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Greener energy: Issues and challenges for Pakistan-geothermal energy prospective

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ABSTRACT

There is an indispensable need to develop geothermal technologies to supplement the long-term energy needs of Pakistan to a significant level. Geothermal energy is one of the oldest, most versatile and also most common form of utilization of renewable energy. Pakistan is rich in geothermal energy, many of the researchers highlighted and emphasized about its importance, but due to less awareness, lack of confidence and management, no realistic work has been done so far in this domain. This paper investigates the progress of geothermal energy sources, technologies and its potential. Finally the prospects for the geothermal energy sources in Pakistan are described to encourage national and international investment in developing these resources.

Contents

1. Introduction

Geothermal energy consists of the thermal energy stored in the Earth's crust. Cataldi et al. [1] had published historical records and stories of geothermal utilization from all over the world. Geothermal energy has been exploited for power generation since 1904 when Prince Piero Ginori Conti invents the first geothermal power plant at the Larderello dry steam field in Tuscany, Italy [2,3]. The development of geothermal energy resources for utility-scale electricity production in the United States began in the 1960s. The progress in geothermal power from 1960 to 2012 is shown in Fig. 1 [4]. As of May 2012, approximately 11,224 MW of installed geothermal power capacity was online worldwide. In US the installed geothermal capacity increased from 3187 MW in early 2012 to 3386 MW in February of 2013.

US is developing additional 2511–2606 MW geothermal based electric power plants in next three years [5]. In Iceland Geothermal power facilities currently generate 25% of the country's total electricity production. In 2009, roughly 84% of primary energy use in Iceland came from indigenous renewable resources, thereof 66% was from geothermal. Almost 99% of Iceland's houses and buildings are heated by natural hot water [6]. Other principal use of geothermal energy is fermentation, heating and cooling homes and businesses, heating in industrial process, heating greenhouse, refrigeration, industrial and

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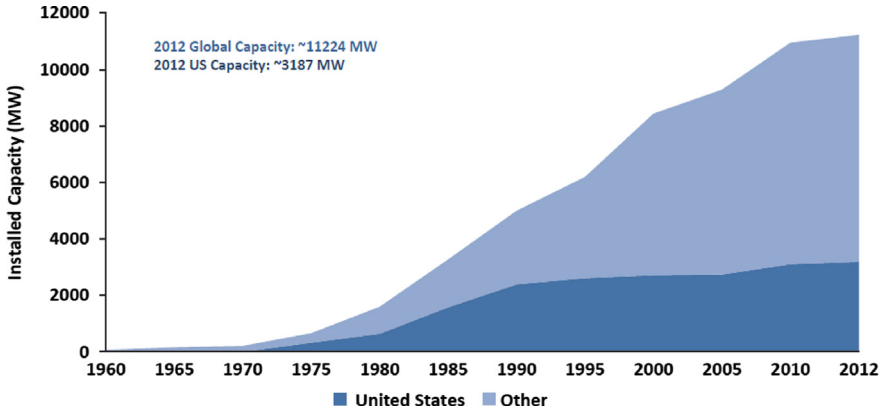

Fig. 1. US and worldwide geothermal installed capacity 1960–2012 [4].

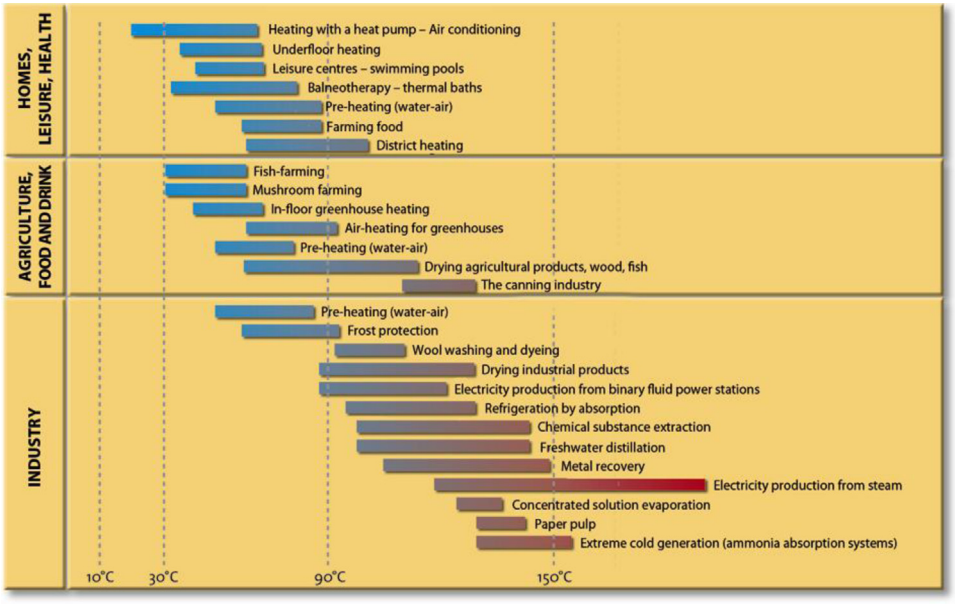

Fig. 2. Principal uses of geothermal energy with respect to temperatures [9].

crop drying, ice melting, balneological utilization, desalination and distillation [7,8] as shown in Fig. 2 [9] and Fig. 3 [10].

Geothermal energy process produces zero carbon emissions, potentially making it one of the cleanest sources of energy at our disposal. In addition, it can create a constant 24 h base-load power where other renewable energies are unable whereas solar energy can only be produced during daylight hours, and is diminished with cloud cover and wind turbines are dependent on wind speed which is inherently variable [11]. It is estimated that geothermal power plants emit only between 13 and 380 g of CO_2-equivalent per kW h of electricity. By comparison, coal-fired power plants emit about 1042 g of CO_2-equivalent per kW h of electricity, oil fired power plant 906 g of CO_2-equivalent per kW h of electricity and natural-gas-fired power plants emit about 453 g of CO_2-equivalent per kW h of electricity [12].

2. Geothermal reservoirs

The geothermal heat originates from the primordial heat generated during the Earth's formation and the heat generated by the decay of radioactive isotopes. The Earth's average heat flow is 82 milli-Watts per square centimeter (mW cm^{-2}), and the total global output is over 4×10^{13} W [3]. Thermal energy in the earth is distributed between the constituent host rock and the natural fluid that is contained in its fractures and pores at temperatures above ambient levels. These fluids are mostly water with varying amounts of dissolved salts typically, in their natural in situ state, they are present as a liquid phase but sometimes may consist of a saturated, liquid vapor mixture or superheated steam vapor phase.

The utilization of geothermal source either for power generation or for different applications depends mainly on location and temperature of resource. High temperature geothermal resources above 150 °C are generally used for power generation whereas moderate-temperature (between 90 °C and 150 °C) and low temperature (below 90 °C) resources are best suited for direct applications such as space and process heating, cooling, aquaculture, and fish farming [13]. Multipurpose utilization of high temperature geothermal resource will not only increase the efficiency of the system but will also make more cost effective [14,15].

In geothermal field the temperature of rocks increases with depth. This gradient averages 30 °C/km of depth. However, there are areas of the earth's crust which are accessible by drilling, and where the gradient is well above the average. This occurs where there is a magma bodies undergoing cooling not far from the surface (a few kilometers), but still in a fluid state or in the process of solidification, and releasing heat. In other areas, where magmatic activity does not exist, the heat accumulation is due to particular geological conditions