Recent Geothermal Activities and Developments in Turkey and Projections for the Year 2013

Orhan Mertoglu, F. Murat Mertoglu, Nilgun Bakir, Tevfik Kaya
ORME Jeotermal Inc., Hosdere cad. No: 190/7-8-12, 06550 Cankaya-Ankara
orme-f@tr.net

Keywords: Turkey, geothermal, development, projection

ABSTRACT

Turkey is the fifth country in the World in existing geothermal direct use applications. Most of the development is achieved in geothermal direct-use applications with 117,000 residences equivalence geothermal heating (983 MW_t) including district heating, thermal facilities and 1 million m^2 geothermal greenhouse heating. Geothermal water is used in 215 spas for balneological purposes (402 MW_t). Engineering design of nearly 310,000 residences equivalence geothermal district heating has been completed. By summing up all these geothermal utilizations, the geothermal direct use installed capacity is 1385 MW_t by April 2007 in Turkey. Main geothermal district heating system applications are Izmir-Balcova, Izmir-Narlidere and Izmir-Medical Faculty Campus of Dokuz Eylül University, Afyon-city center, Afyon-Sandikli, Kirsehir-city center, Kütahya-Simav, Ankara-Kizilcahamam, Balikesir-Gönen, Nevsehir–Kozakli, Manisa–Salihli, Agri-Diyadin, Denizli-Sarayköy, Balikesir-Edremit, Balikesir-Bigadiç and Yozgat-Sarikaya geothermal district heating systems. The electricity generation has been reached 30 MW_e with the addition of Aydin-Salavatli binary cycle geothermal power plant of 10 MWe install capacity to the existing Kizildere geothermal power plant (20 MW_e install capacity).

According to the Geothermal Working Group Report of Turkey's 9th (2007-2013 period) Development Plan of Prime Ministry State Planning Organisation, the geothermal potential for electricity production according to todays commercial conditions is 550 MWe by the year 2013. Moreover, the geothermal direct use (district heating, greenhouse and thermal facilities heating, balneological utilization, drying, cooling, fish farming, mineral recovery) 2013 projections has been estimated as 8000 MWt (35.040.000 MWth/year).

The total investment required to reach the 2013 goals for geothermal electricity production, district heating (houses, thermal facilities etc.), greenhouse heating, thermal tourism, drying, cooling and fish farming is 3,25 Billion USD. But, the economic activity created in Turkey would be 16 Billion USD by reaching the 2013 goals.

1. INTRODUCTION

Turkey is located on the Alpine-Himalayan orogenic belt, which have high geothermal potential. In terms of total geothermal potential, it is the 7th country in the world. The first geothermal researches and investigations in Turkey started by MTA in 1960's. Upon this, 174 geothermal fields have been discovered by MTA, where most of them are low-medium enthalpy fields, which are suitable for direct-use applications and 13 geothermal fields having a production temperature range (130 °C - 242 °C) are suitable for electricity generation. Around 1500 hot and mineralised natural springs and wells exist in Turkey. With the existing geothermal wells discharge water (drilled by General Directorate of Mineral Research and Exploration, as of November 2006, 3000 MWt) and springs (600 MWt), the proven geothermal capacity calculated by MTA is totally 3600 MWt. The geothermal heat potential is estimated as 31,500 MWt (5,000,000 residences equivalence). This figure means also that 30 % of the total residences in Turkey could be heated by geothermal energy.

The total geothermal electricity production potential has been estimated as 2000 MWe (16 Billion kWh/year) in case of governmental support (ecologically driven as green power and high buying price according to EC Resolution (15 Eurocent/kWh)) could be received (like incentive).

A liquid carbon dioxide and dry ice production factory is integrated to Kizildere geothermal power plant.

Nearly 6 % of our total geothermal potential has been utilized yet. For the further development and extension of the geothermal district heating applications in Turkey, 15-20 % financial support of the Turkish Government would be appropriate.

Moreover, the realization of the World Geothermal Congress 2005 in Antalya/Turkey, has been benefited to the development and widening of geothermal applications in Turkey.

2. RECENT SITUATION

In Turkey, 174 geothermal fields which can be useful at the economic scale and about 1500 hot and mineral water resources (spring discharge and reservoir temperature) which have the temperatures ranged from 20-242 °C, have been determined.

The most important developments has been especially obtained in electricity generation, residences heating, greenhouse heating and balneological applications in Turkey in the last years. As of April 2007, the recent situation has been shown in Table 1.

