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RENEWABLE ENERGY POTENTIAL IN PAKISTAN AND BARRIERS TO ITS DEVELOPMENT FOR OVERCOMING POWER CRISIS

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Abstract: This paper has critically analyzed barriers to development of potential renewable energy resources to resolve the power crisis in Pakistan. The study was limited to the electric power sector and based on secondary data, experts' opinions and stakeholder consultations. The study tried to explore the question: why the available substantial renewable energy sources in the country are not being tapped to produce electricity and what are the barriers in development of the power sector of Pakistan? Energy experts and stakeholders including government officials and environmental experts were consulted. Focused group discussions and individual consultations were made for seeking opinions and ideas about development and promotion of renewable energy for the power sector. The findings of the study showed that Pakistan's total installed power generation capacity is 39000 MW and the contribution of renewable energy is less than 10% (6% from renewable: wind, solar and bagasse) as compared to conventional sources of energy despite its huge potential. There are political as well as technical, financial and social issues which marginalize renewable energy in the country. In order to improve the situation, there is a dire need to prioritize options in the energy sector and to promote renewable energy by providing strong financial, technical and legal support. Moreover, political stability, visionary leadership and pragmatic and integrated power policy/energy plan are required to promote renewable energy exploitation in the country. It is hoped that this study will help to pinpoint the loopholes and gaps in the development of the power sector along with factors hindering the development and promotion of renewable energy in Pakistan. Based on the findings, it is suggested that improved governance with strategic planning and appropriate implementation mechanisms in the power sector of Pakistan are needed for sustainable energy development.

Keywords: Power Crisis, Power Sector, Energy Governance, Barriers, Renewable Energy, Pakistan

INTRODUCTION

A balance between demand and supply of energy has to be maintained for any country's economic growth (Ozcan&Ozturk, 2019). Pakistan's energy sector remains one of the main obstacles to economic growth. Specifically with reference to the power sector, if we look back in the history of development of electric power in the mid-seventies, the electric power generation from Mangla and Tarbela Dams were enough to meet the energy demand in the country (Abas et al., 2019). Besides fulfilling electric power demand for industrial and domestic consumption, the surplus supply was also available when Pakistan Railways electrified Lahore to Khanewal section of rail track. Afterwards, the pace of electric power generation could not cope with the pace of development in the country, resulting in power crisis with a demand - supply gap of up to 4,500-5,500 MWt till 2013 (GoP, 2013a) which was lethal for the economy of Pakistan at that time. Later on, Pakistan has managed to increase power generation since 2013 and mitigate power blackouts that plagued the country over the past decade in the form of expensive fuel sources, reliance on imported energy products, chronic natural gas and electricity shortages, major debt in the power sector, aging and insufficient transmission and distribution systems have prevented the sector from growing and modernizing. Similarly, weak governance, uncoordinated energy policymaking and a lack of long-term energy planning only add to Pakistan's current energy woes (NEPRA, 2019; Ahmad et al., 2019)

After facing a long period of electric power generation capacity shortages, Pakistan reached a position where the installed power generation capacity was more than sufficient to meet the total demand in the country in FY 2019- 20. From 2016 till June 2020, a total of 13,298 MW electric power generation capacity was added to the

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power system of Pakistan. The total installed power generation capacity of Pakistan, excluding the K-Electric (KE) System, as on 30th June, 2020 was 35,735 MW. The total installed power generation capacity of KE's own power plants is 2,294 MW. In addition, some IPPs and CPPs with a total power generation capacity of 690 MW are also connected to the KE system (GoP, 2020).Pakistan's current primary energy supply stands at about 90vi MTOE in 2020. The country 's overall primary energy supply will rise to 115.06 MTOE by fiscal year 2023, with a Compound Annual Growth Rate (CAGR) of 5.8% in the business as usual scenario (NEECA, 2020).

