

GEOHERMAL ACTIVITIES AND DEVELOPMENTS IN TURKEY IN LAST THREE YEARS

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KEY WORDS

Turkey, geothermal, direct use, electricity, development

ABSTRACT

Turkey is the fifth country in the World in existing geothermal direct use applications. In terms of total geothermal potential, it is the 7th country in the world. Most of the development is achieved in geothermal direct-use applications with 61,000 residences equivalence geothermal heating (665 MW_t) including district heating, thermal facilities and 565,000 m² geothermal greenhouse heating. Geothermal water is used in 195 spas for balneological purposes (327 MW_t). Engineering design of nearly 300,000 residences equivalence geothermal district heating has been completed. By summing up all these geothermal utilizations, the geothermal direct use installed capacity is 992 MW_t by June 2003 in Turkey. One of the main developments achieved in geothermal district heating system was Salihli 20,000/24,000 residences equivalence geothermal district heating and 2000 residences equivalence capacity geothermal air-conditioning system which has started up in January 2002. The electricity generation has been increased from 90 GWh to 108 GWh in Kizildere geothermal power plant which is the single existing geothermal power plant of Turkey. Besides electricity generation, the CO₂ set free in the condenser is partly supplied to a Liquefied CO₂ and Dry Ice Factory installed next to the plant and about 120,000 t/year dry ice and liquefied CO₂ for the beverage industry in Turkey is produced. Slightly more than 3 % of Turkey's geothermal potential is utilized yet.

1. GEOHERMAL PRODUCTION

63 geothermal production wells have been drilled by MTA, since 2000. This makes the total geothermal production well number 368. This makes an addition of 26,991.15 m well length, which makes a total geothermal production well length of 146,232 m in Turkey. With the existing geothermal wells and springs the proven geothermal capacity is 3235,23 MW_t by June 2003 (exhaust temperature is assumed to be 40 °C) [1]. With the drilled wells by the private sector the total number of geothermal production wells has been estimated as about 425.

2. GEOHERMAL DISTRICT HEATING SYSTEMS

Today 11 cities are heated partially with geothermal in Turkey. These geothermal district heating systems have been constructed since 1987 and many development has been achieved in technical and economical aspects. The rapid development of geothermal district heating systems in Turkey is mostly depending on [2];

- construction of suitable geothermal district heating systems according to Turkey's conditions,

- participation of the consumers to the geothermal district heating investments by about 50 % without any direct financing refund,
- geothermal heating is about 50-70 % cheaper than natural gas heating.

2.1 A Recent Example: Salihli Geothermal Integrated System

The thoughts about utilization of the geothermal resources in Salihli area have begun in 1992 with drilling of 3 geothermal production wells by MTA General Directorate in Kursunlu geothermal field. The geothermal field is at about 4 km distance to the city with a higher altitude of 100 m.

Salihli Geothermal Integrated System includes 20,000/24,000 residences equivalence geothermal district heating, 2,000 residences equivalence geothermal air-conditioning, balneological utilization, greenhouse heating and raisin production which will be explained in further details in this paper.

Geothermal fluid is carried to the heating centre located very near to the city center and transported again to the geothermal field for reinjection.

28 MWt capacity heat exchanger and pump group has been installed in the heating center of the system which is suitable for modular extension. Each modul (unit) has a power of 14 MWt (Figure 1). During 2002-2003 winter season 2,000 residences equivalence geothermal district heating has been operational. According to further plans the installations and connection of the residences are continuing for the extension of the system.

The total investment amount of Salihli Integrated Geothermal System is 35 Million USD. Pay-back period of this investment is 7,4 years. The heating fee paid by the residences (based on 100 m² area) to the Salihli Municipality is 18 USD per month (August 2003, 1 USD = 1,400,000.-TL).

Geothermal District Heating and Air-Conditioning: Geothermal district heating system has an installed capacity of 24,000 residences equivalence. Now, 2,000 residences equivalence are heated geothermally in Salihli City. The extension of the system is continuing by connecting residences to the system. The feasibility report of this investment has been prepared in October 2000 by ORME Jeothermal Inc. This was followed by the application project. The construction is undertaken by the Salihli Municipality. ORME Geothermal fulfills the consultancy services of this investment. Beside of heating, 2,000 residences cooling (air-conditioning) and domestic hot water supply is included in the Salihli Geothermal Integrated System Project. Moreover, studies for geothermal air-conditioning of a hospital with a capacity of 120 residences equivalence are continuing. This air-conditioning system has a capacity of 800 kW and will start-up in 2004.



