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II

NEW DEVELOPMENTS AND INVESTMENT OPPORTUNITIES OF GEOTHERMAL SOURCES IN TURKEY

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SUMMARY

First geothermal exploration and investigations in Türkiye were initiated by MTA in 1962. Up to now, 470 wells, having a total depth of 212250 m, have been drilled, and 187 geothermal fields have been discovered by MTA.

The geothermal potential of Türkiye is estimated (theoretically) as 31,500 Mwt. The total proven geothermal capacity of the wells together with the springs is 4078 Mwt, of which 1342 Mwt is directly used.

Currently, there are 3 geothermal power plants in operation, namely, Kızıldere G.P, Salavatlı GP and Bereket Energy- Sarayköy, with installed capacities of 15, 7.4 and 5 Mwe, respectively. In addition, in Aydın-Germencik field, a 47.4 Mwe installed capacity PV is under construction and is planned to be operated in February 2009.

Since 2005, exploration and research activities of MTA have increased by multiple times. The geothermal heat capacity increased about 23% from 3293 in 2005 to 4078 Mwt in 2008. 17 new geothermal fields were discovered by MTA, 5 of them are suitable for electricity production.

In Türkiye, new legislative regulations, such as The Renewable Energy Law (RES) and the Law on Geothermal resources, were enacted in the recent years.

The year 2013 goals for different types of geothermal utilizations of Türkiye have been specified separately. The required investments for fulfilling the Turkish year 2013 development plan in Geothermal electricity production, heating, greenhouse heating and thermal tourism application is about 2.5 billion USD.

1. GEOTHERMAL POTENTIALS

Türkiye has a unique geographic position at the crossroads between Europe and Asia. It is located on an active tectonic, orogenetic belt, the Alpine-Himalaya Orogen with young faults and active volcanism which is the reason for Türkiye's substantial geothermal resources. Most of the geothermal energy potential is located in the Aegean and Central Anatolian region. The total geothermal potential in Türkiye is estimated to be about 31,500 MWt. With an assumed exhaust temperature of 35 °C, the proven geothermal capacity of the existing wells and springs in Türkiye is about 4078 MWt (calculated by the MTA, General Directorate of Mineral Research and Exploration of Türkiye).

Türkiye's geographic position along geothermal belts in the world is shown in Figure 1.

2. GENERAL TECTONIC AND VOLCANIC FEATURES OF TÜRKIYE

Türkiye holds a significant potential for geothermal energy exploitation. 187 geothermal fields that contain geothermal fluid with more than 40°C temperature exist in Türkiye. Sources that contain high temperature geothermal fluid exist mostly in western Türkiye because of grabens that are formed as a result of recent tectonic activities. Low- and moderate- temperature sources exist in Middle- and Eastern-Anatolia because of volcanism and fault formations and in the north, along North Anatolian Fault Zone (Figure 2).

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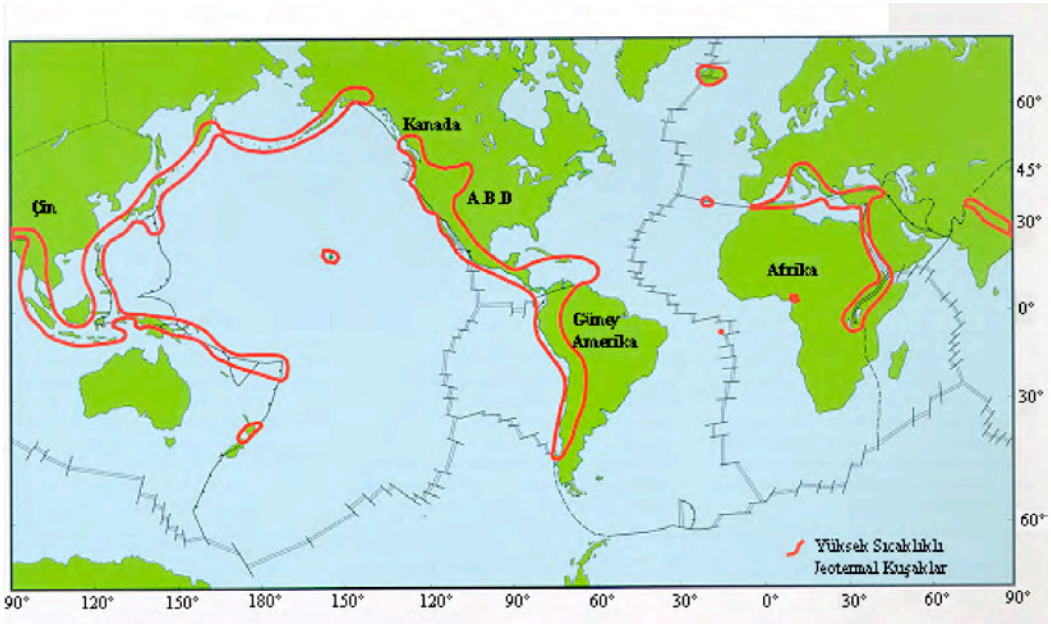