According to National Electric Power Regulatory Authority's (NEPRA) 2019 yearly report, Pakistan's total installed power generation capacity is 39,000 MW, of which 66% of energy comes from thermal (fossil fuels), 24% from hydro, and 6% from renewable (wind, solar and bagasse) and 4% from nuclear. In the current scenario, renewable energy (RE) resources can play an important role in closing the deficit. All the available sustainable energy resources can be utilized to generate more power to fulfill the need of the time, but unfortunately it remained a neglected fact in Pakistan for a very long time. Pakistan currently relies disproportionately on thermal power generation from local gas fields and expensive imported oil to fuel both government and privately owned and rented power plants (Aized et al., 2018). It is not only an increasing burden on the economy of the country as well as having excessive environmental impacts. As fossil fuels are depleting rapidly; power production of the country is dependent on imported fuel and an increase in its price in the international market results in the expensive power generation (Asif, 2009). Almost all countries are concerned about renewable energy (RE) resources for power generation and formulated laws and policies for RE promotion to achieve a sustainable future. RE is the energy obtained from regenerative or almost inexhaustible resources of energy occurring in the natural environment (Munir& Khalid, 2012). Wind energy, Hydro energy, Thermal, Solar Photovoltaic (PV), Geothermal energy, Biomass and Tidal power are RE resources. Pakistan has been reported to have significant potential of RE resources; solar (PV and thermal) is 2,900,000 MW (installed capacity: 200 MW), wind is 360,000 MW (installed capacity: 308 MW), hydro is 60,000 MW (installed capacity: 6556 MW), biomass is 5000 MW (installed capacity: 35 MW), geothermal is 50,000 MW (installed capacity: nil)as illustrated in Fig 1. With the current government's tilt towards renewable energy, the Ministry of Energy has started working on the development of a new 25-year energy policy. The policy reportedly seeks to have 20-30 percent of all energy derived from renewable energy sources by 2030 and would weaken Pakistan's dependence on imported fuel products.

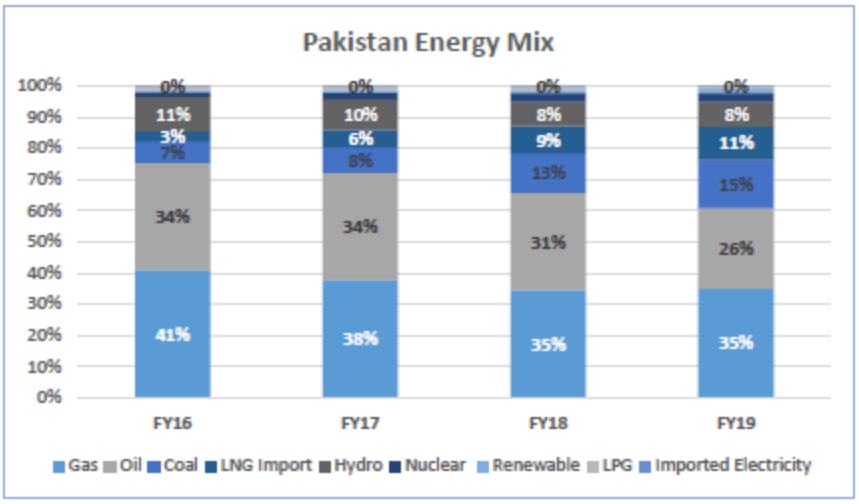

Fig 1: Pakistan energy mix *(Source, PACRA)*

Potential Areas of Renewable Energy Resources

1. Solar

Pakistan is blessed with 5.5 Wh m^{-2} d^{-1} solar insolation with annual mean sunshine duration of 8–10 h d^{-1} throughout the country (Ghafoor et al., 2016). Southwestern province of Balochistan and North Eastern part of Sindh with sunshine between 7 and 8 hours daily offer excellent conditions for exploitation of solar energy. According to the Alternative Energy Development Board (AEDB), the mean global solar irradiance falling on a horizontal surface is about 200–250 W m^{-2} d^{-1} amounting 6840–8280 MJ/m^2 (1.9–2.3 MW h m^{-2}) in a year (Luqman et al., 2015). A study conducted by National Renewable Energy Laboratory (NREL), USA in collaboration with USAID reported that solar energy potential of 2.9 Million MW exists in Pakistan (Ghafoor et al., 2017). Photovoltaic systems of 100-500 W/unit have been used for producing electricity in some rural areas (Sheikh, 2010). Currently, there are 40,000 villages which are far from the national grid for which the

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government of Pakistan (GoP) launched the Rural Electrification Program; solar home systems (SHS) will be used for this purpose (GoP, 2013b). Pakistan Council for Renewable Energy Technology (PCRET) has also started to ensure the establishment and maintenance of solar and other RE based projects. Alternative Energy Development Board (AEDB) also participated in this effort 2003 onward. But finance and technical knowledge appeared a great hindrance in this effort (Sheikh, 2010).

