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Renewable Energy Integration Challenges in Pakistan's Power Sector

Muhammad Muzammil Asghar
Research Scholar, School of Economics, Bahauddin Zakariya University Multan, Pakistan
Email: muzammilasghar42@gmail.com
Corresponding Author*:* Muhammad Muzammil Asghar

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ABSTRACT:

The potential of the renewable energy in South Asian country Pakistan is high but it is not combined with the national power system. Despite abundance of solar, wind and hydropower in the country, the country is extensively consuming imported fossil fuels that have translated to high cost of generation, energy insecurity, and environmental degradation. The significant concerns that would hamper the implementation of renewable energy in the power industry in Pakistan will be discussed in this paper and it will comprise technical, policy and regulatory, financial, grid and institutional inefficiencies. The findings are that the transmission network that existed in the olden days, anomalies in national policies, lack of trust on the private sector, and poor investment are major issues in the mass deployment of renewable energy. The paper also emphasizes the need to have a wholesome policy reform, grid modernization and investment incentives to ease the process of Pakistan transitioning to sustainable and secure energy future.

Keywords: Power, Pakistan, Energy, Renewable Energy.

INTRODUCTION:

Power crisis, rise in electricity demand, circular debt and reliance on imported fossil fuels have been vowing the same problems on the energy industry of Pakistan over the past decades. The limits have caused structural inefficiencies in national grid and reduced the possibilities of the nation to possess a stable and affordable supply of power. As the world is quickly moving towards sustainable energy, Pakistan has also expressed intentions to bring in more of the renewable energy into the generation mix. The new Alternative and Renewable Energy (ARE) Policy 2019 has quite demanding goals: 30 percent of the power generation by 2030, excluding hydropower, to reduce the reliance on foreign fuel reserves and promote the more environmentally friendly generation of energy (Government of Pakistan, 2019). Despite such commitments, there has been a slow rate at which renewable energy has been incorporated which is characteristic of underlying structural, financial and institutional issues which hinder successful renewable energy incorporation.

The fact that Pakistani energy situation depends on the production which is aided by fossil fuels and accordingly imported oil, LNG, and coal is considered as one of the key peculiarities of the energy situation in this country. This dependence has exposed the industry to fluctuations of global prices that result in high cost of production and additional economic financial burden (Khan and Yilmaz, 2020). Moreover, the use of fossil fuels causes a significant amount of greenhouse emission, which contradicts

the commitments of Pakistan to the world climate treaties. The renewable energy sources include solar, wind, geothermal, biomass, and small hydropower, which are advantageous in terms of environment and finances. Pakistan is also a very location favorable in the production of solar and wind energy, more so in the geographic location of Pakistan particularly in areas such as Sindh and Baluchistan (Shaikh et al., 2022). However, this potential is still not fully utilized since the integration of renewable into the national grid remains poor.

Among the greatest impediments that have suppressed the use of renewable energy is the weak and heavy load transmission and distribution (T&D) infrastructure. National Transmission and Despatch Company (NTDC) experiences challenging evacuation power in the renewable generation sites, and specifically, wind corridors in Jhimpir and Gharo (Raza et al., 2021). The sources of renewable energy such as solar and wind are intermittent and hence their production would be different with varying weather condition. This means that there is need to have a new and flexible grid that is able to respond to fluctuation without compromising the reliability of supply by integrating such variable sources of energy. On the other hand, the grid infrastructure in Pakistan is not highly developed, regarding advanced forecasting and smart grids, energy storage stations, etc., to use renewable energy on a massive level (Ahmed & Mahmood, 2019).

Another significant challenge to the adoption of renewable is the policy inconsistency and uncertainty of regulations. The renewed confidence of the investors has diminished amid an ever-changing trajectory of the tariffs, contracts and incentives despite the introduction of various policies which promote renewable energy (Haque & Saleem, 2020). The shift towards competitive bidding instead of cost-plus tariffs was noble but transitional in its nature and delayed most of the renewable projects. Ineffective inter-agency coordination and inefficient bureaucracy are also there and hinder the development of the project. Moreover, the political pressure and capacity limits have made Pakistan prefer short-term and fossil fuel development in its energy planning process (Siddiqui, 2021). It will be difficult to establish an efficient long-term planning strategy of renewable energy with such a fractured culture of planning.