Table 1.: Capacities in Geothermal Utilization in Turkey (April 2007)

Geothermal Utilization	**Capacity**
Heating (Houses, thermal facilities, greenhouses)	983 MWt
Balneological Utilization 215 Spa	402 MWt
Total Direct Use	**1385 MWt**
Electricity Production	30 MWe
Carbon dioxide production	120.000 tons/yr

If the installed capacities of the geothermal applications in Turkey are compared for the years 2000 and 2007, it can be seen that the geothermal heating (residences, greenhouses and thermal facilities heating) applications have been increased by 99,4%, balneological utilization by 23% and geothermal electricity generation by 50%.

The existing geothermal district heating systems are shown in Table 2.

Table 2: Existing situation in geothermal district heating systems in Turkey

Location	**Number of residences Heated Geothermally**	**Temp. of Geoth. Water (°C)**	**Investor**
Dokuz Eylül Unv. Campus+ Balcova + Narlidere (1983)*	20.000	125-145	Equal partnership of Governorship and Municipality Inc. (Dokuz Eylül Unv:Governorship + University Rectorate)
Gonen (1987)*	3.400	80	Mainly Municipality Inc.
Simav (1991)*	5.000	137	Municipality
Kirsehir (1994)*	1.900	57	Local Governorship (Mainly) + Municipality Inc.
K.hamam (1995)*	2.500	80	Mainly Municipality Inc.
Afyon (1996)*	4.500	95	Local Governorship (Mainly) Municipality Inc.
Kozakli (1996)*	1.200	90	Mainly Municipality Inc.
Sandikli (1998)*	3.200/5.000	70	Mainly Municipality Inc.
Diyadin (1999)*	400	70	Mainly Local Governorship Inc.
Salihli (2002)*	4.100/24.000	94	Municipality
Saraykoy (2002)*	1.500/5.000	140	Mainly Municipality Inc.
Edremit (2003)*	2.500/7.500	60	Municipality+Private Sector Inc.
Bigadic (2005)*	500/3.000	96	Municipality
Sarikaya (2006)*	30/2.000	50	Governorship + Municipality+ Private Sector Inc. Company
Thermal Facility and nearly 1 million m^2 Greenhouse Heating (Sanliurfa, Dikili, Simav, Balcova, Simav etc.)			Investment in the field : Governorship + Greenhouse Inv.: Private Sector

* Year of Starting Operation

3. DEVELOPMENTS

3.1. Geothermal Heating

The district heating system applications have been started with large scale geothermal district heating systems in Turkey. This constitutes an important advantage of geothermal district heating investments in Turkey in terms of technical and economical aspects.

3.1.1. Sarikaya - Yozgat Geothermal Floor Heating System

The geothermal waters were used only for balneological purposes in Sarikaya district for centuries. The Sarikaya geothermal field has been investigated and geothermal production well locations and depths have been determined in 2004 by ORME Jeotermal Inc. and Hacettepe University collectively realized geothermal field study. 5 production wells have been drilled during 2005 and 2006. 45-50 °C temperatured geothermal water has been produced from 2 wells. Sarikaya district is located in Central Anatolia, whereas – 25 °C outside temperature have been encountered during winter time. A pilot geothermal floor heating application has been realized firstly in March 2006 by ORME Jeotermal Inc., which has convinced the local government that geothermal heating application could be realized with this geothermal water temperature and climate conditions.

As of April 2007, 30 residences equivalence has been connected already to the heating system. The demand of the citizens for connecting to the geothermal heating system is increasing day by day. The system install capacity is 2000 residences equivalence. Each residence will pay 48,5 US$/month/100 m^2 heating fee (including domestic hot water utilization).

Photo 1: Heat Exchanger System in one of the Buildings in Sarikaya

Additional 2 geothermal wells are going to be drilled with the aim to produce higher temperatured geothermal water. With the utilization of the geothermal water in this project, decrease in Carbon Dioxide emission value will be 20,143 tons/year. The return geothermal water will be used partly for balneological purposes. Also some geothermal fish farming applications is going to be planned.

3.1.2. Balikesir-Edremit Geothermal District Heating System

Edremit is a town of Balikesir province situated 87 km from the Balikesir city center. Its urban population is 39,202. Edremit Geothermal District Heating System is fed

from Edremit geothermal field, which is 3 km away to the Edremit city center located at the Aegean Sea Coast.

Edremit Geothermal District Heating System has begun to operate on December 2003 with 500 residences. Now 2500 residences are connected to the system by April 2007. Total capacity of the project is 7,500 residences. Each residence pays 36 US$/month heating fee. With the utilization of the geothermal water in this project, decrease in Carbon Dioxide emission value will be 15,483 tons/year.

The system supplies heating in winter, hot tap water during the whole year. The geothermally heated clean water is transported with the pre-insulated pipes to the residences. The returning water is planned to be used for thermal tourism facilities.

