ENERGY AND CLIMATE
PANORAMA

In-depth Analysis of Previously Implemented National Solar Energy Policies *and* Recommendations to Support Solar PV Adoption

About Us

Who we are

We are a dedicated team of researchers and experts who recognize the urgent need for action in addressing climate resilience and energy transition in Pakistan. Our mission is to develop and implement effective policies for cleaner, renewable energy sources like solar and wind, aligning with Pakistan's 2030 goal of 30% renewable energy in its electricity mix. As a multidisciplinary team, we leverage expertise in three key disciplines of study—Energy Systems Engineering, Thermal Energy Engineering, and Electrical Power Engineering—to drive our mission forward. We are united by a shared vision of creating a sustainable and resilient future for Pakistan, where cleaner energy sources play a pivotal role in reducing the nation's vulnerability to climate-related challenges.

What we do

We conduct in-depth, evidence-based research to analyze and improve energy policies in Pakistan. Our focus is on advancing renewable energy solutions and engaging stakeholders to ensure effective policy implementation. Our methodology involves a critical examination of current energy policies to pinpoint areas of improvement and formulate strategies for the widespread adoption of renewable energy sources across various levels.

In line with our commitment to fostering sustainable practices, we have established a fellowship program as part of our broader initiatives that aims to facilitate evidence-based research for promoting energy transition in Pakistan. Through research studies, surveys, and forecasting, we plan to assess various aspects of energy transition, including the adoption of renewable energy technologies and their impact on climate change. Our approach involves active engagement with stakeholders to address their concerns and facilitate the effective implementation of policies, fostering the growth of renewable energy manufacturing and marketing facilities.

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1. Introduction

Pakistan has been facing severe energy-related challenges for decades, and it is seen as a critical juncture stopping the country's economic growth. With time, the energy demand has increased exponentially due to the growing population and industrialization; however, the current energy production cannot meet the growing needs. The energy produced through fossil fuels poses an environmental crisis and is worsening air quality, so energy produced through clean means is the most suitable option. Among Renewable energy technologies, the adoption of solar PV is the most viable option since it has already been deployed around the globe and is proven to be energy efficient and effective. Pakistan is in the hot belt and receives abundant solar resources, with an average solar radiation of 5.5 kWh/m^2/day (Adnan Sarwar, 2022). However, the country's solar PV adoption rate remains low, with just 1% of the energy being produced through renewable means out of the total energy mix (Muhammad Wakeel, 2016). Infrastructural investments are required in the sector to utilize this naturally existing source of energy.

In response to these challenges, the adoption of Renewable energy sources like solar, wind, and hybrid systems are emerging as sustainable solutions. Solar PV system technology offers a promising avenue to address Pakistan's burgeoning energy needs while considering environmental safety. Solar energy is explicitly a renewable energy source that has the potential to meet a significant portion of Pakistan's energy needs. Globally, the transition to solar energy has increased many folds, however, the transition momentum has not picked pace in Pakistan due to several reasons.

This report embarks on an in-depth analysis of Pakistan's already implemented energy generation policies viz-a-viz the renewable energy policies with a main focus on policies aimed at solar energy adoption. In addition to the analyses of the previous energy and renewable energy policies, this report also investigates and incorporates the input of important stakeholders namely consumers (domestic, industrial and commercial) and the vendors. Multiple analysis and evaluations shed light on the successes and impacts of all these policies. Building on the insights gained and through empirical data collected from households, commercial entities, and solar PV installation companies, the study mainly aims to provide valuable recommendations that can guide the formulation of future policies and initiatives, ultimately fostering the widespread adoption of solar PV technology in Pakistan.

1.1 Report Structure

The second chapter of the report sheds light on the energy environment in Pakistan, providing a comprehensive understanding of the relevant institutions operating in the energy sector, their roles, responsibilities, and interactions within the sector. This chapter also delves into the legal and regulatory framework that governs the energy sector. Moving forward, the third chapter discusses the historical evolution of energy policies in Pakistan, commencing with the Electricity Act of 1910 and culminating in the contemporary Electricity Policy of 2021. Building upon this

foundation, the fourth chapter explores Pakistan's Renewable Energy policies, with a primary focus on key policies such as the Alternate and Renewable Energy Policy of 2006,2019, and the Framework Guidelines to fast track the implementation of the Solar PV 2021.

Following a comprehensive review of these essential policies, with a specific emphasis on renewable energy, the report sets its sights on its central objective: the adoption of solar PV. Chapter five reviews existing literature to highlight the impediments hindering the widespread adoption of solar PV in Pakistan. These impediments encompass not only technical challenges but also social and cultural factors, all of which have been expertly documented in the field.

Chapter six sheds light on the meticulously crafted methodology and research procedures employed by our researchers. This includes a detailed discussion on sampling size, sampling techniques, and the tools developed to investigate the topic, through the targeted populations. Moving forward to chapter seven, the results and analysis are presented, drawing from the data collected during the research process.

Lastly, in chapter eight, we consolidate our findings and recommendations, synthesizing insights from the literature review and survey results to propose policies and interventions that can enhance the adoption of solar PV in Pakistan. This chapter serves as the culmination of our research, offering actionable insights for policymakers, stakeholders, and industry players in the pursuit of sustainable energy solutions for Pakistan.

2. Evolution of Institutional Landscape in Renewable Energy

2.1 Pakistan's Energy Sector Institutions

The organogram below explains the interrelation of agencies working in the power sector of Pakistan with a detailed explanation of the functioning of the departments given below. Pakistan's power sector is a critical component of the nation's energy needs as it is responsible for ensuring the generation, transmission, and distribution of electricity to meet the growing energy demands of its population and industries. The sector is characterized by a complex network of organizations and entities, each playing a vital role in maintaining a steady supply of electricity across the country. Listed below are all the relevant power sector organizations and their functions.

2.1.1 Ministry of Energy (Power Division)

The Ministry of Energy (Power Division) is a separate entity under the Ministry of Energy, having previously been a branch of the Ministry of Water Resources. Along with the Petroleum Division, the Energy Division investigates matters regarding energy on behalf of the GOP. The power division of the Ministry of Energy deals with matters of electricity, such as generation, transmission, distribution, and policy-related matters on the mentioned three functions. There are 22 public sector companies and 02 statutory bodies working under the power division. power finance, power policies, and administrative and operational matters are being dealt with by the Power division through its various departments such as Power Finance, Entities and DISCOs, Transmission, Tariff & Subsidy, and development wing.

The Ministry of Energy's Power Division has been working on comprehensive strategies to meet the nation's energy demands. In addition

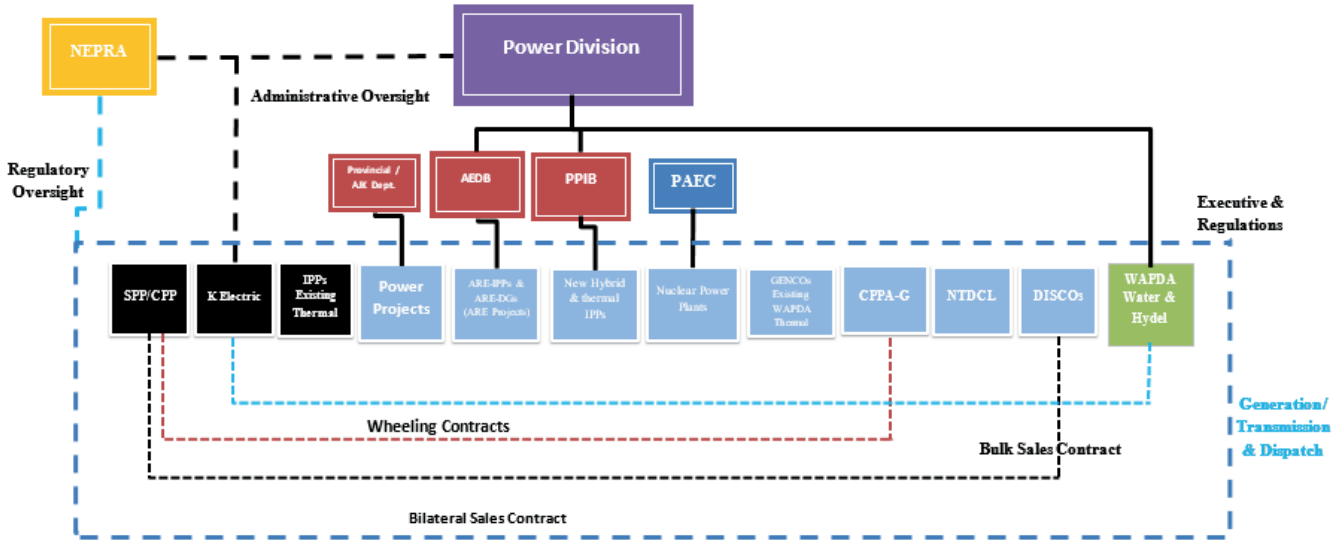

Figure 1: Pakistan's Energy Sector Organizations (GOP, 2019)

to utilizing the domestic hydel-generating resources, an emphasis is being placed on alternative/renewable energy to increase the output of electricity and make Pakistan an energy-sufficient nation. This plan would put Pakistan on a path toward fast social and economic development. Giving Pakistan's inhabitants the much-needed respite they require, will simultaneously solve the major issues facing the electricity industry.

2.1.2 Ministry of Water Resources

The Federal Ministry of Water Resources is the GOP's executive body for all issues relating to electricity generation, transmission and distribution, pricing, regulation, and consumption in the country, and exercises functions through its various line agencies and relevant autonomous bodies. It also coordinates and plans the nation's power sector, and formulates policy and specific incentives with provincial governments on all related issues.

2.1.3 National Electric Power Regulatory Authority (NEPRA)

It is a regulatory body established under the Regulation of Generation, Transmission and Distribution of Electric Power Act 1997, also called the NEPRA Act. Its primary function is to regulate the provision of electric power services in the country. NEPRA's objective is to operate with transparent and fair economic regulation based on sound commercial principles in the power sector. It plays a crucial role in formulating the national electricity plan, ensuring efficient tariff structures, market design, and liquidity in power markets. NEPRA grants licenses, establishes investment and performance standards, specifies accounting standards, and settles issues of licenses and guidelines. Additionally, NEPRA determines tariffs, rates, charges, and terms for the supply of electric power services by generation, transmission, and distribution companies. It encourages industry standards and codes of conduct, provides advice to public sector projects, submits reports to the federal government, and performs other functions necessary to regulate the power sector in Pakistan effectively (GoP, National Electric Power Regulatory Authority, 2023).

Along with all the responsibilities that NEPRA is performing in the energy sector, the GOP has given the licensing authority to NEPRA. Currently, NEPRA is issuing eight types of licenses, which include transmission license, special purpose transmission license, distribution license, market operator trade license, Electric power supply license, Electric power trade license, system operator license assignment of license prohibited, which means that the license cannot be surrendered, transferred, or assigned to the other party/person without the NEPRA's approval and audit. (GoP, National Electric Power Regulatory Authority, 2023)

Another vital duty performed by NEPRA is tariff determination. NEPRA assesses, modifies, establishes rates, and changes the terms and conditions of electric power services as guided by the policies and plans of the government. NEPRA closely examines factors such as government objectives, economic efficiency, and consumer protection. NEPRA also establishes procedures, time frames, and customer participation opportunities for tariff determination. The

The Federal Government notifies approved tariffs, and NEPRA can adjust based on specific factors, with provisions for reconsideration and appeals. NEPRA's role is to strike a balance among these guidelines to optimize benefits for all stakeholders.

2.1.4 National Transmission and Dispatch Company (NTDC)

NTDC is responsible for transmitting electricity from generation companies to distribution companies in Pakistan. NTDC strives to provide reliable, efficient, and stable transmission network and dispatch services by adopting viable practices that ensure maximum utilization of resources to improve the transmission services requirements of generators and recipients. NTDC has worked on some notable solar projects such as the 100 MW Quaid-e-Azam Solar Park Limited (QASPL) in Bahawalpuri, the 50 MW Shams Solar Power Plant in Bahawalpur, and the 10 MW solar power plant in Khanewal. These solar projects have contributed significantly to Pakistan's efforts to increase the share of renewable energy in the country's energy mix and reduce dependence on fossil fuels. (GoP, National Transmission and Dispatch Company Limited, 2023)

2.1.5 Pakistan Electric Power Company (PEPCO)

The Pakistan Electric Power Company (PEPCO) was established in 1998 as a holding company to oversee the operations of the Distribution Companies (DISCOs), Generation Companies (GENCOs), and National Transmission and Dispatch Company (NTDC). The formation of PEPCO was part of the Strategic Plan for Privatization of Power Wing of WAPDA, which was approved by the Council of Common Interest (CCI) in 1993. This plan aimed to improve efficiency and attract investment in the power sector by unbundling and corporatizing the power wing of WAPDA. Before the establishment of PEPCO, the functions of overseeing these companies were performed by WAPDA.PEPCO is responsible for the distribution of electricity to end-users in Pakistan. (GoP, PEPCO Pakistan, 2023)

2.1.6 Independent Power Producers (IPPs)

Independent power producers are privately owned entities that operate independently under the guiding principles of national entities and are licensed through NEPRA. They generate electricity and sell it to the central government.

2.1.7 Alternative Energy Development Board (AEDB)

The Alternative Energy Development Board (AEDB) is responsible for developing national strategies, policies, and plans to achieve the Federal Government's alternative and renewable energy resources targets. AEBD is a forum monitoring, evaluating, and certifying Alternate and renewable energy projects. AEBD works on projects from various sources such as wind, solar, small-hydel, biogas, and biomass. AEDB has a two-way working method; it works on power pilot projects independently and in collaboration with public or private entities. AEDB also conducts feasibility studies and surveys to identify the previously untapped opportunities for power generation through alternative and renewable energy resources. It also provides financial, technical, and economic evaluations of proposals and cooperates in filling out required licensing applications and tariff

petitions to the National Electric Power Regulatory Authority (NEPRA). AEDB works with national and international agencies to develop alternate energy in Pakistan and execution of plans for off-grid electrification with the provincial governments and other concerned authorities.

2.1.8 Private Power and Infrastructure Board (PPIB)

The Government of Pakistan has established the Private Electricity and Infrastructure Board (PPIB), a statutory body to encourage private investment in the electricity industry. One of its duties is acting as a one-stop shop for private power companies. Other duties include recommending and facilitating the development of power policies, coordinating with provincial governments and regulatory bodies, executing and overseeing contracts, and hiring technical advisers and consultants. In some parts of Pakistan, the PPIB also serves as an agency for the creation, facilitation, and execution of electricity policy and related infrastructure. The organization has the authority to carry out any task or use any power that may arise from performing its duties, or the federal government may delegate that to fulfil the Act's objectives (GoP, Private Power Infrastructure Board, 2023).

