The Comprehensive Analysis of the Solar Energy Projects Landscape across Pakistan: Barriers, Socioeconomic impacts and Way Forward

By

Muhammad Talha Rashid

Reg. No. 274922

Session 2018-20

Supervised by

Dr. MUHAMMAD HASSAN

A Thesis Submitted to the US-Pakistan Center for Advanced Studies in Energy in partial fulfillment of the requirements for the degree of

MASTERS of SCIENCE in

Energy System Engineering

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National University of Sciences and Technology (NUST)

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THESIS ACCEPTANCE CERTIFICATE

Certified that final copy of MS/MPhil thesis written by Mr./Ms. MUHAMMAD TALHA RASHID (Registration No. 274922), of U.S. Pakistan center for advanced studies energy (School/College/Institute) has been vetted by undersigned, found complete in all respects as per NUST Statues/Regulations, is within the similarity indices limit and is accepted as partial fulfillment for the award of MS/MPhil 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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Certificate

This is to certify that work in this thesis has been carried out by **Mr. MUHAMMAD TALHA RASHID** and completed under my supervision in, US-Pakistan Center for Advanced Studies in Energy (USPCAS-E), National University of Sciences and Technology, H-12, Islamabad, Pakistan.

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ABSTRACT

God has blessed Pakistan with tremendous potential of solar energy, despite that the share of solar energy in the energy mix is less than 2%. In the wake of slow growth of solar energy various policy and institutional arrangements have been made such as net metering regulations for solar energy projects having capacity less than 1 MW and cost-plus tariff for mega solar energy projects. Even with those arrangements in place share of solar energy was very low. Moreover, the socio-economic impacts of these solar projects have not been assessed, whether they were useful or not. Based on these insights, this paper investigates the barriers and socio-economic impacts of both domestic and mega solar energy projects to overcome these research gaps. Therefore, in this study primary data was collected from three key stakeholders: Prosumers; Solar companies and industrial experts. And secondary data was acquired in the form of published reports, papers and other documents related to the solar energy barriers and their socio-economic impacts. The analysis indicated, at domestic level main barriers are delays in net metering application process, unavailability of energy meters, bribery and low staff at distribution company, while in mega projects are inconsistent regulatory policies, weak grid infrastructure and lack of coordination mechanism between different institutes. Solar energy has positive socio-economic impacts. The identification of these results is critical for developing policies in Pakistan for the rapid uptake of Solar energy.

Keywords:

Barriers, Socio-economic, Environment, Solar and way forward.

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List of Abbreviation

CO_2	Carbon Dioxide
GW	Giga watts
MW	Mega Watt
IEA	International Energy Agency
PV	Photovoltaic
LoS	Letter of Support
LoI	Letter of intent
IRENA	International Renewable Energy Agency
NTDC	National Transmission and Dispatch Company
AEDB	Alternative Energy Development Board
IPP	Independent Power producers
CCoE	Cabinet Committee on Energy
DISCO	Distribution Company
NEPRA	National Electric power regulatory authority
IESCO	Islamabad Electric Supply Company
LESCO	Lahore Electric Supply Company
MEPCO	Multan Electric Power Company
FESCO	Faisalabad Electric Supply Company
HESCO	Hyderabad Electric Supply Company
SEPCO	Sukkur Electric Power Company
QESCO	Quetta Electric Supply Company
TESCO	Tribal Areas Electric Supply Company
GEPCO	Gujranwala Electric Power Company
BTPL	Bahria Town (Pvt.) Limited
PESCO	Peshawar Electric Supply Company
DHA	Defense Housing Authority
R&D	Research and Development
O&M	Operation and Maintenance

Chapter 1
Introduction

1.1. Energy Crisis

By June 2017, the global wind capacity had grown to roughly 539,123 MW, with 17.6 GW connected at the start of 2014. Dropping hardware costs, the fragility of normal fuel expenses, government arrangements and motivational factors, environmental worries, attention to green power, the requirement for vitality security, and rising carbon danger are all factors contributing to recent quick advances. Solar and wind energy are expected to be the least expensive types of energy sources for Asia's largest energy markets during the next ten years, owing to growing knowledge of their benefits.

1.2. The Power sector structure in Pakistan

Pakistan's power sector buys fuel from both domestic and imported sources, with a mix of state-owned generators (GENCOs) and discreetly independent power producers, a transmission company (the National Transmission and Dispatch Company [NTDC]), which handles the country's transmission system, and regional distribution companies known as DISCOs. With the exception of K-Electric in Karachi, which also owns and operates some transmission and distribution assets, they are entirely state-owned. In 1998, the Pakistan Electric Power Company (PEPCO) was formed to oversee state-owned GENCOs, NTDCs, and discos. PEPCO was separated from WAPDA, which is responsible for the construction and operation of hydroelectric power plants. CPPA, which buys electricity from all power providers, including WAPDA, supplies the discos with the majority of their power. Power sector structure of Pakistan is illustrated in figure 1.1.

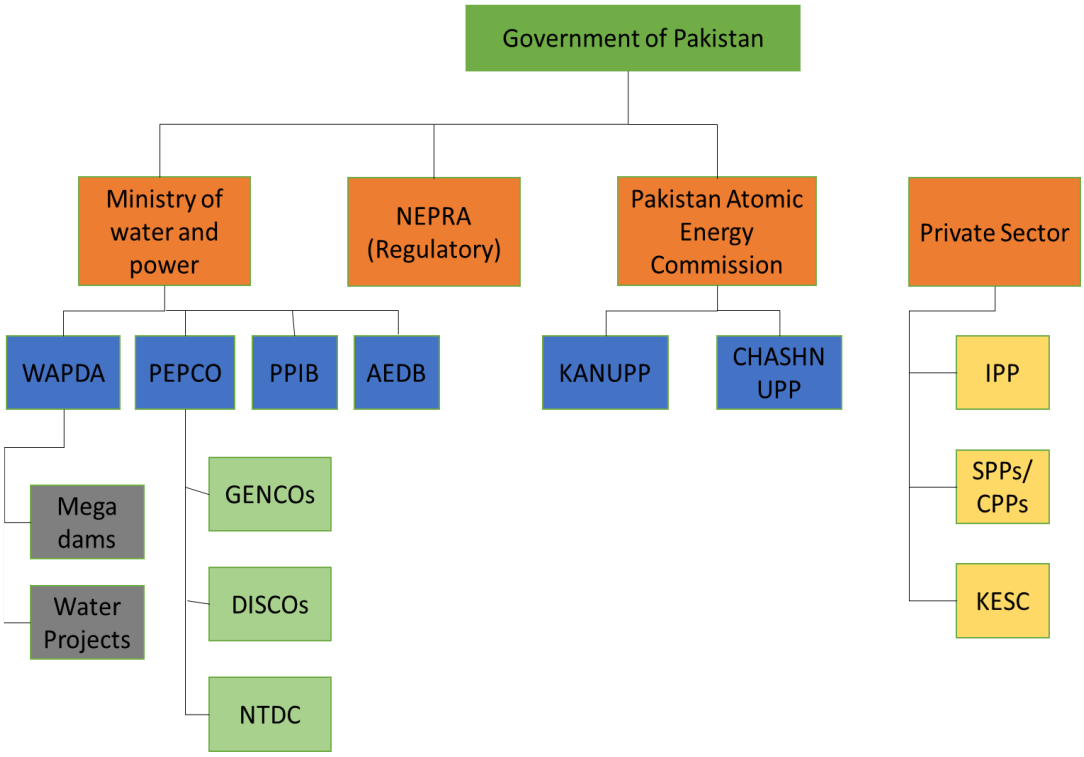

Figure 1.1. Power Sector Structure in Pakistan

1.2.1. Structure Of Energy Sector

In Pakistan, the power sector is driven by both governmental and private enterprises. WAPDA (hydropower), four public sector generation firms (GENCOs), and a number of Independent Power Producers supply generation (IPPs). The Central Power Purchasing Authority Guarantee Limited (CPPA(G)L) is responsible for purchasing electricity. In Pakistan, the transmission system is managed by the National Transmission and Dispatch Company Limited (NTDCL), which distributes generated power to regional, public-sector distribution companies (DISCOs), who subsequently link to end-consumers. The National Electric Power Regulatory Authority (NEPRA) is in charge of overseeing the sector as a whole, with a mandate to promote fairness and transparency among all institutions. Key stakeholder of energy sector are shown in figure 1.2.

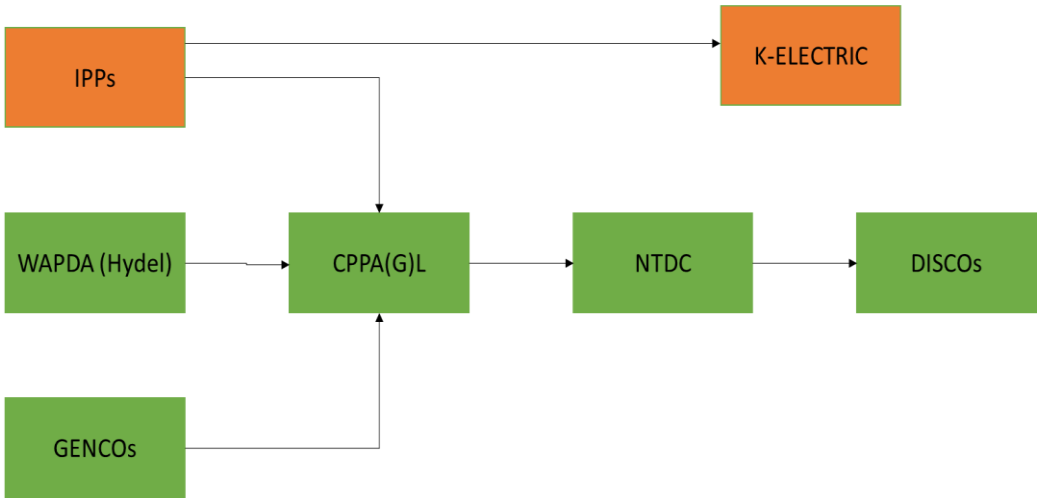

Figure 1.2. Key Stakeholder of energy sector

1.3. Evolution of Pakistan's electricity market

In 1947, when Pakistan's electricity generation capacity was around 60 MW, the power sector has been under complete government control for the majority of the period, growing from 60 MW to 38719 MW today. The majority of electricity sector companies are still run by the government. In Pakistan, the electric power sector is made up of a number of institutes that are either directly or indirectly responsible for ensuring the technical and seamless execution of the responsibilities they are given. Water and Power Development Authority WAPDA, a government semi-autonomous institution founded in 1958, was in charge of controlling, regulating, and monitoring the power market. Along with the Wapda, the Karachi Electric Supply Co- operative KESC was authority for functioning in Karachi. With rising globalization and a shift toward privately owned corporate businesses, Pakistan began to gradually de-regulate the electricity sector. The following milestones have been reached thus far in this procedure.[1]

- WAPDA's dissolution into three sectors is as follows:
    1. The generation businesses that are owned by the government (the GENCOs)
    2. The National transmission and dispatch companies (NTDC)
    3. Distribution companies with regional presence (Discos)

- The National Electric Power Regulating Authority was established as a regulatory body (NEPRA)
- Karachi Electric Supply Company's privatization (KESC)
- The Private Power and Infrastructure Board was established (PPIB).

According to the State of industry report 2018 published by NEPRA, 66 % of the total energy mix comes from thermal power plants, while only 6 % comes from renewable energy sources. Thermal power plants are not only expensive but also damaging the environment. Thermal power plants run on local fuels as well as on imported fuel (such as imported coal, oil, and natural gas). By importing the fuel for electricity not only increases the import bill, reduce the foreign reserves but also compromises the energy security of the country.

1.4. Energy Mix

According to State of Industry Report, the installed power generation capacity of Pakistan as on 30th June 2020 stands at 38,719 MW. As of June 30, 2020, the country's total installed capacity of public sector power plants was 19,621 MW. While private sector power plants, including KE, had a total installed capacity of 19,098 MW. Thermal power accounts for 24,817 MW, hydropower for 9,861 MW, wind for 1,248 MW, solar for 530 MW, bagasse for 369 MW, nuclear for 1,467 MW, and SPPs/CPPs for 427 MW of the total 38,719 MW. The Pakistan’s energy mix is depicted in figure 1.3 [2], [3].

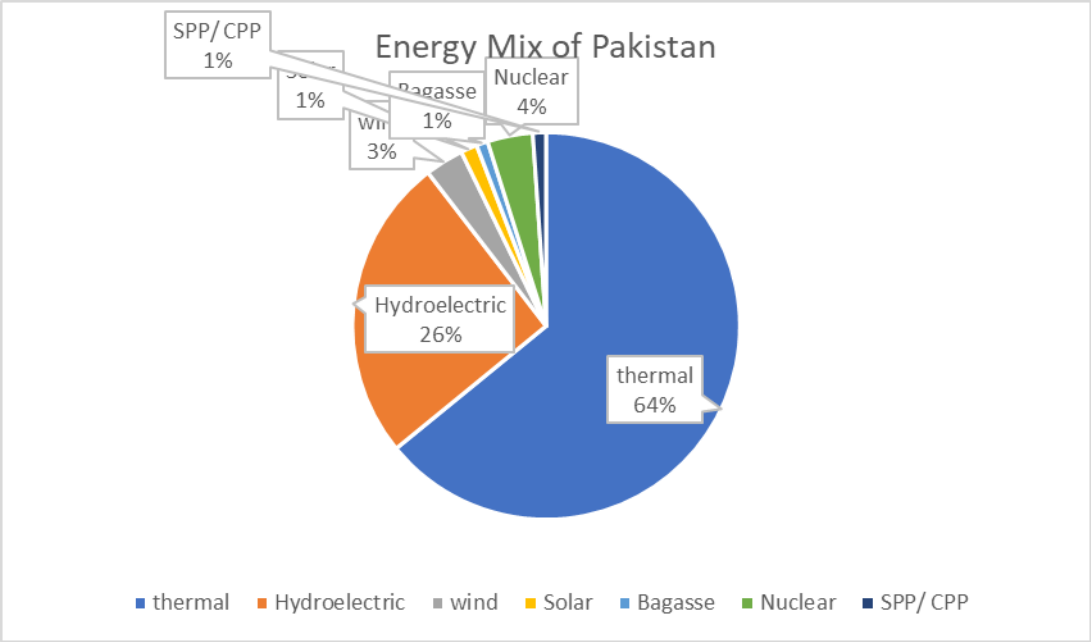

Figure 1.3. Energy Mix of Pakistan

1.5. Pakistan's per capita energy demand

In 2018-19, Pakistan's average per capita electricity usage (KWh) was around 529 KWh, which is 18.1 percent less than Asia (averaged at 646 kWh) and 83 percent less than the universal average (3081 KWh). The main reason behind low per capita energy consumption is low installed generation capacity and the resulting power outages as a result of under-capacity generation. According to the state of the industry report2020, the demand-supply gap during NTDC's peak hour in 2018 was 2.975 GW [2].