Figure 1. Geothermal belts in the world

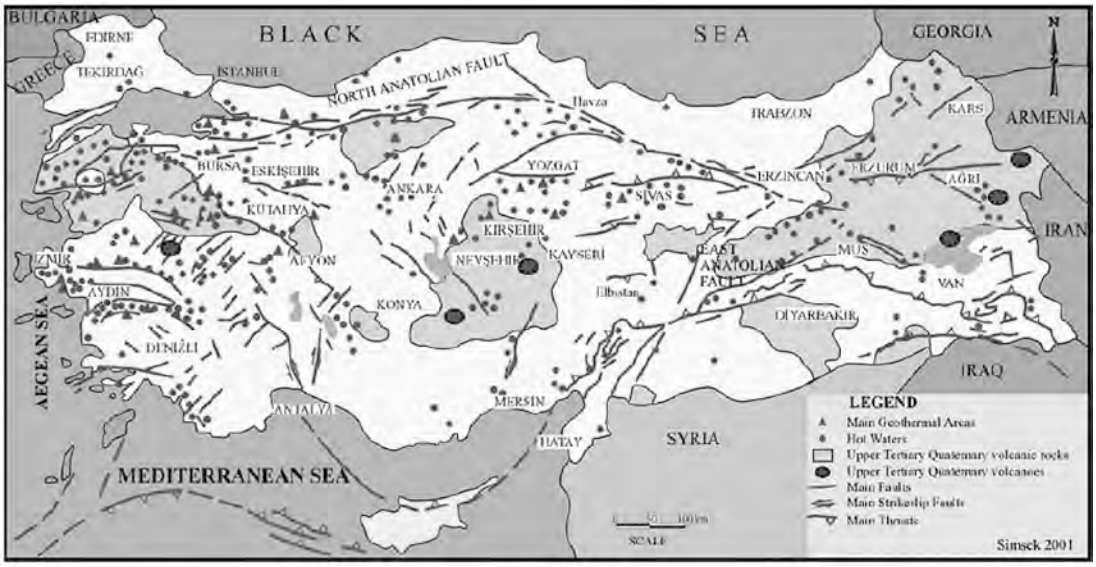

Figure 2. Distribution of hot springs and major geothermal fields in Türkiye

3. GEOTHERMAL APPLICATIONS IN TÜRKIYE

Türkiye is one of the 10 richest countries in terms of geothermal potential in the world. Geothermal energy is a clean, proven and reliable resource for supplying the needs of a sustainable society and helping to improve the environment in Türkiye. The main uses of geothermal energy in Türkiye cover a wide range of applications, such as space heating and domestic hot water supply, greenhouse heating, swimming and balneology, industrial processes and electricity generation. Based upon the current status, the majority of geothermal applications in Türkiye have been realised in district heating systems.

The current geothermal situation in Türkiye is given in Table 1.

