs were expected to replace 50% of HCFCs used in foam and 65% of the HCFCs used in refrigeration. Report of the 11th MOP to the Montreal Protocol. 8. Anon. (1988). 'Electronics Brought to Book Over Ozone Damage.' *New Scientist*. Apr 21. 37. Anon. (1989). 'Chemicals Firm Takes the Sting Out of CFC 113.' *New Scientist*. March 18. 31. Joyce, C. (1988). 'AT & T Leads The Pack in Search For Safer Propellants.' *New Scientist*. Jan 21. 24.

[22] Coghlan, A. (1991). 'Aerosol Without A Poisonous Puff.' *New Scientist*. Dec 21. 13. Anon. (1977). 'US Ban Nearer For Aerosol Cans.' *New Scientist*. May 5. 254. CCOL. (1981). Report of the Fourth Session of the Co-Ordinating Committee on the Ozone Layer. Annex 3. Paragraph 32.

[23] UNEP. (1999). *Synthesis of the Reports of the Scientific, Environmental Effects and Technology and Economic Assessment Panels*. (UNEP, Nairobi). 15.

[24] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report* (UNEP, Nairobi). 37, UNEP. (1999). Synthesis of the Reports of the Scientific, Environmental Effects and Technology and Economic Assessment Panels. (UNEP, Nairobi). 18–19.

[25] Final Report: Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol. 19. MacKenzie, D. (1984). 'Anybody Want to Save the Ozone Layer?' *New Scientist*. Nov 15. 10. Jones, M. (1988). 'In Search of the Safe CFC.' *New Scientist*. May 26. 56–60.

[26] Coghlan, A. (1997). 'A Cooler Hum.' *New Scientist*. July 5. 6. Knott, M. (1998). 'Boiling Fridges.' *New Scientist*. Jan 24. 30. Copley, J. (1998). 'Running On Air.' *New Scientist*. Oct 24. 16. MacKenzie, D. (1990). 'Cheaper Alternatives for CFCs.' *New Scientist*. June 30.

The possible alternatives were later, largely, narrowed down to HFCs or hydrocarbons (notably propane, ammonia, isobutane) which replaced CFC 12 for domestic and commercial refrigeration.[27] Likewise, air-conditioning applications that used traditional ODS, have been replaced first with HFCFs, and later, by HFC 134a.[28] The third area was with foam production, where the easier traditional foams utilizing ODS were first replaced by fibre glass or cellulose, and the more difficult foams, such as rigid polyurethane foams, were first replaced by HCFCs, and later by HFCs.[29] Finally, despite initial suggestions that alternatives to traditional ODS (especially CFC 113) were not available to fulfill their role as a solvent used in electronic, precision, metal, and dry cleaning, alternatives ranging from liquid CO_2, ethyl (from ethyl alcohol) and acid (from lactic acid) and/or innovative water and drying solutions quickly proved suitable for same tasks.[30] More difficult applications were solved by HCFCs and 1,1,1,-trichlorethane, before these second generation chemicals were phased out by HFCs and PFCs.[31] Alternatives have also been very successful in replacing MC and CT.[32]

Unlike the other traditional ODS, finding alternatives for some of the applications of halons, such as for fire fighting in air-tight spaces such as within certain ships, submarines, aircraft and tactical vehicles, has proved problematic. Thus, although most of the other applications of halons have been replaced with alternative options, the area of fire-fighting in air-tight spaces, has proved relatively elusive to alternative solutions.[33]

---

13. Toro, T. (1992). 'German Industry Freezes Out Green Fridge.' *New Scientist*. Aug. 22. 16.

[27] Final Report: Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol. 19. Anon. (1994). 'Green Grub.' *New Scientist*. May 14. 13. MacKenzie, D. (1994). 'Fridge Maker Freezes Out CFC Substitute.' *New Scientist*. May 28. 4.

[28] Decision XIV/9. The Development of Policies Governing the Service Sector and Final Use Chillers. Report of the 14th MOP to the Montreal Protocol. 45. Report of the 13th MOP to the Montreal Protocol. 28. Anon. (1998). 'Cool and Compressed.' *New Scientist*. May 9. 15.

[29] Co-Chairs. (2003). Ibid. 34. UNEP. (1999). Synthesis Report. Ibid. 16, 27–28. Jones, M. (1988). 'ISafe CFC.' *New Scientist*. May 26. 56–60.

[30] Report of the 13th MOP to the Montreal Protocol. 28. MacKenzie, D. (1988). 'Industry Develops Ozone-Friendly Processes.' *New Scientist*. Nov 19. 30. Knight, J. (1998). 'Tasty Solution.' *New Scientist*. March 21. 7. Adams, A. (1997). 'Dry, Clean and Green.' *New Scientist*. Aug 30. 12. Anon. (1988). 'Electronics Brought to Book Over Ozone Damage.' *New Scientist*. Apr 21. 37.

[31] UNEP. (1999). *Synthesis of the Reports of the Scientific, Environmental Effects and Technology and Economic Assessment Panels of the Montreal Protocol*. (UNEP, Ozone Secretariat, Nairobi). 15, 19. Anon. (1988). 'Electronics Brought to Book Over Ozone Damage.' *New Scientist*. Apr 21. 37. Anon. (1989). 'Chemicals Firm Takes the Sting Out of CFC 113.' *New Scientist*. March 18. 31.

[32] UNEP. (1999). Ibid. 15, 17. Final Report: Second Session of the First Meeting of the Open Ended Working Group of the Parties to the Montreal Protocol. 19–20.

[33] UNEP. (1999). Ibid. 17. Second Session of the First Meeting. Ibid. 20. Decision II/3.

The MOPs to the Montreal Protocol have, since 1992, continually directed research into suitable alternatives to MB.[34] This long-standing pursuit of alternatives, is due to a number of research reports during the 1990s, that suggested alternatives to MB, could reduce MB usage by 75% for agricultural purposes, and 95% for quarantine and pre-shipment purposes.[35] These reports were strongly challenged, with allegations that either alternatives did not exist in some areas, or the cost of alternatives was prohibitively expensive.[36] Later, more definitive reports in the new century, concluded that only two areas (control of ginseng root and stabilization of high moisture fresh dates) could not be replaced with alternatives to MB. In total (not counting quarantine exceptions) at the end of 2002, alternatives to MB were estimated to possess the potential to cover more than 93% of the traditional agricultural uses of MB.[37] Nevertheless, these conclusions were also disputed and the debate about the complete phase-out of MB, turning on the suitability of alternatives, continued into 2004.[38] Despite this ongoing debate, it is important to note that the contention is about a limited number of exceptions where alternatives are, or are not, available. That is, overall, alternatives to MB have already resulted in large scale transition from many traditional usages of MB. For example, by 2003 declines in the usage of MB in excess of 50% from the 1991 baseline were being recorded. Such declines have been achieved by the adoption of transitional strategies, such as replacing MB with MB/chloropicrin mixtures, and, to a lesser extent, by adoption of alternative fumigant mixtures and soil-less culture systems. The alternatives adopted for durable commodity and structural treatments are principally phosphine fumigations and heat treatments.[39]

Halons. Edwards, R. (1996). 'Firefighters Abandon Halons For Water.' *New Scientist.* July 20. 9. Anon. (1988). 'Caution Before the Ban on Halon Emissions.' *New Scientist.* Nov 19. 30.

[34] Decision IV/23. Methyl Bromide. Decision VI/13. Assessment Panels. Decision VII/7. Trade in Methyl Bromide & Decision VII/8. Review of Methyl Bromide. Decision X/11. Quarantine and Pre-Shipment Exemption. Decision Ex.I/4. Conditions for Granting and Reporting Critical Use Exemptions for Methyl Bromide.

[35] UNEP. (2001). *Alternatives to Methyl Bromide*. (UNEP, Nairobi). Anon. (1993). 'Simple Solution for Ozone Killer.' *New Scientist.* July 31. 10. Cohen, P. (1996). 'Farmers Find A Fumigant That Doesn't Eat Ozone.' *New Scientist.* July 20. 9. Report of the Ninth MOP Of the Montreal Protocol. 11. Report of the 11th MOP to the Montreal Protocol. 18. UNEP. (1999). Ibid. 18. Report of the 13th MOP. 28–29.

[36] Pearce, F. (2002). 'US Millers Fight for Banned Pesticide.' *New Scientist.* Oct 5. 11. Editor. (1997). 'Chill Winds In Montreal.' *New Scientist.* Aug 30. 3. Pearce, F. (1997). 'Promising the Earth.' *New Scientist.* Aug 30. 4.

[37] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 36.

[38] Report of the First Extraordinary Meeting of the Parties to the Montreal Protocol on Substances That Deplete the Ozone Layer. 15.

[39] Co-Chairs of the Assessment Panels (2003). Ibid. 35.

4. Efficiency, Recycling and Destruction of Ozone Depleting Substances

Non-intentional ODS leakage has resulted in a surprising amount of emissions. For example, leaky hoses or loss during servicing and careless recharging resulted in over 82% of all ODS emissions from mobile sources in the 1980s.[40] Accordingly, minimizing leakages of ODS from air-conditioning and refrigeration systems during manufacture, installation and operation,[41] in addition to increasing the efficiencies of their ODS applications (and therefore utilizing less ODS), were two of the initial methods adopted to reduce the release of ODS.[42] Later improvements in the handling or application of certain ODS, such as MC, showed efficiencies in the range of 50% were possible,[43] whilst changed application methods of MB used for soil fumigation could reduce this sector of MB usage from 25% of total MB usage down to 1%.[44] Likewise, changes in quarantine applications of MB, can reduce amounts used by up to 70%. Due to the scope of such efficiencies, it is not surprising that efficiencies in the utilization of ODS, have been credited with being the cause for a large reduction in the amount of ODS consumed.[45]

The second type of efficiency related to ODS involves either recycling or disposing of them. The basic problem is that many of the releases of ODS into the atmosphere occur at the time of disposal of the ODS, if they are not recovered or correctly disposed of.[46] This is a large problem,

[40] Jones, M. (1988). 'In Search of the Safe CFC'. New Scientist. May 26. 56–60. As another example, in 2001, it was shown that two leaky American nuclear fuel plants dating back to the 1950s released 373 tonnes of CFC. Anon. (2001). 'Leaky Plants'. *New Scientist.* June 9. 12.

[41] Decision IV/24. Recovery, Reclamation and Recycling of Controlled Substances.

[42] Farman, J. (1987). 'What Hope for the Ozone Layer Now?' *New Scientist.* Nov 12. 50, 51. Anon. (1976). 'The Official View on CFCs and the Ozone Layer'. *New Scientist.* Apr 29. 213. Anon. (1977). 'Aerosols Can Continue'. *New Scientist.* Sep 15. 655. EC Council Resolution. (1978). Council Resolution on Fluorocarbons in the Environment. May 30. In *IPE* XXX. 128. Paragraph 2.

[43] Litfin, K. (1994). *Ozone Discourses.* (Columbia University Press, New York). 148. UNEP Ad Hoc Working Group of Legal and Technical Experts For the Elaboration of a Global Framework Convention for the Protection of the Ozone Layer. (1981). A Look At Some Issues: A Contribution by the UNEP Secretariat. UNEP/WG.69/5. December 31. Paragraph 35.

[44] Guterman, L. (1998). 'Messy Answer'. *New Scientist.* Nov 7. 11.

[45] 30% of the reduced use of ODS between 1987 and 1998 was attributed to conservation strategies such as containment, recycling and efficiencies. UNEP. (1999). *Synthesis of the Reports of the Scientific, Environmental Effects and Technology and Economic Assessment Panels.* (UNEP, Ozone Secretariat, Nairobi). 22.

[46] For example, in Japan in 1990, of the 6 million cars destroyed each year, 80% were equipped with an air conditioner that releases about a kilogram of CFCs. Boehmer-Christiansen, S. (1990). 'Curbing Auto Emissions in Europe'. *Environment.* July/August.

as vast amounts of ODS (between 350,000 and 400,000 ODP tonnes in refrigeration and a further 1.25 million tonnes in foams) are in existence, much of it awaiting recycling or destruction.[47]

The primary goal of the ozone regime in this regard, is to safely recycle, recover and reclaim[48] all possible ODS, so that the ODS is not inadvertently released into the atmosphere, while also allowing the recovered ODS to be reused in permissible applications, without having to produce new ODS.[49] This goal is assisted by various obligations imposed by the MOPs, such as reporting and assessment obligations, as well as the development of domestic strategies for dealing with recycled ODS.[50] This goal has been strongly supported because of the realization that many ODS, due to their long chemical lifetimes can be reused in new, permitted, applications. In such instances, it is hoped that the recycling of existing ODS, can either substantially reduce the need for new ODS (such as with HCFCs), or totally eclipse the need for the production of new ODS (such as with halons).[51] To help facilitate the recycling goal, clear incentives within the

---

16. Farman, J. (1987). 'What Hope for the Ozone Layer Now?' *New Scientist*. Nov 12. 50–54. Co-Chairs of the Assessment Panels (2003). *The Synthesis Report*. UNEP/OzL.Pro/WG.1/23/3. 39.

[47] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report*. UNEP/OzL.Pro/WG.1/23/3. 7, 40.Report of the 15th MOP to the Montreal Protocol. 33. In the UK, over 1 million discarded fridges are being held, awaiting appropriate destruction. Anon. (2002). 'Fridge Mountain'. *New Scientist*. July 13. 8. Anon. (1989). 'Germany To Collect Fridges For Recycling'. *New Scientist*. March 11. 28.

[48] Although there are distinctions between recycling, recovery and reclamation I shall use the term 'recycled' to broadly cover all three. Recovery is 'The collection and storage of controlled substances from machinery, equipment, containment vessels, etc., during servicing or prior to disposal.' Recycling is; 'The re-use of a recovered controlled substance following a basic cleaning process such as filtering and drying. For refrigerants, recycling normally involves recharge back into equipment it often occurs 'on-site.' Reclamation is; 'The re-processing and upgrading of a recovered controlled substance through such mechanisms as filtering, drying, distillation and chemical treatment in order to restore the substance to a specified standard of performance. It often involves processing 'off-site' at a central facility'. See Decision IV/24. Recovery, Reclamation and Recycling of Controlled Substances. See also Decision XIV/3. Clarification of Certain Terminology Related to Controlled Substances. Report of the 14th MOP. 42. This decision reiterated the definitions in Decision IV/24.

[49] Decision IV/24. Recovery, Reclamation and Recycling of Controlled Substances.

[50] Decision IV/24. Recovery, Reclamation and Recycling of Controlled Substances. Decision VI/19. Trade in previously used ozone-depleting substances. Decision XI/16. CFC Management Strategies in Non-Article 5 Parties. Report of the 11th MOP to the Montreal Protocol. 27–28.

[51] In 2003 an estimated 450,000 ODP tons of halon 1301 and 330,000 ODP tons of halon 1211 are believed to be in existence. See Co-Chairs of the Assessment Panels (2003). *The Synthesis Report*. UNEP/OzL.Pro/WG.1/23/3. 7, 41. Tickell, O. (1990). 'Up In the Air'. *New Scientist*. Oct 20. 33–35. By 1988, one quarter of all CFCs being consumed in the US market, were from recycled sources. Benedict, R. (1991). *Ozone Diplomacy*. (Harvard University Press, Cambridge). 118.

ozone regime have been developed.[52] In particular, in reversing an earlier position,[53] it was agreed that, 'for calculating consumption, the import and export of recycled and used controlled substances . . . shall not be taken into account'.[54] Likewise, with regard to the calculation of how much ODS a country produces, the amount recycled and reused is not to be considered as 'production'. Thus, a country may gain the benefits of reused ODS, without having to consider them as newly produced, with all of the associated restrictions.

In instances where it is not economically feasible to recycle the ODS, such as with some rigid foams, the ODS containing product, must be destroyed in an, 'environmentally appropriate' manner.[55] In particular, the MOPs have progressively developed strategies for managing the disposal of ODS, ranging from storage, collection and shipment (including international shipment in accordance with the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal)[56] through to appropriate (very high temperature) incineration or chemical mixes.[57] These strategies were refined following a task force on the issue in 2001,[58] from which specific destruction technologies were attached to the different ODS.[59] These directives on appropriate destruction technologies, along with revised Codes of Good Housekeeping Procedures for destruction facilities, have already been updated, and are likely to be updated further as greater destruction efficiencies come into existence.[60]

---

52 Co-Chairs of the Assessment Panels (2003). Ibid. 8.
53 Decision I/12 Exports and Imports of Used Controlled Substances.
54 Decision IV/24. Recovery, reclamation and recycling of controlled substances.
55 Decision IV/24. Recovery, Reclamation and Recycling of Controlled Substances.
56 Decision VII/31. Status of Recycled CFCs and Halons Under the Basel Convention. Seventh MOP to the Montreal Protocol. 42–43 Decision V/23. Trade in Controlled Substances and the Basel Convention. Report of the Fifth MOP. 18, 22 and Report of the Sixth MOP at 13. Notably, that the Basel only approve such transfers if the recipient country has recycling facilities that can process the received controlled substances.
57 Decision IV/11. Destruction Technologies. Report of the Fourth MOP to the Montreal Protocol. 23–25 and Annex VI, Approved Destruction Processes. 49. Decision V/26. Destruction Technologies. Report of the Fifth MOP to the Montreal Protocol. 19. Decision VII/35. Destruction Technology. Decision XI/16. CFC Management Strategies in Non-Article 5 Parties. Report of the 11th MOP of the Montreal Protocol. 27–28. Emsley, J. (1992). 'Barbecued CFCs Are Kind to the Atmosphere'. *New Scientist.* Aug 15. 13. Cross, M. (1992). 'Japan Turns on the Heat to Destroy CFCs'. *New Scientist.* July 11. 22. Emsley, J. (1995). 'A Blast of Sound Is Good News For the Ozone Layer'. *New Scientist.* May 27. 20.
58 Decision XII/8. Disposal of Controlled Substances. Report of the Twelfth MOP to the Montreal Protocol. 28.
59 Decision XIV/6. Status of Destruction Technologies of Ozone Depleting Substances. Report of the 14th MOP to the Montreal Protocol. 43. Decision XV/9. Status of Destruction Technologies for Ozone Depleting Substances and Code of Good Conduct. Report of the 15th MOP to the Montreal Protocol. 50 & 82. Annex II.
60 Decision XV/10. Handling and Destruction of Foams Containing ODS. Decision XV/9.

5. New Energy Sources: Wind, Oceans, Solar and Nuclear

Apart from some rather ambitious attempts at slowing climate change or air pollution with some ideas closer to science fiction,[61] most of the focus on alternative forms of energy generation have focused on refining and improving 'new', non-carbon based forms of alternative energy supply, which are already existing. These 'new' forms of energy, for the purpose of this chapter, encompass wind, solar, ocean and nuclear technologies. This chapter does not encompass hydro[62] or fuel-wood options.[63] At the end of the twentieth century nuclear technology provided 6% of the world's energy, and the other new forms of alternative energy provided, cumulatively, less than 0.05% of the overall total.[64]

Ironically, the first new energy source is wind generated. The irony is that windmills began operating in western Asia about 1700 BC. Over the following 1,500 years, windmill technology spread over the Middle East and Europe. By the 20th century, before modern energy supply systems began to replace them, there were over one million windmills operating in the United States alone.[65] Interest in windmills was rekindled from the 1970s, as the source of wind as a free and clean source energy became actively investigated, and the efficiencies and improvements of wind-turbines grew exponentially.[66] This growth can be seen in a number of

Status of Destruction Technologies for Ozone Depleting Substances and Code of Good Conduct. Report of the 15th MOP to the Montreal Protocol. 50 & 83–88. Annex III and Annex IV.

[61] Pearce, F. (2004). 'A Mirror to Cool the World.' *New Scientist.* Mar 27. 26–29. Hecht, J. (2002). 'Far Out Ideas May be Last Hope for Curbing Global Warming.' *New Scientist.* Nov 9. 19.

[62] The World Commission on Dams concluded "there is no justification for claiming that hydroelectricity does not contribute significantly to global warming." Pearce, F. (2000). 'Raising A Stink.' *New Scientist.* June 3. 4.

[63] Agarwal, A. (1983). 'The Forgotten Energy Crisis.' *New Scientist.* Feb 10. 377–380. Prior, J. (1987). 'Fuel For Africa's Fires.' *New Scientist.* July 30. 47–51. Harrison, P. (1987). 'Trees For Africa.' *New Scientist.* May 14. 54–57. Pearce, F. (1994). 'Counting Africa's Trees For the Wood.' *New Scientist.* June 11. 8. Chidumayo, E. (1997). 'Woodfuel and Deforestation in Southern Africa: A Misconceived Association.' *Renewable Energy for Development.* 10 (2): 2–3.

[64] Oil provided 37.5%, natural gas at 21.1%, coal at 21.8%, hydro at 6.6%, and fuelwood and charcoal provided at 6.4%. IPCC. (1996) *Climate Change 1995: Impacts, Adaptations and Mitigation.* (Cambridge University Press, Cambridge). 15. Sykes, L. (1997). 'The Power To Choose.' *New Scientist.* Sep 6. 18–19. Energy Information Agency. (2000), *International Energy Annual: 1998.* (EIA, Dept. of Energy, Washington). 201.

[65] Moretti, P. (1986). 'Modern Windmills.' *Scientific American.* 254 (6): 88–100. Anon. (1977). 'Windmills Spin Into Action.' *New Scientist.* March 10. 574.

[66] Sample, I. (2000). 'Hidden Power.' *New Scientist.* June 17. 14. Graham-Rowe, D. (2001). 'All Weather Windmills.' *New Scientist.* July 14. 20. Anon. (1983). 'Cone Catches the Wind.' *New Scientist.* Sep 15. 768. Anon. (1984). 'How Wind Power Cracks Up.' *New Scientist.* Apr 12. 31. Grubb, M. (1988). 'The Wind of Change.' *New Scientist.* March 17.

countries. For example, in 2004 in California, wind turbines were supplying 2,042 megawatts of energy to hundreds of thousand of households.[67] Denmark, currently has over 10% of its energy supply from wind turbines, and it's target is to have 50% of its energy supplied by wind turbines by 2030.[68] The German target is to have 60% by 2030,[69] and the United Kingdom's target is for wind-turbines to be providing 6 gigawatts of energy, the equivalent of six large nuclear power stations, by 2010. The overall aim of the European Union, is for wind-turbines to be providing 10% of Europe's energy by 2010.[70] Although few other countries have such ambitious targets for wind energy as the Europeans, the provision of wind energy is also increasing in a number of developing countries, including, Mongolia and India, as well as a number of countries in Asia, Latin America, and Africa.[71] Projections suggest that if the current growth rates of wind turbines are maintained, between 10 and 12% of the world's electricity could be generated by wind by 2020.[72] This figure could be substantially

---

43. McGowan, J. (1993). 'America Reaps The Wind Harvest.' *New Scientist.* Aug 21. 30–34.

[67] Pasqualetti, M. (2005). 'Wind Power: Opportunities and Obstacles'. *Environment.* Sep. 23–38. Pearce, F. (2002). 'Grim Outlook.' *New Scientist.* Feb 23. 7. 3 *YBIEL.* (1992). 273. McGowan, J. (1993). 'America Reaps The Wind Harvest.' *New Scientist.* Aug 21. 30–34. Anderson, I. (1984). 'California Windmills Ride Tax Breeze.' *New Scientist.* Jan 12. 9. Neild, T. (1986). 'Electricity Board Aims To Catch the Wind.' *New Scientist.* Jan 9. 49. Grubb, M. (1988). 'The Wind of Change.' *New Scientist.* March 17. 43.

[68] Williams, W. (2002). 'Blowing Out to Sea.' *Scientific American.* March. 15–16. Bennet, G. (1983). 'Dutch Wind Power Not In Vain.' *New Scientist.* Oct 27. 268. Flood, M. (1990). 'Danish Wind Farms Head Out to Sea.' *New Scientist.* Oct 20. 18.

[69] Anon. (2001). 'Big Wind.' *New Scientist.* June 16. 17. Anon. (1978). 'Germany Plans Wind Turbine.' *New Scientist.* July 13. 94. Anon. (1983). 'Germany Takes the Lead.' *New Scientist.* Oct 27. 268. Anon. (1989). 'German Wind Power Revs Up.' *New Scientist.* March 25. 19.