Given Pakistan's yearly growth rate of 2%, energy consumption must rise at a CARG (compound annual growth rate) of 9.2 percent in the following 5 years. Alternatively, if power generation capacity remains unchanged for the following five years, Pakistan's per capita electricity consumption will fall to 380 kwh, resulting in a worse electricity shortfall.

1.6. Demand supply gap

Pakistan is now experiencing numerous issues with electricity generation. Due to an overreliance on fossil fuel-based energy generation, which is very expensive, the country's electricity producing capacity has decreased by 276 MW in recent years. 640 MW TPS Guddu (Unit 1-4) was decommissioned during the year. Furthermore, on February 13, 2020, 144 MW GTPS Kotri was removed from GENCO-Generation I's License. Load shedding has become severe in Pakistan in the recent years.

Political unrest, increased demand, under capacity generation, and inefficient grid systems are just a few of the causes contributing to the ever-widening supply-demand gap, which has already reached over 5000 MW..[2]

1.7. Pakistan' commitment towards RE development

God has gifted Pakistan with a huge renewable energy resources, which can be tapped to generate electricity and fulfill the energy demand of Pakistan. Alternative and Renewable Energy (ARE) Sector growth began by government of Pakistan (GOP) in a phases, evolutionary approach that established a policy implementation framework under the policy for development of RE for power generation (ARE policy 2006). ARE is expected to account for a huge proportion of Pakistan energy mix [1].

The GOP's strategic objectives of energy security, affordability of electricity, availability for all, environmental protection, sustainable development, social equity, and climate change mitigation are further harnessed in the ARE Policy 2019, which was developed by the Ministry of Energy (Power Division) in consultation with key stakeholders. ARE Policy 2019 aims to provide a favorable environment in Pakistan for the ARE sector's long-term growth.

The experience obtained under RE Policy 2006, as well as international best practises, provide the groundwork for a more systematic approach for ARE Policy 2019. It now covers all major alternative and renewable energy sources, as well as competitive procurement and subjects including distributed generation, off-grid solutions, B2B approaches, and rural energy services. To

retain investor confidence, it keeps most of RE Policy 2006's liberal and attractive incentives while focusing more on high growth of grid-connected ARET applications and systematic development of the dispersed ARE power production market on more competitive terms.

Rather than reacting to RE projects, Pakistan has chosen a new strategic direction in which ARE technologies would account for at least 20% of the country's generation capacity by 2025 and 30% by 2030. Target sizes are 20X25 and 30X30. Such goals are expected to be accomplished, but they will demand transmission infrastructure enhancements, which will be done in conjunction and, where necessary, as a prerequisite. Compared to the heavily dominated mix of imported fossil fuels in the past, this goal, along with over 30% hydel, will resulting in one of the most environmentally friendly and cost-effective power mixes..[4]

1.8. Solar and wind power development in Pakistan

Lists of major solar and wind projects in Pakistan are given in table 1.1 and table 1.2.

Table 1.1. Solar Power Projects in Pakistan

Sr No.	Companies	Tariff Structure	Date	Tariff Rate Rs/kwh	Tariff Rate cent/kWh	References
1	Quaid-e-Azam Solar Power (Private)Limited (QASPL)	Upfront	19-Mar-15	14.8591	14.1516	[5]
2	Apollo Solar Development Pakistan Limited	Upfront	26-May-15	14.8591	14.1516	[6]
3	Best Green Energy Pakistan Limited	Upfront	26-May-15	14.8591	14.1516	[7]
4	Crest Energy Pakistan Limited	Upfront	26-May-15	14.8591	14.1516	[8]
5	Harappa Solar (Private) Limited	Upfront	26-Feb-16	12.1093	11.5327	[9]
6	AJ Power (Private) Limited (AJPPL)	Upfront	20-Apr-16	12.1093	11.5327	[10]

Table 1.2. Wind power projects in Pakistan

Sr No.	Companies	Date	Tariff Structure	Tariff Rate Rs/kWh	Tariff Rate cent/kWh	Reference
1	FFC Energy Ltd	10-Aug-10	Cost Plus	13.6927	16.109	[11]
2	Zorlu Enerji Pakistan Ltd. (ZEPL)	19-Jul-11	Cost Plus	11.3511	13.345	[12]
3	Three Gorges First Wind Farm Pakistan (Pvt.) Ltd.	15-Dec-11	Cost Plus	11.849	13.939	[13]
4	Foundation Wind Energy-1 Ltd	16-Mar-12	Cost Plus	12.1851	14.135	[14]
5	Foundation Wind Energy-11 (Pvt.) Ltd	16-Mar-12	Cost Plus	12.1683	14.116	[15]
6	Metro Power Company Lmt. (MPCL)	15-May-12	Cost Plus	12.7445	14.523	[16]
7	Sachal Energy Development (Pvt.) Ltd (SEDPL)	3-Jan-13	Cost Plus	13.3756	14.861	[17]
8	Tapal Wind Power Energy Pvt. Ltd.	21-Nov-13	Upfront	16.2926	15.901	[18]
9	Yunus energy Ltd	21-Nov-13	Upfront	16.2926	15.901	[19]
10	Sapphire Wind Power Company Ltd. (SWPCL)	21-Nov-13	Upfront	13.1998	13.524	[20]
11	UEP Wind Power (pvt) Ltd	13-Dec-13	Upfront	13.1998	13.524	[21]
12	Gul Ahmed wind Power Ltd	23-Apr-14	Upfront	14.7462	15.108	[22]
13	Master Wind Energy (MWEL)	23-Apr-14	Upfront	14.7462	15.108	[23]
14	Tenaga Generasi Ltd	23-Apr-14	Upfront	13.973	14.316	[24]
15	Hydrochina Dawood Power (Pvt)Ltd (HDPPL)	23-Apr-14	Upfront	13.1998	13.524	[25]

16	Hawa energy (Private) Ltd (HEPL)	20-Jun-14	Upfront	13.1998	13.524	[26]
17	Jhimpir Power (Private) Limited (JPPL)	11-Aug-15	Upfront	10.6048	10.448	-
18	Artistic Energy Private Limited (Formerly hartford Alternative energy (Private) Ltd)	31-Mar-16	Upfront	12.7064	12.897	-
19	Three Gorges Second Wind Farm (Private) Ltd.	31-Mar-16	Upfront	10.6048	10.448	-
20	Three Gorges Third Wind Farm (Private) Ltd	1-Apr-16	Upfront	10.6048	10.448	[27]
21	Zypher Power (Pvt.) Ltd	13-May-16	Upfront	11.6348	11.462	-
22	Tricon Boston Consulting Corporation (Private) Ltd-B (TBCCPL-B)	13-May-16	Upfront	10.6048	10.448	-
23	Tricon Boston Consulting Corporation (Private) Ltd -C (TBCCPL-C)	13-May-16	Upfront	10.6048	10.448	-
24	Tricon Boston Consulting Corporation (Private) Ltd-A (TBCCPL-A)	6-Mar-17	Upfront	10.6048	10.448	-
25	Shaheen Renewable Energy -1 (Pvt) Limited	20-Aug-18	Cost Plus	5.2985	4.415	[28]
26	Western Energy (Pvt) Limited	20-Aug-18	Cost Plus	5.2161	4.346	[29]
27	Master Green energy limited	20-Aug-18	Cost Plus	4.9563	4.130	-
28	Indus wind Energy Limited	19-Nov-18	Cost Plus	5.7517	4.793	[30]
29	Din Energy Limited	19-Nov-18	Cost Plus	5.7388	4.782	[31]

30	Liberty Wind Power 1(Pvt.) Limited	19-Nov-18	Cost Plus	5.7388	4.782	[32]
31	Liberty Wind Power 2(Pvt.) Limited	19-Nov-18	Cost Plus	5.7388	4.782	[33]
32	Tricon wind Power (Pvt.) Limited	19-Nov-18	Cost Plus	5.7388	4.782	[34]
33	Act 2 wind (Pvt.) Limited	19-Nov-18	Cost Plus	5.6655	4.721	[35]
34	Artistic wind power (Pvt.) Limited	19-Nov-18	Cost Plus	5.6655	4.721	[36]
35	Gul Ahmed Electric Limited	19-Nov-18	Cost Plus	5.6655	4.721	[37]
36	NASDA Green Energy (Pvt.) Limited	19-Nov-18	Cost Plus	5.6628	4.719	[38]
37	Lakeside Energy(Pvt.) Limited	19-Nov-18	Cost Plus	5.6584	4.715	[39]
38	Metro Wind Power Limited (MWPL)	19-Nov-18	Cost Plus	5.5633	4.636	[40]
39	Trans Atlantic Energy (pvt.) Limited	20-Nov-18	Cost Plus	5.2157	4.346	[41]
40	Burj Wind energy(Pvt.) Ltd.	20-Feb-19	Cost Plus	5.846	4.871	[42]

1.9. Research Objectives

The main aim and objective of this thesis is to determine and identify the technical challenges and socio-economic challenges in the mega solar and wind power projects in Pakistan. This research work focuses on the following main objectives:

- To investigate the barriers in both mega solar projects and net metering based domestic rooftop solar energy projects that are impeding the rapid uptake of solar energy in Pakistan.
- To investigate the socio-economic impacts of these mega and net metering based projects, whether they improve the lives of people or not.

1.10. Thesis Outline

The following is a breakdown of the Thesis's structure: The second section looks at the literature review and solar energy landscape in Pakistan and barriers in solar power projects in Pakistan. The third section discusses the methodology of this study. The results related to barriers in solar energy projects, socioeconomic impacts of solar energy projects in Pakistan and environmental challenges for mega Renewable energy projects, and are discussed in Section 4. In Section 5, the conclusion is described.

Summary

With the passage of time demand for renewable energy increased over the period of time. God has blessed Pakistan with tremendous potential of solar energy, despite that share of renewable energy is only 6% and the share of solar energy in the energy mix is less than 2%. There are many institutes in Pakistan that are operating the power sector of Pakistan such as WAPDA, NTDC, DISCOs, AEDB, PEPCO and CPPA. WAPDA was divided into 3 sectors: which are generation companies (GENCO), national transmission and dispatch company (NTDC) and distribution companies (DISCOs). Pakistan has low per capita energy consumption as compared to global average value. And heavy dependence on imported fossil fuels is producing many problems for Pakistan. In order to tackle this problem government of Pakistan Introduced ARE Policy 2019, according to which Pakistan intended to attain the target of 30 % RE in the energy mix, which shows the commitment of Pakistan towards RE. Currently there are 6 operational mega solar energy projects. 4 solar energy projects have obtained letter of support from AEDB and 12 solar energy projects get letter of intent form AEDB. The were two main objectives of my study, 1) to find the barriers that are hampering the growth of solar energy projects at both mega and domestic level. 2) to find the socioeconomic impacts of both mega and rooftop solar energy projects. There was a limitation in the study, according to industrial experts, socio economic impacts of QASP cannot be find as QASP is injecting electricity directly into national grid. Socio economic impacts can only be found in a community if it is getting benefit form solar energy project.

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Chapter 2

Literature Review

2.1. Review of existing research work in Solar energy

Pakistan is positioned in the sun belt and receives a huge amount of sunlight throughout the year. It is important to utilize existing solar energy resources in order to address current energy problems. RE sources play an vital role in diversifying the energy mix, ensuring long-term energy security, and preserving the environment. Solar energy, in particular, offers appealing and diverse options for developing sustainable energy services in rural areas and undeveloped countries. As technologies advance and markets expand, initial costs are expected to decrease. Renewable technologies' incapacity to compete with conventional fuels is now the most significant impediment to their widespread adoption [1]. Meanwhile, government and private sector investment is essential to achieving its full potential [2]. Many scientists have concentrated on solar energy in order to assess its potential for effective application in the country [3]. [4] investigated the causes of Pakistan's energy shortages. The significance of solar energy as a natural resource for Pakistan was emphasized by [5]. Solar thermal, according to M. Farooq et al., is the best choice for the country's present energy problems [6]. [7] evaluated the technological possibilities of solar technology for generating power. According to [8], the total potential for solar energy in Pakistan is 1600,000 MW. [9] reviewed the prospects and current state of solar energy use in Pakistan, and emphasize on the importance of research and development organizations in the Pakistan's solar energy growth. [10] discussed how solar thermal, or solar water heaters, could be used in the textile sector. [11] developed a household off-grid PV system. Renewable energy poses several limitations, according to some researchers [9][12][13][14][15][16]. However, no one has attempted to find the barriers and Socio-economic impact of mega and net metering based domestic

rooftop solar power projects in Pakistan for the rapid uptake of solar energy in Pakistan.

