

TRANSITION TOWARDS ALTERNATIVE ENERGY RESOURCES: EMERGENCE OF SOLAR POWER AS SUSTAINABLE GOVERNANCE FOR PAKISTAN

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Abstract

The transition to renewable energy resources in the effort to address Pakistan's sustained energy crisis as well as environmental issues. The objectives of this current study are twofold, the first being to establish the factors that are making people transition to solar energy and the second to identify the barriers when shifting to solar power. To get a better understanding of it a qualitative secondary research approach and case study design was adopted.

From the study the following are the drivers to why solar is adopted in Pakistan today: First there is the decline in the cost of the system, recent advancement in technology and the pursuing of energy security. As Solar energy is a great prospect for reducing the reliance on imported fuels, it can also lessen energy deficits particularly in areas that undergo inadequate service. However, the transition to use solar energy has its own challenges. These are policy inconsistencies issues, high initialization costs, inadequate funding, weak infrastructure, and low public awareness. This study suggests that there is the need to address these problems through action. This paper suggests modifications in policies, partnerships between the public and private domain, new funding mechanisms as well as awareness creation campaigns to advance the use of solar energy that could support the unlimited utilization of actual potential of solar energy, eventually contribute towards creating conditions of sustainable development and thereby secure future

INTRODUCTION

Energy sources other than conventional fossil fuels like coal, oil, or natural gas are referred to as alternate energy resources. Elavarasan (2019) lists solar, wind, hydropower, biomass, and geothermal energy as some of these resources. Since they replace themselves spontaneously and have a much smaller environmental impact than fossil fuels, they are regarded as renewable resources. Because they address issues like resource depletion, energy

security, and climate change, these sources are essential to sustainable development. (Singh, 2024) With increasing concerns about the ecosystem and economic outturn of fossil fuel utilization, many countries, including Pakistan, are exploring alternative energy resources to meet their growing electricity demands. Among these options, **solar power** being one of the most favorable, hopeful and attainable forms of viable and sustainable energy. (Shaikh, ji and Fan, 2015)

WHY TRANSITION TO RENEWABLE ENERGY?

According to Gulzar et al., (2020) transition to a low carbon economy has enormous benefits to society as a whole as well as for the environment.

Cost-benefit being the major advantage from renewable energy for the economy.

Environmental Sustainability as Fossil fuels are major contributors to greenhouse gas emissions, which drive global warming and environmental degradation. Renewable energy sources, on the other hand, produce little to no emissions, making them essential for mitigating climate change.

The **Energy Security** goal as many countries, particularly those reliant on imported fossil fuels, face energy security risks due to price volatility and supply disruptions. Renewable energy can provide a stable and localized energy supply.

Contributing towards **Economic Growth** as Investing in renewable energy can stimulate **job creation** and **technological innovation**. The renewable energy sector, including manufacturing, installation, and maintenance of solar panels, wind turbines, and other systems, has the potential to drive new economic opportunities

Fossil fuels are finite and will eventually run out.

Transitioning to renewable energy ensures a **long-term, sustainable** supply of energy for future generations. (Khalil et al., 2017)

The transition towards alternate energy resources or renewable energy resources is a global movement in the contemporary era focused on the need to address environmental concerns while reducing reliance on fossil fuels to succeed in attaining energy security throughout the world by 2050. According to the International Renewable Energy Agency under United Nations- IRENA, to avoid the worst impact of climate change about 90 percent of the world electricity can and should be coming from renewable energy resources by 2050 (IRENA, 2020). Renewable energy sources, such as solar, wind, hydropower, geothermal, and biomass, provide clean and sustainable alternatives to traditional energy sources like coal, oil, and natural gas. This shift is not only critical for environmental sustainability but also for economic and geopolitical stability.

THE ENERGY CRISIS IN PAKISTAN:

According to Shah, Ahsan and Solangi (2019) Pakistan is one of the many countries that is facing severe energy shortages or crisis with an increasing demand for electricity driven by population growth and industrial expansion.

According to NBR (2015), every one in three people does not have access to electricity in Pakistan. Also the energy demand would rise up-to 24 percent in 2030 according to a report of the Ministry of planning, development and special initiatives (2021). 155% rise in electricity costs since 2021.