Table 1. Current Geothermal Situation in Türkiye

EVALUATIONS	CAPACITY
GEOTHERMAL DISTRICT HEATING (CITY, GREENHOUSES THERMAL FACILITIES etc.)	104.574 RESIDENCES EQUIVALANCE (940 MWt)

BALNEOLOGY	215 THERMAL FACILITIES (402 MWt) (10 MILLION PEOPLE PER YEAR)
TOTAL DIRECT UTILIZATION	1342 MWt

The geothermal applications in Türkiye can be divided as Indirect and Direct applications, as follows:

3.1. Indirect Applications

In Türkiye, there are 17 geothermal fields discovered by MTA, which are suitable for geothermal power production. When all the fields are developed, the total installed capacity will reach to about 600 Mw electricity**.**

The present situation for geothermal electricity production in Türkiye is presented below, in Table 2.

Table 2. Present situation for geothermal electricity production in Türkiye

Present situation for geothermal electricity production in Türkiye

Geothermal Field Name	Temp. (°C)	Status
Denizli-Kizildere	200-242	Running 15 and 5 Mw installed capacity, the field tendered
Aydin-Germencik	200-232	47,4 Mw installed power plant under construction planned to generate in February 2009
Manisa-Alasehir-Kavaklidere	213	Under tender by MTA
Manisa-Salihli-Gobekli	182	Under tender by MTA
Canakkale-Tuzla	174	7,5 Mw at project phase additional drilling goes on
Aydin-Salavatli	171	7,4 Mw installed capacity BCP plant is running and 9,5 Mw at project phase
Kutahya-Simav	162	Direct application
Izmir-Seferihisar	153	3,2 Mw at project phase additional drilling goes on
Manisa-Salihli-Caferbey	150	Under tender by MTA
Aydin-Sultanhisar	145	Under tender by MTA
Aydin-Yilmazkoy	142	will be tendered by MTA
Aydin-Hidirbeyli	143	Tendered by MTA
Aydin-Atca	124	Under tender by MTA
Aydın -Umurlu	155	tendered
Izmir-Balcova	136	Direct usage
Izmir-Dikili	130	Direct usage
Pamukören	188-200	under development

First geothermal electricity production in Türkiye started in Kizildere Geothermal Field by MTA in 1974. A pilot plant with a installed capacity of 0.5 MWe. Afterwards in 1984, the Kizildere Geothermal Power Plant was installed by TEK (Turkish Electricity Establishment, renamed as TEAS) with a total installation capacity of 20,4 MWe, today its installed capasity is 15 Mwe. This power plant generates an average of 12-15 MWe electricity (9 wells are productive). The reservoir which feeds the Kizildere Geothermal Power Plant has a temperature of 242°C and contains 1,5% noncondensable gases. The amount of these gases at the separation pressure in the single flash plant is 15% in weight. A liquid CO2 and dry ice production factory is integrated to this power plant which produces 120,000 tons of liquid carbon dioxide and dry ice annually. The Kızıldere field was privatized in 2008 and its installed capacity will be increased (TEAS, 2007).

Again, in Aydın-Salavatlı, nearly 7,4 MWe install capacity Binary Cycle Power Plant, which is the first private owned plant, is running since March 2006. 167 °C temperatured geothermal brine is used.

In the field, for the additional 9.4 MW installed capacity projects, new production and reinjection wells are completed.

Figure 3. Aydın-Salavatlı geothermal power plant

3.2. Direct Applications

The direct-use applications include; district heating in seventeen sites (67700 residence equivalence, 608 Mwt), green house heating (1579000 m^2, 292 MWt), Thermal facilities & balneological purposes (215 spas, 402 MWt). The total direct use increased from 1131 Mwt in 2005 to 1342 Mwt in 2009.

3.2.1. Geothermal house heating

The existing situation in geothermal house heating systems in Türkiye is given in Table 3. As can be seen from the table, a total of 17 sites in Türkiye are being heated with geothermal energy.