2.2 Legal and Regulatory Framework

The Ministry of Energy (Power Division) is an executive branch of the GOP in implementing Federal Government policies in the power sector. It works with relevant provincial governments and their agencies to achieve policy objectives. The National Electric Power Regulatory Authority (NEPRA), which was formed under the Regulation of Generation, Transmission, and Distribution of Electric Power Act, 1997 (known as the "NEPRA Act"), is the Pinnacle regulatory body, which is mandated to act as a self-governing regulator to provide electric power services in Pakistan. Karachi Electric (K-Electric), the ten public sector distribution companies (DISCOs), and Bahria Town (BTPL) provide electricity distribution services to multiple consumers nationwide under the licenses granted by NEPRA. The National Transmission and Dispatch Company Limited (NTDCL) is the sole public-sector transmission system operator licensed by NEPRA, its purpose is to transmit power which is purchased through the Central Power Procurement Agency Guarantee Limited (CPPA-G) or from three other sources which are legislative regimes authorized by the GOP, Thermal generation companies (GENCO's) owned by the government, Independent Power Producers (IPP's) and Water and Power Development Authority (WAPDA-Hydel Wing). (GOP, 2019)

NTDCL has several other functions; it acts as a system operator and is responsible for safe, secure, and reliable operations. It also ensures control and dispatch of generation facilities, and it is also a Transmission Network operator for the maintenance, planning, operation design, and expansion of the national transmission network.

The Private Power and Infrastructure Board (PPIB) serves as a unified facilitator for conventional projects in the private sector for power generation, including hydel projects. The Alternative Energy Development Board (AEDB) closely collaborates with PPIB to

ensure consistency with the current policies and their effective implementation.

The respective Provincial Governments of Punjab, Sindh, Khyber-Pakhtunkhwa and Balochistan actively support the development and execution of alternative renewable energy (ARE) projects within their territories. Similarly, the Gilgit-Baltistan (GB) region and the State of Azad Jammu and Kashmir (AJK) foster the progress of ARE projects through local departments. Furthermore, the AEDB's Board ensures provincial representation, contributing to the smooth implementation of ARE projects.

(ARE-IPP's) Alternative /renewable Energy based independent power producers are the power generation companies formed for the sale of power under agreements with NTDC/CPPA-G/DISCOS. (ARE DGs) are the Alternative Renewable Energy Generators that power for the purpose of self-use and bulk sales to customers or under bilateral contracts.

3. Review of Energy Policies of Pakistan

3.1 Previously Implemented Energy Policies of Pakistan

Pakistan's power sector is a critical component of the country's energy generation. It is responsible for ensuring electricity generation, transmission, and distribution to meet the growing energy demands of its population and industries. The sector is characterized by a complex network of organizations and entities, each playing a vital role in maintaining a steady electricity supply across the country. Listed below is the list of relevant energy sector organizations.

3.1.1 Electricity Act of 1910

After independence, Pakistan continued to follow the provisions of the Electricity Act of 1910, which was enacted by the British government during the colonial era. This Legislation worked as a guide for matters regarding electricity generation, transmission, distribution, and usage nationwide. This act continued to be the framework for the energy sector until Pakistan started facing frequent and growing energy crises in the form of recurrent power outages, severe electricity supply shortages, and consequently inefficiency in the power sector. Similar to the British era, the government was the sole provider of electricity, and the power sector was heavily subsidized with no private sector participation. (Electricity Act, 1910)

3.1.2 Power Policy of 1994

To respond to the growing energy crisis, the Power Policy of Pakistan 1994 was formulated to grant incentives to the private sector for

power generation. The policy highlighted that the electricity demand is increasing by 8% annually, and to respond to this demand, Pakistan needed to increase its minimum annual additional capacity by 900MW in the year 1994, 1300MW in the year 2000, and 5000 MW by the end of the year 2018 While encouraging the private sector to join hands with the GOP for the generation of electricity, the government listed the choices of fuel that the private partners can opt for as the method of energy generation. Investors were given the freedom to select the site of the plants, technology or method of energy generation, and the choice of fuel, including residual furnace oil, diesel oil, natural gas, LPG, etc. In the choices of technology, the government did not restrict the private sector to a single kind rather, it openly encouraged to opt for conventional or nonconventional methods such as generating energy from renewable sources, namely solar, wind, and geothermal, whichever may deem suitable for the investors. The produced power by the private companies was purchased by WAPDA. The Government of Pakistan (GoP) mentioned several financial incentives in the policy to stimulate investment in the electricity sector. One such incentive was a corporate income tax exemption for private enterprises investing in the area. Incentives for importing plant equipment included exemptions from customs tariffs, sales taxes, and import licensing fees.

Foreign companies were also encouraged to establish operations in Pakistan, and they were given the option to obtain foreign exchange risk insurance (FERI) on standard terms from the State Bank of Pakistan for foreign currency loans. This option was given to provide a shield and reduce the risk of foreign currency fluctuations, thereby making it easier for foreign companies to invest in the country.

Overall, these financial incentives aimed to draw local and international investment into the power industry, which was crucial for supplying the nation's rising energy needs. The GOP sought to establish a welcoming investment environment that would encourage growth and development in the industry, eventually helping the economy by offering tax breaks and other advantages. The anticipated significant increase in electricity generation capacity was expected to respond to the increased supply however, expansion in the infrastructure of the transmission network was required to cater to the increased energy generation. (GoP, Policy Framework and Packages of Incentives for Private Sector Power Generation Projects in Pakistan, 1994)

3.1.3 Transmission Line Policy 1995

To respond to the growing energy crisis, the Power Policy of Pakistan 1994 was formulated to grant incentives to the private sector for Recognizing the positive response from the private sector towards investment in power generation, the GOP has decided to invest in the construction of extra high voltage (EVH) power transmission lines and substations to support this expansion. For this purpose, the GOP made a policy framework and packages of incentives for private-sector transmission line projects in Pakistan in the form of the Transmission Line Policy 1995. The installation of transmission lines was initiated based on tenders resulting from bids. Private partners

joining hands with the government were given attractive financial incentives to encourage their participation. Private sector investors were provided with tax incentives, including exemptions on customs duties and sales taxes, to encourage investment in transmission infrastructure. Private sector investors were allowed to charge a wheeling fee for the use of their transmission infrastructure from the distribution company WAPDA. This fee was based on the cost of providing transmission service under the long-term contract covering the life of EHV assembly for 30 years. The transmission companies were insulated from the possibility of the discontinuity of electricity and any maintenance-related shutdowns but were paid based on service charges covering the capital and maintenance cost and return on equity furthermore, private sector investors were provided with tax incentives, including tax exemptions on customs duties and sales taxes, to encourage investment in transmission infrastructure. As a result of all these collaborations between the public and private sector 1300 MW of electricity was added to meet the growing demand. (GoP, Policy Framework and Packages of Incentives For Private Sector Transmission Line Projects In Pakistan, 1995)

3.1.4 Hydro Power Policy 1995

In addition to the transmission line policy, the government of Pakistan introduced a Hydro Power Generation Policy 1995 in parallel as the hydropower potential was not utilized as compared to its availability, and the large discharges were forgone because of precipitation and the snow melt was being deposited to the Indus River basin. The hydroelectric power policy highlighted the requirements of the feasibility study before setting up a plant at a site which included the analysis of optimum capacity, layout, etc. The feasibility studies carried out in the public sector by various agencies were made available to the private sector investors to materialize them into power-generating plants. The installed capacity of the powerhouses was determined to be 50% minimum plant factor with a minimum of 40% of the annual energy required in low water months of January to July. For the financial returns, the lenders and the investors of the projects will have to earn it from the revenues earned by the sale of electricity for their return on equity and the servicing of their loans. A Private Sector Energy Development Fund (PSEDF) was established with the assistance of the multi-lateral lending agencies, which could provide up to 30% of the capital costs of the project, with a variable interest rate and a maturity period of up to 23 years including a grace period of up to 8 years. (GoP, Policy Framework and Packages of Incentives for Private Sector Hydel Power Generation in Pakistan, 1995)

3.1.5 Power Policy of 1998

The Power Policy of 1998 was a transformation policy by the GOP in the energy sector and a discontinuity to the previous trends in the energy sector. In the form of the policy of 1998, the government brought three significant changes in the overall environment of the energy sector: firstly, the changes in the power system, which called for privatization. Secondly. the government restructured the existing department of WAPDA and formed a regulatory body termed NEPRA under the NEPRA Act 1997 along with the formation of IPP. Lastly, the government formed a competitive bidding

process for the IPPs.

The Privatization phase involved privatizing the existing thermal power generation plants and privatizing transmission and distribution functions and assets of the existing public sector utilities. By creating a fully autonomous regulatory authority, the National Electric Power Regulatory Authority (NEPRA) these independent power producers working privately were regulated. These steps were taken to make the energy sector market-driven and competitive. (GoP, Policy for New Private Independent Power Projects, 1998)

3.1.6 Power Policy of 2002

The power policy of 2002 was formulated with several objectives in mind. First, it aimed to ensure an adequate capacity for power generation at the lowest possible cost while avoiding any capacity shortfalls. The policy recognized the importance of meeting the growing power demand and emphasized the need to promptly start work on new power projects, particularly those based on indigenous resources such as hydel, coal, and gas.

Second, the policy focused on exploiting domestically available renewable resources such as solar, wind, etc. It encouraged the participation of local engineering and manufacturing capabilities in the power sector, promoting indigenization and reducing dependence on imported equipment. The policy aimed to enhance energy security and contribute to the country's economic growth by harnessing indigenous resources and expertise.

Third, the policy emphasized the welfare of all stakeholders involved in the power sector. It sought to create a win-win situation where the interests of power providers and consumers were considered. Additionally, the policy highlighted the importance of safeguarding the environment and promoting sustainable practices. By encouraging the use of renewable energy sources and adopting environmentally friendly approaches, the policy aimed to minimize the environmental impact of power generation activities.

Overall, the power policy 2002 aimed to address the challenges faced by the power sector in the country. It focused on ensuring sufficient power generation capacity, exploiting domestic resources, promoting stakeholder welfare, and safeguarding the environment. The policy set the stage for transforming the power sector into a privatized and competitive industry while promoting sustainable development in line with the country's energy needs.

In current scenario, there emerges a need to comprehensively review the existing solar PV policies, current status of Solar PV Module Manufacturing in Pakistan, identifying technological, financial, policy & regulatory barriers to indigenous manufacturing, evaluating skill and capacity constraints and hence proposing policy measures for overcoming these identified barriers and constraints.

Organizations such as NEPRA, the Private Power and Infrastructure Board (PPIB), and the Provincial and AJK Private Power Cells (PPCs) played a vital role in the growth of private energy production houses. NEPRA is an independent regulatory body in charge of

authorizing rates for private power projects and advising the PPIB or PPCs on the highest pricing allowable. For sponsors of private power projects, the PPIB operated as a one-stop shop, assisting with coordination with governmental organizations, writing the Implementation Agreement, issuing the Letter of Support, and keeping track of project development. The Provincial and AJK PPCs support provincial discussions on the Water Use License/Agreement by releasing pre-qualification materials, assessing bids, and aiding sponsors in liaising with provincial government agencies. These divisions were responsible for fostering a competitive and effective power industry while defending the interests of investors and energy users. These reforms were essential for a competitive energy sector and aided in the competitive bidding process for private-sector investors. (GoP, Policy for Power Generation Projects, 2002)

3.1.7 National Power Policy 2013

The Ministry of Water and Power launched the power policy of 2013 to eradicate the energy crisis faced by the country with a vision to develop consumer-centric power generation, which is efficient in transmission and distribution. When this was made active, Pakistan was facing a severe supply and demand gap where the gap was calculated to be 4,500-5,500 MW. This gap increased from the previous five years and reached a level where 12 to 16 hours of lead shedding was observed nationwide. Due to these increased gaps, the government shifted to thermal fuel energy sources for fuel generation (44% of the total generation) ultimately inflating the electricity price per unit to Rs 12 per unit for mixed sources, Rs 17 per unit for RFO unit and Rs 23 per unit for HSD sources HSD and thermal energy sources are all thermal energy sources. The transmission system recorded losses of 23 – 25 % of electricity due to poor infrastructure, theft of electricity, and mismanagement at the departmental end. The cost of delivering the electricity calculated by NEPRA and the Ministry of Water and Power is way above the actual costs, which is Rs 2.70 additional per unit due to collection losses and the real losses of the distribution companies. Theft alone costs 140 billion annually in taxpayer money.

To overcome the energy challenges the policy highlights five target areas that will need to be accounted for to have sound developments in the energy sector. The first target was to eliminate the supply and demand gap from 4500-5000 MW to zero by 2017. Alongside eliminating the supply and demand gap, increasing financial viability, affordability, and efficiency were also prioritized. Lastly, removing governance issues was also made a priority.

To achieve the goals, the policy aimed to attract local and foreign investment, and to attract investment, it was essential to minimize the subsidy level within the industry at commercial and bulk consumer levels, so the subsidies from the power sector were removed except for those which were for people with low incomes. For power generation projects up-front or feed-in tariffs were given preference to set the upper ceiling.

The policy decided to launch a rehabilitation project at Jamshoro, Muzaffargarh, and

Guddu collectively, which was to yield 700 MW, and the expansion of the Guddu project was to add 747 MW. Other projects that were to reach financial closure in 2013 are listed below.

Table 1: Fossil Fuel Energy Projects

Project	Capacity
FFC Energy Limited	50MW
Zorlu Jhimpir project	56 MW
Foundation Energy I	50MW
China Three Gorges	50 MW
Foundation Wind Energy II	50 MW

Collectively, 256 MW was added to the national grid with the help of these projects in 2013, with an additional 100 MW through Sapphire and Metro projects. Other energy projects in line expected to be completed by 2017 were wind electricity projects with a capacity of 341 MW, Solar Energy Projects with a capacity of 341 MW, and 1,243 MW through Hydropower projects. Additional 969 MW and 1,410 MW of electricity were to be added by the Neelum-Jhelum HPP Project and the fourth expansion of Tarbela.

To enhance electricity supply, the government aimed to increase competition and involve the private sector in the energy market with innovative projects supported by wheeling charges. Under this policy, an energy conservation bill for 2016 was passed to improve efficiency and develop labelling standards. Imports of inefficient electronics were banned, and local industry was given a grace period of three years to bring the product production to the desired levels. Green energy building code was also established and implemented across the country. Other reforms included imposing time restrictions on commercial activities and discouraging electricity utilization in peak hours. Solar and alternative solutions were encouraged for end users, street lighting and billboards. An energy conservation program with the potential of 1000 MW was also launched, which introduced the use of fluorescent bulbs to 50 million users.