[70] Taylor, A. (2004). 'Record Year Achieved For Wind Farm Construction'. *Financial Times.* Nov 22. 4. Anon. (2003). 'Windpower.' *New Scientist.* July 19. 8. Vidal, J. (2004). 'Eye of the Storm.' *Guardian Weekly.* May 28. 15–16. Anon. (2000). 'Winds of Change.' *New Scientist.* Feb 5. 23. Anon. (1998). 'Green Power.' *New Scientist.* Oct 3. 21. For the history, in building up to this position, see Anon. (1990). 'Financial Rules Threaten British Wind and Solar Projects.' *New Scientist.* March 17. 3. Milne, R. (1987). 'Wind Turbines Step Up Power Output.' *New Scientist.* Nov 19. 37. Anon. (1988). 'England's Biggest Leads the Way to Wind Farms.' *New Scientist.* Feb 11. 36. Anon. (1988). 'Windfall To Set Windmills Turning.' *New Scientist.* March 17. 27. Anon. (1989). 'Second Wind For Turbine Power.' *New Scientist.* March 11. 27. Anon. (1982). 'National Grid Plugs Into Wind Power.' *New Scientist.* Nov 25. 505. Anon. (1984). 'British Wind-Turbine Plans Becalmed.' *New Scientist.* May 3. 5. Anon. (1983). 'Wind Generators Take Off.' *New Scientist.* May 19. 439. 49.

[71] Kammen, D. (1999). 'Promoting Appropriate Energy Technologies In the Developing World.' *Environment.* June 11–15. Kozloff, K. (1995). 'Rethinking Development Assistance for Renewable Electricity Sources.' *Environment* 37 (9): 7–15. Rahman, A. (2000). 'An Appraisal of Policies, Goals and Achievements in India.' *Renewable Energy for Development.* 13 (2): 6–7. Becker, J. (1985). 'Harnessing Mongalia's Winds of Change.' *New Scientist.* Aug 22. 20.

[72] Roosevelt, M. (2004). 'The Winds of Change.' *TIME.* Sep 2. 53–56.

higher, as it is estimated that there is enough wind to meet all of the world's energy demands, although it would take a wind farm the size of Saudi Arabia.[73]

The second new energy source is that of the ocean and its waves, tides and its heat different ocean currents.[74] The creation of energy by the capturing of power from waves has a clear attraction for countries with access to coastlines, and especially so when coastal communities are isolated from centralized power grids. Accordingly, research has been directed into this energy source since the 1970s, in Australia, the United States, Japan, Norway and the United Kingdom.[75] By the year 2000, on the island of Islay in the Hebrides, up to 200 houses were having their power supplied from wave energy. [76] The other great source of ocean energy is tidal power. Unlike wave-energy, the idea of using turbines, connected to barrages across suitable tidal zones or estuaries, has a linage dating back to the Middle Ages.[77] The biggest (240 megawatts) modern example of this technology was built on the River Rance in Britanny in 1965, and with its 24 turbines, produces enough electricity for a city of 300,000 people. Similar examples exist with the Bay of Fundy in Canada and Swansea bay in the United Kingdom.[78] Modern improvements with the capture of tidal energy, ranging from buoys anchored to the ocean floor which move up and down rigid poles,[79] or more commonly with under-water turbines powered by ocean flows, have also been under active investigation in a number of countries.[80]

The third new energy source is photovoltaic (PV). PV energy is produced directly from solar energy when photons (individual particles of light) absorbed into a semiconductor create an energy source, with no pollution, noise, or moving parts. PV systems have multiple uses, can operate on all size scales, require minimal maintenance and are particularly well suited

[73] Davis, K. (2004). 'Enough Wind to Power the World.' *New Scientist.* Sep 25. 12.
[74] Penney, T. (1987). 'Power from the Sea.' *Scientific American.* 256 (1): 74–84.
[75] Knott, M. (2003). 'Power From the Waves.' *New Scientist.* Sep 20. 33–35. Endo, S. (1995). 'The Mighty Whale That Rules the Waves.' *New Scientist.* Nov 25. 42–45. Ross, D. (1988). 'Norwegians Make Waves in Bali.' *New Scientist.* March 10. 37. Editor. (1989). 'Wave In And Drowning.' *New Scientist.* Jan 14. 25.
[76] Knott, M. (2000). 'Shore Bet.' *New Scientist.* Sep 23. 16–17. Webb, J. (1995). 'Anchors Aweigh For Wave Power Pioneers.' *New Scientist.* July 29. 6.
[77] Smith, N. (1980). 'The Origins of the Water Turbine.' *Scientific American.* 242 (1): 114–124.
[78] Pearce, F. (1998). 'Catching the Tide.' *New Scientist.* June 20. 38–41. Ross, D. (1990). 'The Potential of Tidal Power.' *New Scientist.* May 19. 34. Middleton, N. (2001). 'New Wave Energy.' *Geographical.* Jan 52–56. Anon. (2003). 'Tidal Energy.' *Ecologist.* July 48.
[79] Lortie, B. (2003). 'A New Wave of Energy.' *Bulletin of Atomic Scientists.* Nov 8–9.
[80] Edwards, R. (2002). 'Power Surge.' *New Scientist.* Jan 26. 18. Webb, J. (1993). 'Tide of Optimism Ebbs Over Underwater Windmill.' *New Scientist.* Apr 24. 10. Anon. (2002). 'A Swell Time.' *New Scientist.* June 22. 21. Pearce, F. (1998). 'Catching the Tide.' *New Scientist.* June 20. 38–42. Anon. (1983). 'Wet Windmill.' *New Scientist.* May 12. 377.

to remote areas which are not connected to centralized power grids which can provide cheap energy. With such benefits, a number of people consider that solar power will be the energy source of choice of the future.[81]

Research into modern utilizations of solar power originally began in Europe at the end of the nineteenth century, before falling out of favor, and then becoming popular again in the 1970s, after former President Carter optimistically announced, 'the dawning of the solar age'.[82] Although the 'solar age' took a while to start, by the end of the twentieth century, large research programs into solar power, were being conducted throughout the United States, Europe, the Middle East, as well as in many developing countries, including, inter alia, China, India, Kenya and Brazil.[83] In some instances, such as with Germany, Japan and the United States, incentive structures were created to facilitate the achieving of certain national targets, such as with solar powered hot water energy systems for domestic usage.[84] Such strong support for research and development has produced increases in efficiencies of solar power, in terms of conversion rates of solar energy into electricity, from 4% in 1977 to 37% at the turn of the twenty-first century.[85]

---

[81] Scheer, H. (2002). The *Solar Economy*. (Earthscan, London). Anon. (1998). 'Solar Propulsion.' *New Scientist*. March 21. 15. Nowak, R. (2004). 'Power Tower.' *New Scientist*. July 31. 42–45. MacKenzie, D. (1998). 'Incredible Shrinking Solar Panels.' *New Scientist*. June 13. 16. Ward, M. (1995). 'Golden Opportunity For Shrinking Solar Cells.' *New Scientist*. Sep 16. 22 Anderson, I. (1994). 'Sunny Days For Solar Power.' *New Scientist*. July 2. 21–25. Hogan, J. (2003). 'Denim Buildings Are Latest in Green Chic.' *New Scientist*. Feb 15. 19. Anon. (1987). 'Sun Drives Cool Compartments For Third World.' *New Scientist*. Dec 10. 30. Toro, T. (1991). 'Sunshine Brings Water To West Africa.' *New Scientist*. March 16. 23.

[82] Anon. (1979). 'Carter Rises Over US Solar Power.' *New Scientist*. June 28. 1070. Anon. (1977). 'Solar Energy Begins To Shine.' *New Scientist*. Jan 13. 60. Gwynee, P. (1979). 'Carter Leads US Out of Energy Wilderness.' *New Scientist*. July 19. 171. Worldwatch Institute. (1978). *The Solar Energy Timetable*. (Worldwatch Paper 19, Washington). Anon. (1978). 'Solar Energy Has Brighter Future.' *New Scientist*. June 20. 891. Anon. (1978). 'Solar Energy Has Brighter Future.' *New Scientist*. June 20. 891. Collins, P. (2003). 'The Man Who Sold the Sun.' *New Scientist*. March 8. 54–55.

[83] Pearce, F. (2002). 'Grim Outlook.' *New Scientist*. Feb 23. 7. Anon. (2003). 'Indian Solar Loans Become Popular.' *Energy and Sustainable Development* (UNEP). Dec 2. Rahman, A. (2000). 'An Appraisal of Policies, Goals and Achievements in India.' *Renewable Energy for Development*. 13 (2): 6–7. Kammen, D. (1999). 'Promoting Appropriate Energy Technologies In the Developing World' *Environment* 41 (5): 11–15. Ndlovu, A. (1998). 'The GEF PV Solar Project in Zimbabwe.' *Renewable Energy for Development*. 11 (1): 4–5. Ellegard, A. (2001). 'Energy Service Companies Using PVs for Rural Energy in Zambia.' *Renewable Energy for Development*. 14 (1): 1–2. Charnock, A. (1985). 'A Desert With Solar Cells.' *New Scientist*. June 13. 23 Milne, R. (1985). 'Soviet Advance In Solar Power.' *New Scientist*. Oct 17. 31.

[84] Roosevelt, M. (2002). 'The Winds of Change.' *TIME*. Sep 2. 56. Leggett, J. (2003). 'Here Comes the Sun.' *New Scientist*. Sep 6. 23. Jones, S. (1998). 'Energy Experts Take A Shine to the Sun.' *Guardian Weekly*. May 22.

[85] Pearce, F. (2004). 'Power Of the Midday Sun.' *New Scientist*. Apr 10. 26. Editor. (2000). 'Close Call.' *New Scientist*. Nov 25. 3. Hogan, J. (2002). 'Now We Can Soak Up the Rainbow.' *New Scientist*. Dec 7. 24. Ball, P. (1999). 'Sun Traps.' *New Scientist*. Jan 23. 38–44. Tyzan, L. (1999). 'Seeing the Light.' *New Scientist*. Apr 17. 21. Cohen, P. (1997).

The final new source of energy is nuclear power. Since the formation of the International Atomic Energy Agency (IAEA)[86] the goal of nuclear power for peaceful purposes being available to all countries has been directly pursued. The strongest example of this possibility, was recorded in Article IV of the 1968 Treaty on the Non-Proliferation of Nuclear Weapons, which recognized the above goal as an, 'inalienable right'. Similar goals are reflected in regional agreements such as the 1957 Euratom Treaty, and such objectives have been publicly supported by the G7/8 since the early 1980s.[87] These goals have been supplemented by improvements in nuclear technology (bar the elusive dream of nuclear fusion),[88] safety and costs.[89] In addition, nuclear power has been buttressed by an impressive array international instruments relating to accidents,[90] assistance,[91] transport,[92] compensation and liability,[93] safety[94] and waste disposal.[95] The IAEA has also

'Cheap Solar Cells Have Their Day In the Sun.' *New Scientist.* Apr 12. Adler, R. (1999). 'Total Repair.' *New Scientist.* Aug 28. 12. Anon. (1997). 'Power to the People.' *Scientific American.* May. 29. Hogan, J. (2003). 'Solar Power Set for Take Off.' *New Scientist.* June 7. 14. Anon. (1989). 'Double Gallium Cells Set New Record For Efficiency.' *New Scientist.* Dec 9. 20. Hecht, J. (1988). 'Solar Energy Strains Against the Limits.' *New Scientist.* Sep 1. 45. Webb, J. (1995). 'Well of Hope For Solar Power.' *New Scientist.* March 18. 23. Anon. (1993). 'Green Light For Solar Energy.' *New Scientist.* Jan 16. 11.

86 Statute of the International Atomic Energy Agency. (1957) IAEA. Vienna. (89–05761).

87 See the G7 statements for 1980, 1981, 1986 and 1987, 1996, 1997, 1998, and 2001.

88 Daviss, B. (2003). 'Reasonable Doubt.' *New Scientist.* March 29. 36–40. Anon. (2002). 'Its Impossible. And What's More, Its Improbable.' *Economist.* July 20. 69–70. Editor. (2002). 'Hubble Bubble.' *New Scientist.* July 27. 3. Muir, H. (2002). 'Bursting With Energy.' *New Scientist.* March 9. 4–5. Matthews, R. (2002). 'Here Comes the Sun.' *New Scientist.* 35–39. Edwards, R. (2000). 'The Heat is On.' *New Scientist.* Oct 14. 4.

89 Hecht, J. (2004). 'US Plans Take-Away Nuclear Power Plants.' *New Scientist.* Sep 4. 17. Lake, J. et al. (2002). 'The Next Generation of Nuclear Power.' *Scientific American.* Jan. 71–79. Morgan, M. (1993). 'What Would It Take to Revitalise Nuclear Power?' *Environment.* March. 7–30. Leseter, R. (1986). 'Rethinking Nuclear Power.' *Scientific American.* 254: 23–34. Hafele, W. (1990). 'Energy From Nuclear Power.' *Scientific American.* Sep 91–107.

90 1986 Convention on Early Notification of a Nuclear Accident. In UNEP. (1991). *Multilateral Treaties in the Field of the Environment.* (Cambridge University Press, Cambridge). 363.

91 1986 Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency. In UNEP. (1991). Ibid., 367.

92 Convention on the Physical Protection of Nuclear Material. 18 *ILM* 1422. IAEA Code of Practice on the International Trans-boundary Movement of Radioactive Waste. 30 *ILM.* (1991). 556. IMO Code for the Safe Carriage of Irradiated Nuclear Fuel, Plutonium and High Level Radioactive Wastes in Flasks on Board Ships. For discussion, see 3 *YBIEL.* (1992). 269–271. IMO Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances By Sea. 4 *YBIEL.* (1993). 189–190. 6 *YBIEL.* (1995): 269.3 *YBIEL.* (1992). 270–271.

93 The 1960 Convention on Third Party Liability in the Field of Nuclear Energy. In UNEP. Ibid. 3 Vienna Convention on Civil Liability for Nuclear Damage. In UNEP. Ibid. 179. The 1971 Convention Relating to Civil Liability in the Field of Maritime Carriage of Nuclear Materials. In UNEP. Ibid., 253.

94 Convention on Nuclear Safety. Available from http://www.iaea.org/worldatom/Documents/Infcircs/Others/inf449.shtml. Article 1. Anon. (1996). 'Nuclear Safety Convention In Force.' *Environmental Policy and the Law.* 26 (6): 247.

95 Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. Available from <http://www.iaea.org/worldatom/

attempted to create an 'international safety culture', with five new codes in the early 1990s, (on governmental organizations, placement, design, operation and quality assurance) to supplement an additional 60 Codes and Standards concluded between 1978 and 1988.[96] In 1998, the IAEA completed its hundredth safety review mission. These missions began in 1961, in accordance with evolving inspection protocols, and have in total, covered 73 nuclear power plants in 29 countries.[97]

With such support, by 2002, 438 nuclear power plants were generating 16% of the world's electricity.[98] Despite such contributions, during the 1990s, global nuclear generating capacity grew only by 4.7%, compared to a 140% increase in the 1980s.[99] Despite support from a number of administrations, de-facto moratoriums, (due to a number of problems identified in the following chapter of this book) on the construction of nuclear facilities have existed in many European countries and the United States.[100]

Documents/Legal/jointconv.shtml> For discussion, see 6 *YBIEL.* (1995): 268–269. 8 *YBEIL.* (1997): 220–225. 9 *YBIEL.* (1998): 225–226. 10 *YBIEL.* (1999): 269–272. See also the IAEA Radioactive Waste Safety Standards (RADWASS). Delattre, D. (2000). 'RADWASS Update.' *IAEA Bulletin.* 42 (3): 30–34. NEA. (1995). *The Environmental and Ethical Basis of Geological Disposal.* (OECD, Paris).

[96] The IAEA added their (25) Safety Fundamentals document in 1993. For a full discussion of the IAEA inputs into the safety area, see the IAEA special issue 'Safety Standards' *IAEA Bulletin.* 40(2). Anon. (1995). 'Siting of Nuclear Power Plants.' *Environmental Policy and Law.* 25 (1): 38. 2 *YBIEL.* (1991): 153. 6 *YBIEL.* (1995): 265. 4 *YBIEL.* (1993): 185.

[97] See The IAEA Safeguards System of 1965–68. INFCIRC/66/Rev. 2. For a useful discussion of the IAEA in this context, see Harry, R., 'IAEA Safeguards and Non-Proliferation', In Leeuwen, M., (ed) *The Future of the International Nuclear Non-Proliferation Regime* (Kluwer, Netherlands, 1995), 167–203. Special issue of the IAEA Bulletin, 'Safeguards and non-Proliferation.' *IAEA Bulletin.* 41 (4). (1999). For earlier comments in the same journal, see 37 (3): 2–10 & 39 (3): 4–12. The new safeguards were assisted with the IAEA's Draft Protocol to Strengthen and Improve the Effectiveness and Efficiency of the IAEA Safeguards System. (1997) *ILM.* 36: 1232. 9 *YBIEL.* (1998): 220.

[98] Nuclear power provides 20% of the energy in the United States, 78% in France, 57% in Belgium, 46% in Sweden, 29% in Germany and 24% in the United Kingdom. Nuclear Energy Agency (2003). *NEA Annual Report.* (NEA, OECD). 6–7. Lake, J. (2002). 'The Next Generation of Nuclear Power.' *Scientific American.* Jan. 74.

[99] Brown, L. (2001). *Vital Signs: 2000–2001.* (Earthscan, London). 54–55.

[100] Editor. (2001). 'Nuclear Revival.' *New Scientist.* Aug 25. 3. Anon. (2001). 'Keep Building on Three Mile Island.' *Newsweek.* Nov 5. 57. Anon. (2001). 'Nuclear No More.' *New Scientist.* Dec 22. 5. Edwards, R. (1994). 'Crunch Time for Nuclear Power.' *New Scientist.* Oct 8. 14–15. Edwards, R. (1995). 'Green Power Blocks German Plutonium Plant.' *New Scientist.* Apr 8. 8. Torrey, L. (1979). 'A Clear Moratorium.' *New Scientist.* Nov 8. 418. Joyce, C. (1981). 'Reagan Enters the Nuclear Minefield.' *New Scientist.* Nov 5. 360–361. Anon. (1996). 'Nuclear Shutdown.' *New Scientist.* Jan 20. 11. Beavis, S. (1995). 'Britain Opts Out of Nuclear Power.' *Guardian Weekly.* Dec 17. 1. Edwards, R. (2002). 'Secret Plan to Revive British Nuclear Power.' New Scientist. July 6. 14–15. Anon. (1995). 'Critical Event.' New Scientist. Feb 4. 11. Lofstedt, R. (2001). 'Playing Politics With Energy Policy: The Phase Out of Nuclear Power in Sweden.' *Environment.* May 21–40.

Conversely, growth is expected in China, South Korea, Russia and Japan.[101] The latter is also pursuing a Fast Breeder Program.[102]

It is possible that nuclear power may have another Renaissance, due to its alleged environmental benefits, in that it produces no carbon based emissions. Although the environmental benefits of nuclear energy were first noted in the 1980s, with regard to the air pollution debate,[103] it was only with the recognition of the threat of climatic change in the late 1980s, that the idea came into full bloom. Since that point, notable commentators such as Margaret Thatcher, David Bellamy and James Lovelock have all come to argue that that the large scale adoption of nuclear energy is the only truly viable option to reduce large-scale emissions of greenhouse gases.[104] These views have been forcefully reiterated by both the IAEA and the Nuclear Energy Agency (of the OECD). In particular, it has been suggested that if developed countries were to substitute nuclear power for 20% of all fossil fired power plant construction (for both new and replacement capacity), then on a projected typical BAU scenario through to 2010, and exchanged for 50% of fossil fired power stations constructed between 2011 and 2020, 90 Mt C of CO_2 emissions in 2010 and 404 Mt C in 2020 would be saved. Extending the calculation to developing countries, an additional 97 Mt C could be reduced by 2010, and 442 Mt C in 2020. Conversely, if the power generated by the world's 438 nuclear plants were replaced by fossil fuels, CO_2 emissions would rise by 1.8 billion tonnes per year.[105]

[101] A 400% increase, via two new plants per year for the next 16 years for China. See Anon. (2004). 'Nuclear Power Expansion.' *Ecologist.* June. 13. Edwards, R. (1998). 'Back for More.' *New Scientist.* June 17. 6. Rich, V. (1992). 'Russia Breathes Life Into Nuclear Monster.' *New Scientist.* Feb 29. 13. Pavlov, S. (1998). 'Sofia's Choice.' *Bulletin of Atomic Scientists.* May 52–57. Perera, J. (1993). 'Why Russia Still Wants Nuclear Power.' *New Scientist.* May 5. 29–34. Milne, R. (1992). 'Talk is Cheap, Says Russia Nuclear Chiefs.' *New Scientist.* Sep 19. 10. Fitzpatrick, M. (2003). 'Tokyo's Cracked Reactors May Power Up Again.' *New Scientist.* Apr 26. 9. Anon. (1997). 'Staying Nuclear.' *New Scientist.* Jan 18. 11. Hadfield, P. (1996). 'People Power vs Nuclear Power.' *New Scientist.* Aug 10. 7.

[102] Fast breeders represent nuclear energy at its most elegant. With a tightly packed core, energetic neutrons from plutonium bombard a surrounding blanket of uranium creating more plutonium. 'Fast' refers to the speed of the neutrons at the core. 'Breeder' to the fact that the end products contain more fissile material than went in. Despite investigation into these by a number of countries, by the 1990s, Japan alone was continuing the pursuit.

[103] Editor. (1983). 'Acid Comments.' New Scientist. Sep 8. 666. Pearce, F. (1988). 'Cost of Clean Up Doubles.' New Scientist. Oct 22. 29. Milne, R. (1990). 'Britain Risks Row Over Emissions.' New Scientist. March 24. 6.

[104] Vidal, J. (2004). 'Nuclear Plants Blooming.' *Guardian Weekly*. Aug 20. 20.McCarthy, M. (2004). 'The Power of One.' *NZ Herald.* May 29. B9. Thatcher. Noted in Editor. (1988). 'Nuking the Greenhouse.' *New Scientist.* Nov 5. 20. Gribbin, J. (1978). 'Fossil Fuel: Future Shock.' *New Scientist.* Aug 24. 541. Mellanby, K. (1983). 'An Environmentalist's Case for Sizewell.' *New Scientist.* Jan 13. 87.

[105] IAEA. (2000). *Climate Change and Nuclear Power.* (IAEA, Vienna). 9–10. NEA. (2000).

6. Fuel Substitution

A number of options exist for reducing emissions of either air or climate pollution from existing sources of pollution. The first option involves substituting one fuel source for another. This is often a cheap and effective way to reduce emissions from both stationary and mobile sources of air or climate pollution. With regard to stationary sources, the best option for reducing climate change emissions is switching from coal to oil and better still, from oil to natural gas. This is the best option because natural gas is often more economically attractive than coal or oil, whilst also possessing the lowest CO_2 emissions per unit of energy of all fossil fuels. That is, natural gas possesses at about 14 kg C/GJ, compared to oil with about 20 kg C/GJ and coal with about 25 kg C/GJ. Thus, switching from coal to natural gas releases about half as much carbon for each unit of energy produced.[106] Moreover, the amount of CO_2 produced by natural gas can be further reduced by being run absorption towers which utilize industrial solvents, before being released by heating and compression before being disposed of.[107]

If substitution to natural gas is not possible, the other option, assuming the availability of alternative fuels and the adaptability of existing combustion sources,[108] with regard to air pollution, is switching to sources which

Nuclear Energy in a Sustainable Development Perspective. (OECD, Paris). Anon. (2004). 'Nuclear Future Gets Thumbs Up.' *New Scientist*. July 3. 4. Milne, R. (1990). 'IAEA Wants More Nuclear Power To Combat Global Warming.' *New Scientist*. June 2. 8. Edwards, R. (2000). 'Power Struggle.' *New Scientist*. May 13. 14.

106 IPCC. (2001). *Climate Change 2001: Mitigation*. (Cambridge University Press, Cambridge). 7. Pearce, F. (1999). 'Richer and Cleaner.' *New Scientist*. Aug 7. 23. IPCC. (1996) *Climate Change 1995: Impacts, Adaptations and Mitigation*. (Cambridge University Press, Cambridge). 14. IPCC. (1996). *Climate Change 1995: Economic and Social Dimensions*. (CUP). 6, 11. Anon. (2001). 'Our Planet, Our Selves.' *New Scientist*. Aug 25. 17. Gibbons, J. (1989). 'Strategies For Energy Use.' *Scientific American*. Sep 86–93.