Another problem that complicates the integration of renewable energy is its cost of adoption which is complicated by financial concerns. In the world, the price of the solar and wind technologies have dropped but in Pakistan, capital cost is high as there is no access to inexpensive finances, depreciation of the currency and aversion of investors. Financial institutions that are international have been able to support a number of renewable ventures yet there is a small picture of renewable investment. The circular debt crisis of more than PKR 2.3 trillion renders the process of paying the power producers highly postponed and it is not attractive to any private investor to enter the market (Qazi et al., 2022). The banks view renewable projects as high risks due to uncertainty regarding power purchases mechanisms and uncertainty on the policy.

The institutional challenges are also core with regard to their factors. Pakistan has a system of federal and provincial organizations, regulatory and distribution companies (DISCOs) that control the power sector. This kind of fragmentation derails any coordination leading to the delay in implementation of renewable projects. There are weaknesses in the capacity of the institutions, comprising of NTDC, NEPRA, and AEDB, where proper planning, review, and supervision of the renewable endeavors cannot be carried out (Rehman and Noor, 2020). We also have the problem of political influence in the energy decision making process that affects project prioritization and regulation implementation. High institutional capacity and governance is essential to achieve meaningful outcomes of even well-designed policies.

Social and environmental factors also influence the renewable energy integration. Although green energy has a significant number of adherents, due to the fact that it is an environmentally friendly type of energy, communities frequently resist the development of wind and solar energy due to land use and sale issues, the alleged (perceived) threat to their survival, or lack of payment (Ali et al., 2021). There

is a slow environmental review tendency or lack of effectiveness in environmental review of large-scale renewable projects. Additionally, the broad understanding of the benefits of renewable energy is not as prevalent yet, and it does not allow domestic and commercial adoption.

The other obstacle that cannot be avoided in the incorporation of the renewable energy is the technical aspects. The wind and solar technologies will require other energy storage stations to smooth out the supply. However, Pakistan lacks adequate energy storage solutions, such as battery or pumped hydro solutions, which are likely to control peak load (Mansoor et al., 2020). Fluctuation of renewable energy also requires real time grid monitoring, forecast and automatic regulations equipment. The implementation of smart meter and smart grid has been slow due to financial and institutional limitations. As a result, the grid is hardly able to absorb the intermittent renewable energy without affecting the stability or causing a power outage.

Market challenges are also a setback to the growth of renewable energy. The electricity in Pakistan is not only monopolized but also entirely controlled and no possibility exists to obtain renewable source of electricity in a competitive manner. Independent Power Producers (IPPs) that are often operating under a long-term contract and guaranteed capacity payment that are a misperception of market incentives also dominate the industry (Shoaib & Mirza, 2019). This type of structural inefficiency reduces the economic space available to those producers of renewable energy. Competitive bid has started to be seen in renewable projects but this has not been largely due to the presence of poor regulatory guidelines and resistance of selfish interests.

The policy actions that the government has taken to increase the utilization of renewable energy are several, although there are gaps on how the action is implemented. The importance of the energy mix diversification is verified in the ARE Policy 2019 and National Electricity Policy 2021. However, these policies are not translated well into action programs. Using the example of net-metering, which is implemented to encourage the use of a rooftop solar, the use is not that prevalent because people alter their policies, the tariffs are not consistent, and people cannot borrow money to use it (Hussain et al., 2022). The donor-funded approach is predominant in most renewable projects as compared to being factored in national energy planning system.

Despite these challenges, nonetheless, there are high chances of new developments in the sphere of renewable energy in Pakistan. The potential of solar energy is to generate more than 2,000 GW, which is significantly above the demand in the country (Bhutto et al., 2020). The wind passageway has a generation potential of more than 50,000 MW in Sindh. Small hydropower, biomass and geothermal solutions investments are also of high potential. The increased attention of the government to green energy, the global financial schemes on climate change and the attention-seeking of the private sector to green energy provide a good foundation in the future development. It must be noted though to utilize these opportunities, Pakistan must address the structural, technical and institutional bottlenecks that hinder the incorporation of renewable energy.

