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AN UPDATE ON GEOTHERMAL ENERGY POTENTIAL OF TURKEY

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ABSTRACT

Nearly 274 geothermal occurrences and fields are known to exist in Turkey according to MTA (the state owned directorate) records. About 25 of them are already being exploited at large scale for direct and indirect geothermal energy use, many fields are mainly used for balneological purposes by local public, and while others are still to be developed. Yet hopes also exist to explore and discover new fields.

In this study, the production data of the exploited fields as well as the available field and fluid data of the unexploited fields are evaluated to estimate the identified potential of each field under the existing field and operational conditions in terms of maximum capacity or annual energy use. The geothermal inventory data given by MTA, and also the data available for the fields studied in the literature and as well as by our department were used for the estimation process.

The preliminary results of our study are presented in this paper. The identified potentials of geothermal energy available for electricity generation and direct applications were classified according to the temperature of the produced fluid and the results are given in tables and figures. Taking into account of produced and outflowing geothermal fluids, the total identified geothermal potential is about 3700 MW_t (based on a reference temperature of 20 ^oC) of which nearly 1450 MW_t is adequate for power generation from 9 known middle and high temperature fields. Our continuing efforts are concentrated in collecting updated field data and obtaining proper guesses for the missing ones. Moreover, further work is planned to obtain accessible geothermal potential of Turkey by evaluating existing geological, geochemical and geophysical data and using some simulation studies. Some lumped parameter modeling approaches are planned to be utilized to refine the results on known and most studied geothermal fields.

INTRODUCTION

Turkey is poor in fossil fuel resources but rich in renewable resources such as geothermal, solar, hydraulics, wind, and biomass. Geothermal energy is used for direct utilization and power generation. The wide spread hydrothermal occurrences due to tectonic activities and some young volcanism indicate significant existence of geothermal resources in Turkey. Nearly 1500 thermal and mineral water springs and more than 170 geothermal fields with a temperature range up to 242 ^oC have been discovered in Turkey which is located on Mediterranean sector of Alpine-Himalaya belt. Turkey is very active with earth crust movements, tectonic movements of the rock formations, and volcanic activities. The geothermal resources in Turkey are mostly moderate and low-temperature ones. Some are distributed mostly at the central and western parts of the country, some at the central and eastern Anatolia volcanic regions, whereas high temperature geothermal resources capable of supporting direct use projects and power generation are discovered primarily in the graben structures of Western Anatolia.

GEOTHERMAL POTENTIAL OF TURKEY

The country update report of Turkey presented at the World Geothermal Congress 2005 (WGC2005) in Turkey indicated that the installed capacity is 1077 MW_t for direct-use and 20.4 MW_e for power production, whereas, the proven potential is calculated at 3293 MW_t for a discharge temperature of 35 ^oC while the estimated geothermal potential for the country is 31500 MW_t (Simsek et al., 2005). Lund et al. (2005) gives 1177 MW_t as the installed capacity for direct-use.

A recent paper by Dagistan (2006) indicates that the installed capacity for direct-use is 1229 MW_t and the identified potential is 3600 MW_t. A total of 415 geothermal wells have been drilled in Turkey so far and the identified capacity determined by wells is about 3000 MW_t whereas 600 MW_t is the capacity of the natural springs and occurrences.

Nearly 274 geothermal occurrences and fields are known to exist in Turkey according to geothermal inventory data given by General Directorate of Mineral Research and Exploration (MTA, 1996 and 2005). Data on wells drilled, flow rate and temperature measurements, water chemistry given by MTA (1996, 2005) were all collected, analyzed and classified. Data related to three new fields recently discovered but not contained in MTA inventories were also added to the data set.

In this study, the inventory data given by MTA and also the data available for the fields studied in the literature and as well as by our department in various projects were used to estimate and revise the energy potential in terms of capacity or annual energy use with the actual production data. The capacity is given in terms of maximum flow rate and expressed as

$$Capacity = w_{\max} x \Delta T x 0.004184 \qquad (1)$$

where capacity represents the thermal power in MW_t, w_{max} is the maximum flow rate in kg/s, and ΔT is the difference between the inlet temperature (or the average field production temperature) in ^oC and the outlet temperature (the waste water, rejection or reinjection temperature whichever applicable) in ^oC. In case of high enthalpy fields producing two phase mixtures, Eq. 1 should be better written in terms of enthalpy rather than temperature. The annual energy use is calculated by

$$Energy\ Use = w_{ave} x \Delta T x 0.1319 \qquad (2)$$

where energy use is in TJ/yr (TJ=10^{12} J) and w_{ave} is the average flow rate in kg/s.