It is very important to find the barriers and socio-economic impacts of solar power projects in Pakistan in order to overcome this research gap. This paper identifies the barriers in the solar energy projects that are hampering the growth of solar energy projects and assesses how mega solar energy projects and net metering based solar energy electrification projects impact society both in economic and social terms. The main objective of this study is to investigate the barriers in solar energy projects at mega and domestic level, see if consumers gain from solar energy projects in terms of socioeconomic development, and see if recipients experience an improvement in their standard of life as a result of solar energy. The data in this study was gathered using questionnaire and one-on-one focus interviews in which the interviewer talked directly with the respondent, eliminating the risk of misinterpretation on the interviewee's part. As the data in this study was collected from two different sources solar energy users and industrial experts, the conclusions made do not claim to be generalizable due to the wide range of participants. Furthermore, the outcomes of this study are dependent on respondents' self-reported perceptions, which may be skewed in terms of downplaying or exaggerating benefits. In the end, policy recommendations was proposed to the government and other key players to assist them in overcoming these barriers and expanding Pakistan's solar energy business.

2.2. Solar Energy landscape and Existing barriers: Pakistan - prospective

2.2.1. Installed capacity of solar power projects in Pakistan

According to International Renewable Energy Agency (IRENA), China is world leader in solar installed capacity. China ranks first in the world with installed capacity of 254,354.8 MW according to installed capacity of 2020, and India ranks fifth in the world with installed capacity of 39,211 MW [15]. Pakistan is far behind from China and India. Pakistan has a huge potential of

Solar energy. Year wise total installed capacity of solar energy projects in Pakistan is shown in figure 2.1 [16].

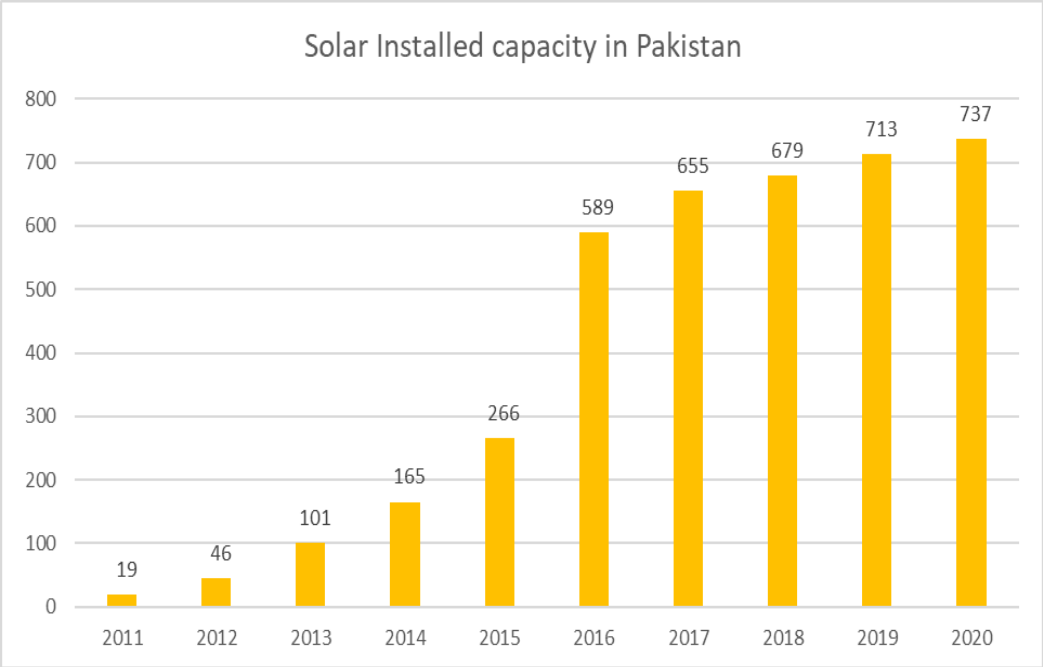

Figure 2.1. Year wise installed capacity of Solar energy in Pakistan

2.2.2. Pakistan Energy Mix

According to State of Industry Report, Pakistan had a total installed power generation capacity38719 MW as of 30 June 2020. And the country have a total installed capacity of power plants in public sector was 19,621 MW. While private sector power plants, including KE, had a total installed capacity of 19,098 MW. Thermal power accounts for 24,817 MW, hydropower for 9,861 MW, wind for 1,248 MW, solar for 530 MW, bagasse for 369 MW, nuclear for 1,467 MW, and SPPs/CPPs for 427 MW out of the total 38,719 MW. The Pakistan's energy mix is depicted in figure 2.2 [17], [18]. This energy mix did not include the net metering based solar energy projects which have a capacity of almost 214.58 MW.

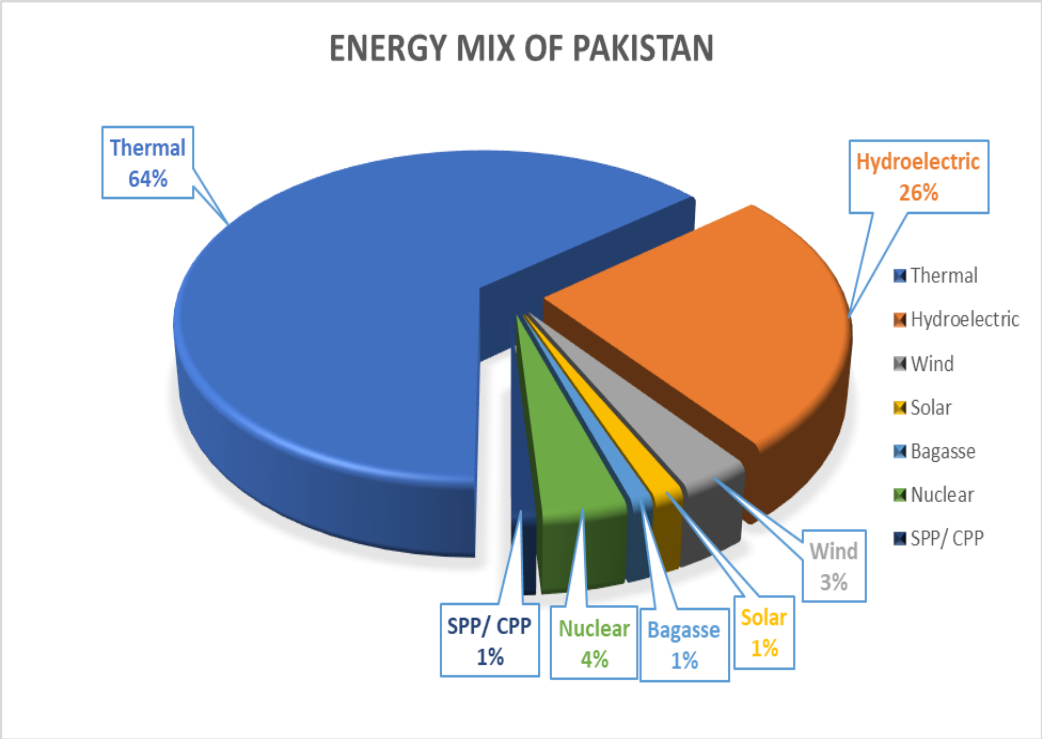

Figure 2.2. Energy Mix of Pakistan

2.2.3. List of mega solar energy projects at different stages in Pakistan

Despite Pakistan's vast solar energy potential, only six mega solar power projects are currently operational in the country. AEDB is now working to increase the installed capacity of solar energy in Pakistan. The AEDB is working on 22 solar projects with a total capacity of 890.80 MW. Table 2.1 shows the six out of the 22 projects which are operating, while table 2.2 shows the four Independent Power Producerss with a total capacity of 41.80 MW which have acquired an AEDB's letter of support (LOS) and are nearing financial close. Table 2.3 shows that AEDB has issued letters of intent (LOI) to the remaining twelve projects, which have a total capacity of 419 MW and are at different stages of development. These 12 projects are obliged to participate in the future CB to be conducted by AEDB, according to a resolution by the Cabinet Committee on Energy (CCoE)[19].

Table 2.1. Table of operational mega solar energy projects in Pakistan

Sr. No	Name of Project	Capacity	Location
1	M/s QA Solar Pvt. Ltd.	100	Quaid e Azam Solar Park, Bahawalpur
2	M/s Appolo Solar Pakistan Ltd.	100	Quaid e Azam Solar Park, Bahawalpur
3	M/s Crest Energy Pakistan Ltd.	100	Quaid e Azam Solar Park, Bahawalpur
4	M/s Best Green Energy Pakistan Ltd	100	Quaid e Azam Solar Park, Bahawalpur
5	Harappa Solar Pvt. Ltd	18	Sahiwal
6	AJ Power Pvt. Ltd.	12	Pind Dadan Khan

Table 2.2. List of Projects got LOS from AEDB

Sr. No	Name of Project	Capacity	Location
1	M/s Access Electric Pvt. Ltd.	10	Pind Dadan Khan
2	M/s Bukhsh Solar (Pvt.) Ltd	10	Lodhran
3	M/s Safe Solar Power Pvt. Ltd	10.28	Bahawalnagar
4	M/s Access Solar Pvt. Ltd	11.52	Pind Dadan Khan

Table 2.3. List of projects obtained LOI from AEDB

Sr.No.	Name of Project	Capacity	Location
1	IPS 22 Pvt. Ltd. – IPS Solar Park	50	Nooriabad, Sindh
2	JA 23 Pvt. Ltd.- IPS Solar Park	50	Nooriabad, Sindh
3	SB 24 Pvt. Ltd. – IPS Solar Park	50	Nooriabad, Sindh
4	R.E. Solar I Pvt. Ltd.	20	Dadu, Sindh
5	R.E. Solar II Pvt. Ltd.	20	Dadu, Sindh
6	ET Solar (Pvt.) Ltd.	25	Thatta, Sindh
7	ACT Solar (SPvt.) Ltd	50	Thatta, Sindh
8	Janpur Energy Limited	12	Sultanabad, Rahim Yar Khan
9	Lalpir Solar Limited	12	Mehmood Kot, Muzaffargarh
10	Siddiqsons Solar Ltd	50	Kalar Kahar, Chakwal
11	ET Solar (Pvt.) Ltd.	50	Fatah-Jang, Attock
12	Asia Petroleum Limited	30	Bahawalnagar, Punjab

2.2.4. Net metering based solar energy projects data

Net metering is incentive based scheme for distributed generation for less the 1000 KW renewable energy system. In this scheme a consumer may install a renewable energy generation system on his site and can inject excess electricity back to grid through bidirectional meter. In order to increase the growth of renewable energy at domestic level, Government of Pakistan introduced net metering in Pakistan on 1st September 2015. From 1st September 2015 to 31 October 2021, total applications received by DISCOs for net metering are 20706, and NEPRA had issued generation license to 17980 applicants. Total install capacity of solar energy projects under net metering scheme at domestic level is 268.71 MW [20]. Details of net metering solar energy projects is given in table 2.4.

Table 2.4. Net metering solar energy projects

Sr No	Name of DISCO	Application received in DISCOs		Applied to NEPRA	Generation License issued by NEPRA		Commissioned System	
		Nos.	Capacity (MW)	Nos.	Nos.	Capacity (MW)	Nos.	Capacity (MW)
1	**IESCO**	4594	55.67	4567	4542	55.43	4352	52.56
2	**LESCO**	5764	112.72	5245	4586	82.89	3926	71.34
3	**MEPCO**	2243	63.99	2095	1853	36.98	1476	29.96
4	**FESCO**	1202	30.69	1091	1070	26.77	873	19.92
5	**HESCO**	56	4.54	40	33	2.13	21	1.47
6	**SEPCO**	30	3.59	20	19	3.05	14	2.05
7	**QESCO**	17	0.89	16	15	0.8	3	0.55
8	**TESCO**	0	0	0	0	0	0	0
9	**GEPCO**	984	28.29	984	948	27.83	778	22.61
10	**BTPL**	519	4.86	519	492	4.63	492	4.63
11	**K-ELECTRIC**	3840	71.9	3441	3014	53.63	2856	50.67
12	**PESCO**	1033	12.58	1012	999	11.95	866	8.31
13	**EME (DHA)**	424	4.81	424	409	4.64	409	4.64
Total		**20706**	**394.53**	**19454**	**17980**	**310.73**	**16066**	**268.71**

2.2.5. Existing barriers

Commercial and industrial level growth of solar energy projects in Pakistan is very slow due to many reasons as mentioned in literature review.

Table 2.5. Major barriers in renewable energy projects

Major barriers	Identified Sub Barriers	References
Political and regulatory barriers	Inadequate regulatory framework	[21][22][23]
	Absence of coherent policies	[22] [23]
	Political instability	[22]
	corruption and nepotism	[24]
	lengthy regulatory approval and permit procedure	[22] [23]
Market competitiveness	High upfront cost	[22]
	Lack of subsidies on renewables	[22]
	Fossil fuel subsidies	[22] [23]
	Lack of access to credit and funds	[22]
Institutional Barriers	Lack of appropriate collaboration between different corresponding organisations	[22]
	Lack of institutional capacity	[22]
Technical barriers	Inadequate technology	[22]
	Lack of skilled manpower	[22]
	lack of local manufacturing unit	[22]
	Lack of infrastructure	[22] [23]
	Lack of R&D facility	[22]
	Lack of O&M facility	[22]
Social barriers	Lack of public awareness	[22]
	Lack of social acceptance	[22]
	Lack of confidence in the technology	[22]

2.3. A Case study of Quaid e Azam Park

Quaid e Azam solar park is first grid connected solar photovoltaic power plant at mega level. In 2013, the Punjab government of Pakistan built a 6500-acre solar park near Bahawalpur with the capacity to generate 1,000 megawatts of solar power. Phase I is 100 megawatts, Phase II is 300 megawatts, and Phase III is 600 megawatts. In the long run, the Solar Park is considered to be crucial in Pakistan's efforts to close the supply-demand imbalance. The first phase of the

pilot plant, which cost 131.15 million dollars to build and commission, was completed in May 2015. It covered over 500 acres and had nearly 392,158 solar modules. This 100 MW pilot project was a huge success, attracting a lot of attention from both domestic and foreign clients. However, only 400 MW of power generating was built due to objections from rival technology power plants, political considerations, and a lack of policy from the federal government.