2. Wind power

Wind power potential is real in the southern and coastal areas of Sindh and Balochistan provinces. Nearly 1,050 km coastline has stable winds with average speeds of 5-7 m/s throughout the year with more than 20,000 MW of economically feasible wind power potential (Ghafoor et al., 2016). It was reported that the total potential of wind energy in Pakistan is around 346,000 MW out of which 120,000 MW is viable (Farooqui, 2014). A study carried out by PMD shows that Sindh coastal areas have gross wind power potential of 43,871 MW out of which viable potential is 11,000 MW higher than that of Balochistan areas (Ghafoor et al., 2016). Having such a large potential and suitable wind speed, the GoP could not tap the wind power potential proficiently. It is pertinent to mention that, according to the India Renewable Energy Market Report, India has World's fourth largest number of wind turbines installed at 7,093 MWt. While Germany has the highest at 21,283 MWt; Spain is at second with 13,400 MWt and the US stands at the third number with 12,934 MWt.

3. Hydro power

Pakistan has huge potential for hydropower especially in the Northern part of the country. Pakistan has approximately 54,000 MW potential of hydropower generation (Ghafoor et al., 2016), but has only 6,599 MW installed capacity of electricity generation through hydro power (Raza et al., 2015). Hydro is the cheapest source of power generation which can provide tariff relief and economic benefits to the consumers and is far less polluting. The major hydropower generation sites include DiamerBasha Dam (4,500 MW) and Bunji (5,400 MW). The major hydropower generation plants installed in Pakistan are Tarbela, Ghazi Barotha, Mangla, Warsak and Chashma with installed capacity of 3,478, 1,450, 1,000, 240 and 184 MW respectively (Raza et al., 2015).

4. Geothermal reservoirs

Geothermal reservoirs exist in Pakistan(Gondal et al., 2017). Numerous hot springs with temperatures ranging from 30-170 ˚C have been identified in the vicinity of Karachi and Pakistani part of the Himalayas (Sheikh, 2010). But, still not a single attempt has been made to utilize geothermal energy. Many countries like Australia, Austria, China, Ethiopia, Germany, Iceland, Indonesia, Italy, Japan, Kenya, Mexico, New Zealand, Philippines, Russia, Thailand, Turkey and USA are utilizing their indigenous geothermal energy.

5. Biomass/waste to energy

As far as waste to energy is concerned, Pakistan has its considerable potential; both for municipal solid waste (MSW) and agricultural solid waste in the form of bagasse, but its contribution in power production is zero.The total power potential from all sources of biomass (municipal and agricultural solid waste) is 77, 311 GW h. Municipal Solid Waste is also available abundantly in the country and can be used as a source of power generation. According to an estimate, about 7,121,626 t per year MSW is generated in the major city centers of the country (Ghafoor et al., 2016) e.g., Karachi 9,000 tons /day and other cities about 2,000 - 6,000 tons/day (AEDB, 2014).

6. Bioenergy

The biogas potential calculated for Pakistan is 27.5 Million m^3 d^{-1}. About 81 million ton/annum biomass production has a huge potential to produce enough bio-energy by employing different technologies viz. combustion, gasification, pyrolysis, trans-esterification process etc. Similarly, available dung from 72 million animals (cows and buffalos) and available poultry droppings from 785 million poultry birds can produce considerable biogas to produce heat and electricity (Ghafoor et al., 2016). Areas having biomass energy production have been identified which can provide energy for electricity. In addition, Pakistan has a suitable climate and soil properties for energy plantation *i.e. Jatrophacurcas*(Jamal Ghotta), *Ricinuscommunis* (Castor), *Pongamiapinata* (Sukh Chain) etc. These plants can be used to produce biodiesel which will ultimately cut-off diesel import bill. Also, a *Jatropha* nursery and a *Jatropha* Model Farm at 22 acres land at PipriMarshalling Yard (PMY), Karachi has been established in collaboration with AEDB and Pakistan State Oil (PSO) Limited (Bhutto et al., 2011).Biogas can also be used in a more energy efficient way throughout the whole year. In many European Union (EU) countries, state ordinance guarantee access to the grid. Quality standards have also been

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defined by many developed countries for biogas injection into the national grid. These countries include Germany, Sweden and Switzerland (Weiland, 2010).

