KEY STAKEHOLDERS' PERCEPTION ABOUT ADOPTING SOLAR AS PRIMARY ENERGY SOURCE AT HOUSEHOLD LEVEL: A CASE STUDY OF PESHAWAR CITY IN PAKISTAN

A thesis submitted in partial fulfillment of

the requirements for the degree of

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In

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By

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This is to certify that the

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Key Stakeholders' Perception about Adopting Solar as Primary Energy Source at Household Level: A Case Study of Peshawar City in Pakistan

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of the requirements for the degree of

Masters of Science in Urban and Regional Planning

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THESIS ACCEPTANCE CERTIFICATE

Certified that final copy of MS thesis written by Mr. **Usman Rasheed** (Registration No. **NUST201362177MSCEE15813F**), of **SCEE/NIT/U&RP** (School/College/Institute) has been vetted by undersigned, found complete in all respects as per NUST Statutes / Regulations, is free of plagiarism, errors, and mistakes and is accepted as partial fulfillment for award of MS degree. It is further certified that necessary amendments as pointed out by GEC members of the scholar have also been incorporated in the said thesis.

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Date:_____

Signature (Dean/Principal): _____

Date:_____

DEDICATION

"The thesis is dedicated to my parents, wife and kids for their continual support without which this achievement would not have been possible."

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First of all I am thankful to Almighty Allah for giving me the opportunity to pursue and complete my post-graduation studies and research work.

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Usman Rasheed

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Abbreviations

ADB	Asian Development Bank
BREEAM	Building Research Establishment Environmental Assessment Method
C&W	Civil & Works Department, KP
CO2	Carbon Dioxide
COP	Conference of Parties
E&P	Energy & Power Department, KP
EPA	Environmental Protection Agency
GBCA	Green Building Council Australia
GDP	Gross Domestic Product
GHG	Green House Gas
IEA	International Energy Agency
INDC	Intended Nationally Determined Contribution
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Producers
LCC	Life Cycle Cost
LEED	Leadership in Energy and Environmental Design
LUCF	Land Use Change and Forestry
MW	Mega Watt
PGBC	Pakistan Green Building Council

PGBG	Pakistan Green Building Guidelines
PHED	Public Health Engineering Department, KP
PV	Photovoltic
R&D	Research and Development
SBCI	Sustainable Buildings and Climate Initiative
SDG	Sustainable Development Goals
UN	United Nations
UNDP	United Nations Development Program
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
USEPA	United States Environmental Protection Agency
USGBC	United States Green Building Council
WGBC	World Green Building Council

Abstract

Exponential increase in population and rapid growth of urbanization has subsequently increased demand for more energy mainly being produced from fossil fuel resources that is the primary catalysts of environmental degradation especially in developing countries. Energy crisis situation coupled with the catastrophic impacts of climate change already visible, has set high time to pay due attention to making buildings self-sustained, energy efficient and with minimal dependence on fossil fuels for energy needs.

The construction industry and the resulting built environment has prominent environmental impacts on global climate including high consumption and depletion of natural resources especially for building sector, which are very resource-intensive. The way buildings consume energy today has drastic direct and indirect impact on environment. Energy efficient buildings are designed for the potential to result in effective reduction in energy use by utilizing all or maximum energy from renewable energy sources thus reducing energy consumption and both direct and indirect GHG emissions. Worldwide leading green building certification systems including Pakistan GBC considers energy as the main catalyst of change. Focus on energy aspect of buildings shift to reduce emissions is possible at the least cost thus minimizing climate change and its impacts.

This study examines the perception of key stakeholders in Peshawar city in adopting solar as renewable energy source at household level. Relevant data in this regard was collected through questionnaire survey and in-depth interviews. Data collected was analyzed using different descriptive statistical analysis techniques such as frequencies, cross-tabulations and multi response analysis. The research questionnaire comprised of five distinct yet closely interconnected thematic areas of individual's awareness level namely policies, initiatives, incentives & subsidies; investment and adoption of renewable energy technologies; access to information; and public choice, acceptability and reliability.

Solar photovoltaic (PV) cell has been identified as the first preference and most common choice of solar energy application among stakeholders at household level. Solar home lighting is given second preference while solar water heater has been given has third preference. With over 98% of the people are convinced that solar energy use as renewable energy at household level can contribute to greener and cleaner lifestyle with evident socio-economic benefits. Around 94.7% of respondents believe that solar energy technology at household level is an adoptable option. More than 95% of the respondents believe that compared to fossil fuel based energy, solar energy based technologies have much lesser impact on biodiversity and environment. Based on the results critical interventions on part of different stakeholders were identified that are required for making the shift from fossil fuel based energy production to solar as renewable energy source at household level. Existing barriers are addressable and can be reduced with a coordinated effort from all key stakeholders including provincial government, public & private sector and public/community.

Chapter-1

1 Introduction

1.1 Background of study

The rising concerns about environmental issues are driving the nations across the world to adopt sustainable models of development. It recognizes the interconnections between society, environment, and economy incorporating a holistic approach to define solutions that deliver benefits to all of these whilst minimizing negative impacts. Given the massive growth in new construction and the inefficiencies of existing building stock worldwide, in a business as usual scenario, the level of GHG emissions from buildings is set to rise in future. In fact, the energy issue is a major aspect of a certain sustainable building. If the desired targets for GHG emissions reduction are to be met, emissions from the building sector need to be tackled with much greater seriousness and vigour than the past efforts by promoting sustainable-energy building practices. The sustainable-energy buildings can be achieved through three main principles including energy-efficiency measures, sustainable design solutions, and renewable energy technologies. This work investigates the prospects of sustainable-energy buildings in the city of Peshawar with a focus on adoption of solar energy at household level as a primary energy source. This work would lead to further work in highlighting the opportunities and challenges for promoting sustainable-energy buildings in Pakistan(Alrashed & Asif, 2014).

1.2 Problem Statement

Buildings are non-extinct part of the society. Though worldwide there exists variation in the amount of time spent indoors. It is estimated that about 60% of world's electricity consumption is accounted for by buildings (residential and commercial). Buildings account for nearly 38% of global greenhouse emissions, utilize globally 12% of portable water and produces in developed countries, and 40 %of solid waste streams (IEA).

Although building sector is the major single contributor to greenhouse gas emissions, but at the same time this sector can offer enormous unexploited potential for reduction in emissions in the least time with the least cost (Levine, 2007).

Buildings are also responsible for one third of resources consumption globally that is approximately about three billion tons of raw materials annually (SBCI, 2009).

1.3 Research Objectives

The research aims to fulfill following objectives;

1. To ascertain perception with regards to adopting solar as primary energy source at household level.
2. To identify key barriers in adopting solar as primary energy source at household level.
3. To identify key intervention areas for Government and other key stakeholders for improving effective implementation of solar energy at household level.

1.4 Significance of Research

The research targets following advantages;

- Possible direct and indirect reduction in greenhouse gas emissions by greater use of solar as renewable and clean energy source.
- Reduced negative impacts on natural environment by increasing share of solar as renewable and clean energy source.
- Reduced energy demand for housing sector hence increased share of energy available for other sectors.
- With increased buildings adopting solar as renewable and clean energy source, there will be less reliance on energy produced using fossil fuels.
- Promotion of energy efficient buildings

- Reduction in emissions from buildings will bring multiple benefits to both the economy and society.

1.5 Thesis Structure

The thesis comprises of six chapters. First chapter is the introduction that signifies the problem statement, research objectives and research questions. Second chapter is based on literature review and establishing connection between direct and indirect greenhouse gas emissions and its relationship to building sector. Third chapter explains the methodology adopted for this particular research. Fourth chapter includes overview on data collected, its representation, analysis and discussions of results with respect to analysis result. The fifth chapter summarizes key findings based on results from data analysis. Sixth and final chapter concludes the research with conclusions and recommendations for possible short-term and long-term interventions by key stakeholders.

Chapter-2

2 Literature Review

2.1 Background

Buildings are an interrelated part of our society as they provide amalgamated area for living, interaction, learning, innovation and collaboration, though globally the proportion of time spent indoors varies considerably. Buildings have a significant contributing share of impact on natural environment both directly and indirectly, yet buildings serve as hubs for our socio and economic lives.

Residential and commercial buildings alone consume nearly 60% of global electricity (IEA). Building sector account for nearly 38% of global greenhouse gas emissions, however the electricity usage and subsequent direct and indirect GHG emissions vary considerably depending upon geographical location, local climatic conditions, and consumption patterns by society in context. Existing substantial consumption share of energy by building sector and considering rapid urbanization trend around the world, it is estimated that by 2030 emissions from building sector alone will be over one-third of total global GHG emissions (Levine, 2007).

Building sector offers a massive but unexploited possibility for reduction in GHG emissions at the smallest capital cost compared to other sectors (Levine, 2007). With proven technological advancements, availability of materials, commercial & social viability and positive impacts on the natural environment, energy utilization in both new development and retrofitting existing buildings is possible to reduce by approximately 30% to 50% with possible net profit during the lifecycle of the structure(SBCI, 2009).

Both developed and developing countries can offer great potential for GHG reductions from buildings((eds.), 2015). Substantial reductions in emissions is possible in building sector

alone and that this sector can offer some of cost effective and practical options to minimize adverse impact on climate and maximize share towards contribution to climate mitigation and adoption.

Apart from building sector own carbon footprint, the sector consumes globally more than one-third of natural resources that is around three billion tons of raw materials annually (SBCI, 2009). Natural resource consumptions by the building sector are supplemented by nearly 12% utilization of the world's potable water. Also lifecycle maintenance, revamping, expansion and demolition of buildings around the world contribute globally to nearly 40% solid waste (SBCI, 2009).

Global analysis of the buildings sector across different regions has established that energy efficient buildings have tremendous potential for delivering abrupt, cost effective and long term reduction in energy use by 30% to 50%, carbon dioxide emissions by 35%, waste outputs by 70% and water usage by 40% (McGraw-Hill Construction, 2008).

It is estimated that green/energy efficient buildings can reduce energy consumption by 29% by 2020 at zero net cost(SBCI, 2009). The buildings sector has the greatest untapped possibility for low capital cost and high return investments with regards to climate change mitigation and adoption("Building Design and Construction: Forging Resource Efficiency and Sustainable Development," June 2012).

2.2 Sustainable Development

The term "sustainability" arose since the realization of "global warming". In 1987, The World Commission on Environment and Development defined sustainability as "meeting the needs of the present without compromising the ability of future generations to meet their own needs." Its purpose is to create a balance between social and economic development with environmental protection, called "triple bottom line".

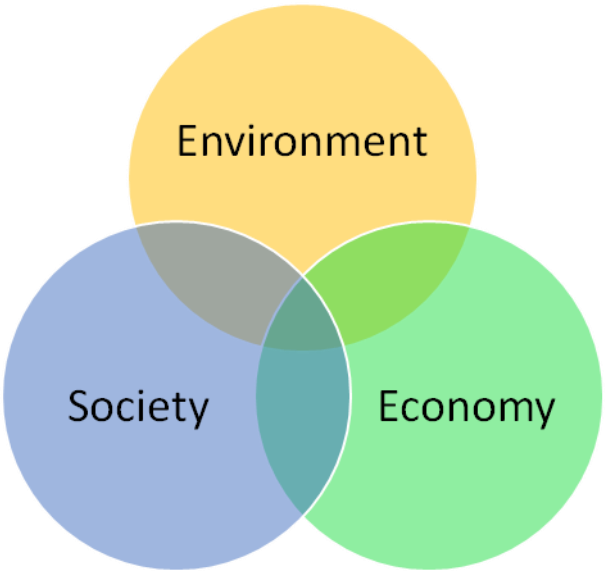


Figure 2-1: Sustainable development triple bottom line

- Economic sustainability – increasing profitability by making more efficient use of resources including labour, materials, water and energy.
    - Reduce operating costs
    - Create, expand, and shape markets for green product and services
    - Improve occupant productivity
    - Optimize life-cycle economic performance
- Environmental sustainability – preventing harmful and potentially irreversible effects on the environment by careful use of natural resources, minimizing waste, protecting and where possible enhancing the environment.
    - Enhance and protect biodiversity and ecosystems
    - Improve air and water quality
    - Reduce waste streams
    - Conserve and restore natural resources
- Social sustainability – responding to the needs of the people at whatever stage of involvement in the construction process (from commissioning to demolition), providing high customer

satisfaction and working closely with clients, suppliers, employees and local communities (Department of Trade and Industry 2002).

- Enhance occupant comfort and health
- Heighten aesthetic qualities
- Minimize strain on local infrastructure
- Improve overall quality of life("Green Building,")

The UN Summit on Environment and Development in 1972, ‘Agenda 21’ followed by the closing document of the UN ‘Earth Summit’ in 1992 in Rio de Janerio and many other international and national meetings and conferences indicated the growing concern about protecting the environment for the future generations and hence introducing sustainable development concept. The Kyoto Protocol which was initially adopted on 11 December 1997 in Japan and entered into force on 16 February 2005 addressing the (UNFCCC or FCCC), aimed at fighting global warming. The UNFCCC is an international environmental treaty with the goal of achieving stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system(Hana).

The sustainable building agenda is well recognized and rapidly growing in developed countries; however, in most developing countries with the largest and fastest growing building markets, resource efficiency and sustainability objectives are largely neglected in both construction and occupancy periods (UNEP, 2013). Consequently, the world’s most populous regions run the risk of locking their economies into inefficient and environmentally detrimental building stock for decades unless efforts are made to introduce and mainstream sustainable building practices.

2.3 Overview of National Energy Use In Comparison To International Usage

2.3.1 Production and Utilization

It is pertinent to consider the existing energy production and utilization capacities of Pakistan which will gives us a clear pathway for attaining cost-effective emission reductions through transferring our buildings that are an integral and major part of the built environment to energy efficient buildings.

Pakistan has installed power generation capacity of 25,906 megawatts (MW)(COMPANY). However, there are fluctuations in thermal generation and variations in hydel production due to seasonal changes(force, 2010)

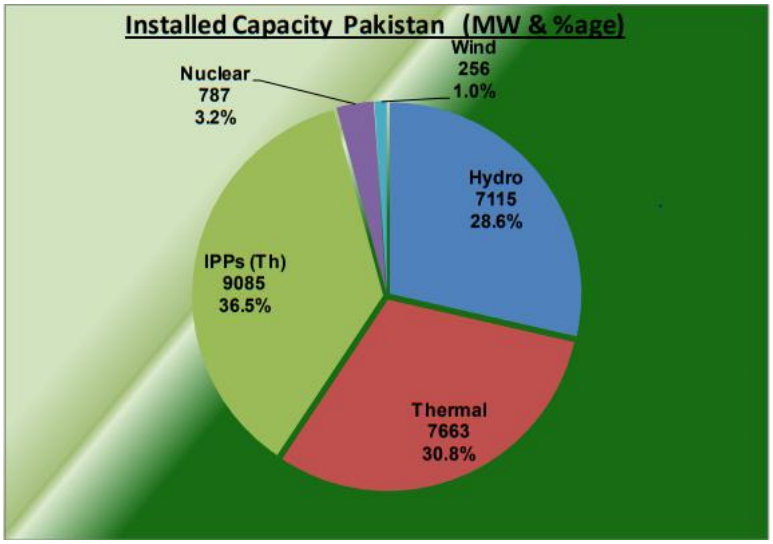


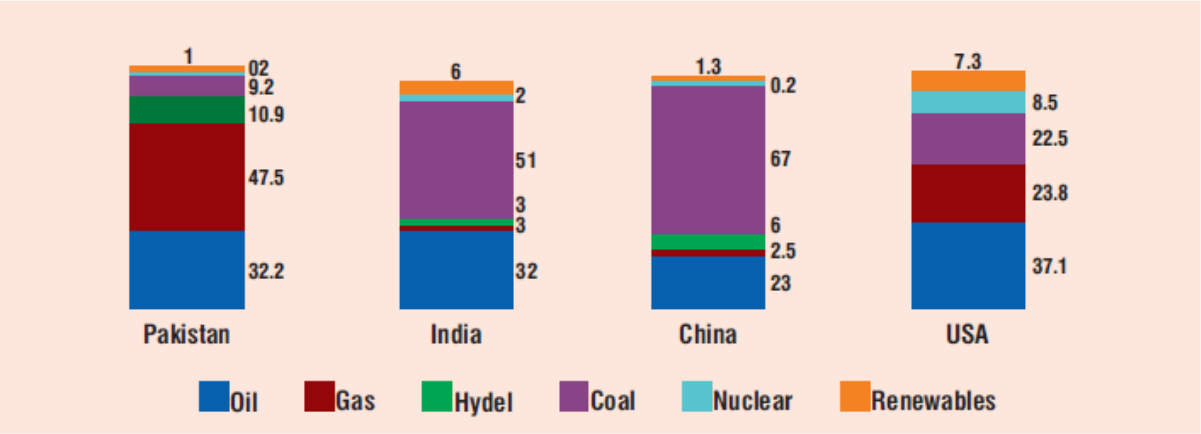
Figure 2-2 Installed energy capacity of Pakistan

Currently local utilization of country's indigenous resources for energy production is meager compared to available potential. For instance, the country's installed hydropower capacity is only 6,500 MW compared to available untapped potential of more than 54,000 MW. Reluctance to tap and utilize this potential, has led to increased local dependence on fossil fuels for power generation with known associated effects of higher production costs, reduced

energy security, adverse climatic impacts both locally and increasing contribution to global warming(force, 2010)

2.3.2 National Energy Mix

Pakistan's current electricity generation mix has a growing and unsustainable reliance on imported gas and fuel oil which further strengthens the need for effective utilization of available hydel capacity. Insufficient diversification among energy production sources exists compared to developed countries such as United States, China and neighboring India that have a more diversified and balanced energy mix. In the case of Pakistan, imported energy is in the range of 30% of the total energy mix and has been increasing each year for the past 5 years. There are, however, options for diversification of local energy mix and increasing reliance on domestic sources including renewable energy sources of wind and solar(force, 2010)



Source: Based on "Integrated Energy Plan 2009-2022", Economic Advisory Council, March 2009 (Updated for USA).

