This document contains the following article:

Direct Use Geothermal Activity in Turkey

From the Geo-Heat Center Quarterly Bulletin Vol. 11, No.2, Fall 1988

DIRECT USE GEOTHERMAL ACTIVITY IN TURKEY

Kadir Karul
Former Assistant Project Manager of Geothermal Drillings
Mineral Research and Exploration General Directorate (MTA)
Drilling Department, Ankara, Turkey

INTRODUCTION

Activity in the field of geothermal energy in Turkey started in 1961 with an inventory of Turkey's hot springs by the Mineral Research and Exploration General Directorate (MTA). Subsequent investigation revealed the great potential of geothermal energy. To enable full utilization of this potential, Turkey was divided into six geothermal regions which are being individually and systematically developed. In 1963, the first geothermal exploration drilling took place in the Agamemnun (Balcova) field which is west of Izmir. At the depth of 40 meters (130 feet) the well yielded a mixture of hot water and steam at the temperature of 124 °C (255 °F). The first geothermal field which was utilized for electricity production is in Denizli-Kizildere. Exploration of this field started in 1968. A power plant which has a generation capacity of 20 MWe is now in operation. Another well known geothermal field that was explored in 1982 is Aydin-Germencik field with a temperature of 231 °C (448 °F). The names of other well known geothermal fields are Izmir-Seferihisar, Afyon-Omer-Gecek, Canakkale-Tuzla, Izmir-Dikili-Bergama, Kutahya-Simav, and Ankara-Kizilcahamam.

GEOTHERMAL ENERGY POTENTIAL OF TURKEY

Turkey is located on the Alpine-Himalayan orogenic belt and has numerous grabens developed under the effects of young tectonic movements, widespread acidic volcanic activities, hydrothermal alterations, fumaroles and hot water springs with temperatures exceeding 100 °C (212 °F). This data indicates that Turkey is located on a geothermal energy belt and has an important potential of geothermal energy (Fig. 1, 2).

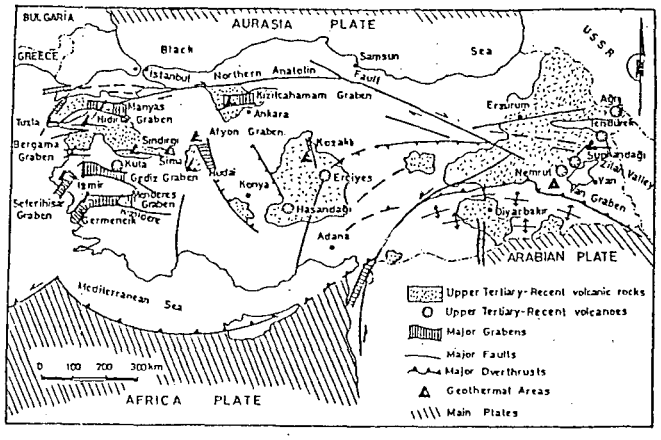

Figure 1. General tectonic and volcanic features of Turkey.

Due to the geological structure of Turkey and the continuous increase in demand for energy of the country directed the Mineral Research and Exploration General Directorate (MTA) towards the exploration of new energy resources as well as geothermal energy.

Geological and geophysical studies followed the initial research works, started in 1962 by making the hot water inventory of the country. The first geothermal fluid was recovered in 1963 by a borehole drilled at Balcova-Izmir area, but no use was made out of that 124 °C (255 °F) fluid at that time, because of rapid scaling effect.

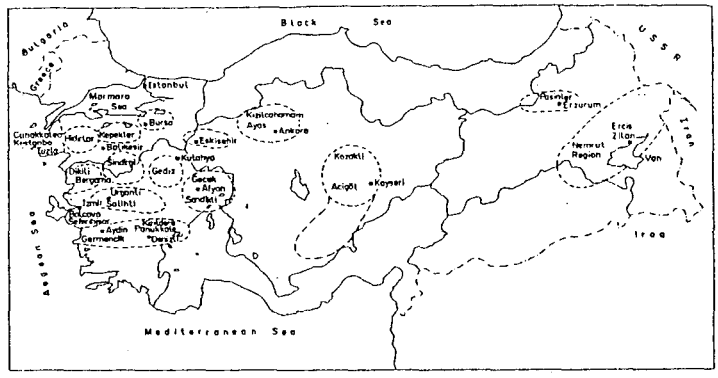

Figure 2. Geothermal areas of Turkey.

The work done up to date is not sufficient for an exact evaluation and calculation of the net potential of the country. Depending on the data obtained during the last 20 years, a potential of 4500 MWe electrical energy can be estimated in high enthalpy fields. This figure is more or less equivalent to the total installed capacity of the energy producing plants of the country in 1982. In addition to this, 31,000 MWt geothermal potential is expected for the direct use from heat discharge such as space and greenhouse heating and industrial uses etc.