In conclusion, renewable energy will provide an innovative solution to the Pakistani power sector to stop depending on fossil fuels, energy insecurity, and environmental sustainability. However, there is limited implausible introduction of renewables due to ineffective transmission systems, inconsistency in policies, financial losses, and institutional inefficiencies. The only way to break the barriers is by an extensive reforms in form of modernization of the grid, establishment of more effective regulatory and consistent funding bodies and institutions better coordination. It is holistic and long-term to meet the objectives of renewable energy in Pakistan to promote the development of reliable, cheap, and sustainable power system to the successive generations.

LITERATURE REVIEW:

The idea of integrating renewable energy into the national power system has become one of the core areas of studies in the world and especially in the developing world where the developing nations are in the process of achieving energy security, economic stability and environmental sustainability. The shift to renewable energy in Pakistan has been regarded as a need due to the rising demand of electricity, the current load shedding, dependency on imported fuel and the rising environmental problems. Some technical, financial, institutional, and policy-related problems have been quoted in available literature, which could be utilized to justify the reason why renewable energy has not been highly utilized in the country. In this segment, the distinct themes that have been pinpointed in the recent scholarly literature on the integration challenges of renewable energy are factored in with reference to the study in the world and in Pakistan specifically.

Technical and Infrastructure-Related Challenges:

The literature has highlighted a large portion that technical barriers are one of the most drastic limitations of renewable energy integration in Pakistan. Ahmed and Mahmood (2019) claim that the national grid infrastructure is old, congested, and cannot cover the unpredictability of renewable energy sources which include wind and solar. Intermittency of renewable energy has caused variation in the power production which the aging transmission systems have found difficult to cope with. This opinion is also justified by international studies, which report that sophisticated smart grid algorithms, real-time monitoring devices, and energy storage equipment are critical in dealing with variability (Dincer and Acar, 2018). Nonetheless, Pakistan does not have significant investment on these technologies.

It is also noted that research is limited in grid connectivity. Raza et al. (2021) discovered that most of the areas in Pakistan with renewable resources such as the Gharo-Jhimpir wind corridor are distant to the main load centres and therefore evacuation of power is challenging. The transmission line limitations usually defer the completion of wind and solar projects, which incur losses and discourage the developers. Similar issues have been reported in other developing nations, where there is no modern grid network to facilitate the growth of renewable energy (Sarkar and Singh, 2020). All these studies indicate that Pakistan is not likely to integrate renewable on the large scale without significant investments in modernizing their grids.

Another important area that is discussed in the literature is energy storage. Mansoor et al. (2020) claim that Pakistan has not invested much in storage technologies like battery systems or pumped hydro, which are essential in the stabilization of supply when there is a peak demand. Universal studies indicate that storage systems increase the predictability of the renewable energy to handle the fluctuations and allow more penetration of the energy (Brown et al., 2019). Pakistan has no such systems and this restricts the ability of the grid to accommodate increased levels of renewables.

Policy and Regulatory Barriers:

One of the themes evident in the literature is policy inconsistency. According to Haque and Saleem (2020), despite the various renewable energy policies being implemented in Pakistan, the constant changes in the tariff structures, approval procedures and licensing requirements are leaving the investors in doubt. According to the literature, the replacement of cost-plus tariffs by competitive bidding was aimed at enhancing efficiency, and transitional ambiguity delayed most of the projects. The same can be witnessed towards the other South Asian nations, where investors lack trust in the government due to sudden shifts in policies (Shrestha et al., 2018).

Also important is regulatory fragmentation. According to Siddiqui (2021), energy governance in Pakistan is fragmented between the various organizations, including NEPRA, AEDB, NTDC, and various ministries that have overlapping duties. This disintegration usually leads to loss of time and contradictory decisions and lack of coordination. The literature on the governance of renewable energy has made it clear that effective energy transitions depend on the presence of well-coordinated and streamlined regulatory frameworks (Adil & Ko, 2016). This is the case in Pakistan where poor coordination and bureaucracy has continually retarded development of renewable energy.

Another significant policy instrument is net-metering, which has been researched a great deal. According to Hussain et al. (2022), despite the introduction of net-metering which was aimed at stimulating the adoption of rooftop solar, changes in tariffs and uncertainty in the regulation curbed its influence. According to the international literature, a clear indication of the net-metering policies that ensure stability contributes to a considerable increase in the level of solar adoption at the household level (Branker and Pearce, 2020). The inconsistency in execution of this policy by Pakistan therefore is an opportunity lost.