3.1.3. Izmir-Balcova Geothermal District Heating System

During the years 2005 and 2006, 2700 residences equivalence geothermal district heating system has been started to operation in Balcova-Tugsuz region (1200 residences equivalence) and Narlidere-Yeniköy region (1500 residences equivalence).

In February 2007, additional 3900 residences equivalence geothermal district heating system has started to operation in Balcova-Teleferik region.

The construction of this total 6600 residences equivalence geothermal district heating system has been realized by ORME Jeotermal Inc.

145 °C temperatured geothermal water has been produced from recently drilled geothermal deep wells.

3.2. Geothermal Electricity Production

3.2.1. Denizli-Kizildere Geothermal Power Plant

First explorations regarding geothermal electricity generation was started in 1968 with the investigation of Kizildere geothermal Field. In 1974 a pilot plant with a capacity of 0.5 MWe has been installed.

In 1984, the Kizildere Geothermal Power Plant was installed by T.E.K. (Turkish Electricity Authority, renamed as TEAS) with an installation capacity of 20.4 MWe (Photo 2). This power plant generates an average of 12-15 MWe electricity annually. The reservoir temperature in the Kizildere geothermal field is 242 °C (Simsek et al. 2000). The reservoir which feeds the Kizildere Geothermal Power Plant contains 1,5 % non-condensable gases. The amount of these gases at the separation pressure in the single flash plant is 15 % in weight.

Photo 2: Kizildere Geothermal Power Plant

A liquid CO2 and dry ice production factory is integrated to this power plant which produces 120,000 tonnes of liquid carbon dioxide and dry ice annually.

3.2.2. Aydin-Salavatli Geothermal Power Plant

In Aydin-Salavatli, nearly 10 MWe install capacity Binary Cycle Power Plant is running since March 2006. 167 °C temperatured geothermal water and steam is used .

3.2.3. Aydin-Germencik Geothermal Power Plant

Is under construction. The plant capacity of the first stage is 48 MWe. The total install capacity is aimed to reach 100 MWe. The geothermal steam temperature is 232 °C. The first stage is planned to be operational in the beginning of 2008.

3.2.4. Denizli-Sarayköy Geothermal Power Plant

Is under construction. Waste geothermal water product of Kizildere Geothermal Power Plant which is 140 °C geothermal water and steam will be used in this plant. Total installed capacity of this plant will be 5,5 MWe.

3.3. Geothermal greenhouse heating applications

The first geothermal greenhouse heating application has been started with 2000 m^2 in 1973 in Denizli-Kizildere with United Nationas Developement Programme. Since then, geothermal greenhouse heating applications have gained a rapid increase in terms of investment especially in the recent years. Especially in the last 2-3 years, this development is achieved. The major greenhouse applications heated geothermally are located in the Aegean region (Dikili, Balcova, Simav) are as follows:

Izmir Dikili : 400.000 m^2

Kutahya-Simav : 300.000 m^2

Sanliurfa : 125.000 m^2

Izmir Balcova : 100.000 m^2

3.4. Balneological Utilization

10 million local and 10.000 foreign visitors are benefiting from balneological Utilities in Turkey. Also the thermal tourism facility investments have gained speed in the recent years.

With the huge thermal tourism capacity potential of Turkey, the target is to increase the local curist (tourists in thermalism) number to 15 million people until the year 2013. The foreign thermal curist number is targeted as 250.000 until the year 2013.

3.5. Geothermal Law

The Geothermal Law of Turkey has been prepared and also gained a big step towards approval. The law is in the programme of Turkish Grand National Assembly and expected to be approved during this year.

4. YEAR 2013 PROJECTIONS

According to the Turkish Prime Ministry State Planning Organisation 9th Development Plan the year 2013 goals for different types of geothermal utilizations have been specified as follows (Table 3-4):

Table 3: Year 2013 projections for different types of geothermal utilizations, export and employment

Geothermal Utilization	Year 2013 Projections	MW	Total annual Energy
Electricity Production		550 MWe	4 Billion kWh/Year
District Heating	500.000 Residence equivalence	4000 MWt	
Balneological application	400 Thermal Facilities equivalence	1100 MWt	
Greenhouse	5.000.000 m^2	1700 MWt	
Cooling	50.000 Resid. equivalence	300 MWt	
Drying	500.000 tonnes/year	500 MWt	
Fish Farming + other appl.		400 MWt	
Total Direct Use		**8000 MWt**	**35.040.000* MWt/Year**
Total Geothermal Direct Use (non-electric) + geoth. electricity production utilization projection fuel-oil saving (substitution) for the year 2013			3,88 Billion Ton/Year = 4,24 Bill. USD/year
The prevented CO_2 emission amount by reaching the 2013 geothermal utilization goals (550 MWe+ 8000 MWt)			10 Million Ton/Year
	Year 2005		**Year 2013**
Geothermal CO_2 Production (gross)	120.000 ton/year		200.000 ton/year
	Year 2005		**Year 2013**
Created Employment (Direct and Indirect)	40.000 persons		200.000 persons
	Year 2005		**Year 2013**
Export (greenhouse products)	15 Million USD		250 Million USD

*Load Factor is 50 %.

