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Energy Conditions and Renewable Energy Potential in Pakistan: An Overview

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Abstract: A constantly increasing demand and supply gap from the past two decades has forced Pakistan to seek short-term and expensive energy generation solutions. About one-fifth of Pakistan's import is formed by the crude oil products out of which 42% is utilized in the energy sector. Economic sustainability of a country is deeply linked to the Energy security of the country. The energy policy introduced in the year 2006 presented a clear direction towards the sustainable energy goal in Pakistan. At the present, renewable generation (excluding hydro projects) in less than 5% of the total energy mix now forming about 1000 MW against the planned 10.000 MW in the year 2030. Pakistan holds an energy generation potential of 167.70 GWh by employing renewable energy sources accounting more than the current requirements. This paper presents a brief overview of the current Energy scenario in Pakistan and sheds light on the potential of renewable energy as a possible solution to the energy problem.

Keywords: Energy Scenario of Pakistan, Renewable Energy, PV, Wind, Biogas.

I. INTRODUCTION

Lack of planning and short-sightedness in the energy sector has been the major reason behind the Energy crisis of the country [1]. In the year 2015, a demand and supply gap of 5200 MW has been recorded causing the distribution companies to shed domestic and Industrial loads for up to 18 hours [2]. A major part of Northern areas of Pakistan are still not connected with the grid and also, the existing transmission and distribution system is old and primitive to cater the current needs.

In the mid-1980's, hydropower generation contributed up to 70% of the total energy mix of the country providing cheap per unit electricity [3]. This is now reduced to 29% with the Thermal generation taking lead and forming 68% of the total generation with rest being formed by Nuclear and Renewable Energy [4] [5]. High price per unit and hiking demand and supply gap are pushing the authorities to seek a viable solution that produces cheap electricity per unit and reduces the import of crude oil.

The concept of Renewable technologies was first introduced in renewable energy policy published in 2006. The objective of the policy focuses on the adoption of renewable means to shift the energy mix from conventional means to renewable. The idea was to promote renewable technology domestically in order to reduce the reliance on conventional generation.

The decentralized nature of renewable energy also enables remote areas to be supplied with electricity. Northern areas and remote districts of Sindh and Baluchistan still lack access to the national grid and renewable technologies can be sought as a cost-effective solution rather than connecting them to the national grid that is expensive and requires the construction of huge transmission and distribution infrastructure.

Pakistan holds enormous potential for renewable energy harvesting. Renewable energy can add up to the existing grid and provide economic benefits in addition to the reduced carbon emissions. With an annual solar irradiance of $15.5 * 10^4$ kWh, an enormous addition of 1600 GW can be made possible that can eradicate the energy crisis from the country. The wind corridors of Sindh and Baluchistan has a generation capacity of 300 GW with the wind speed ranging between 5-7 m/s [6].

Biogas has been given special attention by Alternate Energy Development Board (AEDB) and Pakistan Council of Renewable Energy Technology (PCRET) to harness the potential available across the country. Currently, near 5500 biogas plants are working with public-private partnerships in Punjab and Sindh. Biogas plants are mostly being setup by farmers and housing societies having no connection to the gas grid. In Lahore, three notable projects are working having the cumulative capacity of $6700m^3$. Another notable project is under construction at Okara Military Farms with $1000m^3$ capacity. However, the current installed capacity is still negligible as compared to the overall potential available that indicates a long way to go in this domain.

Significant hydropower potential of 60,000 MW is present in Pakistan that can also enable storage of water in addition to electricity generation. At present, only 6800 MW of electricity is being produced through

hydropower generation that accounts to only 11% of the total potential. Small-scale hydro projects can be established in the northern region of Pakistan that holds a potential of around 900MW that can feed the grid helping reduce the energy gap.

The paper in detail presents the energy situation in Pakistan and the possible solutions in the form of renewable energy. The paper presents the renewable energy potential in Pakistan focusing on Solar, Wind and Biogas. Renewable energy technologies are not only the solution but are a way forward to achieve sustainable energy cutting the carbon footprints in the country.