The energy sector of Pakistan has faced challenges regarding supply shortages and high electricity costs due to inefficient energy infrastructure. Reliance on imported fossil fuels, primarily oil and gas, has not only contributed to frequent power outages but has also placed a heavy financial burden on the economy as the imports of fossil fuels cost a huge amount on the already fragile economy, also the circular debt on Pakistan is around 13 billion dollars. Furthermore, the environmental consequences of burning fossil fuels, such as pollution and carbon emissions, have prompted the need for cleaner and more sustainable energy solutions because it has been listed in top 10 climate-vulnerable countries which makes it more pertinent for the country to take measures and review its energy policy. (Shah, Ahsan and Solangi, 2019)

SOLAR ENERGY POTENTIAL IN PAKISTAN

In reference to Shah, Ahsan and Solangi (2019) Pakistan has immense potential for solar energy due to its **geographical location** and favorable climatic conditions which is more than enough to meet the present as well as the future electricity demands as the country receives around 300 sunny days per year, providing an abundant and reliable source of solar energy.

As per Adnan et al (2012) said that Pakistan is geographically located in a region that benefits from high solar irradiance, making it ideal for the development of solar power. The country receives 5.3 to 5.6 kWh/m²/day of solar radiation, especially in the southern and southwestern regions. Areas like Sindh, Baluchistan, and parts of Punjab have some of the highest solar energy potential, with long

sunlight hours and clear skies throughout most of the year.

Pakistan's solar energy potential is estimated to be in the range of **2.9 million MW**, far exceeding the country's current energy demand. The vast expanses of arid and semi-arid land, particularly in Balochistan and Sindh, are suitable for large-scale solar projects. (Adnan et al., 2012)

In reference to Mirza et al (2003) Sindh and Punjab- These provinces have strong solar potential, especially for photovoltaic (PV) technology. Punjab, with its expansive flatlands, is ideal for large solar farms, while Sindh's Thar Desert is also recognized as a prime location for solar energy development.

AS CASE OF SUCCESSFUL IMPLEMENTATION OF SOLAR PLANT IN HOSPITALS AND SCHOOLS OF THARPARKAR, SINDH.

In the remote, desert region of Tharparkar, Sindh, two essential public service facilities— Government High School (GHS) Sachal Jhinjhi and Basic Health Unit (BHU) Jadam Jhinjhi— have experienced transformative improvements after receiving solar power systems through the “Lighting Up Lives” project by the Research and Development Foundation (RDF, 2021). Both institutions, which were long hampered by the absence of reliable electricity due to their off-grid locations, now serve as

examples of how solar power can provide sustainable solutions in underserved regions. In very remote places where there is no grid electricity, solar power has changed the way people access important services. Rural schools plus health clinics that once had trouble with bad power supply plus few infrastructures now have good improvements next to solar installation. These changes do not only make daily life better for students and people who need health care in these underserved areas, but they also show the potential of solar energy to reduce inequality and improve the quality of life in the places that are left behind. Local projects strongly support the idea that decentralization and moving towards clean energy can help solve Pakistan's energy problem, especially when it works with development goals as solar power proves to be an effective tool for development in Pakistan's most marginalized regions. (RDF, 2021)

DRIVERS OF SOLAR ENERGY ADOPTION

Pakistan's excessive reliance on non-renewable energy sources is becoming a concern. The figure depicts Pakistan's energy consumption from various sources in 2023. The graph makes it clear that the nation's energy sector is heavily dependent on fossil fuels, which are typically used to meet the nation's energy needs. These fuels include imported petroleum oils, coal, and native natural gas. (Orangzeb et al., 2023)