7. Institutions working on RE

Many organizations have been established by the Government of Pakistan (GoP) to develop and promote renewable energy technologies (RETs). Public sector organizations are at the forefront in research, development, promotion and dissemination of RE. For example Pakistan Council for Appropriate Technology (PCAT) was established in 1975, National Institute of Silicon Technology (NIST) in 1981 after that in 2001 GoP established PCRET by merging NIST and PCAT (Sheikh, 2010). In 2003, for the first time, the GoP created an autonomous Alternative Energy Development Board (AEDB), to promote the use of RE in Pakistan. Before it, there was no use of RE at large scale. In 2016, National Energy Conservation Centre (ENERCON) was transformed into National Energy Efficiency and Conservation Authority (NEECA) and took a lead on rolling out energy efficiency and conservation in Pakistan with the formulation of NEECA Strategic Plan 2020-2023. The National Environment Action Plan-Support Program (NEAP-SP) is also concerned about energy conservation and RE resources. It was signed between the GoP and United Nations Development Program (UNDP) in 1997 (Sheikh, 2010). Recently, Alternative and Renewable Energy Policy (ARE), 2019 has been notified by the GoP which aims to create a conducive environment for the sustainable growth of the ARE sector in Pakistan. In the past, in late 1970s and early 1980s, different programs for new RETs dissemination had started in Pakistan, but lack of technical know-how, limited financial support, operational difficulties and high cost of systems proved to be huge barriers to the failure of these programs (Hasan, 2013). Currently, the GoP is also taking some initiatives to solve the issue but the results are not very satisfying. Development of RETs is influenced by a variety of techno-socio-economic factors including the financial and fiscal incentives provided by the federal and provincial governments (Hasan, 2013).

Regulatory Framework for Renewable Energy Promotion

As far as the regulatory framework for RE promotion is concerned, according to the RE policy network for the 21st century (REN21)2013 Global Status Report, Pakistan has regulatory policies and targets, fiscal incentives and public financing for the propagation of RE resources. RE targets, feed in tariff/premium payment and net metering exists at national level under the regulatory policies and targets. In addition, public investment loans and grants also exist under public financing (Al Jaber et al., 2010).Despite having policies and plans, what are the reasons for the power crisis in Pakistan in the context of available RE potential? These questions are the subject of the present study.

METHODOLOGY

The present study is a qualitative study based on both primary as well as secondary data collected from three sources: academic literature, government official documents (secondary data) and expert's opinions/ consultation (primary data).

Academic Literature

A review of the research work available in the scientific literature, i.e., research articles, books and reports on the subject of RE was carried out to establish a link with the potential of development of RE resources in the present scenario of energy crisis in Pakistan.

Government's Official Documents

The reports published by the public sector organizations concerned with power were obtained from various sources and were reviewed to get insight. These reports included

1. State of Industry (SOI) Report prepared by National Electric Power Regulatory Authority, Islamabad, 2020.
2. Renewable Energy Prospects, Policies and Projects prepared by Alternate Energy Development Board, Islamabad.
3. Pakistan Energy Year Book, 2020 prepared by Hydrocarbon Institute of Pakistan, Islamabad.
4. National Energy Efficiency and Conservation Authority (NEECA) – Strategic Plan (2020-2023) by Ministry of Energy (Power Division), Islamabad.
5. Economic Survey of Pakistan, 2020, Government of Pakistan.
6. Power Generation: An overview, PACRA, January 2021.

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Critical Review of other Official Documents

Information about available potential energy resources and their utilization in the power sector were obtained from the departments listed below and examined in the context of the nexus between research and policy related to RE development.

- Alternative Energy Development Board (AEDB)
- Pakistan Council for Renewable Energy Technology (PCRET)
- Water and Power Development Authority (WAPDA)
- National Electric Power Regulatory Authority (NEPRA)
- Hydrocarbon Development Institute of Pakistan (HDIP)
- Private Power Infrastructure Board (PPIB)
- Planning Commission of Pakistan

Experts' Opinion/Consultations

There was a consultation process with different stakeholders e.g. government officials and energy experts. Individual and collective focused group discussions and interviews have been arranged with concerned government departments dealing with power for their opinions and ideas about development of the power sector. Interviews were both open and closed ended aiming at receiving a deep insight of the power crisis.

RESULTS AND DISCUSSION

Presently the power sector of Pakistan is in an immense crisis. Public sector organizations like Water and Power Development Authority (WAPDA) and Karachi Electric Supply Company (KESC) have to face high system losses, mismanagement, poor recoveries, poor service delivery and inefficiency. The overall electricity capacity of RE resources in Pakistan is 12,896 MW (IRENA, 2020) which shows that all these RE resources have great potential to meet the current and future demand of the electric power sector of Pakistan. But their share in power generation of Pakistan is only 40,670 GWh. Total power generation capacity of Pakistan as of 2018 was 147,910 GWh; of which 33,450 GWh hydro/marine, 1,545 GWh solar, 2,651 GWh wind, 3,024 GWh bioenergy (IRENA, 2020). Gross electricity generation in Pakistan increased gradually over the past decade from 90 billion kWh in 2005 to 110 billion kWh in 2015. Key sources of power production in 2015 were oil (35%), natural gas (29%), and hydroelectricity (30%). Nuclear generation made up 5%, and wind and imported electricity from Iran accounted for 1%. Natural gas supply shortages over the past several years have led to an increased share of oil use in power generation. Installed capacity reached 25 gigawatts (GW), increasing by about 5% from 2014 to 2015, primarily because of fossil fuel power plants additions. Despite the increase in total installed capacity, power plants have faced low utilization rates, mostly because of fuel shortages (EIA, 2018).