II. AN OVERVIEW OF ENERGY SECTOR AND CURRENT ENERGY SCENARIO IN PAKISTAN

a. Organizational Structure|

Electricity is considered to be one of the most important factor in the economic prosperity and social development of a country. Over the last three decades, due to the industrial growth and population progression, a demand hike in Energy consumption has been witnessed. After the independence, Pakistan inherited a generation capability of 60MW. In 1959, Water and Power Development Authority (WAPDA) was established to regulate the energy generation and Tariff. In 1998, after the establishment of Pakistan Electric Power Company (PEPCO), two separate utilities were introduced i.e. KESC and WAPDA responsible for dealing Karachi and rest of the country respectively. WAPDA now comprises of GENCOS, DISCOS and TRANSCOS (National Transmission and Dispatch Company).

The prime objective of Ministry of Energy is to provide uninterrupted power supply to the domestic and industrial consumers. Due to the current load shedding, a highly adverse impact on the exports and economy of the country is witnessed affecting the local business. Figure 1 Illustrates the Energy Hierarchy of Pakistan

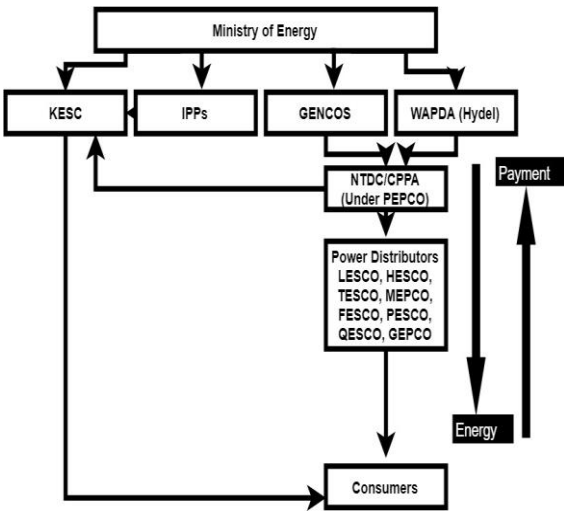

Fig. 1 Key sectors of Pakistan's Energy Mix

b. Current Energy Scenario in Pakistan

Over the past two decades, Pakistan has faced a severe energy crisis with the peak energy short fall soaring up to 6000 MW in summers. The current installed generation capacity of Pakistan accounts to 17,000MW against the peak demand 22,000 MW.

An average deficit of 5000 MW is currently existing causing the DISCO's to do shedding of load. The addition of energy into the national grid per year is 7% only in comparison to demand growth i.e. 10%. This gap is the reason a prolonged energy crisis exists in the country [7]. Table 1 presents the demand and supply gap in Pakistan from the year 2006-2016.

Table 1 Energy Shortfall (2006-2016) [18]

	Year	Installed Generation Capacity (MW)	Maximum Generation (MW)	Peak Energy Demand (MW)	Energy Deficit (MW)
1.	2006	19,550	15,168	15,223	55
2.	2007	19,681	15,575	17,487	1,912
3.	2008	20,232	14,707	19,281	4,574
4	2009	20,556	16,040	20,314	4,274
5	2010	21,614	15,144	21,029	5,885
6	2011	23,342	15,430	21,086	5,656
7	2012	23,487	15,896	22,654	6,758
8	2013	23,725	16,846	21,605	4,759
9	2014	23,702	18,771	23,505	4,734
10	2015	24,961	19,132	24,757	5,625
11	2016	25,374	20,121	25,754	5633

Energy remained neglected as a cornerstone in the five year plans presented that shifted the trend from cheap hydropower to oil based generation. The share of oil imported for the energy generation accounts up to 40% of the total import. Bar graph depicted in figure 2 presents the crude oil imported for the year 2015-2016.

