

Status and outlook of geothermal energy in Jordan

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ABSTRACT

An updated assessment of geothermal energy sources in Jordan and the prospects for their future utilization are presented. Furthermore, a development strategy for geothermal energy in the country is proposed. The results show that Jordan has enormous underground energy resources in many parts of the country in the form of thermal underground hot water (wells and thermal springs), having a temperature ranging from 20 °C to 62 °C. It was also found that the installed capacity of geothermal energy is 153.3 MWt and the annual energy supply potential is 1540 TJ/year in the form of domestic hot water for bathing and swimming, giving an overall capacity factor of 0.42. Possible future applications of geothermal energy were found to be absorption refrigeration to preserve fruit and vegetables or freeze fish and meat, as well as fish farming and greenhouse heating.

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Introduction

Energy issues and policies have been concerned mainly with increasing the supply of energy. Countries around the world have considered the sufficient production and consumption of energy as to be one of their main challenges. Modern economies are energy dependent. The provision of sufficient energy has been perceived a central problem. Energy availability and consumption have been so important a consideration to economies world-wide that the magnitude of energy consumed per capita has become one of the key indicators of modernization and progress in a given country. Attention has begun to shift toward a more balanced perspective, including concerns related both to demand-side and energy consumption patterns. Either way, there is no escaping the fact that the use of energy is a necessary and vital component of development (Reddy et al., 1997; Goldemberg et al., 1987).

Energy issues pose a complex set of challenges for Jordan. Jordan currently imports most of its commercial energy in the form of oil and this is a burden on the national economy. Despite the limitations of Jordan's conventional energy resources, the demand for energy is continuously rising as a result of increasing population and industrialization. Furthermore, utilization of fossil energy resources is becoming a significant environmental concern in the country. In this regard, there is an urgent need to deploy sustainable and environmentally clean energy sources. An important contribution could be made by rapidly expanding the use of renewable energy sources, such as geothermal energy, which has proven to be reliable, clean and safe, and therefore, its use for power production, and heating and cooling is

increasing. It is a power source that produces electricity with minimal environmental impact (Kömürçü and Akpınar, 2009).

This paper presents an updated assessment of geothermal energy sources in Jordan, in addition to the prospects for their future utilization. Furthermore, a development strategy for geothermal energy in the country is proposed.

Jordan's energy sources

Jordan relies almost entirely on imported crude oil and oil products to meet its needs. Therefore, Jordan has been striving hard to minimize dependence on imported energy through investing in the local sources of energy in order to reduce the oil bill which constitutes a heavy burden on its economy, particularly in light of very high world oil prices in recent years. The most important sources of local energy sources are discussed below, along with the efforts exerted to increase their utilization.

Oil and gas

Table 1 represents Jordan's production of oil and gas and their contribution to the overall consumption of energy during the period 2003–2007 (MEMR, 2007). It shows that crude oil and natural gas production was nearly 186.5 thousand tons of oil equivalent (toe), i.e. 3.8% of total energy needs. In view of this limited production, Jordan has depended on imports to meet its energy needs.

Oil shale

Jordanian oil shale – with a proven amount of about 5×10^{10} tons – is of quite good quality. It has relatively low ash and moisture content, gross calorific value of 7.5 MJ/kg, and oil yield of 8–12%. The reserves

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Table 1

Jordan's production of crude oil and gas during the period 2003–2007.

| Year | Crude oil (1000 tons) | Natural gas (billion CF) | Contribution to the overall energy consumption (%) |
|------|--------------------------|-----------------------------|---|
| 2003 | 1.5 | 9.0 | 3.6 |
| 2004 | 1.4 | 10.2 | 3.7 |
| 2005 | 1.2 | 10.4 | 4.0 |
| 2006 | 1.1 | 8.5 | 3.7 |
| 2007 | 1.2 | 8.9 | 3.8 |

should be sufficient to satisfy the country's energy requirements for centuries (Hrayshat, 2008a). Therefore, the Government of Jordan is considering oil shale exploration in a commercial perspective. In this context, international companies interested in utilizing the oil shale have been invited to submit their bids to MEMR to reach an acceptable agreement for constructing a private power station project using this oil shale, or to produce fuel oil from it, using retorting technologies (Hrayshat, 2008b). The role of National Electric Power Company (NEPCO) in this independent power producer (IPP) operation will be restricted to purchasing electricity through some appropriate long term or short term agreement.

Renewable energy

Jordan has a substantial potential of renewable energy sources. However, renewable energy provides approximately 1.5% of the total current primary energy demand in Jordan. The renewable energy sources in Jordan include solar, wind, geothermal, hydroelectric and biomass.

Jordan is endowed with a high potential of solar energy. The average insolation intensity on horizontal surface is about 5–7 kWh/m²/day which is one of the highest in the world (Hrayshat and Al-Soud, 2004). The annual sunshine duration is around 2900 h, which can be considered sufficient to provide enough energy for solar heating/cooling applications. Nevertheless, solar energy technologies are not extensively used, except for solar water heaters (SWH), which are used for heating of domestic-water for about a quarter of the housing stock, thereby avoiding the need for about 1.5% of the total oil imports.