Table 4: Year 2013 Projections for geothermal electricity production in Turkey

Geothermal Field Name	Temp. (°C)	2010 Projections (MWe)	2013 Projections (MWe)
Denizli-Kizildere	200-242	75	80
Aydin-Germencik	200-232	100	130
Manisa-Alasehir-Kavaklidere	213	10	15
Manisa-Salihli-Gobekli	182	10	15
Canakkale-Tuzla	174	75	80
Aydin-Salavatli	171	60	65
Kutahya-Simav	162	30	35
Izmir-Seferihisar	153	30	35
Manisa-Salihli-Caferbey	150	10	20
Aydin-Sultanhisar	145	10	20
Aydin-Yilmazkoy	142	10	20
Izmir-Balcova	136	5	5
Izmir-Dikili	130	30	30
TOTAL		**455**	**550**

The required investment amounts to fulfill the State Planning Organisation 2013 Geothermal Goals for 2007 – 2013 period are shown in Table 5.

Table 5: The required investment amounts to fulfill the State Planning Organisation 2013 Geothermal Goals for 2007 – 2013 period

Geothermal Application	Goals for the year 2013	Required Additional Investm. Difference (USD) (until 2013)
Electricity production	550 MWe (4 Billion kWh/year)	1 Billion USD
District Heating (residences, thermal facilities etc.)	4000 MWt (500.000 residences equivalence)	800 Million USD
Greenhouse heating	1700 MWt (5.000.000 m^2)	350 Milion USD (production wells included)
Drying and other applications	500.000 tonnes/year	100 Million USD
Thermal Tourism (Balneological Utilization)	400 Thermal Facilities equivalence	800 Million USD
Cooling	50.000 Residences equiv.	200 Million USD
Total		**3,25 Billion USD**

The economical activity created by reaching the goals in 2013 for geothermal electricty production, heating (residences, thermal facilities etc.), thermal tourism, greenhouse heating, drying, fish farming and similar direct use applications would be **16 Billion USD/year.**

5. CONCLUSION

The recent geothermal developments achieved during recent years are very pleasing but not satisfactory. With the existing geothermal potential of Turkey, higher capacities should be realized.

Total Geothermal Direct Use (non-electric) and geothermal electricity production utilization projection fuel-oil saving (substitution) for the year 2013 would be 3,88 Billion Ton/Year (= 4,24 Bill. USD/year).

The prevented CO_2 emission amount by reaching the 2013 geothermal utilization goals (550 MWe+ 8000 MWt) would be 10 Million Ton/Year.

The created direct and indirect employment by reaching the 2013 geothermal utilization goals would reach 200.000 persons.

The required investment amounts to fulfill the 2013 Geothermal Goals for 2007 – 2013 period is 3,25 Billion USD.

The economical activity created by reaching the goals in 2013 for geothermal electricty production, heating (residences, thermal facilities etc.), thermal tourism, greenhouse heating, drying, fish farming and similar direct use applications would be 16 Billion USD/year.

The existing geothermal applications are contributing to the Turkish National Economy is calculated as 1,4 Billion US$/year.

To gain a higher speed in geothermal applications the most urgent improvements needed are: Turkish geothermal law should be approved as soon as possible, more geothermal wells should be drilled and the well risk should be taken by the state, a control mechanism should work and more financing aids should be received for the geothermal development projects in Turkey.

REFERENCES

Akkus. I., Geothermal Applications and MTA, JENARUM Summer School Proceedings, 2002, pp.1-32

Mertoglu, O. Bakir, N. and Kaya T., 2003 Geothermal application experiences in Turkey. European Geothermal Conference EGC 2003, No: 1-4-02 Hungary.

ORME Jeotermal Inc., Company Brochure – 2007.

TR. Prime Ministry State Planning Organisation 9th Development Plan Geothermal Working Group Report, 2006, Ankara

10th Energy Congress Turkey, 2006, Istanbul Geothermal Energy Development Report. Turkish Geothermal Association (TJD).Ankara.

WEC Turkish National Committee Report, 2006. Turkish Energy Statistics.Ankara.