Year-end geothermal development status of Turkey, 2002

Gulden Gokcen[1], Gunnur Kocar[2], Arif Hepbaslı[3]
[1] Mech.Eng. Dept., Izmir Institute of Technology, Izmir, Turkey
[2] Solar Energy Institute, Ege University, Izmir, Turkey
[3] Mech.Eng. Dept., Ege University, Izmir, Turkey
E-mail: guldengokcen@iyte.edu.tr
gkocer@bornova.ege.edu.tr
hepbasli@bornova.ege.edu.tr

Abstract

The status of geothermal development in Turkey as of the end of 2002 will be presented in the paper. The potential of geothermal development in Turkey is large in terms of moderate and low temperature resources (<150°C). Therefore, the resources are mostly suitable for direct use applications. Although 6 high temperature fields suitable for generation of electricity have been discovered, only the Kizildere Geothermal Field has been developed already. Today, in Turkey the direct use capacity for heating is about 540.8 MW_t and a number of spas, physical treatment centres with a capacity of about 327 MW_t give a total direct use capacity of 867.8 MW_t. Electricity generation takes place only in Denizli-Kizildere geothermal field with an installed capacity of 20.4 MW_e.

Keywords: *electricity generation, direct use, greenhouses, district heating, heat pump, Turkey.*

1 Introduction

Turkey is among countries with significant geothermal potential. According to the resource assessment, which has been done by the Mineral Research and Exploration Directorate (MTA) (Erisen *et al.*, 1996), the geothermal resources in Turkey are mostly of moderate and low-temperature. The main uses of geothermal energy in Turkey are: direct use applications such as space heating, domestic hot water supply, greenhouse heating, swimming and balneology, industrial processes, heat pumps and electricity generation. The data accumulated since 1962 show that the estimated geothermal power and direct use potential are about 4500 MW_e and 31,500 MW_t, respectively. The direct use capacity in thermal applications is a total of 867.8 MW_t representing only 2.75% of its total potential. Since 1990, space heating and greenhouse development have exhibited a significant progress. A geothermal power plant with a capacity of 20.4 MW_e and a CO_2 plant with a capacity 120,000 tonnes/year have been operated in the Denizli-Kizildere Geothermal Field since 1984 and 1986, respectively. Ground source heat pumps have been used in residential buildings for heating and cooling for approximately 5 years. Present applications have shown that geothermal energy in Turkey is much cheaper compared to the other energy sources like fossil fuels and therefore is a promising alternative. As the projects are recognised by public, the progress will continue.

2 The potential and role of geothermal energy

Turkey's energy use has increased steadily with economic and population growth. The status and projections of the installed capacity of electricity in Turkey are given in Table 1 (at the end of the paper). The Table also shows the situation of geothermal power production as compared to the other sources of electricity as of 2001 and projections for 2010 and 2020.

Turkey is poor in fossil fuel resources but rich in renewables such as geothermal, solar, wind, biomass and hydropower. The studies on renewable energy sources in Turkey were

initiated in 1960's, but could not exhibit a significant progress by the time except hydro-power, as happened in several well-developed countries. Geothermal resources of the country are wide spread but the favourable reserve for heating and generating electricity is limited and even this limited reserve has not yet been used.

Today in Turkey, mostly biomass and hydropower are in use but geothermal is in the third place. Renewable energy sources account for 30% of the total energy consumption of the country and 23% of which accounts for geothermal (WEC-TNC, 2000).

Geothermal electricity generation has a minor role in Turkey's electricity capacity as 0.07%, but the projection foresight an improvement to 0.32% by the year 2020. Contrary to the capacity of installed geothermal the heat capacity is growing at a faster rate.

3 Geothermal energy in Turkey

In Turkey, around 600 geothermal prospects and 170 geothermal fields with a temperature range of 40-242°C have been discovered. The total proven geothermal electricity generation capacity is 200 MW_e while direct use capacity is 2046 MW_t. These proven potential increases by 5% annually with new exploration and drilling activities. The estimated geothermal power and direct use potential are reported as 4500 MW_e and 31,500 MW_t, respectively. The potential of geothermal development in Turkey is generally considered large in terms of moderate and low temperature resources (<150°C). Therefore, the resources are mostly suitable for direct use applications (TGA, 2002).