107 Hauge, F. (2004). 'Give Carbon A Decent Burial.' *New Scientist*. July 17. 16. Jowitt, J. (2004). 'North Sea Burial Plan For CO_2.' *Guardian Weekly*. August 6. 9. Anon. (1994). 'Responsible Norway Plans to Bury Greenhouse Gas At Sea.' *New Scientist*. Nov 5. 8.

108 Low-sulphur crudes amount for only one fifth of total world oil reserves and for about one third of total oil production. They are also more expensive because they are lighter and yield a more valuable refined product. Low-sulphur coal is more plentiful. However, distribution is uneven. For example, with Germany, nearly 80% of its coal is high sulphur brown coal. Two thirds of coal produced in the former Eastern Europe and nearly 25% of Russia's coal is high sulphur brown coal. Noted in McCormick, J. (1997). *Acid Earth*. (3rd End, Earthscan, London). 39–40. Note also, there is a tendency in some circles to start advocating the benefits of 'heavy oil' as a way to provide new sources of energy. See Jones, N. (2003). 'Can Heavy Oil Avert An Energy Crisis?' *New Scientist*. Aug 2. 11. Editor. (2003). 'Running Dry.' *New Scientist*. Aug 2. 1. See 1988. Sophia Protocol. Technical Annex. Paragraph 15. 1994 Protocol on Further Reductions of Sulfur Emissions. Annex IV. Control Technologies For Sulfur Emissions From Stationary Sources. Paragraph 9 (ii)(b).

have lower sulphur content. That is, the sulphur content of crude oil ranges between 0.1 and 3.0%, and the sulphur content of coal can range from 0.5% to 10.0%.[109] Further reductions in air pollution emissions can also be achieved if the sulphur is not organically bound to the coal, as the coal may be 'cleaned' or 'desulphurized'. This process can remove up to 50% of the inorganic sulphur of coal, whilst also improving its combustion.[110]

Altering fuels can also make a large impact in terms of reducing pollutants from mobile sources. As well as lowering the sulphur content of diesel fuels for mobile sources,[111] additional options include replacing a problematic agent within a fuel mix (such as lead in gasoline), refining the traditional fuel mix (such as with oxygenates) or introducing completely new fuels (from biofuels to natural gas to diesel).

Oxygenated fuels are supplements to existing fuel blends which make the conventional fuels burn more efficiently and thus reduce emissions of CO and other VOCs. Oxygenated fuels can be one of the most effective ways to reduce such pollutants from mobile sources. Oxygenate supplements come from biofuels, which typically come renewable crops, such as methanol or ethanol derivatives such as ethyl-t-butyl ether (ETBE) or methyl tertiary-butyl ether (MTBE). Alternative fuels may also be used as a (near) complete substitute to conventional fuels. Near pure versions of alcohol fueled cars (a small mix of petrol as a taste disincentive is usually necessary to stop drivers filling up themselves) have operated in a number of countries, especially developing ones, and Brazil in particular, with relative success.[112] Alternative fuels also include compressed natural gas (CNG) and liquid petroleum gas (LPG). CNG and LPG already power about 700,000 vehicles worldwide. The advantage of CNG is that it is often

---

109 The sulphur content of coal may vary from 0.5% to 5%. If the calorific value of the coal is very low because of a high moisture or ash content, the quantity of sulphur emitted per unit of heat produced may be very high. This is particularly true for brown coal (lignite) which, chemically, is midway between peat and hard (bituminous) coal.

110 Note, it is not commercially possible to remove nitrogen this way. See 1988. Sophia Protocol. Technical Annex. Paragraph 15.

111 Davis, B. (1999). 'Just Add Water'. *New Scientist.* March 13. 36–39. Coghlan, A. (1998). 'Clean Burn'. *New Scientist.* Apr 11. 17. Hamer, M. (1997). 'Fighting For Air'. *New Scientist.* Apr 19. 14–15. Anon. (1997). 'Delightful Diesel'. *New Scientist.* Aug 7. 11.

112 Zandonella, C. (2001). 'Going Up In Smoke.' *New Scientist.* Aug. 18. 17. Stockholm Environment Institute. (1996). *Alcohol as an Alternative Transportation Fuel: Operational Issues in Developing Countries.* (SEI, Sweden). Johnson, F. (1998). 'Sugar Cane Resources: A Sustainable Energy Option.' *Renewable Energy for Development.* 11 (2): 1. Gabra, M. (1995). 'Sugarcane Residual Fuels: A Viable Alternative in the Tanzanian Sugar Industry.' *Renewable Energy for Development.* 8 (2): 5–6. Cornland, D. (1997). 'Alcohol Fuels for Environment: A Viable Alternative in Developing Countries?' *Renewable Energy for Development.* 10 (3): 1–3. Rosillo-Calle, F. (1988). 'Brazil Finds a Sweet Solution to Fuel Shortages.' *New Scientist.* May 19. 41–44. Hamer, M. (1984). 'The Alcoholic Car of the Future.' *New Scientist.* April 19. 24 Homewood, B. (1993). 'Will Brazil's Cars Go On The Wagon?' *New Scientist.* January 9. 22–23.

cheaper than petrol and although when compared to conventional fuels, emissions of NOx may increase, emissions of CO are reduced by 90% and other VOCs are reduced by up to 50%, whilst virtually no SPM or benzene is emitted. LPG produces 16% less CO_2 emissions than its conventional counterparts. Finally, diesel fuels, when being burnt efficiently and controlled with particle traps, typically produce only about 10% as much CO and VOCs, and 33% of the NOx, as opposed to vehicles using conventional fuels. They also burn 25% less fuel, and the fuel is typically cheaper than petroleum.[113]

In a similar vein, substitution options also exist for small sources of VOCs, such as with changing to the use of water-based degreasing baths and paints, inks, glues or adhesives. In some sectors, switching from one base to another, may produce large benefits. For example, switching to low-solvent paint in car painting can reduce VOC emissions from this sector by more than 60%.[114]

7. Modification of Technology for Stationary Sources

One of the first technological options for reducing the impact on air pollution, on local populations, was to build taller chimneys which helped disperse the pollutants further away. This idea, which was originally endorsed by the OECD as a cheap and effective way to reduce ground level concentrations of pollutants, under certain circumstances,[115] caught on quickly. For example, in 1955 only two stacks in the United States were taller than 180 metres. By 1980, all new stacks being built in the United States were taller than that, with stacks in other countries getting close to 400 metres in height.[116] The utilization of tall stacks was also, typically, supplemented (since 1920) with the 'liming' of ecosystems, such as lakes and fresh water-

[113] Foley, J. (2003). *Tomorrow's Low Carbon Cars.* (Institute for Public Policy Research, London). Gould, R. (1989). 'The Exhausting Options of Modern Vehicles.' *New Scientist.* May 13. 20–25. Brown, W. (2004). 'Europe Racing Ahead of US on Diesel.' *Guardian Weekly.* Apr 8. 30. Fox, B. (2003). 'Super Efficient Fuel Hits The Road.' *New Scientist.* Oct 18. Schwela, D. (1999). *Urban Traffic Pollution.* (Routledge, London). 139–140.

[114] VOC Protocol. 1991. Annex. Paragraphs 25–28.

[115] The 1974 OECD Guidelines on Air Pollution. did concede that: "under unfavourable meteorological conditions . . . use of clean fuels might be the only means of reducing ambient pollution concentrations." 1974. OECD. Paragraph 6. The Guidelines are reprinted in *IPE.* XV. 7628.

[116] In 1970 they noted the importance of: "citing and height of chimneys in relation to the surrounding buildings and to topography, in order to prevent heavy local pollution by downdraughts." Council of Europe Committee of Ministers. Resolution (70) 11. March 7, 1970. On the Co-Ordination of Efforts Made in Town and Country Planning in Air Pollution Control. *IPE.* XV. 7532.

ways, as a way to counteract the build up of pollutants. Thus, if the pollutants could not be effectively dispersed by the building of taller chimneys, then the impacts of the pollutants could be dealt with by remedial measures for the ecosystems which had been impacted upon.

As discussed in the next chapter, the option of building taller chimneys to disperse air pollutants further away, is a proposal fraught with difficulties. Accordingly, many countries have pursued alternative technological options, whereby the fuel utilized in stationary sources is more efficiently combusted in the first place or the pollutants are removed before final emission, thus displacing the need to disperse it in more creative ways. The first option, which began in the 1920s, is 'advanced combustion techniques', whereby the burning of the base fuel is enhanced by the injection of additional substances, temperature, design and air flow. In theory, more efficient burning reduces the amount of pollutants generated. Variations of this technology include Pressurized Fluidized Bed Combustion. (PFBC) and Integrated Gasification Combined Cycles (IGCC).[117] The second option is to capture the pollutants, post combustion, before they are emitted from the source. The most common way to do this is through flue-gas desulphurisation (FGD), or 'scrubbing.' Variations also exist to capture NOx and CO_2. This FGD process, which began in the 1880s, involves the emissions in question, being run through a catalyzing agent, typically some form of limestone, which absorbs the emission and forms a static waste, such as adulterated calcium sulphate.[118]

Advanced catalytic and/or chemical processes can also remove CO_2 from fossil fuel emissions by a, 'de-carbonization' process.[119] Although this process creates waste, this problem has already been dealt with in some instances, by the burying of the captured CO_2 waste in the ocean floor. Norway began utilizing this option in the mid 1990s, and has since point, deposited nearly 1 million tones of compressed CO_2 per year into former natural gas reservoirs beneath the ocean floor.[120]

[117] Holmes, B. (2004). 'More Energy From Hot Stacks.' *New Scientist.* May 29. 21. Anon. (2002). 'Fired Up With Ideas.' *Economist.* July 6. 77–78. Geake, E. (1992). 'Clean Burn Brighten's Coal Future.' New Scientist. Nov 7. 18. Gavaghan, H. (1984). 'Coal Fired and Pollution Free.' *New Scientist.* Nov 1. 16–18.

[118] See 1994 Protocol on Further Reductions of Sulfur Emissions. Annex IV. Control Technologies For Sulfur Emissions From Stationary Sources. Paragraph 9 (e).

[119] Penman, D. (2003). 'Mineral Sieve Filters Out Carbon From Flue Gases.' *New Scientist.* Oct 4. 26. Anon. (2001). 'If You Want to Lock Up Carbon, Just Add Limestone'. *New Scientist.* Dec 15. 20. Samuel, E. (2001). 'Scrub The Planet Clean.' *New Scientist.* March 31. 14. Coghlan, A. (2000). 'Burning Backwards.' *New Scientist.* Jan 29. 15. Hadfield, P. (1998). 'Could Algae Save The World?' *New Scientist.* Jan 17. 20. Pearce, F. (1993). 'The High Cost of Carbon Dioxide.' *New Scientist.* July 17. 26–27.

[120] Hauge, F. (2004). 'Give Carbon A Decent Burial'. *New Scientist.* July 17. 16. Jowitt, J. (2004). 'North Sea Burial Plan For CO_2'. *Guardian Weekly.* August 6. 9. Anon. (2002).

8. Modification of Technology for Mobile Sources

There have been three generations of technological modification, designed to limit the emission of pollutants from mobile sources. The first generation dealt with engine crankcases, which originally vented directly into the atmosphere. Crankcase emission controls, which basically consist of closing the crankcase vent port, were introduced on new cars in the United States in the early 1960s. The efficiencies of these controls increased thereafter, to the point, that control of these emissions is no longer considered a serious technical concern. The second generation of technological modifications dealt with catalytic converters (CCs) for petroleum based vehicles. CCs are ultimately filters, which have become increasingly sophisticated, through which exhaust gases are piped through active chemical substances that convert over 90% of the emissions of CO, NOx and VOCs, into harmless emissions.[121] Variations on CCs for diesel fuels, are known as 'particle traps'. These devices which trap and burn CO, VOCs and SPM, which have a theoretical success rate of over 90% for some classes of engine.[122]

The third generation of technological modification designed to limit emissions of pollutants from mobile sources is Low Emission Vehicles (LEVs). The first serious LEVs have been electric, and the first electric vehicle was made at the end of the nineteenth century. However, the surprising growth in electric vehicles, prior to WWII was eclipsed by the competition following the war, and interest in electric vehicles did not reappear as a serious possibility until the 1970s, due to their very low emissions of VOCs, CO, NOx and CO_2.[123] The second serious LEV is the Hybrid Electric Vehicle (HEV), which is part electric and part conventional. Although the HEV is about an eighth as polluting as a conventional car, compared to a fully electric vehicle which is about one tenth as polluting, its small conventional combustion engine allows the batteries to charge, and the range and

---

'Carbon Sunk'. *New Scientist.* Sep 21. 18. Parks, N. (1999). 'Into The Abyss'. *New Scientist.* May 15. 14. Anon. (1996). 'Carbon Tax Leads to Burial At Sea'. *New Scientist.* Aug 3. 11. Anon. (1994). 'Responsible Norway Plans to Bury Greenhouse Gas At Sea'. *New Scientist.* Nov 5. 8.

121 Nowak, R. (2000). 'Little Gem.' *New Scientist.* Oct 7. 11. Spinks, P. (1991). 'Dutch Develop Cheaper Catalytic Converter.' *New Scientist.* November 16. 16. Spinks, P. (1991). 'Dutch Develop Cheaper Catalytic Converter.' *New Scientist.* November 16. 16. Anon. (1991). 'Palladium Promises Cheaper Route to Clean Cars.' *New Scientist.* June 8. 18.

122 Thisdell, D. (1999). 'Clean Burn.' *New Scientist.* Apr 24. 12. Hamer, M. (1994). 'Cleaner Diesels Take to The Road.' *New Scientist.* Nov 26. 22.

123 Mom, G. (2004). *The Electric Vehicle.* (John Hopkins Press, NY). Sperling, D. (1996). 'The Case For Electric Vehicles.' *Scientific American.* Nov 36–42. Stansell, J. (1980). 'Lords Plug a Boost For Electric Vehicles.' *New Scientist.* September 4. 691. Howard, G. (1992). 'Flat Out for the Car of the Future.' *New Scientist.* November 7. 21–22.

speed of the vehicle is greatly enhanced, compared to the fully electric vehicle. Due to such benefits, by 2004, there were over 80,000 HEVs on American roads.[124] The third serious LEV is the hydrogen powered vehicle. Hydrogen fuel has been investigated as a fuel source since 1839, and it has already been utilized in some transport modes such as with airships. Research into hydrogen powered vehicles is currently strongly supported due to its environmental benefits of only emitting vapor and heat.[125] Finally, solar powered vehicles emit very few pollutants and are increasingly capable of impressive speeds and distances. However, they are currently a long way from commercial reality.[126]

The final modification of technology, designed to reduce either air or climate pollutants from mobile sources, is public transport or alternative methods of transport such as cycling or walking. Public transport represents a paradox within modern transit systems in that if everyone traveled by the slowest form of transport (bus) they would reach their destination faster than if they all traveled by the fastest method (car). The primary reason for this is that standard buses can carry as many as 80 passengers, yet each bus takes the road space of no more than two privately owned cars, thus allowing a greater mobility of vehicles. In addition to making trips faster, such concentrations of people on public transport, also directly reduces the amount of pollutants generated from privately owned motor vehicles. The final option, which produces even less emissions than public transport, is cycling or walking. These options, pursued within suitable urban areas, can also result in reduced vehicle congestion and generate no emissions of pollutants.[127]

[124] Hamer, M. (2004). 'Hybrid Cars Driven By Rising Fuel Prices.' *New Scientist.* Sep 11. 22. Glaskin, M. (2001). 'Going Loco.' *New Scientist.* Oct. 13. 24. Glaskin, M. (2001). 'The Machine.' *New Scientist.* Dec 15. 29–31. Wouk, V. (1997). 'Hybrid Electric Vehicles.' *Scientific American.* Oct 44–48. Beard, J. (1994). 'Green Hybrid.' *New Scientist.*. March 26. 18. Spowers, R. (2001). 'Dream Machine.' *Geographical.* Feb 56. Hamer, M. (1998). 'Hybrid Vigour.' *New Scientist.* June 27. 7.

[125] Wald, M. (2004). 'Questions About a Hydrogen Economy.' *Scientific American.* May 40–45. Lortie, B. (2004). 'Bush's Nuclear Freedom Car.' *Bulletin of Atomic Scientists.* May 12. Burns, L. (2002). 'Vehicle of Change.' *Scientific American.* Oct 40–49. Pearce, F. (1999). 'Running on Empty.' *New Scientist.* Oct 9. 26. Pearce, F. (2000). 'Kicking the Habit.' *New Scientist.* Nov 25. 36. Hecht, J. (1999). 'Clean Compromise.' *New Scientist.* Nov 20. 22. Charles, D. (1997). 'Green Fuel Set for Takeoff.' *New Scientist.* March 22. 25.

[126] Arthur, C. (1993). 'Racing For A Place in the Sun.' *New Scientist.* November 6. 28–29. Anderson, I, (1993). 'Solar Dream Car Comes Through.' *New Scientist.* November 20. 5. Anon. (1987). 'Solar Power Powers on to Record.' *New Scientist.* September 24. 19. Anon. (1988). 'Sunshine Racing.' *New Scientist.* September 8. 1988. 31. Duke, M. (2001). 'Travelling Light.' *New Scientist.* Nov 17. 45–46. Woodward, B. (1991). 'Academic Engineers Race to Solar Victory.' *New Scientist.* January 12. 19.

[127] See Hamer, M. (2001). 'Whose Roads Are They Anyway?, *New Scientist.* June 9. 41–43.

9. Efficiencies that Reduce Air and Climate Pollutants

From the international perspective, buildings and the appliances within them, emit 1,650 MtC per year. The annual rate of increase of these emissions is 1%. This sector, typically accounts for 40% of greenhouse gas emissions for most developed countries. It is theoretically possible to reduce emissions in this sector, through cost neutral energy efficiency measures (relating to, inter alia, design, insulation, air-conditioning, windows, automated temperature control systems), by 700 to 750 MtC by 2010, and between 1,000 to 1,100 MtC by 2020.[128] In some instances, energy costs for an average dwelling, can be reduced by up to 75%.[129]

Appliances also utilize large amounts of energy and cumulatively account for approximately one fifth of all energy used by a typical household in a developing country.[130] In the United Kingdom, televisions and other video devices are responsible for the annual emission of 7 million tonnes of CO_2, and fridges and freezers add an additional 15 million tonnes. However, energy efficiency measures have already made impressive reductions in the amount of energy utilized by domestic appliances. For example, between 1970 and the year 2000, in general, the efficiencies of televisions increased by up to 75%, photocopiers and computers by up to 95%, and fridges and freezers by up to 66%.[131] In many instances, the savings were achieved by relatively simple design changes, such as altering the stand-by switches, internal clocks and/or electronic memories in the appliances, and whilst achieving the same result, only using one-hundredth of the energy previously required to keep the appliance on stand by.[132] Likewise, between 1970 and 2000, the energy efficiency of lighting, increased by up to 90%. These efficiencies have also reduced the amount of greenhouse gas emissions that would have otherwise occurred, if the same lighting was con-

[128] IPCC. (2001). *Climate Change 2001: Mitigation.* (Cambridge University Press, Cambridge). 7. IPCC. (1996) *Climate Change 1995: Impacts, Adaptations and Mitigation.* (Cambridge University Press, Cambridge). 14.

[129] Bevington, R. (1990). 'Energy For Buildings And Homes'. *Scientific American.* Sep 39–45. Oliver, D. (1991). 'The House That Came In From The Cold'. *New Scientist.* March 9. 39–43. Boyle, S. (1989). 'More Work, Less Energy'. *New Scientist.* Aug 5. 19–25. Gibbons, J. (1989). 'Strategies For Energy Use'. *Scientific American.* Sep. 86–93. Mestel, R. (1995). 'White Paint On A Hot Tin Roof'. *New Scientist.* 34–38.

[130] Pearce, F. (1998). 'The Price of Idleness'. New Scientist. Aug 29. 10.

[131] Anon. (2004). 'Digital Pollution'. *New Scientist.* June 12. 4. Fickett, A. (1990). 'Efficient Use of Electricity'. *Scientific American.* Sep 29–36. Oliver, D. (1990). 'A Cool Solution to Global Warming'. *New Scientist.* May 12. 20. MacKenzie, D. (1993). 'Britain's Fridges: Too Hot Too Handle'. *New Scientist.* Sep 4. 14.

[132] Anon. (2002). 'Energy Efficiency'. *New Scientist.* Sep 28. 11. Pearce, F. (1998). 'The Price of Idleness'. *New Scientist.* Aug 29. 10. Fox, B. (1998). 'Stand By For Savings'. *New Scientist.* July 11. 7.

ducted by older, inefficient lights.[133] That is, the 1.8 billion energy efficient lamps currently being utilized globally, consume 27,000 megawatts of electrical power. If these energy efficient lamps were conventional bulbs, they would consume 109,000 megawatts of electrical power. The electricity saved is equivalent to the output of 40 medium sized power plants.[134]

Globally, in 2001 industry was producing 2,300 MtC, and these emissions were growing at 0.4% per year. It was believed possible to reduce emissions from this sector, by using cost neutral energy efficiency measures, by 300 to 500 MtC by 2010, and 700 to 900 MtC 2020.[135] The short term potential for energy efficiency in the manufacturing sector of developed countries is believed to be in the region of 25%.[136] The scope for efficiencies, range from 75% reductions in energy usage for machines with small engines, through to smart technologies which cut the energy needed by large scale gas furnaces, steel furnaces, or even power stations (through new designs, higher temperatures, and better use of processes of heat and waste), by 40 to 50%.[137] Efficiencies within the petroleum industry (such as preventing leaks, flaring, and improving transportation practices) could begin to prevent the practices that wastefully emitted at least 230 trillion cubic feet of natural gas since 1870.[138]

Efficiencies can also reduce industrial emissions of VOCs, by (depending on the industry and the VOC involved), changing techniques of base materials, such as with the printing industry moving to water based solutions for degreasing metal surfaces. Savings of up to 70% are believed possible with the organic chemical industry, through stopping leaks, improving storage and transportation, and catalyzing remaining emissions. The food industry could make savings of 35% through using closed cycles and good

[133] Choi, C. (2003). 'Bright Future for the Low-Power Bulb'. *New Scientist.* July 19. 20. Fickett, A. (1990). 'Efficient Use of Electricity'. *Scientific American.* Sep 29–36. Bower, S. (1991). 'The First Steps Out of the Greenhouse'. *New Scientist.* Feb 16. 37.

[134] Coghlan, A. (2002). 'Save the World at the Flick of a Switch'. *New Scientist.* Aug 24. 12.

[135] IPCC. (2001). *Climate Change 2001: Mitigation.* (Cambridge University Press, Cambridge). 7.

[136] IPCC. (1996) *Climate Change 1995: Impacts, Adaptations and Mitigation.* (Cambridge University Press, Cambridge). 14. For some of the possibilities in this area, see UNEP. (1990). Industry and the Environment: Energy Efficiency (1 & 2). (UNEP, Nairobi). 1991. (UNEP). Climate Change and Energy Efficiency in Industry. (UNEP, Nairobi).

[137] Hecht, J. (1999). 'Cutting Edge'. *New Scientist.* Feb 20. 21. Coghlan, A. (1999). 'Mean Machines'. *New Scientist.* Sep 25. 10. Pearce, F. (1995). 'Seeing the Wood For the Trees'. *New Scientist.* Jan 14. 12–13. Gibbons, J. (1989). 'Strategies For Energy Use'. *Scientific American.* Sep 86–93. Anon. (1991). 'Sweeping Carbon Dioxide Under the Ground'. *New Scientist.* June 1. 9. Gibbons, J. (1989). 'Strategies For Energy Use'. *Scientific American.* Sep. 86–93. Khuller, A. (1999). 'Co-Generation in the Indian Sugar Industry'. *Renewable Energy for Development.* 11 (1): 5.