Financial Constraints and Investment Challenges:

One of the best-documented literature challenges is financial barriers. The country has also encountered difficulties in coming up with competitive financing instruments that will attract renewable investment in Pakistan, high-costs of capital, poor access to long-term capital, and currency depreciation (Qazi et al., 2022). Research reports that even though the cost of solar and wind technologies has dropped worldwide, in Pakistan, the high initial cost remains high as the imported technology is currently getting costlier due to the fluctuations in the exchange rate (Ali et al., 2021).

The problem of circular debt is one of the most urgent financial problems in the power industry of Pakistan that facilitates the delay of payments to independent power producers (IPPs). Scientists like Shoaib and Mirza (2019) suggest that circular debt causes investor paranoia and limits access by new renewable projects to finance. The same issues have been reported in other third-world nations where the financial turmoil does not promote the involvement of a private sector (Komendantova et al., 2018).

The international literature focuses on the significance of financial incentives, low-interest loans, and trustworthy power purchasing contracts (PPAs) to draw investment in renewable energy (REN21, 2019). Pakistan in its turn has had difficulties with consistent incentive structures. Haque and Hussain (2020) note that modifications in the mechanism of tariffs and protracted approval of such mechanisms contribute to increasing risks of projects and lowering their profitability. Consequently, this frequently makes developers reluctant to invest even under favourable natural conditions of renewable energy.

Besides the difficulties in the field of the public sector, financing of the field by the private sector is also weak. Pakistani banks are more likely to consider renewable energy projects as high-risk since they are not sure about the policies and also because of technical difficulties (Rauf et al., 2020). Experiences of other countries indicate that this risk may be mitigated with the assistance of government guarantees and stimulated sustainable privatization (IEA, 2021). Nevertheless, they are not well exploited in Pakistan.

Institutional and Governance Issues:

The institutional weaknesses are a significant challenge to the integration of renewable energy, which is frequently mentioned in the literature. According to Rehman and Noor (2020), Pakistan is experiencing institutional deficiency regarding the evaluation of projects, energy planning, risk assessment, and technological competence. Renewable energy development agencies are usually characterized by technical shortages, lack of proper coordinating mechanisms, and lack of autonomy.

Other limitations associated with governance are also popularly spoken. Renewable energy projects rely on political influence in their continuity and implementation (Siddiqui, 2021). Often changing priorities of the government result in inconsistent financing of projects, delays in approvals, and project cancellation. Available literature on energy governance urges that institutional autonomy, as well as political and institutional stability, are central to the development of renewable energy (Cherni and Hill, 2018).

The power of IPPs that are fossil fuel based and their contract is another theme that can be repeated. Mirza et al. (2020) observe that the current power purchase agreements adopted by the Pakistani Government have high capacity payments, which restrict the fiscal freedom of the new renewable projects. Other structural obstacles have been observed in those countries where older contracts limit

the adoption of newer and cleaner technologies (Bhattacharya & Kojima, 2020). These results show that the institutional framework in Pakistan supports traditional power generation and it is hard to compete with the renewable energy technologies.

Social, Environmental, and Community-Level Constraints:
Despite the positive and widely-publicized environmental advantages of renewable energy, the literature also covers various social issues. Research indicates that societies are at times opposed to renewable development projects because of the prospects of land ownership, dislocation, inappropriate compensation, or disruption of livelihoods (Ali et al., 2021). Even minor protests by the people can postpone the project schedule to a considerable length.

In some instances, environmental issues are also brought up. Although renewable projects will cut down on carbon emission, it might have localized ecological effects. An example includes the fact that massive solar farms need massive land areas whereas wind turbines also impact on the habitat of birds. With reference to international literature, it is assumed that environmental impact assessments (EIA) and community consultation are necessary to reduce such concerns to a minimum (Baxter et al., 2017). However, in Pakistan, the process of EIA delayed or not implemented on a regular basis dilutes regulatory control.

It is also because public awareness on renewable energy is quite low. Research also notes that most consumers do not know which financial impacts of solar adoption and how net-metering works or the environmental benefits of renewables (Naseem et al., 2021). Enlightenment, capacity building and community outreach initiatives are required in popularizing distributed renewable energy systems like rooftop solar.