Table 3. Existing situation in geothermal house heating systems in Türkiye

Location	**Geothermal residence equivalence/installed capacity**	**Temp. of Geoth. Water** (°C)	**Investor**
Dokuz Eylül Unv. Campus+ Balcova + Narlidere (1983)*	24000	125-145	Equal partnership of Governorship and Municipality Inc. (Dokuz Eylül Unv:Governorship + University Rectorate)
Gonen (1987)*	3000	80	Mainly Municipality Inc.
Simav (1991)*	7500	137	Municipality
Kirsehir (1994)*	1,800	57	Local Governorship (Mainly) + Municipality Inc.
K.hamam (1995)*	2,750	80	Mainly Municipality Inc.
Afyon (1996)*	5,000	95	Local Governorship (Mainly) Municipality Inc.
Kozakli (1996)*	2000	90	Mainly Municipality Inc.

Sandikli (1998)*	4000/5.000	70	Mainly Municipality Inc.
Diyadin (1999)*	540	70	Mainly Local Governorship Inc.
Salihli (2002)*	6700/24.000	94	Municipality
Saraykoy (2002)*	2.100/5.000	140	Mainly Municipality Inc.
Edremit (2003)*	3200/7.500	60	Municipality+Private Sector Inc.
Bigadic (2005)*	1860/3.000	96	Municipality
Sarikaya (2006)*	250/2.000	50	Governorship + Municipality+ Private Sector
Yerköy	500/3.000 Under construction	55-60	Governorship + Municipality+ Private Sector
Yozgat-Sorgun	1350	80	Municipality
Bergama-□zmir	400		Municipality

3.2.2 Geothermal greenhouse heating applications

The first geothermal greenhouse heating application has been started with 2000 m^2 in 1973 in Denizli-Kizildere. 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, Salihli, Simav). The current situation of greenhouse heating in Türkiye, together with the 2013 projections, is presented in Table 4.

Table 4. Existing situation and 2013 projections in greenhouse heating in Türkiye

Place	**Greenhouse Area (decare)**	**Estimated Power (MWt)**	**2013 Projections Estimated (Decare)**	**2013 Projections Estimated (Mwt)**
□zmir-Dikili	700	137	1000	193.3
Denizli-Yenicekent	26	5	100	20.0
Denizli- Sarayköy	30	5.87	400	78.4
Manisa-Salihli	250	49	400	78.4
Manisa-Urganlı	20	3.5	70	12.3
Kütahya-Simav	275	40	350	70.0
Aydın-Gümü□köy	60	9	100	15.0
Afyon-Sandıklı	40	7.83	200	39.2
Afyon-Merkez			500	98.0
Nev□ehir-Kozaklı	5	0.97	20	3.9
Urfa	40	8.2	80	16.4
□zmir-Balçova	43	8.52	100	19.4
Kızılcahamam	0.5	0.1	-	-
Bergama	80	15.67	100	19.4
Yozgat-Sorgun	10	1.95	50	9.8
Kır□ehir-Mahmutlu	Will be tendered by MTA		200	38.7
□zmir-Alia□a-Samurlu	Will be tendered by MTA		200	40.0
Manisa-Kula	Will be tendered by MTA		100	19.6
Balıkesir-Balya	Will be tendered by MTA		50	9.8
Denizli-Gölemezli			150	26.3
Total	**1579**	**292**	**4000**	**800.0**

In the near future it is expected that greenhouse heating will increase to 800 MWt according to 2013 projections

3.2.3. Balneological utilization and thermal tourism

10 million local and 10.000 foreign visitors are benefiting from balneological Utilities in Türkiye. Also the thermal tourism facility investments have gained speed in the recent years. With the huge thermal tourism capacity potential of Türkiye, 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 planned to be achieved as 250.000 in year 2013.

3.3. Latest Geothermal utilization capacities, 2013 Projections and Investment opportunities

The comparison of geothermal utilization between 2005 and 2008 is presented in Table 5. As can be seen from the table, an increasing trend is dominant regarding all sectors of geothermal utilization. The heating facilities, covering heating of houses, thermal facilities and greenhouse heating, increased from 804 MWt to 940 MWt, showing an increase of about 16%. Balneological utilization, on the other hand, increased about 22 %. The total installed direct use capacity became 1342 MWt in 2008.
The annual production amount of CO_2 remained the same throughout the years. The installed capacity of electricity production, on the other hand, increased from 15 Mwe to 27.4 Mwe.