In Eqs. 1-2, the maximum temperature measured in the field or the average temperature of the fluid produced from the field can be used to represent the inlet temperature. However, notice that they can be considerably different. For example, the maximum temperature measured in the Kizildere field is 242 ^oC whereas the average temperature of the fluid produced is 217 ^oC. If one is interested to find the inlet temperature to be used in Eqs. 1-2 to determine capacity and annual energy use, it seems logical to utilize the average temperature rather than the maximum temperature since the flow rate given in Eqs. 1 and 2 should represent the total production rate from the field.

For the fields under exploitation, the measured flow rate and average production temperature data were used for the flow rate and the inlet temperature. However for the unexploited fields, the field averages of the flow rate and temperature data obtained from the initial tests conducted at the individual wells right after the drilling operations were employed in Eq. 1 to estimate the capacity.

Overall Results

Our data set consists of data related to a total of 277 localities with geothermal occurrences and fields in 63 provinces throughout Turkey. This number includes the natural springs and discharges used for local public and as well as the fields identified by the wells drilled.

According to our analysis, there are about 110 fields discovered and identified by at least one well drilled. Nearly sixty fields are identified only by geothermal manifestations such as natural springs and discharges.

Our analysis indicates that the identified geothermal potential based on 277 localities with a temperature higher than 20 ^oC is 3700 MW_t. It is calculated to be 2461, 1637, and 385.4 MW_t for outlet temperatures of 40, 60 and 140 ^oC, respectively.

A total of 110 fields with a temperature higher than 20 ^oC and 39 fields with a temperature higher than 60 ^oC are identified by wells drilled. Those 39 fields having temperatures of 60 ^oC or higher comprise 35% of 110 fields. Figure 1 shows the frequency of geothermal fields identified by wells as function of temperature.

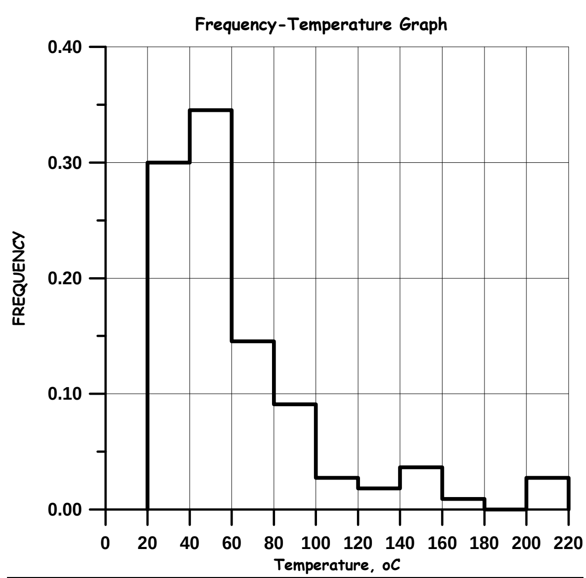

Figure 1. A plot of the frequency of geothermal fields identified by wells as function of temperature.

Fields For Power Generation

The present electricity generating capacity of Turkey is summarized in Table 1. Official statistics (Ministry of Energy and Natural Resources) show that natural gas provides 40%, hydro provides 30%, coal provides 25%, and liquid fossil fuels and renewables provide 5% of the total electricity of the country. Geothermal energy remains as a small contributor to the electric power capacity and generation in Turkey. Geothermal plants constituted only 0.05% of the installed generating capacity and provides around 0.06% of the total electricity. There have been modest additions to geothermal (7.3 MW_e) and, very recently a large increase in wind generation (30 MW_e). Additional capacities for fossil fuels and hydro are not shown in Table 1 since no data were available at the time of writing this paper.

The geothermal potential in terms of power generation capacity refers to resources suitable for electricity generation, which in most cases mean the extraction of geothermal fluid in excess of 130-140 ^oC. In this study 140 ^oC was chosen.

Geothermal fields with field average temperatures higher than 140 ^oC are listed below. The first figure in the parenthesis represents the field average temperature and the second one the maximum temperature measured in the field.