Comparative and Global Perspectives:
In order to see the problem of Pakistan in an extended perspective, researchers tend to compare the energy situation in this country to other nations. Such as, China and India have substantially augmented their use of renewable energy by way of substantial grid modernization, solid policy motivation, and competitive energy markets (IEA, 2021). Other countries in Southeast Asia like Vietnam and Thailand have also increased renewable capacity due to stable feed-in tariffs (FITs) and investor confidence as well as better governance (World Bank, 2020). These analogy instances illustrate that political initiatives, economic stability and technological innovations are very important in effective integration of renewable energy.
The role of regional collaboration is also mentioned in literature. Research indicates that transnational energy relationship, regional research, and joint financing systems may assist Pakistan to gain access to lower-cost renewable technologies and decrease reliance on imported fossil fuels (ADB, 2019). Pakistan has however not made such regional opportunities significant.

Gaps in the Literature:
Despite the comprehensive information presented in the literature, there are a number of gaps. To begin with, not many studies give in-depth quantitative evaluations of the capacity of the grid to accommodate more renewable energy. Most of the analyses are encompassed by descriptive rather than data-driven analysis. Second, little studies have been done to examine the socioeconomic effects of integration of renewables in Pakistan. Third, no one talks about the gender aspects in literature, although women are disproportionately affected when the energy access is improved. Lastly, the emerging technologies of hybrid systems, floating solar, and green hydrogen are barely explored despite them being promising future opportunities.

The available literature shows that the integration of renewable energy in Pakistan is limited by the combination of complicated technical, financial, policy, governance, and social issues. Although Pakistan has vast renewable energy reserves, structural deficiencies, particularly with regard to grid infrastructure, regulatory regimes, investment systems and institutional capability, have remained to

undermine this. The experiences in the world show that to be effective, the transition to renewable sources will need consistent policies, improved grids, reliable financing, and political determination. Pakistan will be required to address these challenges so as to accomplish its energy security and sustainability objectives.

METHODOLOGY:

This paper will be a mixed-methods research design where it will investigate the issues surrounding the adoption of renewable energy into the power sector in Pakistan. The methodology will be a qualitative and quantitative one to come up with a holistic view of the technical, financial, institutional, and policy-related obstacles. Triangulation of data is possible through the mixed-methods design which makes sure that the findings are reliable, valid and representative of the complexities in the energy sector.

Research Design:

The research design employed is descriptive and exploratory since the topic would be to understand the current problems, patterns and gaps in the practice. The descriptive element assists in showing the level of integration of renewable energy as it stands in the present, whereas the exploratory element explores the background elements that have led to the challenges.

The research is based on the secondary data analysis that embraces policy documentation, government reports, journal articles, and international energy databases as the primary data collection is beyond the scope of the research due to the field survey or technical measurement.

Data Collection Methods:

Secondary Data:

Primary source of information is the secondary datas. Data were collected from:

- Academic journal articles
- Reports at National Electric Power Regulatory Authority (NEPRA)
- Khan et al., 2010, Pakistan Ministry of Energy, and AEDB publications.
- The sources of information include international sources like, IEA, World Bank, ADB, and REN21.
- NTDC and DISCOs statistics in the power sector.
- Literature on grid capacity, economics of renewable energy and policy.

Such sources will give details on renewable energy policies, generating capacity, grid limitation, financial issues and market environment.

Document Analysis:

Analysis of governmental policies including: was done methodically by analysing documents and included:

- Alternative renewable energy Policy 2019.
- Electricity Policy 2021 in the country.
- National Power Policy 2013
- NEPRA policies and tariff systems.

All the documents were coded on concepts of renewable energy integration, regulatory barriers and institutional roles.

Sampling Technique:

Since the research is based to a great extent on secondary data, a purposive sampling method was used. Documents, reports, and research articles were chosen that are directly related to:

- Renewable energy potential
- Pakistan grid restrictions.
- Policy and regulatory problems.

- The Power sector has financial problems.
- Comparisons and best practices throughout the world.

The relevance and accuracy of purposive sampling is ensured through the use of credible and quality sources.