Table 5. Comparison of Geothermal Utilization between 2005 and 2008 in Türkiye

Utilization (Install Capacity)		**2005**	**2008**	**Increament(%)**
Heating (Houses + Greenhouse+Thermal facilities)		804 MWt	940 MWt	16
Balneological Utilization		327 MWt	402 MWt	22
Total Direct Use		**1131 MWt**	**1342 MWt**	**19**
Mineral Production CO2		120000 ton/yıl	120000 ton/yıl	
Electricity Production	**Install Capacity**	**15 Mwe**	**27.4 Mwe**	**35**
The proven capacity of drilled geothermal wells and natural discharges		3293 MWt	4078 MWt	23

The year 2013 goals for different types of geothermal utilizations of Türkiye have been specified separately. The required investments for fulfilling the Turkish year 2013 development plan in Geothermal electricity production, heating, greenhouse heating and thermal tourism application is about 2.5 billion USD (Table 6).

Table 6. The required investments for fulfilling the Turkish year 2013 development plan in Geothermal electricity production, heating (residences, thermal hotels etc.), greenhouse heating, thermal tourism application, Expected progress

Geothermal application	**2013 targets**	**Additional Investment amount required (USD) (until 2013)**
Electricity production	565 MWe (4 Billion kWh)	1,3 billion USD
Heating (residences, thermal hotels etc.)	1350 MWt (150.000 res.Equiv.)	500 million USD
Greenhouse heating	800 MWt (4 million m2)	200 million USD
Thermal Tourism (Baln.)	300 thermal facility equiv.	500 million USD
Total		**2,5 billion USD**

4. NEW DEVELOPMENTS

4.1. Exploration

In Türkiye, geothermal resource prospection was initiated by MTA (General Directorate of Mineral Research and Exploration of Türkiye) in 1962.

Since 2005, the rate of geothermal fields exploration and research activities of MTA have increased by multiple times. The number of geothermal fields discovered by MTA increased from 170 in 2005 (Lund et al. 2005) to 187 in 2008. 5 of the newly discovered geothermal sites are suitable for electricity production. These are Aydın-Umurlu (150 °C), Aydın-Sultanhisar (146 °C), Aydın-Bozköy (143 °C), Aydın-Atça (124 °C) and Aydın-Pamukören (188 °C) geothermal fields.

The proven capacity of the drilled geothermal wells and natural discharges, on the other hand, increased from 3293 Mwt in 2005 to 4078 Mwt in 2008.

In Türkiye, the budget of geothermal research and exploration studies increased after 2005 and for this purpose 12 - 15 billion Dolars was allocated annually to such studies.

In 2008, geothermal researches and explorations were increasingly completed by MTA in distinct sites. Geothermal wells of totally 16500 m in depth have been drilled by MTA, from these wells in this year proven geothermal heat capacity is about 150 Mwt.

The privatization of geothermal fields discovered by MTA is ruled in the Geothermal Law and that is why, as a first step, six of the geothermal fields suitable for power production were taken into tendering process by MTA in 2008. In the next step, about 33 geothermal fields appropriate for heating and balneological purpose will be tendered in 2009, and also 30 geothermal wells will be given to the local governmental authorities or mayors (MTA, 2008).

4.2. Future Studies to be conducted by MTA

MTA, while continuing to prospecting deeper fluid circulating geothermal fields, plans to identify sites in the future years where hot rocks having insufficient porosity and permeability with high temperatures exist, and by determining their physical and chemical parameters, plans to perform mapping and inventory studies beginning from the year 2009.

When the geothermal energy studies performed until now and the geological structure and heat flow maps are examined, the possibility of the existence of potential sites with high temperature hot dry docks can be seen. For these studies, young volcanic sites and sites where crust thins and plate boundaries intersect can be selected as target areas. For example, sites such as the Nemrut volcanism field, Ala□ehir Kavaklıdere, Kızılcahamam, Nevsehir Acıgöl, Aksaray, Konya Ilgın, Kütahya-Saphane and Çanakkale are the ones that will be considered the first in this respect.