To increase the affordability of energy the policy focused on shifting low-cost energy mix sources to produce electricity such as biomass, nuclear, hydel, gas, and coal. (GoP, National Power Policy, 2013)

3.1.8 Power Generation Policy of 2015

The Government of Pakistan launched the power generation policy of 2015 launched the power generation policy of 2015 with the mission to explore and capitalize on indigenous energy resources such as coal and hydropower in the form of public and private sector investments. The hydropower projects covered in the policy included raw site hydropower projects and run-of-river hydropower projects, and for the thermal projects, the policy suggested a diversification in the fuel mix, either indigenous or imported. Alongside the energy generation plan, the government launched a transmission line policy in 2015 for Alternate Current, Direct Current, and Extra High Voltage Power Stations, Substations, and converter Stations. (GoP, Policy Framework for Private Sector Transmission Line Projects, 2015)

3.1.9 Transmission Line Policy of 2015

The government of Pakistan launched its transmission line policy in 2015 to engage the private sector for investment in EHV AC, DC

transmission lines, substations, and converter stations. The transmission line projects were granted to the public sector companies based on bidding. These transmission line projects were handed over to the private companies on a Built-Own-Operate and Transfer basis (BOOT) based on Overhead Transmission Lines (OHL) and Grid Stations (GS) or Convertor Stations (CS). The maturity of these projects was 25 years, after which they had to be handed over to NTDCL. The Transmission Service Charges (TSC) were used as a tool to recover all operational and maintenance costs, return on equity and debt servicing throughout TSA of the projects. (GoP, Policy Framework for Private Sector, Transmission Line Projects, 2015)

3.2 Current Energy Policy of Pakistan

The policy which is currently implemented is the National Electricity Policy of 2021.

3.2.1 National Electricity Policy 2021

The National Electricity Policy designated nine critical areas within the electricity sector to achieve sustainable development and realize its goal. In the generation sector, there was a focus on adopting an integrated and sustainable approach to energy supply and ensuring there was enough capacity to satisfy peak demand. Generation was to be based on the lowest cost except for government-funded critical projects. The variety of energy sources would shift away from foreign fuel imports to domestic resources like coal, hydro, renewables, gas, and nuclear.

To fully utilize the location's potential, hydropower projects were to be run-of-river installations predominantly. Cross-sectoral decisions considering economics, tariffs, and sector demand were to be used to determine how much more nuclear capacity would be added. The directive strongly emphasized a sustainable market for renewable energy that is sustainable and expands on the principles of least cost and priority areas for renewable resources. Based on the lowest cost and competitiveness, the use of local coal and gas resources for power generation was encouraged. Efforts were undertaken to build a strong transmission network to ensure smooth electricity distribution, prevent congestion, and prevent blackouts. The National Grid Company (NGC) and provincial governments coordinated transmission projects.

The distribution segment was essential for maintaining financial viability, thus improvements in operational effectiveness and prompt recovery were made. For state-owned distribution firms, strategic roadmaps were created focusing on corporate governance, technical prowess, security, and financial success.

The strategy strongly emphasized effective system operations, which allowed for safe, dependable, and cost-effective power dispatch. Options for restructuring and privatization were investigated to improve the effectiveness of state-owned organizations. In order to efficiently control the demand for and supply of electricity, energy efficiency and conservation techniques were advocated. The National Energy Efficiency and Conservation Authority (NEECA) established efficiency requirements that entities had to abide by.

Ministry of Energy (Power Division), Power Division regularly receives updates on the status of the policy's implementation. (GoP, National Electricity Policy of 2021).

4 Review of Renewable Energy Policies of Pakistan

4.1 Previously Implemented Renewable Energy Policy of Pakistan

After the realization that Pakistan needed to explore and invest in renewable energy sources, the first renewable energy policy was launched in 2006. This policy was the first policy of the renewable sector, which

Table 2: Energy Policies of Pakistan

Year	Policy	Objective
1994	Policy framework and packages of incentives for private sector power generation projects in Pakistan	To increase installed capacity and mobilize resources on a massive scale to develop the infrastructure in the power industry
1995	Policy framework and packages of incentives for private sector transmission projects in Pakistan	To encourage private investment in EHV Transmission lines and substations
1995	Policy framework and package of Incentives for the private sector Hydel Power Generation Projects in Pakistan	To encourage proposals for power generation based on indigenous resources namely its hydel resources.
1998	Policy for New Private Independent Projects	To establish a privatized, competitive electricity industry
2002	Policy for Power Generation Projects	To increase power generation at least cost and increase local participation in manufacturing and engineering
2013	National Power Policy of 2013	To develop a customer-centric power generation, transmission, and distribution system
2015	Power Policy	To increase power generation at the least cost and explore indigenous resources for power generation
2015	Policy Framework for Private Sector Transmission Line Projects	Transmission Line Project offered to Private Sector on BOOT basis
2021	National Electricity Policy of 2012	To ensure access to electricity through self-sustainable power sector, competitive market, and friendly outcome for customers

proposed a long-term plan to develop the infrastructure in renewable sources, with set milestones to be achieved at a specific time. After the 2006 policy, the renewable policy of 2019 was brought into action.

4.1.1 Alternate and Renewable Energy Policy of 2006

The Ministry of Water and Power proposed its first renewable energy policy in 2006, aiming to prioritize and explore Pakistan's viable renewable energy options. The policy pinpointed all the energy options that were indigenous to the land and are found in abundance. However, the renewable energy sector happened to be untapped despite its abundant benefits to the environment and viability to meet the growing demand for electricity on both household and industry levels the infrastructural developments required hefty investments. In the form of the renewable energy policy 2006, the government put forward its objective of harnessing power from renewable resources. The policy mentioned resources to attract investments in electricity generation projects utilizing hydro (up to 50 MW capacity), wind, and solar power (of all capacities). The policy also highlighted all the prominent stakeholders who were to partner with the government in supporting the energy sector through facilitation and assistance to electricity-production such as licensing of the companies and providing transmission permits The policy provided the available energy resources in Pakistan along with the potential and existing status of their usage in the table below:

Table 3: Pakistan's Renewable Energy Capacity

Resources	Potential	Status
Hydro	The total hydroelectric potential in the country has not been fully investigated but is conservatively estimated to be 45,000 MW. This consists of all sizes of hydropower plants, including storage-based and high-head schemes on mountainous streams in the north and low-head, run-of-the-river plants on rivers and canals in the southern plains.	Pakistan has an installed. hydroelectric capacity of 5,928 MW of large (>250 MW), 437 MW of medium (>50 MW and <250 MW), and 253 MW of small to micro (<50 MW) plants, mainly in the northern parts of the country. This amounts to 6,608 MW in total capacity or less than 15% of the identified potential.
Wind	Commercially exploitable wind resources exist in many parts, especially in southern Sindh and coastal Baluchistan, with monthly average wind speeds exceeding 7-8 m/s at some sites along the Keti Bandar-Gharo corridor	No commercial wind farms in operation. Some micro-wind turbines pilot tested for community use.
Solar Photo Voltic (PV) and Thermal.	Much of Pakistan, especially Baluchistan, Sindh, and southern Punjab receives. abundant solar irradiation on the order of over 2 MWh/m2 and 3,000 hours of sunshine a year, which is at the highest. end of global insolation averages	Negligible use in niche applications. No significant marketing of rooftop PV or household and commercial thermal systems.
Biomass: Bagasse, rice husk, straw, dung, municipal solid waste, etc.	Pakistan's large agricultural and livestock sector produces. Copious amounts of biomass in the form of crop residues and animal waste, such as bagasse, rice husk, and dung, much of which is currently. collected and used outside the commercial economy as unprocessed fuel for cooking and household heating. In addition, municipal solid waste produced by a large urban population is presently open dumped, which could instead be disposed of in proper landfills or incinerated to produce usable methane gas or electricity.	Sugar mills in the country use bagasse for cogeneration purposes and have recently been allowed to sell surplus. power to the grid up to a combined limit of 700 MW. No other significant commercial biomass-based technology is presently employed for energy production/use in the country. beyond experimental deployment of biogas digesters, improved. cookstoves, and other small-scale end-use applications. The use of biogas digesters in rural households, after a promising start, has stagnated due to the withdrawal of external subsidies.

The strategic objectives identified in the policy were:

1. Energy Security
2. Economic Benefits
3. Social Equity
4. Environmental Protection

The policy set forward several goals to develop renewable energy infrastructure in Pakistan. Among these, the renewable energy policy aimed to boost the deployment of renewable energy technology (RET's) so that the renewable energy-derived energy supply mix reaches a minimum of 9,700 MW by 2030. Further, it aimed to address the increasing electricity demand, guaranteeing that the public will have access to electricity and that the increased production will meet the rising national demand for power. The policy also emphasized increasing competition in the market for renewable energy, attracting private sector participation, and building an atmosphere that was conducive to investment. The program also emphasized the integration of renewable energy solutions with social infrastructure, including education, healthcare, water supply, sanitation, roads, and telecommunications, to increase social welfare and economic prosperity in undeveloped regions. Building capacity and establishing a domestic renewable energy manufacturing base were additional goals to lower costs, create employment opportunities, and enhance local technical skills. The scope of the policy particularly targeted three energy sources, namely hydro, solar and wind, with the set goal to install small hydro plants of 50 MW or less capacity and establish infrastructure for Solar photovoltaic (PV) and thermal energy and Wind power generation. The renewable energy policy is divided into three phases, each dependent on the completion of the other for its initiation.

- **Short term phase**

During this phase, the emphasis would be on RE choices that are economically viable right away, i.e., where commercially established technologies and resources are readily available, such as small hydro, wind, solar, and biomass-based power generation. This phase offered liberal risk coverage and attractive power purchase tariffs, allowing the private sector the option to expand its energy generation capacity with RE projects. During this time, advancements in developing an appropriate regulatory framework, market and resource assessment, rural energy program design, pilot testing of distributed generation systems, capacity building, and the development of RE financing and market facilitation measures were taken. The short-term policy was time-barred with achieving its financial closure on 30 June 2008.

- **Medium-term Phase**

The medium-term phase incorporated experiences and knowledge from the short-term phase. A comprehensive policy framework for the methodical adoption of RE technologies and scaling up capacity deployment was developed. The framework placed greater emphasis on competition within a RET application category (e.g., grid-connected wind farms) and programmatic development of the dispersed RE power generation market (e.g., solar home systems). It included more competitive terms, reduced subsidies, and risk cover in comparison to the very liberal incentives and guarantees being offered for the short term. The medium-term phase achieved its financial closure on 30th

June 2012.

- **Long-term phase**

In the final long-term Phase, renewable energy will be fully utilized in all its forms and integrated into the nation's energy planning process. Renewable energy producers will have to compete with the market first within the alternative sources market and gradually with the conventional sources as well based on full price. In the third phase, RE IPPs will thus ultimately operate under 'mandatory wholesale wheeling', with utilities free to choose between all available supply options competing against each other on an equal footing (i.e., without discriminatory biases, hidden subsidies, and discounted externalities) and with energy prices reflective of actual technology costs and benefits. RE used at the rural and urban household level will become widespread, served by an established local manufacturing and service base.

4.1.2 Incentives given to Investors under the renewable energy policy of 2006

The government divided renewable energy projects into two broad categories based on certain assumptions; for example, public sector projects focused on remote areas that are economically unviable, such as Sindh, Baluchistan, KPK, FATA, AJK, and the Northern Areas. These projects come under the public category and were financed through public funding and the funding of donors, NGOs, or communities and groups. On the other hand, the private sector was encouraged to install projects that yield profits and are commercially viable. Lucrative incentives are offered to attract private sector participation in renewable energy projects. The private sector was given many incentives to contribute to power generation in the form of Independent Power Projects (IPPs.) These IPPs come under two categories, the first being solicited projects which are requested by the government and the other category is the unsolicited, these projects were proposed by the private sector.

- **Grid connection and take off voltage**

It was mandated that electricity distribution utilities must purchase all the electricity offered by renewable energy projects, adhering to the following provisions. The electricity pricing was based on different voltage levels and their proximity to the transmission lines and distribution feeders. In situations where a power producer needs a new transmission line for a connection with the main electricity grid, power purchase tariffs were adjusted according to the chosen voltage options and the costs associated with the transmission lines.

- **Wheeling**

The GoP gave the (RE-IPPs) to enter into a bilateral sales contract with their clients. Under this arrangement, the IPPs can sell either all or part of the power generated directly to their clients. For such direct sales, the IPPs must pay wheeling charges for utilizing the transmission line and the distribution grid network to transmit electricity directly to the clients. These wheeling charges were determined by NEPRA and were to cover the cost of providing and maintaining the transmission interconnection, including the energy losses incurred.

- **Risk Coverage and Production Incentive**

Grid-connected RE IPPs producing electricity

through wind power projects and small hydropower projects had their variability risk covered by the power purchaser with the underlying principle of the benchmark electricity production level based on mean availability of wind or water flow along with the project location independently monitored data will be utilized in this regard. IPPs able to generate electricity above the benchmark level will be given bonus payments.

- **Carbon Credits**

All RE IPPs (preferably wind and small hydro) financed under the clean development mechanism (CDM) were registered to claim certified emission reduction credits (CER). This offset the additional costs incurred by RE power purchasers; any obtained credits were used to partially alleviate the burden and improve the economic competitiveness of RE-based grid power. (GoP, Policy for Development of Renewable Energy Power Generation, 2006)

- **The Power Purchase Agreements**

The power purchasing utilities entered into a power purchase agreement with the independent power producers to guarantee payment obligation extending over the term of the power purchase agreement. These agreements were simple and based on purchasing power generated at a per-kWh rate, excluding the capacity charges, risks, penalty conditions, and capacity testing.

- **Facilities for Captive and Grid Spillover Projects**

RE power generators with captive grid spillover power projects that will transmit surplus power to the national grid were facilitated in the following ways.

- **Net Purchase and Sales**

For renewable energy projects with a capacity over 1 MW, the excess electricity supplied to the grid, or the electricity drawn from the grid, will be measured using separate meters. The power utility will pay the producer a tariff equal to the average energy cost per kWh for oil-based power generation, minus 10%, for the surplus electricity supplied. If the power producer receives more electricity from the utility than they supply, they will be billed at the applicable retail tariff based on their user connection type.

- **Net Metering**

For RE power projects with a capacity of up to 1 MW intended for self or dedicated use, there is an option to supply surplus electricity to the power utility and draw electricity from the utility when needed. The net electricity exchanged between the power producer and the utility in a month, either supplied by the producer or received from the utility, will be compensated based on the applicable retail tariff. This arrangement can be facilitated through separate unidirectional or bidirectional meters capable of recording net power transfers. This approach encourages small-scale renewable energy generation, such as rooftop PV panels, by optimizing utilization and eliminating the need for costly on-site storage batteries.

- **Banking**

Net billing involves maintaining a rolling energy unit account like a bank account, where units are either credited or debited. This account was reconciled annually based on the rates specified. With this arrangement, a producer supplied power to the grid at one

location and received an equivalent number of units for self-use at a different location without paying wheeling charges within specified distance limits. Any additional units consumed by the producer beyond those supplied to the utility were billed at the applicable retail tariff. Excess units supplied were credited to the producer monthly, with accumulated credits paid by the utility at a tariff based on the average energy cost per kWh for oil-based power generation minus 10%.