Utilization of RE resources for power generation is an option Pakistan is blessed with, it also leads to sustainable development (Farooq& Kumar, 2013). Being a power-deficient country, Pakistan needs to exploit its indigenous RE resources, as the RE potential of Pakistan can make attractive contributions to its power supply mix (AEDB, 2014). In 2015, Pakistan and China entered into the China-Pakistan Economic Corridor (CPEC) agreement, which could help Pakistan decrease costs of electricity generation and alleviate electricity shortages by 2020. The agreement includes $34 billion of investment from China to be used for developing energy infrastructure, including more than 10,400 MW of power plant capacity from coal and renewable energy (EIA, 2018)

Pakistan's energy supply market can be diversified easily through the exploitation of R.E resources. The long term sustainable energy supplies can also be maintained and import dependency for fuel can be cut down in addition to environmental pollution (Asif, 2009; Ahmad et al., 2019). The government is now taking some initiatives to solve the issue, but the results are not very satisfying. Pakistan has tremendous opportunities for exploiting RE resources due to its favourable climatic conditions, coastline and plentiful fresh water resources. Pakistan is yet to take maximum advantage of these gifts of nature.

The total energy production in the country in 2018 was 67.96 Mtoe and total primary energy supply was 111.28 Mtoe and electricity final consumption was 125.76 Mtoe shows that Pakistan is a net importer of energy (IEA, 2018). The reason is the imbalance in the energy mix of countries (Aized et al., 2018). Electricity production is mainly achieved by utilizing thermal resources while having huge RE resource potential. According to the Pakistan Energy Year Book 2013, the country's energy needs are heavily dependent on oil and gas. Pakistan is a net importer of energy and is importing around 30% of energy requirements in the form of crude oil, petroleum products, coal, LPG etc., which costs over US$ 14.45 billion on imports and every increase in oil prices in international market results an increase in fuel prices in the country (GoP, 2013b). Thus, increasing fuel price results in increased cost of electricity production, which also enhances the power crisis. Per unit cost of electricity is very high in Pakistan due to lack of appropriate funding to the concerned authorities, inflation and

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poor government policies (Ali, 2011). It shows a very desperate situation in terms of RE exploitation. There are surely many political, technical and social issues related to this negligence which have evoked the power crisis.

Analysis of Stakeholder's Views

On analysis of the response of stakeholders, various hindrances in the development of renewable energy resources in Pakistan were identified, which are summarized below.

Although many technical, political, financial and social issues were identified, the lack of visionary leadership was found to be the root cause of all hindrances in the development of RE resources in the power sector as it was not the first priority of the past governments. Due to mismanaged law and order situation and terrorism in the country after 9/11, the attention of government remained diverted to other issues like security and terrorism. Due to the poor law and order situation of the country, investors did not invest in the power sector of Pakistan. In addition, lack of pre planning due to non-availability of demand and supply data was also a deficiency of government which led to non-fulfillment of power demand. It was also configured that there is a lack of implementation of power policies and the government should take this matter seriously. Also, there is a lack of coordination in national power policy making which leads to future conflicts of provinces. As a result, RE based power projects cannot be established in the country. Moreover, policies are declared as just commitments lacking practical implementation, one example is the metering system mentioned in RE policy 2006, but it is still not implemented. Non-payment of circular debt from the GoP to independent power producers (IPPs) was another contributing factor to the power crisis. Institutional inefficiency and corruption were also identified as a big hindrance in the way of RE promotion in the country.

Moreover, high capital cost of RE based power projects was recognized as the main hindrance for RE promotion in the country. Lack of technical knowledge is also a problem, and the available technical human resource is not provided with job opportunities to work in the RE sector. On the other hand, administrative mismanagement is also playing a big role in RE marginalization. Side by side transmission and distribution loss/electricity theft is enhancing the power crisis. It is a governance issue; the government should make suitable strategies in order to control such illegal activities. IPPs were identified as a great hindrance in the way of RE promotion in the country because they cannot get urgent profit by investing in RE based power projects. So, they prefer thermal electricity production to gain profit in a short time. Also, the grid code was acknowledged as a worthwhile issue related to RE based power generation. Low voltage wires are also a problem to evacuate electricity from RE based power production systems. In addition, absence of base load plants in case of RE based power generation systems is also a big issue to be considered by the government. Inconsistency of RE resources is a major hindrance for power production through RE resources. Additionally, lack of awareness and social acceptance hinder RE promotion in the country. It is restricted to some parts of the country; for example biogas potential is abundant in Punjab, solar in Balochistan, wind potential resides in Sindh and hydro potential is mostly restricted to the northern part of the country. So, it is expensive to deliver transmission lines to all over the country, which results in the issue of power evacuation especially in mountainous areas, where provision of transmission lines is very costly.