Summary

Existing work done regarding solar energy projects has been discussed in this chapter. An overall brief landscape of solar energy projects is presented whether what were the barriers in the adoption of RE projects. According to IRENA the total installed capacity of solar energy projects was 737MW by the end of 2020, which is less than 2 % of the energy mix of Pakistan. AEDB is working on the 22 mega solar energy projects, which are at different stages of development. Out of these 22 projects, 6 projects were operational, 4 IPP have obtained letter of support from AEDB, 12 IPP have obtained letter of intent from AEDB. Apart from these 22 mega solar projects, there is also installed capacity of 268.71 MW under net metering scheme at domestic level. Commercial and industrial level growth of RE projects in Pakistan is very slow due to many barriers which is discussed in the chapter. A case study of QASP was also studied, Government of Pakistan (GOP) intended to accommodate 1000 MW in 3 phases. In the first Phase Gov of Punjab installed 100 MW as a pilot project, in the second phase 300 MW were installed.

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Chapter 3

Methodology:

3.1. Introduction

This chapter explains and illustrates the research methodologies used to conduct this study. It explains how the study's intended research objectives were met and fulfilled. Main topics which will be discussed in this chapter are: Research Design, Research Approaches, Study Area, Sampling Procedures and Techniques, Data Generation Methods, Data Analysis, issues related to ethics, and limitations of Study.

3.2. Research Design

Research design is a step-by-step guide to conducting research. It's a strategy for conducting scientific research that outlines what topics will be investigated, how participants will be chosen, how data will be collected and processed, and how legitimate conclusions will be reached. According to Ogden [1], research design is a basic and integral aspect of actually conducting research. It's a road map and a conceptual framework for how the research work will be conduct. It allows a study to be as efficient as feasible, delivering the most information imaginable, according to C. R. Kothari [2]. As a road map, it aids in finding the optimal route to the desired goal, and it lays out the rules or precise processes that must be followed in order to obtain data relevant to the study's questions.

In this study, a descriptive design was used. A research design focuses on information regarding people's views, beliefs, habits, or any of the numerous educational or societal aspects of the study, according to Kombo and Tromp. It was used in order to increase the chances of obtaining sufficient information on the study problem. It assists the researcher in deeply describing the opinions

and people's insights regarding the research issue, as stated by [3] in social research methodology.

3.3. Research Approach

Throughout the analysis, a qualitative technique was used. This method was used since it is the most suited method for researching social reality. [3] states in his social research methodologies that a qualitative approach is more appropriate in examining social realities using different qualitative data gathering tools. Qualitative approaches are employed to investigate the meaning of people's lives, according to Bryman and Burgess (1999). It aims to collect data in natural rather than contrived settings, and it works inductively, constructing theories from observations. A qualitative technique was determined to be the most effective way to conduct it. Furthermore, the use of a descriptive study design allows researchers to find the reasons of the research problem [2].

3.4. Sampling Methods

A Purposive sampling strategy was used to find respondents who were suitable for my study. Purposive sampling was done in two (2) stages. In order to deciding on the area in which the study would be done, to analyze the barriers and socio-economic impact of solar energy in Pakistan. Solar energy projects was divided in two categories, mega solar energy projects and net metering-based rooftop solar system at domestic level. For mega solar energy project, Bahawalpur was specifically chosen because this is the area where the mega solar energy project was built. Similarly, for net metering-based rooftop solar system at domestic level different net metering consumers were surveyed. Again, these are the areas that has suffered a lot from load shedding in the past for a long time. These are, nevertheless, areas that are rich in natural solar, and a high poverty rate.

Participants in the interview were selected on the basis of non-probabilistic purposive approach. And all the respondents and interviewee were interviewed

under an identical condition of instruction. And these sorts of interviews are referred to as extensive person sampling. The methodology of the study is subdivided into two different sections, which is shown in figure 3.1.

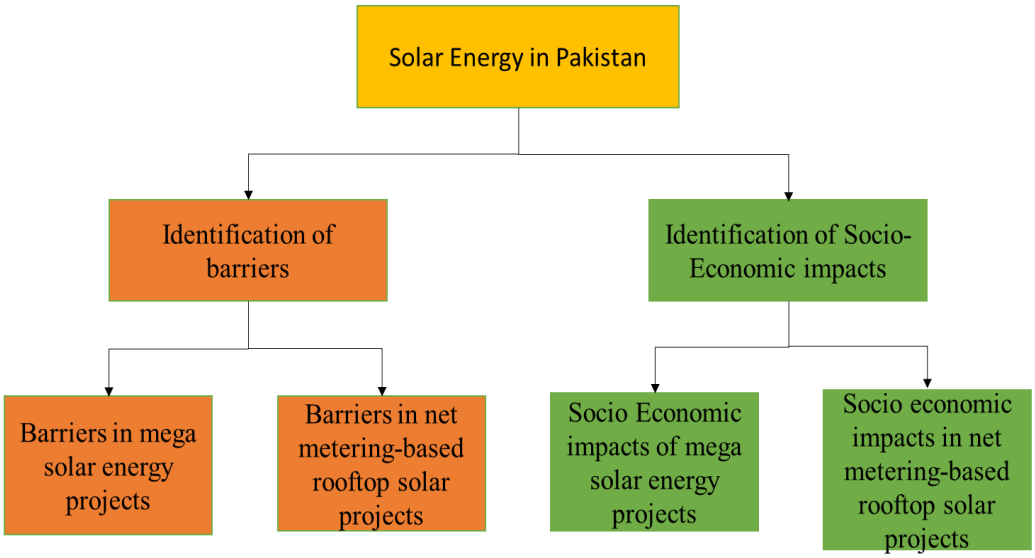

Figure 3.1. Methodology of study

The respondents of this survey were purposefully chosen in the second stage. Several criteria were employed at this level as well. Furthermore, this research focused on two aspects barriers and socio-economic impacts of solar. I looked for the most resourceful persons in each of these energy resources, people who had enough knowledge and information to offer legitimate and reliable data for my study. However, not all experts were interviewed in this regard; rather, a small number of them were purposefully chosen.

3.5. Data Generation method

In this study two phase approach was used. Phase 1 involved evaluating existing literature and projects as indicated in the literature. Phase-2 consists of data collection that include questionnaire formulation, collection of data and data analysis. Various key indicators that measure the change in each dimension were identified. In this study data was collected with the help of interviews and questionnaire that was made with the help of literature review.

3.5.1. Primary Data

In current research, primary data was collected through extensive literature review, in depth interviews conducted from industrial experts, project reports and direct observation. This data mainly focused on the overall barriers in solar energy projects in Pakistan and socio-economic impact of solar power projects in Pakistan; Specialists' perceptions, feelings, and perceptions of barriers in Pakistani projects; and new possible barriers and ideas from solar energy project experts to enhance conditions in Pakistan.

3.5.1.1. Identification of barriers in mega and net metering based solar energy project

A case study of Pakistan's Quaid-e-Azam solar photovoltaic power plant was selected as the country's largest solar project to determine the challenges to mega solar projects in Pakistan. It's at an elevation of 118 meters above sea level, with coordinates of 29.394 N (latitude) and 71.664 E (longitude) [4]. With the cooperation of China, the Quaid-e-Azam solar park was built in Bahawalpur, Punjab. It commenced operations in 2016 with a total capacity of 100 MW. At the end of 2018, three more projects on the same location were operational, bringing the total installed capacity of Quaid-e-Azam Solar Power plants to 400 MW. Open-ended interviews with industrial specialists were undertaken to determine the hurdles in the Quaid-e-Azam Solar power projects. They supplied information about potential roadblocks. After then, the interviews were transcribed. Furthermore, the study's findings were based on respondents' self-reported judgments, which might be biased because they undervalue or exaggerate benefits.

Fig: a

Fig: b

Figure 3.2. Fig a and b represent Quaid e Azam solar park Site location [5]

The net metering-based solar energy projects at the rooftop level also have a huge chunk in the total installed capacity of solar energy and it has a huge potential for exponential growth of a country like Pakistan. For a net metering license, a consumer must submit an application to their local DISCO. After assessing the application, DISCOs submit it to NEPRA for consideration of a generation license. The standard method for acquiring a net metering license as laid forth by the Alternative Energy Development Board (AEDB) in Net Metering Reference Guide for Electricity Consumers: How to Connect Your Solar System to the National Grid in Pakistan. It demonstrates that an applicant acquires a license in 45 days or less [6]. Primary data regarding barriers in net metering process was collected with the help of interviews with representatives from solar companies. 30 solar companies registered under V1 and V2 categories of AEDB provide barriers in the way of net metering based solar energy projects.

3.5.1.2. Identification of Socio-economic Impact of mega and net metering based solar energy projects

Finding the socio-economic effect of major solar energy plants in Pakistan has proven to be difficult. In Pakistan, massive solar energy projects were delivering electricity into the national grid. As a result, in order to determine the socioeconomic impact of solar energy, A survey was needed to perform in a specific society that was directly benefiting from a solar energy plant, which

was not achievable in the current instance. To find the socio-economic impact of net metering-based solar projects, primary data collection in this study was based on online survey from solar energy consumers at domestic level. The questionnaire was adapted from previous literature which they used to find the socio-economic impact of solar energy in Afghanistan [7]. 21 net metering consumers provided information about socio-economic impacts of net metering based solar energy projects. Physical sites visit were not possible due to lockdown during covid-19. Because of the diversity of consumers, the key findings do not pretend to be generic. As a result, the conclusions in this paper cannot be applied to all consumers. This was because of the consumer's socioeconomic profile, the energy usage pattern, and primary sources of money all have an impact.

Finally, the current article will present policy recommendations to the government and other key players to assist them in overcoming these obstacles and expanding Pakistan's solar energy business.

3.5.2. Data collection Instruments

Various instruments were used in the data collection process. The library, phone calls, Zoom application, and note books were employed to gather enough data for this study. Furthermore, a literature review was conducted, which aided in the capture of various barriers and socio-economic impacts of mega solar energy projects, face by different neighboring countries, and what steps they adopt to overcome these barriers. Apart from that literature review also help in capturing already mentioned problems and barriers in renewable energy in Pakistan.

3.5.3. Secondary Data

Many documents on general barriers in renewable energy in Pakistan, and socio-economic impacts of solar projects in Pakistan and neighboring countries and other information about Quaid e Azam Solar power and net metering-based rooftop solar projects were reviewed. Some of them were obtained from Alternative Energy Development Board (AEDB), National Electric Power

Regulatory Authority (NEPRA), documents from government institutes, and from other researchers. These documents added to the information gathered in the primary data collection.

3.6. Participants in Study

Primary data was collected through interviews and surveys for barriers and socio-economic impacts of mega and net metering-based rooftop solar energy projects. 30 solar companies registered under VI and V2 category of AEDB provide barriers in the way of net metering based solar energy projects. 21 net metering consumers provide information about socio economic impacts of net metering based solar energy projects. Industrial experts give information about barriers in the mega renewable energy projects, while socio economic impact of mega solar energy projects is a limitation of the study.

Finally, policy recommendations was presented to the government and other key players to assist them in overcoming these obstacles and expanding Pakistan's solar energy business.

3.7. Data processing and analysis

Qualitative approach was used to process and analyze the data. Information gathered through phone conversations from in-depth interviews was rigorusly transcribed and translated from Urdu, the language of data collection, to English, the study's standard language. This aided in comprehending the meaning, comprehension, experiences, attitudes, and perceptions of hurdles in renewable energy initiatives, technical barriers and socioeconomic challenges of mega solar and wind projects in Pakistan. Most importantly, it helped in capturing the main root cause which is hindering the growth of renewable energy in Pakistan. Data arrangements was performed on the data, that was collected from literature review, for the aim of identifying the themes related to the barriers in renewable energy projects, technical barriers and socio-economic challenges of mega solar and wind power projects. A full summary of the facts was presented before the conclusion was reached.

3.8. Ethical issues

Ethics is an issue of sensitivity to others' rights based on principles. Being ethical restricts the options in the search of truth. While truth is beneficial, ethics dictates that human dignity is preferable, even if respecting human dignity leaves one unaware about human nature in the extreme situation. This is and was a critical factor to consider during the research [8]. The participants' dignity, privacy, and safety must all be protected during the research process. Scheyvens and colleagues (2003). The ethical conduct of social research was ensured in this study. Permission and an introduction to the study research team based at the National University of Science and Technology were processed in order to perform this study. Self-introduction to the expert was completed after entering the research interview. During and after the study, they were all assured of anonymity and safety.

3.9. Limitations to study

There were some limitations to this investigation. The major constraint was not being able to conduct interview face to face or visit offices due to Covid 19 situation throughout the country and it was not a good environment for the data collection. Another barrier in the way of data collection is limited data availability in literature review in the case of Pakistan for barriers and technical and socioeconomic challenges in mega renewable energy projects in Pakistan.