1. Kizildere Field (217 ^oC and T_{max}=242 ^oC, used for power generation)
2. Salavatli-Sultanhisar Field (157.5 ^oC and T_{max}=171 ^oC, used for power generation)
3. Germencik-Omerbeyli Field (220 ^oC and T_{max}=232 ^oC)
4. Tuzla Field (160 ^oC and T_{max}=174 ^oC, used for direct applications)
5. Simav Field (145 ^oC and T_{max}=162 ^oC, used for direct applications)
6. Seferihisar Field (144 ^oC, T_{max}=153 ^oC)
7. Yilmazkoy-Imamkoy Field (142 ^oC)
8. Kavaklidere Field (215 ^oC)
9. Caferbeyli Field (155 ^oC)

The temperatures for the last three fields correspond to the bottomhole temperatures of the discovery wells in those undeveloped fields. Fields with limited data and/or low flow rates are not considered in the list above.

The Kizildere field already has a power unit installed and operated for about 20 years. The Tuzla and Simav fields can be considered as partly developed fields and are currently used for direct utilization. The well average temperature and the annual average flow rate data are used for capacity calculations of these three fields. The Kavaklidere and Caferbeyli fields are recently discovered with limited data. Flow rate and temperature data for these two fields and the Imamkoy field correspond to the measurements taken during completion stages of discovery wells. The Seferihisar field is known for years but not developed and used yet. There are nine wells drilled already in the Germencik field with a minimum temperature of 203 ^oC, however the field has not been used for any energy utilization purposes. The flow rate of Germencik corresponds to the lumped sum flow rate measurements of the individual wells taken during their completion stages or obtained from some production tests whereas temperature corresponds to the wellhead average.

Equations 1-2, wherever applicable, were used to estimate the electric capacity potential of the fields listed above. The electric capacity potential was referred to the amount of thermal energy that could be used to generate electricity from these resources.

Table 2 summarizes geothermal power generation capacity potential. The electric capacity potential of the fields in excess of 140 ^oC is estimated to be 385.4 MW_t whereas the thermal energy available in excess of 130, 40, and 20 ^oC are 473.1, 1261.4, and 1 436.5 MW_t, respectively. By assuming that 10% of the thermal energy based on a reference temperature of 20 ^oC can be converted to electricity production, the corresponding electrical power generation capacity is estimated about 144 MW_e. Figure 2 shows the capacity versus temperature relationship. Notice that the geothermal capacity of those nine high temperature fields is 39% of Turkey's total geothermal capacity as far as the identified resources are concerned. The Germencik field has the highest capacity corresponding to about 60 % of the total electric capacity potential, and still yet to be developed. The insert bar-chart in Fig. 2 gives the power generation capacity potentials of the fields for comparison purposes.

At present, the installed capacity of electricity power plants in Turkey is 24.7 MW_e. This means that about 6.7% and 5.5% of Turkey's potential for electricity generation has been taken into use so far for the 140 ^oC and 130 ^oC outlet temperatures, respectively. For comparison, it is 3.5% for the world in the case of 130 ^oC outlet temperature (Stefannson, 2005). Stefannson gives 209 GW_e as the world potential for electricity generation which means that 0.23% of the world potential is in Turkey.

Table 2 indicates that the present installed capacity of 24.7 MW_e from Kizildere and Salavatli fields corresponds to 22% utilization of the geothermal energy capacity available over 140 ^oC from those two high temperature resources.

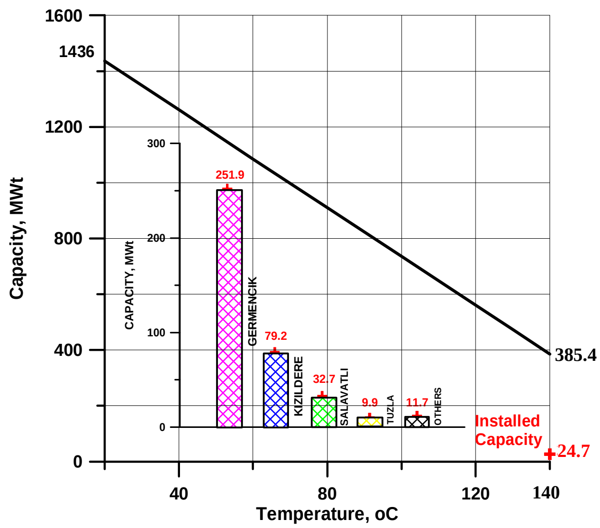

Figure 2. Capacity versus temperature graph.