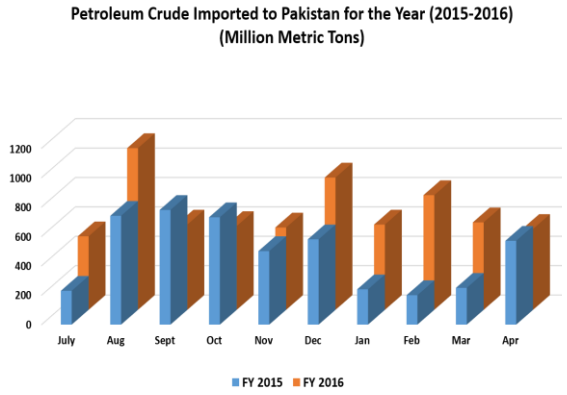

Fig. 2 Crude oil import (2015-2016) [8]

c. Generation Mix of Pakistan

The current National Energy mix comprises of two main sources i.e. Hydel forming 28.4% and Thermal forming 67.82%. The rest of 3.78% is formed by Nuclear, Wind, Solar and Biogas etc. [9].

Pakistan is facing adversities at different levels due to the high energy prices in Pakistan. The energy crisis has turned severe due to the country's sole reliance on Hydel and Thermal Power Generation. Currently, 3 Hydel plants are generating energy that includes Tarbela, Mangla and Ghazi Bharotha but their generating capacity is less as compared to the cumulative energy demand.

In order to make up the gap of demand and supply, few concrete steps to set the direction in order to harvest renewable energy has been taken by the authorities. Alternate Energy Development Board (AEDB) has exempted the tax on the import of PV panels in order to encourage public-private partnership. Quaid-e-Azam solar park is a 1000 MW landmark solar generation project started by Government Punjab that will be completed in stages. Currently 300MW has been added to the National grid [10]. Over the last few years, PV-grid integration has witnessed a considerable rise however a long way still has to be covered. . Table 2 presents notable grid connected solar parks.

Table 2. Grid Connected PV Systems in Pakistan [19] [20]

	Location	Installed Capacity (kW)
1.	Planning Commission of Pakistan	178
2.	Pakistan Engineering Council	178
3.	Parliament of Pakistan	1000
4	CERAD UET Lahore (KSK Campus)	149
5	University of Central Punjab Lahore	500

Wind energy generation is concentrated in the Sindh region of Pakistan. The present installed wind generation capacity accounts up to 1300 MW being installed and feeding the grid on the wind corridor of Jhimpir and Gharo. AEDB has further issued Letter of Interest to companies for public-private partnerships.

Currently installed capacity of the biogas plants accounts up to 201 MW that is connected and feeding the national grid and public-private partnerships are erecting more in collaboration with AEDB.

III. TAPPING OF RENEWABLE ENERGY POTENTIAL IN PAKISTAN TO SOLVE ENERGY CRISIS

The renewable energy can prove to be as the long-term solution to Energy crunch in Pakistan. With an approximate covered area of 800,000km, the land is blessed with wind corridors and rich solar insolation. Being an agricultural based land, an abundant amount of residue is produced annually that can be utilized for the generation of electricity.

a. Solar Energy Potential in Pakistan

Pakistan is located in a region with long and sunny days with the potential to harvest solar energy throughout the year. The average sunshine in most of the areas is around 8-10 hours a day with tilt solar irradiation in the optimum range of 5-7 kWh/m^2. [11].

The calculated potential is estimated to be 40 times greater than the current generation capacity i.e. 1600GW annually. The province of Baluchistan has the highest solar generation potential with solar insolation of 20Mj/m^2 with average 8.5h sunlight [12].Figure 3 presents the tilt solar radiation for the season of summer and winter. With average solar radiation of 5-7 kWh/m^2, Pakistan lies in a highly optimum region.