There were also some recommendations from the side of stakeholders that include; RETs should be imported from developed countries. But, the political instability and bad governance were identified as main hurdles in the way of technology import. It was also suggested that there should be international exposure of students for technical training in the power sector. There is a lack of scientific culture in the country. There is a need to develop the manufacturing industry of RET in the country so that RET import expenses can be cut down which will ultimately lower the electricity production cost. Campaigns should be started at all levels to educate masses about RETs in order to increase its acceptability and mainstreaming.

As far as power policies are concerned, some changes were recommended by stakeholders, for example, bagasse was not included in the scope of RE policy 2006, but now it is also added. In addition, standalone projects were recommended as a favourable solution for the areas not connected to the grid. Moreover, power conservation was declared as an approachable strategy to cope with the energy crisis. Most important of all, it was emphasized to make practical power policies in the right direction.

While endorsing the views of stakeholders following barriers have been identified in the development of the power sector of Pakistan in the context of RE.

Barriers in the Development of Power Sector of Pakistan

1. Bad governance

The reason for the energy crisis in Pakistan, as in other developing countries, is generally the low priority given to the energy sector by the governments for a long time. There has been a lack of visionary leadership since long in the history of Pakistan in harnessing the potential of RE. Power produced by the public sector has higher

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production cost than the private sector. The reason is that the public sector is not willing to invest in upgrading its power plants which results in inefficiency in power production. Moreover, political instability in Pakistan also hinders private investment in the power sector. Fund allocation for the development of RE is not satisfactory. Government can attract technical human resources to the energy sector by benefiting them with handsome incentives. However, the present Government has shown seriousness towards neglected RE potential in the country by taking up several initiatives for escalating RE contribution in the energy sector.

2. Electricity theft and line losses

WAPDA is facing a problem of huge line losses due to electricity theft or illegal usage of electricity. According to NEPRA, electricity theft from the national grid stood at 3.9 per cent. Based on an energy supply of 120,400.5GWh, and unit sale price of Rs11.37/kWh, power theft came out to be Rs53.4bn. This burden is borne by the GoP, which pushes the government towards financial crisis.

3. Circular debt

As a consequence of aforementioned reasons, the government cannot release payments to IPP's; IPP's in turn cannot pay off their petroleum import expenses which affect their production capacity and they have to stop electricity production or have to import fuel on credit under pressure, which leads to circular debt. As a result, consumers have to bear long hours of load shedding and to pay higher per unit price to the IPP's. Almost half of the country's electricity is provided by IPP's due to which, not only our local industries and homes are getting affected, but also our exports of manufacturing goods are going down. As of June 30, circular debt was recorded at Rs1.196 trillion, of which Rs613bn is outstanding towards independent power producers and fuel suppliers. It is the government's failure to provide promised incentives to investors, which hinder them from investing in the power sector, ultimately affecting RE promotion in the country. To overcome such a crisis, the circular debt must be paid by the government.

4. IPPs and power crisis

According to 1994 power policy, the GoP permitted the private sector to invest in the power sector with the aim to ensure continuous electricity supply, and 19 IPPs were commissioned. These IPPs brought over $3.0billion investment in the power sector. In addition to lavish tariffs, power purchase and fuel supply was also guaranteed to IPPs by GoP. Power policy 1994 has ruined the financial performance of WAPDA and KESC. For the first 10 years, the GoP offered to purchase electricity from IPPs at $ 0.060/Kwh that was twice the KESC thermal generation and four times WAPDA's average hydropower generation. This high front-end tariff resulted in high tariffs i.e. $ 0.083/kWh in initial years. An additional premium of $0.0025/kWh for the first 10 years was also offered for projects commissioned by1997. This exacerbation of power purchase from IPPs also led to underutilization of indigenous capacities within WAPDA and KESC. In addition to this, according to the 1994 power policy, if the Government does not purchase power from IPPs, the GoP would still pay the IPPs for 60.0 percent of their plant capacity. In this way, IPPs affected the power sector of the country seriously. Also the location of IPPs being far from load centers laid severe stress on the country's physical infrastructure, including the electricity transmission system. Therefore, the introduction of IPP's was only an addition to the already growing problem of power crisis rather than any relief (SDPI, 2014).