Figure 2-3 Pakistan energy mix compared to International

Huge renewable energy potential is available in Pakistan that ranges from around 50,000 MW from hydropower and 40,000 MW from wind energy alone. Solar energy too offers rewarding opportunities as much of Pakistan, especially Baluchistan, Sindh, and southern Punjab, receive abundant solar irradiation on the order of over 2 megawatt hours/square

meter and nearly 3,000 hours of sunshine a year, which is among the highest in the world. Un-tapping this massive compendium of renewable energy sources, can pave way for sustainable energy harvesting and promoting environmental friendly built environment, ensuring reduced impact on natural resources for its abundant availability for the future generations (force, 2010)

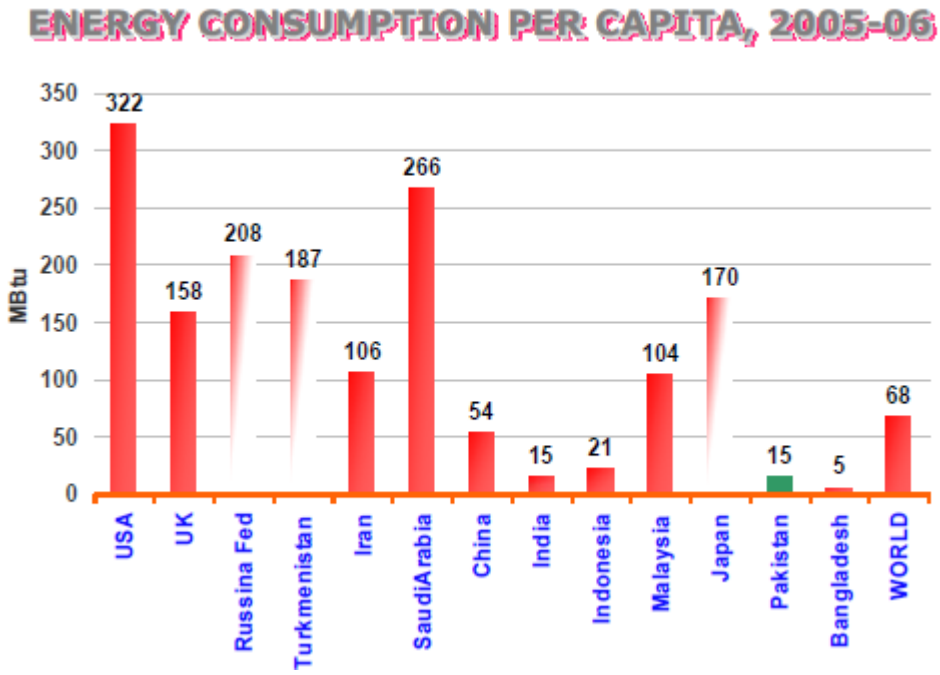


Figure 2-4: Energy consumption per capita

2.4 Overview of National GHG Emissions In Comparison To International GHG Emissions

Task force on climate change submits that Pakistan's total GHG emissions in 2008 amounted to 309 million tonnes (mt) of Carbon dioxide (CO2) equivalent, comprising about 54% CO2, 36% Methane, 9% Nitrous Oxide and 1% other gases. The biggest contributor is the energy sector with 50% share, followed by the agriculture sector (39% share), industrial processes (6% share) and other activities (5% share) (Pakistan, 2010)

Pakistan is a small GHG emitter: It contributes only about 0.8% of the total global GHG emissions. On per capita basis, Pakistan with 1.9 tonnes per capita GHG emissions stands at a level which corresponds to about one-third of the world average, one-fifth of the average for Western Europe and one tenth of the per capita emissions in the U.S., putting it at 135th place in the world ranking of countries on the basis of their per capita GHG emissions(Pakistan, 2010)

Pakistan Number sat at a Glance (2012)
342 $MtCO_2e$
Total GHG emissions
(0.72% of world total)
World: 47,599 $MtCO_2e$
179,160,111
Population
World: 7,043,181,414
1.9
tCO_2e per capita
World: 6.76 tCO_2e
US$ 137,744 Million
GDP
World: US$ 55,261 Billion
2,480
tCO_2e/million US$ GDP
World: 861 tCO_2e/million US$
GDP

+159 $MtCO_2e$ (+87%)

Change in GHG emissions

(1990–2012)

World: +13,661 $MtCO_2e$

Source: (USAID, 2016)

Pakistan's GHG profile is dominated by emissions from the energy and agriculture sectors, whose combined emissions total 87% of national GHG emissions. According to the World Resources Institute's Climate Analysis Indicator Tool (WRI CAIT), energy contributes 46% of Pakistan's total annual GHG emissions, of which 26% is attributed to electricity consumption, 25% to manufacturing, 23% to transportation and the remaining 25% to other energy subsectors (USAID, 2016)

Agriculture accounts for 41% of total GHG emissions, of which enteric fermentation is the primary contributor (46%). The land use change and forestry (LUCF) sector contributes 6%, dominated almost entirely by changes in forest land. Industrial processes (IP) and waste contribute 5% and 2%, respectively(USAID, 2016)

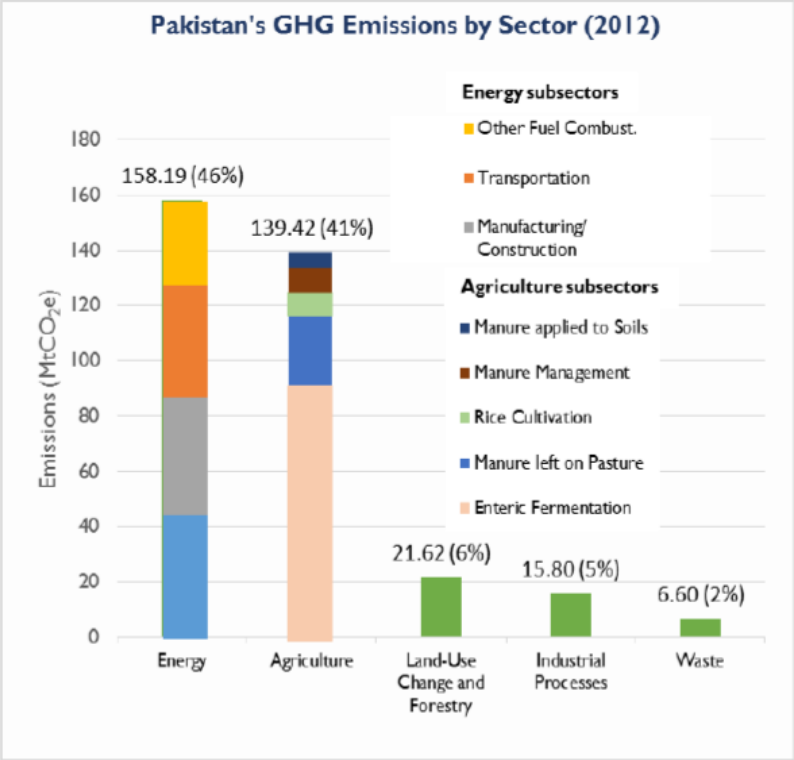


Figure 2-5: Pakistan GHG emissions by sector (2012)

Source: (USAID, 2016)

2.5 Overview of International Green Buildings Standards

2.5.1 Green Building Definitions

Green building is a holistic concept that starts with the understanding that the built environment can have profound effects, both positive and negative, on the natural environment, as well as the people who inhabit buildings every day. Green building is an effort to amplify the positive and mitigate the negative of these effects throughout the entire life cycle of a building.

2.5.1.1 United States Green Building Council

USGBC defines green building as, "While there are many different definitions of green building out there, it is generally accepted as the planning, design, construction, and operations of buildings with several central, foremost considerations: energy use, water use,

indoor environmental quality, material section and the building's effects on its site”(Kriss, 2014)

2.5.1.2 United States Environmental Protection Agency

USEPA defines green buildings as, “Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from siting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high performance building”("Green Building,")

2.5.1.3 Green Building Council Australia

Green building council Australia (GBCA) defines green building as, “A green building incorporates design, construction and operational practices that significantly reduce or eliminate its negative impact on the environment and its occupants. Building green is an opportunity to use resources efficiently while creating healthier environments for people to live and work in. Green building can also significantly reduce construction and performance costs”(Australia)

Figure 2-6: World map showing countries using the four predominant ranking/rating systems (WGBC)

Source: (Say & Wood, 2008)

2.5.2 Green buildings rating mix

Green building rating systems are a mix of different categories mainly consisting of site selection, water conservation, energy, materials and resources, indoor air quality and others. Among different green building rating systems used globally, energy category shares the maximum weightage further substantiating the fact that focus lies primarily on reduction in use of energy from fossil fuels thus reducing GHG emissions(Say & Wood, 2008). An overview of point's breakdown for different global green building standards is given below;

2.5.2.1 Leadership in Energy and Environmental Design (LEED)

LEED is USGBC green buildings certification system that is adopted outside United States and is among the few popular international green building certification systems. LEED certification points breakup with respect to sustainability priority areas is depicted below.

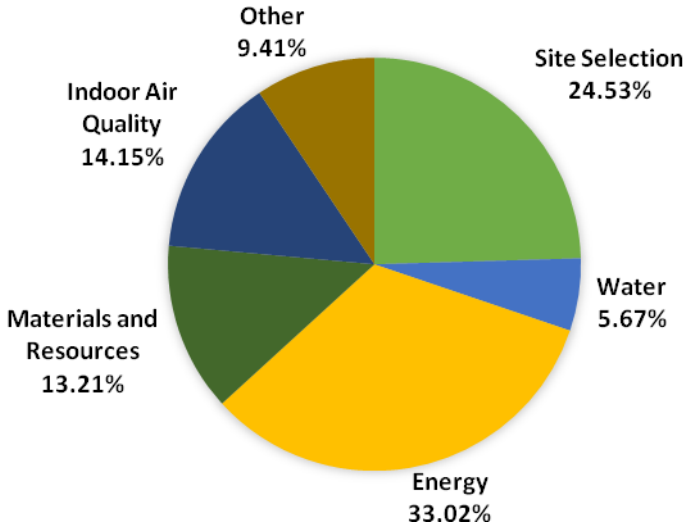


Figure 2-7: Breakdown in LEED 3.0 New Construction points

Source: (Say & Wood, 2008)

2.5.2.2 Building Research Establishment Environmental Assessment Method (BREEAM)

BREEAM is United Kingdom green buildings certification system that is also adopted outside United Kingdom and is among the few popular international green building certification systems. BREEAM certification points breakup with respect to sustainability priority areas is depicted below.

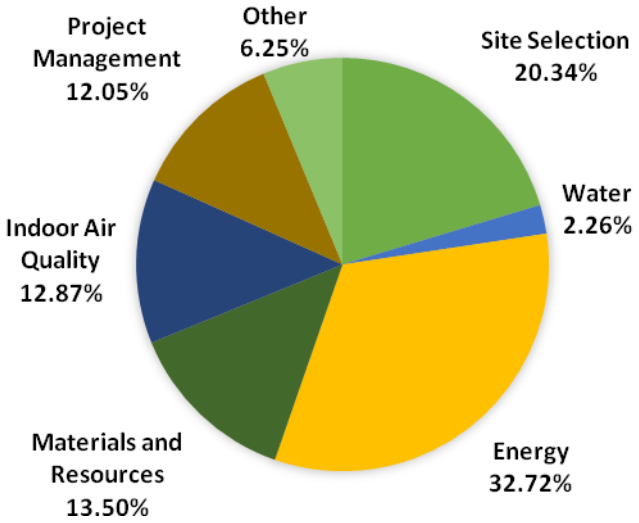


Figure 2-8: Breakdown in BREEAM Office 2008 points

Source: (Say & Wood, 2008)

2.5.2.3 GREEN STAR

GREEN STAR is Australian green buildings certification system. GREEN STAR certification points breakup with respect to sustainability priority areas is depicted below.

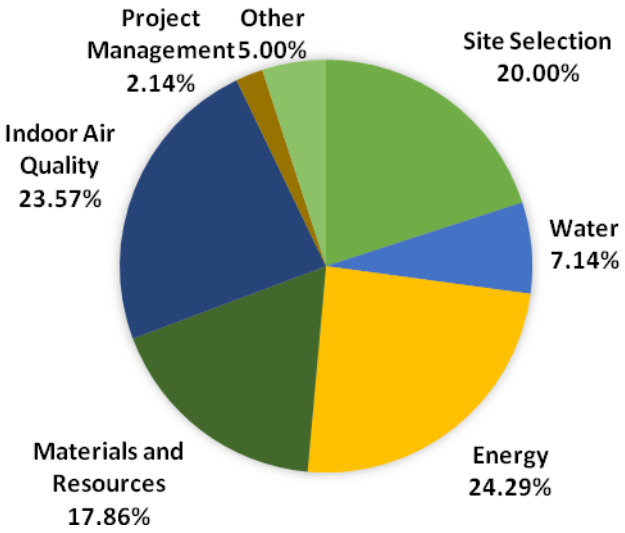


Figure 2-9: Breakdown in GREEN STAR points

Source: (Say & Wood, 2008)

2.5.2.4 GREEN GLOBES

GREEN GLOBES is United States and Canadian green buildings certification system which is an offshoot of BREEAM. GREEN GLOBES certification points breakup with respect to sustainability priority areas is depicted below.

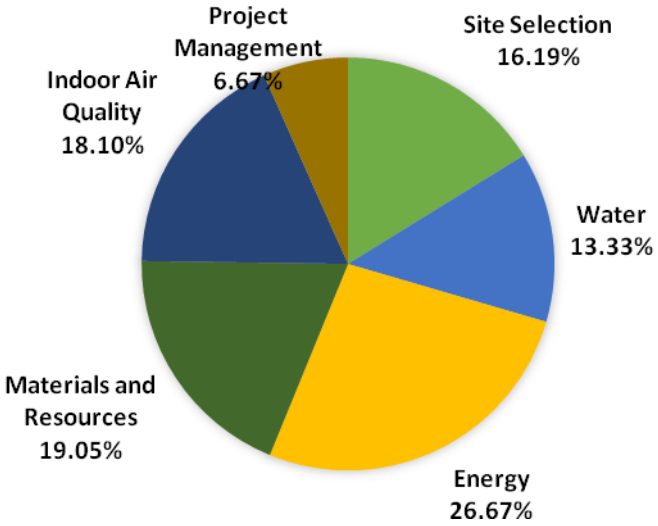


Figure 2-10: Breakdown in GREEN GLOBES Design of New Buildings or Significant Renovation points

Source: (Say & Wood, 2008)

2.5.2.5 Pakistan Green Building Council (PakistanGBC)

Pakistan green building council has also developed its very own green buildings certification system. Certification points breakup with respect to sustainability priority areas is depicted below.

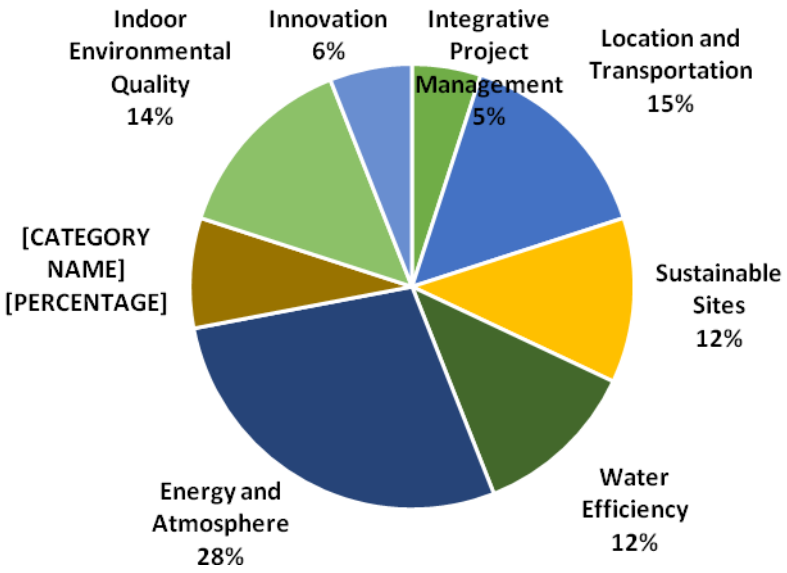


Figure 2-11: Breakdown in Pakistan GBG points

2.6 Study Area

Pakistan is geographically and strategically placed in South Asia, stretching over 1,600 kilometres from north to south and 885 kilometres from east to west covering an inclined rectangular area about 796,095 square kilometres with a coastline of 1,046 kilometres along the Arabian Sea. Pakistan borders with China in the far northeast, India to the east, Afghanistan to the west and Iran to the southwest respectively. Pakistan also shares a maritime border with Oman. Pakistan is one of the key countries of the region with unique geo-strategic and socio-economic representation and lying on the crossroads of South Asia, the Middle East and Central Asia ("Pakistan's intended Nationally Determined Contribution ")

Pakistan’s current population is estimated at 195 million, making Pakistan the sixth-most-populous country of the world. With population growing at an annual rate of 1.89%, the population of Pakistan is estimated to be 229 million by 2025 and double by 2045. Social mobility and search for better economic growth opportunities is pushing increased uncontrolled urbanization, making Pakistan the second-most rapidly urbanizing country of South Asia with urban population accounting for about 36% of the total population. In years to come the current urbanization trend is set to grow further on a faster pace hence resulting in sizeable urban masses despite ever increasing economic, social and environmental pressures on the already dense urban centres of Pakistan ("Pakistan's intended Nationally Determined Contribution ")

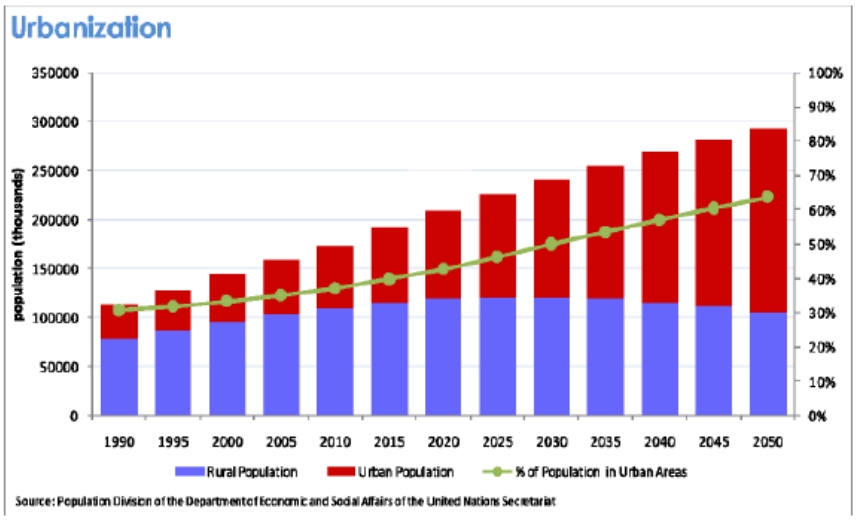


Figure 2-12: Urbanization trend in Pakistan

Source: (S. ARIF, 2011)

This particular research focuses further on the city of Peshawar in the province of Khyber Pakhtunkhwa. Peshawar is the capital of Khyber Pakhtunkhwa. It also serves as the administrative centre and economic hub for the Federally Administered Tribal Areas. Situated in a broad valley near the eastern end of the historic Khyber Pass, close to the border of Afghanistan and is surrounded by mountain ranges on three sides, with the fourth opening to the Punjab plains. The city is located in the level base of the valley, known as the Gandhara Plains.

2.7 Climate Variability

Pakistan is well known for its climate variability due to its extraordinary geographic location. The country has some of the world's highest mountainous regions in the north with numerous peaks over 7,000 meters above sea level and vast spread deserts in the southeast and south spread over about 11 million hectares, making 14% of the country's total landmass. The coastline in the south stretches about 1,046 kilometres. The country exhibits some of the most differentiated altitudes as well as diversely rich geophysical conditions.