Some significant steps were taken to address these limitation. On the first limitation, it was decided to collect data from specialists via phone conversations and other web portals, and then deal with data processing later. On the second limitation, literature review of neighboring countries was also made to get better idea of the study.

Summary

The research methodology of the study has been described in this chapter. In order to achieve the objective of the study qualitative approach was used. First of all, key stakeholders were identified for primary data collection. There were 3 main key stakeholders 1) Solar companies 2) industrial experts and 3) prosumers. After the identification of key stakeholders, in the second step criteria was identified, on the basis of which data was collected. Participants in the interview were selected on the basis of Non probabilistic, purposive sampling strategy for data collection. And all the interviewees were interviewed under identical condition of instructions. Data was collected with the help of open-ended interviews or literature review. Then collected data was segregated into different categories according to objectives. Then this collected data was converted into graphical form. In the end collected data was assessed and results were drawn from it and recommendations were made and proposed to policy makers to increase the growth of solar energy in Pakistan. There was a limitation in finding the socio-economic impacts of mega solar energy projects.

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Chapter 4
Results and Discussion

4.1 Barriers in Solar Energy projects in Pakistan

There are several misconceptions regarding the factors that may be preventing the expansion of solar projects specifically at mega as well as at household level. However, no comprehensive research or empirical analysis has been conducted on this topic. As a result, this section highlights key findings from surveys and interviews done as part of the study in order to better understand the hurdles and problems and socioeconomic impacts of solar energy projects on end users.

4.1.1. Barriers in mega solar energy projects

Experts from industry and policy makers were interviewed for the identification of barriers in mega solar energy projects. They expressed their thoughts and experience regarding barriers stalling the growth of mega solar projects. The most important challenge impeding the growth of mega solar energy in Pakistan is the lack of grid infrastructure. Due to a lack of evacuation facilities, under development projects were being delayed as they are site-specific and located far from load centers [1]. For operational projects, continuous tripping and forced shutdowns were common, which make it very difficult for mega projects to work smoothly. Similarly, Pakistan power companies also lack in the equipment and the necessary services which are required for mega solar power plants [2].

Solar and wind energy are the two most common renewable energy sources in Pakistan. The primary solar energy potential locations in Pakistan are in southern Punjab and Baluchistan, whereas the main wind energy potential sites are in Sindh Jhimpir and Pakistan's coastal region. Because the production points of renewable energy sources are located far from load centers, there are

numerous transmission losses as a result of the large distance between load centers and production points, due to which investors are unwilling to invest in transmission lines. Pakistan's transmission line infrastructure is now in poor condition, there are problems of electricity theft, no billing, line losses etc. New more efficient transmission lines from the generating site to the load centre should be erected. Policy inconsistency is another barrier to large solar and wind energy projects. To encourage the growth of big solar energy projects through private investment, a stable policy environment is required. The renewable energy policy of 2006 provided the groundwork for Pakistan's renewable energy development. Government policies, according to experts, are inconsistent and sometimes threaten not only the implementation but also the commercial feasibility of mega renewable energy projects. In 2017, the cabinet committee on energy voted to abolish the feed-in tariff scheme for new renewable energy projects, and a new renewable energy strategy was announced in 2019. During this time no mega projects were developed.

One of the most significant obstacles was the unreliability of local renewable energy technologies. The majority of renewable energy technologies have to be imported from other countries. There was no national solar cell manufacturing plant, and local production was limited. Foreign technology was required for key parts and equipment. Previous studies also discussed that due to unavailability of local renewable technologies manufacturing, equipment had to import [3], [4]. Due to which the price of renewable energy technologies increase, which made them cost disadvantaged in Pakistan against conventional energy resources and it also delayed the development of local industry. Another factor contributing to Pakistan's high solar energy pricing was the high feed-in tariffs for operational projects, which helped to attract investment in solar energy projects, as shown in figure 4.1 [5]. However, all new solar energy projects will now be built through competitive bidding, lowering rates

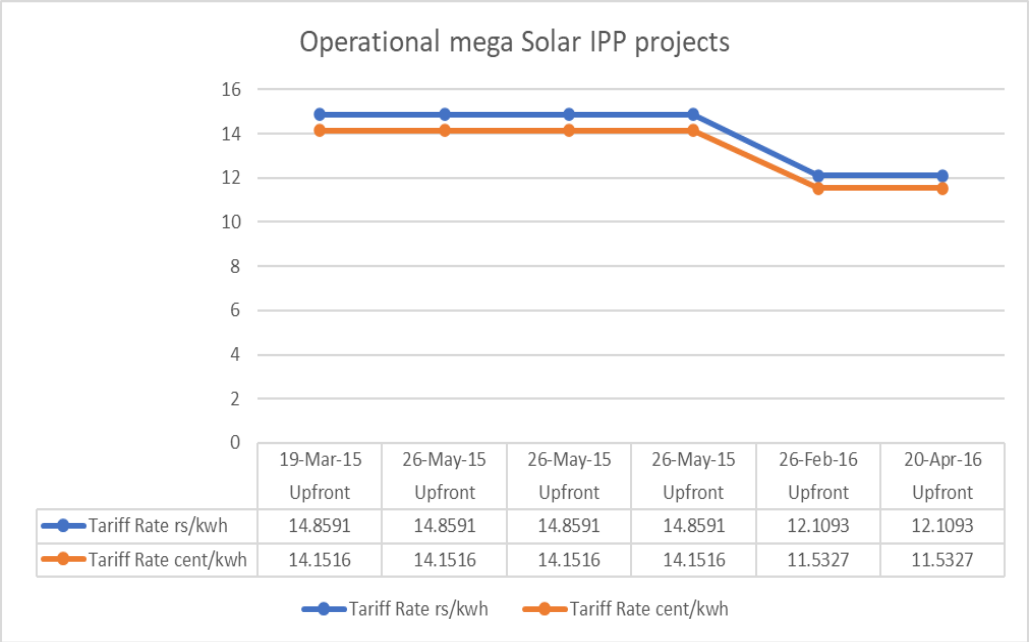

Figure 4.1. Operational cost of mega solar IPP in Pakistan

Pakistan had inadequate technology in solar energy. Pakistan also lacked the required infrastructure to facilitate the growth of solar and wind technologies. In Pakistan, there was a scarcity of skilled personnel to teach locals, demonstrate, maintain, and run the renewable energy strutures [3], [6].

At the government level, the government's target of 30% renewable energy in Pakistan's energy mix by 2030 is unattainable. Furthermore, as per the renewable energy policy of 2019, 20 % renewable energy must be included in the energy mix by 2025, time is running out and there are no short or long-term plans in place in Pakistan to properly install renewable energy [7].

Pakistan needs to conduct a research to identify the potential of renewable energy in Pakistan. Solar energy is abundant in Baluchistan. However, load centres are located far from places with abundant renewable energy resources. Government should make a proper transmission plan from load centers to project site. Currently, Pakistan has a weak transmission plan, but generation plan is useless without efficient transmission plan.

According to renewable energy policy of AEDB mature renewable energy projects (solar and wind) will be installed under competitive bidding but IGCEP

report prepared by NTDC was not approved since 2005, so main quantum was not set. Without the approval of IGCEP report competitive bidding was not started and mega solar energy projects delayed for a long period of time. There was documentation problem for competitive bidding. No competitive bidding documents, legal framework documents, and no EPC documents assessable and hence without them there will be no projects.

Apart from all above-mentioned barriers there were also some site-specific problems faced at Quaid e Azam solar park, which are given below in the table 4.1. Quaid e Azam solar park is located 20 km away from Bahawalpur in Cholistan desert. Accumulation of dust on the PV modules is very common in the harsh environment of desert. Due to soiling energy yield of solar system reduced. Maximum efficiency of solar system can be retained by regularly cleaning it with fresh water. But due to unavailability of fresh underground water, scarcity of on ground water, very less rain fall, and frequent dust storm, cleaning of solar panels in Cholistan desert is very challenging. During summer seasons, due to higher ambient temperature energy yield of solar system also decreased as a result of thermal losses.

Table 4.1. Site related barriers in Quaid e Azam Solar Pak

Site Related Barriers in Quaid e Azam Solar Park	
Operation and maintenance barriers	Gathering of dust layer, waste of birds, modern deposit like air poisons
	Frequent dust storm
	Higher ambient temperature
	Unavailability of fresh underground water which makes project site very complicated
	Scarcity of water
	Very little rain fall
	Losses due to higher temperature

4.1.2. Barriers in the net metering based solar energy projects

There are many views about what have caused the slow increase in the net metering based solar energy projects but not any comprehensive research or empirical proof was present on this topic. So, this section highlights the major

results from interviews conducted from solar companies, in an attempt to gain a holistic understanding of barriers and problems.

Fig. 7 shows the results of main barriers in the net metering based solar energy projects. These barriers were found by conducting the interviews with solar companies. It can be seen that delays in the net metering application process at distribution company and national electric power regulatory authority end has been ranked as the most important barrier in impeding net metering-based rooftop solar energy development in Pakistan. 84 % solar companies mention that they are facing the problems of delays in net metering application process. This finding aligns with a recent study conducted to find the barriers in the distribution generation in Pakistan. The authors reported that across all the DISCOS in Pakistan, 29% DISCOs take on average 30-60 days, and 26% DISCOs take 61- 90 days for issuing net metering license[8].

For net metering license a consumer has to submit an application to their local DISCO. After assessing the application, DISCOs submit it to NEPRA for consideration of a generation license. The normal procedure for obtaining a net metering license, as outlined by the Alternative Energy Development Board (AEDB) in Net Metering Reference Guide for Electricity Consumers: How to Connect Your Solar System to the National Grid in Pakistan, is showed in Figure 4.2. It shows that an applicant receives a license within 45 days [9].

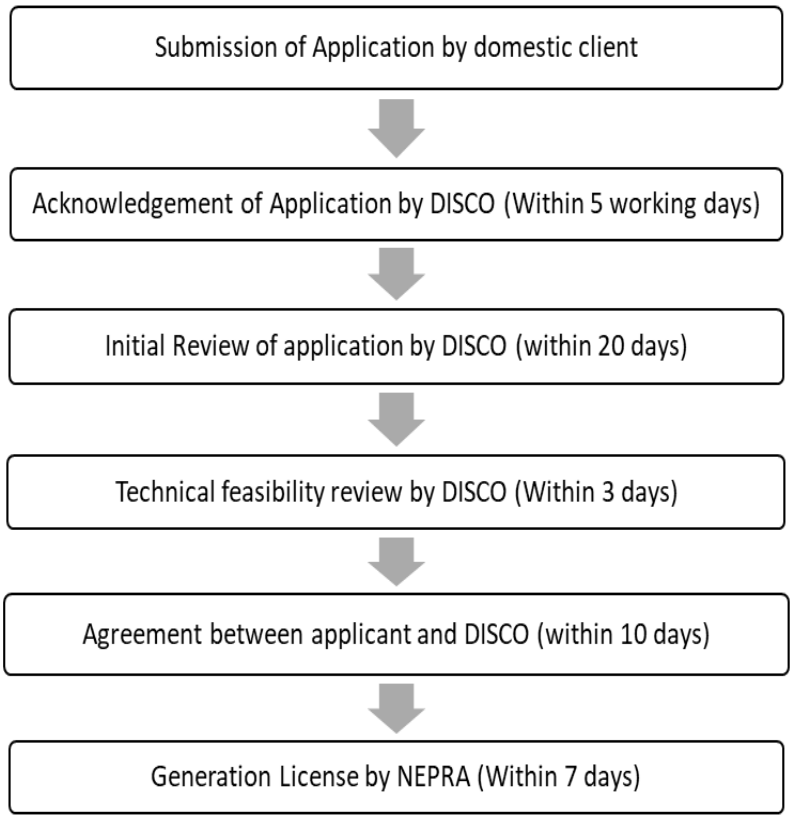

Figure 4.2. Standard procedure for Net metering application process

There were many views about what have caused the slow increase in the net metering based solar energy projects but not any comprehensive research or empirical proof was present on this topic. So, this section highlights the major results from interviews conducted from solar companies, to gain a holistic understanding of barriers and problems.

Figure 4.3 depicting the results of main barriers in the net metering based solar energy projects. These barriers were found by conducting the interviews with solar companies. Delays in the net metering application process at DISCO and NEPRA end has been ranked as the most important barrier in impeding net metering-based rooftop solar energy development in Pakistan. 84 % solar companies mentioned that they were facing the problems of delays in net metering application process. This finding aligns with a recent study conducted to find the barriers in the distribution generation in Pakistan. The authors reported that across all the DISCOs in Pakistan, 29% DISCOs take on average

30-60 days, and 26% DISCOs take 61- 90 days for issuing net metering license [8].

Net metering problems at interconnection stage ranked at second highest position as 76 % solar companies mention that they had to face problems such as unavailability of 3 phase energy meters, unavailability of green energy meters and unnecessary delay at nearly every single step. Both domestic consumers and solar firms are discouraged by delays in the net metering application process and challenges during the interconnection phase, because end clients are unable to access the benefits of net metering despite their large investment owing to delays in the net metering process. Third highest barrier in this category is bribery as 52 % solar companies complained that they had to pay bribery at DISCO level, otherwise file took a lot of time to move from one step to another. Clients were frequently required to pay bribes to members (including lower-level workers) for their paperwork to be completed. Solar vendors had to face extortion by dishonest officials and staff members for performing their sworn duties. This problem has also been discussed many times in literature as well. Corruption and nepotism are rampant in Pakistan, not even a single office from government sector is free from this disease [10]. The detrimental effects of corruption on the economic growth of Pakistan were also inspected, which further confirmed that corruption was one of the country's greatest roadblocks to economic growth [11]. There was less staff to deal with the solar projects at the DISCO, according to 36% of interviewees. As a result, it finished fourth in a row. The majority of the employees were devoted to other high-demand projects and departments.