3.1 Electricity generation

High temperature geothermal fields suitable for conventional electricity generation are Denizli-Kizildere (242°C), Aydin-Germencik (232°C), Aydin-Salavatli (171°C), Canakkale-Tuzla (174°C), Kutahya-Simav (162°C) and Izmir-Seferihisar (153°C). The other high temperature fields with electricity generation potential are Manisa-Salihli-Caferbeyli (150°C), Aydin-Yilmazkoy (142°C), Izmir-Dikili (130°C) and Izmir-Balcova (125°C). a list of current and possible utilisation opportunities of high temperature geothermal fields is given in Table 2 (at the end of the paper). The assessment of the other fields is still in progress. The only operating geothermal power plant of Turkey is Kizildere geothermal power plant, located near Denizli City in Western Anatolia. Kizildere geothermal power plant was installed in 1984 with a capacity of 20.4 MW_e. The total capacity of the field is estimates as 200 MW_e.

3.2 Direct use

Direct use of geothermal resources has expanded rapidly in the last 36 years from space heating of single buildings to district heating, greenhouse heating, industrial usage, modern balneology and physical treatment facilities.

Before the 1960's, geothermal resources were only used spontaneously in bathing and medical treatment in Turkey. The first space heating application by geothermal energy was in a hotel in Gonen-Balikesir in 1964. Then, the first district heating system was built again in Gonen in 1987 with a capacity of 16.2 MW_t (Mertoglu and Basarir, 1995; Mertoglu, 1998). After 1990, development of direct use applications increased steeply as 185% from 1990 to 1995, 173.4% from 1995 to 1998, 131.2% from 1998 to 2002. Development of installed direct use capacities from 1990 to 2002 is listed in Table 3.

Geothermal district heating applications have started in 1987 in Turkey with heating of 600 residences in Gonen and reached to about 32,000 residences recently (540 MW_t)(TGA, 2002; Mertoglu and Bakir, 2002). Data about major district heating systems are given in Table 4.

Table 3: Development of direct use (excluding spas) installed capacity in Turkey.

Year	Installed Capacity (MW_t)
1988	40.0
1990	45.5
1995	129.7
1998	354.6
2000	493.0
2002	540.0

Table 4. The major district heating applications in Turkey (Mertoglu and Bakir, 2002).

System	Temperature (°C)	No. of residences	Operational since	Potential (MW_t)
Gonen-Balikesir	80	3400	1987	32
Simav-Kutahya	120	3200	1991	25
Kirsehir	57	1800	1994	18
Kizilcahamam	80	2500	1995	25
Balcova-Narlidere-Izmir	137	11500	1996	115
Sandikli-Afyon	70	1700	1998	45
Afyon	95	4000	1996	40
Kozakli-Nevsehir	90	1000	1996	11.2
Diyadin-Agri	78	1037	1998	42
Salihli-Manisa	94	1500	2002	142

In Turkey, the first greenhouse heating system of 0.45 ha by geothermal energy was applied in Denizli-Kizildere geothermal field in 1985 and has growth to 1.395 ha today. Recently, the total area of greenhouses heated by geothermal energy has shown a rapid growth totalling an area of about 36 ha and a heating capacity of 81 MW_t for an average heat load of 2.25 MW_t/ha. However, if the potential of the country is taken into account, the utilisation of this form of energy is seen to be highly insufficient (Ozgener and Koçar, in press)**.**

Ground Source Heat Pump (GSHP) systems have been in service in residential buildings for heating and cooling in Turkey for 5 years, while they have been in use in commercial buildings in the U.S. for approximately 50 years. There are a few Turkish companies importing GSHPs from abroad and making efforts to put them onto the Turkish market at an increasing rate. But in reality, interest in GSHPs is growing very slowly. At first GSHP is applied two buildings with a total capacity of 26 kW, representing a total floor area of 596 m^2. It is estimated that around 65 units are presently installed in Turkey, representing a total capacity of 800 kW. Considering the ongoing installations, it appears that the growth rate will increase in next years. (Hepbasli and Yilmaz, 2001; Hepbasli *et al*., 2001a, b, c; Hepbasli *et al*., 2002).