Pakistan lies on a steep incline, dropping sharply from almost 8,500 meters down to sea level within a distance of less than 3,000 km. Presence of about 15,000 sq. km of glacial area and nearly 7,000 glaciers makes it one of the most glacially populated regions of the world outside the polar region. Apart from being the most prominent source of water to meet the needs of the country, these massive and widespread glaciers in the north are also key contributors in stabilizing regional and global climatic changes. Currently rate of glacial melt in Pakistan stands at 2.3% per annum, that places Pakistan's north amongst the fastest melting glacial regions in the world. The country's extreme vulnerability to climate change is a logical certainty owing to its geographic location, elevation as well as demographics. (Pakistan, 2010)

Climate induced natural disasters pose a grave challenge to the Governments around the world. These disasters have depicted over time, huge human, livestock and agricultural losses having direct impact on national and global economies. The situation is aggravated and worrying with the fact that developing countries have been on the forefront of climate change adverse effects and its induced natural disasters. (Pakistan, 2010)

Pakistan's contribution to the global GHG emissions is marginal. According to the Global Economy rankings, the share of Pakistan in total global GHG emissions is merely 0.8% and it is ranked 135th in the list of global emitters on a per capita basis. However, due to its geo-physical conditions, climatic extremes, high degree of exposure and vulnerability etc, Pakistan has been ranked 3rd in the 2012 assessment of the Global Climate Risk Index 2014 with over 6 billion USD losses primarily due to climate change (Pakistan, 2010)

2.8 Solar Energy Prospect in Pakistan

Geographically Pakistan lies in the region of some of the highest solar isolation in the world. Most of the areas in the country receive high solar radiation intensities throughout the year

(Khalil & Zaidi, 2014). Pakistan lies in ideally located sun belt that receives 200-25- watt per m2 in a day with about 1500 – 3000 sunshine hours in a year (Mirza, Maroto-Valer, & Ahmad, 2003). Such conditions offer ideal potential for untapping solar energy using different solar energy mediums such as photovoltaic and solar thermal technology.

US National Renewable Energy Laboratory developed solar maps of Pakistan which indicates that many regions of the country are blessed with higher solar insolation levels averaging from 5 kWh/m2/day to 7 kWh/m2/day(Amer & Daim, 2011).

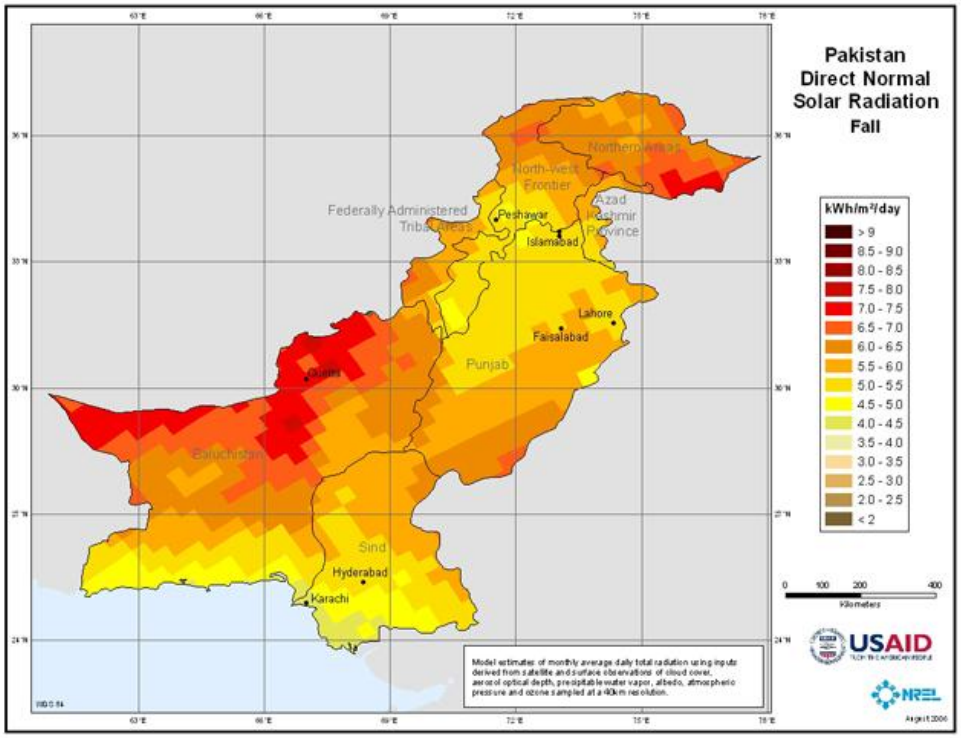


Figure 2-13: Pakistan direct normal solar radiation fall

2.8.1 Solar Energy Applications in Pakistan

2.8.1.1 Photovoltaic (PV)

Among the solar energy production option available, photovoltaic is the best way to utilize solar energy and covert sun radiation into direct electricity even on micro level (Mirza et al., 2003). Photovoltaic technology has been proven to be a viable option due to its modular size,

light weight, ease of installation and movement. The need of electricity is not only for rural areas in Pakistan, but the grid connected urban locations are also seeking the alternate electricity supplies because of ongoing electricity shortfall and load shedding problem which last for 4–6 h in urban areas and 8–12 h in rural areas (Bhutto, Bazmi, & Zahedi, 2012).

Since the study focuses mainly on utilizing solar energy for electricity usage at household level, therefore solar photovoltaic option is considered for further discussion.

2.8.1.2 Solar Thermal

There are numerous forms in which solar thermal energy can be used directly by exploiting the heat from solar radiation. Different forms of solar thermal applications are comparatively easy to use and relatively low in cost. These applications include cooking, heating and cooling for buildings, generating high temperature steam for industrial use and drying agricultural products (Mirza et al., 2003).

Chapter-3

3 Research Methodology

The main purpose of this research was to ascertain perception among professional community of Peshawar city in regard to solar energy use as renewable energy source at household level, therefore exploratory research offered assistance in understanding perception.

3.1 Research Method and Design

3.1.1 Research Method

A contemporary research method i.e. mixed method research that utilizes both quantitative and qualitative research designs was opted for this study. Mixed method research encompasses the weaknesses of both paradigms building upon diverse strengths and possibilities respectively and hence attributing to enhanced reliability and generalization of findings.

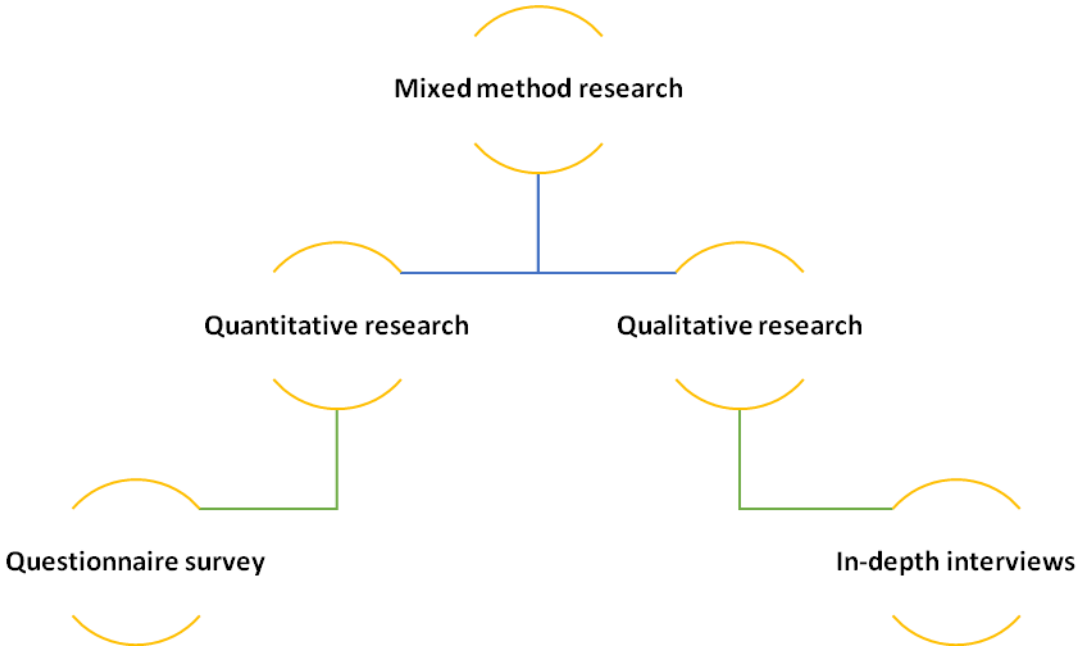


Figure 3-1: Research method flowchart

3.1.2 Limitations

Since the target of this survey was professional community of Peshawar City, therefore considering prevailing security situation in the city, cultural barriers, financial constraints and generally lower response rate on public surveys, detailed discussions with some of academic institutions in Peshawar involved in social sciences were conducted and it was ascertained that referral and snowball sampling method shall be adopted for this study with major urban built-up areas of the city to be targeted.

3.1.3 Research Design

Considering the existing scenario with respect to the research area in the context of Peshawar and to address the research problem through perception survey, following two types are considered;

3.1.3.1 Descriptive Design

The descriptive research is appropriate for clearly knowing about the current status of any problem and it also describes "what exists" regarding variables or different situations. The current study is also focused on assessing the perception of professional community of Peshawar and identifying effective implementation issues related to solar energy at household level.

3.1.3.2 Exploratory Design

There is no sufficient awareness and data available on professional community perception regarding use of solar energy as renewable energy source at household level as this area of research is in its early stage in Pakistan and particularly in Peshawar (KP). Keeping this in view, exploratory design is chosen to establish information about the current situation and give direction for future research in this field.

3.2 Sample Size and Sampling Technique

3.2.1 Sample Size

Considering research limitations, questionnaire was circulated to 437 professionals using referral and snowball sampling method targeting major built-up areas of Peshawar. With a response rate of 25.85%, 113 valid responses were received.

Smaller sample size is attributed to financial constraints and cultural barrier in Peshawar city. However sample size was sufficient for carrying out statistical analysis. It is suggested that future survey should be carried out on larger sample size with sufficient financial resources available for confirming results.

3.2.2 Sampling Techniques

Collection of both quantitative and qualitative data was administered through non-probability sampling technique.

3.2.2.1 Sampling for Quantitative Data

Non-probability sampling technique was selected to get quantitative data from different urban areas of Peshawar City in order to ascertain the perception about use of solar energy as primary source of energy at household level. Considering limitations for this research study, referral and snowball sampling technique was adopted but at the same time keeping in view that all major urban areas were covered and represent the overall perception.

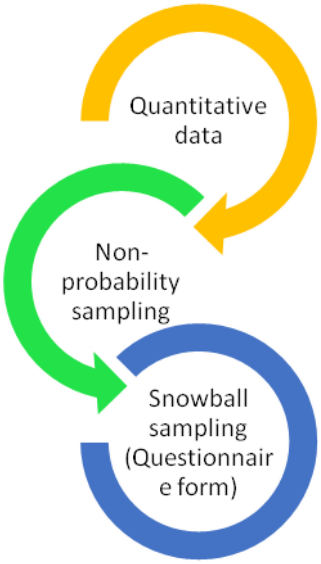


Figure 3-2: Quantitative data flowchart

3.2.2.2 Sampling for Qualitative Data

Non-probability sampling technique was also selected for qualitative data from different key stakeholders in Peshawar City to ascertain provincial Government policies, plans, initiatives about use of solar energy as primary source of energy at household level. In this regard, purposive/judgmental sampling technique was adopted to carry out in-depth interviews with key concerned stakeholders.

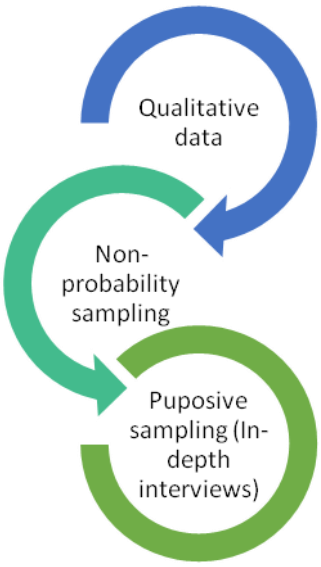


Figure 3-3: Qualitative data flowchart

3.3 Tools of Data Collection

Data collection techniques used for this research study consist of following two main components;

- Questionnaire form
- In-depth interviews

3.3.1 Questionnaire Form

Questionnaire form for this research comprised of mainly two parts and the questionnaire had both closed and few open-ended questions that was optional. It was envisaged that closed-ended questions are for recoding direct responses of respondents whereas open ended questions shall help in gathering detail perception from respondents on few questions. The first part of the questionnaire is related to general information on respondent background covering age, profession, locality of living (within Peshawar) and academic qualification.

The second and main part of the questionnaire tries to capture the respondent perceptions on use of solar energy as primary source of energy at household level. The questionnaire is presented in Annexure-A.

The questionnaire was circulated primarily through bulk emailing, e-networking platforms and using referral technique. In addition the questionnaire was also distributed among government departments, local architects, engineers and academic institutions directly involved in higher education and research with a focus on greater use of renewable energy. To increase the sample size, it was requested from respondents to further disseminate the questionnaire among their circles.

3.3.2 In-Depth Interviews

In-depth interviews were conducted with Energy and Power Department, Khyber Pakhtunkhwa (2 interviews), some of users (3 interviews) and non-users (3 interviews) of solar energy technology at house hold level. The in-depth interview form is presented in Annexure-B

3.4 Data Analysis

Data obtained from closed ended questionnaire was analysed using primarily SPSS and MS Excel. Descriptive statistics, frequencies and cross tabulation techniques were used to provide key statistics of data and to explain relationship between different variables.

Chapter-4

4 Data Analysis and Discussions

The chapter discusses results of data analysis carried out on questionnaire feedback using SPSS software and discussion on in-depth interviews carried out with key stakeholders including users and non-users of solar energy from community. Different forms of descriptive statistics such as frequencies and cross tabulations have been carried out to further elaborate the key statistical relationship between different variables and to highlight results.

4.1 Respondents Profile

The questionnaire form had two sections. First section relates to general information with regards to respondent that covered age, profession, locality of living and academic qualification. The detail results of these parameters are discussed in subsequent sections.

The ages of respondents were divided into five different age groups less than 25, 25 to 35, 35 to 45, 45 to 55, 55 to 65 and 65 & above and above using bin technique in SPSS in which age ranged from 18 years to 64 years. Further data analysis revealed that 7.1% of the respondents are in age group of less than 25, 29.2% are in the range of 25 to 35, 27.4% are in the range of 35 to 45, 23.9% are in the range of 45 to 55, 8.8% are in the range of 55 to 65 and only 3.5% are in the range of 65 and above. It means that major share of 80.5% of the respondents is between the range of 25 to 55 as shown in the figure below.

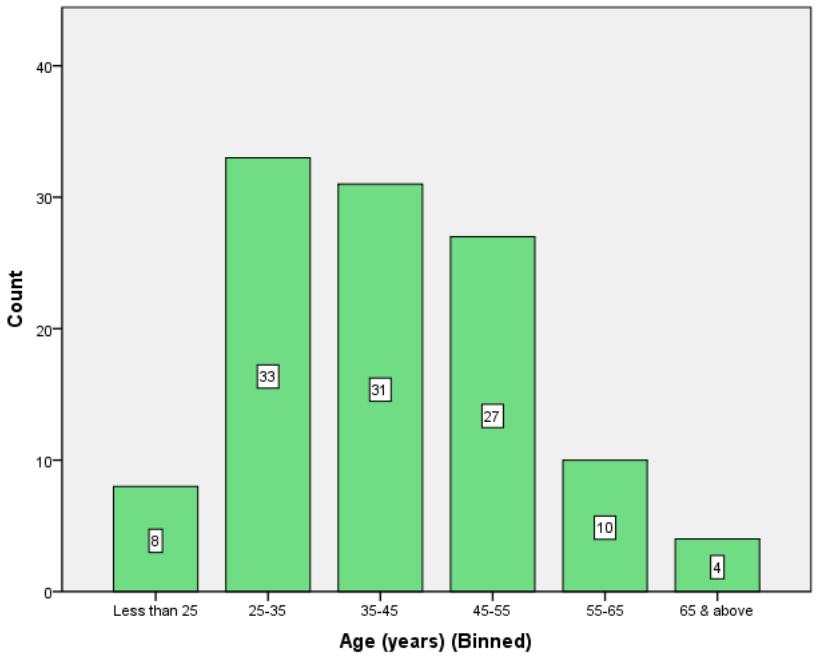


Figure 4-1: Grouped age count

Further analysis of section-1 of the questionnaire survey revealed that majority of the respondents i.e. 87.6% had attained higher level of education that corresponds to bachelor and masters. The data further shows that 2.7% of the respondents had education till intermediate (FSc), 5.3% of the respondents had a diploma in technical fields and 4.4% of the respondents had doctorate degree as shown in the figure below.

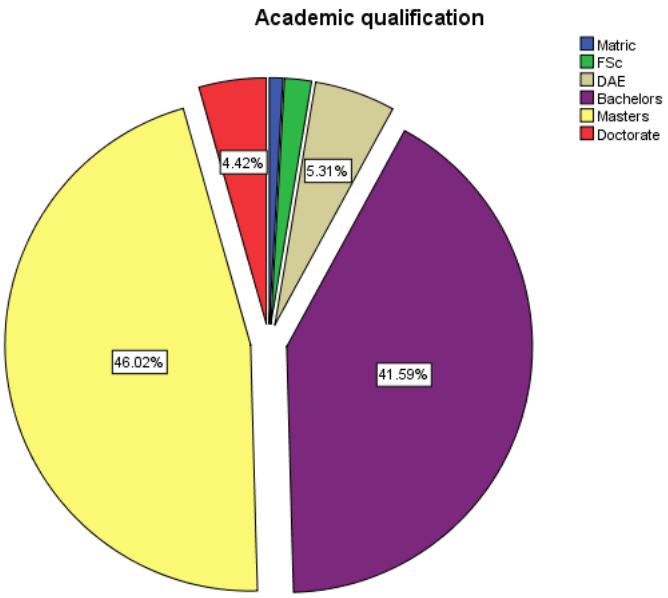


Figure 4-2: Share of academic qualification

With regards to professional practice of the respondents, a wide range of professional backgrounds were observed that helped in recording of holistic perception with regards to intended study. Among the respondents, 33% were afflicted with the profession of engineering field, 12.5% of the respondents run their own business, 11.6% respondents were students and 11.6% belong to public sector. Further breakup of respondents with respect to profession is shown below.