- **Facilities for Off-grid and Dispersed RE Power Generation**

The government announced deregulation and simplification of off-grid power generation for personal use and local communities. The relevant agencies, such as AEDB/Provincial and AJK Agency, developed new procedures based on initial results. Small hydropower projects and distribution grids were developed at specific locations without specific approvals.

- **Other Incentives**

In addition to the notable financial and fiscal incentives, renewable energy-based power projects in Pakistan also benefited from a range of other favorable measures. These incentives were extended to private, public-private, and public-sector renewable energy power projects, fostering a conducive environment for sustainable energy initiatives. These included Term Finance Certificates (TFCs), tax exemptions such as customs duty and sales tax on machinery and equipment Additionally, these projects were exempt from income tax, including turnover rate tax and withholding tax on imports. The repatriation of equity and dividends was allowed as per the State Bank of Pakistan's rules and regulations. Parties involved could raise local and foreign finance following applicable industry regulations, although GoP approval might have been required under these regulations. Moreover, non-Muslims and non-residents were exempted from paying Zakat on dividends distributed by the company. (GoP, Policy for Development of Renewable Energy Power Generation, 2006)

4.2 Current Renewable Energy Policies of Pakistan

The alternationate and Renewable Energy Policy of 2019 is sill an activr policy today along with the Framework Gudie lines to Fast Track Solar PV innitatives of 2022. Both these vital documents are discussed in this section.

4.2.1 Alternate and Renewable Energy Policy for 2019

In the Alternate Renewable Energy Policy 2019, the government broadened its scope in terms of renewable energy technologies and the policy aimed to cover the following resources.

- Biomass (including but not limited to bagasse, agricultural waste, and other waste)
- Geothermal
- Ocean /Tidal Wave energy
- Solar (PV or Thermal, or any technology that uses heat and/or light of the sun to make electricity)
- Wind
- Storage Technologies (Battery systems, Cells of all types, compressed gas, pumped storage)
- Biogas using any organic material (except fossil fuels)
- Energy from Waste (including but not limited to municipal solid waste, industrial

waste, sewage, Refuse Derived Fuel).
- Hydrogen or Synthetic Gas (made from any source except fossil fuels)
- Hybrids of any of the above technologies

The policy also aimed to work on retrofitting existing solar and wind projects to convert them into hybrid units, and additionally, any proprietary technology or new technology developed during the applicability of this ARE 2019 Policy fell under its ambit.

The policy covered all projects implemented with Alternative or Renewable Energy technologies for power production in the past, whether intended for sale to a public utility or private sale to consumers seeking incentives provided by this Policy. This included projects developed in the Private Sector, Public Sector, or through Public-Private Partnerships. While the policy was structured to cover projects integrated into the NTDC/DISCO system, it also covered projects by Karachi Electric (KE). Pakistan's long-term integrated energy plan in the past envisioned four guiding principles: sustainability, affordability, responsibility, and availability. The ARE 2019 Policy, as a component of the plan, had a vision for developing an efficient, sustainable, secure, affordable, competitive, and environmentally friendly power system while promoting the indigenization of energy resources and the development of local manufacturing capabilities in such technologies. Under this policy, significant financial and fiscal incentives were designed to encourage and support renewable energy projects. These incentives applied to projects selling electricity to public utilities, distributed/off-grid projects, and those operating on a business-to-business (B2B) basis.

4.2.2 Incentives given to Investors under the Renewable Energy Policy of 2019

The discussion below includes all the incentives given to the investors of Renewable energy technologies.

- **Tax Exemptions**

One of the key fiscal incentives was the exemption from Corporate Income for projects implemented under this policy. However, Dividend withholding tax was applicable at the time of bid submission.

- **Customs Duty Exemption**

Projects were also granted exemption from customs duty on imported equipment and machinery not manufactured locally for installation in renewable energy projects. To avail of this exemption, project companies were required to provide an undertaking to AEDB, ensuring that these items were exclusively used for their designated purposes and not sold in the local market. If the customs duty rate changed in future bidding rounds, it would be specified in the bidding documents, and the rate applicable would be determined on the bidding date.

- **Goods and Services Tax (GST)**

GST on services varied across provinces and was subject to change. The applicable taxes were to be checked with the relevant provincial agency at the time of project implementation.

- **Sales Tax Exemption**

A sales tax exemption was granted on plants, machinery, and equipment, although specific details needed to be verified.

- **Repatriation of Equity and Dividends**

Project developers were allowed to repatriate

equity and dividends freely, subject to prescribed rules and regulations, including a lock-in period for repatriation of capital.

- **Financing Options**

Parties involved in these projects had the flexibility to raise local and foreign finance under industry regulations. Approval from the State Bank of Pakistan (SBP) was required for foreign finance.

- **Carbon Credits**

The policy also encouraged the procurement of carbon credits through various mechanisms, including the Carbon Crediting Mechanism (CDM) and voluntary markets. AEDB played a role in facilitating, coordinating, and assisting ARE project developers in accessing global carbon crediting markets and other financing options related to mitigation and adaptation. Revenues generated from the sale of carbon credits were exempted from income tax or duty. AEDB was tasked with developing local capacities and raising awareness about various carbon crediting mechanisms available under the United Nations Framework Convention on Climate Change (UNFCCC). In the event of new international climate treaties, the government was committed to revising incentives to align with these agreements, and AEDB would facilitate necessary adjustments. (GOP, 2019)

4.2.3 Framework Guidelines to Fast Track Solar PV Initiatives 2022

Framework guidelines to track solar PV in Pakistan can aim to reduce the dependence on expensive imported fossil fuels by switching to the adoption of solar PV. This strategic shift will bring down the cost of electricity generation and will increase the production of renewable energy in the overall energy mix. In this energy transition, the existing transmission networks will be utilized to the maximum extent as a vital component for this initiative, specifically the federally owned public power utilities (FPU) through integration into 11 KV feeders which will enhance the resilience and reliability of the electrical grid.

These framework guidelines will support the environment and substantially lessen the strain on foreign exchange reserves by reducing the need for imported fuel, liquified natural gas, and coal. This initiative will be materialized by two methods: competitive bidding or government-to-government arrangements. Further, this initiative also encourages private sector investments and foreign investments. To bring the shift towards solar the government will first solarize the public buildings. This example will not only reduce the carbon footprint but will also set a compelling example for sustainable energy practices.

Introducing the electricity produced through solar means will lower the overall basket cost of the electricity in the daytime while still utilizing the thermal generated electricity at peak time. This target will be materialized by introducing medium-scale Solar PV into the medium voltage feeding network, this will provide cost-effective electricity into the national grid without the need for augmentation or any major upgrades in the infrastructure (GoP, Framework Guidelines Fast Track Solar PV Initiatives , 2022). The three main targets of the framework are listed below.

Table 4: Framework Guidelines to Fast track Solar PV,2022

Targets	Term and Lease Model
Substitute expensive fuel with solar PV	25 years on a BOOT Basis
Solar PV generation on 11 Kv feeders	25 years BOO basis extendable
Solarization of Public Sector Buildings	10 years BOOT Basis

5. Policy Gaps Identified through Review of the Existing Literature on Promoting PV Adoption in Pakistan

The adoption of photovoltaic (PV) systems for renewable energy generation has gained significant attention in recent years due to its potential to mitigate climate change and reduce dependence on fossil fuels. However, despite the numerous environmental benefits and technological advancements, impediments still hinder the widespread adoption of PV systems. The following section of this study aims to explore and analyze obstacles that resist PV adoption for energy generation.

5.1 Obstacles in PV Adoption

Installation of solar PV systems for energy generation provides smooth, steady, and cost-effective energy generation for households, institutions, commercial entities and large businesses; however, the installation cost, which requires a high initial investment in solar panels, inverters and technical labour makes it highly difficult for households and small businesses to invest in this renewable energy option. The demand for PV systems has increased globally and is expected to continue however, the significant capital requirements of transforming the demand into installed capacity remains a challenge for many (Galen Barbose, 2014). In the United States and other countries of the global north such banking, tools are available that allow investors to materialize solar projects. These projects are financed through "tax equity investors" in the

form of solar asset back securities (ABC) through large insurance banks and investment companies (Bolinger, 2009) however, in countries like Pakistan, such tools are not available for small investors which make it increasingly challenging to invest while having the will and requirement. The absence of subsidies and incentives for households and commercial entities is one of the main reasons that resists the influx of investments in this sector. Some investments are observed in this sector in the form of loan schemes provided by the State Bank of Pakistan, but these schemes are limited to only electricity producers with a capacity of 4KM to 50MW (Qureshi, 2017).

To utilize solar energy at its maximum, it is essential that all solar energy-producing entities are connected and synced to the national grid through the transmission lines, A survey form 2005 revealed that almost 32% of Pakistan's 125,000 villages, i.e. 40,000 villages are not grid-connected (Hassan A. Khan, 2013) which means even if this population starts generating its electricity through solar means, it will not be utilized at its fullest as surplus energy will be wasted.

With the advancing technologies and increasing supply of PV infrastructure and material globally, the costs of solar PV has declined globally. The cost of solar panels itself has declined by 60% from 2008 to 2011 to $0.7/Wp (Wolf D. Grossmann, 2013) and the cost of overall grid-tried PV systems, including panels, electronics, labor, and other parts has decreased to 1.67/Wp. However, in Pakistan, consumers observe an opposite trend in the form of increasing prices of this technology due to various reasons. Such increases are due to import taxes and inflated dollar rates in exchange for PKR which is why the infrastructure is becoming increasingly expensive. These import duties and dollar rates make the environment unpredictable and hostile. Another challenge for the households is the expensive labour and the technical experts, which makes the overall transition to green energy options full of obstacles and financial barriers.

Promoting green energy solutions and environment-friendly options face numerous obstacles, financial constraints and lack of knowledge (Yatish Joshi, 2015) which enhance or reduce consumer intentions for adopting solar energy in different regions. For instance, in Italy (Extend theory of planned behaviour model to explain rooftop solar energy adoption in emerging market. Moderating mechanism of personal innovativeness) Korea (Tuan Duong Vu, 2023) and several other studies help us recognize the main constituents that motivate users and enhance their intentions for using renewable solar energy options such as innovation, environmental concerns, government incentives, policies, on the other hand, these researches have also highlighted barriers such as financial limitations, technical challenges, ecological and geographic challenges (Neelam Rathore). If we consider the case of Pakistan, the cost of PV systems appeared to be the most significant barrier to the diffusion of solar PV, while the attraction for adopting solar PV was not the clean energy but due to its economic feasibility. (Factors responsible for solar PV adoption at household level: A case of Lahore, Pakistan, 2017).

Technical disability in photovoltaic technology is one of the issues that hinder the growth of photovoltaic technology in Pakistan; despite having high demand and requirement, Pakistan is not a local manufacturer of photovoltaic sheets and equipment. (Khattak, Hassnain, Shah, & Mutlib, 2007). Lack of access to required material, inadequate technical knowledge, and very small research and development in this field introduce influential barriers.

High transmission and distribution losses and difficulties in extending the grid to inaccessible remote areas are the main hurdles to adopting renewable energy technologies and a steady flow of electricity throughout the country (M. Mujahid Rafique, 2017). In these circumstances, off-grid solar energy in remote areas is a great option to make electricity accessible.

In the list of all the obstacles listed, solar PV adoption faces many obstacles, but with a targeted approach and will to harness electricity through solar means, it will be fruitful to implement an action plan.

6. Data and Methodology

To gain firsthand knowledge and practical insights, primary data was collected from the target population which helped to incorporate the practical experiences of the stakeholders within the energy market. Three subcategories were explored to gain insights: households, commercial entities, and solar installation companies. This chapter provided all the necessary information pertaining to the data collection journey.

6.1 Methodology

The Sampling technique deployed was stratified simple random sampling. Our target populations were twin cities so the residents of twin cities, business entities located in twin cities and lastly solar PV installation companies operating in Rawalpindi and Islamabad were targeted. For data collection of households, researchers targeted different localities and each resident within the locality had the equal possibility to be selected. For commercial entities and PV installation companies, the same selection method was deployed. The table below indicates the sample size of each category.

The research utilized nonnumerical data collection and analysis. In other words, the data collection process involved the use of questionnaires and unstructured interviews. The questionnaires were designed to address all the themes and concerns of different populations and were tailored specifically according to the requirements of research from each group. If we divide our data collection process into phases, then our data

collection process is divided into three main phases.

6.1.1 Phase 1

The first phase involved identifying our target population and a sample size for each population. We identified three target populations: households, Commercial entities, and Solar PV installation companies. These three different categories were selected based on their vital role in the energy sector. Households and commercial entities were selected as they are dependent on electricity to commence with everyday activity, and they are sensitive to any changes occurring in the energy sector. On the other hand, Solar PV installation companies are the service providers and offer renewable and alternative means of generating electricity for the service users.

6.1.2 Phase 2

Once the sample size for each population was recognized the questionnaires were developed for each category. The research team began to collect data from these different populations. The outreach activity involved floating surveys with our target population of households in different localities. For commercial entities diversified list of different businesses was identified with companies engaged in different businesses such as pharmaceuticals, manufacturing, service providers, and sellers of different goods. This diverse pool allowed the research activity to incorporate a variety of responses and experiences. For solar PV installation companies, a list of companies was developed having a presence in twin cities, these companies were providing services to different clients such as households businesses, government institutes, and others. For the data collection from commercial entities and solar PV installation companies' emails were sent to these companies providing all the necessary information and survey forms. However, the data was collected through personal visits by our research team. The table below explains the sample size and the number of responses received for each category.

Table 5: Sample Size

Target Population	Sample Size	Responses
Households	Above 100	40
Commercial Entities	25	15
PV installation Companies	25	15

6.1.3 Phase 3

After the data collection, all the data collected from different means was analyzed under the concept of grounded theory. The phenomenon of grounded theory suggests identifying patterns and themes emerging from data rather than applying preconceived theories. This concept allows value addition to existing literature and applying an open-minded approach. The data collected is studied and analyzed with great care.

6.2 Rationale for Developing Three Different Questionnaires

Exploring three different categories was vital for our study as it helped us to capture and analyze different perspectives within the energy sector further, it also helped us to understand their unique challenges and concerns. These inputs were utilized to tailor recommendations for these three subcategories These questionnaires could understand the significant barriers hindering

the adoption of solar PV systems in Pakistan, as revealed by survey data collected from several households and organizations representing various sectors. The findings illuminate households' and organizations' challenges and provide valuable insights for policymakers and stakeholders looking to promote solar energy in the country. Pakistan has a high solar resource potential however, solar PV adaptation in Pakistan is still in its early stages, with only 1.16% of the country's electricity generated from solar power in 2022.