Simsek et al. (2005) gives 2 000 MW_e as Turkey's geothermal potential for electricity production. The difference between our figures (385.4 MW_t for T_{outlet}=140 ^oC and 473.1 MW_t for T_{outlet}=130 ^oC) and their figure is large and what caused this difference is not known since they only present the figure but do not explain how to reach it.

The installed power generation capacity of geothermal energy in the world is about 8.9 GW_e as of 2005. This means that about 0.3% of the world's installed capacity is in Turkey.

A new plant with 45 MW_e capacity is to be installed at Germencik field. This could be a major contribution to the electrical capacity of Turkey and this would nearly triple the existing capacity. Notice in Table 2 that the Germencik geothermal field has the highest capacity.

Fields For Direct Applications

The direct utilization of geothermal energy includes space heating and district heating, the heating of pools, baths and spas, greenhouses, and industrial applications. Direct use of geothermal energy in Turkey has shown an impressive growth with considerable increases in space and greenhouse heating. Tables 3 and 4 give the direct use capacities of district and greenhouse heating systems, respectively.

At present, there are 38 geothermal space heating systems in Turkey. However, only eleven of them are city based geothermal district heating systems. The total capacity of those eleven systems is given to be 253.1 MW_t by Erdogmus et al. (2006). Table 3 shows the systems with their maximum flow rates, inlet and outlet temperatures of geothermal fluid in primary heat exchangers.

The capacity figures given in Table 3 represent the capacity of the district heating systems, and they should not be confused with the capacity of the field.

Lund et al. (2005) reports that the installed capacity for Turkey is 1 177 MW_t with 645 MW_t utilized in district heating systems, 327 MW_t for geothermal heated pools for bathing and swimming, 131 MW_t in greenhouse heating systems, and 74 MW_t in individual space heating systems. It should be noticed that 645 MW_t in district heating systems given by Lund et al. is larger than 253.1 MW_t given by Erdogmus et al. This difference could be due to the fact that Erdogmus et al.'s capacity in Table 3 reflects the thermal power utilized by the eleven district heating systems whereas Lund et al.'s figure may cover all the heating systems including minor and individual ones.

The true amount of power produced from a geothermal field (energy use) utilized for the district heating system should consider the amount of annual production rate represented by an annual average flow rate, the inlet temperature reflecting the field average temperature, and the outlet temperature reflecting the field average temperature of the waste water or reinjection water, whichever applicable. For example, the Afyon (Omer-Gecek) field studied by Satman et al. (2005b, 2007) has a maximum flow rate of about 236 kg/s considering not only the wells flowed to the district heating system but all the wells operating in the field, an annual average flow rate of close to 114 kg/s, the field average temperature is 100 ^oC, and nearly half of the geothermal liquid is reinjected. Then the capacity based on maximum flow rate is calculated to be 71.4 MW_t (Satman et al., 2007) which is different than Erdogmus et al. (2006)'s 33.9 MW_t.

Table 4 indicates that there are 11 greenhouse operations in Turkey using geothermal energy, (Serpen, 2005). These cover an area of about 809 decares (80.9 hectares), have an estimated heat capacity of 142 MW_t. Greenhouse heating has been the largest growth area, mainly with installations in Simav and Dikili. For example, existing greenhouses have been expanded from 180 to 400 decares in Simav and from 240 to 550 in Dikili and larger expansions are planned in near future. Precise areas and capacities for these installations are hard to determine due to lack of any centralized data gathering. Thus, Table 4 gives only the estimates as of 2005. With addition of new installations, the greenhouse area is expected to be near 1500 decares (150 hectares) and estimated capacity close to 240 MW_t (Harzadin, 2006).

Table 5 provides a direct use update on geothermal energy capacity of Turkey. A total of 53 fields and occurrences with reservoir temperatures greater than 60 ^oC are shown in this table. 39 of those 53 are the geothermal resources identified with wells drilled and other 14 are resources only identified with natural springs and discharges. In Figure 3, the frequency of geothermal resources with T_{res}>60 ^oC as function of the capacity is plotted on a lin-log graph. On this scale, the distribution is not symmetrical.

