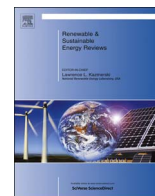




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## Review of geothermal energy development efforts in Pakistan and way forward

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## ABSTRACT

One of the ways to address the woes of energy crisis effectively in the developing world is through the use of Geothermal energy resources. This paper discusses the Geothermal technologies in use globally with emphasis on the development paths. The development efforts in Pakistan are discussed focusing on the areas requiring attention. It has been found that while considerable potential for Geothermal energy is available in the form of Hydrothermal resources and Hot Dry rocks, however no appreciable practical steps have been undertaken in this regard. Shallow geothermal energy and Direct-use of Geothermal energy that is independent of terrain and resource has also not been pursued in Pakistan. The study discusses the stages of development, the current status of Geothermal energy in Pakistan and identifies the steps for initiating progress.

Further, it is an established fact that the maximum consumption of energy in the domestic and industrial sector is in HVAC and process heat respectively. Shallow geothermal energy can fulfill this demand efficiently. Government support can play an important role in developing the Geothermal resource of the country. A number of steps have been suggested for the Government as well as research institutions that can inject impetus and enhance the pace of development of this significant but ignored Energy resource in the developing world.

## 1. Introduction

Globally Renewable energy provided an estimated 19% of the total final energy consumption for the year 2012. Of this total share, 9% accounted for traditional Biomass and 3.8% for hydropower. Amongst the modern Renewables, Solar/Wind and Geothermal provided for an estimated 5.4% of the total share (Fig. 1). The share of Geothermal resource on the whole may seem to be relatively insignificant however an in-depth analysis reveals that the potential, prospects and growth of this important resource is very promising.

In 2013, Geothermal resources provided electrical energy and power for HVAC applications amounting to a total of 600 PJ (167 TWh). About 50% of this i.e. 76 TWh was in the form of Geothermal electricity generation [1].

In 2014, the total global geothermal capacity reached 12.8 GW, of which 640 MW came online in the same year. The growth rate of cumulative capacity is recorded at 5.3% compared to an annual growth rate of 3.6% for the preceding years i.e. 2009 through 2014.

Geothermal energy has attracted great interest worldwide owing to the reliability issues of fossil fuels, depleting stocks of the tapped

resources and to offset the effects of climate change. This has been discussed in detail in the 2014 Annual U.S. & Global Geothermal Power Production Report [2]. According to this report the Geothermal growth for the year 2014 has been recorded at 4–5% with 700 projects under development in 76 countries. Most of the countries understanding the threat from climate change are investing in Geothermal projects for meeting the base-load requirements with additional demand met from other flexible renewable resources. These countries range from small developing states to huge economies like China and USA. The geothermal projects in pipeline would have a cumulative capacity of 13500 MW by 2017 if they are completed in the scheduled time frame ( Fig. 2).

The size of the geothermal-based power plants range from a few MWs to 100 MW. The practicability is further evident from the fact that in United States, the average size of geothermal power plant is 25 MW while those under installation in Ethiopia and Kenya (least developing countries) are rated at 100 MW [2]. The growth in geothermal development is so quick in some countries for example Indonesia which has a planned capacity addition of 4400 MW equivalent to that of United States. Fig. 3 gives a country wise overview of the capacity

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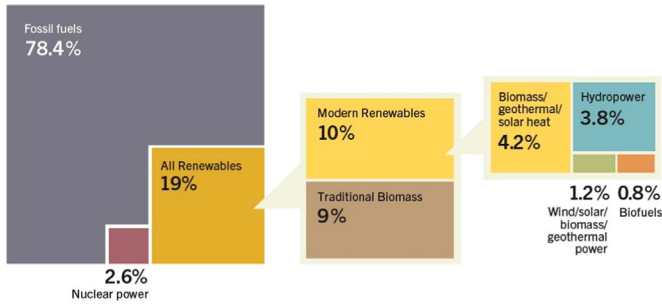


Fig. 1. Estimated Renewable Energy Share of Global Final Energy Consumption, 2012 [1].

addition of over 50 MW power plants.

Tables 1, 2 list the countries with established Geothermal power plants and those under development respectively.