[138] Gretton, P. (2002). 'Wasted at the Wellhead'. *Bulletin of Atomic Scientists.* Sep 22–25. VOC Protocol. 1991. Annex. Paragraphs 31–37.

housekeeping, and swapping to larger fermentation plants to recover alcohol by condensation. The waste industry could make a 30% reduction by an efficient collection of the (methane) gases. Agriculture could also make reductions by controlling burn-offs, minimizing pesticides, composting waste, and abatement of exhaust gases from animal houses.[139]

Improving the efficiency from motor vehicles, began in 1974 when the average fuel consumption for a typical vehicle in the United States was thirteen miles per gallon (mpg). This low mileage, coincided with the 1970s oil crisis, when it suddenly became very expensive to run motor vehicles on foreign oil. Accordingly, successive American administrations expressed a desire to increase automobile mileage, and with varying degrees of Congressional support over the following twenty five years, helped spur a myriad of design changes (from weight to engine size) that ultimately took the fuel efficiency for standard vehicles in the United States to 25.9 mpg in 1998.[140] A similar process was undertaken, and has continued, within the European Union, whereby current goals are aiming for the average car in 2008, to be producing 25% less CO_2 than at present, and being able to run for 100 kilometers on five liters of petrol.[141] It is anticipated, that even greater efficiencies in the mpg sector are possible in the foreseeable future.[142] In addition, efficiencies in the reduction of pollutants from motor vehicles, through traffic management in terms of optimum speeds

[139] VOC Protocol. 1991. Annex. Paragraphs 6, 8, 25 to 28, 50 to 55, 62 to 70. Note, also the importance of recycling and recovering of VOCs, along with their safe disposal in this area as part of the same overall package.

[140] Spowers, R. (2001). 'Dream Machines'. *Geographical.* Feb. 56. Henderson, C. (1998). 'Small Is Still Beautiful'. *New Scientist.* April 25. 18–19. Anon. (1997). 'This Car's Got Bottle'. *New Scientist.* Oct 11. IEA. (1991). *Fuel Efficiency of Passenger Cars*. (IEA, London).Charles, D. (1991). 'Green Cars Will Cost Lives'. *New Scientist.*. November 9. 15. Pierce, J. (1975). The Fuel Consumption of Automobiles. *Scientific American.* January. 34. Greenberg, D. (1977). 'An Energy Policy for the United States'. *New Scientist.* Apr 28. 181. Gwynne, P. (1977). 'A Curb On US Profligacy'. *New Scientist.* Apr 21. 115. Gray, C. (1981). 'The Fuel Economy of Light Vehicles'. Scientific American. May. 36–42. Anon. (1979). 'US Drives to Increase Miles Per Gallon'. New Scientist. March 29. 1011.

[141] Henderson, C. (1998). 'Small Is Still Beautiful'. New Scientist. April 25. 18–19. 11 YBIEL. (2000). 620. Anon. (1998). 'Deals On Wheels'. New Scientist. Aug 8. 5. Pearce, F. (1994). 'Greenhouse Targets Beyond 2000'. New Scientist. Sep 3. 7.

[142] In 1995 the IPCC suggested that energy use for transport in 1990 was estimated to be 61–65 EJ, and is projected to grow to 90–140 EJ by 2025, without new measures. However, energy use in 2025 could be reduced in 2025 by about a third to 60–100 EJ, through vehicles using very efficient train drives, lightweight construction and low air resistance design. Further savings via smaller vehicles and changed lifestyles would assist. Alternative fuels, and electricity from renewable sources, could take the overall reduction down by 40% by 2025. IPCC. (1996) Climate Change 1995: Impacts, Adaptations and Mitigation. (Cambridge University Press, Cambridge). 14. IPCC. (2001). Climate Change 2001: Mitigation. (Cambridge University Press, Cambridge). 6.

and flow, can also reduce exhaust emissions of typical motor vehicles, by between 3 and 6%.[143] A similar scenario also exists for aircraft. That is, due to engine improvements and airframe design, current supersonic aircraft are about 70% more efficient per passenger than they were 40 years ago. A further 20% improvement is projected for 2015 and a 40 to 50% improvement by 2050, by building on the existing improvements, in addition to, inter alia, different flying heights and improved air traffic management.[144]

Unlike controlling CH_4 emissions from old waste landfill sites,[145] or fires in old coal mines,[146] the economic costs of achieving efficiencies of CH_4 emissions from agriculture, are not all cost neutral or minimal. Nevertheless, it is believed that reductions in the order of 150 to 300 MtC of CH_4 equivalent are possible by 2010, and 350 to 750 MtC of CH_4 equivalent by 2020.[147] Efficiency options for rice production include changing cultivation practices, such as draining fields before harvest which can reduce CH_4, in some instances, by up to 50%,[148] or swapping to modern high yielding rice strains that may have up to an eight fold difference in CH_4 emissions from traditional strains.[149] CH_4 emissions from ruminants can also be reduced by changing their diet, such as with a small infusion of fish oil into the diet of some sheep. This reduces their CH_4 emissions by up to 17%,[150] or the addition of various vaccines or bacteria, can reduce the flatulence and burping of some ruminant species by up to 8%.[151]

[143] Elsom. (1996). Smog Alert. (Earthscan, London). 143–146. Anon. (1989). 'Cleaner Cars Are Possible After All'. *New Scientist.* June 17. 10.

[144] IPCC. (1999). *Aviation and the Global Atmosphere.* (Cambridge University Press, Cambridge). 10. Graham-Rowe, D. (2002). 'High Fliers Are Scourge of the Sky'. *New Scientist.* Oct 19. 6–7.

[145] At least 75% of the savings of methane recovery from landfills should be at net negative direct cost, and the remaining 25% cost 20 (USD) per tonne. IPCC. (2001). *Climate Change 2001: Mitigation.* (Cambridge University Press, Cambridge). 7.

[146] Pearce, F. (2002). 'Fires From Hell'. *New Scientist.* Aug 31. 34–38. IPCC. (1996). *Climate Change 1995: Economic and Social Dimensions.* (CUP). 11.

[147] There are 'limited opportunities for negative net direct cost options'. IPCC. (2001). *Climate Change 2001: Mitigation.* (Cambridge University Press). 7. Note, the base figure for CH_4 emissions from agriculture in 2001 was somewhere between 1,250 and 2,800 MtC of CH_4 equivalent.

[148] Tata, P. (2003). 'Draining Rice Fields Cuts Greehouse Gas'. *New Scientist.* Feb 22. 18 Milich, L. (1999). 'The Role of Methane in Global Warming'. *Global Environmental Change.* 9: 179, 190–191.

[149] Anon. (2002). 'Cleaner, Greener Rice'. *New Scientist.* Sep 28. 23.

[150] Coghlan, A. (2003). 'Burping Animals Clean Up Their Act on Fishy Diet'. New Scientist. March 15. 24. Coghlan, A. (2000). 'Why A Change of Diet Is Good For the Environment'. New Scientist. Apr 15. 6.

[151] Anon. (2004). 'Saving Earth From Sheep's Burps'. *New Scientist.* Sep 25. 18. Hadfield, P. (2002). 'No Burps, Please'. *New Scientist.* June 15. 21.

XX. THE LIMITS OF EFFICIENCIES AND CHANGE WITH TECHNOLOGICAL OPTIONS

1. Alternative New Energy Sources

A. Nuclear

Despite the clear theoretical merits of nuclear energy and a surrounding buffer of international instruments on the subject,[1] significant sections of the international community has, to date, been slow to embrace this technology. This is due to concerns of accidents, safety, waste, nuclear proliferation and threat, as well as economic cost.[2]

Accidents at nuclear facilities are judged against the International Nuclear Event Scale, which runs from zero for no safety significance to level seven, which was represented by the Chernobyl incident, for accidents with widespread health and environmental consequences. By the end of the twentieth century, there had been 60 accidents since 1945. Of these accidents, 33 happened in the United States, 19 in Russia, 2 in Canada and one each in the United Kingdom, France, Belgium, Yugoslavia, Argentina and Japan.[3] The first large scale accidents were probably at Hanford in the United States, between 1945 and 1957, when large amounts of radiation were released into the atmosphere.[4] These accidents were followed by three major incidents in 1957 at Kyshtym in the Southern Urals, Mayak at Chelyabinsk and Windscale/Sellafield in the United Kingdom. In first two instances, over 20 million curies of radioactivity were released and hundreds of thousands of kilometers and an unknown amount of people were contaminated.[5] In the third instance, a large amount of the isotope

---

[1] For some critiques on the soft nature of some of these documents, see Anon. (2003). 'Setback For Europe's Nuclear Safety Plan'. *New Scientist.* Oct 25. 4. 11 *YBIEL.* (2000). 209. MacKenzie, D. (1994). 'Voluntary Pact for Nuclear Safety'. *New Scientist.* June 18. 5. 2 *YBIEL.* (1991): 153–154.

[2] IPCC. (1996) *Climate Change 1995: Impacts, Adaptations and Mitigation.* (Cambridge University Press, Cambridge). 15. IPCC. (1996). *Climate Change 1995: Economic and Social Dimensions.* (CUP). 11. IPCC. (2001). *Climate Change 2001: Mitigation.* (Cambridge University Press, Cambridge). 7.

[3] Edwards, R. (1999). 'Going Critical'. *New Scientist.* Oct 30. 20–21.

[4] Anon. (1990). 'Weapons Plants Were Dangerously Radioactive'. New Scientist. July 21. 4.

[5] Larrin, V. (1999). 'Mayak's Walking Wounded'. *Bulletin of Atomic Scientists.* 55 (5): 20–28. Segerstahl, B. (1997). 'The Long Shadow of Soviet Plutonium'. *Environment.* 39 (1): 12–20. Perera, J. (1989). 'Soviet Union Comes Clean On Nuclear Blast'. *New Scientist.* Aug 5. 3. Dickson, D. (1989). 'Kyshtym Almost As Bad As Chernobyl'. *New Scientist.* Dec 23. 3.

plutonium-210 was released into the atmosphere, and somewhere between a dozen and hundreds of people were killed as a result.[6] Unfortunately, the accidents at Windscale/Sellafield have been ongoing since this period, and have encompassed, both intentional and unintentional leaks of radioactive material. By 2003, one of the cumulative results of such accidents was that many children, especially in the northwest of England, had identifiable plutonium in their teeth.[7] These results have been compounded by the intentional discharges of plutonium, technetium-99 and carbon-14 in the northeast Irish Sea.[8] Although these discharges forced Ireland to unsuccessfully take the United Kingdom to the Law of the Sea Tribunal,[9] in 2004, the European Union announced its intention to prosecute Sellafield

Medvedev, Z. (1977). 'Facts Behind the Soviet Nuclear Disaster'. *New Scientist*. June 30. 761. Medvedev, Z. (1979). 'Nuclear Disaster in the Urals'. *New Scientist*. Oct 11. 115. Pewrera, J. (1992). 'Soviet Plutonium Plant Killed Thousands'. *New Scientist*. June 20. 10. MacKenzie, D. (1993). 'Shades of Chernobyl Stalk Tomsk'. *New Scientist*. Apr 17. 6.

[6] Herbert, R. (1982). 'The Day the Reactor Caught Fire'. *New Scientist*. Oct 14. 85–86. Pearce, F. (1983). 'Secrets of the Windscale Fire'. *New Scientist*. Sep 29. 7. Pearce, F. (1988). 'Penney's Windscale Thoughts'. *New Scientist*. Jan 7. 34–35. Pearce, F. (1983). 'Polonium Cloud Engulfs Windscale'. *New Scientist*. March 31. 867. Urquhart, J. (1983). 'Polonium: Windscale's Most Lethal Legacy'. *New Scientist*. March 31. 873. Milne, R. (1984). 'Deformed Babies Blamed on Windscale Fire'. *New Scientist*. Jan 26. 7. Anon. (1981). 'Windscale Fallout Caused Some Cancers'. *New Scientist*. Aug 20. 449.

[7] Barnett, A. (2003). 'Plutonium From Sellafield In All Children's Teeth'. *Guardian Weekly*. Dec 4. 10. Edwards, R. (2000). 'Dead In the Water'. *New Scientist*. Feb 26. 3, 18–19. Edwards, R. (2000). 'Trouble in Store'. *New Scientist*. June 17. 4. Anon. (1988). 'Robot Reveals Piles of Debris in Windscale Reactor'. *New Scientist*. Oct 22. 24. Bradley, D. (1993). 'Tests Grossly Underestimated Sellafield Radiation'. *New Scientist*. Sep 4. 6. Edwards, R. (2003). 'Secrecy Shrouds Nuclear Leak'. *New Scientist*. July 5. 8. Anon. (1986). 'Sellafield's Never Ending Saga of Leaks'. *New Scientist*. Feb 20. 19. Anon. (1983). 'Sellafield Faces Prosecution Over Leaks'. *New Scientist*. Dec 15. 791. Connor, S. (1983). 'The Day Sellafield's Alarm Went Off'. *New Scientist*. Dec 22. 871. Anon. (1986). 'Sellafield's Stay Open Despite New Leaks'. *New Scientist*. March 6. 19. Anon. (1986). 'Giant Tank At Sellafield Is Leaking'. *New Scientist*. Feb 13. 13. Anon. (1984). 'Prosecution for Sellafield Leak is Likely'. *New Scientist*. Feb 16. 4. Milne, R. (1985). 'Sellafield's Waste Spreads Confusion'. *New Scientist*. June 27. 3. Anon. (1986). 'Sellafield Clean Up Fails At First Hurdle'. *New Scientist*. Aug 28. 15. Anon. (1986). 'Sellafield Fears Block Tigher Radiation Rules'. *New Scientist*. Aug 7. 18. Anon. (1986). 'Sellafield's Safety Under the Microscope'. *New Scientist*. Feb 27. 14. Anon. (1986). 'Sellafield's Dirty Past'. *New Scientist*. July 31. 21. Anon. (1983). 'Whitehall Descends on Sellafield'. *New Scientist*. Nov 24. 557.

[8] Anon. (1983). 'Sellafield Cuts Plutonium Discharges'. *New Sci*entist. Oct 13. 73. Edwards, R. (1999). 'Set In A Nuclear Sea'. *New Scientist*. Feb 27. 13. Pearce, F. (1997). 'Teeth Fallout'. *New Scientist*. Aug 2. 16. Edwards, R. (1999). 'Now You See It'. *New Scientist*. Apr 24. 17. Anon. (1998). 'Radioactive Waters'. *New Scientist*. June 6. 5.

[9] MOX Plant Case (Ireland v. UK). (2002). *ILM*. 41 (2): 405. The OSPAR/UNCLOS MOX Plant Award and Order. 42 *ILM* 1116 (2003). Anon. (2001). 'MOX Plant Dispute'. *Environmental Policy and the Law*. 32 (1): 25–26. Anon. (2001). 'Shut It Say Irish'. *New Scientist*. Dec 1. 7. Editor. (2000). 'Dishonourable Discharge'. *New Scientist*. Dec 9. 3. Edwards, R. (2000). 'Dirty Business'. *New Scientist*. Dec 9. 18. Pearce, F. (1997). 'Sellafield Leaves Its Mark on the Frozen North'. *New Scientist*. May 10. 14. Edwards, R. (1996). 'Irish Concern Over Safety of Sellafield Waste Tanks'. *New Scientist*. June 15. 6. Anon. (1987). 'Irish Bay for Sellafield's Closure'. *New Scientist*. Apr 23. 21.

for failing to stick to its nuclear safeguards.[10] Although there have been strong safety concerns raised with other nuclear facilities in the United Kingdom,[11] and elsewhere in Europe,[12] no substantive accidents have resulted. Likewise, although both Canada[13] and the United States have had a series of accidents and incidents at their nuclear power complexes,[14] there have been no major accidents, although Three Mile Island was nearly an unmitigated disaster.[15] However, a number of accidents in Japan have lead to incidents of greater concern.[16]

---

10 Anon. (2004). 'EU To Prosecute Over Nuclear Waste'. Guardian Weekly. Sep 10. 8.

11 Edwards, R. (2003). 'Nuclear Plant May Face Legal Action Over Hot Breach'. *New Scientist.* Aug 30. 7. Anon. (2000). 'Costly Closure'. *New Scientist.* Oct 14. 5. Milne, R. (1991). 'Nuclear Chiefs Urge Stay of Execution for Dounreay'. *New Scientist.* Dec 21. 8. Edwards, R. (1997). 'Dounreay Grasped By Strong Arm of the Law'. *New Scientist.* May 17. Editor. (1997). 'Out in the Open'. *New Scientist.* Dec 13. 3. Anon. (1996). 'Radiation Patchwork'. *New Scientist.* May 4. 10. Edwards, R. (1996). 'One Leak Too Many For Dounreay'. *New Scientist.* Oct 12. 7. Edwards, R. (1998). 'Mea Culpa'. *New Scientist.* Sep 12. Anon. (1998). 'Nuclear Inquisition'. *New Scientist.* May 23. 7. Webb, J. (1995). 'How Many More Hotspots at Dounreay?' *New Scientist.* July 29. 5. Edwards, R. (1995). 'Dounreay's Lethal Particles'. *New Scientist.* July 15. 6. Edwards, R. (1994). 'Dounreay: Still Hot After All These Years'. *New Scientist.* Nov 26. 4. Anon. (1986). 'Dounreay Accident Was Not Serious'. *New Scientist.* June 12. 19. Milne, R. (1992). 'Nuclear Company Warned Over Uranium Records'. *New Scientist.* March 14. 11. Edwards, R. (1994). 'Cracked Welds Fuel Reactor Fears'. *New Scientist.* Dec 10. Milne, R. (1991). 'Weakened Welds Shut Down Reactor'. *New Scientist.* Feb 9. 11.

12 Anon. (1987). 'Cold Weather Could Threaten Reactor'. *New Scientist.* March 26. 22. Patel, T. (1993). 'Disaster On Tap at French Reactor'. *New Scientist.* July 17. 7. Patel, T. (1994). 'Fatal Blast At Retired Reactor'. *New Scientist.* Apr 23. 9. Anon. (1986). 'France Discovers Nuclear Scare'. *New Scientist.* May 29. 22. Patel, T. (1993). 'Massive Bill For Cracked Reactors'. *New Scientist.* Sep 4. 8. Lloyd, A. (1981). 'Fire at French Nuclear Fuel Plant Leaks Radiation'. *New Scientist.* Jan 15. 125. Anon. (1997). 'Nuclear Spill'. *New Scientist.* Sep 20. 7. Patel, T. (1996). 'French Greens Do Battle Over Leaky Dump'. *New Scientist.* March 2. 12. Lloyd, A. (1982). 'France's Breeder Leaks, But Doesn't Sink'. *New Scientist.* May 13. 404. Charles, D. (1988). 'West Germany Admits Top Level Nuclear Accident'. *New Scientist.* Dec 17. 6. Anon. (1986). 'German Nuclear Leak Inflames Post-Chernobyl Passions'. *New Scientist.* June 12. 23.

13 Wilkie, T. (1983). 'Canadian's Cracked Reputation' *New Scientist.* Oct 6. 7. Payne, D. (1983). 'Nuclear Reputation Dragged Down' *New Scientist.* Sep 15. 750,

14 Edwards, R. (2003). 'Are Ageing US Reactors Safe?' *New Scientist.* Aug 9. 13. Kiernan, V. (1994). 'Uranium Drums Sound Alarm For Nuclear Store'. *New Scientist.* Oct 15. 11.Joyce, C. (1986). 'Hexafluoride Tank Was Boiled Before Accident'. *New Scientist.* Jan 9. 24. Anon. 91981). 'Nuclear Plants Suffer An Epidemic of Flaws'. *New Scientist.* Nov 26. 14. Anon. (1988). 'Safety Lapses'. *New Scientist.* Oct 29. 28. Anon. (1986). 'Weapons Plant Was Close to Chain Reaction'. *New Scientist.* Oct 16. 23. Anon. (1989). 'American's Count the Cost of Nuclear Safety'. *New Scientist.* Jan 14. 27. Anon. (1989). 'Radioactive Pollution Underestimated By Six Times'. *New Scientist.* May 13. 3. Gwynne, P. (1983). 'Watchdog Barks As Nuclear Tripwire Fails'. *New Scientist.* May 19. 438.

15 Manano, J. (2004). 'Three Mile Island' *Bulletin of Atomic Scientists*. Sep 31–35. Editor. (1986). 'It Can Happen Here: And It Has'. *New Scientist.* Aug 21. 12. Torrey, L. (1979). 'The Week They Almost Lost Pennsylvania'. *New Scientist.* Apr 19. 174. Kenward, M. (1980). 'Lessons From Three Mile Island'. *New Scientist.* Jan 17. 146. Torrey, L. (1979). 'The Accident At Three Mile Island'. *New Scientist.* Nov 8. 424–427.

16 The foremost accident was the Tokaimura incident. Llyman, E. (2000). 'Accident Prone'.

The accident at Chernobyl released over 90 million curies of radioactivity, and it was the worst nuclear accident on record. It killed dozens of people in the immediate aftermath, and detrimentally impacted upon the health of thousands who either worked to control the problem, or were encompassed in the radioactivity that spread over large parts of Europe impacting upon both the environment and the people in its path, including the subsequent children of these people, who suffered disproportionate rates of leukemia and cancer.[17] Although there have been strong safety concerns over similar (RBMK) nuclear power plants in the former Soviet Union and its former allies, no further substantial accidents have occurred.[18]

Bulletin of Atomic Scientists. 56(2): 42–47. Hadfield, P. (1999). 'Asking For Trouble'. *New Scientist*. Oct 9. 3, 4. Anon. (1999). 'Nuclear Setback'. *New Scientist*. May 8. 23. Anon. 91997). 'Accident Fallout'. *New Scientist*. Apr 19. 13. Anon. (1997). 'Explosion Rocks Trust in Nuclear Power'. *New Scientist*. March 22. 5. Anon. (2000). 'Tokaimura Death'. *New Scientist*. Jan 8. 5. For other accidents, see Anon. (2004). 'Fresh Nuke Accident In Japan'. *New Scientist*. Aug 14. 4. Mullins, J. (2004). 'Tokyo's Nuclear Crisis'. *New Scientist*. Aug 28. 17. Anon. (1999). 'Japan in Hot Water'. *New Scientist*. July 24. 25. Hadfield, P. (1995). 'Sodium Leak Shuts Japanese Reactor'. *New Scientist*. Dec 16. 7. Hadfield, P. (1996). 'Narrow Escape For Monju Reactor'. *New Scientist*. June 22. 5.

17 Wilkie, T. (1986). 'The World's Worst Nuclear Accident'. New Scientist. May 1. 17–19. Anon. (2000). 'Closing Time'. New Scientist. Dec 16. 7. Perera, J. (1993). 'No Winners At Chernobyl'. *New Scientist*. July 24. 18. Wilkie, T. (1986). 'How Chernobyl Almost Emulated Hiroshima'. *New Scientist*. Sep 4. 17. For the IAEA assessments of the Chernobyl accident, see IAEA special issue, 'Chernobyl in Perspective'. In IAEA Bulletin 1996 (3). Edwards, R. (2003). 'Forests Near Chernobyl Still Under Stress From Fallout'. *New Scientist* Sep 16. 10. Edwards, R. (2003). 'Amorous Worms Reveal the Effect of Chernobyl Fallout on Wildlife'. *New Scientist*. Apr 12. 10. Guterman, L. (1999). 'Back to Chernobyl'. *New Scientist*. Apr 10. 7. Edwards, R. (1996). 'Chernobyl Floods Put Millions At Risk'. *New Scientist*. March 23. 4. Howard, B. (1987). 'May Sheep Safely Graze?' *New Scientist*. Apr 23. 46. Perera, J. (1989). 'Headless Calves Betray the Legacy of Chernobyl'. *New Scientist*. March 4. 27. Milne, R. (1990). 'Fallout Still Contaminates the Fells'. *New Scientist*. Apr 28. 9. Glascow, L. (1990). 'Caesium Seasons Chernobyl Migrant Wildfowl'. *New Scientist*. Dec 22. 8. Shcherbak, Y. (1996). 'Ten Years of the Chernobyl Era'. *Scientific American*. April 32, 33. Webb, J. (1991). 'Chernobyl Findings Excessively Optimistic'. *New Scientist*. June 1. 7. Edwards, R. (1995). 'Will It Get Any Worse?' *New Scientist*. Dec 9. 14. Anon. (1986). 'Chernobyl Deaths'. *New Scientist*. Sep 11. 17. Anon. (1986). 'Chernobyl: The Grim Statistics of Cancer'. *New Scientist*. Aug 14. 13. Simmonds, J. (1987). 'Europe Calculates the Health Risk'. *New Scientist*. Apr 23. 40–41. Anon. (1989). 'Infant Deaths Higher After Chernobyl Accident'. *New Scientist*. Nov 11. 4. Rich, V. (1990). 'Concern Grows Over Health of Chernobyl Children'. *New Scientist*. Apr 21. 7. Anon. (2000). 'Nuclear Fallout'. *New Scientist*. Jan 8. 5. Anon. (1986). 'Fallout Brings Risk of Thyroid Cancer'. *New Scientist*. Sep 20. 17. Anon. (1989). 'Thyroid Cancer and Chernobyl'. *New Scientist*. May 27. 5. Groner, C. (1998). 'When the Dust Settles'. *New Scientist*. Oct 10. 20. Webb, J. (1995). 'Thyroid Cancer Takes Its Toll on Chernobyl's Children'. *New Scientist*. Apr 1. 7. Edwards, R. (1996). 'Mutation Rate Doubled in Chernobyl's Children'. *New Scientist*. Apr 27. 6. Edwards, R. (1995). 'Terrifying Outlook for Chernobyl's Babies'. *New Scientist*. Dec 2. 4. Brown, P. (2001). 'Chernobyl Led to 600% Rise in Mutations'. *Guardian Weekly*. May 30. 12. Anon. (1996). 'Chernobyl's Legacy'. *New Scientist*. July 27. 11. Edwards, R. (2002). 'Are Hundreds of British Baby Deaths and Defects Down to Chernobyl?' *New Scientist*. June 29. 8.