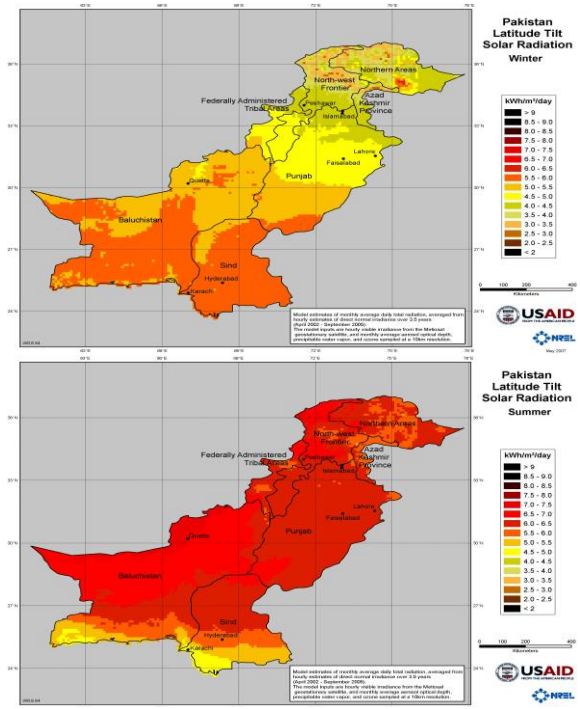

Fig. 3 Tilt Solar Radiation (Summers and Winters)

b. Wind Energy Potential in Pakistan

Pakistan is blessed with Wind corridors in Sindh, Baluchistan and certain regions of Punjab. AEDB in collaboration with NREL and Metrological department of Pakistan has developed a wind map of Pakistan..

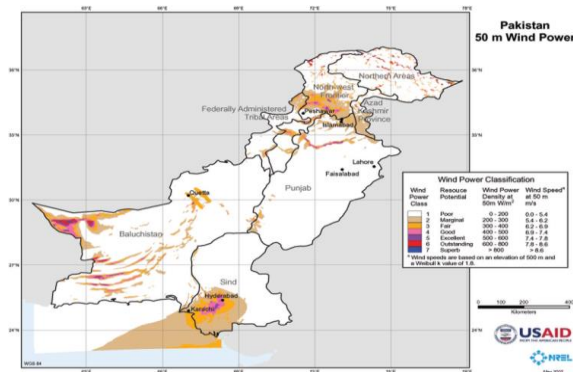

Fig. 4 Wind mapping of Pakistan at 50m [13].

On the site of Gharo-Keti Bandar wind corridor, the average wind speed at a 50m level above the ground is recorded to be 5-7m/s [14]. With a capacity factor of around 25% and 400watt/m^2 power density, the site is ideal for wind energy harvest [15]. Overall, an energy generation capacity of 346GW is estimated across the country that can help overcome the energy crisis in Pakistan.

c. Biogas Potential in Pakistan

Energy generation using biogas holds immense potential in Pakistan. Being an agricultural country, the crop waste and animal dung are easily available to run the Biogas plants. Ministry of National Food and Security research states that for the year 2012-13, 652 million kg of dung on average is produced by 170 million livestock animals that can be used to generate biogas [16]. On average, 15kg of animal dung can produce 2.5m^3 of biogas while 2.5kWh energy production is possible by utilizing 1m^3 of biogas. This averages 35.625 million kWh/day utilizing the total dung potential in Pakistan. Biogas in Pakistan is an effective method to generate cheap electricity [17]. In addition to the electricity generation, biogas also tends to reduce the aspect of pollution in the environment.

IV. CONCLUSION

This paper critically analysis the current energy situation of Pakistan and presents the potential of renewable energy across the country as a possible solution. A huge renewable energy potential is available across the country. Harvesting the Solar energy will enable the country to have 1600GW of energy per year; enough to end the energy crisis and meet the forecasted energy demand for the next few decades. The wind potential in Pakistan can prove to be an important factor to help end the electricity crisis in the country. Biogas plants utilizing the entire cow dung can generate up to 35 million kWh/day enabling access to cheap electricity.

Being a developing country, Pakistan needs energy security that is only possible by harvesting renewable energy. Tapping this potential will help reduce the demand and supply gap and will also enable cheaper energy generation as compared to the conventional means.

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