Less staff availability for processing of net metering application for solar system; leads to the regulatory gap which increase the processing time. Domestic clients faced high eligibility criteria from banks for securing loans, according to 32% of solar companies. A recent study in Pakistan, also support our findings as they documented the barriers in acquiring the finance from banks for domestic solar system [12]. Catherine also mentioned that lack of viable financing for distributed generation is a barrier in Brazil as well [13].

Similarly, 32 % solar vendors mentioned that existing regulations for net metering are old, and they need to be revised and both barriers got fifth position. On the sixth spot is high charges for generation license, 20 % solar vendors mentioned that previously distributed generator had to pay onetime fee through pay order in the favor of NEPRA for getting generation license, but there was not any fee for systems less than 20 kW [9]. But currently government have imposed a fee of 1000 Rs. / KW for systems less than 20 kw. On the seventh position is absence of online processing of net metering application. 16 % solar vendors show their concerns as manual processing is more time consuming as compared to online processing. Online processing is transparent, and there are less opportunities of bribery, as well as concerns with a lack of workers and their availability. The majority of net metering constraints are governmental and regulatory in nature.

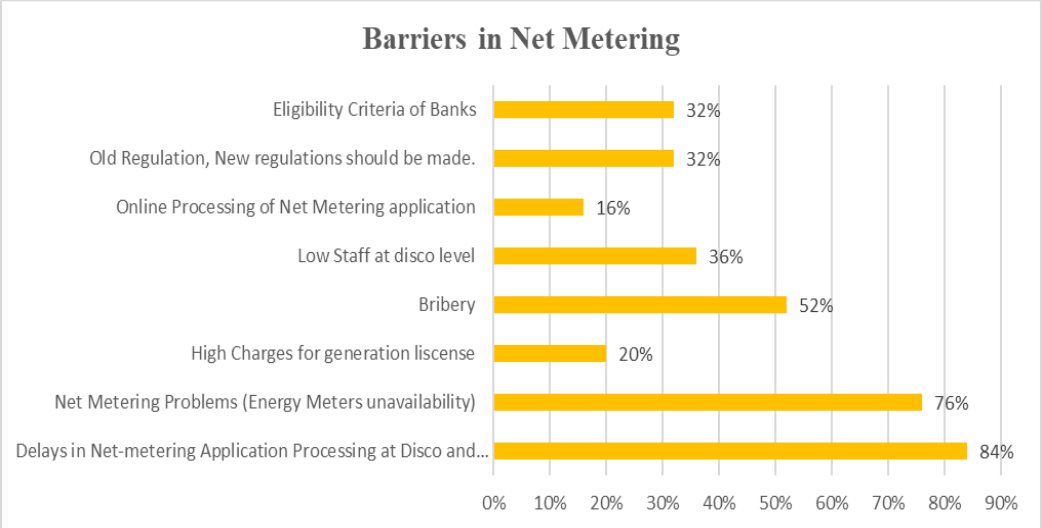

Figure 4.3. Barriers in Net Metering based solar energy projects at domestic level

4.2. Socio economic impacts of solar energy projects in Pakistan

4.2.1. Socio economic impacts of Solar energy at domestic level

The socio-economic impact of a net metering-based solar energy project at the household level was determined using the indicators. These variables were

picked from prior research of a similar nature and tailored to the socioeconomic profile of the users [14] . Based on the perceptions of the receiving community, a questionnaire was created to measure these indicators. A total of 21 users were questioned. People from both rural and urban areas were included in this sample.

Overall, the participants expressed satisfaction with the net metering-based solar energy projects, according to the questionnaire. When asked particular questions, however, their responses were mixed. Participants viewed solar energy projects based on net metering as a favorable development in overall. They believed that net metering-based projects resulted in modest improvements in social (75.13 % agreed) and economic (77 % agreed) situations. Another study in rural Bangladesh evaluate the affects of solar home systems on the social development, which align with this study. They find out that due to solar home systems education of children improve, indoor pollution reduced and quality of life also improved [15].

According to the current study, time flexibility for domestic and productive tasks, learning conditions for children, working hours for domestic activities, and entertainment opportunities were the indicators that were significantly improved out of 11 indicators used to assess the social benefits of net metering based solar energy projects. Children used to sleep early in the night during load shedding hours, which hampered their schooling. According to 85.7 percent of prosumers, they now have enough light in the evening to do homework, which has improved their children's learning conditions. Due to the solar system, time flexibility for productive work (such as stitching and sewing-related work by women at night) increased according to 85.7 percent prosumers. Rooftop solar has also enhance the scope of entertainment according to 81 percent of prosumers. The indicator that showed the least improvement was hygiene and health according to 61.9 percent of prosumers as illustrated in figure 4.4.

Similarly, in the case of economic benefits of net metering based solar energy projects 3 out of 6 indicators improved significantly which were energy

expenses decreased, Small solar companies flourish due to installation of the solar system at domestic level and jobs creation as a result of solar system installation at domestic level. Prosumers are of opinion that due to net metering-based solar projects their electricity bills reduced a lot and also inject excess electricity into the grid in some cases, according to 90.5 percent of prosumers. Further, due to the increased installation of rooftop solar systems, the business of solar companies flourish and as a result jobs were also created according to 90.5 percent of participants. Moreover, the indicator to which least participants agree was, the affordability of solar energy projects at the domestic level, 57.1 % of participants agreed that the solar system was affordable at the domestic level despite its high upfront cost shown in figure 4.5 .

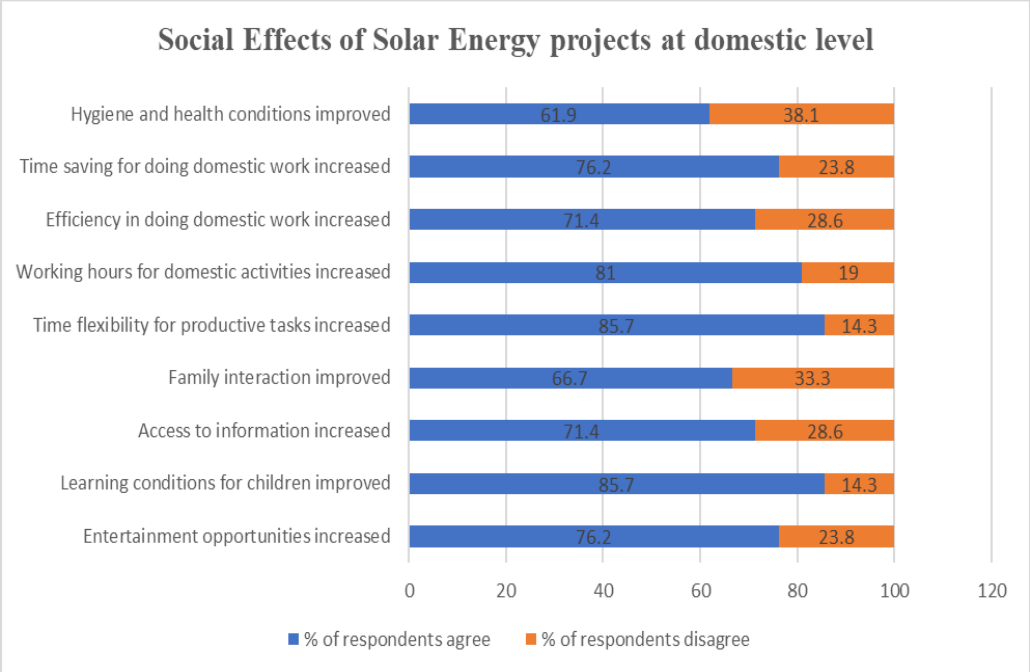

Figure 4.4. Social effects of solar energy projects at domestic level

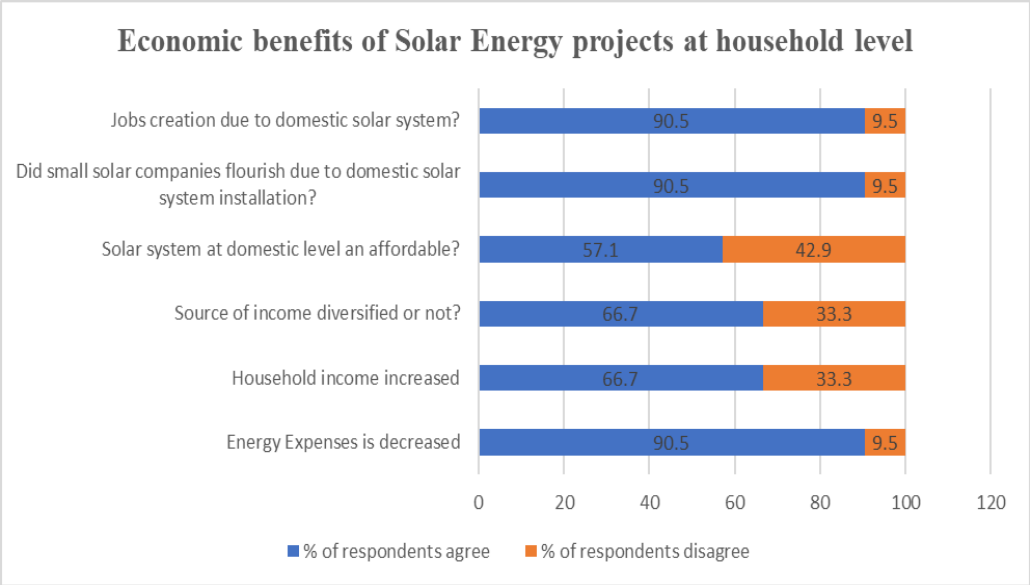

Figure 4.5. Economic advantages of solar energy projects at household level

Social advantages of solar energy projects at the domestic level

Table 4.2. Results of Social parameters improved due to solar energy at domestic level

Social advantages of solar energy projects at domestic level		
Potential improvements	**Percentage of respondents agree**	**Percentage of respondents disagree**
Entertainment opportunities increased	73.7	26.3
Learning conditions for children improved	84.2	15.8
Access to information increased	68.4	31.6
Family interaction improved	68.4	31.6
Time relaxation for household and productive work	84.2	15.8
Increased working hours for performing domestic tasks	78.9	21.1
Increased Efficiency in doing household tasks	73.3	26.3
Increased Time saving for doing domestic work	73.7	26.3
Hygiene and health conditions improved	63.2	36.8
Increased efficiency in doing household work	73.3	26.3

Economical advantages of RE projects at domestic level.

Table 4.3. Results of economic parameters improved due to solar energy projects at domestic level

Economic advantages of RE projects at domestic level		
Potential improvements	**Percentage of respondents agree**	**Percentage of respondents disagree**
Energy Expenditure is decreased	89.5	10.5
domestic income increased due to solar project	68.4	31.6
Source of income diversified due to solar energy project	63.2	36.8
Is solar system at domestic level an affordable option?	63.2	36.8
Did small solar companies flourish due to solar system installation at domestic level?	89.5	10.5
Were jobs created as a result of solar system at domestic level?	89.5	10.5

4.2.2. Socioeconomic impact of mega solar energy Projects

According to the expert interviews, mega solar energy projects inject electricity directly into the grid. To find the socio-economic impacts of solar energy projects, a survey was needed to be conduct from society which was directly getting benefits from solar energy projects. In our country one of the mega solar energy projects was Quaid-e-Azam solar park, which was injecting energy into the grid so, it was difficult to find the direct impact of Quaid-e-Azam solar in Pakistan. However, this project claimed to produce 165000MWh of energy over the time span of the initial crediting period, according to project documentation. The first phase of this project eliminated 98,043 tonnes of CO^2 from the atmosphere in a year [16]. Furthermore, the initiative brought long-term Socioeconomic stability to the region, claiming factors such as the creation of local employment, less dependency on foreign fuels and lower carbon dioxide emissions as justification. After the implementation of this project load shedding in the nearby regions was also reduced.

4.3. Environmental impact of mega renewable energy projects

4.3.1. Environmental challenges of mega wind energy projects

Wind Energy is very popular source of energy and, it is capacity is increasing day by day. It is a clean source of energy, but it also have some adverse effects on environment which is given below.[17]

4.3.1.1. Aesthetic Problems

When a wind farm/ power plant is built and it is located near populated area, then it will create aesthetic problems for population living in the surrounding of the wind power plant, due to its huge size and size of big turbines nobody would like to make home near wind turbines.

In the USA, the ideal wind farm locations are often at the crests of horizon-defining mountains and in areas with a certain degree of wilderness cachet. Furthermore, a GW station of wind power project will require complex hundreds of individual units as compared to a big central station fossil-fired or nuclear. For a large portion of the public, the overall visual impact is upsetting. The presence of a large population in Western Europe is an even more contentious aspect.

4.3.1.2. Noise

Another Environmental issue by wind turbine is noise creation. Sometimes these wind turbines produce huge noise. As the no of blades in wind turbine decrease the noise generate by wind turbine will increase, and speed of wind turbine will also increase. By increasing the no of blades of wind turbine thrust will increase, noise will decrease, but speed will decrease. Wind turbines with higher no of blades can be used to pump the water. But for power generation speed of wind turbine should be high, so mostly 3 blade wind turbines are used in the world for power generation, which have high speed but these wind turbines also produce noise as a result.

Low-frequency blade noise is a significant disadvantage, particularly in western Europe, where open space is limited and wind turbines are located close to population areas. Noise from machinery can be hushed or engineered out. Except for particularly sensitive individuals, a buffer zone of up to half a kilometer from the nearest habitations appears to be sufficient.[18]

4.3.1.3. Disturb Ecosystem (Birds)

Wind turbines also disturb eco system by killing the birds.it is a common phenomenon in some areas. Migrating birds from different countries, have to change their path. They are forced to migrate due to these wind turbines.