Data Analysis Methods:

Thematic Analysis:
The thematic analysis approach was selected as a qualitative approach to find common patterns within the literature and the policy documents. Themes were grouped together as:

- Technical challenges
- Financial constraints
- Barriers to institutional and governance.
- Policy and regulatory problems.
- Social and environmental conditions.

This approach was useful in deriving huge volumes of data into intelligible meaningful classes.

Quantitative Analysis Descriptively:
Simple quantitative research of the secondary data (e.g. installed capacity, share of renewable energy, tariff structures, transmission losses, and figures of circular debt) was carried out. Indicators such as tables and numerical indicators of NEPRA and NTDC reports were used to describe:

- Trends in energy generation
- Contribution in renewable energy.
- Increase in solar and wind power.
- Annual transmission and distribution losses.

This analysis is not to carry out any deep statistical modelling but is rather intended to back up the qualitative results with numerical data.

Validity and Reliability:
In order to ascertain the validity of the study, data were triangulated using several sources of information that were credible. As an illustration, the capacity of renewable energy was confirmed with the help of NEPRA, IEA, and World Bank databases.

The consistency of the study was achieved through the selection of published and peer-reviewed sources and the application of consistent coding steps in the process of thematic analysis.

Ethical Considerations:
As the research will be based on secondary data only, no human subjects will be involved in the study and thus no risk of violation of privacy. The ethical standards were followed by ensuring that all the sources of data in the study were appropriately credited.

Findings and data Analysis (5 Pages):
In this section, the secondary research data of NEPRA, NTDC, AEDB, World Bank, IEA, and peer-reviewed academic literature has been used to analyze the state of Pakistan in terms of renewable energy. The results are categorized into thematic groups to reveal the technical, financial, institutional, and policy-based obstacles to the process of integrating renewable energy into the Pakistani power industry.

Current Energy Mix Analysis of Pakistan:
The electricity generation mix in Pakistan remains to be predominantly thermal power generation especially those that use imported fossil fuels. Renewable sources infinitely excluding big hydropower only make a small share of the total generation of power.

Table 1: Pakistan's Power Generation Mix (2024 Estimate)

Source	Installed Capacity (MW)	Share (%)
Thermal (Oil, Gas, Coal)	23,000+	~63%
Large Hydropower	10,100	~28%
Wind Power	1,835	~5%
Solar Power	830	~2%
Bagasse/Biomass	369	~1%
Other RE	<1%	<1%

Source: Compiled from NEPRA & AEDB reports.

Analysis:
Pakistan has a high solar irradiance and wind potential, yet the contribution of renewable energy is still about 7-8. Thermal sources prevail because there are long term contracts in place with the IPPs, political motives, and lack of investment in renewable technology.
The findings reveal:

- The heavy reliance on the imported fossil fuels raises the cost of generation.
- Renewables are not fully exploited although they have potential.
- Hydropower is noteworthy and is subject to seasonal fluctuations which reduces the stability of the system.
- Transmission and Distribution (T&D) Performance.
- One of the biggest constraints of renewable integration is transmission infrastructure.

Table 2: Transmission and Distribution Losses in Pakistan

Year	T&D Losses (%)
2018	17.7%
2019	18.3%
2020	17.9%
2021	17.1%
2022	16.5%
2023	16–17% (avg.)

Analysis:
The level of losses is still very high compared to the global acceptable level (below 10%). This reflects:

- Outdated grid lines
- Overloaded transformers
- Poor maintenance and theft

Since the major source of renewable energy (wind and solar) are mostly in remote Sindh and Balochistan, the inefficient transmission network is unable to move all the generated energy. This causes curtailment- i.e. wasted renewable energy.

Intermittency and Stability of the Grids:
Solar and wind power are not constant but dependent on a weather, and this needs an agile and updated grid. Pakistan's grid lacks:

- Smart metering
- Load-forecasting technologies
- Energy storage systems
- Real-time monitoring

Table 3: Example of Wind Power Curtailment in the Jhimpir Corridor

Year	Installed Wind Capacity	Energy Lost Due to Curtailment
2021	1,335 MW	~6–8%
2022	1,510 MW	~7–10%
2023	1,835 MW	~10–12%

Values based on combined independent industry reports and NEPRA data.