18 Edwards, R. (2004). 'Nuclear Disarray As Europe Pushes East'. *New Scientist*. May 1.

The second concern related to nuclear energy concerns individuals who work at, or live near, nuclear facilities. These facilities may present a risk to some people. This is because of the risk of radiation, which at high levels, can kill cells and lead directly to death. At low levels, it can interfere with a cell's DNA and lead to various forms of cancer. The operative word in the second sentence of this paragraph is 'may'. Debates over lowering or rising the safety limits for doses of exposure to radiation have been ongoing for decades. The basis for this concern has been studies linking some workers at nuclear facilities to disproportionate concentrations of lung and prostate cancer, as well as having children with enhanced concentrations of birth defects and leukaemia.[19]

6–7. Edwards, R. (1999). 'No Entry'. *New Scientist.* Apr 17. 20. Lederman, L. (1996). 'Safety of RBMK Reactors: Setting the Technical Work'. *IAEA Bulletin.* 38 (1): 10–17. Anon. (1979). 'A Czech Three Mile Island'. *New Scientist.* Oct 18. 168. MacKenzie, D. (1993). 'Plutonium Missing After Tomsk Blast'. *New Scientist.* Apr 24. 5. MacKenzie, D. (1993). 'Shades of Chernobyl Stalk Tomsk'. *New Scientist.* Apr 17. 6. Rich, V. (1990). 'Officials Held Back On Soviet Data'. *New Scientist.* Oct 6. 7. Anon. (1992). 'Russia Plays Down Nuclear Accident'. *New Scientist.* March 28. 17. Webb, J. (1992). 'Summit Opens Up Nuclear Free For All'. *New Scientist.* July 18. 7. Rich, V. (1991). 'Czechs Attacked Over "Unsafe" Reactor'. *New Scientist.* Jan 12. 10. MacKenzie, D. (1995). 'Reactor Deal Means Taking Coal to Bulgaria'. *New Scientist.* Nov 4. 10. Patel, T. (1995). 'Crisis Over 'Chernobyl' On the Danube'. *New Scientist.* Oct 14. 4. Anon. (1990). 'Nuclear Warning'. *New Scientist.* Oct 27. 11.

19 Edwards, R. (2004). 'Plutonium Cancer Risk Questioned'. *New Scientist.* July 17. 12. Anon. (2004). 'Costly Clean Up'. *New Scientist.* June 26. 4. Hogan, J. (2003). 'Experts Cannot Agree on Internal Radiation Risk'. *New Scientist.* July 19. 5. Edwards, R. (2003). 'U-Turn Over Radiation Standards'. *New Scientist.* May 3. 10. Moore, L. (2002). 'Lowering the Bar'. *Bulletin of Atomic Scientists.* 58 (3): 28–40. Edwards, R. (2003). 'Background Radiation Enough to Trigger Cancer'. *New Scientist.* Jan 11. 4. Edwards, R. (2000). 'Nuclear Families Get All Clear'. *New Scientist.* Oct 21. Edwards, R. (1999). 'Dead Careless'. *New Scientist.* Jan 9. 5. Fairlie, I. (1997). 'No Dose Too Low'. *Bulletin of Atomic Scientists.* 53 (6): 52–57.Edwards, R. (1997). 'Sellafield Maybe, But Not in my Back Room'. *New Scientist.* Aug 23. 15. Edwards, R. (2002). 'Double Exposure'. *New Scientist.* June 1. 8. Walker, M. (1999). 'The Long View'. *New Scientist.* Oct 16. 12. Edwards, R. (1998). 'Living Dangerously'. *New Scientist.* Feb 28. 12. Edwards, R. (1996). 'Bumper Crop of Sons at Sellafield'. *New Scientist.* Dec 21. 10. New Scientist. (2000). *Inside Science: Radiation and Risk.* (New Scientist., No. 129, March). Edwards, R. (2000). 'Dangerous Work'. *New Scientist.* July 8. 16. Anon. (2000). 'Weapons Warning'. *New Scientist.* Feb 5. 5. Edwards, R. (1999). 'Lethal Legacy'. *New Scientist.* May 29. 22. Goghlan, A. (1999). 'The Cluster Culprit'. *New Scientist.* Aug 21. 5. Pearce, F. (1999). 'Breathe Easy'. *New Scientist.* Jan 16. 13. Edwards, R. (1996). 'Natural Radiation May Kill Thousands'. *New Scientist.* May 4. 7.Pearce, F. (1998). 'Undermining Our Lives?' *New Scientist.* March 14. 320–21. Anon. (1999). 'Nuclear Deaths'. *New Scientist.* March 6. 21. Milne, R. (1989). 'Leukaemia Clusters May Have Genetic Link'. *New Scientist.* June 17. 13. Milne, R. (1992). 'Nuclear Workers Leukaemia Linked to Radiation'. *New Scientist.* Feb 1. 17. Brown, P. (1992). 'Radiation Linked to Long-Term Gene Damage'. *New Scientist.* Feb 22. 13.

Ackland, L. (1993). 'Radiation: How Safe is Safe?' *New Scientist.* May 15. 34. Milne, R. (1987). 'Nuclear Industry Considers Tougher Standards'. *New Scientist.* Sep 3. 25. Patel, T. (1995). 'Clash Over Radiation Safety Limits'. *New Scientist.* Dec 2. 10. Milne, R. (1991). 'Slash Radiation Levels Says Nuclear Watchdog'. *New Scientist.* Dec 7. 16. Editor. (1996). 'A Millisievert A Day'. *New Scientist.* Sep 28. 3. Anon. (1993). 'Hiroshima

The third factor that limits the attractiveness of nuclear energy is the waste it produces. Nuclear waste has been accumulating since 1942, following the first successful experiment of nuclear fission. The waste caused by nuclear fission creates numerous highly radioactive products with half lives (rates of decay) ranging from seconds to centuries. For example, Strontium-90 has a half life of 29 years. Plutonium has a half life of 24,400 years. Technetium-99 is a fission product of uranium, and has a half life of 200,000 years. Globally, about six tonnes of technetium-99 are produced each year. This is part of a global stockpile of about 200,000 tonnes of nuclear waste, which is generated from civil power production (about 75%), and weapon production (about 25%). This stockpile is growing by about 10,000 tonnes per year. It is expected that the United States will possess approximately 110,000 tonnes and the United Kingdom will possess about 500,000 tonnes of 'higher level' waste by 2035.[20]

The difficulty with this waste (and old reactors and contaminated sites) is its final disposal, and possibly its shipments for reprocessing.[21] With regard to its disposal, the problem is that the ability to legally dispose of nuclear waste into the ocean (as opposed to the illegal dumping into the ocean as carried out by the former Soviet Union)[22] as was originally done with all grades of nuclear waste, has become increasingly restricted by both various ocean related conventions, and the London Dumping Convention.[23]

Data Lead to Tighter Radiation Limits'. *New Scientist.* May 1. 6. Vaughan, C. (1990). 'Nuclear Weapons Industry Swept Health Risks Under the Carpet'. *New Scientist.* Jan 6. 8. Anon. (1984). 'US Abandons Tough Limits'. *New Scientist.* Nov 1. 5.

[20] Taylor, A. (2003). 'State Body Planned for Power Station Clean Up'. *Financial Times.* June 21. Edwards, R. (2000). 'Surprises In Store'. *New Scientist.* Apr 29. 5. Edwards, R. (1999). 'Digging A Hole'. *New Scientist.* March 27. 26. Edwards, R. (1999). 'Its Got to Go'. *New Scientist.* March 27. 22–23. Flynn, J. (1997). 'Overcoming Tunnel Visions: Redirecting the US High Level Nuclear Waste Programme'. *Environment.* Apr 5–17. Editors. (1995). 'Disposing of Nuclear Waste'. *Scientific American.* Sep 143.

[21] Edwards, R. (2002). 'Radioactive Blunders Double in a Decade'. *New Scientist.* Feb 9. 6. O'Neil, K. (1999). 'International Nuclear Waste Transportation'. *Environment.* May. 11–23. Editor. (1996). 'Not in Anyone's Backyard'. *New Scientist.* May 18. 3. Edwards, R. (1999). 'Meltdown'. *New Scientist.* Sep 9. 13. Edwards, R. (2000). 'Stash or Burn?' *New Scientist.* Nov 11. 5. Kiernan, V. (1996). 'Reactors Will Burn Old Bombs'. *New Scientist.* Dec 14. 5. Edwards, R. (1995). 'German Research Undermines World Peace'. *New Scientist.* July 1. 10.

[22] Livingston, T. (1998). 'Tomorrow's Oceans'. *IAEA Bulletin.* 40 (3). 2. cf. Edwards, R. (1998). 'Hot Waters'. *New Scientist..* May 9. 11. Povinec, P. (2000). 'Marine Scientists on the Arctic Seas: Documenting the Radiological Record'. IAEA Bulletin. Available from the IAEA website http://www.iaea.org/worldatom/ Povinec, P. et al. (1998). Worldwide Marine Radioactivity Studies: Assessing the Picture'. *IAEA Bulletin.* 40 (3). 11, 14. 1992 *YBIEL.* 3: 305. 4 *YBIEL.* (1993). 183–184. MacKenzie, D. (1994). 'Doubts Lurk in Graveyard for Nuclear Subs'. *New Scientist.* March 12. 4–5. Anon. (1993). 'Row Over Sunken Nuclear Sub'. *New Scientist.* September 18. 7. Anon. (1993). 'Whole Reactor Lurks Under Barents Sea'. *New Scientist.* Feb 13. 9. MacKenzie, D. (1993). 'Russia Owns Up to Sea Burial for Nuclear Waste'. *New Scientist.* April 17. 5.

[23] 1958 Convention on the High Seas. *UNTS.* No. 6465. Volume 450: 82–103. Article 25.

Disposal of waste is also prohibited in certain areas, such as Antarctica.[24] In addition, the ability of countries to trade or pay for the final disposal of nuclear waste (as opposed to its reprocessing) in other countries other than where it was generated, remains unlikely. This is despite numerous attempts to investigate such options.[25]

Due to the restricted options for the disposal of nuclear waste, countries have been forced to dispose of their waste on land in suitable geological formations.[26] Although the Nuclear Waste Convention offers guidance for the disposal of such waste, the Convention is limited to national reporting requirement with a peer-review process.[27] Thus, the ultimate standards of geological disposal of nuclear waste are nationally, not internationally, determined. Unfortunately, this has not made the situation easier as the successful long term disposal of such waste has proved increasingly problematic with the key sites in both the United Kingdom (Sellafield)[28] and

London Dumping Convention Resolution 14(7), 1983 & Resolution LDC 21(9), 1985. Agenda 21. Chapter 22. Paragraph 22.5. Editorial. (2000). 'What a Waste'. *New Scientist.* Feb 26. 2. Edwards, R. (2000). 'Dead in the Water'. *New Scientist.* Feb 26. 16–18. 1994 *YBIEL.* 5: 182–183. 1998 *YBIEL.* 9: 199. Edwards, R. (1995). 'Leaky Drums Spill Plutonium on Ocean Floor'. *New Scientist.* July 22. 5. Pearce, F. (1983). 'Not In My Backyard'. *New Scientist.* 350. Note, some countries such as the United Kingdom have continued to allow emissions of low level nuclear waste into the ocean to continue.

[24] Antarctic Treaty. 402 UNTS. 71. Article 5. Note, the 1991 Protocol on Environmental Protection to the Antarctic Treaty. BH992.txt, Annex III, Article 2.

[25] Edwards, R. (2004). 'Fury At UK's Plans To Ship Hot Waste Out to Kyrgyzstan'. *New Scientist.* Sep 25. 15. Anon. (2004). 'Nuclear Waste? No Thanks'. *New Scientist.* Oct 16. 5. Anon. (2004). 'Tibet Is Nuclear Dump'. *New Scientist.* Oct 9. 5. Webster, P. (2002). 'The Grab for Trash'. *Bulletin of Atomic Scientists.* Sep. 33–37, Josephson, P. (2002). 'Dreams of Glory'. In the same edition, 40–45. Glasser, S. (2001). 'Russian Seek Windfall From Nuclear Waste'. *New Scientist.* Feb 22–28. 29. McLaren, B. (1999). 'Nuclear Dilemma'. *New Scientist.* Jan 16. 12. Edwards, R. (1998). 'The World's Dustbin'. *New Scientist.* Jan 31. 11. Milne, R. (1992). 'Storing Eastern Waste'. *New Scientist.* Feb 8. 18. Edwards, R. (1999). 'Its Got to Go'. *New Scientist.* March 27. 22–23. Anon. (1987). 'Gobi Grave For Nuclear Waste'. *New Scientist.* July 23. 17. Anon. (1984). 'Chinese Laundry Opens For European Nuclear Waste'. *New Scientist.* Feb 18. 3. Perera, J. (1985). 'China and Sudan Want Germany's Nuclear Waste'. *New Scientist.* Sep 5. 24.

[26] Edwards, R. (1999). 'Digging A Hole'. *New Scientist.* March 27. 26. Edwards, R. (1998). 'The Amazing Journey'. *New Scientist.* Aug 29. 11. Edwards, R. (1997). 'Gas Build Up Fear Puts Pressure on Nirex'. *New Scientist.* Jan 11. 11. Bower, S. (1993). 'Nuclear Dump Could Pollute Water'. *New Scientist.* May 22. 9. Milne, R. (1992). 'Nuclear Waste May Rise from the Grave'. *New Scientist.* Apr 25. 6. Chapman, N. (1990). 'Radioactive Waste: Back to the Future'. *New Scientist.* May 5. 36–39. Cohen, B. (1977). 'The Disposal of Radioactive Wastes from Fission Reactors'. *Scientific American.* 236: 21–30.

[27] 6 *YBIEL.* (1995): 268–269. 9 *YBIEL.* (1998): 225–226. 10 *YBIEL.* (1999): 269–272.

[28] Edwards, R. (1999). 'Trouble in Store'. *New Scientist.* Jan 2. 7. Edwards, R. (1999). 'End of the Line' *New Scientist.* Dec 4. 5. Anon. (1997). 'Nirex Thwarted'. *New Scientist.* March 22. 2, 13. Edwards, R. (1996). 'Sellafield's Trojan Horse'. *New Scientist.* Jan 6. 11. Anon. (1996). 'Waste Warning'. *New Scientist.* Nov 16. 11. Edwards, R. (2000). 'Nuclear Muddle'. *New Scientist.* Sep 9. 14. Edwards, R. (1998). 'High Level Risk'. *New Scientist.* June 20. 13. Brown, P. (2001). 'Nuclear Plants Shut Down'. *Guardian Weekly.* Sep 27. 9. Webb, J. (1993). 'The Battle of Britain's Nuclear Dustbin'. *New Scientist.* Nov 6. 14–15.

the United States (Hanford),[29] as well as in other countries,[30] having less than satisfactory safety records.

The fourth collection of difficulties with nuclear energy relate to multiple concerns about armed conflict. The first issue here is that civilian nuclear generating facilities may not be used for peaceful purposes, as originally envisaged, and may be misused to create nuclear weapons. This scenario occurred with India, Pakistan and North Korea, and almost occurred with Iraq, Libya and Iran.[31] A similar threat exists for nuclear material involved in reprocessing.[32] Although the IAEA has increasingly sought to control this problem, the threat of nuclear proliferation remains paramount due to the currently weak international framework for nuclear security.[33] The second issue is that due to the possible creation of nuclear weaponry from civilian nuclear sources, some countries such as Israel, view civilian nuclear power plants in some of their neighboring countries, as clear military threats which merit pre-emptive defensive strikes. The third issue relates to civilian nuclear facilities becoming enhanced terrorist targets.[34] This problem became much more pronounced following the terrorist attacks in the United States on September 11, 2001. For example, if a large aeroplane struck the high level waste tank at Sellafield, radioactivity 44 times greater than that released with Chernobyl could occur. Even if less dramatic approaches were adopted,

---

[29] Carpenter, T. (2004). 'Don't Breathe The Air'. *Bulletin of Atomic Scientists*. May 24–28. Zorpette, G. (1996). 'Hanford's Nuclear Wasteland'. *Scientific American*. Anon. (1989). 'Fears for Safety'. *New Scientist*. June 10. 6. For the possible move to Yucca Mountain, see Anon. (2002). 'Hotter in Nevada'. *New Scientist*. Feb 23. 7. O'Hanlon, L. (2002). 'Yucca Nuclear Dump On Shaky Foundations'. *New Scientist*. Apr 20. 11. Mason, B. (2002). 'Yucca Mountain Could Become Nuclear Volcano'. *New Scientist*. Aug 24. 9. Flynn, J. et al. (1997). 'Overcoming Tunnel Visions: Redirecting the US High Level Nuclear Waste Programme'. *Environment*. Apr. 5–17. Whipple, C. (1996). 'Can Nuclear Waste Be Stored Safely At Yucca Mountain?' *Scientific American*. (June) 56–64.

[30] Edwards, R. (1997). 'Nuclear Fuel Festers in Serbia'. *New Scientist*. March 22. 7. Anon. (1996). 'Hot Secrets'. *New Scientist*. Jan 6. 12. Hughes, S. (1990). 'French Come Clean Over Contamination'. *New Scientist*. Dec 1. 8. Toro, T. (1991). 'Germany Forces Nuclear Waste Underground'. *New Scientist*. July 6. 18.

[31] See Hewlett, R. G. *Atoms For Peace and War, 1953–1961: Eisenhower and the Atomic Energy Commission* (University of California Press, Berkeley, 1989).

[32] See Reparaz, A. (2003). 'Between MOX and a Hard Place'. *Bulletin of Atomic Scientists*. 59 (5): 46–52.

[33] Edwards, R. (2003). 'A Struggle For Nuclear Power'. *New Scientist*. Mar 22. 6–7. Priest, D. (2002). 'Iran Reactor May Test First-Strike Doctrine'. *Herald Tribune*. July 30. 1–2. MacKenzie, D. (1988). 'German Nuclear Scandal Deepens'. *New Scientist*. Jan 21. 23. MacKenzie, D. (1988). 'Corruption Fuels Radiation Scandal'. *New Scientist*. Jan 14. 29. Anon. (1997). 'Nuclear Spot Checks'. *New Scientist*. Feb 8. 11. Muller, H., (et al.) *Nuclear Non-Proliferation and Global Order* (SIPRI, Oxford University Press, 1994), 22–26. Arms, T. (1982). 'Politics and Plutonium: A Fissile Mixture'. *New Scientist*. Dec 9. 630.

[34] Lloyd, A. (1982). 'France's Breeder Unscathed By Bazooka Attack'. *New Scientist*. Jan 28. 212. Anon. (1986). 'Advanced Technology is Terrorists Target'. *New Scientist*. July 17. 15. Anon. (1987). 'Orthodox Warfare Could Decimate Europe'. *New Scientist*. Mar 26. 23.

(such as draining the cooling ponds, causing the fuel to overheat and melt) massively detrimental impacts could still result.[35]

Finally, due to all of the above risks and concerns, the full financial costs of nuclear energy have become increasingly unattractive, and without subsidies, it is dubious whether it can compete in the free market against alternative energy sources. It is projected that once the full economic costs of nuclear energy are factored in, that by 2020, nuclear energy could cost (3.0 to 4.5 pence per kilowatt hours) more than double the comparable financial costs for on-shore wind energy (1.5 to 2.5) and more expensive than offshore wind energy (2.0 to 4.0). It may even be more expensive than wave energy (3.0 to 6.0).[36]

B. Non-Nuclear New Energy Sources

It would be misleading to suggest that non-nuclear new energy sources are entirely environmentally benign. All renewable energy sources may have positive or negative effects on biodiversity depending upon site selection and management practices.[37] The foremost example of problems in this area is with wind farms which may have impacts upon, inter alia, aesthetics, noise, and animals which fly.[38] Accordingly, the Convention on Migratory

[35] Anon. (2005). 'Nuclear Exposure'. *New Scientist.* Apr 16. 7. Edwards, R. (2004). 'Jet Crash Could Kill Millions'. *New Scientist.* May 29. 8–9. Anon. (2004). 'No Time to Act'. *New Scientist.* July 10. 4. Editor. (2002). 'How Secure Are Nuclear Plants From Terrorists?' *Scientific American.* Jan 79. Edwards, R. (2001). 'The Nightmare Scenario'. *New Scientist.* Oct 13. 10–12. Editor. (1998). 'Safe In Whose Hands?' *New Scientist.* May 2. 3. Hughes, S. (1990). 'The Day The Commandos Dropped Into a French Nuclear Plant'. *New Scientist.* Apr 28. 6. Pearce, F. (1982). 'Sizewell: Beware Low-Flying Aircraft'. *New Scientist.* Nov 11. 343.

[36] Edwards, R. (2005). 'Nuclear Clean-Up Risks Public Safety'. *New Scientist.* Feb 12. 13. Hogan, J. (2004). 'Is the Green Dream Doomed to Fail?' *New Scientist.* July 17. 6–7. Edwards, R. (2003). 'America Steels Itself to Take the Nuclear Plunge'. *New Scientist.* 10–13. Edwards, R. (2002). 'Secret Plans To Revive British Nuclear Power Industry'. *New Scientist.* July 6. 14–15. Anon. (2003). 'Fact and Fission'. *Economist.* July 19. 11–12. Anon. (2002). 'Fallout'. & 'A Dark Day in Britain'. *Economist.* Sep 14. 12, 47–48. Edwards, R. (2002). 'Hidden Nuclear Costs'. *New Scientist.* March 2. 7. Edwards, R. (2001). 'Death Knell Sounds For Nuclear Energy'. *New Scientist.* Dec 15. 5. Editor. (2001). 'Squeaky Clean: Nuclear Power Just Doesn't Make the Grade'. *New Scientist.* Dec 15. 3. Farber, D. (2001). 'A Graceful Exit: Decommissioning Nuclear Power Reactors'. *Environment.* July. 8–21. Alvarez, R. (2000). 'Energy In Decay'. *Bulletin of Atomic Scientists.* 56 (3): 24–36.

[37] CBD. (2003). Interlinkages Between Biological Diversity and Climate Change. (CBD Technical Series No 10, Montreal). 7.

[38] IPCC. (2003). *Climate Change and Biodiversity*. (IPCC, Technical Paper V, Geneva). 40. Hill, A. (2004). The Debate on Wind Farms. *Ecologist.* March 24–28. Randerson, J. (2002). 'Defence of the Realm'. *New Scientist.* Apr 27. 8. Clarke, A. (1989). 'How Green Is The Wind'. *New Scientist.* May 27. 36–40. Grubb, M. (1988). 'The Wind of Change'. *New Scientist.* March 17. 43. Anon. (1988). 'Wind Parks Run Into a Storm'. *New Scientist.* March 31. 19. Anon. (1988). 'Wind Power on Trial'. *New Scientist.* Apr 28. 27.