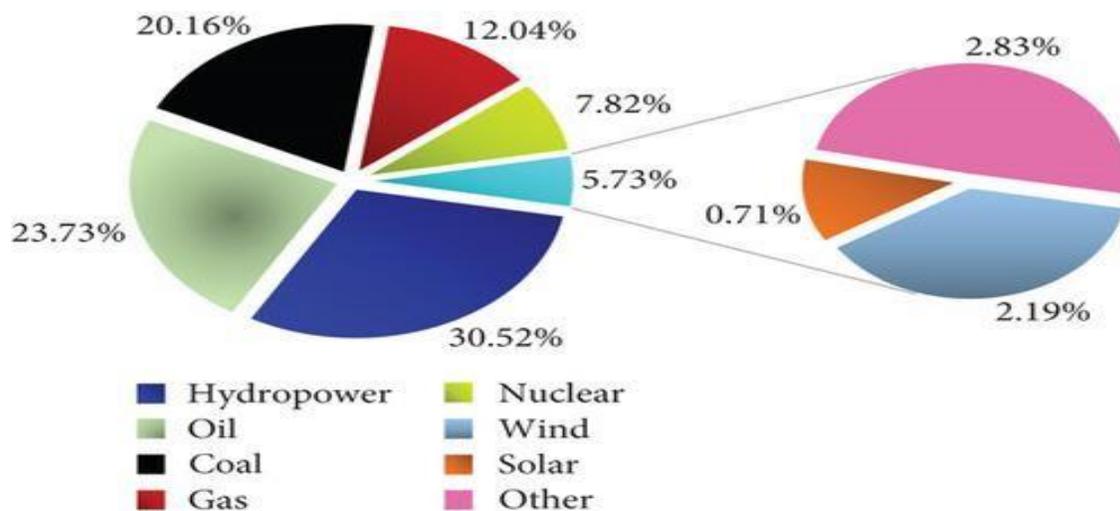


Figure:01 The energy sources used by Pakistan

Source: International journal of Energy Research 2023- Research gate, (Orangzeb et al., 2023)

Due to the problems faced by traditional energy resources, several factors push the adoption of solar power, that includes:

According to Timilsina (2021) the declining cost of solar PV technology has made solar power competitive with traditional fossil fuels. According to the International Renewable Energy Agency (IRENA, 2020), solar PV costs dropped to as low as \$0.068 per kWh, making it cheaper than coal and natural gas in many regions. As it is the cheapest and most promising technology for the future. (Kannan and Vakeesan, 2016)

As said by Lackner et al (2012) there is an urgent need to reduce the greenhouse gas emission moving towards more efficient solutions as relying on fuels is not a sustainable choice and is creating environmental issues. Solar energy is seen as a critical component in reducing carbon emissions and mitigating climate change. (Shahsavari and Akbari, 2018). The shift toward decarbonization has prompted many countries to adopt renewable energy policies that prioritize solar energy deployment. According to Teske (2019) in reference with IPCC (2018) & Joeri et al (2018), limiting global warming to 1.5°C requires a significant increase in the share of renewable energy in the global energy mix, with solar power playing a pivotal role.

In reference to Cherp et al (2012) Countries are turning to solar energy to reduce their reliance on imported fossil fuels, enhancing their energy security and reducing vulnerability to volatile global energy prices. Moner-girona et al (2019) argue that decentralized solar energy systems can also improve energy access in remote and rural areas, contributing to greater energy independence. Improvements in solar PV efficiency, battery storage, and grid integration technologies have made solar energy more reliable and scalable. Hasan et al (2023) emphasize that innovations in energy storage technologies, such as lithium-ion batteries, allow solar energy to be stored and used when the sun is not shining, addressing one of the key limitations of solar power. Thus, making solar energy adaptive by technological advancements is driving people to move towards solar energy instead of traditional resources.

BARRIERS TO SOLAR ENERGY ADOPTION

Despite the solar potential present in Pakistan, solar energy faces several barriers, especially in developing countries like Pakistan:

One of the main barriers in going towards renewable energy resources is inconsistent policies and lack of supportive regulatory frameworks often hinder the growth of solar energy. Yaqoot, Diwan and Kandpal (2016) argue that many developing countries lack long-term renewable energy strategies, which creates uncertainty for investors. The high initial costs of installing solar systems, particularly in regions with underdeveloped financial markets, pose a significant barrier. According to Bazilian et al. (2013), high upfront costs for setting up solar energy systems particularly in rural or areas that have no grid access can put a damper on broad use although the long-term advantages are clear. The lack of adequate infrastructure to support solar energy systems, for example connections to the grid or energy storage can hold back the use of solar energy also limits solar adoption. Also, Khoury et al (2016) highlights several developing nations have difficulties incorporating on-and-off renewable energy sources like solar into their existing power grids. In many developing countries the general public still isn't that aware of what solar energy can do. Hanger et al (2016) state that getting people to accept solar energy is essential for projects especially in the countryside where there's a need to boost education and understanding about these renewable energy methods.

THE ROLE OF POLICY IN SOLAR ENERGY ADOPTION

The success of solar energy uptake is largely dependent on policy frameworks. The solar capacity of nations that have enacted feed-in tariffs (FITs), **renewable portfolio standards (RPS)**, and subsidies for solar installations has grown quickly. Strong governmental backing and financial incentives for utility-scale and domestic solar projects are responsible for the success of solar energy in Germany, Japan, and the US, as per Bohringer et al. (2017).