6.2.1 Rationale to Develop the Questionnaire for Households

Households play a significant role in energy consumption in Pakistan, and studying the adaptation of solar PV for households was an essential aspect of our research. This questionnaire was designed to ask various questions from energy-centred households and explored all the factors that concern people on energy-related decisions and factors that majorly contribute to adopting energy-efficient ways for households. Each question was carefully crafted and designed to support this study and delve into the study area deeply while providing clear insights. The questionnaire included questions from all aspects, such as level of awareness, policy-related awareness, and financial factors. Addressing all these questions was pertinent to this research and provided us insights into what the public is facing and what could be the motivational factors to adopt solar PV.

6.2.2 Rationale to Develop the Questionnaire for Commercial Consumers

Like households, commercial consumers such as trading and manufacturing sectors consume a large amount of electricity. Many industries need a 24-hour supply of electricity to fulfill their production needs and some other businesses may not need a 24-hour supply however they run heavy machines that need a continuous smooth supply of electricity. Considering the energy situation in Pakistan, it is common knowledge that the country is facing a major shortage and many industries state that they cannot run their industry because of continuous load-shedding.

To comprehensively assess the energy landscape within various industrial and business entities, this questionnaire was tailored to effectively capture the prevailing conditions across diverse countries. The primary objective of this questionnaire was to take out meaningful responses that not only address the concerns and inquiries of these sectors but also shed light on their interest in integrating solar energy systems.

This questionnaire was devised to explore a spectrum of relevant facets, encompassing the feasibility of solar system installation, the rationale for opting for this technology, and the government's initiatives in addressing their energy-related challenges. It further aimed to explore the trust-building endeavours of solar companies, the consideration of environmental factors in decision-making, and the envisioned future trajectory of Pakistan's energy landscape.

6.2.3 Rationale to Develop the Questionnaire for PV Installation Companies

In addition to conducting surveys among

households and commercial entities, it was imperative to garner insights from solar installation companies, given their pivotal role in the solar PV market in Pakistan. A comprehensive questionnaire was designed to elicit vital information that would significantly enhance the depth and breadth of our research findings.

This questionnaire covered a wide array of pertinent aspects within the domain of solar PV systems. It delved into critical areas such as the working domains of these installation companies, their primary client base, system preferences, and the underlying motivations driving their clients' interest in solar system adoption. Furthermore, the financial dynamics surrounding these systems were also enquired to discern whether clients perceive them as cost-prohibitive or financially viable.

7. Results and Discussion

7.1 Households

At the start, a detailed questionnaire was designed targeting households to get some insights from the public on solar PV adaptation that may clearly describe the areas of improvement and factors that may encourage or stop them from solar PV adoption.

- **Survey Inclusiveness**

The survey included people from general households mainly based in the Punjab region of Pakistan mostly the respondents were aged between 25 to 35 years of age and most of them are well educated, where 72% of the respondents are male while remaining are female. These households are mostly middle class, single home type, and have people around 5 to 6 people, which is quite a perfect figure to understand the real-time ground situation of the adaptation needs.

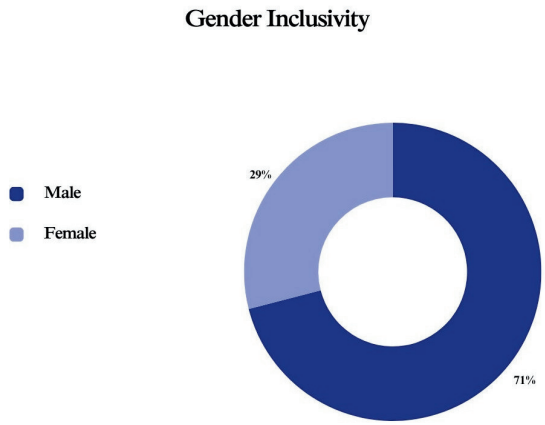

Figure 2: Gender Inclusivity

The education level of participants is quite good, and it is believed that respondents of this questionnaire are well literate and their answers to the questionnaire are quite

effective for research work.

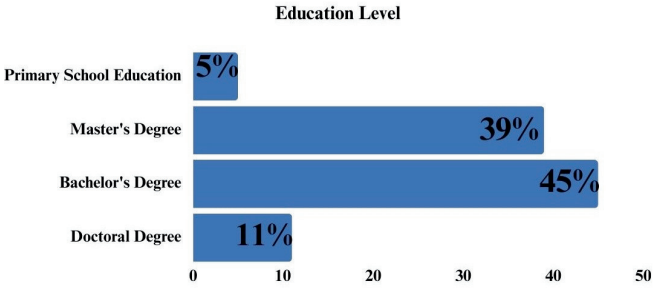

Figure 3: Education Level

We further discuss each question in depth to understand how their answers helped us analyze key factors for adaptation related to solar PV technology.

- **Consumption Needs**

Most households' electricity consumption needs lie between 300 to 500 KW per month and second to that most households have consumption less than 300 KW per month, which accurately depicts that the households included are from the middle class and have average electricity needs as most of the country's households. It will help us to frame overall Pakistan's energy consumption in a greater perspective.

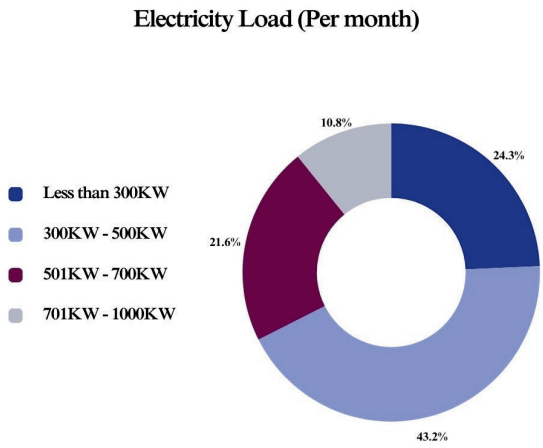

Figure 4: Consumption Needs

- **Participant Awareness and Survey Effectiveness**

As discussed earlier, most of the participants are well educated so it automatically makes them aware of the general understanding of solar PV systems. Many of them stated they have expert-level knowledge in this term, which surely has enhanced the outcome & efficiency of this questionnaire, as their input will be very much knowledge-based.

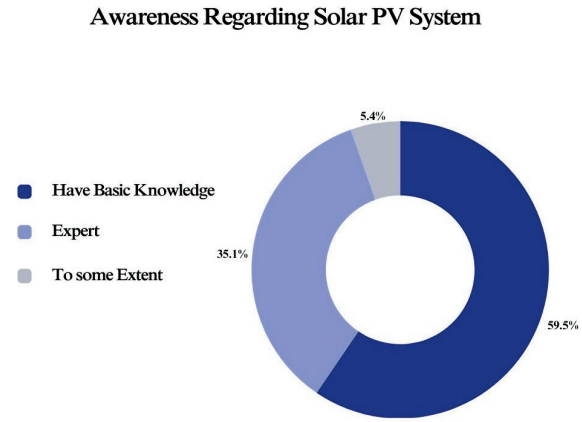

Figure 5: Participant Awareness and Survey Effectiveness

- **Concerns related to Electricity Prices**

Respondents answered the above question, as they are highly concerned about soaring electricity prices. About 87% of respondents showed their concern and are interested in installing solar PV systems, while 43% of them think that solar PV is too costly and is difficult for them to install such high-cost systems. Very few stated that they are not looking to install solar and 3% stated that they are not concerned with electricity.

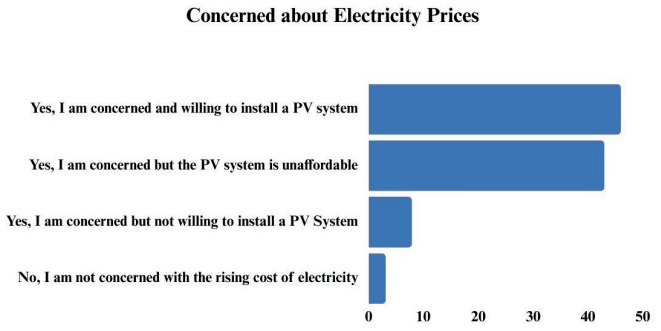

Figure 6: Concerns Related to Electricity Prices

- **Concerns Related to Power Outage**

Respondents have shown their great concerns related to power outages. About 91% of respondents were concerned about electricity shortage and repetitive load-shedding, out of which some are considering, and some have installed PV systems, while 33% of them are not interested in solar PV systems. The reason for this is unknown, however, it is assumed that they may not have proper information about the system or may have other backup options available, like generator, UPS, etc.

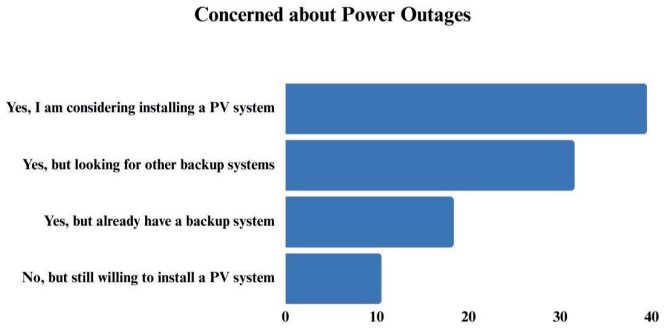

Figure 7: Concerns Related to Power Outage

- **Concerns Related to the Environment**

When respondents were asked if they are worried about the environment, how fossil fuels are impacting it, and if they are willing to pay upfront cost for using PV systems, about 83% of them stated that they are concerned, however, 35% are unaware of this term, 33% showed their willingness to pay the upfront cost to save the environment, while remaining 25% are not willing. The remaining respondents stated that they are not concerned about the environment, and however willing to pay for collective benefits.

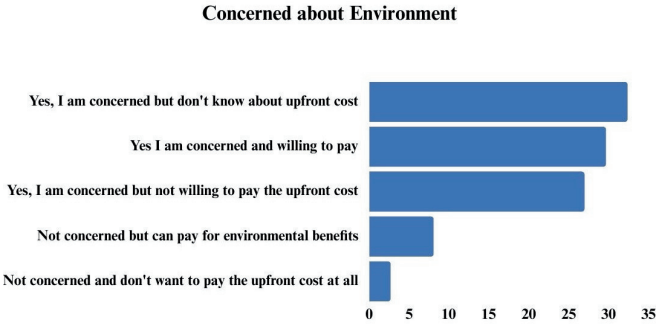

Figure 8: Concerns Related to Environment

- **Solar PV System Adoption Trend**

Most people stated that someone from their area or known has installed PV systems, which depicts how fast this technology is making its space in the region.

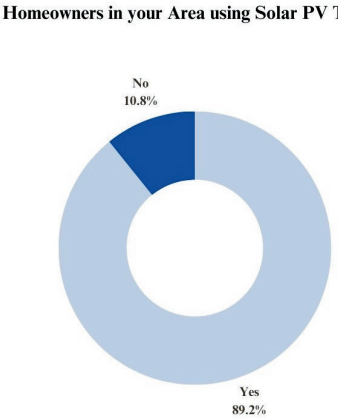

Figure 9: Perceived Solar PV Use

- **Solar PV Affordability and the Role of Incentives**

Respondents stated that solar PV system is affordable but with incentives and subsidies only. This means that respondents are aware

of subsidies and incentives and have knowledge about them. Secondly, to boost the adoption of solar PV technology, policymakers must consider including subsidies and incentives.

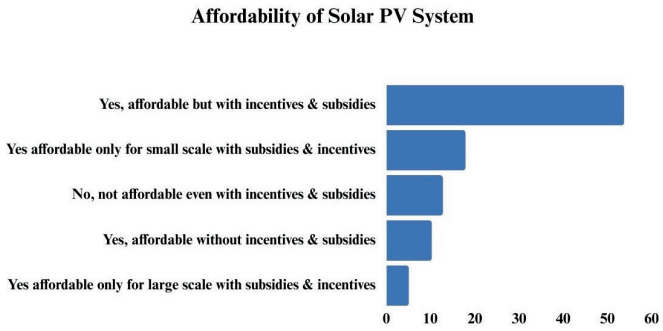

Figure 10: Affordability

- **Financing Consideration**

Respondents stated that they are aware of financing options and are very much interested in such options. This possibly could be due to the high cost of solar PV systems, and security issues related to them. Financing options may be a reliable source to not overburden their pockets while installing the system and provide them with security in parallel.

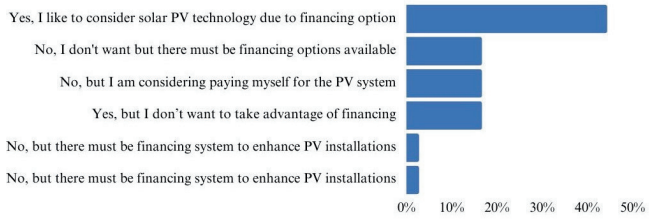

Figure 11: Financing Options

- **PV System Installation Challenges and Support Concerns**

The respondents of the questionnaires believe that there is limited support in terms of proper customer care and sparse technical expertise in terms of installation, safety, maintenance, and understanding available, which one way or another makes them rethink while considering installation of such PV systems.

The charts below clearly depict what would convince the owners to include solar in their system.

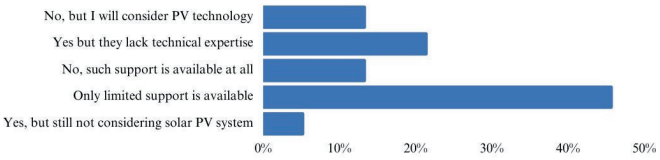

Figure 12: Concerns Related to Installation

- **Consideration for Net Metering**

Approx. 58.3% of the participants of the questionnaire are aware of net metering systems and stated their willingness to switch to net metering systems because of current economic conditions.

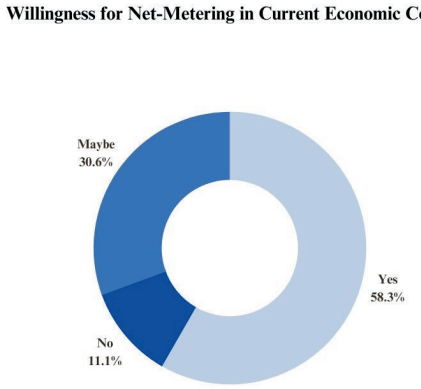

Figure 13: Net Metering

- **Analysis**

Responses from the questionnaires depicted that the public, literate specifically, is actively considering solar PV systems for their households. As questioned, most of the respondents stated the role of economic conditions and tariffs included in the electricity bills. However, when interviewed many of the respondents stated their need for uninterrupted electricity. Many of them stated their concerns over the behavior of solar PV

installation companies, who not only fail to install efficient systems but also fail to deliver proper maintenance to the buyer, which only worsens their recommendations on such systems and companies.

The collected data from this underscore the importance of informed policy interventions that support solar PV adoption in Pakistan. To accelerate this transition, policymakers should consider not only affordability but also the provision of technical support, financing options, and incentives. Moreover, the willingness to embrace net metering reflects a potential avenue to empower households to actively participate in the sustainable energy landscape. These findings lay the foundation for further research and policy development aimed at advancing solar PV adoption in Pakistan's middle-class households and, by extension, the broader energy landscape.