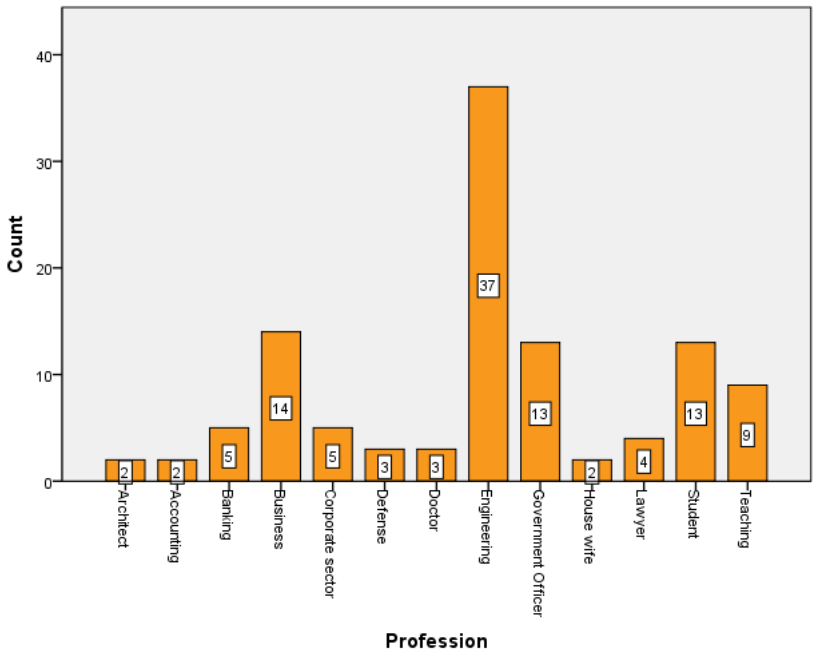


Figure 4-3: Professional background count

Further analysis in the form of cross tabulations was carried out between different variables from section-1 of the questionnaire in order to ascertain context specific relationships.

In this regard comparison between locality of living and academic qualification was carried out. Overall education level of the respondents is uniformly distributed with few of the areas such as Hayatabad and University Road have more residents with higher education. The statistics may also be supplemented by the fact that most of the academic institutions in Peshawar City are either located in Hayatabad or near the vicinity of University Road that also included University of Peshawar.

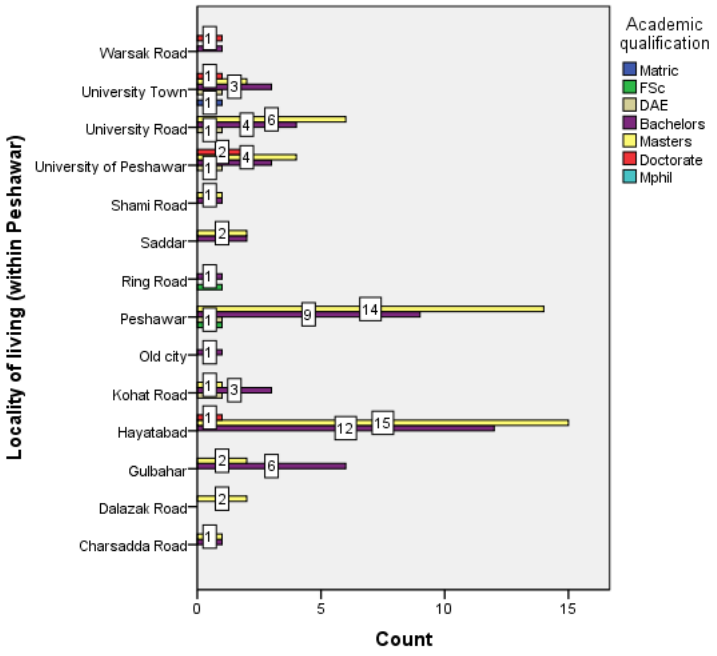


Figure 4-4: Comparison between location and academic qualification

Comparison between locality of living and professional background was also carried out. Overall professional background of the respondents is uniformly distributed across the city with Hayatabad having the highest count of residents with engineering related professional backgrounds. The statistics may also again be supplemented by the fact that most of the engineering universities in Peshawar City are either located in Hayatabad or near the vicinity of University Road that also include University of Peshawar. Also a variety of professional background mix is observed that portrays the fact that Peshawar city has a diverse job sector.

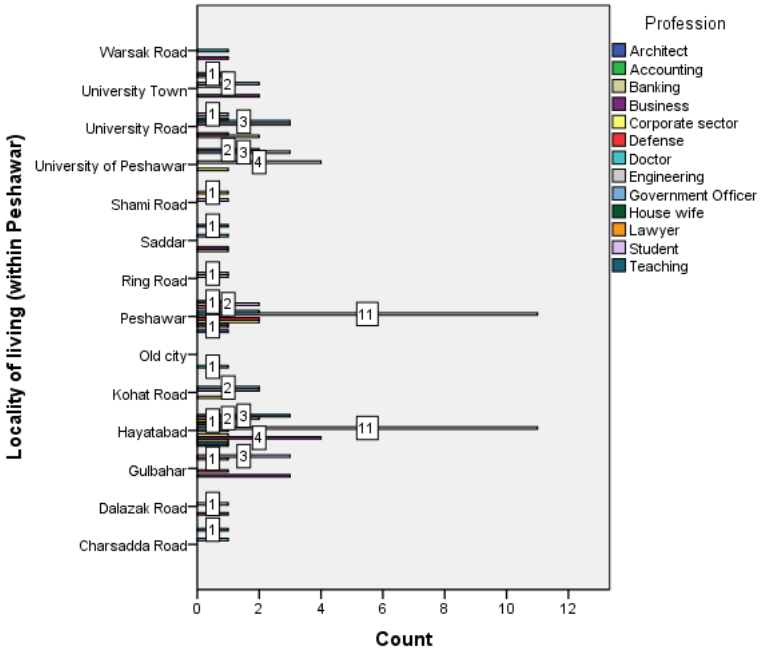


Figure 4-5: Comparison between location and profession

4.2 Study Thematic Areas

The questionnaire form adopted and used for the survey enabled us to identify broad themes that are depicted in the figure below. These themes link to core objectives of this study that helped in identification of critical interventions required by different stakeholders.

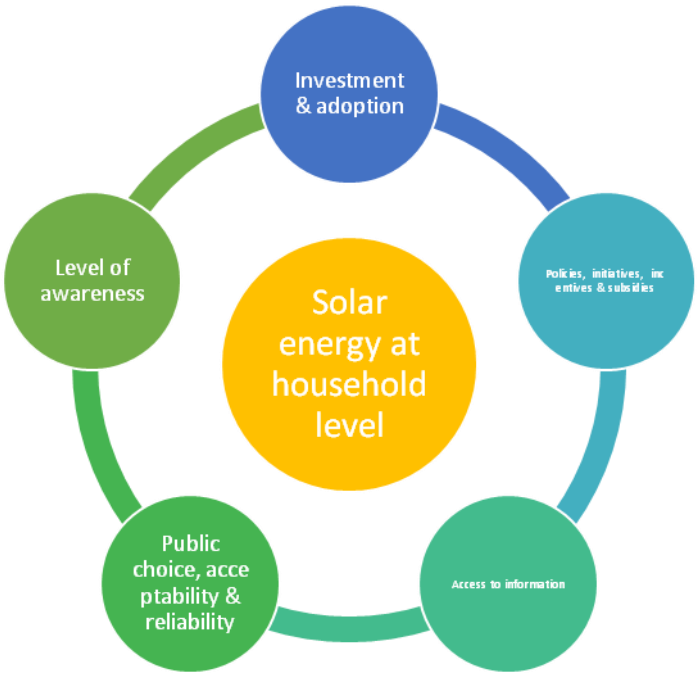


Figure 4-6: Thematic areas based on questionnaire

4.2.1 Level of Awareness (thematic area-1)

Questions (1-6) presented in the questionnaire form have been merged under the thematic area of awareness level. The set of questions helps in collecting perception of people with regards to awareness on solar energy potential of replacing fossil fuels, time frame required for substantial shift to occur, potential renewable energy sources in local context and impacts of solar energy on biodiversity in relation to fossil fuels.

Potential of solar energy use as clean energy source and to replace fossil fuel based energy showed a positive trend with 78.8% (89 respondents) agreeing to the proposition. Thus it can be concluded that people are optimistic about solar energy prospect and that it can play vital role in near future with a potential to gradually replace dependence on fossil fuels for energy production. Very few respondents disagreed (1.8% or 2 respondents) to the question posed. The lower number of responses implies that limited/no awareness related to solar energy potential as well as uncertainty about solar as renewable energy at house hold level since the

technology is relatively new in local context. Respondents who were not sure about the possibility of replacement of fossil fuel based energy production with that of solar based were 19.5% (22 respondents) who opted for this option. This lot of people may also be unaware of solar energy potential and its associated benefits both on environment and socio-economic conditions due to lack of information regarding the global shift that is happening from fossil fuels to renewable energy sources.

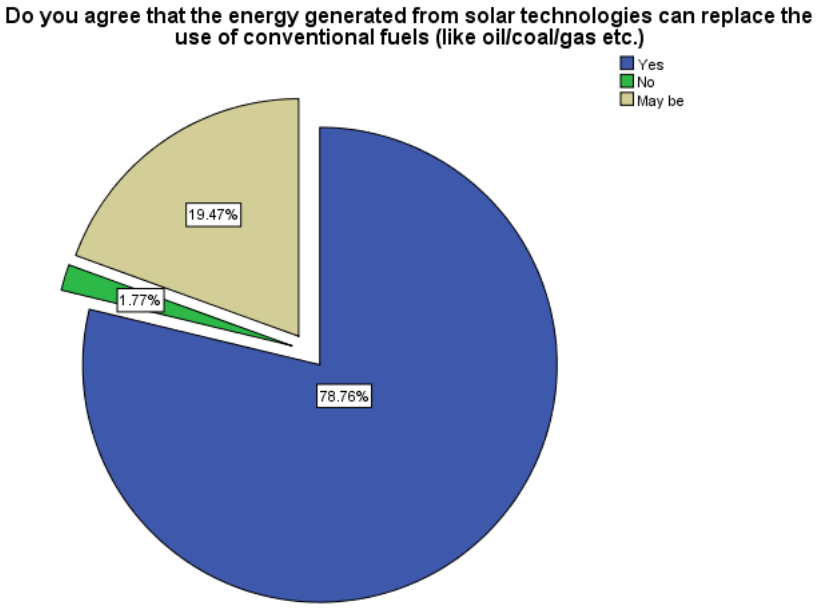


Figure 4-7: Solar energy replacing fossil fuels

It was pertinent to know the perception about time required for switching from fossil fuel based energy to solar based energy at household level. Most of the responses opted for medium term timeframe with 66.1% (74 respondents), which portrays factual understanding on part of the key stakeholders as government initiatives, plans, policies and programs on promotion of solar energy shall require time for better coordinated implementation and regulation in order to have a wider penetration at household level in the context of Peshawar. Further 23.2% (26 respondents) considered short term category for the replacement to take place. These might be the people who are either already using solar energy technology at

household level or are people who foresee fast transformation already happening. Regarding long term time frame required for switching from conventional to renewable energy source of solar, 10.7% (12 respondents) opted for this option thus agreeing with the fact that wider adoption of solar energy application at household level is a long term process considering government priorities and prevailing investment opportunities.

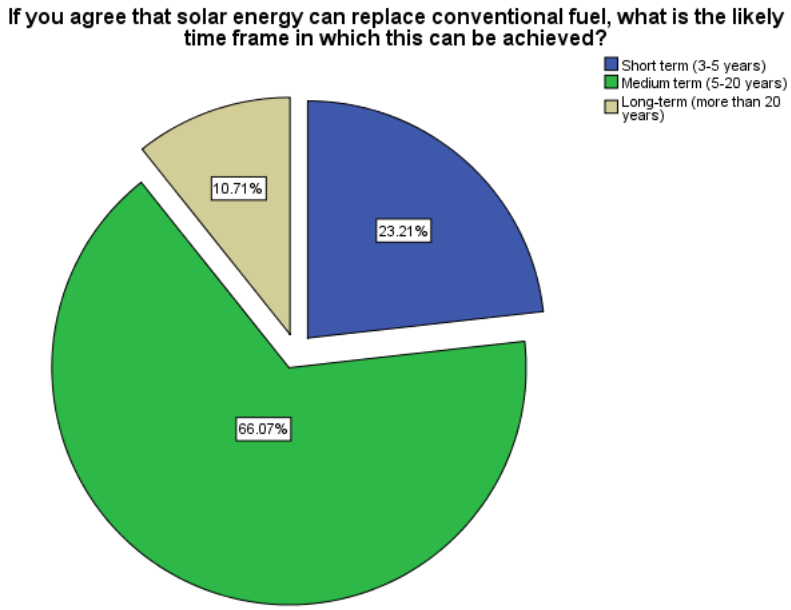


Figure 4-8: Timeframe for shift from fossil fuels to solar energy

Through in-depth interviews with some of current users of solar energy applications at household level, the respondents shared that the provincial government has not taken visible steps for promotion of solar as clean energy source at household level. Also considering the energy demand in the country and shortfall in generation, government should have prioritized alternate energy sources including solar, wind etc. The respondents further shared that considering government non-seriousness, they feel that the shift will take 10-15 years.

With regards to potential of different renewable energy sources, question was posed asking respondents to identify one renewable energy source that they think has the most potential in Peshawar. Solar energy received the highest response rate of 90.3% with 102 respondents

who are convinced of its potential in Peshawar. Further waste to energy ranked second in potential with 7.1% (8 respondents) followed by thermal as third potential with 2.7% (3 respondents). Wind and small hydropower received no response (0% of the total) from respondents .Renewable energy potential ranked by respondents clearly depict that the respondents have a clear understanding on renewable energy options that can be explored in the local context given government takes necessary initiatives for promotion of the same.

The awareness level can also be attributed to the fact that respondents have a clear perception on amount of sunshine available in the region and city that can be tapped and utilized as a clean energy source.

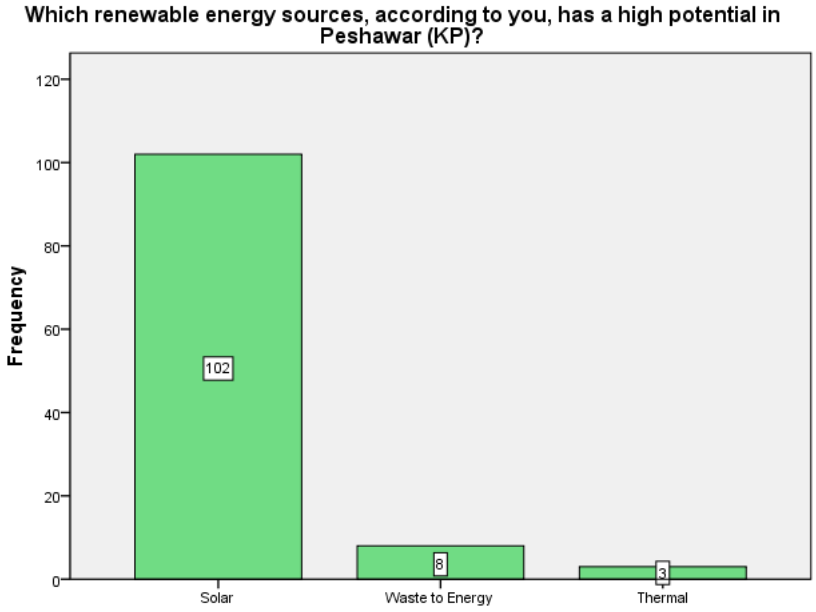


Figure 4-9: Renewable energy sources prospect

Worldwide solar energy and its allied products have witnessed a sharp decline in costs as the market for renewable energy is gaining momentum and governments around the globe are enhancing efforts towards compliance with sustainable development goals and Paris

agreement. Of the respondents, nearly 84.9% are hopeful that solar energy cost is going to reduce to a substantial level and will eventually become cheaper than conventional fossil fuel energy, which is also the case in some of the developed countries moving rapidly towards renewable energy technologies such as US, China and many European countries.

Almost half of the total respondents i.e. 56.6% (64 respondents) agreed with the assumption that solar energy will become cheaper than conventional energy. Further 28.3% (32 respondents) strongly agreed solar energy will become cheaper than conventional energy. Clearly this is an encouraging inclination with clear understanding on part of the stakeholders about the long term benefits and positive impacts of solar energy initial investment.

On the other hand only 4.4% (5 respondents) opted for don't agree option thus depicting that there are sections still not fully persuaded of investing in solar energy technology at household level. There is this possibility that was also shared by interviewing respondents that decision of many people for shifting to solar is mainly influenced by the perception that solar energy technology is expensive with high capital cost involved which is correct and that government, R&D institutions and private sector need to mass communicate life cycle costing with emphasis on payback period on investments so that people are able to make informed decision based on authentic and localized data.

Respondents who opted for need more information option were 10.6% (12 respondents). These are the people with either very limited or no information on capital investments and return period. This group of people needs attention during media campaigns and information dissemination so that wider implementation of solar energy based technologies is made possible.

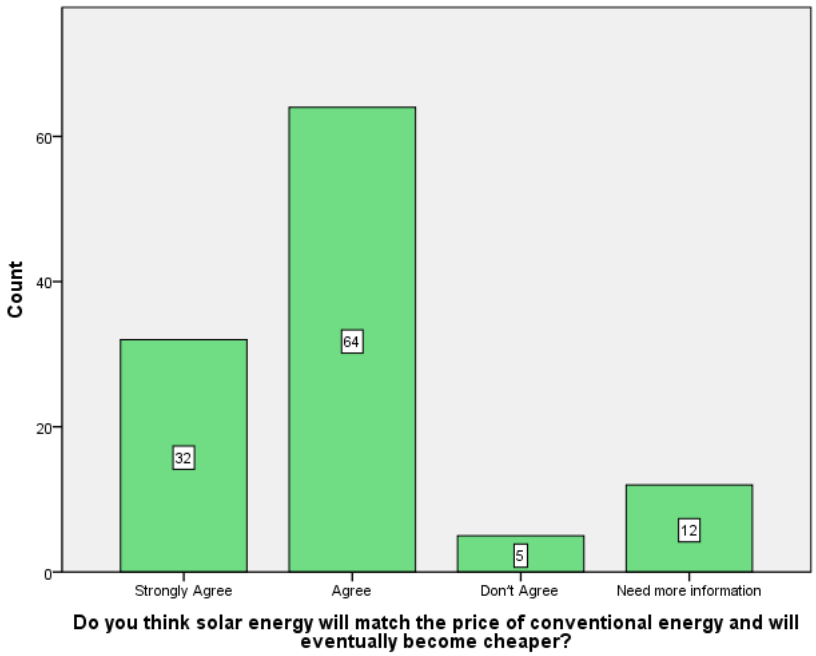


Figure 4-10: Renewable energy price compared to conventional energy

Considering the harmful impacts in the form of GHG emissions and unsustainable use of natural resources for energy production using fossil fuels, renewable energy sources have gained tremendous global attention and momentum in curtailing negative impacts on biodiversity. In order to analyze the perception of linkage between solar energy and biodiversity, a couple of interconnected questions were asked from the respondents. First question in this regard designed at analyzing common perception with regards to paramount harmful effects of these technologies on biodiversity (fossil fuels v. solar energy) while the subsequent question explored the latest belief and school of thought regarding harmful effects of solar energy technology on the environment and biodiversity.