As far as RE resource marginalization in the power sector is concerned, following challenges are faced by RE resources.

5. Lack of concurrent planning

Existing policies are mere commitments, but not practical. Incentives promised to IPPs are not provided to them. A big example is circular debt, which is a big issue to be solved between the government and IPPs. In addition, at the time of planning and policy making, the government overlooks the availability of energy infrastructure which will become the reason for the long time period required or failure to complete RE based power projects. Moreover, pre planning on the basis of future demand and supply is required so that before the occurrence of expected energy shortfall, projects will complete. Unfortunately, there is lack of concurrent planning which should involve all the organizations dealing with power.

6. Tariff determination issue

There is no logical tariff determination mechanism adopted by NEPRA. Government officials with irrelevant qualifications do not have capability to deal with tariff decisions of all RE resources. Every RE has its own requirements which are neglected while determining tariff. Technological issues and capital cost investment are not considered while determining tariffs. Due to lack of expertise of regulators, tariff determination remains a problem as a result investors hesitate to invest in RE power production.

7. Corruption

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Preference of the personal benefits of responsible authorities over national interest is also a great hindrance in RE promotion. There is no proper monitoring and evaluation system where honesty and dedication to national interests is certified by the government through proper check and balance. Mere demand of finances and release of funds for RET projects is insufficient to bring technological revolution (Sheikh, 2010).

8. Inconsistent resources

Some RE resources are inconsistent as they are not available all the time, e.g. wind speed varies with time but to generate electricity through wind, steady speed of wind should be maintained to run a turbine. Moreover, other characteristics of wind like humidity also affect electricity production. In the case of hydro, there is a risk of seasonal variation.

9. High capital cost

RE has a high initial cost due to import of RETs e.g., wind turbine and solar panel import. For example; estimated cost of wind power projects in 50MWt or higher denomination accounts US$120-130 million /50MWt with a 20 years project life. Similarly, the estimated cost of small hydro power projects accounts US$ 1.5-2.0 million per MWt and the estimated cost of the waste to energy (WTE) plant would be US$ 2.5-3.0 million/MWt with the project life of 25 years. Likewise, for PV/Thermal power projects it costs US$ 200 – 240 million per 50 MWt with a project life of 20 years (AEDB, 2014). R.E development depends on the capital cost of RE based projects and technological progress, both of which are driven by energy policy priorities.

10. Financial barriers

Although RE is exempted from tax, its capital cost is high. Investors are also not very interested to invest in power projects based on RE due to non-reliability of resource assessment data for example, unreliable wind speed projections (Yazdanie& Rutherford, 2010) and water flow data. Due to these limitations, there is no appreciable international investment on RE based power projects and the problem of finance persists. Also, old technology should be replaced with new one, but it is expensive (Shah et al., 2019).

11. Lack of technical knowledge

Lack of technical knowledge is a great hindrance in the propagation of RE. History is a witness that in early 1980s, the Government of Pakistan had 18 PV systems with a composite output of 440 kW installed in various parts of the country. In the 1990s, these systems collapsed due to lack of know-how about operation and maintenance (Sheikh, 2010). RE based power plants are not manufactured in the country and are still imported from other countries. Unfortunately, due to lack of planning and coordination with other countries at government level, RETs are still not imported (Sheikh, 2010). Research and development activities are also needed to support RETs promotion in the country. Practical information about RETs installation is also missing. Similarly, there is a lack of scientific culture in Pakistan. Technical exposure of human resources through foreign training is missing which has much significance for the promotion of RETs.

12. Lack of RET manufacturing industry

Due to the financial crisis, it is difficult for Pakistan to develop a RET manufacturing industry and have to import it from other developed countries. Ultimately, the cost of RE based power projects has become so high that it is not affordable by people which is one of main hurdles in dissemination of RE in the country. If the manufacturing industry is established in Pakistan, this cost will be in the affordable range. Currently, solar panels are assembled in Pakistan, but not at large scale. Another option is to import only solar cells and assemble solar panels in Pakistan. It will also reduce transportation cost ultimately minimizing power cost per unit (Raza et al., 2020).

13. Institutional inefficiencies

Another issue is that there is not sufficient cooperation among different governmental agencies. Before the formation of AEDB and PCRET, there was not a single responsible institute for the RE policy making and RET research. But, these institutions are also not empowered with suitable technical human resources and adequate finance.