Another interesting application of solar energy is for electricity generation using the photovoltaic (PV) systems. At present, Jordan does not have an organized commercial PV program. However, there are some installations, with a total peak power of about 100 kWp. Under the solar conditions, each kWp gives an average of 5 kWh/day. Thus the total yearly energy output of PV systems in Jordan is about 182.5 MWh.

The northern and southern parts of Jordan have high wind potential with average wind speeds of 6.5 m/s and more. Currently some electricity is produced using wind turbines at Al-Ibrahimyya and Al-Hoffa wind plants. Al-Ibrahimyya wind plant consists of four horizontal axis 80 kW wind turbines, with a hub height of 24 m while Al-Hoffa wind plant contains five wind turbines of 225 kW each. Their electricity production during the year 2007 was nearly 2.8 MWh (CEGCO, 2007). This is insignificant compared to the total 2007 generation of 13,001 GWh.

Table 2

Primary energy consumption (thousand toe), 2003–2007.

| Year | Type of primary energy | | | | Total |
|------|------------------------|-------------|------------------|-------------|-------|
| | Crude oil | Natural gas | Renewable energy | Electricity | |
| 2003 | 4954 | 188 | 79 | 78 | 5299 |
| 2004 | 5030.7 | 432 | 77 | 234.6 | 5774 |
| 2005 | 5012.4 | 1194.9 | 82 | 199.7 | 6489 |
| 2006 | 5325 | 1382.3 | 82 | 238.2 | 7028 |
| 2007 | 4953 | 1995.9 | 111 | 127.1 | 7187 |

Table 3

Sectorial distribution of final energy consumption (thousand toe), 2003–2007.

| Year | Sector | | | | Total |
|------|-----------|----------|-----------|---------------------|-------|
| | Transport | Industry | Household | Others ^a | |
| 2003 | 1435 | 846 | 868 | 662 | 3811 |
| 2004 | 1495 | 878 | 945 | 722 | 4040 |
| 2005 | 1693 | 1034 | 1007 | 792 | 4526 |
| 2006 | 1779 | 1159 | 1060 | 804 | 4802 |
| 2007 | 1822 | 1182 | 1064 | 821 | 4889 |

^a Including the trade and agricultural sectors along with street lightings.

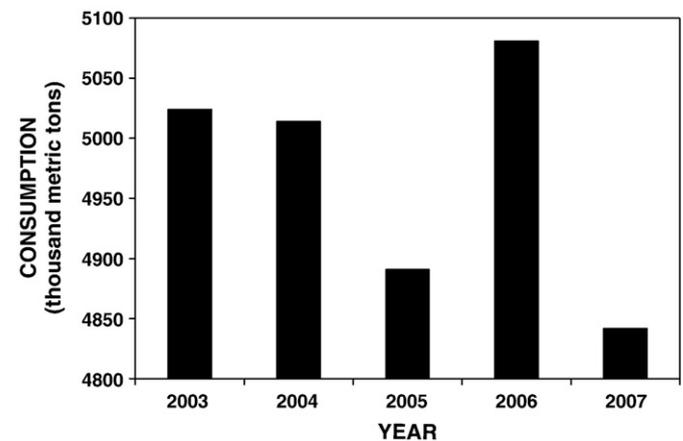
Hydropower sources are very limited in Jordan. Currently, there are two small hydropower systems: King Talal dam spanning the river Zarqa near Jerash with a rated electricity generation capacity of about 5 MW and the hydro turbine, utilizing the available head of cooling sea water at the Aqaba thermal power station with a capacity of about 5 MW (Jordan Valley Authority, 2007). The total electricity generated in 2007 was 45 GWh, i.e. 0.58% of total national electric generation. This represents, at present, the total economically feasible capacity for hydropower in Jordan. However, there is a great possibility to generate electricity, using hydropower stations, by exploiting the elevation difference between the Red and Dead Seas.

The biogas plant at the Amman municipal waste disposal site was founded to extract gases from the landfill site in order to fuel the 1-MW generation unit and to supply the network with generated electricity. The volume of the solid and liquid wastes – treated in 2007 – reached around 4812 tons, and the amount of electricity generated was 6240 MW. By burning the methane gas contained in the landfill gas instead of releasing it into the atmosphere, the plant prevented – since 2002 – the emission of 13 thousand tons of methane gas, i.e. equivalent to 275 thousand tons of carbon dioxide. To the extent that electricity generated from renewable sources offsets generation using fossil fuels, all renewable electricity generation also reduces CO₂ emissions.

Jordan's generation and consumption of energy and electricity

Primary and final energy consumption

Jordan's primary energy consumption between 2003 and 2007 is shown in Table 2. In 2007, the overall consumption of primary energy was about 7187 thousand toe, yielding a growth of 2.3% against 2006, while the total consumption of final energy (see Table 3) – which is the energy available to consumers – was nearly 4889 thousand toe with a growth rate of 1.8% compared to the 2006 consumption levels. On the other hand, the year 2007 has witnessed a significant decline in the consumption of oil products (see Fig. 1), with a consumption of nearly 4842 thousand tons compared to around 5081 thousand tons in

**Fig. 1.** Oil consumption in Jordan, 2003–2007.

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