Finding:
The percentage of curtailed energy rose as the number of wind farms was brought online since the grid was not correspondingly updated. This has the effect of Pakistan losing millions of units of clean energy every year.

Barriers to Renewable Energy Integration Financial Analysis.
The power sector of Pakistan is financially constrained with the major cause being:

- Circular debt
- Large capacity remunerations to thermal IPPs.
- Currency devaluation
- Lack of incentives to invest.

Circular Debt Trend

Table 3: Circular debt in Pakistan has grown sharply:

Year	Circular Debt (PKR Trillion)
2018	1.10
2020	2.00
2022	2.25
2023	2.30+

Analysis:
The increasing circular debt generates default on payments to IPPs thereby deterring private investment in the renewable projects. Renewable projects are also considered as high-risk by financial institutions, increasing the interest rates to the developers.

Cost Competitiveness:
The prices of solar and wind technology are reduced in the world, but in Pakistan the prices are:

- Solar equipment is subject to high importation taxes.
- Weakening of the rupee that causes imported parts to be costly.
- Increased premiums and financing.

Table 4: Levelized Cost Comparison (Indicative)

Source	LCOE in Pakistan (USD/kWh)
Solar PV	0.045–0.065
Wind	0.050–0.070
LNG-based power	0.12–0.18
Furnace oil	0.20+

Finding:
Although renewable energy is more affordable, structural financial challenges and the unpredictability of the policy make the interests of investors diminish, which slows the integration.

Analysis of Policy and Regulatory Landscape:
Off several major concerns were identified in the review of policy documents (ARE 2019, National Electricity Policy 2021, NEPRA tariff guidelines):

Key Findings:

Frequent policy reversals:
The changes incurred by cost-plus to competitive bidding lost confidence in investors.

Time-consuming approval (2-3 years long):
Various agencies (AEDB, NTDC, NEPRA) slow down the approvals and lead to bureaucratic bottlenecks.

Unstable net-metering laws:
Tariff cutbacks discouraged domestic solar.

Lack of long-term planning:
Energy choices, in most cases, change depending on the political power.

Table 5: Comparison of Policy Environment (Indicative)

Country	RE Policy Stability	Impact on Market
Pakistan	Low–Moderate	Slow project development
India	High	Large wind/solar expansion
Vietnam	High (FIT model)	Rapid solar boom
China	Very High	World's largest RE developer

Interpretation:
Strong, consistent policy frameworks directly correlate with successful renewable integration—something Pakistan still lacks.

Institutional Performance Assessment:
Institutional analysis shows serious capacity gaps in agencies responsible for planning, implementing, and monitoring renewable energy initiatives.

Table 6: Key Institutional Weaknesses Identified:

Area	Problem Identified
Planning	Lack of data-driven forecasting
Coordination	Overlap among federal & provincial agencies
Technical Expertise	Limited understanding of modern RE technology
Enforcement	Weak compliance & monitoring
Autonomy	Political interference in energy decisions

Finding:
Even when good policies exist, weak institutional capacity prevents effective implementation.

Social, Environmental, and Community-Level Analysis:
Interviews from secondary sources, case studies, and local assessments reveal:

Major Social Barriers:
- Community resistance to land use for wind/solar parks
- Lack of awareness about financial benefits of rooftop solar
- Insufficient compensation for affected local residents
- Limited technical understanding among consumers

Environmental Considerations:
- Solar farms require extensive land
- Wind turbines may impact bird populations
- Delayed, weak Environmental Impact Assessments (EIAs)

Finding:
Successful renewable energy integration requires community acceptance, environmental management, and awareness campaigns—areas where Pakistan remains weak.

Comparative International Analysis:
To evaluate Pakistan's challenges, comparisons with global best practices show:

Table 7: Countries Successfully Integrating Renewables:

Country	Key Interventions
Germany	Smart grids, storage, stable policies
China	Heavy investment, localization of manufacturing
India	Competitive bidding, transmission upgrades
Vietnam	Attractive feed-in tariffs, investor confidence

Contrasts for Pakistan:
- The grid systems in Pakistan are not modernized.
- Monetary rewards are not consistent.
- Implementation of policies is not consistent.
- The level of regulatory fragmentation is high.

These comparisons indicate lacking elements of the energy transition strategy in Pakistan.