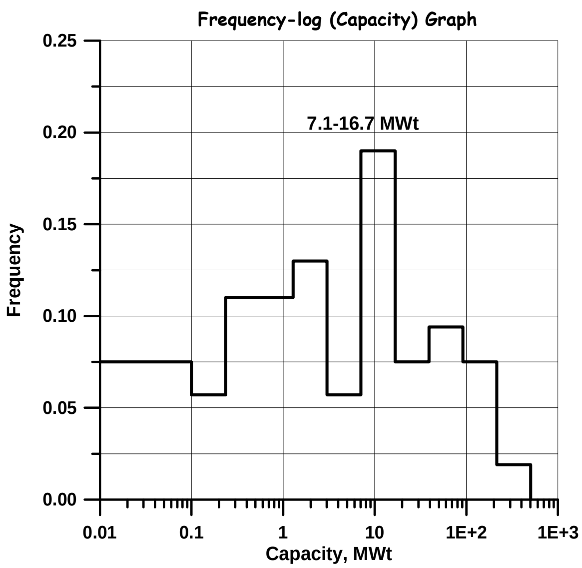

Figure 3. A lin-log plot of the frequency of geothermal resources within a given capacity class as function of capacity (for T_{res}>60 ^oC).

In Figure 4, the cumulative frequency of geothermal resources as function of the capacity is plotted on a lin-log graph. On this scale, the capacities follow a straight line reasonably well. This means that the cumulative frequency distribution follows a logarithmic (or exponential) function.

DISCUSSION

Capacities presented in this paper represent the amount of energy exploitable from the fields with the available well and field data under existing conditions. Capacity is, by definition, a portion of the potential. Increasing the capacity should be possible by proper field and reservoir management. Increasing the number of wells, increasing the amount of energy produced from the reservoir by maximizing reinjection into the field, paying attention to conservation and thermal efficiency, etc. can contribute to grow the capacity.

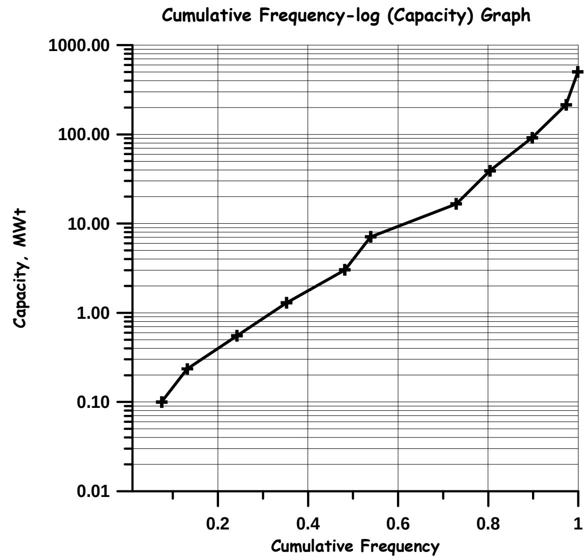

Figure 4. A lin-log plot of the cumulative frequency of geothermal resources within a given capacity class as function of capacity (for T_{res}>60 ^oC).

Satman et al.'s (2005c) study indicated that by increasing the amount of reinjection the capacity of the Kizildere geothermal field could be increased by nearly a factor of two. The capacity of given in Table 2 could grow by possible higher production rate supported by field wide reinjection application, and also developing the field into the deeper zones where temperature is higher.

Capacity and energy use (Eqs. 1 and 2) are applicable only for the fields discovered. However, potential includes also the undiscovered fields. Some papers in the literature (Simsek et al., 2005; Lund et al., 2005) indicate that the geothermal energy potential of Turkey is 31500 MW_t and moreover they also conclude that this potential is enough to heat 5 million residences in Turkey. Even the Ministry of Energy and Natural Resources of Turkey reflects those in the official views and use them in geothermal energy projections of the country. According to the authors of this paper, such a potential figure and conclusions based on it are not only confusing but also misleading, statements with no scientific basis, therefore, should be avoided.

The installed capacity should refer to the capacity of the field based on deliverability from the already installed production facilities such as wells. Capacity figures based on the installed capacity of the surface facilities of the district heating systems reflect the capacity of the surface facilities but not of the reservoir. Capacity based on the heat that can be extracted from the reservoir is the one to be determined.

Requirement of new methodologies for providing a standardized assessment of geothermal energy reserves has always been an attractive issue. Clotworthy et al. (2005) discusses characteristics of geothermal reservoirs, problems in assessing deliverability and energy recovery, and points out the importance of dynamic changes caused by the heat convection of water or heat conduction from depth, and finally suggests methods for reserve estimation and classification.