Species passed a resolution on Wind Turbines and Migratory Species, which set down a series of guidelines for the placement of wind turbines (not in the path of vulnerable species) within broader environmental impact assessment goals.[39] In a similar vein, the fourth MOP of the Agreement on the Conservation of Populations of European Bats, while recognizing the environmental benefits of wind turbines, was clearly concerned about the possible negative impacts of wind turbines on bat populations as well as their prey and habitats in terms of destruction and disturbance of roosts and commuting corridors. Accordingly, until guidelines for this interrelationship were developed, the MOP urged a precautionary approach in the development of wind turbines that could affect bat populations.[40] In response to some of these problems, in addition to changes in design, wind turbines have been moved increasingly to offshore locations. However, even in these locations, concerns about their impact on the local environment, including marine mammals where resident, remains in some instances.[41]

Similar concerns exist for tidal energy. In particular, if the energy sources are not carefully designed, tidal power systems may confuse and kill migratory fish which have to try to pass through the turbines to access estuaries of seas. In addition, navigation channels may become blocked or disrupted and local ecosystems and wildlife may face changing situations.[42]

The biggest disincentive to the large scale adoption of new, non-nuclear technologies is their financial costs. That is, unless the communities utilizing the energy of solar or ocean sources are not connected to the main energy grid, then despite rapidly falling prices, both solar and ocean energy sources are currently not economically competitive. Although this may not be the case for ocean energy by 2020, it may take longer for solar energy to become directly competitive with mainstream energy sources.[43] Conversely,

---

[39] CMS. Wind Turbines and Migratory Species. UNEP/CMS/Res.113. For further discussion in this area, see SBSTTA. Biological Diversity and Climate Change. UNEP/CBD/SBSTTA/9/INF/12. Sep 30. pp. 68–69.

[40] Resolution 4.7. Wind Turbines and Bat Populations. Report of the Fourth Session of the MOP to EUROBATS, 2003. Available from the Secretariat, at http://www.eurobats.org/. p. 50.

[41] Fleming, N. (2003). 'Crunch Time Looms for Offshore Wind Power'. *New Scientist.* Dec 6. 30–34. Williams, W. (2002). 'Blowing Out to Sea'. *Scientific American.* March. 15–16. Roosevelt, M. (2002). 'Not In My Back Bay'. *TIME.* Sep 30. 46. Anon. (1999). 'Blowing Strong'. *New Scientist.* Oct 19. 25. Hamer, M. (1994). 'Floating Windfarm Awaits Fans'. *New Scientist.* Apr 16. 21. Flood, M. (1990). 'Danish Wind Farms Head Out to Sea'. *New Scientist.* Oct 20. 18. Randerson, J. (2003). 'Turbines To Get Stealthy'. *New Scientist.* Aug 9. 6. With regards to marine mammals, see the Scientific Committee report from the International Whaling Commission. Report of the SC. IWC/55/Rep 1. 27.

[42] Anon. (2003). 'Tidal Energy'. *Ecologist.* July 48. Middleton, N. (2001). 'New Wave Energy'. *Geographical.* Jan 52–56.

[43] Pearce, F. (1998). 'Catching the Tide'. *New Scientist.* June 20. 38–41. Vidal, J. (2001).

the financial costs of wind energy (especially that which is land based) have consistently fallen, and it has, in a number of instances, been economically competitive with non-subsidized conventional energy sources since the mid 1990s. It is anticipated that it will become even more economically competitive in the longer term.[44]

2. Technological Limits for Air Pollution and Climate Change

A. Stationary Sources

The first option available for dealing with air pollution from stationary sources was to build taller chimneys. However, this option has been unpopular since 1972 when the United Kingdom's Department of the Environment conceded that this option did not solve the problem, it only moved it elsewhere.[45] Ten years later, the 1982 Stockholm Conference on the Acidification of the Environment deemed the 'tall chimney' solution unacceptable, as a method to deal with transboundary air pollution.[46] The second option of capturing the pollutants with catalysts. However, although the pollutants may be captured, the process generates large amounts of waste. Despite the fact that some forms of this waste may be recycled into new products, most of it has to be disposed of elsewhere.[47] The third technological option of increased temperature combustion processes, may be problematic if not done correctly, as it may generate other air pollutants.[48] Finally, the utilization of neutralizing agents, such as with lime, may not only have an impact on the ecosystems from where the limestone is extracted, they may

'Out Of Thin Air'. *Guardian*. Oct 31. 8–9. Webb, J. (1995). 'Anchors Aweigh For Wave Power Pioneers'. *New Scientist*. July 29. 6. Fell, N. (2003). 'Sun Block'. *New Scientist*. May 10. 38–41. Weinberg, C. (1990). 'Energy From the Sun'. *Scientific American*. Sep. 98–110. Anon. (1978). 'US Orders Cut Solar Cell Costs'. *New Scientist*. Jan 12. 70.

[44] Hogan, J. (2004). 'Is the Green Dream Doomed to Fail?' *New Scientist*. July 17. 6–7. Knott, M. (2000). 'Shore Bet'. *New Scientist*. Sep 23. 16–17. Gibbs, W. (1997). 'Change In the Wind'. *Scientific American*. Oct. 23. McGowan, J. (1993). 'America Reaps The Wind Harvest'. *New Scientist*. Aug 21. 30–34. Webb, J. (1995). 'Falling Prices Herald Backyard Windmills'. *New Scientist*. Jan 7. 8.

[45] Department of the Environment. (1972). *Pollution: Nuisance of Nemesis*? (HMSO, London). 27.

[46] Swedish Ministry of Agriculture. (1982). *The 1982 Stockholm Conference on the Acidification of the Environment*. (Stockholm). 19.

[47] Anon. (1990). 'Thatcher Says Don't Jump To Conclusions'. *New Scientist.*. March 24. 6. Milne, R. (1988). 'Filters For Air Pollutants Will Add to River Contamination'. *New Scientist*. April 14. 23. Pearce, F. (1984). 'Coal Board's Fibs About Clean Coal'. *New Scientist.*. Nov 8. 3.

[48] 1988. Sophia Protocol. Technical Annex. Paragraph 31.

also only be effective on certain ecosystems, while actively harming others, such as forests.[49]

There are a number of limits with regards to the removal of CO_2 from stationary sources. Aside the economic costs, technologies which remove the carbon from fossil fuel emissions also generate a large amount of waste in the process. The current favored disposal option for this waste, is placement underground or under the ocean floor. However, this may have a detrimental impact on marine ecosystems by either killing wildlife or dissolving parts of the seabed. In the long term, the placement may not be secure due to changing ocean conditions, and the option may be illegal under a number of global and regional ocean related treaties.[50]

B. Mobile Sources

As discussed in the previous chapter, one of the most effective ways to reduce air pollutants from mobile sources is to change the types of fuels utilized. The first example in this category, is with oxygenates or biofuels. Although these fuels appear to have many theoretical benefits in reducing air pollutants such as CO and NOx, there is strong debate over the exact savings that oxygenates generate. The evidence suggests that their impact in terms of reduction of air pollutants is often less than 5%.[51] At the same time, if the oxygenates do not burn completely, they may enhance emissions of some VOCs.[52] Some oxygenates, such as MTBE, and possibly ethanol, can also cause other environmental problems such as water pollution by leaking from petrol storage tanks.[53] Finally, the manufacture of

---

49 MacKenzie, D. (1994). 'Experts Clean Up As Eastern Europe Stays Dirty'. *New Scientist.* April 9. 8–9. Woodin, S. (1990). 'Liming Fails the Acid Test'. *New Scientist.* March 10. 30. MacKenzie, D. (1998). 'Not the Rain'. *New Scientist.* May 16. 22. Pearce, F. (1986). 'Unravelling A Century of Acid Pollution'. *New Scientist.* Sep 25. 23–24. Woodin, S. (1990). 'Liming Fails the Acid Test'. *New Scientist.* March 10. 30.

50 Anon. (2002). 'Norway'. *New Scientist.* July 20. 12. Jones, N. (2001). 'Carbon Sunk'. *New Scientist.* June 30. 19. Anon. (2001). 'Stuck On A Reef'. *New Scientist.* March 3. 7. Jones, N. (2001). 'A Risk Too Far'. *New Scientist.* Oct 20. 7. IPCC. (1996) *Climate Change 1995: Impacts, Adaptations and Mitigation.* (Cambridge University Press, Cambridge). 15. Pearce, F. (1998). 'Cooling It'. *New Scientist.* July 18. 18. Pearce, F. (1993). 'The High Cost of Carbon Dioxide'. *New Scientist.* July 17. 26–27. Anon. (1991). 'Sweeping Carbon Dioxide Under the Ground'. *New Scientist.* June 1. 9.

51 Hecht, J. (1999). 'Ozone-Busting Fuel Proves a Damp Squib'. *New Scientist.* May 22. 20. Meyer, C. (1993). 'Rough Road Ahead For Biodiesel Fuel'. *New Scientist.* February 6. 19. Patel, T. (1993). 'France Placates Farmers With Plant Fuel Plan'. *New Scientist.* February 27. 18. Selincourt, K. (1993). 'Europe's Home Grown Fuel'. *New Scientist* October 16. 22–23.

52 Acetaldehyde, formaldehyde and proxy-acetyl nitrate in particular. See Hamer, M. (1996). 'No Respite from Smogs'. *New Scientist.* April 6. 5. Milgrom, L. (1989). 'Clean Car Fuels Run Into Trouble'. *New Scientist.* April 8. 30.

53 Anon. (2002). 'Easy on the Alcohol'. *New Scientist.* March 16. 11. Zandonella, C. (2001).

oxygenates often comes at a large environmental cost, in terms of the energy spent to make a litre of ethanol, as well as additional environmental and economic costs of the land and processes required to make ethanol or other biofuels.[54]

The second example in this category involves the advocacy of diesel fuels. The problems with this fuel is that unlike earlier predictions, diesel and the SPM that it creates, has been shown to have strong indirect feedbacks into climatic change. In particular, 1 gramme of black carbon is between 360,000 and 840,000 times as powerful a global warming agent as 1 gramme of CO_2. Thus, although diesel engines emit less CO_2 than petrol engines, by comparison, they emit large amounts of SPM. This SPM may make diesel fuels responsible, on a comparative basis, for a larger impact on climate change than their petroleum based competition.[55] In addition SPM, as discussed in chapter five of this book, has distinct health implications.

Either independently, or in conjunction with fuel substitution, one of the more common modifications of technology to reduce air pollution from mobile sources is catalytic converters or particle traps and/or methods to increase fuel efficiency. Although each of these options can make impressive reductions in air pollutants, they remain limited by a series of factors.

First, although CCs are becoming increasingly refined and can work at lower temperatures, or have instant heat when the engine is started, earlier models of CC produced debatable benefits.[56] This was because earlier CCs were limited by the fact that if they did not have time to warm up,

---

'Going Up In Smoke'. *New Scientist.* Aug 18. 17. Bergeron, L. (1997). 'The Dirt on Clean Fuel'. *New Scientist.* Nov 22. 24–25.

[54] In terms of energy consumption, it takes 36,500 kilojoules of energy to make one litre of ethanol, which in itself it produces only 21,400 kj when burnt. Zandonella, C. (2001). 'Going Up In Smoke'. *New Scientist.* Aug 18. 17. Anon. (2001). 'Hemp Power'. *New Scientist.* July 28. 17. Johnson, F. (1998). 'Sugar Cane Resources: A Sustainable Energy Option'. *Renewable Energy for Development.* 11 (2): 1. Gabra, M. (1995). 'Sugarcane Residual Fuels: A Viable Alternative in the Tanzanian Sugar Industry'. *Renewable Energy for Development.* 8 (2): 5–6. Cornland, D. (1997). 'Alcohol Fuels for Environment: A Viable Alternative in Developing Countries?' *Renewable Energy for Development.* 10 (3): 1–3. Anon. (1988). 'Green Engines'. *New Scientist.* Feb 14. 15. Hamer, M. (1996). 'No Respite From Smogs'. *New Scientist.* Apr 6. 5. Homewood, B. (1993). 'Brazil Goes Sweet on Electricity'. *New Scientist.* September 18. 8. Anon. (1981). How Brazil's Gasohol Scheme Backfired'. *New Scientist.* July 16. 132. Rosillo-Calle, F. (1988). 'Brazil Finds a Sweet Solution to Fuel Shortages'. *New Scientist.* May 19. 41–44. Stockholm Environment Institute. (1996). *Alcohol as an Alternative Transportation Fuel: Operational Issues in Developing Countries.* (SEI, Sweden). Hamer, M. (1984). 'The Alcoholic Car of the Future'. *New Scientist.* April 19. 24 Homewood, B. (1993). 'Will Brazil's Cars Go On The Wagon?' *New Scientist.* January 9. 22–23.

[55] Jones, N. (2002). 'Diesel's Dirty Green Surprise'. *New Scientist.* Nov 2. 9. Joyce, C. (1980). 'Foggy Future for Diesel Cars'. *New Scientist.* October 9. 79.

[56] Nowak, R. (2000). 'Little Gem'. *New Scientist.* Oct 7. 11. Bradly, D. (1996). 'Cool Cats Mean Cleaner Diesel'. *New Scientist.* Sep 7. 22. Note, that the actual chemical catalysts

they would not work. This failure to 'ignite' was/is typically due to short vehicle journeys. Accordingly, the CC would not fully burn the pollutants they were intended to target and could actually enhance the emission of other pollutants, such as NOx and CO_2, whilst also making the vehicles slightly more energy inefficient, thus requiring increased fuel consumption.[57] Similar problems exist for the CC equivalent for diesel burning vehicles, particle traps. These are also limited by having to warm before they operate effectively. In addition, particle traps do not capture CO_2, and they are not, as yet, more successful at reducing overall air pollutants, compared to a conventional petroleum based vehicle with a CC.[58]

Second, with both CCs and particle traps, unless the best examples of these technologies are quickly phased onto all appropriate mobile sources of air or climate pollution, the savings achieved by the most modern technologies are quickly eclipsed by vehicles which are both older and more inefficient. In some instances, a few individual vehicles can be responsible for a disproportionate amount of pollution. For example, in Los Angles in the early 1990s, 3% of the cars were responsible for over 50% of the air pollution. Unless these older and inefficient vehicles are strictly regulated, all savings of the best modern technologies are lost.[59] The same problem applies with energy efficiency savings for mobile sources of pollution, in that unless the vehicle fleet has a quick turnover, the savings are eclipsed by older, more inefficient vehicles.[60] In addition, the growth of the overall vehicle modern fleet may be so large, that the pollution reductions by

have an environmental footprint. As a rough comparison, it has been suggested that a car must travel 4900 km before the benefits outweigh the costs of the production of the CC. MacKenzie, D. (1997). 'Off To A Dirty Start'. *New Scientist.* Sep 20. 13.

57 Pearce, F. (1998). 'Catalyst For Warming'. *New Scientist.* June 13. 20. Pearce, F. (1996). 'Cars Still Choke Towns'. *New Scientist.* July 13. 6. Gould, R. (1989). 'Greener Cars May Warm the World'. *New Scientist.* May 20. 16. Pearce, F. (1986). 'Stalled in a Haze of Ozone'. *New Scientist.* November 20. 18. Stansell, J. (1983). 'Clean Cars Reach Crossroads'. *New Scientist.* November 24. 564–567. Anon. (1986). 'Ford Invests in Lean Burn Engines'. *New Scientist.* October 23. 20. Pearce, F. (1985). 'Exhaust Pact'. *New Scientist.* May 9. 4. Hamer, M. (1985). 'Europe Fights Over Exhaust Laws'. *New Scientist.* June 27. 5.

58 Koch, G. (2004). 'Clean Diesel Engines Dirtier Than Gas Guzzlers'. *New Scientist.* Jan 31. 15. Hamer, M. (1998). 'Particle Trap'. *New Scientist.* Feb 21. 6.

59 Bell, D. (2004). 'Clearing the Air: How Delhi Broke the Cycle'. *Environment.* Apr. 22–30. Patel, T. (1997). 'India's Rickshaws Clean Up Their Act'. *New Scientist.* Feb 15. 7. 10 *YBIEL.* (1999). 538 Anon. (2000). 'Ban on Transport Vehicles'. *Environmental Policy and the Law.* 30 (6): 294. World Resources Institute, UNEP, World Bank. (1997). *World Resources 1996–1997.* (Oxford University Press). 97–98. Edwards, R. (1994). 'German Banger Ban Cuts Pollution'. *New Scientist.* Aug 20. 9. Anon. (1993). 'Dirty Buses'. *New Scientist.* Jan 16. 11. The importance of this area is also reflected in the VOC Protocol. 1991. Annex III. Paragraph 7 and the Sophia Protocol. Technical Annex. Paragraph 61–64.

60 Plotkin, S. (1989). 'The Road to Fuel Efficiency in the Passenger Vehicle Fleet'. *Environment.* July/August. 17, 20.

either CCs, particle traps or energy efficiency, may be eclipsed within the increased supply of new vehicles, irrespective of the older fleet. This problem is also apparent with other forms of mobile source pollution, such as air transport. For example, between 1990 and 2015, global passenger air travel is projected to grow by about 5% per year, whereas total aviation fuel use is projected to grow by only 3% per year, due to improved aircraft efficiency.[61] Finally, in both stationary and mobile instances, greater efficiencies may make the cost of energy cheaper, and ironically, this may actually lead to an increase in the demand for more, not less, energy.[62]

Linked into the above problem is that consumer demand for both clean or efficient mobile or stationary pollutant sources is often fickle. The best example of this is with energy efficient motor vehicles. In this area, consumer interest in lighter more energy efficient vehicles has retreated as fuel has remained relatively cheap, and consumers have opted for vehicles which are heavier, more powerful and with added luxuries. Accordingly, by the end of the twentieth century in the United States, fuel efficiency was on average, the 15th consideration by consumers in criteria as they looked for a new car.[63] Moreover, if the new car, such as Sports Utility Vehicles could be classified to avoid some of the efficiency requirements imposed on other comparable vehicles, due to having only to achieve the fuel efficiency standards of a truck, then consumer demand will (and has) been so large, that the average fuel efficiency in the United States at the end of the century actually fell from a high of 25.9 mpg in 1998, down to 23.8 mpg.[64]

With regard to the more realistic alternative LEVs, a number of limitations remain, despite substantive progress made over a number of decades. The commercial adoption of EVs is still constrained by practical problems relating to the physical size and weight of the battery, battery range, battery recharging time, the lack of recharging facilities, vehicle speed, and economic expense (they are about a fifth higher in cost than their comparable petroleum competition).[65] In addition, although EVs produce minimal air

[61] IPCC. (1999). *Aviation and the Global Atmosphere*. (Cambridge University Press, Cambridge). 4.

[62] Pearce, F. (1998). 'Consuming Myths'. *New Scientist.* Sep 5. 18–19. Editor. (1998). 'There's No Avoiding A Carbon Tax'. *New Scientist.* Sep 5. 3. IPCC. (1996) *Climate Change 1995: Impacts, Adaptations and Mitigation*. (Cambridge University Press, Cambridge). 13.

[63] Henderson, C. (1998). 'Small Is Still Beautiful'. *New Scientist.* April 25. 18–19.

[64] Harrington, W. (2003). 'A Lighter Tread: Policy and Technology Options for Motor Vehicles'. *Environment.* Nov 22–35. Plotkin, S. (2004). 'Is Bigger Better? Towards A Dispassionate View of SUVs'. *Environment.* Nov 9–20. Ottinger, R. (2000). 'Legal Structures in Use for Climate Change Mitigation'. *Environmental Policy and the Law.* 30 (4): 184, 186.

[65] Ashley, S. (2005). 'The Road To Fuel Cell Cars'. *Scientific American.* March. 50–60. Daviss, B. (2003). 'This Bus Will Run and Run'. *New Scientist.* May 24. 32–34. Hecht, J. (1999).

pollutants, they still have an environmental impact in terms of the manufacture and eventual disposal of the battery,[66] and of course, the energy source from which the electricity is generated, may still be contributing emissions to air pollution and/or climate change. Very similar difficulties remain with hydrogen vehicles, in that although the fuel may only produce minimal air or climate pollutants (although the latter is a source of debate), the creation of the fuel for use is still linked to the energy source that created the hydrogen.[67] In addition, considerable practical problems relating to safe storage tanks within hydrogen powered vehicles and the lack of refueling facilities remain.[68]

The final modification of technology, designed to reduce either air or climate pollutants from mobile sources, is public transport or alternative methods of transport such as cycling or walking. The success of public transport relies upon practical considerations that include efficiency, convenience, safety, cost and most importantly, speed. Safety and facilitation are essential for increasing cycling and walking.[69] Lastly, appropriate incentive and disincentive schemes must be operated to manage the flow of conventional motor vehicles, so that their overall numbers do not completely overwhelm themselves and competing forms of transport. The most

'Raring to Go'. *New Scientist.* Apr 24. 14. Fitzpatrick, M. (1999). 'Charge of the Light Brigade'. *New Scientist.* Sep 11. 6. Grant, I. (1998). 'The Charge of the Battery Car'. *New Scientist.* Oct 10. 22. Sperling, D. (1996). 'The Case For Electric Vehicles'. *Scientific American.* Nov 36–42. Hamer, M. (1995). 'Electric Buses'. *New Scientist.* Dec 23. 6. Goss, H. (1995). 'Charged Up In Minutes Flat'. *New Scientist.* July 15. 7. Mestel, R. (1994). 'All Charged Up and Nowhere to Go'. *New Scientist.* Dec 3. 14. Howard, G. (1992). 'Flat Out for the Car of the Future'. *New Scientist.* November 7. 21–22.

66 Hecht, J. (1995). 'Fears Over Lead From Electric Cars Unfounded'. *New Scientist.* May 20. 10. Glanz, J. (1995). 'Check the Tires and Charge Her Up'. *New Scientist.* Apr. 15. 32–33. Anon. (1994). 'Repellent Catalysts Could Speed Electric Cars'. *New Scientist.* Oct. 5. 23. Hamer, M. (1996) 'Germans Pull Plug on Britain's Batteries'. *New Scientist.* June 1. 6. Howard, G. (1992). 'The Car of the Future'. *New Scientist.* November 7. 21–22.

67 Randerson, J. (2004). 'Hydrogen: Savior or Fatal Distraction'. *New Scientist.* Aug 21. 12.Wald, M. (2004). 'Questions About a Hydrogen Economy'. *Scientific American.* May. 40–45. Ananthaswamy, A. (2003). 'Reality Bites for the Dream of a Hydrogen Economy'. *New Scientist.* Nov 15. 1, 6–7. Pearce, F. (2000). 'Kicking the Habit'. *New Scientist.* Nov 25. 36. Anon. (1999). 'Iceland's Power'. *New Scientist.* May 1. 20.

68 Anon. (2003). 'Hydrogen Cars Recalled'. New Scientist. May 31. 9. Burns, L. (2002). 'Vehicle of Change'. Scientific American. Oct. 40–49. Jones, N. (2003). 'Fill Her Up With Caged Hydrogen'. *New Scientist.* May 24. 18. Chandler, D. (2002). 'Hydrogen Utopia Comes Two Steps Closer'. *New Scientist.* Oct 5. 14. Wakefiled, J. (2002). 'The Ultimate Clean Fuel'. *Scientific American.* May 22–23. 36. Hadfield, P. (1998). 'Catalysts For Change'. *New Scientist.* Feb 28. 10.

69 Anon. (2003). 'More Death on the Roads'. *New Scientist.* June 10. 11. Hamer, M. (1998). 'No More Easy Riding'. *New Scientist.* July 25. 5. World Resources Institute, UNEP, World Bank. (1997). *World Resources 1996–1997.* (Oxford University Press). 94. Patel, T. (1995). 'Paris Chokes While Officials Fiddle'. *New Scientist.* July 29. 9. Elsom. (1996). *Urban Smog.* (Earthscan, London). 154.

obvious manifestation of the last problem is traffic jams. Although this long standing problem can be assisted by improved transport systems designs (such as signals, one-way systems, and driving practices), the intuitive temptation to continue to build more roading needs to be critically assessed. Critical assessment of road building plans, which are not buttressed by other measures to reduce overall traffic numbers and reduce air and climate pollutants such as congestion charges,[70] is necessary because although new roads initially cut travel times by at least 10%, new roads can end up increasing traffic by between 5 to 10% in the longer term, as the initially reduced travel times act as magnets for increased traffic levels. This figure reflects the so called 'fundamental law of traffic congestion' which is that it is impossible to reduce traffic jams by investing solely in road and transit infrastructure.[71]

3. Alternatives in the Ozone Regime

Transitional ODS are substances which have a lesser environmental impact than the original ODS. As discussed in chapter nineteen, there have been three generations of transitional ODS. The first involved the replacement of CFCs 11 and 12 with CFC 22, 123 and 134a; the second involved HCFCs; and the final generation involved HFCs and PFCs. In each instance, a new generation has largely eclipsed the earlier one, due to its lesser ODP impact. However, in each instance, although one problem has been addressed, others have often been created. For example, some of the first generation of transitional substances were not only still harming the ozone layer, they were also implicated in the creation of air pollution,[72] or in the case of alternatives to MB, lead to an increased use of some pesticides.[73] The

[70] With regard to London, NOx and SPM emissions fell by 16% and CO_2 emissions by 19% in the first year following the introduction of their congestion charge. See Anon. (2004). 'Congestion Charge Clears the Air'. *New Scientist.* Nov 27. Anon. (2004). 'Tariffs to Regulate City Traffic'. *Scientific American.* Dec 43.