Furthermore, if the "hot dry rock" projects which are planned in coming years, give positive results, the geothermal energy potential of Turkey, with no doubt, will highly be increased.

ELECTRICAL USES

Kizildere-Denizli area is the first geothermal field explored in Turkey which is suitable for electricity generation.

The 0.5 MWe pilot power plant, constructed-installed and operated by MTA, had successfully tested and provided electricity to three neighboring villages for nearly 7 years.

20 MWe capacity power plant which was installed by the Turkish Electricity Authority started production in Feb. 1984. Besides electricity generation, the waste products of geothermal fluid are planned to be used in obtaining dry-ice (CO_2), and the waste water will be applied for greenhouse heating purpose.

The evaluation of drilling operations and interpretation of reservoir studies showed that the geothermal energy potential of Kizildere Field is much greater than 20 MWe. This capacity is limited by chemical polluters such as boron content which creates serious irrigation problems in the Menderes River when the production is over 1500 tons/h. Also $CaCO_3$ scaling is encountered in this field. The projects are prepared to solve these problems. In the meantime, chemical inhibitors are being tested to avoid the scaling and waste water disposal.

NON-ELECTRICAL USES

Non-electrical uses have been continuing in some geothermal fields in Turkey for 10 years. These fields, which have low enthalpy and high scaling characteristics, are being utilized and operated for space heating purposes. Non-electrical uses in different fields may be summarized as follows (Table 1):

Table 1

Present Utilization of Geothermal Energy for Direct Heat

Names of Localities	Type of Use	Flow Rate (kg/sec)
Izmir-Balcova	G+B+D	61.1
Afyon-Omer-Gecek	G+B+F	182.8
Denizli-Kizildere	G+I	400.0
Denizli-Tekkehamam	B+G	50.0
Balikesir-Havran	B+G	20.0
Izmir-Seferihisar	B+G	50.0
Afyon-Sandikli	B+D	50.0
Ankara-Kizilcahamam	B+D	50.0
Eskisehir	B+D	50.0
Balikesir-Gonen	G+D	30.0
Canakkale-Kestanbol	G+B	20.0
Main Balneological Centers of Turkey	**Temperature C**	
Bursa	82	50.0
Aydin-Germencik	90	10.0
Aydin-Salavatli	42	5.0
Aydin-Gumus	40	5.0
Balikesir-Sindirgi	98	50.0
Balikesir-Kepekler	62	5.0
Erzurum-Ilica	38	20.0
Erzurum-Dumlu	37	10.0
Erzurum-Pasinler	38	5.0
Nevsehir-Kozakli	90	20.0
Kirsehir-Terme	48	10.0
Kirsehir-Mahmutlu	62	28.0
Kirsehir-Karakurt	50	10.0
Kutahya-Simav	98	10.0
Kutahya-Gediz	78	8.0
Manisa-Kursunlu	78	5.0
Manisa-Urganli	90	25.0
Van-Zilan	78	20.0
Izmir-Dikili-Bergama	90	20.0
Canakkale-Tuzla	102	15.0
Canakkale-Hidirlar	80	15.0
Istanbul-Termal	65	10.0
Denizli-Pamukkale	36	50.0
Samsun-Havza	54	55.0
Rize-Ayder	55	14.0
Ankara-Haymana	43	52.0
Tokat-Sulusaray	54	21.0
Samsun-Kocapinar	38	35.0

I : Industrial process heat
F : Fish and other animal farming
D : District heating
B : Bathing and swimming
G : Greenhouses

KIZILDERE-DENIZLE GEOTHERMAL FIELD

This is the first geothermal field where the test greenhouse unit was built and operated successfully by MTA in order to show the use of geothermal fluid in heating. This test unit of greenhouses which covered an area of 1.0×10^3 sq. meters (0.25 acres) have now been operated by the local agricultural organization and enlarged to 4.5×10^3 sq. meters (1.1 acres). After the 20 MWe power plant was constructed on the field the new additional greenhouses are planned to be built in order to use the discharged water from the plant on a total area of 1.06×10^6 sq. meters (260 acres). The discharged geothermal fluid is also considered for different uses in textile industry, cord-leaching, production of some chemicals and for the recreational purposes as well. These uses will increase the economical value of geothermal energy.

BALCOVA-IZMIR GEOTHERMAL FIELD

The first geothermal energy well was drilled in this field in 1963 and yielded a mixture of hot water and steam of 124 °C (255 °F) temperature at a depth of 40 meters (131 ft). Because of rapid scaling problem, the well became inefficient in a short period, thus, no use was made at that time.

The first application of down-hole heat exchanger system in Turkey took place at this field in 1982, in order to avoid the scaling. The first well used for this purpose has a depth of 100 meters (328 ft) and bottom-hole temperature of 115 °C (239 °F). With this new application, heat transferred to fresh water circulated through "U" shaped pipes which are placed in the well (Fig. 3). The temperature of clean circulating water in the system varies in between 50-95 °C (122-203 °F) depending on the external effects and flow-rate.