To get over financial challenges, developing nations now need to have access to global financing channels like the **Green Climate Fund (GCF)**. **Power purchase agreements (PPAs)** and third-party

ownership models are two examples of creative financing methods that Collin, Speer, and Cory (2009) contend can assist lower the high initial costs of solar installations and promote larger adoption and sustainable goals.

THE ENERGY POLICY OF PAKISTAN:

As referenced by Asfand, Suleman, and Ahmed (2022) The 2019 ARE Policy is essential in guiding Pakistan toward a dependably sustainable energy setup. This policy is designed to tackle the severe energy crisis of the nation marked by regular power outages, and a heavy reliance on costly imported fossil fuels, it sets an ambitious and lofty target of having 20% renewable energy in the national grid by 2025 and aims to elevate this to 30% by 2030.

This policy focusing on a variety of renewable sources such as solar wind, biomass and small hydro. This policy moves away from the traditional fossil fuels. It places a strong emphasis on indigenization by fostering local manufacturing capabilities for renewable energy tech, additionally this policy helps in decreasing greenhouse gas emissions and depending on homegrown resources further contributing to environmental sustainability and strengthening economic stability simultaneously.

It introduces measures to promote public-private partnerships, improve grid integration for renewables, and support rural electrification. Specific initiatives include the development of microgrids and net metering systems, particularly in underserved areas. Furthermore, the policy supports innovative business models to attract investments in renewable energy, alongside offering fiscal and financial incentives to reduce initial costs for renewable projects. Global cooperation, such as partnerships with German organizations like GIZ, has been instrumental in promoting renewable energy and energy efficiency programs in Pakistan.

The study argues that the policy, if implemented effectively, can reduce Pakistan's reliance on costly energy imports, minimize environmental degradation, and contribute to the country's energy independence and economic growth.

While all the existing studies examined that the solar energy adoption promotes a better and sustainable future, these studies are limited to the context of several developing countries, there

is limited research that specifically investigates both the drivers and barriers of this transition within the Pakistani context. Most available research have focused largely on either technical feasibility and policy frameworks, with less emphasis on how the socio-economic, financial, and infrastructural factors is shaping the adoption landscape. So, this study addresses that gap by offering an analysis of the key enablers and constraints influencing solar energy adoption in Pakistan's context.

Pakistan as a developing country has always been troubled with a significant energy crisis which usually includes regular power outages, a strong dependence on fossil fuels and climbing energy prices. Such issues lead to energy insecurity, environmental harm and rising prices of electricity. The area most affected by this energy crisis is the residential sector, where households are grappling with the dual challenge of unreliable electricity supply and skyrocketing energy costs. Rural areas, in particular, suffer from limited access to electricity, while urban households face high monthly bills that strain their finances. Pakistan urgently needs to accelerate its transition towards alternative energy resources such as solar power to ensure affordable electricity supply, to ensure long-term sustainability and reliability.

This study is mainly based on Diffusion of Innovations Theory (Rogers, 2003). This theory shows how new technology is adopted in society. Next to perceived benefits, cost, social influence, plus guidelines with existing values. This is helpful to understand why people in Pakistan more and more choose solar energy. Besides, some parts of Energy Transition Theory (Yang et al, 2024) are also in this research. These parts explain the big shift from old energy kinds to sustainable options. Along with that, the study looks at how policy, new ideas, and public opinion work together. They all help to make this energy transformation happen. Also, this theoretical perspective helps frame the analysis of how Pakistan can effectively implement solar power as a sustainable solution for its electricity needs.

Therefore, the study aims to identify the main drivers of solar energy in Pakistan along with key barriers that are hindering the transition and its implementation. For this purpose, following are the questions that the study addresses:

What are the main drivers of solar power adoption in Pakistan? What are the key challenges in fully transitioning towards solar energy? The study contributes to address the challenges faced by Pakistan in its energy sector. The findings aim to shed light and provide a pathway to a more sustainable, economically manageable and environmentally responsible future. This study also aims to enlighten the challenges faced by the residential sector decoding the drivers and the hurdles that are currently facilitating and limiting the adoption of solar power in Pakistan. This study offers to give valuable and actionable insights to the policy makers to facilitate the adoption of solar power in Pakistan.