Industrial usage of geothermal energy is not common in Turkey. The most well known application is liquid CO_2 and dry-ice production process operating adjacent to the Denizli-Kizildere geothermal power plant since 1986. The process installed with a capacity of 40,000 tons/yr then the capacity was increased to 120,000 tons/yr in 1999. Another industrial usage in the region is in textile industry using chemical properties of geothermal fluid as a whitening material. In Balikesir-Gonen, the wastewater of the district heating system has been used for process hot water supply in 54 tanneries (Mertoglu and Basarir, 1995).

4 Conclusions

The main conclusions that can be drawn regarding the utilisation of geothermal energy in Turkey are listed below.

- Since Turkey is an energy importing country, renewable energy including geothermal energy use is very important.
- Geothermal energy offers technically and economically feasible possibilities for development of different agricultural production sectors in Turkey.
- GSHPs are economically preferable to the conventional space heating/cooling systems used in Turkey. The primary barrier to marketing GSHP systems in Turkey is, however, the incremental cost of installing ground heat exchangers, which makes the total investment higher. There is customer resistance to GSHPs technology in the country because Turkish heating systems differ in many respects from the US ones and the first installation cost of GSHPs is relatively higher compared to the other conventional systems.
- Up-to-date information on geothermal energy utilisation in Turkey could not be easily and completely found. Especially as regards city-based geothermal district heating systems and greenhouses, there were some differences between the data given by various researchers and companies. This means that, in general, good documented systems for geothermal energy should be established in the country.
- New financing mechanisms are needed to promote investment in energy efficiency and renewable energy.
- The first barrier preventing widespread use of renewables is the lack of a coherent national energy plan in which the role of renewables is well explained, as well as defining properties among alternatives.
- In Turkey, governmental investment on energy sector is far behind the demand. To meet the fast growing demand, the privatisation and restructuring studies have started on energy sector and required legislations for private sector and foreign investment are arranged. Electricity Market Law was enacted in March 2001 and the transition period was completed in September 2002. Electricity Market Regulatory Agency (EMRA) is fully authorised to regulate the market and licence the activities.
- Although Turkey has no specific laws for development of geothermal resources yet and the lack of governmental support, direct use applications have been growing rapidly and proved by public sector.
- Geothermal development offers a viable energy alternative to fossil fuel. However, environmental and social dimensions of geothermal development must be carefully and properly managed.
- In the long term, geothermal energy will remain a viable option to furnish clean, reliable power in Turkey.
- It should be underlined that is already confirmed and proven that geothermal energy can be commercially competitive with other energy sources (Gunerhan *et al*., 2001).

5 References

Arman, F.A. (2002). Focusing on hydropower developments in Turkey. *IBC's 5th Annual Gas&Power in Turkey Conference*, Istanbul, Turkey.

Erisen, B., Akkus, A., Uygur, N., Kocak, A. (1996). Turkish Geothermal Inventory, MTA, Ankara (In Turkish).

Gokcen, G., Ozturk, H.K. and Hepbasli, A. (in press). Geothermal fields suitable for power generation, *Energy Sources*.

Gunerhan, G. G., Kocar, G. and Hepbasli, A. (2001). Geothermal energy utilisation in Turkey. *International Journal of Energy Research*, V. 25, N.9, pp.769-784.

Hepbasli, A., and Yilmaz, H. (2001). Geothermal (ground-source) heat pumps in Turkey: Past, present and future. *CD-Proceedings of Seventh World Congress, CLIMA 2000*, Napoli, Italy.

Hepbasli, A., Yilmaz, H. and Eroglu, S. (2001a). Geothermal (ground source) heat pump applications in Turkey. 4th Workshop*, CD Proceedings of IEA ECES-IA Annex 14*, April 19, Istanbul, Turkey.

Hepbasli, A., Eltez, M. and Duran, H. (2001b). Current status and future directions of geothermal heat pumps in Turkey. *Proceedings of Twenty-Sixth Workshop on Geothermal Reservoir Engineering Stanford University*, Stanford, California, USA, pp. 398-405.