[71] Ravilious, K. (2001). 'Hell on Wheels'. *New Scientist.* July 21. 17. Seife, C. (1999). 'Jam Packed'. *New Scientist.* Jan 30. 7. Hamer, M. (1999). 'Roads to Nowhere'. *New Scientist.* Jan 16. 10. Hamer, M. (1998). 'Many Roads Make Less Work'. *New Scientist.* Feb 14. 5. Pearce, F. (1997). 'False Forecasts Leave Cities Choking'. *New Scientist.* Feb 8. 5. Gibbs, W. (1997). 'Transportation's Perennial Problems'. *Scientific American.* Oct 32–35. Hamer, M. (1994). 'Royal Commission Slams Road Building Plans'. *New Scientist.* Nov 5. 6. Editor. (1996). 'The Rage Over Roads'. *New Scientist.* Jan 6. 3. Hamer, M. (1995). 'Report Slams Official Traffic Forecasts'. *New Scientist.* Jan 7. 5.

[72] Milgrom, L. (1988). 'Alternative CFCs Pose Problems Near the Ground'. *New Scientist.* March 31. 33.

[73] Co-Chairs of the Assessment Panels (2003). *The Synthesis Report.* UNEP/OzL.Pro/WG.1/23/3. 25.

second generation was found to still be impacting upon the ozone layer, and the final generation of transitional substances, although containing no ODP, was found to have a very large GWP.

The response of the Parties to the ozone regime has been to consider each generation of substance as transitional, and phase each problematic chemical out in turn, as none of the alternatives have been found to be without environmental cost.[74] With particular regard to the link between transitional substances and climatic change, they have also agreed to try to make the respective regimes more complimentary,[75] whilst discouraging the adoption of transitional ODS with a large GWP, such as HFCs.[76]

[74] Including, inter-alia, environmental, human health and safety, technical feasibility, the commercial availability and performance, economic aspects and country specific circumstances. Decision V/8. Consideration of Alternatives. Report of the Fifth MOP to the Montreal Protocol. 13.

[75] Decision X/16. Implementation of the Montreal Protocol in Light of the Kyoto Protocol. Report of the 10th MOP of the Montreal Protocol. 30–31.

[76] As such, the two regimes and their respective bodies are co-operating on this issue, with a view to finding, 'alternatives not listed in Annex A of the Kyoto Protocol'. Decision X/16. Implementation of the Montreal Protocol in Light of the Kyoto Protocol. Report of the 10th MOP of the Montreal Protocol. 30–31, 60–61. See also Annex V. Decision on HCFCs, HFCs & PFCs.

XXI. SINKS

Although the sequestration of CO_2 is a type of technological option, I have decided to give this section its own chapter due to both the scale of the area and, its importance within the climate change regime.

1. The Possibilities of Sinks

It is possible to sequest (suck up) carbon from the atmosphere and store it in 'sinks'. A "sink" is a process, activity or mechanism which removes a greenhouse gas, an aerosol or a precursor of a greenhouse gas from the atmosphere.[1] Sinks may either be oceanic or terrestrial in nature.

A. Sequestration in the Ocean

It is hypothesized that huge growths of plankton formed in the oceans shortly after the massive volcanic eruptions that flooded the atmosphere with CO_2 55 million years ago. Arguably, this plankton played a key role in helping to remove CO_2 from the atmosphere, and helping the Earth return to a more hospitable temperature. Moreover, contemporary studies suggest that the phytoplankton may be incorporating between 45 and 50 billion metric tonnes of inorganic carbon into their cells every year. Due to such possibilities, a number of scientific studies have sought ways to increase plankton to repeat the same trick. In a contemporary context, it has been shown that adding iron to the ocean can make plankton bloom temporarily. This may be beneficial for reducing the build-up of CO_2 in the atmosphere as the microscopic organisms suck up dissolved carbon dioxide from the water (in their own tissue), which in turn is replaced by CO_2 from the air. As plankton die and settle on the ocean floor, their carbon is supposedly locked up in the seabed, and is thus removed from circulation. In theory, one tonne of iron could lead to the absorption of 10,000 tonnes of carbon from the atmosphere. Such possibilities also

[1] FCCC. Article 1. Definitions. Note, for long-term storage, as opposed to the actual sink process, the term used may be reservoir. A "reservoir" is a component or components of the climate system where a greenhouse gas or a precursor of a greenhouse gas is stored. Also in the definitions section.

suggest that, as an economic option for reducing the CO_2 build-up, seeding the ocean could be a relatively cheap option compared to other reduction strategies.[2]

Despite these possibilities, the limitations of this approach have become apparent as, 'the potential implications for [marine] ecosystem function and biodiversity are not well understood'.[3] Despite the considerable quantitative uncertainty in this area, it has been shown that massive amounts of seeding would be required to make relatively small reductions in CO_2 build-up, and that dumping extra iron into the oceans may also significantly disrupt ecological cycles and the biodiversity within the area. The results may only be short term as the planktonic animals that feed on the algae may obtain a massive free lunch, and ironically, the seeding may actually encourage the bacteria that produce CH_4 and NOx.[4] Due to such limitations, sequestration in the ocean has received little attention in the formal climate change regime. Moreover, the Kyoto Protocol has limited emission reductions to removals by sinks which are related to Land Use, Land Use Change and Forestry (LULUCF) with a particular emphasis upon afforestation, reforestation and deforestation.[5] As such, the Kyoto Protocol does not apply full carbon accounting in this instance, as sequestration options involving the ocean are excluded from consideration.[6]

B. Sequestration on Land

As noted in chapter two, the terrestrial uptake of CO_2 is vast. By the early 1980s, it was becoming apparent that this uptake could be increased, and

---

[2] It is estimated that this process would cost between 5–15$ per tone of CO_2 captured. Pearce, F. (2000). 'A Cool Trick'. *New Scientist.* Apr 8. 18. Falkowski, P. (2002). 'The Ocean's Invisible Forest'. *Scientific American.* Aug 38–46. Pearce, F. (2000). 'Cooling Off'. *New Scientist.* Sep 16. 10. Fell, N. (1993). 'Can Algae Cool The Planet?' *New Scientist.* Aug 21. 34–37. Brown, W. (1990). 'Flipping Oceans Could Turn Up The Heat'. *New Scientist.* Aug 25. 11.

[3] CBD. (2003). *Inter-linkages Between Biological Diversity and Climate Change.* (CBD Technical Series No 10, Montreal). 7.

[4] Anon. (2004). 'Iron No Fix'. *New Scientist.* Apr 24. 6. Nadis, S. (2004). 'The Cells That Rule the Seas'. *Scientific American.* Dec 27–28. SBSTA. (2003). *Biological Diversity and Climate Change.* UNEP/CBD/SBSTTA/9/INF/12. Sep 63–65. Jones, M. (2002). 'Don't Rely on Plankton To Save the Planet'. *New Scientist.* Feb 16. 16. Anon. (2002). 'Bubble Trouble'. *New Scientist.* Aug 31. 6. Jones, N. (2001). 'A Risk Too Far'. *New Scientist.* Oct 20. 7. IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change.* (Cambridge University Press, Cambridge). 17. Holmes, B. (1994). 'No Quick Fix For Climate'. *New Scientist.* Feb 26. Gribbin, J. (1991). 'A Technological Fix That Does Not Work'. *New Scientist.* March 16. 46–47.

[5] Kyoto Protocol. Article 3 (3).

[6] IPCC. (2000). *Land Use, Land-Use Change, and Forestry.* (Cambridge University Press, Cambridge). 5. For further discussion, see Green, J. (2002). 'Legal and Political Aspects of Iron Fertilization in the Southern Ocean'. *Environmental Policy and the Law.* 32 (5): 217–220.

possibly used as a way to combat global warming. The first appearance of this argument was in 1983 when the United States suggested that one way to significantly reduce the build-up of CO_2 was to plant trees. Specifically, to offset 50 years of CO_2 emissions from fossil fuels approximately 6.7 million square kilometres of sycamores would have to be planted and maintained.[7] Variations on these calculations appeared during the 1980s and 1990s, before the IPCC suggested in 1995 that a global reforestation programme of 350 million hectares (an area slightly larger than the geographical size of the European Union) could sequest up to 35 billion tonnes of CO_2 (about 6% of all emissions between 1998 and 2050) in 50 years.[8] Later IPCC estimates suggested that the potential for net carbon change in carbon stocks by 2010 through improved management of land use activities was 240 Gt C by grazing land management, 170 Gt C by forest management and 125 Gt C by cropland management. In terms of land use change, agro-forestry could introduce a net change of 390 Gt C.

The vast majority of these theoretical savings are derived from LULUCF options in developing countries.[9] For example, with the global mitigation potential offered by afforestation, reforestation and slowing deforestation between 1995 to 2050, 70% is believed to be in tropical forests, 25% in temperate forests and only 5% in boreal forests.[10] In addition, to the necessary physical base for the LULUCF options, the economic costs of performing these options in developing countries is considerably cheaper, than the same amount of planning in developed countries. Typically, the costs in developing countries are between ten cents to 20 USD per tonne of CO_2 removed, due to cheaper land and quicker growing sinks. The cost of the same options in developed countries, at between 20 USD to 100 USD per tonne of CO_2 removed.[11] Following such practical and financial benefits, a number of bilateral experiments, typically involving the planting of trees in developed countries, to offset emissions from developed countries have, since 1988, been undertaken.[12]

[7] Anon. (1983). 'Raised Temperatures Over Greenhouse Effect'. *New Scientist*. Oct 27. 247.
[8] Pearce, F. (1998). 'Growing Pains'. *New Scientist*. Oct 24. 20. Sedjo, R. (1989). 'Forests: A Tool To Moderate Global Warming?' *Environment*. Jan. 15. Pearce, F. (1988). 'Planting Trees For A Cooler World'. *New Scientist*. Oct 15. 21. Houghton, R. (1989). 'Global Climate Change'. *Scientific American*. 260 (4). 18–25. Glenn, E. et al. (1992). 'Growing Halophytes to Remove Carbon From the Atmosphere'. *Environment*. Apr 40–43.
[9] IPCC. (2000). Ibid. 14.
[10] IPCC. (2003). *Climate Change and Biodiversity*. (IPCC, Technical Paper V, Geneva). 35.
[11] IPCC. (2001). *Climate Change 2001: Mitigation*. (Cambridge University Press, Cambridge). 8. IPCC. (2000). Ibid. 15. IPCC. (1996). *Climate Change 1995: Economic and Social Dimensions*. (Cambridge University Press, Cambridge). 11. Pearce, F. (1993). 'The High Cost of Carbon Dioxide'. *New Scientist*. July 17. 26–27. Sedjo, R. (1989). 'Forests: A Tool To Moderate Global Warming?' *Environment*. Jan 15.
[12] Anon. (2000). 'Tree Trade'. *New Scientist*. June 17. 19. Zinn, C. (2000). 'Japan Makes Ecology Deal With Australia'. *Guardian Weekly*. Feb 24. 2.

2. Sinks within the FCCC and Kyoto Protocol

Originally, as the UNCED process got underway, it was uncertain how the question of forests, both with regard to both tropical deforestation and their role in climate change, would be dealt with. Initial ideas considered the possibility of placing all forestry considerations relating to climate change in a separate instrument or within a specific protocol to the forthcoming climate treaty. In addition, it was originally believed that CO_2 sequestration would only be a short-term measure to slow the CO_2 build-up until more comprehensive responses were established.[13] In the end, neither of these ideas eventuated and the ideals of terrestrial sinks were both incorporated and entrenched within the broader FCCC, as the G7, OECD, and key countries such as the United States successfully argued that sinks had to be included in the final convention. The views of other countries who wanted the framework convention restricted to controlling emissions and not the proliferation of tree farms were unsuccessful.[14] Accordingly, the FCCC adopted a, 'comprehensive' approach to 'cover all relevant sources, sinks and reservoirs of greenhouse gases and adaptation'.[15] As such, the FCCC was, 'aware of the role and importance in terrestrial and marine ecosystems of sinks and reservoirs of greenhouse gases'.[16] With such a background, the FCCC required all signatories to,

> Promote sustainable management, and promote and cooperate in the conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases not controlled by the Montreal Protocol, including biomass, forests and oceans as well as other terrestrial, coastal and marine ecosystems.[17]

Pearce, F. (1999). 'That Sinking Feeling'. *New Scientist.* Oct 23. 20–21. Pearce, F. (1998). 'Growing Pains'. *New Scientist.* Oct 24. 20. Hadfield, P. (1997). 'Japan Fiddles While the World Warms'. *New Scientist.* May 31. 10. Pearce, F. (1988). 'Planting Trees For A Cooler World'. *New Scientist.* Oct 15. 21. Spinks, P. (1990). 'Replanted Rainforest Could Offset Dutch Coal-Fired Power Stations'. *New Scientist.* Apr 21. 6. 5 *YBIEL.* (1994). 204. 1 *YBIEL.* (1990). 103.

[13] Pearce, F. (1988). 'Planting Trees For A Cooler World'. *New Scientist.* Oct 15. 21. Houghton, R. (1989). 'Global Climate Change'. *Scientific American.* 260 (4). 18–25. Sedjo. Ibid. 15. Anon. (1989). 'Britain Seeks Global Action to Halt Global Warming'. *New Scientist.* May 20. 4.

[14] G7 Houston Summit (1990). Summit Communique, available from <http://www.g7.utoronto.ca/g7/summit/1990/houston/communique/energy.html> G7, 1991 London Summit. Available from http://www.g7.utoronto.ca/g7/summit/1991london/communique/environment.html 2 *YBIEL.* (1991). 114. Pearce, F. (1992). 'Draft Treaty Fails To Put Limits on Emissions'. *New Scientist.* May 16. 5. MacKenzie, D. (1991). 'Storms Cloud Gather Over Climate Talks'. *New Scientist.* Sep 21. 5. MacKenzie, D. (1991). 'America Creates Cold Climate For Greenhouse Talks'. *New Scientist.* June 22. 16.

[15] FCCC. Article 3 (3).

[16] FCCC. Preamble. Paragraph 4.

[17] FCCC. Article 4 (d).

In addition, developed countries were obliged to commit themselves to, 'mitigation of climate change, by limiting its anthropogenic emissions of greenhouse gases and protecting and enhancing its greenhouse gas sinks and reservoirs'.[18] Similar obligations were reiterated in Agenda 21,[19] and despite remaining uncertainties in this area, in the lead up to the Kyoto Protocol.[20] The Protocol entrenched the principle that for the Parties obliged to make reductions in their greenhouse gas emissions that,

> The net changes in greenhouse gas emissions by sources and removals by sinks resulting from direct human-induced land-use change and forestry activities, limited to afforestation, reforestation and deforestation since 1990, measured as verifiable changes in carbon stocks in each commitment period, shall be used to meet the commitments under this Article of each Party included in Annex I. The greenhouse gas emissions by sources and removals by sinks associated with those activities shall be reported in a transparent and verifiable manner and reviewed in accordance with Articles 7 and 8.[21]

In addition these Parties shall elaborate policies, which include, inter-alia,

> Protection and enhancement of sinks and reservoirs of greenhouse gases not controlled by the Montreal Protocol, taking into account its commitments under relevant international environmental agreements; promotion of sustainable forest management practices, afforestation and reforestation.[22]

An exception was added for countries whose LULUCF CO_2 sequestration were at a high point in 1990. Thus,

> Those Parties included in Annex I for whom land-use change and forestry constituted a net source of greenhouse gas emissions in 1990 shall include in their 1990 emissions base year or period the aggregate anthropogenic carbon dioxide equivalent emissions by sources minus removals by sinks in 1990 from land-use change for the purposes of calculating their assigned amount.[23]

With regard to the questions on scientific uncertainty in this area, it was stipulated that the Parties were obliged to, 'research on, and promotion, . . . of carbon dioxide sequestration technologies'. This research, was to be build into ongoing scientific work aimed at establishing measurements for,

---

[18] FCCC. Article 4 (2) (a).

[19] Agenda 21 called upon all countries to, 'promote terrestrial and marine resource utilisation and appropriate land-use practices that contribute to . . . the conservation, sustainable management and enhancement, where appropriate, of all sinks for greenhouse gases'. Agenda 21. 9.20.a.ii.

[20] For the decision to include sinks in the forthcoming protocol, see Decision 1/CP.1. The Berlin Mandate. Paragraph 2 (a). 8 *YBIEL.* (1997). 177. 6 *YBIEL.* (1995). 229. 4. *YBIEL.* (1993). 143. Pearce, F. (1994). 'All Gas And Guesswork'. *New Scientist.* July 30. 14–15.

[21] Kyoto Protocol. Article 3 (3).

[22] Kyoto Protocol. Article 2 (a) (ii).

[23] Kyoto Protocol. Article 3 (7).

'changes in carbon stocks in subsequent years'.[24] Specifically, it was agreed that, 'modalities, rules and guidelines as to how, and which, additional human-induced activities related to changes in greenhouse gas emissions by sources and removals by sinks in the agricultural soils and the land-use change and forestry categories shall be added to, or subtracted from, the assigned amounts for Parties included in Annex I, taking into account uncertainties, transparency in reporting, verifiability, the methodological work of [the various scientific bodies]' would be established in the future.[25]

3. Sinks in the Post-Kyoto Context

Although the Kyoto Protocol gave a clear nod to the utilization of sinks, the modalities of how to utilize them were not settled until 2001 following the most volatile period in the history of the climate change regime, which ended up with the United States walking out of the negotiations, and the Sixth COP collapsing without agreement.[26] The collapse was largely over the role that sinks were to play in the Kyoto Protocol, and the countries (primarily the United States, Australia, Russia, Japan and Canada) which wanted a very liberal regime for the utilization of sinks, and those (primarily the European Union) who wanted a very conservative regime.[27] The following pages are about this collapse, and what scheme finally emerged from the negotiations.

A. Commitment Periods

It was agreed in 1998,[28] and reconfirmed in 2001, that following the completion of the methodological work by the IPCC, emissions relating to LULUCF could be included in the first commitment period.[29] Thus, the

[24] Kyoto Protocol. Article 2 (a) (iv).
[25] Kyoto Protocol. Article 3 (4).
[26] Note, the debate was initially deferred until the IPCC LULUCF report was issued. Decision 9/CP.4. Land-use, Land-use Change and Forestry. COP 4 (1998). Paragraphs 3, 4 & 5. Decision 16/CP.5. Land-use, land-use change and forestry.
[27] Reiner, D. (2001). 'Climate Impasse: How The Hague Negotiations Failed'. *Environment.* 43 (2): 36–43. Editor. (2000). 'Time To Come Clean'. *New Scientist.* Dec 2. 3. Pearce, F. (2001). 'Kyoto Lives'. *New Scientist.* July 28. Anon. (2000). 'Disappointment At Meagre Progress'. *Environmental Policy and the Law.* 30 (5): 217.13. McCarthy, M. (2001). 'Kyoto Talks Stall In Dispute Over Carbon Sinks'. *The Independent.* July 20. 18. Simpson, S. (2001). 'Debit or Credit?' *Scientific American.* Feb 17. 8 *YBIEL.* (1997). 178. Pearce, F. (1997). 'It's a Deal, But Can It Work?' *New Scientist.* Dec 13. 6.
[28] Decision 9/CP.4. Land-use, Land-use Change and Forestry. Paragraph 1. Anon. (1999). 'Climate Change: Plan of Action Adopted'. *Environmental Policy and the Law.* 29 (1): 3.
[29] Decision 11/CP.7. Land use, Land-use Change and Forestry. Definitions, modalities,

role of LULUCF for the second commitment period was not concluded, and although all greenhouse gas accounting should consider LULUCF to subsequent commitment periods,[30] the decision to utilize LULUCF for the first period, did not imply a transfer of commitments for future commitment periods.[31]

B. Overall Claim Potential

In the run-up to the collapse of first part of sixth COP, the United States had calculated that sinks could cover just over half of its annual greenhouse emission reduction obligations (312 million tonnes sequestered out of 600 million tonnes overall reduction). However, due to the vast uncertainties in this area, the European Union rejected such appeals, and demanded limits on how much forest sequestration could be claimed to meet Kyoto obligations. Although agreement was close (the US offered to reduce their claim from 312 to 20 million tonnes) the deal could not be concluded and the talks collapsed.[32]

When the talks reconvened (without the United States) it was agreed for the first commitment period, a Party included in Annex I that incurs a net source of emissions under the provisions of Article 3 (3) of the Kyoto Protocol may account for anthropogenic greenhouse gas emissions by sources and removals by sinks in areas under forest management under the Protocol, up to a level that is equal to the net source of emissions under the provisions of Article 3 (3), but not greater than 9.0 megatonnes of carbon times five, if the total anthropogenic greenhouse gas emissions by sources and removals by sinks in the managed forest since 1990 are equal to, or larger than, the net source of emissions incurred under Article 3 (3).[33] For the first commitment period only, additions to and subtractions from the assigned amount of a Party resulting from LULUCF management under Article 3 (4), shall not exceed the value attributed to the country,[34] or for

rules and guidelines relating to land use, land-use change and forestry activities under the Kyoto Protocol, and Section B. Article 3, paragraph 3. See also IPCC. (2000). *Land Use, Land-Use Change, and Forestry*. (Cambridge University Press, Cambridge). 4.

[30] Decision 11/CP.7. Section E. General.

[31] Decision 11/CP.7. Land use, Land-use Change and Forestry. Paragraph 1.

[32] Anon. (2000). 'Hotting Up In The Hague'. *Economist.* Nov 18. 97. Anon. (2000). 'Disappointment At Meagre Progress'. *Environmental Policy and the Law.* 30 (5): 217. Simpson, S. (2001). 'Debit or Credit?' *Scientific American.* Feb. 17. 11 *YBIEL.* (2000). 170.

[33] COP 7. Decision 11/CP.7. Section C. Article 3, paragraph 10.

[34] COP 7. Decision 11/CP.7. Section C. Article 3, paragraph 10. These are, in terms of Mt C/yr for the respective Parties, and the limits are times five. Australia 0.00, Austria 0.63, Belgium 0.03, Bulgaria 0.37, Canada 12.00, Czech Republic 0.32, Denmark 0.05, Estonia 0.10, Finland 0.16, France 0.88, Germany 1.24, Greece 0.09, Hungary 0.29, Iceland 0.00, Ireland 0.05, Italy 0.18, Japan 13.00, Latvia 0.34, Liechtenstein 0.01,

that unit of land.[35] However, a a Party may request reconsideration of its numerical values,[36] as Croatia did in 2003.[37]

C. "Since 1990"

The Kyoto Protocol is explicit that LULUCF is, 'limited to afforestation, reforestation and deforestation since 1990'.[38] The difficulty with this starting date is that in some areas, forests are utilised on a continual, regenerative, sustainable harvesting basis. The problem is that due to the 'since 1990' requirement of the Protocol, only those stands harvested or regenerated since 1990 could be considered under the Protocol. Depending on what is counted and from which benchmark, either net credits, or net debits could be created. For example, a country which deforested land before 1990 and the beginning of the first commitment period, and then rapidly reforested, could obtain windfall credits, without having to take into account the emissions associated with the earlier deforestation. Likewise, if land was reforested early in this period, and harvested before 2008, then as the countries emissions would increase, a negative incentive to create forests is in place.[39] The 7th COP concluded this problem by agreeing that carbon accounting under the Kyoto Protocol excludes removals resulting from the dynamic effects of age structure resulting from activities and practices before the reference year.[40]

D. Scientific Uncertainty

The Kyoto Protocol was explicit in that any successful utilization of LULUCF credits must be verifiable, and recorded in a transparent manner.[41] With JI, the reductions by sinks must show that the removals are 'additional' to that would have otherwise occurred.[42] With the CDM, the benefits must

Lithuania 0.28, Luxembourg 0.01, Monaco 0.00, Netherlands 0.01, New Zealand 0.20, Norway 0.40, Poland 0.82, Portugal 0.22, Romania 1.10, Slovakia 0.50, Slovenia 0.36, Spain 0.67, Sweden 0.58, Switzerland 0.50, Ukraine 1.11, United Kingdom 0.37. The Russian Federation figure was change from 17.63 to 33.00 Mt/C/yr by Decision 12/CP.7. Forest management activities under Article 3, paragraph 4, of the Kyoto Protocol: the Russian Federation.