What makes the geothermal energy a renewable one is the dynamic processes and should always be considered in reserve estimation. Geothermal systems are dynamic systems and continually being recharged by flow of heat by conduction from depth and by forced-convection of water. The reservoir behavior is influenced by the recharge to the reservoir and the performance of the wells, thus potential, capacity and reserve figures could be expected to vary from time to time and from evaluator to evaluator. Dynamic changes need to be accommodated in reserve calculations. Simulation by numerical models or lumped parameter models is probably the most applicable method for reserve estimation.

Capacity and energy use equations, Eqs. 1-2, seem adequate for conventional high temperature reservoirs. However, special considerations are required for low-temperature integrated direct-use applications. Various inlet and outlet temperatures and flow rates involved by users make the capacity calculations difficult.

The capacities discussed in this paper refer to the fields and occurrences where surface manifestations like wells and hot springs are present. In general, it is assumed that the number of undiscovered hidden resources is larger than the number of identified resources. Stefannson (2005) indicates that the total potential of geothermal resources might be five to ten times (four to six times for the U.S.A.) larger than the potential of identified resources. This means that the total geothermal potential including the undiscovered hidden resources of usable energy for the whole country is estimated 19 000 MW_t as a lower limit.

The capacity and potential figures presented here are only preliminary results of an ongoing study and are based on the best estimates made by the authors. With addition of new, revised, and updated data better and more accurate estimates of the geothermal energy capacity and potential will be possible.

While the emphasis is on developing geothermal energy for direct applications, particularly the private investors are looking to increase the power use of geothermal energy. Geothermal energy as a renewable energy resource needs some encouragement, support and incentive programs for development and implementation of projects. With some government incentives and tax rebate programs, the geothermal energy is expected to grow at a higher rate. There are some positive signs with growth in greenhouse, health-SPA and district heating projects, administration of a new geothermal law, along with the increased interest in electric power generation.

Our continuing efforts are concentrated in collecting updated field data and obtaining proper guesses for the missing ones. Moreover, further work is planned to obtain accessible geothermal potential of Turkey by evaluating existing geological, geochemical and geophysical data. Finally, some methods for assessing energy that can be extracted including lumped parameter modeling approaches, Satman et al. (2005a, 2005b) and some simulation studies are to be utilized to refine the results on known and most studied geothermal fields.

CONCLUSIONS

An updated estimate of Turkey's identified geothermal potential in terms of capacity is presented in this paper. The basis for this estimate is geothermal assessment carried out the data currently available to us. The total geothermal energy capacity is 3700 MW_t. The total amount of electric capacity potential of the fields in excess of 140 ^oC is estimated to be 385.4 MW_t.

The following results are obtained:

1) Considering a total of 277 geothermal occurrences and fields studied in this work, the identified geothermal capacity of Turkey is calculated to be 3700 MW_t based on a reference temperature of 20 ^oC.
2) 53 fields having temperatures of 60 ^oC or higher comprise 31% of the total number of the fields (170) and 45% of the total geothermal energy considered whereas the remaining 55% is available potentially for the direct utilization with temperature lower than 60 ^oC.
3) If those fields with temperatures higher than 140 ^oC given in Table 2 are assumed to be used only for electricity generation with a capacity of 1086 MW_t then 551 MW_t is the geothermal energy available for the direct utilization with temperature higher than 60 ^oC. Using the same assumption, the geothermal energy available is 1171 MW_t for higher than 40 ^oC and 2264 MW_t for higher than 20 ^oC direct utilization.

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TABLE 1. PRESENT PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (Wind)		Total	
	Capacity MW_e	Gross Prod. GWh/yr	Capacity MW_e	Gross Prod. GWh/yr	Capacity MW_e	Gross Prod. GWh/yr	Capacity MW_e	Gross Prod. GWh/yr	Capacity MW_e	Gross Prod. GWh/yr	Capacity MW_e	Gross Prod. GWh/yr
In operation in Jan. 2006	17.4	95	$26x10^3$	$122x10^3$	$13x10^3$	$40x10^3$	0	0	33.6	57	$39x10^3$	$162x10^3$
Completed in 2006 (renewables)	7.3	--					0	0	30	--		