7.2 Commercial Entities

In the next step, commercial businesses are focused on as a target of our survey. A questionnaire was designed to properly address all the key factors that would give an in-depth analysis of the behavior of the commercial sector towards solar PV adaptation. The survey is tried upon multiple commercial sectors; development sector, services sector, and government sector, etc. to make it as inclusive as it can be. Some of the respondents were HR organizations, others included admin staff, supervisors, principals, and managers. The main location of respondents was twin cities and most of the company's staff size was 50-100 which lies in the nominal capacity business range.

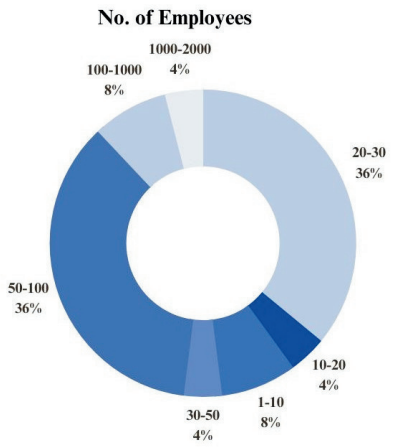

Figure 14: Company Size

Almost all the responding organizations work in morning shifts, and about half of them work in the evening, which adds to their energy consumption needs. The organizations included mainly give an insight into the overall commercial sector's solar adaptation and what's encouraging or stopping them from adopting it.

Further, we will discuss the questionnaire and responses to carefully analyze the needs of this sector. To amplify the earlier policies and their result needs benefit to solar PV adaptation.

- **Diverse Sectoral Participation**

Organizations participating in the survey are from various sectors of Pakistan. Approximately 41% of respondents are from the services sector, which includes IT sector banks and other similar entities. Then about 17.6% of respondents are from the development sector, which includes 56 developers, state agents' offices, etc. Lastly, 6 % each are from industrial sectors, restaurants, and other similar domains. The inclusion of such a variety of sectors makes it a complete package for our research as we get to include input from this variety of sector

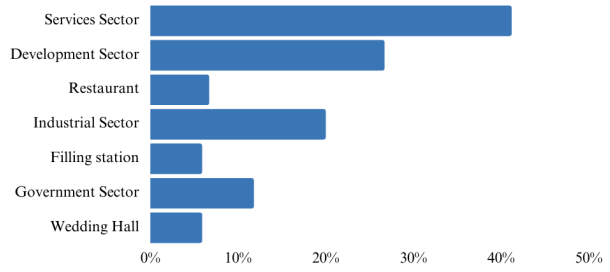

Figure 15: Working Sector of Organization

- **Electricity Consumption Needs**

As observed from the respondents' answers, many organizations stated that they work in the morning shift only while others work in both shifts, as shown in the graph below.

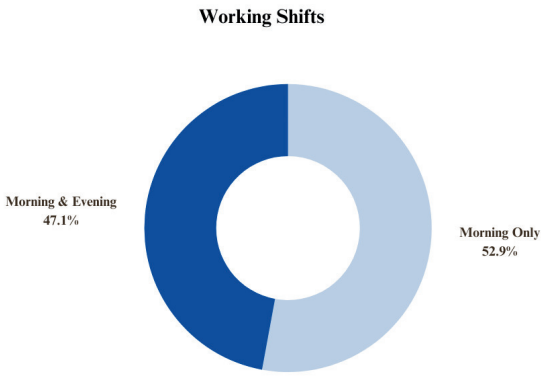

Figure 16: Operational Time

Majorly the participating organizations have energy consumption under 1000KW per month. About 35% of respondents have energy consumption between 700 to 1000KW per month, while 29% have energy consumption greater than 1000KW per month, mostly from the development sector which mainly operates on morning and evening shifts and is more likely to consume much energy.

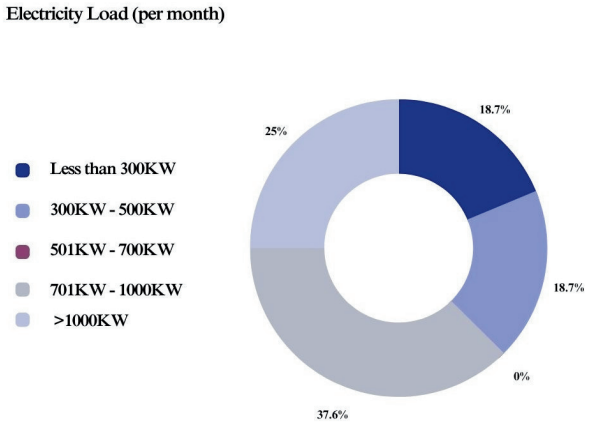

Figure 17: Electricity Load

- **Commercial Sector's Solar Knowledge Gap**

From the responses to the surveys, it is observed that currently commercial organizations mainly have basic knowledge of solar PV technology to some extent, which is not very effective in encouraging them to adopt solar PV systems. About 35% of respondents believe that they know about solar. While 24% stated they are naive in understanding solar PV systems. Compared with the households' the commercial sector lags greatly in terms of awareness. This could be because of multiple factors, like aged managers/ directors sitting at key positions, for whom it is difficult to understand such systems are surely a great hurdle towards the adaptation.

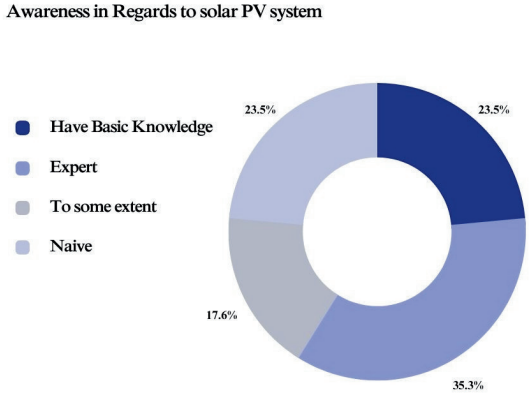

Figure 18: Awareness of Solar PV System

- **Commercial Sector's Growing Interest in Solar PV**

About 70% of respondents stated that they are actively considering implementing solar PV systems for their business. This could be for multiple reasons, like a tariff, economic crisis, and load shedding. Under the awareness section, we discussed that these commercial sectors don't consider this system because of less awareness, however, in the later term, they believe that they need such a system to maximize their output and minimize their billings.

- **Optimal PV System Preferences for Organizations**

Most respondents on behalf of organizations understanding PV systems, have shown their interest in installing PV systems, the capacity they mostly looking for is 20KW to 50KW however most organizations are considering systems heavier than 100KW.

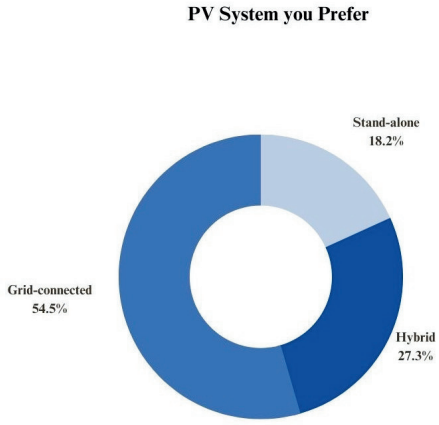

Figure 19: Optimal PV System

Approximately 54% of the organizations are looking for a grid-connected system, where they could opt for net metering. As most commercial sectors are operational in the morning and the production of such energy in excess will be a waste, most organizations neglect the need for hybrid systems. However organizations with evening working hours are looking forward to hybrid options, where they could minimize their load on the grid. These knowledgeable approaches are helpful for organizations.

- **Solar PV Affordability Perceptions**

From the surveys it is observed that many organizations believe that solar PV technology is affordable for large-scale businesses only, however, alternatively, few suggested that it's affordable for them to implement this technology but all this with subsidies and incentives only. Few of the respondents even claimed that it's not affordable even with subsidies or incentives. This mixed view on affordability defines the lag of communications and the need for the development of a proper site from the government side, where one can find related authentic news.

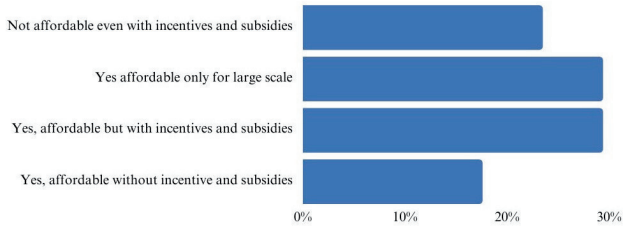

Figure 20: Affordability

- **Financing Consideration**

Financial Considerations play an important role in building the minds of commercial sectors like household sectors. Initial costs are sometimes stopping organizations from adopting solar, as they are neglecting the payback period survey suggested that more than 50% of respondents stated that they are willing to go for readily available financing options for installing solar PV, one of the respondents from services sector stated that he will consider Islamic banking option if

available.

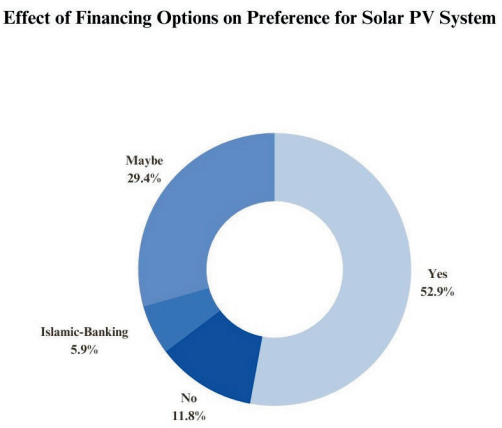

Figure 21: Financing Consideration

- **Awareness of Government Solar Policies**

From surveys and interviews, it is observed that most respondents haven't heard of any government policies or initiatives related to solar. Some of them stated that they just heard statements circulating in the market, no more than that. Also, some policymakers and people who have a good understanding believe that current policies are not properly addressing the ground needs of this system for the country. This gives some points in this analysis, that much of the market is unaware of any government policies and they don't know if the government is properly working on these areas or if it's just the talk of the town.

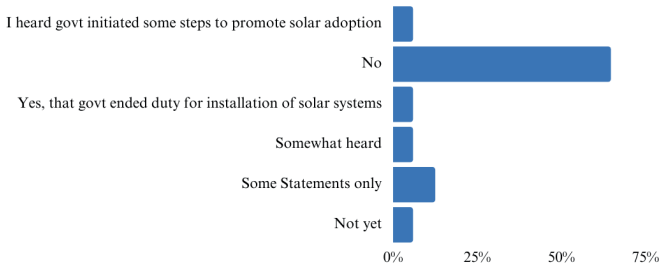

Figure 22: Awareness of Government Solar Policies

- **Satisfaction Catalyzes Commercial Solar Adoption**

All respondents who have installed the PV system have marked their experience as satisfied. This shows that solar PV systems are well-suited for commercial businesses. On interviewing it was seen that there might be some hurdles related to maintenance, financing, and sourcing of a reliable installation company, but their experience after installation in terms of results is very satisfactory. This factor will greatly encourage neighboring companies and knowledgeable workers to adopt solar technology.

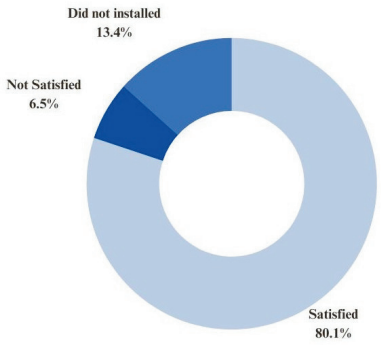

Figure 23: Experience having a PV System

- **Technical Concerns in Commercial Solar Installations**

Views of respondents from the commercial sector are parallel with households. They believe that proper technical assistance and maintenance needs are not addressed properly by installation companies. They also believe that the proper technical knowledge of experts installing these types of technologies is not up to the mark which is a great concern from their side.

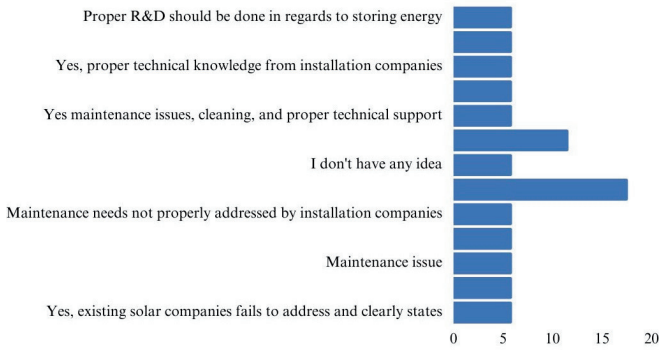

Figure 24: Technical Concerns

- **Encouraging Businesses to Adopt Solar**

Respondents gave valuable input to our questionnaire, as they put in their views that define the understanding of the current issues related to electricity. One of the respondents stated that bill adjustment, formulating tax schemes, and giving subsidies to people installing solar PV systems. Another respondent stated that there should be incentives for people to install big and small grid-connected systems. It will help the government to include much of its national grid.

- **Future Commercial Solar Integration**

As observed from the questionnaire, a respondent believed that solar is a way to exclude some of our fuel imports. If most households and commercial sectors switch to solar energy it will greatly reduce our oil imports by enhancing energy fulfilment from within our country. Another respondent believes that solar energy systems are already playing a great role in decreasing energy shortage, while another respondent believes that its a future technology, environment friendly, and making our environment safer for our future generations.

- **Analysis**

The extensive survey targeting commercial entities in various sectors within Pakistan has provided valuable insights into the behavior and attitudes of the commercial sector towards solar PV adaptation. This analysis has encompassed multiple sectors, including development, services, and government, shedding light on factors that encourage or hinder solar PV adoption. The survey data highlights the potential for solar PV adoption in various sectors of Pakistan. To unlock this potential, addressing awareness gaps, providing financing options, and formulating effective policies that align with ground-level needs are essential. The willingness of commercial organizations to consider solar solutions, coupled with their positive experiences, offers a promising outlook for the future integration of solar energy into Pakistan's commercial sector.

7.3 Solar Installation Companies

The data collected from the solar installation companies provided insights that are a valuable aid to bring reforms to this market for the maximum utility of this clean energy resource. The companies surveyed were providing services to customers in the twin cities and were also operational in different parts of Pakistan. Below is the information shared which is collected from solar PV installation companies.

- **Company Location**

The companies surveyed provided services to customers in the twin cities. The 15 companies surveyed were operational in Rawalpindi and

Islamabad, some were also operational in different parts of Pakistan. 4 of the companies had their business operations established in Lahore, three were functional in Peshawar. Four other companies reported that they had business operations in Karachi, Gilgit Baltistan, and Faisalabad. This means that out of 15, 11 companies had their business operations in more than one city. This shows that solar PV companies are not large-scale companies with large networks nationwide.