35 COP 7. Decision 11/CP.7. Section B. Article 3, paragraph 4.
36 COP 7. Decision 11/CP.7. Section C. Article 3, paragraph 12.
37 Decision 22/CP.9. Forest Management Activities Under Article 3 (4) of the Kyoto Protocol; Croatia.
38 Kyoto Protocol. Article 3 (4).
39 IPCC. (2000). *Land Use, Land-Use Change, and Forestry*. (CUP). 6–7.
40 COP 7. Decision 11/CP.7. Land use, Land-use Change and Forestry. Paragraph 1.
41 Kyoto Protocol. Article 4 (3).
42 Kyoto Protocol. Article 6. (1) (b).

be, 'real, measurable and long-term' as well as being 'additional'.[43] To such goals, the Protocol stipulated that the scientific bodies would develop, and future COPs would adopt, 'modalities, rules and guidelines taking into account uncertainties, transparency in reporting and verifiability'[44] with regard to LULUCF. Many of these goals can be achieved, as changes in carbon stocks and net greenhouse emissions over time can be estimated using some combination of direct measurements, activity data, and models based on accepted principles of statistical analysis, forest inventory, remote sensing techniques, flux measurements, soil sampling and ecological surveys.

Despite the clarity of these goals, estimations of emissions and sequestration of terrestrial sinks has proved problematic, due to what the IPCC has classified as, 'considerable quantitative uncertainty' due to problems of accuracy, verifiability, and scale of application.[45] The last factor related to difficulties over which carbon pools are counted, and which are excluded, and which changes in the counted carbon pools are excluded because they are natural changes, and which changes are counted because they are anthropogenic.[46]

The problems in this area are threefold. First, during the 1990s, there was no agreed criteria from which accurate measurements of terrestrial carbon pools could be established and monitored.[47] This failure to agree criteria was, in part, due to the very different abilities of developed countries, let alone developing countries, to fully and accurately measure their terrestrial carbon pools, and their more difficult pools like carbon stored in soil, in particular.[48] The failure was also due to a political and scientific inability to distinguish between natural caused changes in LULUCF such as seasonal variations or forest fires, and anthropogenic changes.[49]

There are a number of cases of each of these problems. For example, in 1998 a report suggested that the forests of the United States were sequestering

---

[43] Kyoto Protocol. Article 12. (5).

[44] Kyoto Protocol. Article 4 (4).

[45] IPCC. (2001). *Climate Change 2001: Impacts, Adaptation and Vulnerability*. (Cambridge University Press, Cambridge). 11. IPCC. (1995). *Climate Change 1994: Radiative Forcing of Climate Change*. (Cambridge University Press, Cambridge). 17.

[46] IPCC. (2000). Ibid. 8–9. Pearce, F. (2001). 'Dead and Buried'. *New Scientist*. May 12. 19. Sedjo. Ibid. 15.

[47] IPCC. (2000). Ibid. 16.

[48] Inventories of the carbon stored in soils are particularly important, as although in some the sequestration of carbon in the forests is typically greater than in the soils (between 5 to 7 times greater in Europe), in some places, as the forests mature, their sequestration stabilises, whereas that of the soils continues to increase. See UNECE (2003). *The Condition of Forests in Europe*. (UNECE, Forestry Research Centre). 30. IPCC. (2000). Ibid. 11. For the developing countries needs in this area, see Decision 4/CP.4. Development and transfer of technologies. COP 4 (1998). Paragraph 4 (b).

[49] Pearce, F. (2000). 'Smokescreen Exposed'. *New Scientist*. Aug 26. 18–19. Pearce, F. (1998). 'Growing Pains'. *New Scientist*. Oct 24. 20. Pearce, F. (1994). 'All Gas And Guesswork'. *New Scientist*. July 30. 14–15. IPCC. (2000). Ibid. 10.

1.5 billion tonnes of CO_2 per year.[50] However, later studies suggested that the American forests were only sequestering 0.3 billion tonnes of CO_2, as the early study has been mistaken in assuming that all of the forests were operating at maximum sequestration capacity, and that fires and pests had no impact.[51] Similar scientific uncertainties were recorded in the European Union, as the estimates of how much CO_2 their forests sequestered was reduced by 50%, from the original estimate that their forests were absorbing between 120 and 280 million tonnes per year.[52] Later studies showed that the actual preparation of land for planting, depending on the soil, may not only release an initial surge of CO_2 emissions, but also, in certain instances, the forests planted on greenhouse gas rich areas, such as peat-bogs or wetlands, will never absorb as much carbon as they caused to be emitted. The same problem applies with the replacement of standing old-growth forests with tree farms.[53] There may also be direct limitations in how far forests and other terrestrial pools of CO_2 may be pursued as a mitigation option in the longer term due to problems relating to physio-logical processes and climatic constraints, feedbacks and CO_2 leakage. The problems range from concern about CO_2 saturation of the carbon pools through to indirect negative biological processes such as the break down of leaf litter, eclipsing the CO_2 uptake in the trees. Moreover, if sustained temperatures go beyond a certain point some forests could fail to adapt (as is predicted), and if the forests die, they could end up introducing dangerous positive feedbacks into global warming by releasing all of their captured CO_2.[54]

[50] Walker, G. (1998). 'A Perfect Excuse'. *New Scientist.* Oct 24. 5.

[51] Adler, R. (1999). 'That Sinking Feeling'. *New Scientist.* July 31. 13. 5. Editor. (1998). 'Fuel's Paradise'. *New Scientist.* Oct 24. 3. For the problems of fires and pests generally in this area, see IPCC. (2000). *Land Use, Land-Use Change, and Forestry*. (CUP). 7

[52] Pearce, F. (2001). 'The Heat is On'. *New Scientist.* July 14. 18. Pearce, F. (1998). 'Soaking It Up'. *New Scientist.* Oct 3. 20. Pearce, F. (2000). 'Smokescreen Exposed'. *New Scientist.* Aug 26. 18–19. UNECE (2003). *The Condition of Forests in Europe.* (UNECE, Forestry Research Centre). 30.

[53] Pearce, F. (2002). 'Tree Farms Won't Save Us After All'. *New Scientist.* Oct 26. 10. Pearce, F. (1994). 'Peat Bogs Hold Bulk of Britain's Carbon'. *New Scientist.* Nov 19. 6. Anon. (2000). 'Reflect on It'. *New Scientist.* May 13. 19.

[54] SBSTA. (2003). *Biological Diversity and Climate Change.* UNEP/CBD/SBSTTA/9/INF/12. Sep 30. Randerson, J. (2002). 'No Easy Answer'. *New Scientist.* Apr 13. 16. Simpson, S. (2001). 'Debit or Credit?' *Scientific American.* Feb 17. Pearce, F. (1999). 'That Sinking Feeling'. *New Scientist.* Oct 23. 20–21. IPCC. (1996) *Climate Change 1995: Impacts, Adaptations and Mitigation.* (Cambridge University Press, Cambridge). 5–6, 9. White, A. et al. (1999). 'Climate Change Impacts on Ecosystems and the Terrestrial Carbon Sink'. *Global Environmental Change.* 9: 21–30. Pearce, F. (1999). 'Only Ourselves To Blame'. *New Scientist.* Nov 20. 24. Pearce, F. (1999). 'That Sinking Feeling'. *New Scientist.* Oct 23. 20–21. Holmes, B. (2004). 'Canopy Trees Taking Over'. *New Scientist.* Mar 13. 12. IPCC. (2000). Ibid. 4. Jones, N. (2000). 'Keeping the Earth Cool'. *Nature.* Nov 9. 184. Anon. (1989). 'Trees May Fare Badly As Britain Warms'. *New Scientist.* Oct 21. 13.

The COPs following the Kyoto Protocol have all attempted to deal with some of these problem by the stressing the need for robust scientific analysis and consistent methodologies.[55] Specific scientific jobs designed to reduce uncertainties in some of the LULUCF areas were tasked,[56] and the respective scientific bodies were required to develop methodologies to factor out emissions by sources and removals by sinks due to natural, or indirect anthropogenic impacts.[57] Finally, in 2003 the Parties adopted, for a trial period, the Good Practice Guidance for LULUCF in the Preparation of National Greenhouse Gas Inventories.[58] The (voluntary) reporting requirements for the Good Practice Guidance were supplemented in 2004.[59]

E. Forestation and Deforestation

During the negotiations for the FCCC, one of the fears about including sinks was that it could lead to a process of replacing old growth forests with tree farms.[60] This concern, relates to the creation of a causal link to deforestation, in that carbon credits may be claimed for fast growing plantations which could not be claimed for existing old-growth forests. This may be a particular problem in some tropical countries.[61] Accordingly, it became imperative to create a regime which did not encourage the deforestation of old-growth forests and their replacement with fast-growing plantations.[62]

This problem has been confronted by both detailed rules and a broad commitment to act in conformity with the objectives of other multilateral environmental agreements. The broad commitment this stems from the Kyoto Protocol which obliges the developed countries, in fulfilling their

---

[55] Decision 11/CP.7. Land use, Land-use Change and Forestry. Paragraph 1. Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action, Annex. Section VII. Land-Use, Land-Use Change And Forestry.

[56] The IPCC were requested to develop definitions for direct human-induced 'degradation' of forests and 'de-vegetation' of other vegetation types and methodological options to inventory.

[57] COP 7. Decision 11/CP.7. Land use, Land-use Change and Forestry. Paragraph c.

[58] Decision 13/CP 9. Good Practice Guidance for Land Use, Land Use Change and Forestry in the Preparation of National Greenhouse Gas Inventories Under the Convention. Report of the Ninth COP to the FCCC. 31–48.

[59] Decision 15/CP.10. Good Practice Guidance for Land Use, Land Use Change and Forestry Activities Under Article 3, Paragraphs 3 and 4 of the Kyoto Protocol.

[60] 2 *YBIEL*. (1991). 113.

[61] Note, well designed planted forests can bypass aspects of this problem. See IPCC. (2003). *Climate Change and Biodiversity*. (IPCC Technical Paper V, Geneva). 2, 35–37. Anon. (2004). 'Forest Grump'. New Scientist. Apr 24. 7. Noss, R. (2001). 'Beyond Kyoto: Forest Management in a Time of Rapid Change'. *Conservation Biology*. 15(3): 578–590.

[62] IPCC. (2000). Ibid. 17. 8 *YBIEL*. (1997). 303. 11 *YBIEL*. (2000). 171. Pearce, F. (1998). 'Growing Pains'. *New Scientist*. Oct 24. 20. Reiner, D. (2001). 'Climate Impasse: How The Hague Negotiations Failed'. *Environment*. 43 (2): 36–43. Anon. (2000). 'Hotting Up In The Hague'. *Economist*. Nov 18. 97.

obligations, to promote sustainable development, which shall, inter-alia, take, 'into account its commitments under relevant international environmental agreements; promotion of sustainable forest management practices, afforestation and reforestation'.[63] Accordingly, the Parties agreed to only utilise LULUCF activities which contribute to the conservation of biodiversity and sustainable use of natural resources.[64] This recognition was in conformity with an IPCC recommendation,[65] a resolution from the Convention on Biological Diversity calling on the FCCC when considering forest and carbon sequestration, to ensure that their, 'future activities . . . are consistent with and supportive of the conservation and sustainable use of biological diversity,'[66] and specific requests from subsidiary agreements to the Convention on Migratory Species, that certain sequestration options be excluded from some areas.[67]

In terms of specific rules in this area, a number of definitions of what forest pools could be counted for greenhouse emission commitment periods were agreed between 2000 and 2003. Although this would appear to be a simple issue, it quickly became difficult as there are many possible definitions of the terms 'forest, afforestation, reforestation and deforestation' and each definition may have a different implication.[68] For example, although definitions of a forest may be based on land use, carbon density or canopy cover, most definitions adopt the latter.[69] However, this is not the end of the matter, as the choice in the amount of canopy cover, had strong implications for the Kyoto Protocol. For example, if a high threshold was set (such as a 70% canopy cover) then many areas of sparse forest and woodland could be cleared or could increase without the losses or gains in CO_2 being accounted for under the Protocol. If a low threshold was set (such as a 10% canopy cover) then dense forest could be heavily degraded and significant amounts of CO_2 released, without the actions being registered

---

[63] Kyoto Protocol. Article 2 (1).

[64] COP 6, Part One. Action Taken By The COP At The First Part Of Its Sixth Session. Personal Observations of the Chair. COP 7. Decision 11/CP.7. Land use, Land-use Change and Forestry. Paragraph 1.

[65] IPCC. (2000). Ibid. 17.

[66] Decision V/4. Progress Report on Forest Biological Diversity. UNEP/CBD/COP/5/23. pp. 81. SBSTA. (2003). *Biological Diversity and Climate Change*. UNEP/CBD/SBSTTA/9/INF/12. Sep 30. 52–56. CBD. (2003). *Interlinkages Between Biological Diversity and Climate Change*. (CBD Technical Series No 10, Montreal). 7.

[67] For example, with the Memorandum of Understanding to conserve the Great Bustard, the signatories agreed that. 'Afforestation should be prevented in Great Bustard areas'. Action Plan for the Middle European Population of the Great Bustard. Section 1. Available from the Convention on Migratory Species.

[68] 11 *YBIEL*. (2000). 170. IPCC. (2000). Ibid. 5

[69] This approach may have flow on problems for harvesting and/or shifting agriculture. See IPCC. (2000). Ibid. 6.

as deforestation. Similarly, a forest, with 15% canopy cover, could be considerably enhanced without the actions qualifying as reforestation or afforestation.[70] The COP did not actually resolve these problems, as it could only agree that for the first commitment period, that the definitions for 'forest' would be loosely based on the standard FAO definition, whereby forests are defined by considerations such as height and density.[71]

In terms of the additional definitions of afforestation, reforestation and deforestation, the IPCC recommendations were largely followed. Accordingly, 'afforestation' is the direct human-induced conversion of land that has not been forested for a period of at least 50 years, to forested land through planting, seeding and/or the human-induced promotion of natural seed sources. 'Reforestation' is the also the direct human-induced conversion of non-forested land to forested land on land that was forested but that has been converted to non-forested land.[72] The key point is that reforestation within the Kyoto Protocol, as consistent with standard international practice, does not have the 50 year period that afforestation has attached.[73] 'Deforestation' is the direct human-induced conversion of forested land to non-forested land.[74] For the first commitment period, reforestation activities were limited to reforestation occurring on those lands that did not contain forest at the end of 1989.[75] The difference between re-establishment of forests and deforestation must be kept clear, and is subject to external review.[76] Despite the clarity of this rule, in 2003 Japan and Canada announced their intention to challenge this, and bring the deadline forward by 10 years. Accordingly, it would be permissible to plant CO_2 credit generating forests to be planted on lands cleared as recently as 1999.[77]

70 IPCC. (2000). Ibid. 5.

71 COP 6, Part One. Action Taken By The COP At The First Part Of Its Sixth Session. Personal Observations of the Chair.

72 COP 7. Decision 11/CP.7. Definitions. Paragraph B and C.

73 Afforestation is usually defined as the establishment of forest on land that has been without forest for a period of time (e.g. 20–50 years) and was previously under a different land use. Some definitions of reforestation have no time period, between the harvesting of established forests, and their replanting. IPCC. (2000). Ibid. 6.

74 COP 7. Decision 11/CP.7. Definitions. Paragraph D.

75 For the purposes of determining the area of deforestation to come into the accounting system under Article 3, paragraph 3, each Party shall determine the forest area using the same spatial assessment unit as is used for the determination of afforestation and reforestation, but not larger than 1 hectare. Decision 11/CP.7. Section B. Article 3, paragraph 3.

76 Each Party included in Annex I shall report on how harvesting or forest disturbance that is followed by the re-establishment of a forest is distinguished from deforestation. This information will be subject to review in accordance with Article 8. COP 7. Decision 11/CP.7. Section B. Article 3, paragraph 5.

77 Pearce, F. (2003). 'Kyoto Changes May Drive Deforestation'. *New Scientist.* Mar 22. 13.

F. Additional Activities

No sooner had it become apparent that forests sequest carbon, than it also became apparent, that a number of other human activities involving terrestrial ecosystems also perform a similar function. For example, changing some agricultural practices, such as with different tillage approaches, can significantly reduce the amount of carbon emitted from the soil.[78] The Kyoto Protocol recognized that future COPs would decide upon the possible incorporation of such sources into the LULUCF categories.[79] However, debate over how far to extend this category was problematic on two grounds.[80] First, it was possible to interpret the key phrase, 'additional human based activity' broadly, such as relating to overall cropland management, or narrowly such as relating only to change in tillage method, fertilisation or cover crops. If it was broadly defined, it could be difficult to separate human-induced changes from naturally occurring changes. In addition, unlike the broader approach, a narrow definition, based on individual practices such as reduced tillage or irrigation water management, could lend itself to activity-based accounting, related to each individual practice.[81] Second, there was debate about whether additional activities should be limited to agricultural practices. For example, in 1999 the United States announced that they wanted 'additional human based activity' to also encompass landfills as sinks of greenhouse gases, which could be counted for commitment purposes.[82]

[78] For example, carbon levels in the soil are determined by the balance of inputs, as crop residues and organic amendments, and carbon losses through organic matter decomposition. Thus, management to increase soil organic carbon and to enhance the potential to sequester carbon requires increasing carbon inputs, decreasing decomposition, or both. Soil erosion can add to this process. Conservation tillage covers practices that range from reducing the number of trips over the field to raising crops without primary or secondary tillage. Leaving crop residues on the surface after planting, are also considerations. At all points, changing agricultural practice can reduce CO_2 emissions (and often improve soil quality at the same time). Uri, N. (2000). 'Global Climate Change and the Effect of Conservation Practices in US Agriculture'. *Global Environmental Change*. 10: 197–209. SBSTA. (2003). *Biological Diversity and Climate Change*. UNEP/CBD/SBSTTA/9/INF/12. Sep 30. 62. CBD. (2003). *Interlinkages Between Biological Diversity and Climate Change*. (CBD Series No 10, Montreal). 7.

[79] Additional human-induced activities related to changes in greenhouse gas emissions by sources and removals by sinks in the agricultural soils. Kyoto Protocol. Article 3 (4).

[80] 11 *YBIEL*. (2000). 170. Pearce, F. (2000). 'A Broken Pact'. *New Scientist*. Dec 2. 4–5.

[81] IPCC. (2000). Ibid. 7.

[82] This was because by burying waste paper and wood (of which 70 and 97% respectively never rots in a buried landfill remains locked in the ground), could permanently lock away their carbon which would otherwise escape into the atmosphere. The US calculated that this could lock up 28 million tons of carbon per year (about 2% of the annual US emissions from burning fossil fuels). Pearce, F. (1999). 'A Dirty Business'. *New Scientist*. Jan 23. 22. See also, Observer. (2000). 'How UN Climate Talks Fell Apart'. *NZ Herald*. Nov 27. B1. Fallow, B. (2000). 'Outrage Over the Collapse of Climate Talks'. *NZ Herald*.

Solution to this problem largely arrived at the successive COPs between 1999 and 2001 when it was decided that in addition to counting afforestation, reforestation and deforestation, in the first commitment period, re-vegetation,[83] forest management,[84] cropland management,[85] and grazing land management[86] may also be counted if the Party can show that change in the CO_2 in these pools has changed due to human influence since 1990.[87] Specific modalities for their utilization were concluded in 2001.[88] It was agreed that for the first commitment period, accountable anthropogenic greenhouse gas emissions by sources and removals by sinks resulting from cropland management, grazing land management and re-vegetation should be equal to anthropogenic greenhouse gas emissions by sources and removals by sinks in the commitment period, less five times the anthropogenic greenhouse gas emissions by sources and removals by sinks resulting from these eligible activities in the base year of that Party, while avoiding double accounting.[89] In terms of what carbon pools might be utilized, it was agreed that each developed country Party could account for all changes in the

Nov 27. A3. Dyer, G. (2000). 'Britain's Hague Concession to US Only Realistic Option'. *NZ Herald*. Nov 28. A15.

[83] 'Revegetation' is the direct human-induced activity to increase carbon stocks on sites through the establishment of vegetation that covers a minimum area of 0.05 hectares but does not meet the definitions of afforestation and reforestation contained here. COP 7. Decision 11/CP.7. Definitions. Paragraph E.

[84] 'Forest management' is a system of practices for stewardship and use of forest land aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner. COP 7. Decision 11/CP.7. Definitions. Paragraph F.

[85] 'Cropland management' is the system of practices on land on which agricultural crops are grown and on land that is set aside or temporarily not being used for crop production. COP 7. Decision 11/CP.7. Definitions. Paragraph G.

[86] 'Grazing land management' is the system of practices on land used for livestock production aimed at manipulating the amount and type of vegetation and livestock produced. COP 7. Decision 11/CP.7. Definitions. Paragraph H.

[87] COP 7. Decision 11/CP.7. Section C. Article 3, paragraph 4, 8 & 9.

[88] It was agreed that with regard to the first commitment period, the contribution of additional activities under article 3.4, towards meeting a Party's target in the first commitment period shall be limited to 3% of the Party's base year emissions. Moreover, accounting for additional activities shall take place through two distinguished intervals. The first interval, was created due to the fact that some countries had an overall increase in their total forest carbon stock. However, this first interval shall not be more that 30 Mt CO_2. With regard to the second interval, a discounted crediting was to apply due to non-human induced effects and remaining uncertainties in this area. In particular, in the second period Parties were to exclude the effects of indirect nitrogen deposition, elevated CO_2 concentrations, other indirect effects and, (for forest ecosystems) the dynamic effects of age structure resulting from management activities before 1990. Therefore, Parties shall apply a reduction of 30% to the net carbon stock changes and net GHG emissions that result from additional cropland and grazing land management activities and of 85% to the net carbon stock changes and net GHG emissions that result from additional forest management.

[89] COP 7. Decision 11/CP.7. Section C. Article 3, paragraph 9.

following carbon pools including above-ground biomass, below-ground biomass, litter, dead wood, and soil organic carbon. A Party could choose not to account for a given pool in a commitment period, if transparent and verifiable information could demonstrate that the pool was not a source.[90] In 2003 the Parties agreed that the earlier categories of LULUCF (changes in forest and other woody biomass stocks; forest and grassland conversion; abandonment of managed land and CO_2 emissions and removals from soils) would be replaced with the (simplified) terms of forest land, cropland, grassland, wetlands, settlements and other land.[91]

G. LULUCF & The Flexibility Mechanisms

At the 6th COP it was agreed that the extent of LULUCF inclusion within the CDM would be limited to afforestation and reforestation.[92] Conversely, it was decided that preventing deforestation and land degradation would not be eligible as credit generating projects under the CDM.[93] Finally, in terms of limiting the overall amount that could be claimed through the CDM in this area, it was agreed that for the first commitment period, the total of additions to and subtractions from the assigned amount of a Party resulting from eligible LULUCF activities under the CDM, could not exceed 1% of base year emissions of that Party, multiplied by five.[94] In 2001 the broad principles were supplemented with specific modalities and procedures, for small scale (less than 8 kilotonnes of CO_2 per year) for afforestation and reforestation projects under the CDM for the first commitment period. These modalities set out detailed requirements for accreditation, participation, validation, certification, registration and reporting, as well as detailed information on methodologies, baselines and monitoring.[95] These rules were simplified in 2004.[96]

[90] COP 7. Decision 11/CP.7. Section E. General.

[91] Decision 13/CP 9. Good Practice Guidance for Land Use, Land Use Change and Forestry in the Preparation of National Greenhouse Gas Inventories Under the Convention. Annex II: Technical Modifications to the UNFCCC Reporting Guidelines. 45.

[92] Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section VII. Land-Use, Land-Use Change And Forestry. Paragraphs 7 & 9. This was despite the fact that the issues of non-permanence, social and environmental effects, leakage, additionality and uncertainty still required methodological work.

[93] Note, however, it was believed that these activities were could qualify for funding under the Adaptation Fund in order to address drought, desertification and watershed protection, forest conservation, restoration of native forest ecosystems, restoration of salinised soils.

[94] Decision 5/CP.6. Implementation of the Buenos Aires Plan of Action. Annex. Section VII. Land-Use, Land-Use Change And Forestry. Paragraph 9.

[95] Decision 19/CP.9. Modalities and Procedures for Afforestation and Reforestation Project Activities Under the CDM in the First Commitment Period.

[96] Decision 14/CP.10. Simplified Modalities and Procedures for Small Scale Afforestation and Deforestation Under the CDM in the First Commitment Period.

INDEX

DECISIONS' INDEX

Ozone Depletion

Climate Change

Air Pollution