TABLE 2. ELECTRIC CAPACİTY POTENTIAL OF THE FIELDS (for T_{res}>140 ^oC)

Locality	Flow Rate (kg/s)	Temperature (^oC)	Capacity (MW_t) T_{outlet}=140 ^oC	Capacity (MW_t) T_{outlet}=130 ^oC	Capacity (MW_t) T_{outlet}=40 ^oC	Capacity (MW_t) T_{outlet}=20 ^oC
Kizildere	250	217	79.2	89.5	182.1	202.7
Salavatli	454	157.5	32.7	51.3	219.3	256.7
Germencik*	765	220	251.9	283.4	566.8	629.8
Tuzla+	120	160	9.9	14.8	59.3	69.2
Simav*	223	145	4.6	13.8	96.4	114.7
Seferihisar	264	144	4.4	15.3	112.9	134.6
Yilmazkoy-Imamkoy+	40	142	0.3	2.0	16.8	20.1
Kavaklidere	6.5	215	2.0	2.3	4.7	5.2
Caferbeyli	6.5	155	0.4	0.7	3.1	3.6
TOTAL			385.4	473.1	1261.4	1436.5

* MTA (1996), + MTA (2005)

TABLE 3. THE MAJOR CITY BASED GEOTHERMAL DISTRICT HEATING APPLICATIONS (Erdogmus et al., 2006)

Locality	Year Commissioned	Inlet Temperature (^oC)	Outlet Temperature (^oC)	Maximum Flow Rate (kg/s)	Capacity (MW_t)
Gonen	1987	75	45	110	13.8
Simav	1991	100	50	125	26.2
Kirsehir	1994	54	49	270	5.6
Kizilcahamam	1995	70	42	150	17.6
Balcova	1996	118	60	294	71.3
Omer-Gecek	1996	90	45	180	33.9
Kozakli	1996	92	52	100	16.7
Sandikli	1998	70	42	250	29.3
Diyadin	1998	86	73	200	10.9
Salihli	2002	98	40	70	17.0
Saraykoy	2002	97	50	55	10.8
TOTAL					253.1

TABLE 4. MAJOR GREENHOUSE HEATING SYSTEMS (Serpen, 2005)

Locality	Greenhouse Area (decare=10^3 m^2)	Estimated Capacity (MW_t)
Dikili	240	42
Urganli	20	3.5
Simav	180	31.5
Gümüsluk	80	14
Edremit	50	9
Tuzla	50	9
Gediz	9	1.5
Afyon	20	3.5
Alasehir	20	3.5
Urfa	60	10.5
Balcova	80	14
TOTAL	809	142

TABLE 5. CAPACİTY OF GEOTHERMAL ENERGY FOR DIRECT HEAT (for T_{res}>60 °C)

Locality	Inlet Temperature (°C)	Outlet Temperature (°C)	Flow Rate (kg/s)	Capacity (MW_t) for T_{outlet}=60 °C
Germencik+	220	60	765	503.8
Salavatli	157	60	454	181.1
Kizildere	217	60	250	162
Omer-Gecek*	94	60	673	95.7
Simav*	109	60	476	96.1
Seferihisar	144	60	264	91.2
Dikili	120	60	250	61.7
Tuzla*	160	60	120	49.4
Balcova	117	60	369	88.3
Kula-Emir*	135	60	140	43.2
Kozakli*	91.2	60	247	31.8
Diyadin*	72.3	60	560.5	28.3
Salihli	104	60	150	27.4
Kuzuluk*	80.9	60	271	23.4
Sandikli*	67.6	60	496	15.6
Hisarkoy*	96.7	60	103	15.6
Golemezli*	70	60	340	14
Yilmazkoy-Imamkoy*	142	60	40	13.5
Aliaga*	96	60	80	11.9
Gediz	83.3	60	119	11.4
Hisaralan*	72.3	60	176	8.9
Tekkehamam*	138.7	60	26.6	8.6
Kizilcahamam*	80.1	60	91.5	7.6
Ercis-Zilan*	86.7	60	66	7.3
Gonen	80	60	83	6.9
Kavaklidere	215	60	6.5	4.2
Yenice*	65	60	164	3.4
Koprubasi*	70.7	60	67	2.9
Banaz*	66	60	114	2.8
Caferbeyli	155	60	6.5	2.5
Others				16.3
TOTAL (53)				1637

* MTA (2005), + MTA (1996)