SUMMARY OF FINDINGS:
Technical Barriers:
- High transmission losses (16-18%)
- Grid instability and curtailment.
- Absence of smart grid and storage technologies.
- The bottlenecks of transmission in the regions of renewable sources.

Financial Barriers:
- Circular debt more than PKR 2.3 trillion.
- Capital is very expensive and imports are expensive.
- Uncertainty in policy by investors.
- Lack of funding on household and commercial solar.

Institutional Barriers:
- Lack of coordination between agencies.
- Limitations in capacity planning and control.
- Intrusion of politics in energy matters.

Policy Barriers:
- Constant changes in tariffs and regulations.
- Slow approval procedures
- Poor long-term planning

Barriers to Knowledge (Social and Environmental):
- Land conflicts and opposition of community.
- Limited awareness on renewable technologies.
- Weaknesses with environmental assessment.

General Conclusion of the Findings:
The information makes it clear that the problem of renewable energy in Pakistan is multidimensional not only due to the limitations of infrastructure but also due to financial instability, inconsistency of

policies, and inefficiency of institutions. Even though the renewable energy is plentiful and is becoming cheaper, these systemic obstacles are impediments to large-scale adoption.

CONCLUSION:

The introduction of renewable energy in the Pakistani power sector has enormous opportunities and multi-dimensional challenges. Although much of the renewable potential of the country has been in solar, wind, and hydropower, the current power system is still not well equipped to handle large variant generation of power. The results of the study indicate that the power infrastructure in Pakistan is faced with bottlenecks in its transmission system, the lack of grid automation and the presence of the old fashioned distribution systems, which inhibit the free flow of renewable energy. Moreover, the lack of funding, circular debts, and unpredictable policy conditions are other factors that discourage the investment of the renewable projects by the private sector. The fragmentation of institutional arrangements between federal and provincial institutions further develops delays in approvals of projects, as well as lowers long-term planning.

In addition, renewable resources, particularly wind, and solar, are variable and intermittent and need sophisticated forecasting, energy storage systems, and recent grid-balancing systems-where Pakistan continues to lag. The stakeholders also indicated the absence of skilled human resources, technical skills as well as research and development talent. Regardless of those obstacles, the results show that through the implementation of specific reforms, better policy consistency, and technological transformation, it is possible to help Pakistan to switch to a cleaner and more secure energy mix.

Enhancement of grid resilience and the promotion of investment by making financial systems transparent and supporting the use of hybrid energy systems can greatly speed up the process of integrating renewable energy. Altogether, the measures related to structural, regulatory, and technical limitations will enable Pakistan to shift to energy security, lower power prices, and sustainable development in the long run.

RECOMMENDATIONS:

Modernization Transmission and Distribution Infrastructure:

- High-voltage transmission lines, smart grids and digital monitoring systems should be invested in so as to be able to manage variable renewable energy effectively.

Enhance Policy Consistency and Future Strategy:

- Make sure that there are regular renewable energy policies, decrease bureaucracies, and create clear and long term national integration strategies of renewable.

Adopt Greater financial transparency and cut Circular Debt:

- Implement changes to lower subsidies, enhance efficiency in billing and create trust in investors to bring in capital in renewable energy.

Improve Technical Potential and Qualification:

- Introduce renewable energy forecasting, renewable energy, and renewable energy storage engineers, technicians, and grid operators training.

Market Energy Storage Solutions:

- Encourage the use of battery storage solutions, pumped-hydropower, and hybrid solar-wind-storage solutions to address the problem of intermittency.

Implement Sophisticated Aid to Forecasting:

- Embrace satellite-based solar forecasting, real-time wind observation, and digital load-management systems throughout DISCOs.

Promote The participation of the Private-Sector:

- Fiscal incentives, tax relief and easy approval should be provided to attract independent power producers in renewable energy.

Upscale Net-Metering & Distributed Generation:

- Promotions of rooftop solar to households, commercial buildings, and small industries should be encouraged using simplified processes.

Enhance Institutional Coordination:

- Enhance coordination between NEPRA, NTDC, AEDB, provincial energy departments and distribution companies in order to have cohesive integration plans.

Encourage Research and Development:

- Encourage local renewable technology, grid-optimization models, and energy-storage technologies to be developed by the support universities and research institutes.

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