14. Poor energy infrastructure

Lack of supportive infrastructure is another reason for the marginalization of RE. As high-voltage transmission lines cost very high, rural areas of Pakistan are not provided with sufficient transmission and distribution lines where demand is low and dispersed (Yazdanie& Rutherford, 2010). Poor energy infrastructure is also adding to the severity of the energy crisis and needs to be upgraded. In addition transmission, distribution is also inefficient. There is a need for more investment in infrastructure, equipment and in research and development so

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that energy mix can be moved from fossils to RE (Bhutto et al., 2011). As RE is restricted to some specific areas in Pakistan, for example, wind corridors are present in Jhumpir and Gharo, solar exploitation is suitable in desert areas to save agricultural lands; hydro resources mostly exist in mountainous areas. So it is very much expensive to connect the power plants of various R.Es to the national grid.

15. Lack of base load plants

RE is not able to provide base load power, i.e. power availability at all times on all days. A base load power plant provides electricity continuously throughout the year. Base load power plants are only turned off for maintenance or up gradation purposes, for example, coal based and nuclear power plants. Geothermal power plants provide base load power which is not yet exploited in Pakistan. Other forms of RE do not provide base load power.

16. Competitive gap between RE and non REs

One of the main reasons for slow uptake of RE is its lack of competition with nonrenewable energy. Subsidy on fossil fuels brings down the prices of fossil fuel, further damaging the market of RE (Yazdanie& Rutherford, 2010), hence, decreasing the competitive gap between RETs and conventional energy. Moreover, negative externalities related to fossil fuels like health impacts and environmental pollution are neglected while considering energy prices (Rehman et al., 2019). Also, positive externalities related to RE like social and environmental benefits are overlooked which affects the market penetration of RETs (Østergaard et al., 2020).

17. Power conversion problem

Another issue is power production through RE results in direct current (DC), which will have to be converted into alternative current (AC). In this process, a lot of power loss occurs.

18. Social barriers

Land availability is also another social barrier in the way of RETs acceptance as there is a lack of social awareness regarding benefits of RETs which make local people reluctant to accept RETs in their area. One of the main examples of such a case is Kalabagh Dam (Sabir et al., 2017), the first hand beneficiaries of which i.e., Khyber Pakhtunkhwa and Sindh are denying it. Moreover, ideal locations for wind and solar energy projects are often located on traditional lands. In order to convince local people, expensive compensations are required.

19. Large area requirement

In case of hydro power production there is the problem of population displacement and resettlement. People are not willing to migrate from their land. Similarly in the case of wind mills, establishment area requirement increases with the increase of production capacity. Same is the case with power production through solar energy. These are some bitter issues related to RE establishment.

20. Long time required for project completion

Due to the long time requirement for the completion of RE based power projects, investors move toward thermal power generation to get output in a short period of time.

CONCLUSIONS

Economic and social stability of a country has a direct link with its energy availability. No doubt RE resources have a high capital cost, but they are economical in the long run. There is a dire need to understand the importance and benefits of alternate RE resources as RE has a potential of national development by improving social, environmental and economic growth. RE can be exploited to overcome the demand-supply gap in the future. But, it is not taking much part in electricity production. There is a necessity to increase electricity production in order to fill the supply demand gap. RE can play a great role in coping with the power crisis of a country, but it is getting neglected due to some reasons like lack of finance and technical expertise. In order to increase the finance to exploit RE, private sector involvement is compulsory. There are also many other reasons which are welcoming power crises like poor institutional arrangements, bad administrative management, inefficient transmission and distribution system, population explosion, lack of technology, lack of institutional cooperation, political instability, law and order situation of the country, incoherent policies and lack of social consensus. Currently, Pakistan's energy sector depends on local gas fields and expensive imported oil. It is not only an increasing burden on the economy of the country, but also has extreme environmental impacts. Pakistan is not economically a strong country, and therefore needs such energy resources which are cost effective, unlike non-renewable energy resources, which are not cost effective in the long run as they deplete once used. Comparatively, RE resources are economical in the long run as their use can reduce dependency on costly

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imported fuel; help in health improvement and gender equality through supporting job creation. Despite of all these issues, RE resources have more positive sides for the economic, social and environmental domains of Pakistan. RE can be established in the country by eradicating the existing hurdles. The recently launched 'Alternate Renewable Energy Policy (2019-20)' aims for 30% renewable energy generation by 2030and 'Energy Efficiency Policy for Electric Motors (2020)'needs to be implemented in a coordinated manner through implementation of an integrated energy plan.

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