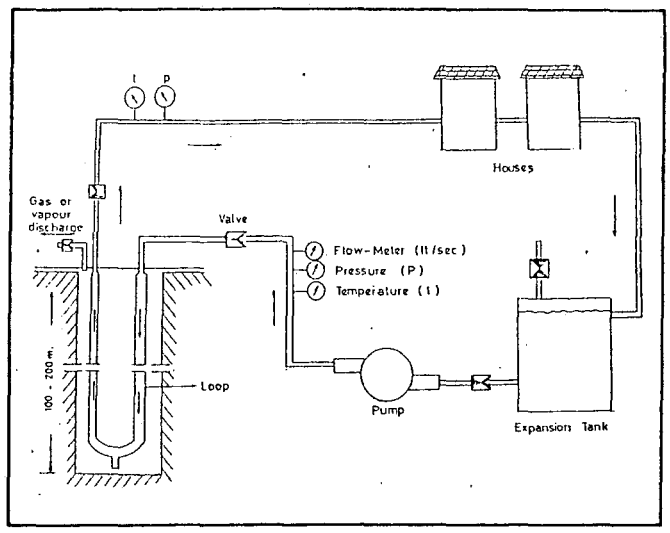

Figure 3. Down-hole heat exchanger system applied at Balcova-izmr and Afyon area.

Today, the touristical spa-hotels and its recreational facilities, with 250 room capacity in Balcova, are heated by a single well. Some units of Izmir-Dokuz Eylul University are also heated by the other three wells. The total present production potential is about 4.5×10^6 Kcal/h (17.8×10^6 Btu/hr) by 9 wells drilled up to now in the field.

The economical comparison of geothermal energy to lignite and fuel-oil for Balcova-Izmir Area is given on Table 2.

Studies are continuing to predict the total potential of the field for the purpose of residential heating some parts of Izmir City by geothermal energy. In the mean time, the greenhouses in this district are already planned for heating. For the Hotel in Balcova, absorbtion refrigeration unit cooling by geothermal energy using ammonia is under construction.

Table 2

THE ECONOMICAL COMPARISON OF GEOTHERMAL ENERGY TO LIGNITE and FUEL-OIL FOR BALCOVA-İZMİR and ÖMER-GECEK-AFYON AREA

Field Name	Heat Capacity	Amount of Lignite Equivalent	Amount of Fuel-Oil Equivalent	Amount of Lignite Saved in a year	The Cost of Lignite Saved in a year	Amount of Fuel-Oil Saved in a year	The Cost of Fuel-Oil Saved in a year
	Kcal/hour	kg/hour	kg/hour	tons	T.L. and U.S.$	tons	T.L. and U.S.$
Balcova Izmir	4.5×10^6	1125	469	1350	14,175,000 T.L. or $ 51629	563	58,552,000 T.L. or $ 142327
Ömer Gecek Afyon	2.8×10^6	700	292	2016	21,168,000 T.L. or $ 51629	841	87,464,000 T.L. or $ 213327

1- Equivalent Heat Capacities are considered as below:
Lignite: 4000 Kcal/kg and Fuel-Oil 9600 Kcal/kg

2- The average usage in a year is considered as follows:
In Balcova-Izmir Area: 10 hour/day and 6 Months.
In Ömer-Gecek-Afyon Area: 16 hour/day and 6 Months.

OMER-GECEK-AFYON GEOTHERMAL FIELD

This is another field where a rapid scaling is in effect. The temperature of geothermal fluid is around 98 °C (208 °F) at the average depth of 120-200 meters (390-650 ft). In order to avoid the scaling effect, down-hole and well-head heat exchanger systems had been tested successfully and a down-hole heat exchanger system is now in use. The temperature of fresh water circulated in the system varies in the range of 58-95 °C (136-203 °F) depending on external effects and flow rate. Greenhouses on an area of 2.0×10^3 sq. meters (0.50 acres) have already been constructed and economically operated for 3 years and new additionals are planned up to the total area of 100×10^3 sq. meters (25 acres). The geothermal energy is also used at the spa-hotel in the area for heating of swimming-pool and restaurant, and other facilities are planned to be heated in near future as well. The field is still at the stage of development and new additional wells will be drilled.

The total heat potential of 2.8×10^6 Kcal/h (11.1×10^6 Btu/hr) is produced from 3 wells in the field today.

The economical comparison of geothermal energy to lignite and fuel-oil for Omer-Gecek-Afyon Area is given on Table 2.