Figure 1: Salihli Geothermal Heating Center

Balneological Utilization: Balneological utilization in Salihli geothermal field refers to many decades. Previously it was in the form of primitive utilization, but now there exist two curing

centers and Apart houses with 270 bed capacity and two thermal pools. 300-400 people in average make use of this facility per day during the year.

Additional to the existing spa utilization in Kursunlu geothermal field, a big thermal facility complex (aqua parks, curing centers etc.) is planned to be build as an integration to the system.

Greenhouse Heating: Due to;

- the existence of suitable land area for greenhouse construction
- the convenient outside temperature and other meteorological conditions
- the progress obtained in agriculture in Salihli region, 240,000 m² greenhouse heating application is integrated to the system.

Raisin Production: In Salihli and its vicinity, grape raising is very popular and developed. Raisins are produced and exported in this area which constitutes one of the main commercial occupation. Drying of the grapes are made under the sun naturally as the existing situation. Whereas great areas are required for this purpose and carries limited quality conditions. Also, raisin production is taken into account in Salihli Geothermal Integrated Project and 175,200 tons/year capacity (25,000 kW heat power) geothermally dried raisin production is integrated to the system.

The general technical data of the system is as follows:

District Heating inst. capacity	: 139,400 kW
Geothermal	: 121,400 kW
Fuel-oil (peaking system)	: 18,000 kW
Cooling installed capacity	: 16,800 kW compl. with geoth.
Grape Drying	: 25,000 kW compl. with geoth.
Greenhouse Heating	: 37,584 kW, 240,000 m ² compl. with geoth.
Peak geothermal fluid demand	: 600 kg/sec

4 production wells exist in the geothermal field, whereas, 3 of them are used for geothermal district heating and 1 well is used for balneological utilization in the spa's. The existing 4 production wells are adequate by now, but to be extended to the total capacity of the integrated geothermal system, 13 production wells with a varying depth of 300 – 1,100 m, and 5 reinjection wells with an average depth of 300 m are planned to be drilled in Kursunlu and Caferbeyli geothermal fields. The existing production wells are all artesian wells. LSP will be installed to increase the production amount of the wells.

3. THERMAL FACILITIES HEATING AND BALNEOLOGICAL APPLICATIONS IN TURKEY

Turkey is one of the rare countries, where combining of sea/sun/cultural tourism with thermal tourism and balneological applications is possible. The main advantage of this combination is the increase of the variety and number of the tourists and the extension of the high tourism season to the whole year, instead of limiting it with 4-5 months which is mostly the case by the sea/sun/cultural tourism. This will bring an important economical development to these regions. Some of the regions which are suitable for sea and thermal tourism combination are; Bodrum, Kusadasi, Datca and Edremit cities which are located at the Aegean and Mediterranean Sea's. In Cesme (district of Izmir City), thermal water is transported to the hotels for balneological utilization and this combination is applied there with a great success.

A possible producable potential amount of geothermal flowrate (~ 40°C) which has been estimated for the balneological use in Turkey, is 50,000 L/sec. This equals to the benefit of 8 million people/day from thermal waters in spa's in Turkey [3].

The number of the local thermal curists is around 7 million and the number of the foreign thermal curists is around 10,000 in Turkey [3].

Bolu-Karacasu (44 °C) and Cankiri-Cavundur (56 °C) Thermal Facilities heating has been start-up in 2001 with a total capacity of nearly 100 residences equivalence.

Construction of Balpas Thermal Facilities (Main Building and geothermal water transportation pipeline) in Balıkesir Pamukcu have been completed. 2 geothermal production wells with 67 °C temperature and 40 L/sec flowrate will feed the geothermal heating and balneological utilization system of the thermal facility.

The foreign tourist (tourists in thermalism) target number is 1 million and the local tourist target number is 30 million for the year 2020 [3].