Certain areas in California have proven dangerous to large predatory birds like hawks and eagles, while others have reported bat killings. If corrective actions are ineffective, this issue could create a new barrier on site selection[19].

4.3.1.4. Huge Area

Wind energy is a low-density energy source, so a large area is needed to establish a wind power plant. In case of wind power projects land consumption is an issue. As the wind turbine blades are at a height and only base of the wind turbine is present at the ground. And these lands can be used for another purpose as well.

Despite wind energy fluxes in the horizontal plane can be several hundred watts per square metre, equivalent to vertical solar energy fluxes, wind power is a dilute resource due to the large front-to-back and side-to-side spacings required to reduce interference. Despite this, the tower's actual footprint is small, allowing for dual land use (for example, farming, cattle grazing, or even solar photovoltaic or thermal units).

4.3.1.5. Difficult maintenance

As wind turbines are huge in size and blades are at a height, the maintenance of these huge wind turbine is very difficult. For maintenance, employees have to

climb at a huge height, and accidents may take place at such a height and workers may lost their life. By the advancement of technology maintenance equipment has been develop for sensing of fault, but it does not completely eliminate the issue.

Maintenance employees are at risk. The dangers that steeplejacks and high-rise construction ironworkers face are similar to those that windmill maintenance workers encounter. However, because the wind farm's owner/operator pays higher workplace insurance rates, the related additional expenses are probably reflected in the busbar price [20].

4.3.1.6. Electromagnetic Interference

Wind turbines interface in T.V., radio, radar, and telecom signals. Wind turbines will generate noise in the signals. Interference with radio and television transmissions, as well as radar, both domestically and internationally. Interference has been and continues to be an issue in some cases, but it looks to be decreasing as cable and satellite systems become more common, electronic technology improves, fibreglass blades replace metal blades, and siting requirements evolve.

4.3.1.7. Offshore siting impacts

Impacts of offshore siting Offshore wind turbines bring with them the added concern of obstructing fishing, navigation, and pleasure. They have the potential to cause beach erosion in some circumstances. The effects of waves and ice must also be considered.

4.3.2. Environmental challenges of mega solar energy projects

Photovoltaic is very clean and green source of energy during operation. According to rough estimations, the silicon PV collector will return the amount of energy used to create it after two years of operation.

4.3.2.1. Land Use

Solar energy is low energy density source. A large area will be required to produce considerable amount of energy from solar plant, as solar energy projects are installed horizontally. Large-scale solar or wind energy farms necessitate large swaths of land. Land availability is a sensitive issue, particularly in developing countries. But now a days with the advancement of technology they can be installed on buildings. Solar mounting structure can also be designed in a way that they will need less space [21].

4.3.2.2. Chemical and Health Risks during manufacturing

The sorts of materials being examined, such as CdTe and CuInSe2 or GaAs, raise environmental and health problems for advanced PV systems. Many of these materials are poisonous in various chemical forms, and the methods for recovering, purifying, and employing them have their own set of consequences [18].

During operations solar energy does not produce pollution but during manufacturing a lot of chemical risks and health hazards are involved. Materials that are used in the fabrication of solar sell other parts may be toxic. Materials such as HF, HNO3, H2SO4, NAOH, POCL3, B2H4, PO5, SiH4, PH3 (phosphorus gas) etc are used in the doping of solar cells [22].

Good point is that these materials are used only in the restricted places (such as in factory).

4.3.2.3. Disposal

Not only in manufacturing but also in disposal solar panels may harm the environment as they contain a lot of toxic material that can penetrate in the land and underground and exposed water sources. Strict rules should eb imply for disposal of chemical materials used in solar cell as well as chemical itself.

4.3.2.4. Use of toxic material in Fabrication

In any case, each solar energy system's energy, material, and other natural resource requirements for manufacturing and maintenance should be assessed. Toxic materials are used into the fabrication of solar cells such as Fluorine. Fluorine penetrates to skin and then penetrates to the bones and degrade them, when workers are in direct contact with them [23].

4.3.2.5. Gas emission during manufacturing

During the manufacturing of solar cell, strong acids and alkalis are used when theses are processed, gases emit. And they can go out to atmosphere which can pollute environment with poisonous gases. These gases have to be captured and restricted from emitting into environment.

4.4. Barriers in the way of renewable energy in Pakistan

Although Pakistan has a lot of solar energy potential, there are some challenges that must be overcome before this technology can be used correctly and successfully. The high initial cost is one of the most significant hurdles, as solar energy installations take a long time to pay for themselves financially. Figure 4.6 provides detail of these impediments in more detail.

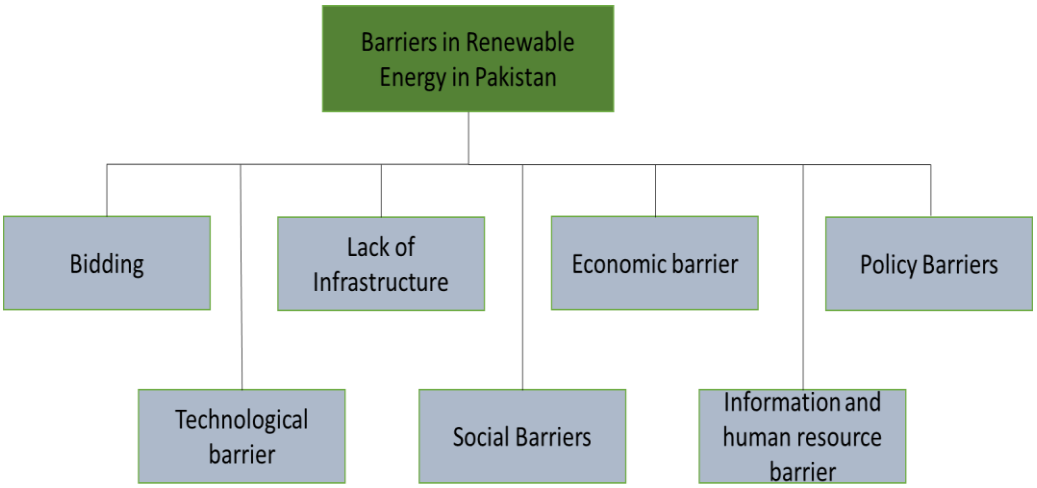

Figure 4.6. Barriers in Renewable energy in Pakistan

4.4.1. Bidding

There are two types of renewable energy Support mechanisms mentioned below:

1. Feed in tariff (FIT) / feed in premium
- Cost Plus tariff
- Upfront tariff
2. Auction Scheme / Competitive bidding (solicited mode)

4.4.1.1. Feed in tariff (FIT) / feed in premium

Feed in tariff is certain amount of payment/KWh that is being paid to IPP for producing renewable energy and then fed it into grid. In feed in tariff scheme, quantity/ capacity is determined by the market and prices are set by regulatory authority, such as NEPRA. Similarly, in the case of auction scheme mechanism quantity of the renewable energy project is determined by regulatory authority, while prices of energy project are set by market.

This study will focus only on feed in tariff and auction schemes, because existing tariff structure of Pakistan is feed in tariff and Pakistan is planning to shift from FIT to auction mechanism.

- **Cost Plus tariff**

In the cost plus tariff, renewable energy independent power plants (IPP) are given their actual cost as well as agreed profit. In this tariff mechanism, independent power plant (IPP) has to submit tariff petition to NEPRA for the award of tariff for a specific project, along with the proposed tariff and supporting papers proving the cost.

- **Upfront Tariff**

The Regulator determines and announces an upfront tariff based on its own examination and computations, as well as specified terms and restrictions. The Upfront Tariff may be accepted by the project sponsors if it is viable for their project.

In cost plus tariff mechanism, the project owner submits a proposed tariff to NEPRA, which examines it and makes any required adjustments. While in the case of Upfront Tariff, before defining a final feed-in tariff, NEPRA and other relevant agencies predetermine rates or specific project types and invite industry representatives and experts to comment.

4.4.1.2. Auction Schemes/ Competitive Bidding

Auction systems are a common policy tool. Early attempts at implementing this type of program failed miserably, prompting most governments to turn to other mechanisms for example feed-in tariffs (FIT) and renewable purchasing obligations (RPO). A "second wave" of interest in RE auctions gained traction, spearheaded primarily by emerging countries, after more than a decade later (see, for example, [24]–[28]).

In auction-based methods, the price and quantity of the projects are established prior to the choice to develop them through a public bidding procedure. Due to this feature, auctions can accomplish the “best of both mechanisms” of FITs and RPOs. It also give investors predictable revenue assurances (akin to the FIT system) while also ensuring that the renewable generation target is fulfilled accurately (similar to an RPO). Auctions have been criticized for their poor performance in terms of deployment rates and increased transaction costs, despite the fact that they have proven to be effective methods for assuring economic efficiency by reducing the amount of subsidies necessary (delayed or cancelled constructions) [29].

Because of unpleasant experiences with competitive bidding in many parts of the world, adoption of competitive bidding has been slow. This posture has shifted dramatically in recent years: whereas the number of nations using FIT or RPO systems almost double from 2005 to 2013, the number of countries implementing auction schemes grew six-fold. Similarly, from 2013 to 2020, the number of countries participating in auctions more than doubled. It's also worth noting that developing countries have been at the forefront of the growing interest in auction methods. Table 4.4 shows the countries that will be implementing renewable fostering policies in 2020, organized by income level.

Consequently, auction procedures have become a hot topic that has piqued the interest of a number of governments, investors and multilateral organizations. [30][31][32].

Table 4.4. Number of countries with different active renewable policies

Countries no with various forms of active renewable policies			
Mechanism	**count of countries with active policies**		
	2005	**2013**	**2020**
Feed in Tariff/ premium payment (FIT)	34	71	87
Electricity utility quota obligations / RPS (RPO)	11	23	34
Auctions	7	45	109

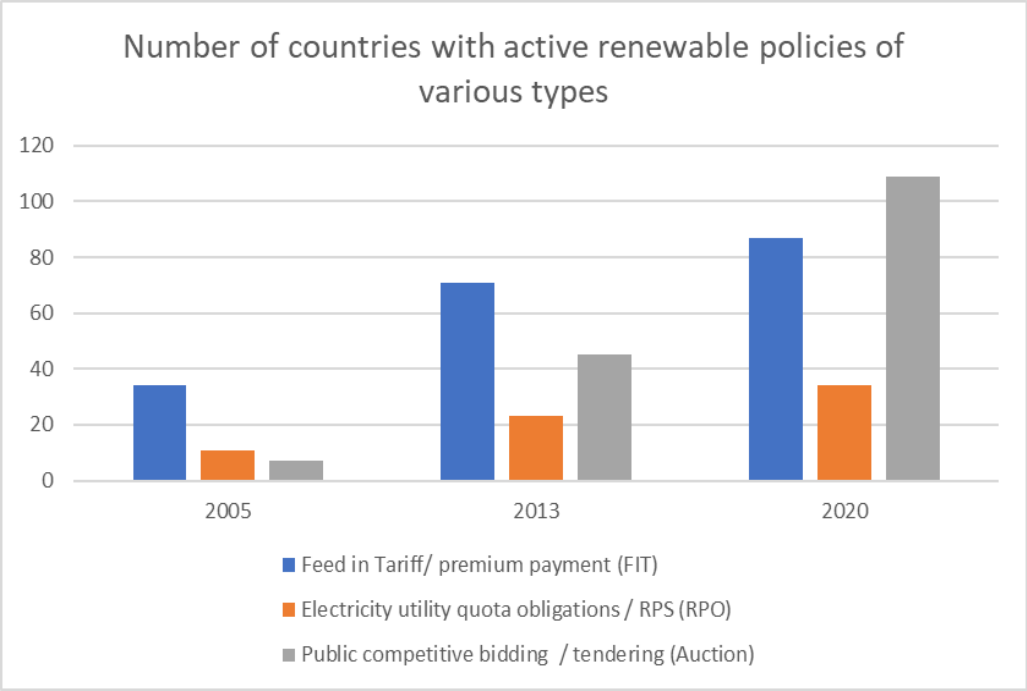

Figure 4.7. Countries with active renewable energy policies

Table 4.5. Categorization of countries implementing renewable fostering policy in 2020

By income category, countries implementing renewable fostering policy in 2020				
Policies	**Countries with high income**	**Countries with upper middle income**	**Countries with lower Middle income**	**Countries with lower income**
Feed in Tariff/ premium payment (FIT)	32	19	20	9
Electricity utility quota obligations / RPS (RPO)	16	6	9	1
Public competitive bidding / tendering (Auction)	38	29	25	17

Overall auction periods for China and India

Until 2007, Auctions were used by China for onshore wind and until 2010 for PV. In case of India, they introduced national solar mission according to which they have to achieve the ambitious target of 100 GW by 2022. For this purpose, they also set yearly targets for solar systems deployment from 2016 to 2022. But there were no any specific targets in china. In the case of India, both federal level and state level policies interact in a complex way, with CB being employed in some areas and tax exemptions playing a significant role. The overall time period of auction for China and India is given in table 4.6.