Theoretically the global potential of geothermal energy surpasses all other renewable sources, however investment in geothermal projects is the least as compared to other alternate energy resources. World Energy Assessment report of the United Nations (2000) for the global potential placed Geothermal at the top of all renewable energy resources at 5000 EJ/yr, Solar 1575, Wind 640, Biomass 276, Hydro 50, giving a total of 7541 EJ/yr [3]. Global Energy Assessment [4] lists geothermal energy as the resources with the highest technical potential amongst the Renewable resources second only to Solar energy.

Another significant attribute of Geothermal energy usage is its high capacity factor in Power plants. Table 3 lists the capacity factor for four major renewable energy resources.

Geothermal energy is already playing a significant role in many countries of the south. Amongst the top 15 producers of electricity from geothermal, 10 are developing countries including Philippines, Kenya, Indonesia, Mexico and several Central American states. Also with improvements in technology, countries and regions outside the tectonic/volcanic belt can also benefit from direct use of Geothermal energy.

As far as South Asian region is considered, neighboring countries like India, Vietnam and Burma also have Geothermal projects under development.

Pakistan is an energy deficient country drawing most of its energy

supplies based on imported fossil fuels. The country has vast potential of Renewable energy resources however the same are yet to be exploited for practical use and power generation. The oil import bill for the financial year 2014–15 is estimated at around US \$15.5 billion [6] which amounts to almost 200% of the national export earnings [7]. The profile of “Electricity generation by fuel” shown in Fig. 4 indicates that Hydro, Natural gas and oil all have an almost equal contribution to power generation. Renewable resources have no share in the almost 100,000 GWh electricity production.

Among the Renewable resources various projects pertaining to solar, wind and biomass are under way in various stages of development as per reports of Pakistan’s Alternate Energy Development Board (AEDB) [8]. Renewable energy projects and initiatives though encouraging are relatively slow owing to various socio-economic factors, however Geothermal energy has so far remained a neglected field although the potential is promising. This study discusses the efforts made so far in the development of Geothermal resources for power generation, and recommends measures for future planning.

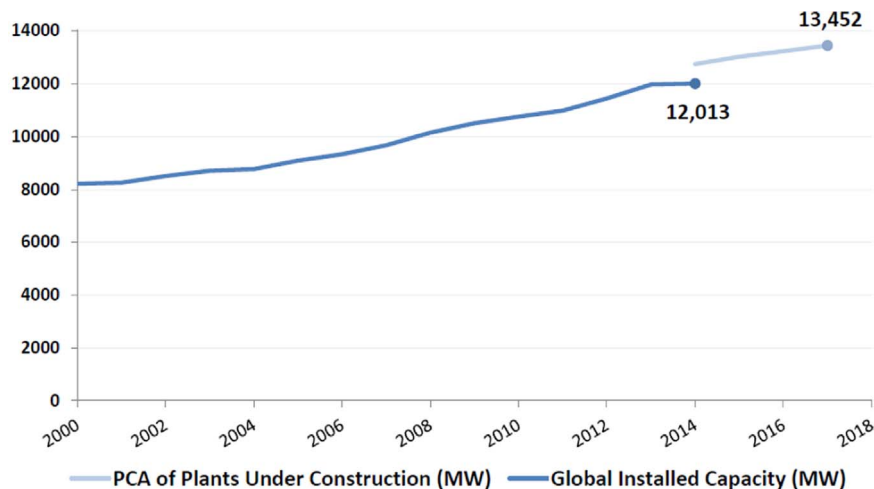
## 2. Geothermal status-Pakistan

We now take a look at the current status of Geothermal development in Pakistan.

### 2.1. Studies

Published literature indicates studies as old as 1975 [9] when Abid first evaluated the geothermal resources of Pakistan. In 1982, Tahirkheli and Khan [10] investigated the geology of Himalaya, Karakorum and Hindukush. From early 80s till early 90s various geological surveys were undertaken by the Geological Survey of Pakistan resulting in the discovery of various thermal springs of Pakistan depicted in Fig. In 1994 Hussain et al. [11] investigated the chemical characteristics of Geothermal waters of Northern areas of Pakistan. Hussain concluded that most of the sites have estimated reservoir temperatures in excess of 150 °C and suggested that further exploration to assess the potential of the sites for economic production of electricity is required. Bakht [12] presented an overview of Geothermal resources of Pakistan during the World Geothermal Congress.

Zaigham and Nayer [13] have concluded that the surface geologi-



Note: PCA (Planned Capacity Additions), pilot plants and utility scale geothermal plants built in the first half of the 20th century and then decommissioned are not included in the above time series.

Fig. 2. International Geothermal Power Capacity [2].

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