In comparison of harmful effects of fossil fuels and solar energy, 35.4% (40 respondents), strongly agreed with the fact that solar energy technologies have less impact on biodiversity compared to fossil fuels. Group of people agreeing with this fact might have the knowledge and information that they have gained through media, articles, research findings or personal experience. Further 61.1% (69 respondents) also agreed with the question statement, but are

not as convinced as those strongly agreeing. This might be due to the reason that these people have heard about less impacts of solar energy technologies compared to conventional but are not fully convinced due to knowledge gap. There are also respondents who are willing and require more information on the issue and comprised of 3.5% (4 respondents). These are probably the people who are not aware of this concept and would definitely need authentic information on the subject before sharing any view.

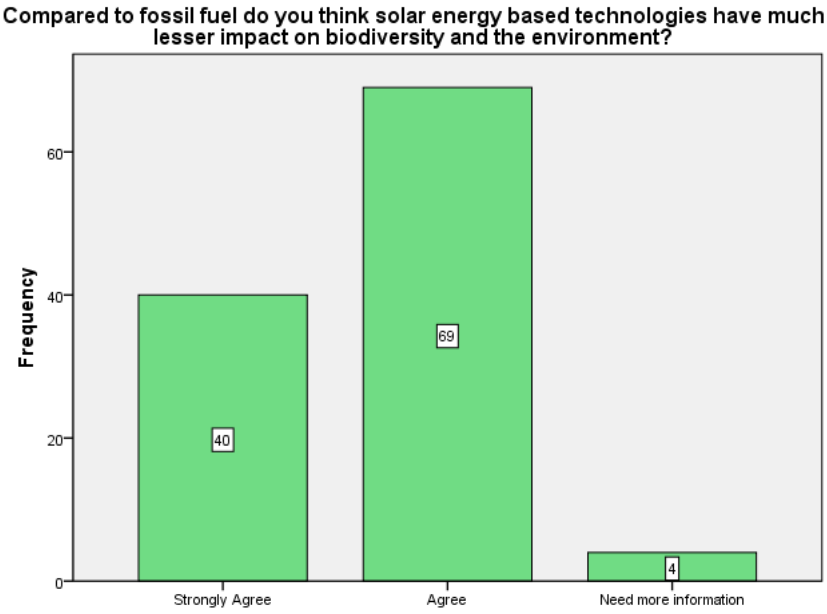


Figure 4-11: Solar energy impact on biodiversity compared to fossil fuels

With regards to latter whether solar energy technologies have harmful effects, majority of the respondents 85.7% (96 respondents), did not agree that solar energy technologies can cause any harmful impact on biodiversity. However 1.8% (2 respondents) strongly agreed that harmful impacts are caused on biodiversity by solar energy based technologies. This represents people who are convinced on the information on adverse impacts of solar energy technologies on environment and biodiversity.

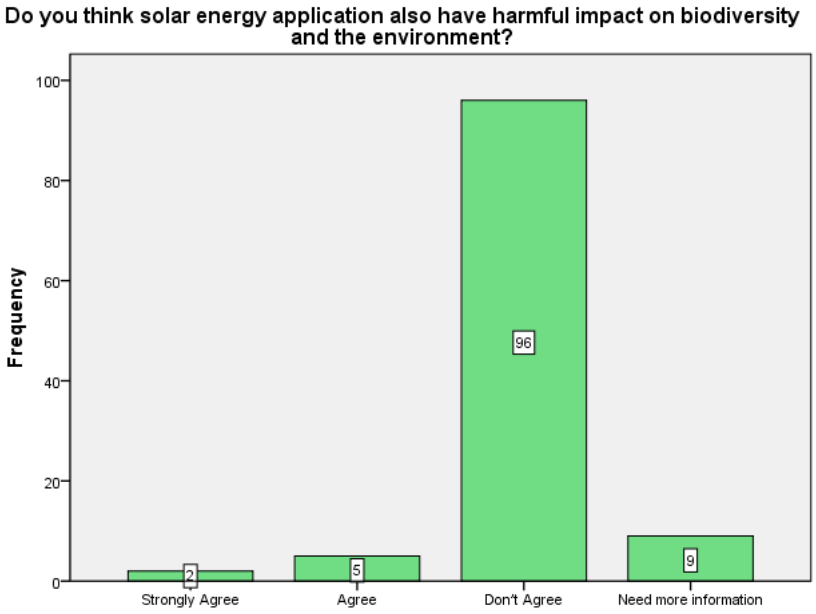


Figure 4-12: Harmful impact of solar energy on biodiversity

One of the respondents who opted for the option "strongly agreed" said, solar energy has harmful impacts on environment, shared additional feedback that at present the solar panels are disposable. There is no maintenance facility available in any part of the country. If available, I am unaware of it. We don't know how to dispose of the damaged panels. This is why it is not good for environment. Being a poor nation at the moment this is just a luxury not a development. The Government of Pakistan needs to start the subject in various technical schools, colleges and universities. When experts are there, we will be able to use this technology. If one cell in the panel is damaged, no one can change or repair it. This is why I will call it expensive. Therefore, shift toward solar energy is neither economical nor environment friendly.

4.2.2 Policies, Initiatives, Incentives and Subsidies (thematic area-2)

Questions (7-9) presented in the questionnaire form have been merged under the thematic area of policies, initiatives, incentives and subsidies. The set of questions helps in collecting

perception of people with regards to plans/initiatives/policies by government for promotion of solar energy application at household level and any sort of subsidy given by government as a relief to public considering high costs of on-grid solar energy in local context.

Initiatives, policies and plans by governments around the world regarding solar energy technologies are the key catalyst of change required for national level shift towards sustainable development by focusing on renewable energies. In this context it was necessary to analyze perception of respondents regarding people's awareness of government initiatives with regard to solar energy technology at household level and subsidies available for solar energy based applications.

Regarding initiatives taken by the government, more than half of the total respondents, 60.2% (68 respondents) shared that they do not have any kind of information. This signifies an important fact that adoption of solar energy at household level is not taking place as should be the case (considering the rate at which solar energy technology and its manufacturers and suppliers are increasing in the country). However, 31.9% (36 respondents) are of the view that government has taken initiatives but respondents think that the initiatives are not enough to encourage and motivate household users to make the switch. Thus clearly highlighting the gap that exists in government led initiatives related to switch from conventional to solar energy technology at household level. Only a small portion of 8% (9 respondents) are fully aware of solar energy initiatives taken by the government. This mainly consist of people who are convinced of switching to particular renewable technology and have also attempted on their own.

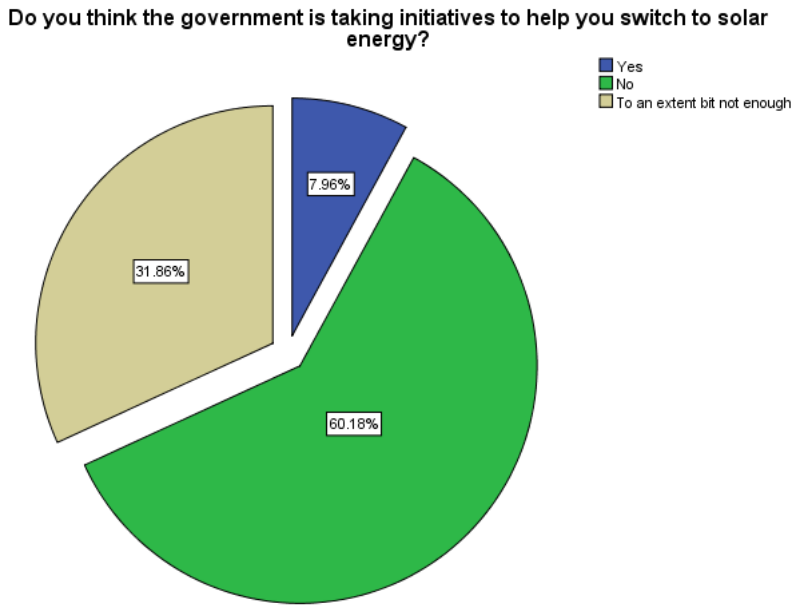


Figure 4-13: Initiative by Government for solar energy promotion

Through in-depth interviews with some of current users of solar energy applications at household level, the respondents shared that there is no positive feedback on government initiatives for promoting solar energy at household level. The respondents also shared that whatever progress has been made by public at the household level is purely their own initiative.

Through in-depth interviews with Energy and Power Department (E&P) KP officials, the officials informed that the provincial government has not taken any significant initiative in terms of promoting solar energy at household level. It was shared though there have been few initiatives in the North of the province in the Chitral district where 2,750 households have been installed with 1,300 standalone off-grid systems in order to give relief area affected due to floods in 2015. Each of the system includes the following:

- Solar panel 200 Watts
- Three (3) LED lights
- One ceiling fan

- One pedestal fan
- One mobile phone charging slot
- Two batteries

It was also shared that E&P department KP has been tasked with the formulation of standardization committee. The task of this committee will be to ensure and implement approved and standardized technical, operational and maintenance protocols that shall be applicable to all other provincial departments such as Civil & Works department (C&W), Irrigation department, Public Health and Engineering department (PHED) and housing department etc. for undertaking solar energy initiatives in respective domains.

Connected with initiatives by government for promotion of solar energy technology and application at household level, question related to government plans and policies was put forward. Major portion of the respondents 85.8% (97 respondents) had no information with regards to any plans or policies of the federal or provincial governments. Only 14.2% (16 respondents) have information on government plans and policies with regards to implementation of solar energy technologies. It is quite evident from the perception that mass level coordinated action on part of the government with regard to effective dissemination of information on plans and policies that have both household level socio-economic benefits and macro level promotion for control in climate change and its impacts is essence of the time and need of the hour.

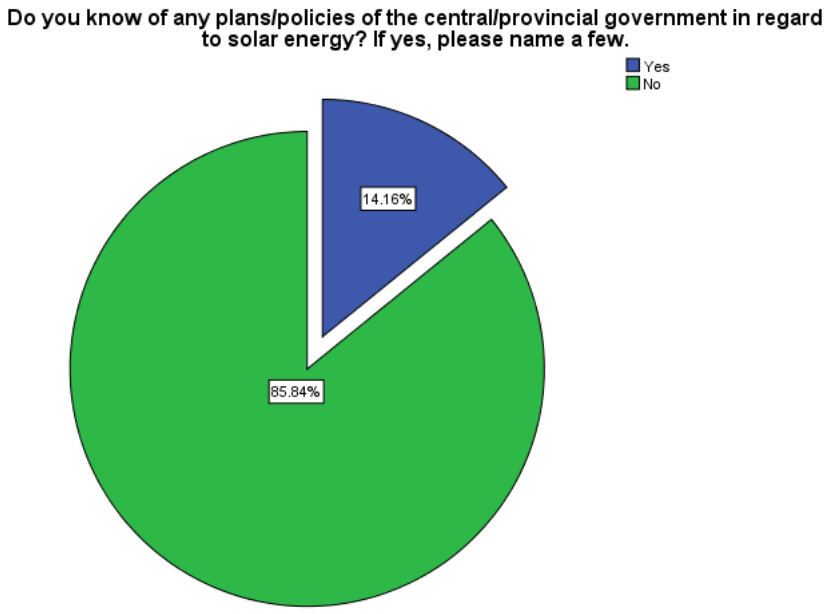


Figure 4-14: Government plans/policies regarding solar energy

Through in-depth interviews with Energy and Power Department KP officials, the officials informed that the provincial government has plans to solarize selected villages in the north and South of the province. It was also shared that these initiatives primarily focus areas that are remote and are either not connected to national grid or have power shortage due to insufficient capacity available.

Some of the provincial government plans shared in this regard are as follow:

- Solar direct current standalone home systems for 100 villages in Southern & central districts and 100 villages in Northern districts of Khyber Pakhtunkhwa
- Off-grid solarization (standalone) of 4,000 mosques across Khyber Pakhtunkhwa
- Off-grid solarization (standalone) of 8,000 primary and secondary schools across Khyber Pakhtunkhwa
- Off-grid solarization (standalone) of 180 basic and rural health units across Khyber Pakhtunkhwa
- Full standalone solarization of Chief Minister House and Secretariat in Peshawar

It was further shared that in order to inject public ownership in development projects, KP government has introduced 90-10 investment split where 90% of the funding is being done by provincial government where 10% is by community.

Subsidized costs for purchase of solar technology application/products by citizens is a key stimulator for governments to promote the shift from conventional energy applications to solar based. In this context major portion of the respondents 91.1% (102 respondents) have no information related to existing subsidies on solar energy products. Further only 8% (6 respondents) were aware of any government subsidies on solar energy but have limited information on availing them. This propels the fact that government needs to step up efforts by either making available from annual budgets for subsidizing solar energy products or government needs to actively pursue carbon credits and international funding available under different initiatives such as green financing.

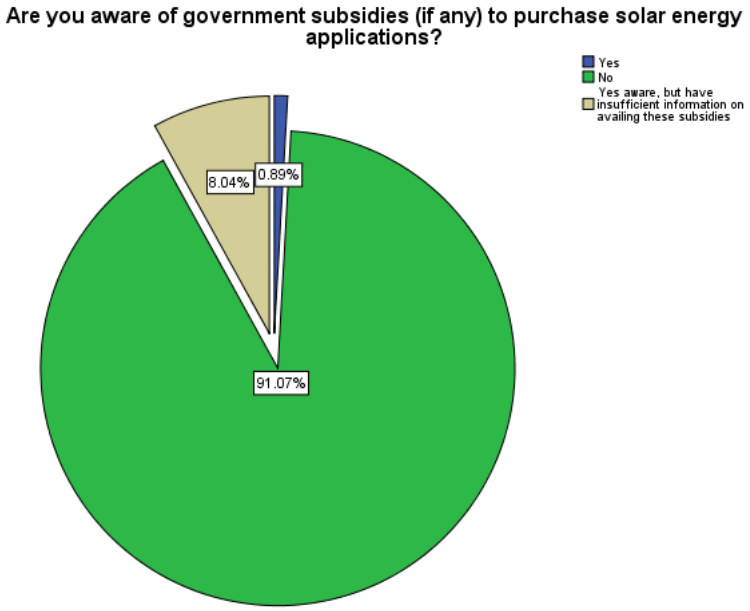


Figure 4-15: Government subsidies

Through in-depth interviews with Energy and Power Department KP officials, the officials informed that the provincial government is currently not providing any sort of subsidy wither

solar energy products available in the market nor in some of planned macro solar park projects. Officials shared that cost of on-grid solar energy is dropping with advances in technology and more international investors keen on investing in clean energy sources. It was also shared that government is also planning to utilize carbon credits and also opt for international funding related to green and sustainable development.

4.2.3 Investment and Adoption of Renewable Energy Technologies (thematic area-3)

Questions (10-15) presented in the questionnaire form have been merged under the thematic area of investment and adoption of renewable energy technologies. The set of questions helps in collecting perception of people with regards to inclination to adopt solar energy technologies, motive for making the switch from conventional energy source to solar as renewable/clean energy source, identification of stakeholders for leading promotion of solar energy adoption, identification of barriers causing hindrance in immediate shift to solar energy as clean energy source at household level and readiness to invest in solar energy applications at household level.

In order to analyze the aspect of shift to solar energy based technologies, 64.6% of the respondents (73 respondents) showed willingness to use solar energy based technology at household level. With substantial demand available for use of solar energy based technology, government needs to fast track positive action for which information regarding application of these technologies, dissemination of government plans/ policies/programs to people and conducive environment to manufactures, importers and vendors need to be made available by government. Also R&D in both public and private sector needs to be boosted both trough national and international collaborations. Of the total 30.1% (34 respondents) of the public opted that they may use solar energy application. This further intensifies the fact that willingness is there but at the same time there exist less awareness with regards to solar

energy application and that government needs to mass communicate the short term and long-term benefits of solar energy applications.

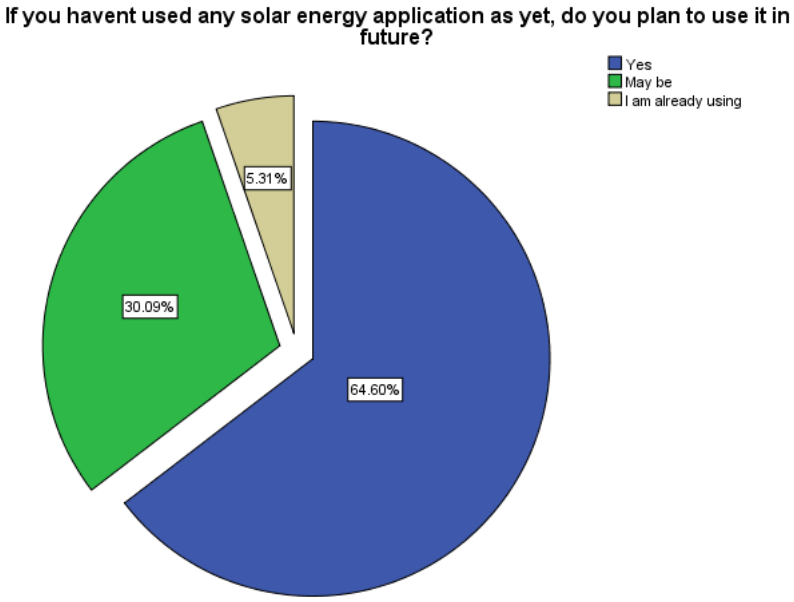


Figure 4-16: Plan to use solar energy

In order to analyse the main reason of the respondents for shifting from conventional fossil fuels based energy to solar as renewable energy source at house hold level, respondents were asked to choose from four available responses. Analysis revealed that 38.7% respondents chose uninterrupted power supply as the main reason for switching from conventional to solar based technology. This also seems a fair assessment on part of the respondents considering current energy shortfall and load shedding in the city and country. Respondents opting for contribution in reduction of emissions from fossil fuels made up 22.6% of the total. Whereas promotion of clean energy source and promotion of green/energy efficient buildings received 19.5% and 19.2% responses respectively.

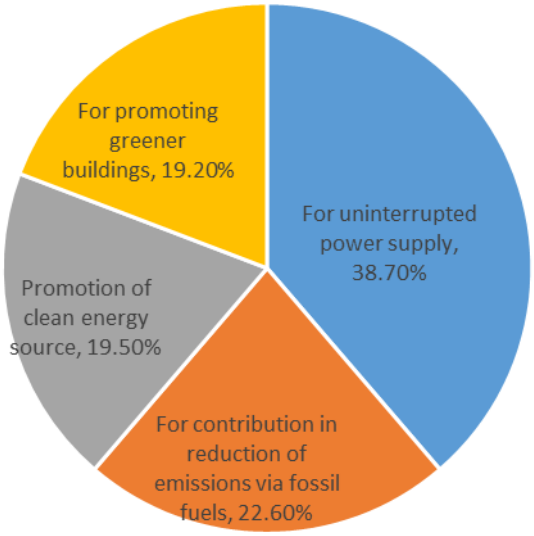


Figure 4-17: Reason for switching to solar energy

In order to analyze major role of key stakeholders in promoting improved application of solar based energy and products, respondents were required to prioritize key stakeholders for leading promotion of solar energy adoption at household level.