4. GEOTHERMAL ELECTRICITY PRODUCTION

Because of its relatively low installation and operational cost as well as being more environmentally benign, in comparison to the conventional thermic and hydraulic power plants geothermal electricity production is advantageous. At present, seven of the geothermal fields of Turkey are of high enthalpy and are appropriate for the geothermal-electric energy conversion by Binary Cycle or by Flashing Cycle. These fields are [4]:

1. Denizli-Kizildere	(242 °C)	
2. Aydin-Germencik-Omerbeyli	(232 °C)	
3. Canakkale-Tuzla	(173 °C)	
4. Aydin-Salavatli	(171 °C)	economy is doubtful
5. Kutahya-Simav	(162 °C)	at limited conditions
6. Manisa-Salihli-Caferbeyli	(155 °C)	
7. Izmir-Seferihisar	(153 °C)	

At present there is one operating geothermal power plant in Kizildere (Figure 2). Geothermal power plant in Germencik (on the Aydin-Germencik geothermal field) is expected to be constructed in a very near future.

The portion of geothermal in Turkey's total electricity production in 2002 is 0,05 % [5].

4.1 Kizildere geothermal power plant

The plant operates on Single Flash with Condensing Cycle. Geothermal steam and brine mixture of about 12% quality with 150°C well head temperature and 15 bar pressure is separated to dry steam and brine at 147 °C and 3.5 bar. The dry steam is supplied to turbine which drives an electric generator and a compressor.

In 2002 electricity generation has been increased from 90 GWh to 108 GWh in Kizildere geothermal power plant, due to the exploration of a new well with 242 °C downhole temperature and connecting it to the system. 25 % of the produced geothermal brine reinjected back to the reservoir since 2001.



Figure 2: Kizildere geothermal power plant

4.2 Germencik geothermal power plant

Germencik 25 MWe B.O.T. project; the geothermal field consists of 5 production wells and 3 reinjection wells. Total flow rate of geothermal fluid is 1,434 t/h, at 210 °C with well head pressure of 15-18 bar. Foundation has not been realized yet.

5. GREENHOUSE HEATING

The geothermal greenhouse heating capacity has been increased to 130,97 MWt, especially due to additional construction of total 120,000 m² greenhouses in Dikili (District of Izmir) and others.

Table 1. The existing geothermal greenhouses in Turkey are as the following

LOCATION	AREA (m ²)	CAPACITY (MWt*)	LOCATION	AREA (m ²)	CAPACITY (MWt*)
Sanliurfa	106,000	24.5	Dikili	120,000	24
Simav	120,000	33	Gölemezli	1,000	0.2
Sindirgi	2,000	0.4	Seferihisar	6,000	1.06
Afyon	5,500	1.5	Bergama	2,000	0.4
Kizildere	10,750	2.4	Germencik	500	0.1
Balcova	100,000	17.6	Edremit	49,620	8.7
Kestanbol	2,000	0.4	Ezine	1,500	0.3
Saraykent	2,000	0.6	Niksar	500	0.14
Tekkehamam	8,000	1.8	Kizilcahamam	5,000	1.45
Yalova	600	0.12	Gediz	8,500	2.1
Kozakli	4,000	1.2	Canakkale-Tuzla	50,000	9

Note 1: The existing geothermal greenhouses in Turkey (*Load factor is 0.6)

A 100 m² geothermal heat pump assisted greenhouse project in Erzurum City is approved by UNDP Energy for Sustainable Development Thematic Trust Funds Standing Committee in June 2002 and will be realized with the received fund in year 2003 [2].

6. MINERAL RECOVERY

There has been no additional contribution to mineral recovery obtained in last three years. The yearly production of 120,000 tons of liquid CO₂ and dry ice is continuing.

7. OTHER PROJECTS

Feasibility reports have been prepared for Aliaga (district of Izmir City), Edremit (district of Balıkesir City) and Sivas City Geothermal Utilization Systems. Also pre-feasibility reports for Denizli-Saraykoy and Bursa geothermal utilization systems had been prepared.

Edremit geothermal project includes 7,500 residences equivalence geothermal district heating system. The fuel-oil equivalence of the used geothermal energy in the system is 17,318 tons/year. By avoiding burning of this amount of fuel-oil, CO₂ emission of 53,586 tons/year will not be discharged to the atmosphere. It has been advised in the feasibility report to integrate the greenhouses which will be newly installed also to the geothermal district heating system will make the good economical conditions much more better.

