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Prospects of renewables penetration in the energy mix of Pakistan

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ABSTRACT

Pakistan is the sixth most populous country of the world comprising 2.56% of the total global population. However, it ranks 37th in the energy consumption, at 0.37% of the world total. The per capita energy availability is only 43 W, which is 1/7th of the world average. The greatest reason for such a huge energy deficiency is its heavy dependence on imported oil for power generation. The country is however, rich in renewable energy sources and has vast potential for their exploitation. In this article, a survey of the availability of various renewable energy sources, including hydel, solar, wind and biomass, and their current and future penetration prospects in the total energy mix have been carried out, with some recommendations. It is estimated that Pakistan has the feasible potential of 30 GW of installed power capacity from hydel and 50 GW of installed capacity from wind by 2030.

Contents

1. Introduction

One of the greatest impediments in the current economic growth of Pakistan is the huge shortfall in the demand and supply of electricity. A heavy dependence on the imported oil, which comprised 40% of all imports in 2011 with 14% trade deficit severely restricts the establishment of new industries, and smooth functioning of the already established ones [1]. The difference between the electric supply and demand has registered new heights of up to 50% in the summer of 2012, inciting large scale public outrage, nationwide demonstrations and law and order challenges for the government. Many industrialists are choosing to shift to other neighboring countries. The situation is alarming and demands immediate short term, medium term and long term measures.

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The energy demand in Pakistan is rapidly growing, registering nearly 80% growth during the last fifteen years—from 34 million tons of oil equivalent (MTOE) in 1995 to 1961 MTOE in 2010 [2,3]. Currently, it is growing at a rate of 10% per year. The current overall energy mix consists of 46% indigenous natural gas, 35% imported oil, 12% hydel, 6% coal and 2% nuclear. The currently installed electric power generation capacity is 21 GW, but the actual generation remains limited between 9 GW to 13 GW, while the actual demand fluctuates between 16 GW to 19 GW. The current electric power generation comprises of 27% indigenous natural gas, 36% imported oil, 32% hydel and 5% others including coal and nuclear. This mix, though already a huge burden on national economy due to oil imports, is under severe threats due to rapidly diminishing domestic gas reserves, which are the second major contributors to electric power generation. The electric power demand in the country is growing at a rate of nearly 8% per year, as shown in Fig. 1.

While the prospects for the discovery of new local oil and gas reserves are not very encouraging, a huge untapped renewable energy resource exists in the country.

2. Renewable energy potential in Pakistan

Pakistan occupies a land area of 803,950 km^2, and a coast line of 1146 km. There are four main sources of renewable energy, namely hydel, solar, wind and biomass, which have substantial potential to overcome the energy shortage problem in the country. A steady growth in their effective penetration in the energy mix of the country is crucial to address the existing energy challenges. So far Pakistan has set a target to add 10,000 MW to its energy mix through renewables by 2030 [4], though the actual growth potential seems to be much higher. Potential of each form of renewable energy source has been examined in the following sections.

2.1. Hydel power

The hydel and thermal power plants account for 95% of the total electricity generation in Pakistan, with respective shares of 35% and 65%. The thermal power share comes from three sources—Government owned Power Generation Companies (GENCOs), Independent Private Power Producers (IPPs) and Rental Power Plants (RPPs), with respective shares of 23%, 43% and 3%. The electricity produced by the hydel sources costs 1.25 ¢/kW h, while the one supplied by IPPs and RPPs costs 11.8 ¢/kW h and 17.3 ¢/kW h, respectively [5,6]. Thus, the per unit electricity supplied by the thermal sources costs up to 14 times as much as that of the hydel sources. This places a huge burden on the national economy due to the substantially dominant role of the thermal sources.

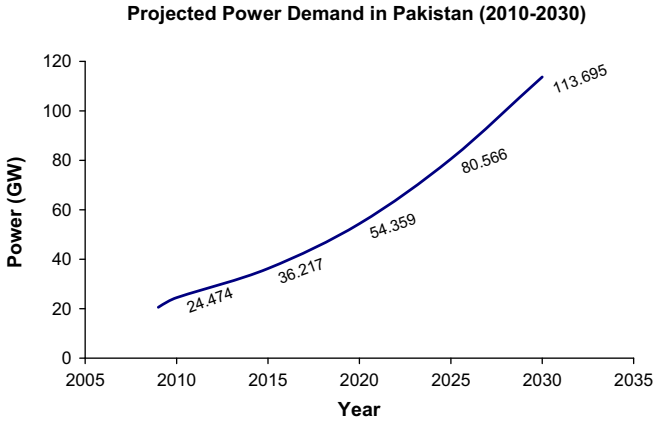

Fig. 1. Current and projected power demand in Pakistan—2010 to 2030 [5].

Pakistan is situated between the Arabian sea and the three great mountain ranges namely Himalayas, Hindukush and Karakoram. The area has great economic, political and strategic importance. It has five major rivers namely Ravi, Sutlej, Beas, Chenab and Jhelum, which ultimately fall into the grand Indus River. With current water storage capacity of 15 million acre feet (MAF), Pakistan can store only 13% of its annual rivers flow of 136 MAF. An average of 35.2 MAF flows down to the Arabian sea every year [5]. To save and utilize the available water, construction of additional storage facilities is essential for sustainable irrigation and power production. The per capita annual water availability in Pakistan was 5260 m^3 in 1951 when its population was 34 million, but now with a population of 186 million, it has reduced down to 962 m^3. Pakistan has reached the stage of "acute water shortage".

The above mentioned rivers in the Pakistan's mountainous terrain have an estimated combined electricity generation potential of over 100 GW with 48 identified sites of 59 GW [5]. The major share of the identified sites (74.9%) is with the Indus river basin (13 sites), while Jhelum river basin (10 sites) has 13.6% share. The remaining 11.5% share is with smaller Swat river (3.9% with 5 sites), Chitral river (3.8% with 4 sites) and small (below 50 MW) hydropower projects (3.8% with 16 sites). Pakistan Water and Power Development Authority (WAPDA) has carried out feasibility studies and engineering designs for several hydropower projects with combined capacity of over 21 GW. Table 1 shows the currently installed hydel power generation capacity in Pakistan, while Table 2 shows the capacity to be added until 2015, bringing the total hydel power capacity to over 8 GW.

Table 3. shows the identified sites for hydel power projects in Pakistan whose feasibility study is complete. In most cases the detailed engineering designs are also complete, while construction work on the first two projects has already commenced. For the last three projects, which are under the public–private partnership scheme, EOIs have already been invited. If all these projects – which are technically ready for launching – get materialized during the next seven to fourteen years, will bring the total installed hydel power capacity in Pakistan to over 29 GW. They will also nearly double the current water storage capacity. Increasing the water

Table 1
The currently installed hydel power generation capacity in Pakistan. Based on data from [5].

S. No	Power station	Installed capacity (MW)
1.	Tarbela	3578
2.	Ghazi Barotha	1450
3.	Mangla	1000
4.	Warsak	243
5.	Chashma	184
6.	Khan Khwar	72
7.	Duber Khwar	130
8.	Allai Khwar	121
9.	Others	178
	Total Capacity	6956

Table 2
Near completion hydel power projects in Pakistan. Based on data from [5].

S. No.	Power station	Capacity (MW)	Expected completion
1.	Jinnah Hydropower	96	Dec. 2012
2.	Gomal Zam Dam	17.4	Feb. 2013
3.	Golen-Gol	106	Feb. 2015
4.	Neelum Jhelum	969	Oct. 2015
	Total	1188.4	