Based on international best practices and application of solar energy at household level, a cross-functional approach from key stakeholders is of prime importance. Instead of assigning responsibility to any single stakeholder, effective transition to solar energy at household level is mainly possible through cooperative and mutual responsibility of all key stakeholders whether that be central or provincial governments, private sector or the community. It is internationally established fact that a wider adoption of solar energy is possible only through amalgamated efforts. In relation to question posed in this regard, the federal and provincial governments both were preferred as the leaders of change and leading the action in making the transition possible, with 34.6% and 37% voicing their opinion respectively. This further strengthens the fact that government via short, medium and long term plans, policies and subsidy initiatives can act as effective promoter in the adoption of solar energy at household level. Respondents opted for public/community as their second choice with 17.3% that also

echoes the fact that community considers themselves as a key stakeholder in deciding future development at neighborhood and town level.

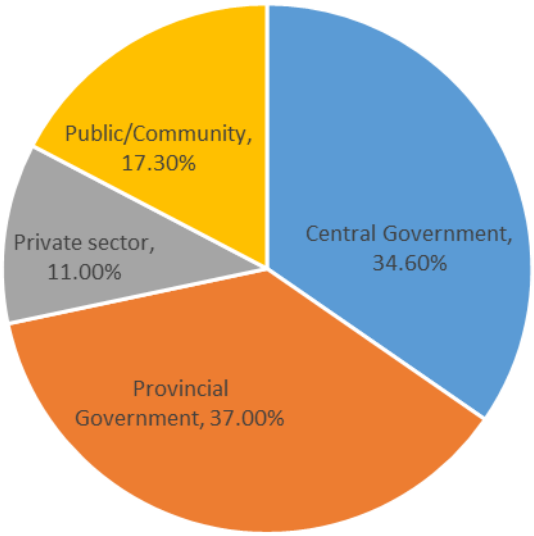


Figure 4-18: Leader for promotion of solar energy application

Shift from conventional energy utilization to solar energy based technologies at household level poses obvious yet resolvable barriers. In order to analyze this aspect, the respondents were asked to identify reasons for being reluctant to shift from conventional energy source to solar. These reasons shall serve as most common barriers and that they need highest priority in terms of attention and resolution from government. Majority of the respondents (46.6%) were of the opinion that solar energy technology is expensive. Some other percentages relating to less impact barrier are as follows:

- 29.1% respondents believe that solar energy technology will be unable to meet their complete or partial energy requirements at household level.
- 15.9% respondents consider non-availability of space at household level as a barrier for solar energy adoption.

- 5.8% respondents shared that solar energy application operation is a barrier while 2.2% respondents feel that these technologies are not attractive.

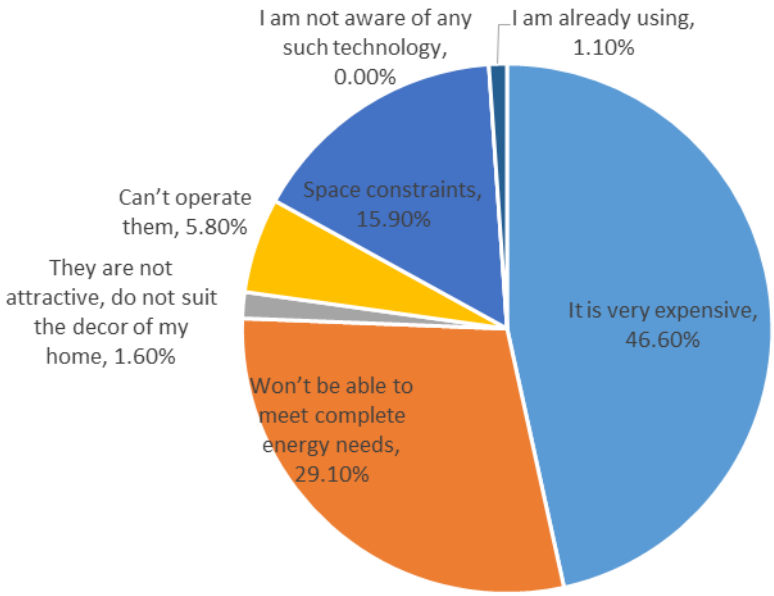


Figure 4-19: Barriers to solar energy adoption

Solar energy application at household level requires capital investment that is dependent on household energy requirements. For making renewable energy interventions a success at household level, payback period on capital investment needs to be detailed and clear enough for understanding and convincing people.

With regards to long term financial sustainability of solar energy, positive inclination is observed for investment which is evident from the share of responses given by respondents. In this context 26.5% (30 respondents) strongly agreed while another 61.1% (69 respondents) also agreed with long term financial sustainably of solar energy. From the responses it can be fairly concluded that major portion of the respondents understand the long term benefits that are associated in case of switching to solar energy.

There are respondents lacking sufficient information with regards to financial sustainability and payback period of these investments. This lot constituted about 7.1% (8 respondents).

Only 5.3% (6 respondents) think that solar energy investment is not sustainable. This can be attributed to existing information, research gap in the local context, understanding and prevailing perception that solar energy is expensive and not financially feasible.

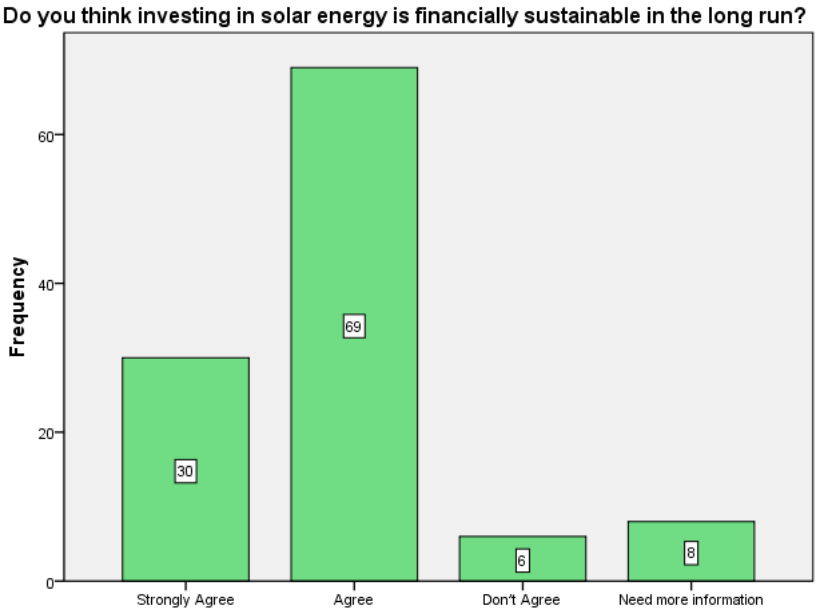


Figure 4-20: Financial sustainability of solar energy investment

Through in-depth interviews with some of current users of solar energy applications at household level, the respondents shared that there is no authentic source either from government side or academia that can show the payback period based on capital investment. They further shared that some of the private solar energy vendors operating in the market give figures but they cannot be trusted since private business aim is only profit through increasing sale. These individuals strongly stressed on the need for having detail and authentic working in the local context on investment payback period considering the fact that solar energy application at household level requires reasonable capital investment.

An interconnected question that links financial sustainability with the capital cost was presented to the respondents. Major share of respondents 80.5% (91 respondents) consider capital investment an immediate barrier. This is further adamant of the fact that there is general lack of understanding in terms of payback period on investment and long term sustainability benefits associated with solar energy. Thus this perception hampers their plans, if any, to shit to solar energy at household level. The above category is also supplemented by respondents who require further information i.e. 13.3% (15 respondents), which portrays unclear approach on part of these respondents with regards to higher initial cost and sustainable benefits associated with solar energy technologies. Only 6.2%(7 respondents) may have access to capital investment and also a clear understanding of long-term economic benefits associated with solar energy investment and believe that higher initial cost is not a barrier to adopt solar energy technologies.

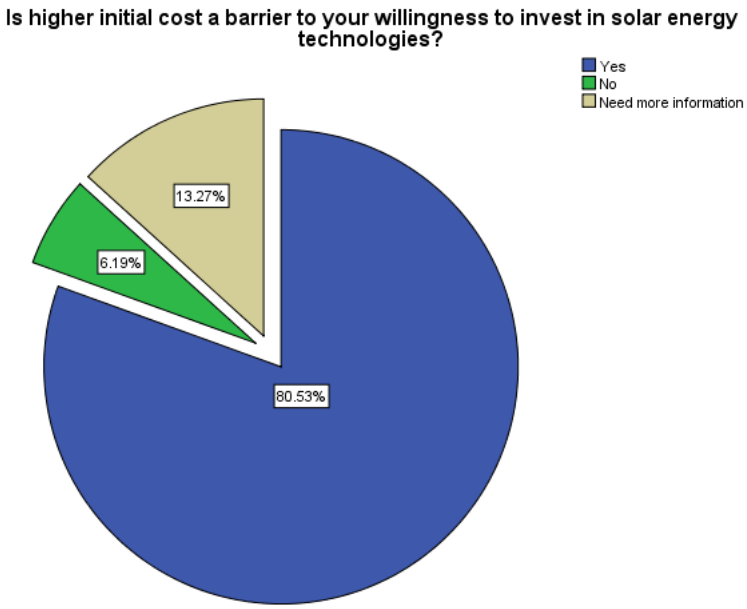


Figure 4-21: Capital cost as a barrier to solar energy adoption

4.2.4 Access to Information (thematic area-4)

Questions (16-19) used in the questionnaire form have been merged under the thematic area of access to information. The set of questions helps in collecting perception of people with regards to easy access to different information dissemination platforms related to solar energy, media coverage showing government plans and policies on solar energy as clean energy source and information on vendors/outlets dealing in sale and after sale maintenance of solar energy products for household level.

For making a shift from any conventional practice to a different and new system requires integrated approach with regards to relevant information sharing with primary beneficiaries of the change. Similar is the case with promoting shift from fossil fuel based energy to solar as renewable energy sources. This requires systematic and authentic information dissemination by relevant stakeholders of which government must be on the leading front is of prime importance that can have positive impacts in terms of success rate. Analysis of the responses reveal that majority of the respondents i.e. 79.5%(89 respondents)do not know about any information dissemination platforms (like websites, magazines, etc.) for the people of Peshawar where they can read and understand more about solar energy prospects, status and its benefits. There is clearly a dire need for effective dissemination of authentic information based on local context by government departments and related public and private organizations on renewable energy application through mass communication mediums like local newspapers, magazines, websites, editorials etc. Only 15.2% (17 respondents) of respondents know about any platforms where they can read about solar energy initiatives. These are the group people who are already using solar energy technology at household level and have read about solar energy applications and benefits by self-searching on different

available platforms. Further 7.6% (6 respondents) of people think that they need more information.

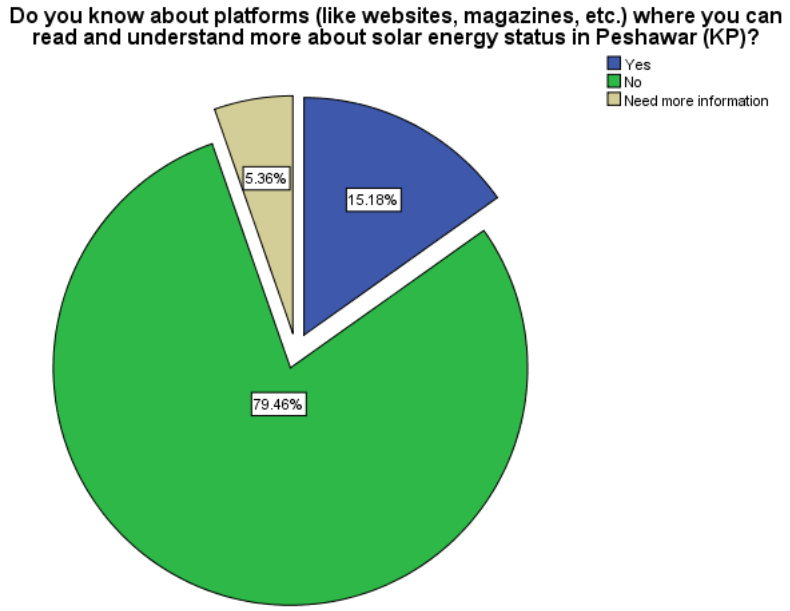


Figure 4-22: Platforms for information on solar energy

Further by cross tabulating knowledge about platforms and professional background the analysis revealed that major share is for engineering background respondents with 52.9% (9 out 17 respondents knowing about any platform). This authenticates the fact that professionals involved in engineering, teaching, corporate sector and students have interest and knowledge about exploring platforms related to solar energy information.

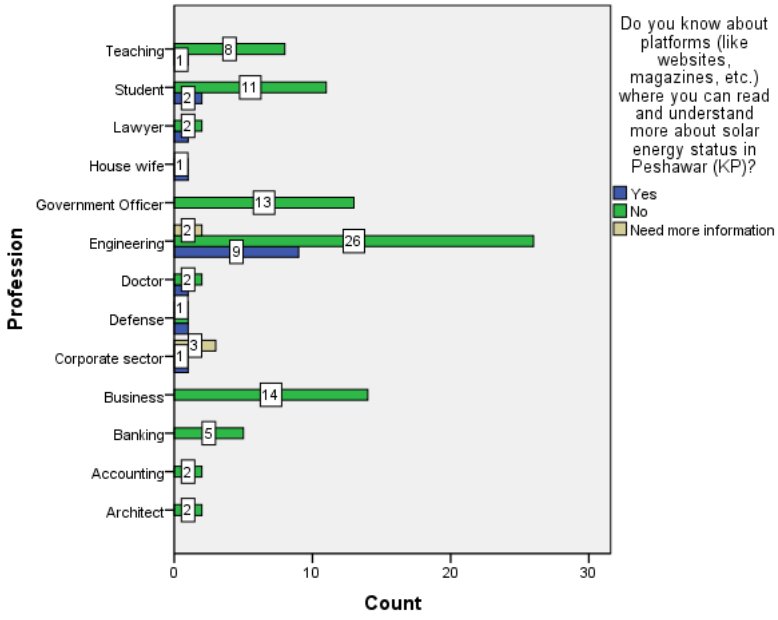


Figure 4-23: Cross relation between profession and information on awareness platforms

Effective and successful communication and community engagement requires utilization of all available communication mediums and platforms. Local news channels in a city can have immediate and wide spread reach to thousands of viewers. With regards to this, respondents were asked about local media coverage with regards to solar energy policies, programs, products and innovations. Substantial portion of the respondents, 87.5%(98 respondents), do not have any information regarding local media coverage related to solar energy policies, programs, products, innovations, etc., if any introduced by the government, NGOs, academia and other private agencies. This portrays the fact that huge potential audience is available who also are keen enough on getting information on solar energy related activities and initiatives in the city by the government. Further around 8% (9 respondents) have no idea regarding coverage on local solar energy initiatives. Based on the above, it is evident that if relevant and authentic information is readily available to people at the local level, there is huge untapped potential for making 95.5% of the respondents more aware and positively

inclined towards solar energy application at household level. Only 4.5% of the respondents (5 respondents) admitted that local media gives coverage related to solar energy application.

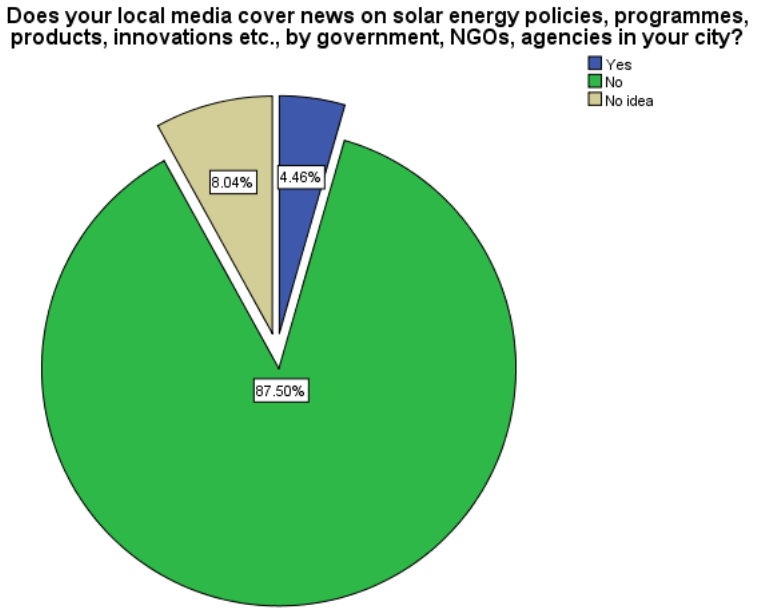


Figure 4-24: Media coverage on solar energy

It was felt necessary to ascertain individual's awareness with regards to outlets for purchase of solar energy products preferably within the city of Peshawar. Analysis revealed that 39.8% (45 respondents) are not aware of any outlets from where they can purchase solar energy equipment. But on the other hand 55.8% (63 respondents) have information on avenues/outlets to purchase solar energy products. This is due to the reason that substantial private market vendors are now dealing in solar energy products (mainly PV panels) that are quite visible in the markets of Peshawar city.

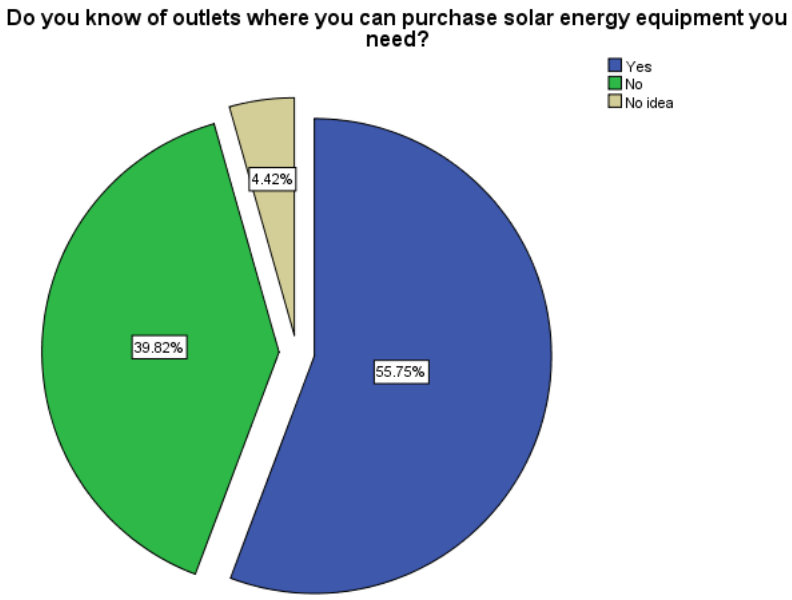


Figure 4-25: Solar energy product outlets

In continuation to question related to information with regards to solar energy product outlets, it was pertinent to know the perception of respondents about availability of a list (on websites, newspapers, social media platforms etc.) of solar energy product vendors in Peshawar. Analysis revealed that major share of the respondents 88.5% (100 respondents) showed willingness by responded ‘yes’. This clearly shows that enhanced adoption of solar energy application at household level is possible if information related to authorize vendors is available to community via different easily accessible mediums.