In addition to above mentioned utilization, 1.0×10^3 sq. meters (0.25 acres) Kestanbol-Canakkale, 6.5×10^3 sq. meters (1.6 acres) in Havran-Balikesir and 3.0×10^3 sq. meters (0.74 acre) greenhouses in Tekkehamam-Denizli are being heated by this natural source with direct use. Gonen-Balikesir, Sandikli-Afyon and Eskisehir spa-hotels have already been heated. The studies for heating some parts of Ankara and Eskisehir Cities are still continuing.

CONCLUSIONS

Turkey is located on a very important geothermal energy belt, in terms of its geology, where there are many grabens, widely spread acidic volcanism, hydrothermal alteration, fumaroles and lots of hot springs over 100 °C (212 °F) temperature. All of these data indicate the importance of the young tectonic activity for the geothermal potential. Geological, geophysical and geochemical studies and drilling operations carried out by MTA General Directorate since 1962, resulted with the exploration of many geothermal areas, which are mostly located in Western Anatolia. As a result of above studies, 4500 MWe electrical and 31,000 MWt non-electrical geothermal potential are expected.

Kizildere-Denizli Field, one of the most important fields in Turkey, is the first one suitable for power generation. The 20 MWe power plant is installed on this field and started production in Feb. 1984.

Germencik-Aydin and Tuzla-Canakkale fields are being developed for the purpose of electricity generation as well as the other purposes. There are numerous fields which are expected to be developed in near future.

Balcova-Izmir and Omer-Afyon Fields are the most important ones where the successful results of non-electrical uses are obtained.

The development of geothermal energy suitable for either power generation or space heating in Turkey, where a great geothermal potential is available, will help the country to meet its current energy requirement, and the economy.

REFERENCES

Akkus, Mehmet F., (1983) Geothermal Energy Exploration In Turkey And New Developments: Symposium New Mineral Raw Materials, Karlovy Vary 1983 Czechosiovakia.

Akkus, M.F., Yuksel, V. and Simsek, S., (1984) New Developments on Geothermal Energy Exploration In Turkey: U.N. Seminar On Utilization of Geothermal Energy For Electric Power Production and Space Heating, Florance (Italy), May 1984.

Erentoz, C. et Ternek, Z. (1969), Les sources thermominerales de la Turquie et l'etude de l'energie geothermique: MTA Bull. no. 70, Ankara.

Karul, K. (1987) Presentation at the 1st Unitar/UNDP Workshop on Small Geothermal Resources, Pisa, Italy (11-22 May).

Kurtman, F. (1973) The importance of volcanology and tectonics in geothermal field explorations: First Geothermal Energy Symposium of Turkey, Ankara.

Kurtman, F. and Samilgil, E. (1975) Geothermal Energy Possibilities, Their Exploration in Turkey: U.N. Symp. Dev. Use Geothermal Resources, San Francisco.

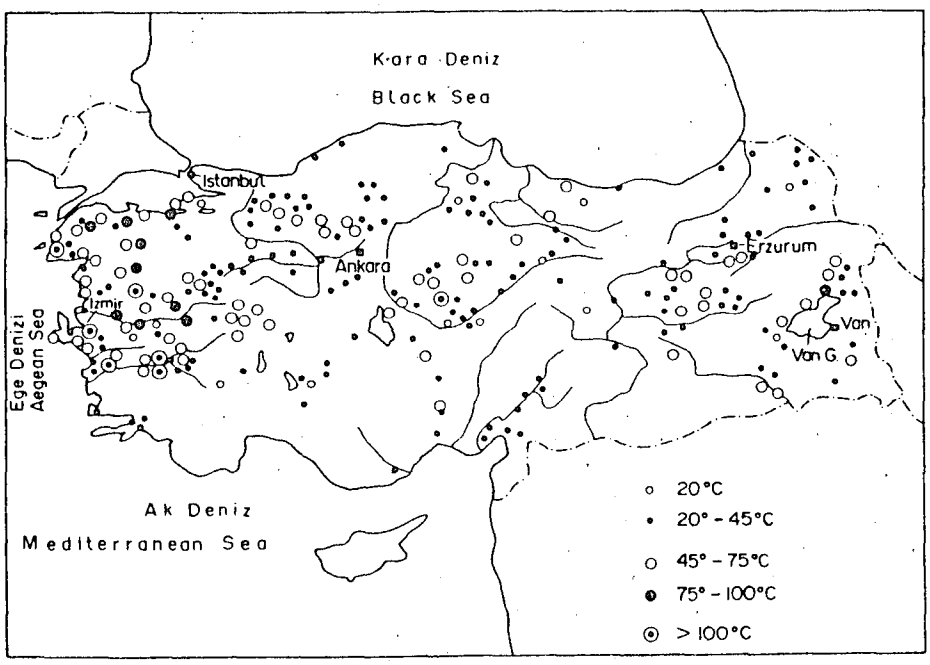

Figure 4. Distribution of Hot Springs in Turkey.