Table 4.6. Overall Auction period for India and China

Technology	Country	Time frame
Solar	India	2010-2022
	China	2009-2010
Wind	India	2017
	China	2003-2007,2011

Barriers in the way of Competitive bidding in Pakistan

Following barriers are hampering renewable energy growth in Pakistan through competitive bidding:

- Target of 30% Renewable energy in the energy mix of Pakistan is not achievable at government level, because according to renewable energy policy 2019 share of renewable energy should be 20% in energy mix by 2025, time is passing by and competitive bidding has not started yet.
- IGCEP report is not approved yet, so main quantum is not set. Without the approval of IGCEP report competitive bidding will not start.
- Documentation problem (no competitive bidding documents, legal framework documents, and no EPC documents) are available yet.
- Pakistan needs to conduct a study to identify the potential of renewable energy in Pakistan. Baluchistan is very rich in solar and wind energy. But load centers are away from the areas which are rich with renewable energy potential. Government should make a proper transmission plan from load centers to project site. Currently, Pakistan don't have transmission plan but generation plan which is useless without transmission plan.
- Network of existing transmission lines need to be improved in Pakistan. Currently, transmission line system is very weak in Pakistan. E.g. (electricity theft, no billing, line losses etc.). New more efficient transmission lines should be installed to load center from generation point.
- Weak grid infrastructure: The most important challenge impeding the growth of renewable energy in Pakistan is a lack of grid infrastructure. For operational projects, forced shutdowns and frequent tripping are prevalent. Due to a lack of evacuation facilities, development projects are being delayed.
- Limited ability of the provincial government: Pakistan's electricity system is centralised, with the federal government's entities having a monopoly on power evacuation, offtake, and distribution. The provincial government has

failed to establish an institutional framework for power acquisition and delivery.

- Lack of coordination mechanism: Based on existing policies, policymakers at both levels have failed to build clear and coherent operating processes and power procurement plans. More than 2,500 MW of LOI issued by the Sindh government are not included in NTDC's grid expansion plan, because they were granted without the involvement of a grid operator.
- Inconsistent regulator and policy decisions of the government: The federal government's arbitrary policies have hampered Pakistan's renewable energy advancement greatly. The cabinet committee on energy halted renewable energy projects in 2017, including one undertaken by Sindh under the feed-in tariff framework. Plants based on coal and RLNG, on the other hand, were allowed to be built. Due to discontinuity of policies, projects halt and the interest of investors in energy projects reduce.

4.4.2. Lack of Infrastructure

For the social and economic growth of any country renewable energy services are critical. A huge chunk of population of Pakistan does not have access to electricity, as conventional energy resources insufficient to meet Pakistan’s present energy needs. Energy demands have risen dramatically as a result of technological advancements, putting additional strain on infrastructures. Pakistan's historic grid structure is primarily designed for conventional electricity, and it is incapable of supporting current power loads and it is also very difficult to integrating renewable energy sources in the existing grid structure. System losses in Pakistan, like as distribution and transmission losses, are substantially higher as compared to other South Asian countries, which further exacerbate the problem. The only way to address the energy shortage is to build more lines and substations. As a result, grid infrastructure must undergo significant changes in order to meet rising electrical consumption. The current grid system needs be converted to a smart autonomous system in order to attain significant levels of renewable energy output. Furthermore, with the

implementation of smart grids, the issues of transmission and distribution losses can be reduced [33].

4.4.3. Economic Barriers

Solar energy projects require a lot of money and don't have a lot of economies of scale. It takes a long time for the debt to be repaid.

- Currently in Pakistan most of the Government departments and solar companies don’t have any exact knowledge about potential of solar and wind energy in Pakistan, due to which they lack in understanding of market potential as well.
- Another economic barrier in the way of solar and wind energy uptake is the initial upfront cost of these technologies. The initial costs of launching a new solar energy project are too high.
- Due to poor financial health government of Pakistan, government is reluctant to provide subsidies to larger projects, banks are hesitant to lend money to large projects.
- When it comes to the performance of solar and wind energy projects, there are always uncertainties, and solar and wind companies have to face a huge risk in the form of generation, and in the absence of any favor or subsidy, private companies prefer to invest in any other better opportunity.

4.4.4. Policy barriers

- When private companies invest in any business, they calculate all the risks before making any investment. In the case of energy sector, their decision depends mainly on the policies made by government. Private investor participation is governed by complicated policies. And there many uncertainties in the energy policy of Pakistan. These polices uncertainties are hampering the companies to invest in capital intensive renewable energy projects.

- Pakistan has a weak renewable energy structure. The environment has a poor structure. Pakistan is facing a serious lack of coordination between institutions. Pakistan Alternative Renewable Energy policy 2019 is facing a clash with IGECP made by NEPRA. Governing institutes of Pakistan are not coordinating with each other in efficient way. This problem can be resolved by making one central governing body to ensure the effective coordination between relevant major and sub energy institute [34].
- Currently Pakistan is planning to shift from feed in Tariff to competitive bidding. According to ARE policy 2019 by AEDB, all the new projects of mature technologies such solar and wind energy will be install under competitive bidding. But currently documents for competitive bidding are not prepared. So all the new projects are on hold until the preparation of competitive bidding documents [7]. There is no feed-in tariff scheme in place for mature technologies.
- Currently, in Pakistan conventional energy sources are given top priority, while renewable energy is not subject to any structural regulations. Every government that come in power have their own preferences, last few governments did not give preference to renewable energy recourse, their main focus was on thermal power plants.
- In comparison to solar energy and other renewable technologies, fossil fuels receive more subsidies.

4.4.5. Technological barriers

- One of the main technical barriers is unreliability of local renewable technology. Most of the renewable energy technology component have to be import from abroad.
- Domestic manufacturing is restricted, and there is not any single solar PV cell manufacturing facility at commercial level.
- Key parts and equipment of renewable energy projects are dependent on foreign technology, and they have to import from different countries.

- Sun maps that aren't authentic are used to verify the strength of solar radiation.
- Large solar energy installations rely on foreign labor to install and operate them.

4.4.6. Information and human resource barriers

- There is insufficient knowledge on energy efficiency to develop an effective policy for societal mobilization.
- Marketing and business management abilities are limited.
- There is a lack of understanding of latest solar technology, equipment, Vendors, and possible financiers.
- For the O&M of major solar projects, there are a lack of professionals and trained human resource is also limited.
- Problems in the collection of solar energy data and project development is inefficient. (There is a scarcity of solar energy data, therefore project development is inefficient.)

4.4.7. Social barriers

- Social acceptance and lack of participants are lacking. Traditional kinds of electricity continue to be used, posing a substantial obstacle for new solar energy projects.
- Few solar energy initiatives, such as the installation of solar rooftop geysers, have to face resistance from neighbors.
- Domestic clients have minimal practical knowledge of how to fix a problem on their own if one occur. Solar energy is underutilized, especially in rural areas.

Summary

Results drawn from this study has been described in this chapter. As there were 2 main objectives of the study: 1) identification of barriers and 2) Identification of socio-economic impacts. Interview questions were made by keeping in mind these 2 objectives with the help of literature review. Primary data was collected in 4 different stages. 1) in the first stage barriers in the net metering-based rooftop solar energy projects were found with the help of interviews from solar companies. For that purpose, 109 solar companies were contacted which were registered in V1 and V2 category of AEDB, and got response from 30 companies. Main barriers in net metering based solar energy projects were delays in net metering based solar energy projects, unavailability of energy meters, and bribery etc. In the second step barriers in the mega solar energy projects were find out with the help of interviews from industrial experts. The main barriers identified in the mega solar energy project were weak grid infrastructure, inconsistent policy and regulatory mechanism, no local production, no documentation for competitive bidding etc. In the third step socio economic impact of net metering based solar energy projects were find out with the help of interviews from prosumers. The prosumers show overall satisfaction with the net metering-based solar energy projects and considered it as a positive development. Out of 9 parameters, Learning conditions for children improved and time saving for doing domestic work increased are the two most important social impact of net metering based solar energy projects according to 85.7 % solar companies. In the 4th step, according to industrial experts, socio economic impacts of QASP cannot be find as QASP is injecting electricity directly into national grid. Socio economic impacts can only be found in a community if it is getting benefit form solar energy project. Similarly, in the case of economic benefits of net metering based solar energy projects 3 out of 6 indicators improved significantly which were 1) energy expenses decreased, 2) Small solar companies flourish due to installation of the

solar system at domestic level and jobs creation as a result of solar system installation at domestic level. Moreover, the indicator to which least participants agree was, the affordability of solar energy projects at the domestic level, 57.1 % of participants agreed that the solar system was affordable at the domestic level despite its high upfront cost.

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Chapter 5
Conclusions & Future Recommendations

Conclusions & Future Recommendations

- The core objective of the research work was to find the barriers and socio-economic impacts of solar energy projects in Pakistan including both mega projects and net metering-based rooftop solar energy projects. These barriers are limiting the growth of solar energy in Pakistan. As Pakistan have enormous solar energy potential, but despite that solar energy is not growing rapidly. And AEDB have target of increasing the proportion of RE, in Pakistan's energy mix by 30 % by 2030.
- Interviews from the solar companies for barriers in net metering based solar energy projects, mention that they are facing the problems of delays in the net metering application process at disco and NEPRA level, unavailability of energy meters, high fee for generation license, bribery, low staff at disco level, unavailability of online net metering application process, old regulations and high eligibility criteria of banks.
- Interviews from experts for barriers in mega projects show that there are problems of inconsistent regulatory and policy decision, weak grid infrastructure, lack of coordination mechanism between different institutes, prices of renewable energy are disadvantaged as compared to conventional power projects in Pakistan.
- On the other hand, survey from domestic clients using solar energy mention that there are many socio economic impacts of net metering based solar energy such as relaxation in time for productive and

domestic tasks increased, learning conditions for children improve, range of working time for household tasks increase, and recreational opportunities increase, energy expense decreased, small solar companies flourish due to solar system at domestic level and Jobs creation as a result of solar system installation at domestic level.

- Social economic impacts of mega solar energy projects cannot be find as they are injecting their energy into main grid, and their effects cannot be measured, more work need to be done in this field. Findings of the study will help policy makers to remove these barriers and make new short-term policies for rapid uptake of solar energy in Pakistan. Without remove these barriers, growth of solar energy cannot be increased.

Way Forward

- The time frame mentioned in NEPRA regulations for the whole process took almost 3-4 months. There should be a new time frame to complete the process in 40 – 60 days. If the compulsion of generation license is waved off, then the process of net metering will be complete in a month.
- In the pilot phase, the application procedure was made online in LESCO and IESCO, but currently online portal is closed. There should be online processing of net metering cases. All the net metering applications from consumers ought to go through the online portal. Timelines should be mentioned in the online portal, and it should be flagged which agency is taking more time. So, the issues of undue favors and bribery will be eliminated in an online system. Moreover, all the agencies must follow given timelines and if someone could not follow these timelines then they must give a reason.
- Solar vendors mentioned that NEPRA imposed a fee of 1000 Rs / kW for generation license since last year, while there was no generation license fee previously. There should be no necessity for a generating license for systems up to 25 kW when applying for net metering. Consumers should apply directly to the DISCO, and the DISCO ought

to process their application and connect them to the internet. Solar systems are capital intensive, and they require a huge upfront cost. Banks' qualifying conditions for providing solar loans under the State Bank of Pakistan's renewable finance plan are currently quite strict, excluding over 80% of Pakistan's population. As a result, the Pakistani government should make qualifying criteria simple and implement regulations that encourage the OPEX business model.

- Avoid power plant shutdowns owing to transmission issues, like China. Before implementing new megaprojects, Pakistan must enhance its transmission grid. To avoid grid availability and stability difficulties for renewable energy projects, private investment in transmission infrastructure should be encouraged. Pakistan should ensure regulatory and policy stability and dependability since this would boost investor confidence in the long run. To demonstrate a political commitment to renewable energy development, provincial governments should make an ambitious renewable energy policy that is consistent with their mandate and, to the extent practicable, with the federal government's policy.
- The Council of the Common interest is an appropriate platform for proactive coordination of renewable energy policy, planning, and development between the federal and provincial governments.
- Pakistan has to set goals for each year and make them technology-specific, such as meeting a specified solar and wind objective in the future years. Because policy implementation entails several tradeoffs, policymakers should perform thorough research to prevent losses.
- Pakistan should develop a mechanism in Competitive bidding that winning bid prices should not lower than the actual cost, otherwise it will reduced the growth of RE in Pakistan just like China. Careful design of auction scheme is very important and play a vital role in the success and performance of auction scheme.
- The renewable energy strategy of every country showed the country's unique demands and properties, such as the volume and quick expansion

of its energy market. So, any country cannot simply replicate the successful policy of another country. Because these policies are according to their local circumstance and blindly following them may not lead to the most effective results.

Appendix - A: Publications

Title: The comprehensive analysis of the solar energy projects landscape across Pakistan: Barriers, socioeconomic impacts and way forward

Muhammad Talha Rashid [a], Muhammad Hassan [a, *], Saira Kanwal [a]

Journal Name: Energy policy (Submitted)

Abstract

God has blessed Pakistan with tremendous potential of solar energy, despite that the share of solar energy in the energy mix is less than 2%. In the wake of slow growth of solar energy various policy and institutional arrangements have been made such as net metering regulations for solar energy projects having capacity less than 1 MW and cost-plus tariff for mega solar energy projects. Even with those arrangements in place share of solar energy was very low. Moreover, the socio-economic impacts of these solar projects have not been assessed, whether they were useful or not. Based on these insights, this paper investigates the barriers and socio-economic impacts of both domestic and mega solar energy projects to overcome these research gaps. Therefore, in this study primary data was collected from three key stakeholders: Prosumers; Solar companies and industrial experts. And secondary data was acquired from research papers, national and international reports and other published documents related to the solar energy barriers and their socio-economic impacts. The analysis indicated, at domestic level main barriers are delays in net metering application process, unavailability of energy meters, bribery and low staff at distribution company, while in mega projects are inconsistent regulatory policies, weak grid infrastructure and lack of coordination mechanism between different institutes. Solar energy has positive socio-economic impacts. The identification of these results is critical for developing policies in Pakistan for the rapid uptake of Solar energy.

Key words: Barriers, Socio-economic, Solar and way forward.

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