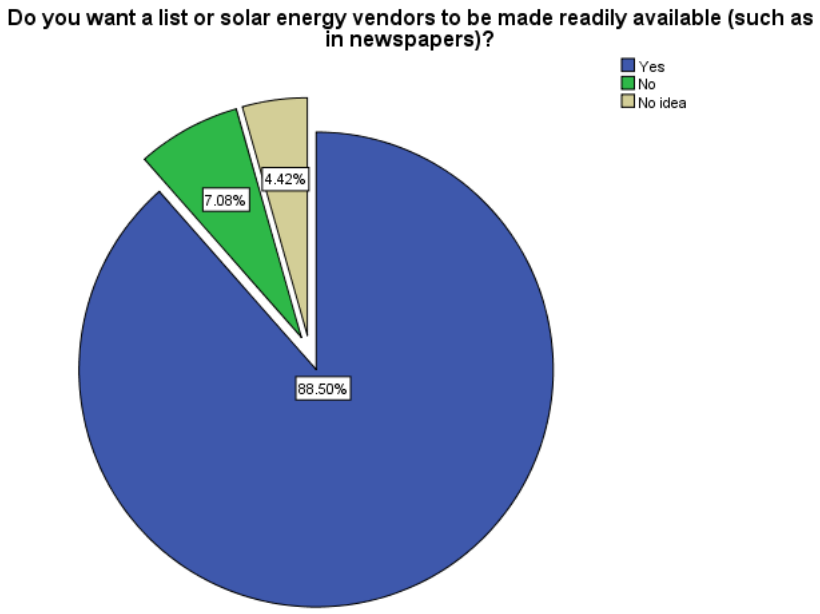


Figure 4-26: List of solar energy product vendors

4.2.5 Public Choice, Acceptability and Reliability (thematic area-5)

Questions (20-27) presented in the questionnaire form have been merged under the thematic area of public choice, acceptability and reliability related to solar energy and allied products. The set of questions helps in collecting perception of people with regards to knowing major share of type of solar energy application use at household level, type of user depending on source of solar energy as individual or macro level, solar energy shift at household level fulfilling energy demand completely or partially, reliability of solar energy technology and products available in the local market, contribution of solar energy application at house level to a greener/sustainable lifestyle, technical problems faced related to solar energy products and after sale maintenance services provided by vendors.

Establishing a baseline with regards to existing use of a particular item which is under investigation is necessary. Therefore in order to determine acceptability of solar energy applications at household level, it was necessary to establish share of respondents

directly/indirectly using solar energy applications at household level. Major share of the respondents 70.8% (80 respondents) do not use solar energy applications at household level, while 29.2% (33 respondents) use solar energy applications at household level. Greater number of solar energy users is due to the fact that referral sampling technique has been adopted for this particular study and that some of the direct solar energy application users were also sent the questionnaire form who may have further shared it with direct/indirect solar energy application users.

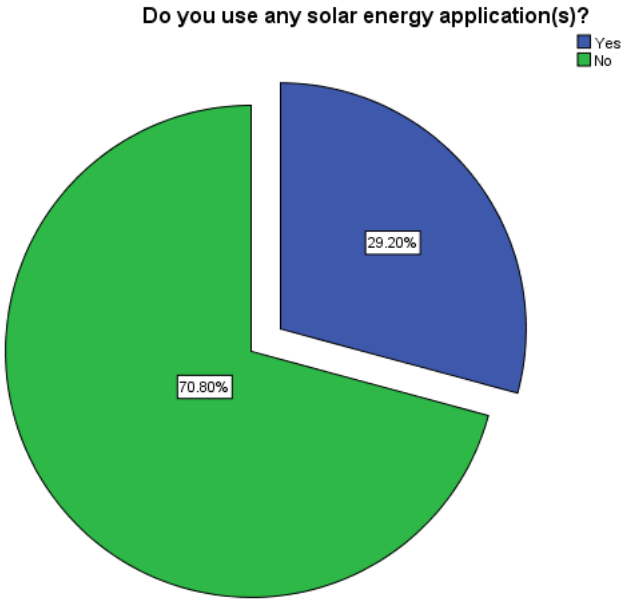


Figure 4-27: Solar energy use at household level

Since the premise of this study is investigating adoption of solar energy at household level therefore, it was pertinent to evaluate the direct household users of solar energy applications. In this regard respondents were asked to identify their category of solar energy application user. Based on the results, 87.8% (29 respondents) of the 29.2% (33 respondents) solar energy application users shared that they are individual household users. This means these users are using standalone off-grid solar energy technology. Two categories equally shared

3% each (1 respondent each) i.e. residential society/community user and institutes while there was respondent using solar energy under industries and commercial user category.

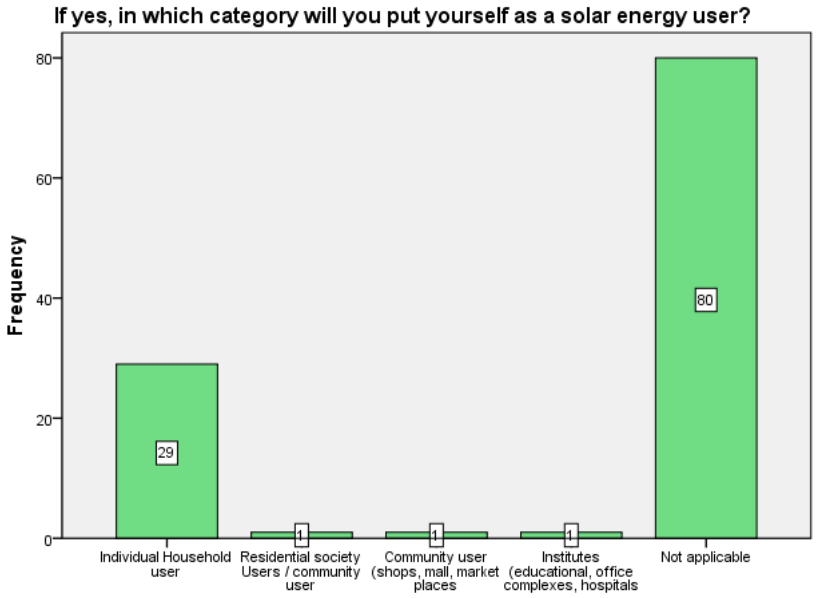


Figure 4-28: Solar energy user category

Apart from photovoltaic panels for generation of direct current as energy, there has been apparent advancement in allied solar energy products that can either run directly on direct current produced by PV panels or products that are conventional (runs on alternate current as provided by WAPDA) that require in inverter for conversion of direct current to alternate current. Though local market of direct current appliances is very limited in case of Peshawar. It was felt necessary to establish what kind of different solar energy products users are using. Majority of the respondents (40.4%) opted for solar photovoltaic panel for electricity production, followed by solar home lighting with 34% respondents. Also 12.8% respondents use solar water heater, 8.5% use other solar stand-alone systems such as garden lighting, periphery lighting and solar street lighting, etc. while 2.1% each use solar cookers and solar lantern respectively.

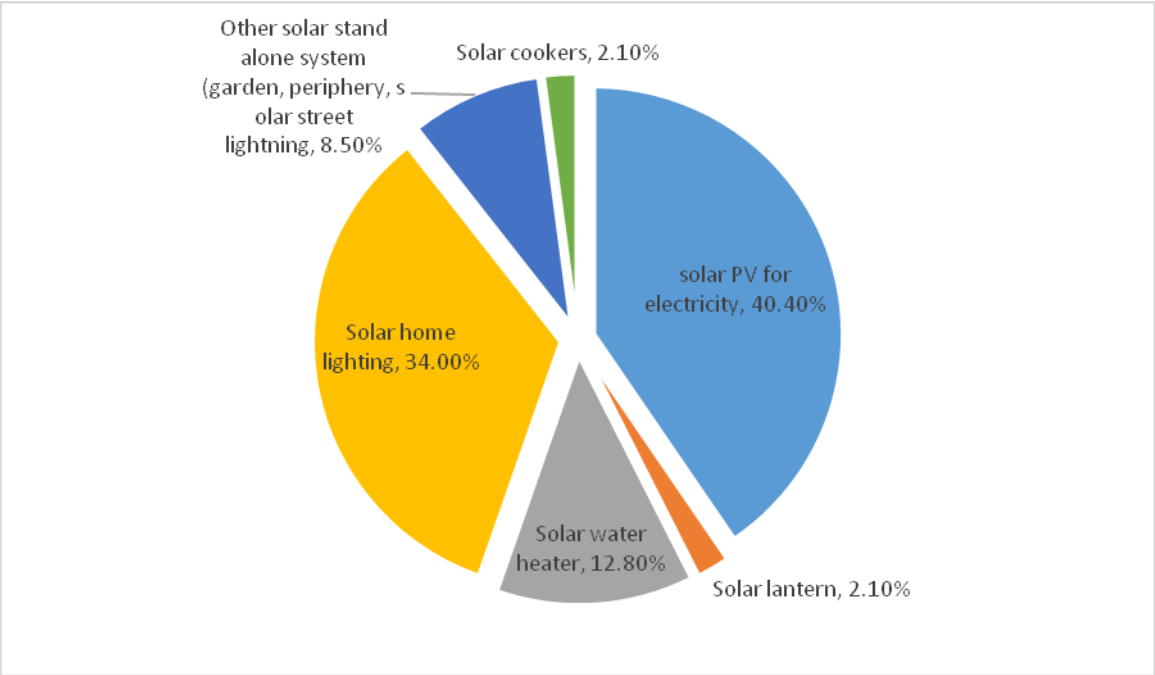


Figure 4-29: Solar energy product user

Different options are available in off-grid solar energy applications depending on capital investment available, energy (load) requirements for a particular house and willingness to shift to energy efficient energy products. In this regard a common perception was tested that questioned the participants whether shift to renewable energy can fulfill household energy demand partially or completely. Acceptability of solar energy at household level can only be made possible when people believe in its potential to meet their existing and future energy demand keeping capital investment cost within affordable limits.

Most of the respondents agreed with the idea that solar energy at household level can generate enough electricity to meet their energy demand partially or completely. This means that 67.3% (76 respondents) of the respondents are in favor of moving towards solar energy at household level and are assertive of its potential benefits. This share of the respondents is favorable to act with regards to shift from conventional to solar as renewable if more authentic information on solar energy is provided to them.

Other responses include:

- 24.8% (28 respondents) of the respondents strongly agreed that their energy demand can be partially or completely met by solar energy at household level. This comprises of people who either are already using solar energy application at household level or have relevant necessary information that is sufficient to make the shift to solar energy at household level. The in-depth interviews with some of the solar energy users at household level also shared that they have better access to information on solar technology based on their own research.
- With regards to respondents who did not agree that solar energy at household level can achieve their energy demands partially or completely, only 2.7% (3 respondents), opted for this option. This depicts that there are people who do not believe in the potential of solar energy and that they do not consider it appropriate to be used at the household level. These people can be convinced with real time examples from nearby surroundings and also informing on minimizing demand by utilizing energy efficient home appliances.
- While 5.3% (6 respondents) required more information for assessing the potential of solar energy to meet their energy demand partially or completely so that an informed decision can be made. This shows that there are target groups for government and other solar energy promotion agencies whom can be focused for information disseminating and sharing advantages of solar energy application at household level.

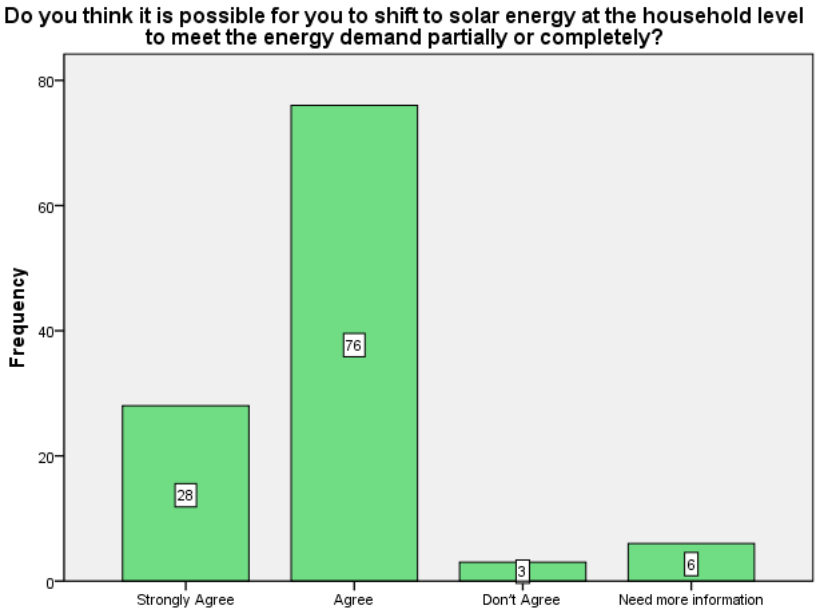


Figure 4-30: Shift to solar energy at household level

Perception on reliability of solar energy technologies was also assessed that is major aspect while promoting shift from conventional energy sources. Of the total 38.9% (44 respondents) responded in support of solar energy technological reliability. This section of respondents may comprise of current solar energy application users and prospective buyers of solar energy technology in Peshawar who have not encountered any kind of technical problem. 18.6% (21 respondents) showed concern about complete satisfaction with solar energy applications but the situation can be improved through information sharing regarding reliability. Also such concerns highlight critical intervention areas for government where quality checks on local manufacturers as well as imported products can be developed and implemented for improving customer reliability on solar products. Only 1.8% (2 respondents) of the respondents shared complete dissatisfaction with solar energy technology. In addition, 40.7% (46 respondents) of the respondents were unable to assess the reliability of solar energy technology. Since major share of the respondent are not using solar energy technology

at household level therefore majority were also unable to know about solar energy applications reliability.

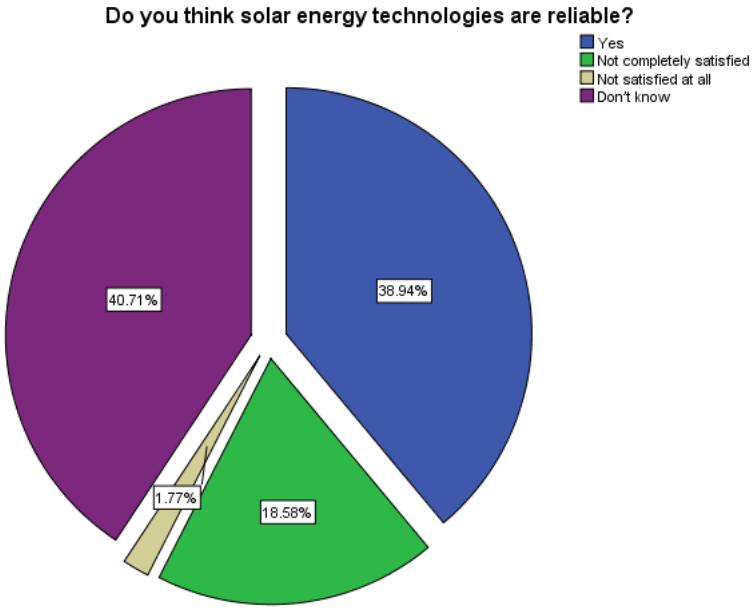


Figure 4-31: Solar energy technology reliability

One of the key underlying objective of this study is to promote green/energy efficient buildings by shifting towards sustainable and renewable energy sources at off-grid level. Thus it was important to capture perspective of the respondents as to how they feel about the added advantage solar energy brings along in terms of making lifestyles greener and cleaner. Analysis reveal that fairly large number of respondents i.e. 98.2% (111 respondents), firmly believe that solar energy application can contribute to a greener lifestyle. This further strengthens the fact that people with right information do comprehend the long term socio-economic benefits of shifting to renewable energy sources such as solar energy at household level.

Through in-depth interviews with Energy and Power Department KP officials, the officials informed that a key step taken by provincial government and E&P department is formulation of standardization committee. It was shared that the role of this committee will be to

standardize technical and quality parameters of solar energy products. Officials informed that initially the domain of this committee is all government concerned departments that take up any solar energy intervention. It was informed that latter upon maturity of private sector related to solar energy in the city and province, this committee shall expand its role to this sector as well so that quality and reliable products are available to end users.

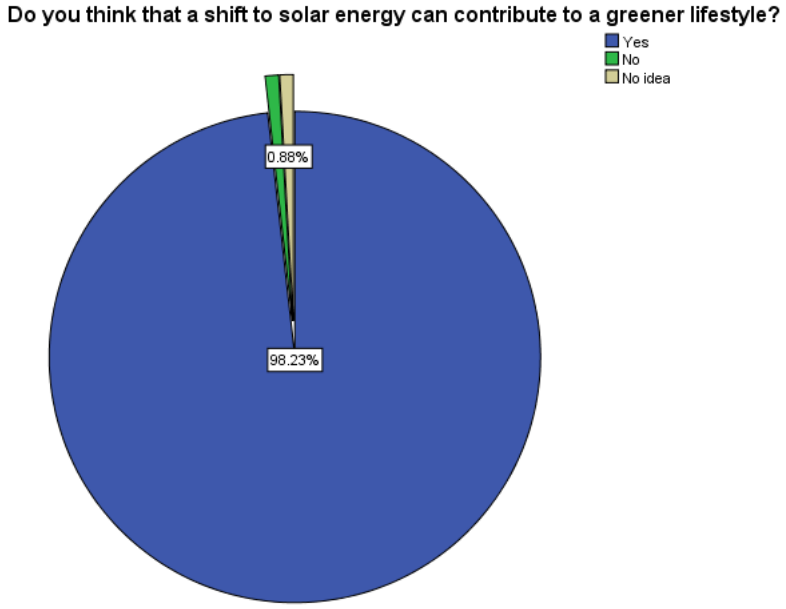


Figure 4-32: Solar energy and greener lifestyle

It was pertinent to identify the share of respondents who faced technical problems after purchasing a solar energy application at household level. Results show that majority of the respondents i.e. 29.7% did not face any technical problem after installation while 5.4% faced problems and required service maintenance. Since major share of the respondents are non-users of solar energy application at household level therefore, 64.9% of the respondents answered in not applicable category. Hence it has been identified that performance issues do exist and that government need to implement regulatory checks on the manufacturers and

vendors for bring quality products to the market and also provide robust after sale services to customers.