In these studies, provinces lying at depths of 2500-3000 m with high temperatures will be identified, and information related to the feasibility of heat gain will be generated by determining parameters such as heat conduction of hot rocks at depth and the physical and chemical properties of the rock.

4.3. New Legislative Regulations Concerning Geothermal Resources

4.3.1. Renewable Energy Resources Law for the Purpose of generating Electricity ('LAW ON RES')

Law No. 5346

Date of Approval: 18/5/2005

Within the scope of this law, Renewable energy resources (RES) are wind, solar, geothermal, biomass, biogas, wave, current and tidal energy resources suitable for the electricity generation together with hydraulic generation plants, either canal or run of river type or with a reservoir area of less than fifteen square kilometers. It is purchased guarantee for a price that will not be below Turkish Lira corresponding to at least 5 Euro Cent/kWh during 10 years.

4.3.2. Electricity Market Law

Law No. 4628

Date of Approval: 3/3/2001

The regulation provides incentives for RES generation facilities:

- Pay only 1% of the total licensing fee.
- Exemption from annual license fees for the first eight years following the facility completion date.
- May purchase electricity from private sector wholesale companies on the condition not to exceed the annual average generation amounts.
- Priority for system connection.
- Generating units based on renewable energy resources that are not designed for frequency and voltage control, are not subject to these conditions and requirements.
- Exempt from the liability of being a Balancing Mechanism entity.

- Wind generation and canal-type hydro-electric generation facilities which sell electricity to wholesale and retail licensees are exempted from settlement.

❖ Real persons or legal entities, who establish generation plant using renewable energy resources with a generation capacity of maximum 500 kW for their own demands, shall be exempted from the obligations of taking licence and establishing companies.

4.3.4. Law on Geothermal Resources and Natural Mineral Water

Law No. 5686

Date of Approval: 3/6/2007

The purpose of this law is to set forth the procedures and principles regarding effective exploration, research, development, production and protection of geothermal and natural mineral water resources, holding rights on these resources and devolution of the rights, economic utilization of the resources in a compatible way to the environment, and abandonment of these resources.

This law encompasses the procedures, principles, and sanctions on holding and devolving the rights on the resources; abandonment of the resources: tendering, terminating, and supervising resource utilization; and protection of the resource and accumulation reservoir during exploration and operation periods of detected or to be detected geothermal and natural mineral water resources and geothermal gases.

In the law advantages for geothermal appliers are:

- After the enforcement date of this law, rent, mesne profits shall not be taken for the activities in the places of private ownership of treasury and places under the adjudication and management of the State.
- Companies that make geothermal resource distribution and production shall be considered as industrial and waste treatment organizations. In accordance with this assessment they shall benefit from first of all electric tariffs and all the other incentives and rights that are granted to the industrial organizations and waste treatment organizations.

5. CONCLUSIONS

MTA is ready to cooperate with foreign colleagues, such as the Research and Development institutes and funding agencies, in studies concerning the research and development of both existing geothermal fields and fields under exploration.

In order to benefit from the geothermal potential in a sustainable manner, more geothermal wells should be drilled for extending geothermal applications throughout the country, and new financing mechanisms are needed to promote investment in renewable energy, which will support the development of geothermal energy in the country.

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Hayrullah Dağıstan graduated at the Middle East Technical University (METU) in 1989. Since then, he has worked in MTA as a project manager and geo-logical engineer in Geothermal Energy Research and Drilling Projects. He attended in the main energy committees of the State Planning Organization and also in Geothermal and Coal sub-committees for preparation of the 9th Development Plan of Türkiye,.
He worked as a member of the World Energy Council's Turkish National Committee and the Geothermal Association of Turkey's Scientific Committee. He is married and has three children. Today he is the Head of the Energy Raw Materials Research and Exploration Department of MTA since 2004.