Hepbasli, A., Eltez, A. and Hancioglu, E. (2001c). A feasibility study on geothermal heat pumps in Aegean region of Turkey, *CD-Proceedings of 4th International Thermal Energy Congress* (ITEC2001), Izmir, Turkey, pp. 44-48.

Hepbasli, A, Yilmaz, H. and Eroglu, S. (2002). Ground source (geothermal) heat pumps installations in the Turkish buildings: An energy efficiency outlook. *CD Proceedings of Fifth International HVAC and Refrigeration Technology Symposium.* Turkish Society of Heating, Ventilating, Air-Conditioning & Sanitary Engineers, Istanbul, Turkey (In Turkish).

Mertoglu, O. (1998). Alternative energy sources of the future: Geothermal energy. *Energy World*, WEC-TNC, 20, 53 (in Turkish).

Mertoğlu, O. and Basarir, N. (1995). Geothermal utilisation and applications in Turkey, *Proc. of the World Geothermal Congress*, 18-31 May, Florence, Italy, 1, 345-350.

Mertoglu, O., Bakir, N. (2002). Examples from Turkey. *International Workshop on Possibilities of Geothermal Energy Development in the Aegean Islands Region*, Milos-Greece.

Ozgener, O., Koçar, G. (in press). Geothermal Heating Applications. Energy Sources.

TGA (Turkish Geothermal Association) (2002). *The Importance of Geothermal Energy in Turkey and the World*, Report (In Turkish).

WEC-TNC (World Energy Council-Turkish National Committee) (2000). 1999 Turkey Energy Statistics.

Table 1: Present and planned installed electricity capacity of Turkey (WEC-TNC, 2000; Arman, 2002).

Year	Geothermal		Hydro		Fossil Fuel		Nuclear		TOTAL	
	Inst.Cap. (MW_e)	Ann. Prod. (GWh/a)	Inst.Cap. (MW_e)	Ann. Prod. (GWh/a)	Inst.Cap. (MW_e)	Ann. Prod. (GWh/a)	Inst.Cap. (MW_e)	Ann. Prod. (GWh/a)	Inst.Cap. (MW_e)	Ann. Prod. (GWh/a)
2001	20.4	90	12,476	42,216	20,907	100,148	-	-	33,403.4	142,454
2010	258.0	4372	19,413	65,387	41,077	229,143	2,000	14,035	62,748	312,937
2020	350.0	5651	28,466	97,456	76,427	458,234	9,000	63,159	114,243	624,500

Table 2: High temperature geothermal fields and possible utilisation opportunities (Gokcen et al., in press).

No.	Geothermal Field	Temperature (^oC)	Current utilisation	Possible utilisation opportunities
1	Kizildere-Denizli	242	Electricity generation, greenhouse heating, space heating, simple balneology applications, CO_2 production, textile industry	Electricity generation, building heating and industrial applications, drying, thermal tourism, thermal facility heating, and cooling applications.
2	Germencik-Aydin	232	Greenhouse heating of 0.05 ha	Electricity generation, district heating and cooling, greenhouse, drying, textile industry, cold stores, thermal tourism and thermal facility heating
3	Tuzla-Canakkale	174	Greenhouse heating, space heating, simple balneology applications, salt production.	Electricity generation, thermal tourism and thermal facility heating and salt production.
4	Salavatli-Aydin	171	Thermal tourism	Electricity generation, district heating and cooling, greenhouse heating, drying, industrial process heat, thermal tourism and thermal facility heating.
5	Simav-Kutahya	162	Thermal tourism, thermal facility heating, greenhouse heating of 12 ha, district heating with the residences of 3200.	Electricity generation, thermal tourism, thermal facility heating, greenhouse heating, industrial applications, district heating application at Simav, industrial use.
6	Seferihisar-Izmir	153	Simple balneology applications, greenhouse heating of 0.6 ha at Seferihisa	Electricity generation, thermal tourism, thermal facility heating, district heating, greenhouse and industrial facility heating.
7	Salihli-Manisa	150	District heating application of 200 residences at Salihli	Electricity generation, thermal tourism, thermal facility heating, drying.
8	Yilmazkoy-Aydin	142	Not available	Electricity generation plus integrated use.
9	Dikili-Izmir	130	Simple balneology applications, greenhouse heating of 1 ha	Electricity generation plus integrated use.