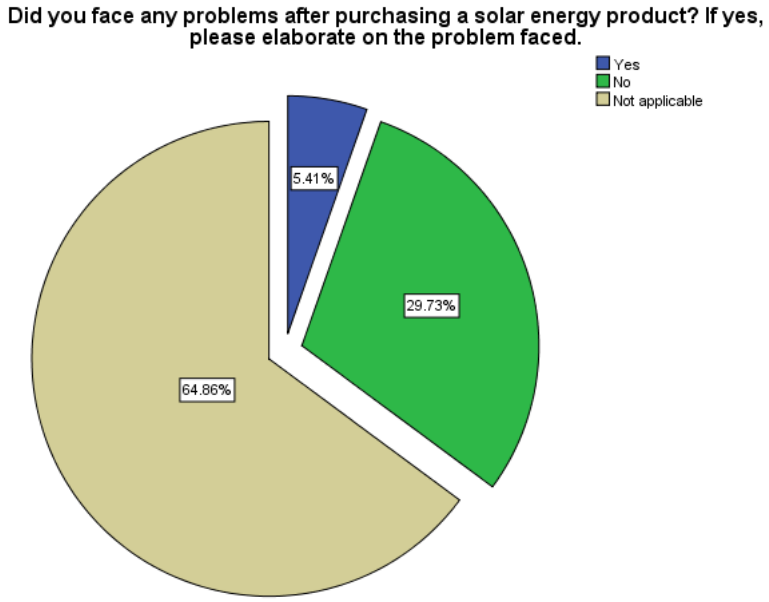


Figure 4-33: Technical problems in solar energy products

After sales service and maintenance is very crucial marketing strategy. Internationally major solar energy product manufacturers provide maintenance services after product sale that also covers full replacement during warranty period. This also plays an important role in customer satisfaction in the products and ensures growth for the manufacturing firms. Major of the respondents 74.5% (79 respondents) answered not applicable due to the fact that major share of respondents are not using any kind of solar energy application at household level. Of the total respondents who are currently using any kind of solar energy application (33 of 113 respondents), only 15% (5 out of 33 users) shared that they were given after sale maintenance services by respective vendors while 24.24% (8 out of 33 users) shared that maintenance services by respective vendors was not provided to them. On the other hand, 42.42% of the target respondents (14 out of 33 users) did not even approach the vendor which may be due to the reason that either no fault has been developed yet or once a fault/problem appeared or the

customer realized that the product was unreliable and therefore thought it would not be a sensible decision to approach the vendor or the user rectified the issue through other means utilizing local technician.

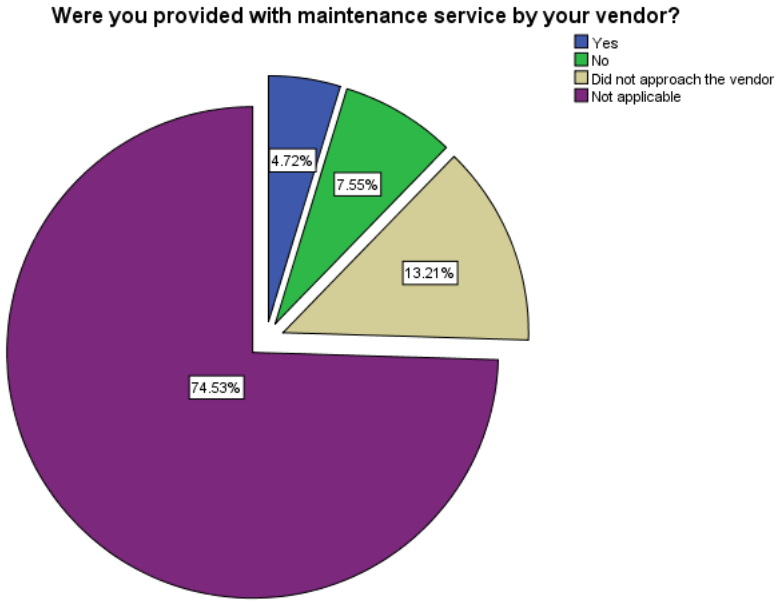


Figure 4-34: After sale services

Through in-depth interviews with some of current users of solar energy applications at household level, the respondents shared that mostly solar energy products they are using are reliable and that they have not encountered any major technical issues. It was further shared that people usually reduce capital cost of the system by opting for local low quality batteries for backup at night which usually results in reliability issues and needs to be frequently changed. Respondents shared that solar PV panels available in the local market are of different makes from around the world and are very reliable in terms of quality and output.

4.3 Key Findings With Respect to Thematic Areas

- Among various renewable energy options, solar energy has been identified as the most commonly known clean energy source among individuals with most of the respondents signifying solar energy has the highest potential renewable energy source

in the city. This is further supplemented by the fact that vendors and manufacturers of renewable energy products are encouraging solar energy based technologies more in this region as compared to other renewable energy technologies.

- Solar photovoltaic (PV) cell has been identified as the first preference and most common choice of solar energy application among individuals at household level. Solar home lighting is given second preference while solar water heater has been given has third preference.
- 70.8% of the respondents still do not use any solar energy application at household level. Also more than 94.7% of respondents believe that solar energy technology at household level is an adoptable option. This clearly augments the fact that tremendous untapped scope for expansion of solar energy at household level is available in the city.
- The most common perception that can also be ranked as top barrier to micro level implementation and adoption of solar energy technology is that solar energy is expensive considering capital investment and payback period. A substantial share of 80.5% respondents believe that initial investment is a key barrier for adoption of solar energy at household level. Also respondents voiced opinion related to doubts that solar energy at household level will be able to meet their energy needs partially or completely. The same has been voiced by concerned government quarters.
- Staggering 91.07% of the people are not aware of any sort of government subsidies as a relief to household users with regards to solar energy applications. Government official shared that currently there is no subsidy on any solar technology application that is being given to either manufacturers or end users.

- Access and dissemination of authentic information on solar energy products and government initiatives/plans/policies has been observed as one of major barrier for individuals willing to adopt to solar energy applications at household level.
- Around 85.7% did not agree that solar energy technologies can cause any harmful impact on biodiversity.
- Major portion of the respondents .i.e. 98.2% strongly believe that shift to greener and cleaner lifestyle is possible with the use of solar energy technology at household level.
- In terms of leading the initiative with regards to action on solar energy as renewable energy at household level, a collective approach and action on part of all key stakeholders is required. Nearly 71.6% of the people feel that the federal and provincial governments must lead in facilitating widespread adoption of solar energy at household level.

Chapter-5

5 Conclusion and Recommendations

5.1 Conclusion

The objectives of this particular study were to ascertain perception level with regards to adoption of solar as renewable and clean energy source at household level for promotion of energy efficient building practices, extraction of key barriers in implementing energy efficient building practices by focusing on solar as renewable energy source at household level and identification of key areas that require attention from government bodies and other key stakeholders in order to improve interventions for streamlining effective implementation of solar energy at household level that supplements energy efficient building practices.

Buildings consume major portion of the energy produced in Pakistan. Further the energy is based mainly on production from fossil fuels which is a source of direct greenhouse gas emissions. Energy efficient buildings present multiple avenues in reducing reliance on energy produced from conventional sources and thus contributing greatly towards reduction in both direct and indirect emissions. Apart from environmental gains made possible by energy efficient buildings, numerous interconnected social and economic benefits can be achieved which fosters the triple bottom line of sustainable development concept. Worldwide leading green building certification systems consider energy as the main catalyst of change. Focus on energy aspect of buildings shift to reduce emissions is possible at the least cost thus minimizing climate change and its impacts.

The findings of this study clearly offers plausible scenario for solar application as renewable energy adoption and further expansion at the household level. Over 98% of the people are convinced that solar energy use as renewable energy at household level can contribute to greener and cleaner lifestyle with evident socio-economic benefits. Around 94.7% of

respondents believe that solar energy technology at household level is an adoptable option. Such high demand offers tremendous investment opportunities for manufacturers and vendors. Moreover people are optimistic about solar energy based technologies and are of the opinion that it presents massive potential to replace fossil fuels over next 5–20 years. Majority also believe that solar energy technology has no harmful impact on biodiversity or environment as compared to fossil fuels.

Despite a positive outlook for solar energy at household level in the city of Peshawar, various challenges have also been identified through this study. These challenges act as barriers to implementation of solar energy technology at household level and therefore need collective efforts for resolution and making strategies for future course of action in combating climate change. The results of the study reveal that most of the barriers are various misconceptions due to lack of information available to prospective solar energy adopters. The most common and highest rated barrier identified is that solar energy application at household level is expensive which is followed by second most highly rated barrier that relates to inability of solar energy to meet energy demands at household level.

Awareness with respect to any subsidies offered by government and respective polices on solar energy as renewable energy and allied products accounts to be very low among the citizens.

Considering the opportunities and constraints identified through this study, there is a strong need for a shared vision and action at all levels in terms of better awareness, authentic information availability and dissemination, investment opportunities, research& development and capacity building. The vision, strategy and steps for intervention are apparent on behalf of all the stakeholders including governments both federal and provincial, public and private institutions, corporate and industrial sector, NGOs, academia and individuals.

5.2 Recommendations

Shift to solar energy at household level requires a cross-sector and multi stakeholder approach with clear and defined actions to be taken.

Based on results of the study and in-depth interviews conducted, following actions on part of different stakeholders are warranted for successful implementation of solar energy as renewable energy source at house hold level in Peshawar.

5.2.1 Government

- Formulation of long term strategies that are in line with sustainable development goals and Paris agreement to include, progressively, the renewable/solar energy technologies in the national energy policy and also at the grass root level i.e. household.
- Allocation of budget in annual development programme (ADP) for schemes for promotion of renewable energy avenues.
- Institutional development and capacity building.
- Adequate funding for R&D to be made available and for transforming lab-scale products into commercial products. Students at universities should be encouraged to conduct research projects in renewable energy.
- Motivate local entrepreneurs through policy initiatives such as incentives through reduction/exemption from import duties and taxes.
- Put in place mechanism for soft loans/subsidies to the end users at house hold level
- Utilizing mass media, awareness to be increased through exhibition, field demonstration, education and training programs.
- Efforts to be made in revamping government communication mediums for effectively communicating policies, incentives, technology, initiatives and pilot projects etc.

- Demonstrate and encourage through installation of solar energy applications such as solar lights and PV panels for electricity generation in public buildings, parks, parking areas & open spaces etc.
- Solar energy products should be made available at economical rates. To achieve this objective, competitive market environment should be achieved along with injecting subsidy for initial period.
- Policies promoting technology transfer must be formulated and pursued in order to ensure that international investors transfer the technical knowledge related to solar energy devices.
- International cooperation in renewable energy sector must be actively sought for climate change financing related to renewable energy projects and also building local capacity of public sector.
- Subsidies being offered to IPPs producing energy from fossil fuels should be gradually reduced considering environmental damages and the same to be shifted towards IPPs producing energy from renewable sources.
- Developing mechanism of energy audits and training relevant departments.
- Setting up operation & maintenance training institutes.

5.2.2 Civil Society and NGOs

- Organize and promote awareness via effective knowledge sharing among communities on solar energy as primary renewable energy source at household level.
- Encouragement of policymakers for developing policies for better promotion of renewable energy and enabling a rational transition to solar energy as renewable energy source.
- Liaison with solar energy product manufacturers and technology providers, and develop projects at the grassroots to promote sustainable energy.

- Organize exhibitions on solar energy applications to popularize its effectiveness.

5.2.3 Individuals and Community

- Shift to energy efficient equipment that is also compatible with solar energy applications and be part of renewable energy shift.
- Ask for and share authentic information on solar energy products and retailers.
- In coordination and collaboration with other stakeholders, individuals must also lead the shift to solar energy at household level.
- Assess individual household energy peak demand and utilization level. Incur knowledge and comprehensive understanding of the value addition that will be possible as a result of shifting to solar energy as renewable energy source at household level.
- Spread awareness in the neighborhood of the benefits of solar energy on environment.

5.2.4 Mass Media

- Create a positive outlook for solar energy as renewable energy.
- Increased coverage on solar energy policies, programs and initiatives. Sufficient coverage of international, national and local level initiatives related to solar energy applications.
- Facilitate and conduct dialogue among policy makers and implementers, solar energy technologists, academia and end users. Propagate interventions on solar energy adoption at household level across the globe in order to enhance wider adoption of these technologies.
- Regular editorials in newspapers and magazines related to solar energy as renewable energy source preferably by an expert in renewable energy field in the local context.

- Communication of socio-economic benefits of solar energy application should be highlighted and effectively communicated.

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Annexures

Annexure-A

QUESTIONNAIRE FORM

Key Stakeholders' Perception about Adopting Solar as Primary Energy Source at Household Level: A Case Study of Peshawar City in Pakistan

As part and requirement of graduate thesis, a questionnaire survey is being conducted on "perception about adopting solar energy at household level in the city of Peshawar".

Worldwide the market for renewable energy is gaining attention and momentum both in retrofitting and new construction projects inorder to curtail adverse impacts on surrounding environment and climate through control of direct/ indirect greenhouse gas emissions from the building sector. The purpose of this study is to ascertain perception at household level by focusing mainly on end-users and Government agencies. The findings of this study will support the growing importance of sustainable development with emphasis on micro level i.e. energy efficient buildings with focus on solar as renewable energy source at household level.

Initially, it is expected from you to fill out general information section followed by main section focusing on perception level in regard to use of solar energy at household level.

This survey, which you are about to complete, should take approximately 10 to 15 minutes. Any information provided by respondents will be strictly confidential and shall be used only for academic purposes. Your time and valuable contribution to our study is highly appreciated.

Section-1 General information

1. Name:
2. Age:
3. Profession:
4. Locality of living (within Peshawar):
5. Email address:
6. Academic qualification:

Section-2 Main Section

1. Do you agree that the energy generated from solar technologies can replace the use of conventional fuels (like oil/coal/gas etc.)

Yes	No	May be

2. If you agree that solar energy can replace conventional fuel, what is the likely time frame in which this can be achieved?

Short term (3-5 years)	Medium term (5-20 years)	Long-term (more than 20 years)

3. Which renewable energy sources, according to you, has a high potential in Peshawar (KP)?

Wind	Solar	Waste to Energy	Biogas	Thermal

4. Do you think solar energy will match the price of conventional energy and will eventually become cheaper?

Strongly Agree	Agree	Don't Agree	Need more information

5. Compared to fossil fuel do you think solar energy based technologies have much lesser impact on biodiversity and the environment?

Strongly Agree	Agree	Don't Agree	Need more information

6. Do you think solar energy application also have harmful impact on biodiversity and the environment?

Strongly Agree	Agree	Don't Agree	Need more information

7. Do you think the government is taking initiatives to help you switch to solar energy?

Yes	No	To an extent bit not enough

8. Do you know of any plans/policies of the central/provincial government in regard to solar energy? If yes, please name a few.

Yes	No

9. Are you aware of government subsidies (if any) to purchase solar energy applications?

Yes	No	Yes aware, but have insufficient information on availing these subsidies

10. If you haven't used any solar energy application as yet, do you plan to use it in future?

Yes	No	May be	I am already using

11. What would be the main reason for switching from conventional to solar energy source? Choose more than one if applicable

For uninterrupted power supply	For contribution in reduction of emissions via fossil fuels	Promotion of clean energy source	For promoting greener buildings

12. To increase the use of solar energy, who do you think should take the lead in facilitating action on renewable energy adoption? (Rate from 1-4)

Central Government	Provincial Government	Private sector	Public/Community

13. If you don't plan to install a solar energy technology in your home, which of the following reason applies? Choose more than one if applicable

It is very expensive	Won't be able to meet complete energy needs	They are not attractive, do not suit the decor of my home	Can't operate them	Space constraints	I'm not aware of any such technology	I am already using

14. Do you think investing in solar energy is financially sustainable in the long run?

Strongly Agree	Agree	Don't Agree	Need more information

15. Is higher initial cost a barrier to your willingness to invest in solar energy technologies?

Yes	No	Need more information

16. Do you know about platforms (like websites, magazines, etc.) where you can read and understand more about solar energy status in Peshawar (KP)?

Yes	No	Need more information

17. Does your local media cover news on solar energy policies, programmes, products, innovations etc., by government, NGOs, agencies in your city?

Yes	No	No idea

18. Do you know of outlets where you can purchase solar energy equipment you need?

Yes	No	No idea

19. Do you want a list or solar energy vendors to be made readily available (such as in newspapers)?

Yes	No	No idea

20. Do you use any solar energy application(s)?

Yes	No

21. If yes, in which category will you put yourself as a solar energy user?

Individual Household user	Residential society Users / community user	Community user (shops, mall, market places	Industries	Institutes (educational, office complexes, hospitals	Other

22. Which solar energy application do you use? Choose more than one if applicable

Solar PV for electricity production	Solar lantern	Solar water heater	Solar home lighting	Other solar stand alone system (garden, periphery, solar street lightning	Solar cookers	Other

23. Do you think it is possible for you to shift to solar energy at the household level to meet the energy demand partially or completely?

Strongly Agree	Agree	Don't Agree	Need more information

24. Do you think solar energy technologies are reliable?

Yes	Not completely satisfied	Not satisfied at all	Don't know

25. Do you think that a shift to solar energy can contribute to a greener lifestyle?

Yes	No	No idea

26. Did you face any problems after purchasing a solar energy product? If yes, please elaborate on the problem faced.

Yes	No	Not applicable	Other

27. Were you provided with maintenance service by your vendor?

Yes	No	Did not approach the vendor	Vendor did not respond	Not applicable

28. Additional feedback

Annexure-B

IN-DEPTH INTERVIEW

Key Stakeholders' Perception about Adopting Solar as Primary Energy Source at Household Level: A Case Study of Peshawar City in Pakistan

Worldwide the market for renewable energy is gaining attention and momentum both in retrofitting and new construction projects inorder to curtail adverse impacts on surrounding environment and climate through control of direct/ indirect greenhouse gas emissions from the building sector. The purpose of this study is to ascertain perception at household level by focusing mainly on end-users and Government agencies. The findings of this study will support the growing importance of sustainable development with emphasis on micro level i.e. green/energy efficient buildings with focus on solar as renewable energy source at household level.

Name: _____

Profession: _____

Department: _____

Date of Interview: _____

- **In-depth discussion point-1:** Level of awareness among end users related to use of solar energy at household level.

- **In-depth discussion point-2:** Provincial government current policies, initiatives and subsidies related to solar energy and for its promotion at household level.

- **In-depth discussion point-3:** Willingness of end users to invest and adopt solar energy as primary energy source at household level and thus promoting renewable energy share.

- **In-depth discussion point-4:** Ascertaining level of information available from government quarters to end-users through different mediums.

- **In-depth discussion point-5:** End user choice, acceptability based on reliability of solar energy products available in the local market.