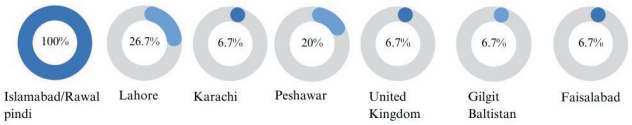

Figure 25: Company Location

- **Market Presence**

According to our data, 6.7% of the companies commenced their operations in 1998, and we observed a consistent market presence of solar companies by 6.7% in 2005 and 2010. In the year 2015, the market of solar companies was developed by 26.7% this sudden increase in the market development was due to the energy shortage in the county followed by a 20% market development by the year 2018 and another 20% increase in solar companies in 2020. The exponential increase in solar PV companies was due to the growing energy crisis and increasing electricity prices in the country.

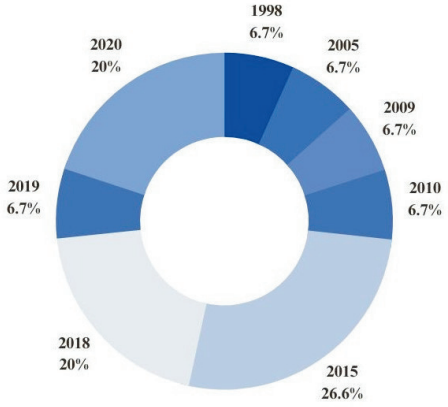

Figure 26: Market Presence

- **Customer Base**

The clientele that these companies have developed has diverse backgrounds and different requirements. 93.3% which is a total of 14 companies reported to have installed solar PV for homeowners and commercial businesses. 86.7% which is a total of 13 companies have extended their services to the services sector. 10 companies have served in the production and manufacturing sectors. 8 companies have extended their services to government institutions which is a total of 66.7%. 53.3% of companies have reported having extended their service to clients with different setups not identified in our category chart while 1 company has installed solar PV at agricultural setup. These companies have maximum customers coming from Punjab and a small number of customers are from other parts of Pakistan.

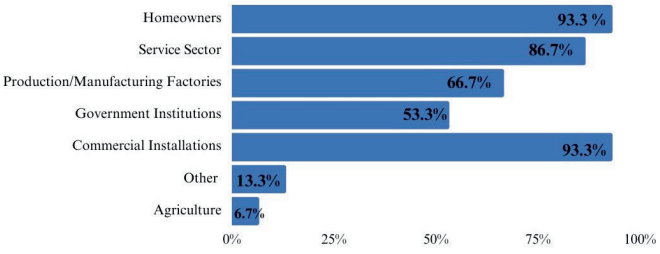

Figure 27: Company Base

- **Area Category of Maximum Customers**

14 companies have developed their businesses in urban setups while 7 have a presence in rural areas.1 company has developed its setup in a semi-urban area. This area categorization clearly shows that many consumers are neglected due to their rural location. These solar PV companies have limited outreach.

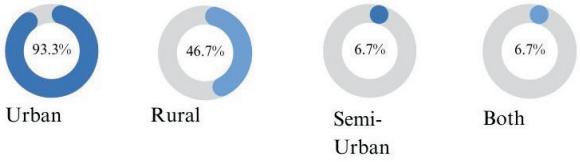

Figure 28: Area Category of Customers

- **Annual Installations in terms of Customer Data (2022 -2023)**

With the increasing electricity prices, an influx of households and businesses are shifting to solar PV. The companies surveyed share that 66.6% of the companies have catered to about 100 -500 customers within the current year while 13.3% of companies reported having extended their services to customers between 500 to 1000 customers.

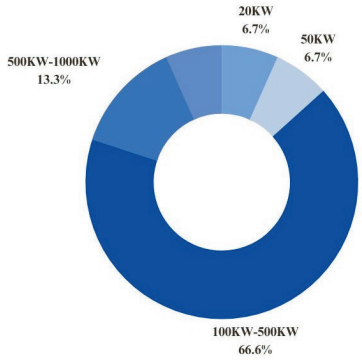

Figure 29: Annual Installations

- **Annual Installed Capacity**

According to the data shared by solar PV companies 60% of the clients install solar PV at the capacity of 300KW-1000KW while 20% install at a capacity between 1000KW -3000 KW, and 13% approach these companies with the need of 5000KW-10000KW. 6.7 % of companies reported to have installed 30MW of solar PV for their clients.

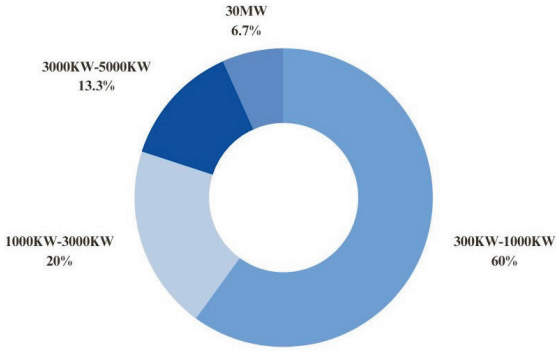

Figure 30: Installed Capacity

- **Customer Growth Rate**

46.7% of the solar PV companies have experienced a 50% growth rate, while 20% have experienced a 100% growth rate and 20% have experienced a 200% growth. This growth rate shows the increasing demand for solar PV in the national market.

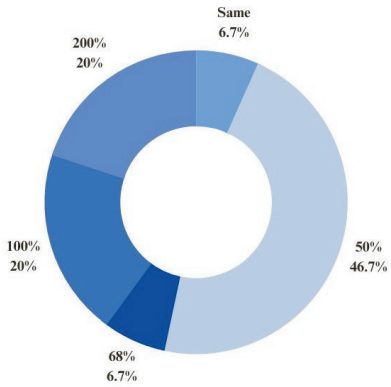

Figure 31: Customer Growth

- **Customer Concerns**

The customers installing Solar PV systems have different underlying reasons for switching to this clean option. The highest recorded concern is the increasing tariff charges on conventional electricity. The end

users' main concerns are increasing prices and heavy taxes being levied on conventional electricity. In recent times, electricity charges have increased exponentially, so people who can make this investment are switching to solar PV. According to this survey, 66.7% of people switching to solar are to experience uninterrupted electricity supply. Due to a shortage of electricity and transmission issues, load shedding in urban and rural areas is a common concern for households and business entities. Through solar PV, consumers can generate and consume their electricity, so the convenience attached to this option is one of the reasons why people are inclined towards this option. The last reason recorded through our survey is environmental reasons. Solar PV systems come under renewable energy technologies and naturally exist in abundance; this technology has no negative impact on the environment, which is why this technology is referred to as clean and green energy. 26.7% of our survey respondents have switched to this option to stop the environmental damage using fossil fuel-generated electricity and to make a responsible choice of clean energy resources.

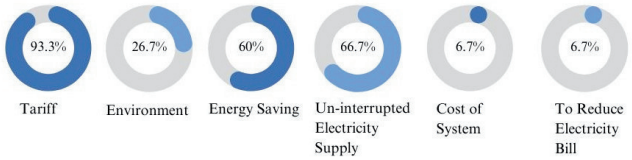

Figure 32: Customer Concerns

- **Impact of Government Regulations on Customers**

According to solar PV installation companies, within the last five years, they have experienced an increased customer base for solar PV within the business sector and among households. 11 out of 15 companies reported an increase in demand for solar PV installation within the business sector. 7 out of 15 companies reported an increase in demand for solar PV within the households. We can see from the data that the increased demand for solar PV in the business sector is more than that for households. There are several reasons for the difference in demand in both the sectors such as awareness and resources. Compared to businesses, households have less awareness. The households are not running businesses, so the stake of surviving is not as high as that of businesses. The second most important reason is financial backing, Businesses can take loans from banks and money lenders based on their business activity but it's not a simple procedure for households to secure loans as the paybacks for households are risky, because of the risk factor attached to the loans granted to households are of high-interest rates as compared to that of businesses.

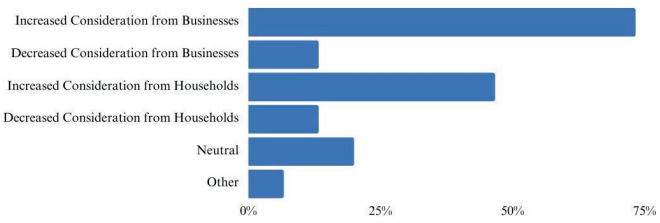

Figure 33: Impact of Govt. Regulations

- **Best Year of Sales**

Based on our survey 73.3% of the companies reported 2022 as the best year for their sales. 6.7% of the companies reported 2019 as the best year of sales. 13.3% of the companies reported 2020 as the best year of sales while in 2021 the increase in sales was reported to be 6.7%. The increase in sales is a compounding trend but we observe sharp increases in the year 2020 and year 2022. As reported by the companies, souring electricity

prices is the number one reason for the boost in sales followed by some other underlying reasons such as government incentives given to the solar energy sector and tax rebates.

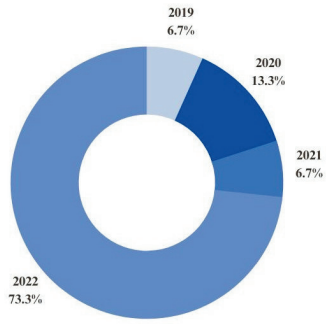

Figure 34: Year of Sales

In the year 2022, 73.3% of companies reported a boost in their sales which is more than double if we compare it with the previous years. As reported by the solar PV companies the credit behind the boost in sales is due to the increasing electricity prices which are making the electricity produced through conventional means increasingly expensive.

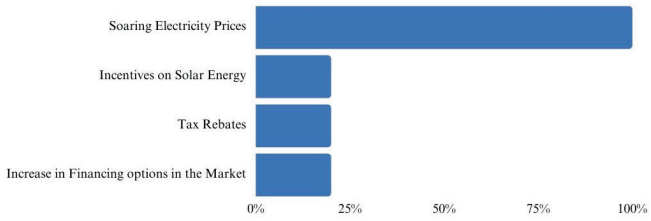

Figure 35: Increase in Sales

- **Payment Preference**

14 out of 15 companies prefer full one-time payment in exchange for their services. These solar PV installations are expensive and currently, there are no financing options available in the market for homeowners are small businesses that can be used for such installations which is why full payments are the most suitable option for these companies.

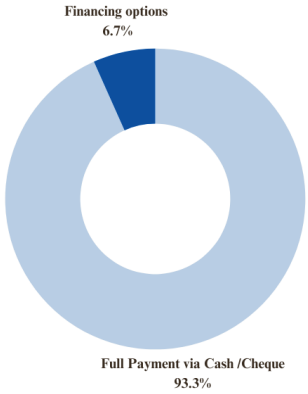

Figure 36: Payment Preference

- **Effect of Economic Conditions**

73.3% have observed that there is more consideration for solar PV systems in the markets in comparison to the previous years as the conventional electricity precise are extremely volatile and are only going up so the individuals having the financials available are switching to this option. 6.7% of the companies have experienced less consideration for solar PV systems which is due to the high prices of these installations and increasing tax duties and import taxes. 20% of companies have observed the response to be neutral which can be due to different reasons such as the populations living in the residential area are not the owner of the houses or the lack of financial resources.

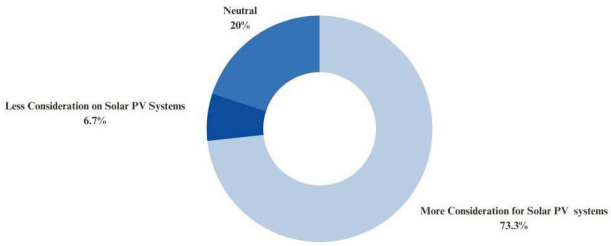

Figure 37: Effect of Economic Conditions

- **Analysis**

Government regulations, energy sector institutions, and all the stakeholders within the energy sector shape and form the overall energy environment. The energy environment is a dynamic and complex interplay of technological advancements, market forces, regulatory framework, regulatory policies, and various stakeholders' actions. The interactions of these entities form the direction of the energy sector. The decisions and actions made today deeply impact the future environment. According to our data, in the past five years, there has been a shift towards solar energy options in all sectors for a steady flow of electricity. Within these past five years, our respondents reported that 2022 was the year in which they recorded the maximum sales, with a 73.3% increase in overall sales. The respondents believe that the increase in sales is due to the soaring electricity prices through conventional methods, which is the electricity derived from fossil fuels. The data shows that many customers switching to solar options are homeowners using it for domestic purposes, which means that this is the most ignored class from the energy equation. The burden of increased electricity prices has passed its maximum limit and they have started switching to this renewable option; the transaction cost is also substantial, which is associated with switching from one source to another. The cost associated with energy change is so high that marginalized groups, which is the real burden, are unable to consider solar PV as an option. Solar PV installation requires a substantial monetary investment, and currently, no loans, instalments, or financial tools are available in the market for people to make this transition easy and smooth. The residential sector is also isolated from the government's subsidy zones. It may be concluded that despite having a high demand and need, the most significant hurdle in the proliferation of solar PV technology is the high cost. The data further shows that only the users with higher steady and surplus financial resources can make this switch. The data shows\ that small businesses and commercial entities are also switching to solar PV to run their everyday businesses. These businesses have operations in services, production, and manufacturing. The maximum capacity of the installation bracket that we have observed is 300 KW to 1000 KW, which again suggests that users are households and small businesses. This trend is because of two reasons: large businesses and industries are in economic zones that are charged subsidized per unit rates and are often given tax rebates, so the electricity burden is less on them. On the other hand, it can be inferred that the infrastructure required for such large businesses requires substantial capital investments, so the businesses are reluctant to switch to this option.

The survey further shows that the market for solar PV is developing only in urban areas, mainly due to the lack of awareness and resources to generate demand. It is also essential for the technical experts to make a market capture strategy and introduce solar PV options to the rural populations. Currently with minimal to absolutely no effort, solar PV companies are experiencing boosts in these sales in the country. Better results can be achieved if the government is interested in this sector and devises financial tools to shift

to this alternative. The shift to solar PV in Pakistan's market is due to the increased electricity prices; nevertheless, it also serves a more significant cause for the overall environment.

The survey data provides a compelling snapshot of the barriers hindering Pakistan's widespread adoption of solar PV systems. The challenges of limited awareness, skepticism, financial constraints, and indifference to environmental and social responsibility call for a multi-faceted approach to drive change. Solar PV has the potential to play a significant role in meeting Pakistan's energy needs and reducing its greenhouse gas emissions. Addressing the mentioned barriers is pivotal in unlocking the potential of solar energy to meet Pakistan's growing energy needs sustainably.

7.3.1 Households and Commercial Businesses Perspective

The survey data suggests that companies and households are not acknowledging the environmental benefits of solar PV. This is a concern, as businesses significantly affect greenhouse gas emissions. It is crucial to convince businesses about the environmental benefits of solar PV and how they can contribute to reducing Pakistan's carbon footprint.

The data also suggests that companies and households are more likely to be interested in the financial benefits of solar PV. This is a positive development, as it suggests that businesses are becoming more open to investing in solar PV if financing options exist. However, it is essential to note that the upfront cost of solar PV systems can still be a barrier for some businesses. The government and other stakeholders can help to reduce this barrier by providing financial incentives for businesses that adopt solar PV.