RESEARCH METHODOLOGY

According to Daniel and Sam (2011) and Kothari (2004), Research Methodology is about the organized methodologies and actions taken to accumulate and scrutinize data within a study, aiding the collection of data, its analysis and the deduction of conclusions. To be certain they mention research methodology assures research is pursued in a reliable manner attests validity and stays objective.

Secondary Research is the process of collecting information from other source whereas Secondary research is particularly very useful in endeavoring to find out trends and patterns and to acquire insights from many already prevailing perspectives (Saunders, Lewis, and Thornhill, 2016). For this study, secondary research is perfectly suited for figuring out what's pushing and what's holding back the use of solar energy in Pakistan. The information obtained from these materials offers a strong foundation to help those making policies and others involved in the energy area with practical proven suggestions for pushing forward with sustainable energy.

This study adopts a **case study design** to explore the drivers of solar energy adoption and the challenges in transitioning toward solar power in Pakistan. By focusing on Pakistan, the research provides a contextualized understanding of socio-economic, environmental, and policy-related factors influencing solar energy. A significant part of this method is to look at actual and real-life projects like the **Tharparkar Solar Project**. This project shows how it helps with the lack of energy and helps the area's

economy grow. The design of this case study includes practical examples and insights that can be acted on. This doesn't just make the academic understanding of how renewable energy is adopted better but also gives useful advice to people making policies and other important people working on fixing Pakistan's energy problems effectively.

This particular study employs a **qualitative approach** focusing on gathering and understanding texts and contexts, it tries to learn more about how and why Pakistan is taking up solar power (Creswell, 2014) work discusses this. According to Bryman (2012) talks about how Qualitative Secondary Analysis, the QSA works by taking previously collected qualitative data which was meant for other research but is now being used to answer new questions that research raises. This qualitative secondary data collection method is quite effective when looking into how Pakistan is leaning more towards using solar energy as a steady way of making electricity.

To find patterns and organize findings into meaningful dimensions such as cost dynamics factors, new technology, policy and regulatory obstacles, and awareness among the public, **qualitative analysis** was used. This careful way of studying things helps us understand better how factors that help and factors that do not help interact in adopting solar energy. Each of these dimensions connects back to the data collected from academic research policy documents and Cases hence ensuring that every element involved in the adoption process is recorded in an organized way. The goal is to pull out important insights that deal with the questions related to both the drivers and obstacles of switching to solar energy. By using both existing qualitative and quantitative insights from secondary sources this analysis aims to fully understand all the elements that influence the adoption of solar power in Pakistan and these findings can help guide policy changes and practical strategies that aim to remove these barriers and quicken the switch to renewable energy in Pakistan.

FINDINGS AND DISCUSSION

A Case study analysis reveals several cases that are related to the drivers of solar adoptions and barriers in the transition towards solar in Pakistan. The categories were developed through reflective patterns

that have emerged from the qualitative data and generated from case studies & documents.

Interpretation of the key findings in light of the theoretical framework and existing literature draws connections between the identified categories and broader patterns observed in the literature. This section interprets the findings of the study in response to the two core research questions, integrating the results with insights from existing literature. The research was guided by the factors that drive solar energy adoption in Pakistan and also to identify the major

challenges present in the transition process. Based on a qualitative approach and analysis, the study aimed to understand how individuals and institutions perceive solar energy and what influences their decisions to adopt or resist it.

Successful Implementation of Solar project in Tharparkar, Sindh

Background: It reveals how solar energy for example through the work of implementing solar power projects in less served areas like Tharparkar can transform local communities. This type of projects has ensured that many people get supply of electricity to their homes. It has also ensured schools and health care facilities become better illustrating the benefits of solar energy and how it supports demands and assists local businesses. However, these good results are still visible only in small particular areas. For these projects to be bigger; there have to be solutions for big problems like high startup costs, low returns, and lack of awareness of these opportunities.

RO:01 Analyzing the Drivers of Solar Energy Adoption in Pakistan

The findings of this research highlight several pivotal drivers behind the adoption of solar energy in Pakistan.