The total investment amount of Edremit geothermal project is 8.5 Million USD and the pay-back period is 8 years.

The foundation ceremony have been realized on 19 May 2003 and the installation of the pipeline and production system has begun. As the first stage 1,500 residences equivalence will be heated geothermally in 2003-2004 winter season. 2 production (60-62 °C, total 110 L/sec. production with downhole pump) and 1 reinjection well exist in the Derman geothermal field, which is the geothermal field feeding the system.

Aliaga geothermal project includes 7,500 residences equivalence district heating and domestic hot water supply, 30,000 m² greenhouse heating and thermal water supply to the spa's.

Total installed capacity of 7,500 residences equivalence geothermal district heating and 30,000 m² greenhouse heating system is 56,650 kW, whereas 45,900 kW is met by geothermal and 10,750 kW is met from the peaking system by means of conventional fuels.

The fuel-oil equivalence of the used geothermal energy in the system is 11,215 tons/year. By avoiding burning of this amount of fuel-oil, CO₂ emission of 36,132 tons/year will not be discharged to the atmosphere.

The geothermal field is about 4 km distance to the city. It has been planned that the heat load demand will be met by means of changing the circulation flowrates of produced geothermal water and clean hot water.

The total investment amount of Aliaga geothermal project is 11 Million USD and the pay-back period is 7 years.

Sivas-Sicakcermik geothermal project includes 7,300 residences geothermal district heating, thermal water supply to the thermal facilities, treatment of geothermal water to drinking water, production of irrigation and water for fire department from Yildiz River, collecting of thermal discharge water and treatment of it.

System's total installed capacity 97,700 kW, whereas 71,000 kW is met by geothermal fluid and 26,700 kW is met from the peaking system by means of conventional fuels. The fuel-oil equivalence of the used geothermal energy in the system is 30,261 tons/year. By avoiding burning of this amount of fuel-oil, CO₂ emission of 73,569 tons/year will not be discharged to the atmosphere.

The total investment amount of Sivas-Sicakcermik geothermal project is 13 Million USD and the pay-back period is 7 years.

For further development of new geothermal projects "Geothermal Utilization Development Reports" have been prepared by Turkish Geothermal Association for different geothermal fields in Turkey. Geothermal fields of Aydin, Nevsehir, Yozgat, Usak, Eskisehir, Mugla and Afyon cities are constituting the content of these reports.

8. CONCLUSIONS

The development achieved in geothermal direct use in last 3 years in Turkey is 21 % in direct use, 20 % in electricity generation (Table 2).

Table 2. Comparison of the geothermal applications for the years 2000 and 2003

Applications (Install capacities)		2000	2003	Change in %
Space Heating (Residences + Thermal facilities)		392 MWt	534 MWt	36 ↑*
Greenhouse Heating		101 MWt	131 MWt	30 ↑
Bathing and Swimming		327 MWt	327 MWt	-
Total Direct Use		820 MWt	992 MWt	21 ↑
Mineral recovery		120,000 t/year	120,000 t/year	-
Electricity Production	Install capacity	20.4 MWe	20.4 MWe	-
	Generation	90 GWh	108 GWh	20 ↑
Existing proven capacity of Wells and Natural springs		2,600 MWt	3235,23 MWt	24 ↑

* ↑ = change in form of increase

Slightly more than 3 % of our total geothermal potential has been utilized yet.

By utilizing the estimated total geothermal heat potential (31,500 MWt) in residences heating, air-conditioning, greenhouse and thermal facilities heating, balneology, mineral recovery, industrial utilization, 20 Billion US\$/year net domestic value could be targeted.

For the further development and extension of the geothermal applications in Turkey, 15 % financial support of the Turkish Government would be appropriate.

31,500 MWt total geothermal heat potential is estimated in Turkey, which 500 MWe power production and 3,500 MWt space heating is aimed for the year 2010.

With the huge thermal tourism capacity potential of Turkey, the target is to increase the local tourist number to 30 million people until the year 2020. In this case, additional domestic economical activity of total 12 Billion USD/year will be created. The foreign thermal tourist number is targeted as 1 million until the year 2020.

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