Overall, the survey data provides valuable insights into the factors hindering the adoption of solar PV in Pakistan. This information can be used to develop policies and programs to promote solar PV adoption in companies and households.

8. Road Map to Solar PV Adoption

8.1 Policy Interventions Recommended

After an in-depth analysis of Pakistan's energy sector with a focus on Solar PV, below is the list of carefully crafted policy interventions recommended that can bring positive developments in the energy sector.

8.1.1 Economic Interventions

Installations of solar PV systems require high initial costs for the investors, and currently, there are no financing options and support mechanisms available in the market, which adds obstacles to this process. If the government were to boost the adoption of solar PV, it is essential to provide financial support to the investors; that can happen by devising financial tools tailored for different clients that help these investors to switch to this alternative. For households, solar PV requires a massive chunk of investment, while for businesses, it is a prolonged return on investment and with long payback periods, such financial considerations hinder the adoption without appropriate financing options. The State Bank of Pakistan, along with other commercial banks, may play a vital role in promoting solar PV installation in Pakistan through innovative financing options such as:

- **Solar Loans**

Solar loans can be provided to the customers to install solar PV at their locations; if these loans are given at low interest rates, the market capture will be efficient. These solar loans can be of two types: secure and unsecured. Secured loans will require borrowers to offer collateral such as a home or an office building. These loans will come with low interest rates due to the collateral backing, while unsecured loans can also be offered to borrowers without asset backing with high interest rates.

- **Power Purchase Agreements**

This option can be offered by solar installation companies. In this option, solar installation companies will install solar panels at the owner's property, and the owner will agree to purchase the electricity at a fixed rate from the solar company. The solar company will be responsible for the operation and maintenance of the equipment.

- **Solar Leases**

Like power purchase agreements, solar leases may allow homeowners or businesses to use the electricity generated without owning it. Regular lease payments to the solar companies in exchange for electricity produced from the installed system will substantially lower the high initial costs of installations.

- **Solar Panel Leasing**

Another creative option can be leasing solar panels, where banks can lease solar panels at fixed monthly charges. Such an arrangement may ensure that borrowers will be safe from long-term purchase and lease agreements and must pay fixed monthly charges for a certain period.

- **Green Grants and Subsidies**

The government can offer green grants and subsidies to large businesses using mega kilowatts of electricity or to homeowners living in polluted areas. These green grants and

and subsidies can be given to target populations to control pollution and the use of fossil fuel-generated electricity.

- **Crowdfunding and Community Solar for Rural and Peri-Urban Areas**

That can be a targeted strategy by the government for specific areas to initiate crowdfunding projects where the entire community can benefit from the green energy option. This option can be used in areas where marginalized populations are located.

8.1.2 Capacity-Related Interventions

To scale up the PV adoption in the country, it is critical to integrate the grid accordingly to minimize losses. When the influx of solar-generated electricity is intermitted into the system, a large amount of energy is lost, resulting in no value addition. In Pakistan's case it is observed that solar-generated electricity is coming from the clusters of posh areas. These concentrated installations from specific areas overload distribution lines, which results in technical challenges such as voltage fluctuations and thermal overloading. Grid integration and load management systems are highly essential for the maximum utilization of solar-generated electricity.

8.1.3 Climate Action Plan

The commitment to curtailing climate change is crucial for future generations and the existence of mankind. As Pakistan has been directly impacted by climate change in the past years, initiating a renewable energy transition in the energy sector is pertinent. A shift from fossil fuels to renewable energy sources will make Pakistan a low-carbon economy and show its commitment to restoring the climate.

8.1.4 Inclusive Policy Making

To have effective policies it is essential that policies are not made in isolation by a single department or a government entity. For policies to bring positive changes in the environment and achieve the set targets big datasets must be utilized and all the stakeholders be it energy-generating companies, money-lending investors, customers and clients, households, businesses, and industries and most importantly the climate must be incorporated within the equation. Policies that are made with reference to small data and small populations yield small benefits.

8.1.5 Long-Term Planning

To fully utilize solar energy, it is essential to form clear-cut goals and targets for its adoption that can be materialized over time for proper planning. Such planning requires collaboration between various governmental departments and the private sector to form public-private partnerships. Learning from international experiences and different case studies worldwide will be helpful. The government must initiate joint projects between planning departments, the State Bank, technical departments, and energy sector organizations. Massive investments will be required from national and international investors to finance energy-related megaprojects.

8.1.6 Research and Development in Solar PV

Investment in research and development is a prerequisite to yield effectiveness and efficiency of the technology and improve the local manufacturing process. Experts from the field must take the initiative in research and

development with the support and funding of the government and energy institutions.

8.1.7 Local Solar PV Manufacturing

It is essential to manufacture solar equipment locally. In this survey, the solar installation companies reported that procurement of solar panels and other materials is complex and involves multiple challenges, such as increasing taxes and import duties alongside the inflating dollar prices. These challenges make it increasingly difficult for solar PV companies to commit to clients on a single quoted price, making the overall process full of obstacles. One solution to all these problems is the local manufacturing of solar PV; it will not only be immune to import taxes and duties but also lower the price of this technology.

8.1.8 Political Will and Support

Adopting renewable energy options requires persistent political support for the renewable energy technologies, specifically those that are feasible and well-advanced in technology and in delivering results. Solar PV is a practical option for Pakistan since it is located in the the hot belt. Solar PV has all the ingredients required to produce fruitful results. The ones lacking are political support and will.

8.1.9 Awareness Campaigns

Education and awareness are a solution to many problems; simple campaigns advocating and promoting solar PV will boost its usage locally, and households and local businesses will consider it a feasible option once educated about its benefits.

8.2 Customized Strategies for Community Engagement in Solar PV Adoption

Policies and interventions are insufficient without target actions tailored for each specific group in the community to encourage various transitions. A multifaceted approach is necessary that caters to the needs and demands of each sector, this will involve customized strategies designed to empower and engage diverse segments within the community. These tailored actions are imperative for encouraging various sectors to transition to solar PV.

8.2.1 Actions for Businesses

To encourage private entities and businesses to adopt solar PV, the government should promote Energy efficiency assessment within the businesses to help them identify areas of improvement such as energy waste incurred by businesses. Further conducting financial analysis is essential, it will provide an evaluation to businesses of the Return on Investment (ROI) pertaining to the solar panel installation. Introducing tax incentives will encourage businesses to shift their business operations to solar PV.

Aligning Solar PV with corporate sustainability goals and green certifications will also encourage businesses to shift to this option.

8.2.2 Actions for Households

Interaction between government institutes and households is necessary for maximum participation. Energy Audits of different areas where energy efficiency can be improved through efficiency measures will educate the residential sector to invest in solar PV.

Assessing solar exposure in different regions and educating the residents about this cost-effective and environment-friendly option will improve their participation. Net metering which is already available to the citizens should be publicized by the government so more and more people become aware.

8.3 Conclusion

This study has attempted to present an objective landscape of the energy mix of Pakistan to prove the significance of the need to adopt solar PV. The government may use evidence-based policy recommendations and policy gaps identified by this study to improve the existing solar PV and renewable energy policies. This study has identified that the prevailing policy structure does not entirely consider the socioeconomic and demographic realities of the country. While fossil fuel plays the primary role in power generation, it leads to large import bills, high environmental costs, and a relatively low supply of the most expensive electricity to end users, resulting in overall energy demand-supply imbalance and inflated prices of goods and services.

Embracing solar PV will help reduce the import bill by generating electricity locally through renewable sources. This may only be possible through effective policy interventions to promote solar equipment production locally and make this available across the board for the urban and rural population. Most of Pakistan's population resides in rural areas, often neglected and lacking a consistent energy supply. Solar PV is a cost-effective way of deploying electricity infrastructure for rural areas. It will uplift the quality of life and improve agricultural practices, reducing food insecurity and poverty. In urban areas, solar PV adoption must not be limited to high-income households and business entities. The government must ensure its adoption through incentives and subsidies to low-income households and small businesses equally. Adopting solar PV will promote energy security by reducing power costs and eliminating power outages that hamper industrial growth and economic prosperity.

Climate change is not an invisible threat anymore. Pakistan has experienced many floods, leaving the country in devastated conditions, which clearly shows Pakistan's vulnerability to climate change. Supporting renewable energy technologies in Pakistan and implementing solar PV will be a positive development to reduce environmental costs caused by fossil fuels. Solar PV adoption will reduce Pakistan's dependence on fossil fuels and help meet its energy needs with a more concrete commitment to the Sustainable Development Goals such as Affordable and Clean Energy-SDG7, Responsible Consumption and Production- SDG12, and Climate Action-SDG13.

Only an inclusive policy can guarantee holistic improvement, which may lead to sustainable development, environmental preservation, and economic growth. It is high time to incorporate renewable energy as the most urgent priority in the energy policy mechanism of Pakistan.

References

- Adnan Sarwar, M. T. (2022). Design and Optimization of Solar PV system for a Fish Farm in Pakistan. IEEE. doi:https://doi.org/10.1109/CCWC54503.2022.9720822
- Bolinger, M. (2009). PTC, ITC, or Cash Grant? An Analysis of the Choice Facing Renewable Power Projects in the Unites States. National Renewable Energy Laboratory . Lawrence Berkeley National Laboratory. Retrieved May 2023, from https://escholarship.org/uc/item/5xf361wm
- (1910). Electricity Act. NEPRA. Retrieved March 2023, from www.nepra.org.pk/Legislation/Act/Regulation%20of%20Generation%20Transmission%20and%20Distribution%20of%20Electric%20Power%20Act%201997%20along%20with%20all%20amendments.pdf
- Galen Barbose, S. W. (2014). Tracking the Sun VII: An Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2013. Laboratory, Lawrence Berkeley National. Retrieved May 2023, from https://escholarship.org/content/qt8cp9c2v2/qt8cp9c2v2.pdf
- GoP. (1994). Policy Framework and Packages of Incentives for Private Sector Power Generation Projects in Pakistan. NEPRA. Retrieved March 2023, from chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://nepra.org.pk/Policies/Power%20Policy%201994.pdf
- GoP. (1995). Policy Framework and Packages of Incentives for Private Sector Hydel Power Generation in Pakistan. NEPRA. Retrieved March 2023, from chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://nepra.org.pk/Policies/Hydel%20Power%20Policy%201995.pdf
- GoP. (1995). Policy Framework and Packages of Incentives For Private Sector Transmission Line Projects In Pakistan. NEPRA. Retrieved March 2023, from chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://nepra.org.pk/Policies/Transmission%20Line%20Policy%20-%20March%201995.pdf
- GoP. (1998). Policy for New Private Independent Power Projects. NEPRA. Retrieved April 2023, from chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://nepra.org.pk/Policies/Power%20Policy%201998.pdf
- GoP. (2002). Policy for Power Generation Projects. NEPRA. Retrieved April 2023, from chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://nepra.org.pk/Policies/Power%20Policy%202002.pdf
- GoP. (2006). Policy for Development of Renewable Energy Power Generation.
- GoP. (2013). National Power Policy. Ministry of Water and Power. Retrieved April 2023, from chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://nepra.org.pk/Policies/National%20Power%20Policy%202013.pdf
- GoP. (2013). National Power Policy of 2013.
- GoP. (2015). Policy Framework for Private Sector Transmission Line Projects. Ministry of Water and Power. Retrieved May 2023, from chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://nepra.org.pk/Policies/Power%20Policy%202015.pdf
- GoP. (2015). Policy Framework for Private Sector, Transmission Line Projects.
- GOP. (2019). Alternate and Renewable energy Policy of 2019.
- GoP. (2022). Framework Guidelines Fast Track Solar PV Initiatives .
- GoP. (2023). National Electric Power Regulatory Authority. Retrieved from https://nepra.org.pk/About.php
- GoP. (2023). National Transmission and Dispatch Company Limited. Retrieved from https://ntdc.gov.pk/
- GoP. (2023). PEPCO Pakistan. Retrieved from https://www.pepcopakistan.com/
- GoP. (2023). Private Power Infrastructure Board. Retrieved from https://www.ppib.gov.pk/ju-download/tag/10-performance-guarantee-standard-format
- GoP. (n.d.). National Electricity Policy of 2021. NEPRA. Retrieved May 2023, from chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://nepra.org.pk/Policies/National%20Electricity%20Policy%202021.pdf

References

- Hassan A. Khan, S. P. (2013). Technological review on solar PV in Pakistan: Scope, practices and recommendations for optimized system design. Renewable and Sustainable Energy Reviews, 23. doi:https://doi.org/10.1016/j.rser.2013.02.031
- Khattak, N., Hassnain, S. R., Shah, S. W., & Mutlib, A. (2007). Identification and Removal of Barriers for Renewable Energy Technologies in Pakistan. doi:https://doi.org/10.1109/ICET.2006.335984
- M. Mujahid Rafique, S. R. (2017). National energy scenario of Pakistan – Current status, future alternatives, and institutional infrastructure: An overview. 69. doi:https://doi.org/10.1016/j.rser.2016.11.057
- Muhammad Wakeel, B. C. (2016). Overview of Energy Portfolio in Pakistan. Energy Procedia. doi:https://doi.org/10.1016/j.egypro.2016.06.024
- Neelam Rathore, L. P. (n.d.). Outline of solar energy in India: advancements, policies, barriers, socio-economic aspects, and impacts of COVID on solar industries. International Journal of Ambient Energy. doi:https://doi.org/10.1080/01430750.2022.2075925
- Qureshi, T. M. (2017). Factors responsible for solar PV adoption at household level: A case of Lahore, Pakistan, 78, 754-763. Renewable and Sustainable Energy Reviews. doi:https://doi.org/10.1016/j.rser.2017.04.020
- Tahir Masood Qureshi, K. U. (2017). Factors responsible for solar PV adoption at household level: A case of Lahore, Pakistan. Science Direct, 78. doi:https://doi.org/10.1016/j.rser.2017.04.020
- Tuan Duong Vu, H. V. (2023). Extend theory of planned behaviour model to explain rooftop solar energy adoption in emerging market. Moderating mechanism of personal innovativeness. Journal of Open innovation Technology Market and Complexity, 9. doi:https://doi.org/10.1016/j.joitmc.2023.100078
- Tuan Duong Vu, H. V. (2023). Extend theory of planned behaviour model to explain rooftop solar energy adoption in emerging market. Moderating mechanism of personal innovativeness. Journal of open Innovation:Technology, market and complexity. doi:https://doi.org/10.1016/j.joitmc.2023.100078
- Wolf D. Grossmann, I. G. (2013). Distributed solar electricity generation across large geographic areas, Part I: A method to optimize site selection, generation and storage. Elsevier, 25. doi:https://doi.org/10.1016/j.rser.2012.08.018
- Yatish Joshi, Z. R. (2015). Factors Affecting Green Purchase Behaviour and Future Research Directions. Science Direct , 3. doi:https://doi.org/10.1016/j.ism.2015.04.001

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