Cost Dynamics as a Driver of Solar Energy Adoption

One of the prominent factor that stands out is how the price of photovoltaic or PV systems is falling. This has made using solar energy a lot cheaper and more people can access it now. In the last ten years the price of these PV systems went down by 68.24% this shows a bigger trend across the world of renewable technology becoming more cost-effective. On the other hand, the price of regular electricity keeps going up and this has become a big reason

pushing both people and businesses towards using solar energy. For example, since 2021 the cost of electricity in Pakistan has gone up by about 155% which has put a lot of financial pressure on both homes and companies. Because of these rising costs, a lot of them are now choosing solar energy as a cheaper option to help reduce their bills. This situation supports the idea that being economically sensible is playing a big role in why solar energy is getting more popular in Pakistan. Since these systems don't cost a lot, it helps more people across different social and economic groups to start using this energy while also dealing with the problem of not having enough energy.

As a result, many are turning to solar energy as a cost-effective alternative to mitigate these escalating expenses. This category aligns with the idea that economic feasibility is a critical motivator for adopting solar energy in Pakistan. The availability of low-cost systems facilitates wider adoption across socio-economic strata while addressing energy shortages.

Technological Advancements and Innovations

The second major category stands out is how important technology advancements are. Better solar panels and new energy storage options like the batteries made from lithium-ion help solve problems with solar power not being always available. This part talks about how technology can make things more reliable and efficient showing how solar power can meet the energy needs now and in the future in Pakistan. Also, it's important that these improvements mean less need to rely on energy from other countries which helps keep the country safe and its economy stable.

So, importantly these advancements also reduce dependence on imported fossil fuels, improving energy security and ultimately results in economic stability as technology brings innovation and fills infrastructure gaps.

Socio-Economic Factors of Solar Projects

A recurring pattern that comes up again is the good things solar energy brings to places that don't have much like Tharparkar. Solar energy projects there have made it easier for people to get electricity, healthcare and schooling. These changes show the

crucial difference renewable energy can make. Even the small scale and local nature of these efforts show that more efforts in this area needs to be done to reach more people. Not only these advancements has raised the quality of life, but they have also pointed to the broader potential of renewable energy solutions as the real life example of Tharparkar, Sindh solar project of Lightning up the lives.

Energy Security

Solar energy assures that the energy security can be enhanced by limiting dependency on imports of fossil fuels and supporting a distributed energy system. It is especially vital for regions lacking or unreliable with traditional energy infrastructure in place, like Tharparkar. With the solar energy being integrated, electricity will be reliable, consistent and therefore contributing to stability in living and the local industries.

Job Creation

Solar energy projects employment opportunities exist across different stages from installation, general maintenance to the operation. These jobs have put the local communities in Tharparkar to work, provide a stable income sources, reduce poverty and develop skills in the renewable energy technologies

Economic Growth

Any solar project is an implementation that inflates local economies by encouraging entrepreneurship and lowers energy costs for businesses. It promotes the growth and success of micro and small enterprises, thereby helping spur economic growth in economies characterized by under development. Sustained growth is also supported by the long-term reduction in energy costs.

Cost-Benefit

With the sun free, free cost benefits make solar energy a wallet friendly source for electricity. Households in Tharparkar have been able to utilise the affordability of solar energy systems to save some money and reinvest this back into education, health services and other essentials.

Environmental Sustainability

Solar energy replaces conventional fossil fuel-based power generation, reducing carbon emissions and reducing environmental degradation. This shift in places like Tharparkar has resulted in cleaner air and healthier ecosystem improving the current as well as the future generation.

Integration of solar energy in the underserved areas such as Tharparkar shows a way to fully address Pakistan's energy and socio-economic challenges. Solar projects help increase the energy security by reducing reliance on fossil fuels and make a steady supply of electricity for households and lifesaving facilities, such as healthcare and education facilities. The initiatives help generate jobs, build skills and support local economic growth by lowering the energy costs and allowing for reallocation of resources. Furthermore, solar energy is helping us to be more environmentally sustainable by cutting emissions and fighting climate change. Replication of these transformative benefits across a nation scale could make such efforts sustainable to resolve Pakistan's energy crisis as well as lead to inclusive socio-economic development and environmental resilience.

Identifying the Challenges in Transitioning Towards Solar Power

Despite the promising drivers, significant barriers hinder Pakistan's transition to solar energy.

Policy and Regulatory Barriers

The move toward solar energy faces challenges that include policy inconsistency and weak regulatory setups. There's no united long-term planning which causes an unsure atmosphere for both investors and other key players, this slows down the process of embracing solar energy. These issues underscore the broader obstructive frameworks that hold back renewable energy progress in places like Pakistan. For example, there's a noticeable absence of specific policies aimed at duplicating successful solar ventures seen in regions such as Tharparkar blocking the expansion of these efforts. The missing long-term goals for renewable energy also add to the uncertainty for those investing which hampers the rise in solar energy use. Such problems are even

more pointed in developing areas like Pakistan where the mix of political and economic instability makes the policy problems even worse.

The lack of long-term renewable energy strategies creates uncertainty for investors, impeding the growth of solar energy adoption. This challenge is particularly acute in developing countries like Pakistan, where political and economic instability exacerbate policy inefficiencies.

Financial and Infrastructure Challenges

Another key pattern is financial barriers which incorporate high initial costs and inadequate infrastructure; these obstacles especially affect rural and low-income areas. They limit their chances of accessing solar energy. Even though it's clear that solar energy has long-term

economic benefits, the cost to start often surpasses what many families and businesses can handle. Old systems for the grid and lacking facilities for energy storage also block the smooth blending of solar power into the energy network of Pakistan. The Tharparkar Sindh case study shows that targeted financial aids like donor contributions or partnerships between public and private sectors can help overcome such challenges in specific places. Yet expanding these solutions calls for changes throughout the systems of funding and building up the infrastructure.

The high initial investment cost of solar power system is a hurdle is transitioning towards solar energy as the financial capabilities of many households and even businesses is limited, so targeted financial interventions are needed as highlighted by the Tharparkar, Sindh case study. Also the outdated grid system further hinders the homogenization of solar energy.

Lack of Public Awareness and Acceptance

In the final category many people don't really know much about the benefits and possibilities that come with solar energy. This lack of awareness often leads to people not wanting to switch to these renewable energy methods; this is seen a lot in places where they haven't been exposed to these technologies. A lot of communities in Pakistan aren't aware of all the good things solar power can bring; they don't want to switch to renewable energy because of this. It's really

important to educate people and get them involved in the community to break down these obstacles and help everyone be more open to solar energy projects. The example of Tharparkar shows that when the community pushes for it and there are programs to help make people more aware it really helps them to accept and take part in solar energy activities.

The lack of public awareness about the advantages of transitioning towards solar that is resulting in resistance to renewable energy solutions also, whenever the society transitions it shows resistance in acceptance to the new things and follows a pattern where elite class are the early adopters and policy innovations also plays a huge role in societal acceptance of the transition.

CONCLUSION AND POLICY RECOMMENDATIONS:

This study aimed to explore the key drivers and barriers associated with the adoption of solar energy in Pakistan, this move to solar energy is seen as a fix to the electricity issues of Pakistan leading towards sustainability. The study points out main factors as cost benefit, technological

improvements and the need to protect the environments that are crucial in pushing for the use of solar power. However, some challenges like lack of funds, inconsistent policies and lack of infrastructure pose big hurdles. But successful examples from Tharparkar show the big impact solar power can have in bettering lives and helping growth in areas that don't get much help. To make the most of this Pakistan needs to tackle these issues with careful planning and strong policies.

Pakistan needs to create a steady policy framework that lasts a long time to push people to invest in solar power. It can be aligned with what is done worldwide and set clear goals for using more renewable energy and how to reach these goals.

By introducing incentives programs giving subsidies, or low-interest loans giving installments plans for solar power installations to reduce the financial burden on households and businesses.

An awareness campaigns can be launched laying out specific objectives for the adoption of renewable energy along with a comprehensive strategy to meet these goals. This could start from promoting awareness at the grassroots level, this would help

bring the community on board by enlightening them about both the financial and environmental perks of solar energy. This initiative could lower the reluctance usually seen towards adopting new technologies.

By Implementing more community-based solar energy projects that are based on community participation, especially in neglected districts, could serve as real-life examples. They could display the immediate positive outcomes of employing solar energy improving the overall quality of life mirroring the success seen in the Tharparkar project in Sindh.

Establishing Green Energy Funds to encourage local and international investors to contribute to renewable energy funds specifically aimed at scaling solar energy projects in Pakistan.

By advancing performance-based contracts and Implementing PPP models with performance-based contracts where private firms are rewarded based on the energy output or number of households electrified.

Supporting local manufacturing of solar panels and associated equipment to reduce dependency on imports as it will create jobs, driving economic growth.

By working in partnership with private companies to set up solar micro-grids in remote villages. The government can subsidize part of the installation cost, while private operators manage the systems and collect small service fees.

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