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Geothermal Energy and Its Economic Dimension in Turkey

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ABSTRACT

Energy demand of Turkey is increasing day by day because of Turkey's rapid development. Although Turkey has various energy resources, the available fossil energy resources do not meet the consumption needs. For this reason, Turkey has to evaluate her energy resources in the most economic manner and in a way as to make maximum usage. She also must use alternative energy resources in addition to fossil types.

One of the alternative energy resources is the geothermal energy and Turkey, bearing suitable structures for the occurrence, has a significant potential on this area. In Turkey, there are 170 geothermal areas in which approximately 600 hot water resources are located. The potential of natural discharge is about 600 MWt. As a result of the 380 geothermal purposed drillings carried out by MTA (General Directorate of Mineral Research and Exploration), Turkey's proved thermal capacity has increased to 3293 MWt. The petroleum equivalent of the proved potential is 2480000 TEP. If this potential is used completely, a significant contribution for fuel saving as well as prevention of environmental pollution would be realized. Carrying out drilling studies in geothermal sites, where wells have not yet been drilled and carrying out development studies in areas where wells have been previously opened will significantly increase this potential and the corresponding economic support.

In Turkey, the natural springs and well discharges provide a wide range of usage from fish farms to industrial applications. However, a significant part of this potential is used in thermal tourism, therapeutic uses and district heating.

Studies carried out for geothermal energy research have gained importance in 1970's with the discovery of high potential areas. After the 1990's the interest shown by the private sector and municipalities have risen and today geothermal energy is being significantly used in Turkey. Electricity production, residential heating, greenhouse heating, industrial applications, thermal tourism and therapeutic uses are the main used areas. Turkey is among the first five countries in the world considering the direct usage of this energy. The direct usage capacity of geothermal energy is 1077 MWt. 619 MWt is used in residential and thermal base heating, 131 MWt in greenhouse heating and 327 MWt in 195 spas for therapeutic purposes.

1. INTRODUCTION

Energy problem has reached serious dimensions in the world as well as in national scales. Seeking for the development and utilization of alternative energy resources besides the conventional energy resources, in order to meet the energy necessities, has accelerated. Due to rapid evolution of Turkey, energy consumption is increasing day by day. Unfortunately, even though our country owns various energy resources, fossil energy potentials do not meet the present energy consumption. As declared in the report of the Turkish National Committee of the World Energy Council (1999), only 35% can be met by local resources. The usage of energy resources can not be differentiated and if the increment of consumption continues, the ratios will also increase. For this reason, Turkey has to evaluate energy resources for optimal usage and use alternative energy resources. In addition, having in mind the depletion of the fossil resources in future, exploration and evaluation of known as well as alternative energy resources, would provide solutions to the energy problem.

Geothermal energy, an important potential in our country, having a wide range of usage possibilities, has to be more used in order to decrease negative environmental effects. At the same time, this energy usage seems to be obligatory when having in front the energy imports. Geothermal energy is an important and renewable resource for our country. Low investment expenses, minimum environmental pollutions and discovered big potentials make "geothermal energy" more attractive for us.

Turkey, due to wide spreads of geothermal system elements, has placed herself among the world's richest countries and holds the first place in the European countries, as geothermal energy potentials.

The geothermal heat potential of Turkey is expected to be 31500 MWt.

In Turkey, geothermal investigations first started in the 1960's. At first, determinations of inventories were realized, whilst later, in the 1970 and 1980's, discovery of high potential sites gained importance. The interest of the municipalities and private companies has increased, especially after the 1990's. Unfortunately, improvements for geothermal resources and explorations of geothermal potentials were not realized sufficiently. For this reason, management of these resources and economic gains are not as much as desired.

In this study, results of the geothermal energy studies, present utilizations and economical dimensions will be given, as well as information about geothermal sites and potentials, and economic gains which the usage of such resources give the investors.

2. GEOTHERMAL ENERGY STUDIES AND RESULTS IN TURKEY

The elements necessary for geothermal system occurrence have a wide extent in Turkey. According to the geothermal energy potential, Turkey is placed among the richest countries in the world and holds the first place in Europe.

Figure 1. Distribution of young tectonic zones and hot water springs in Turkey.

Geothermal energy explorations start 42 years before in Turkey. Studies necessary for geothermal resource discovery and economical usage have been held out systematically since 1962.

As a result, according to the accepted classification, (low temperature sites (20-70°C), medium temperature sites (70-150°C) and high temperature sites (> 150°C)) 170 sites were discovered. During the explorations realized in sites, having a total of 600 hot water springs, 300 gradient and 380 investigation/observation wells have been drilled. The number of wells drilled reached 500 in total including ones drilled apart from MTA.

Tectonic and volcanic activity zones in Turkey, on which geothermal systems have been developed, are the principal zones for geothermal energy explorations (Fig.1).

11 geothermal sites with high enthalpy, suitable for electricity production, are found in Turkey (Table 1.). Today, the Denizli – Kizildere plant, having 20.4 MWe of gross production, continues to produce electricity at a power of 12 MWe. Investment for the construction of a power plant of 100 MWe at Aydin – Germencik (232 °C), and prestudies for the development of Canakkale – Tuzla and Manisa – Salihli – Caferbey Geothermal sites are continuing. No investments are present for the remaining sites.

Apart from the electricity production sites, the others consist of low and middle temperature fluids. These are suitable for house heating, greenhouse heating, industrial applications, thermal tourism and balneology usage.

In Turkey, 92 sites have been discovered, suitable for district heating, which are of natural spring flow or discharging from a production well of 50°C at least, (Table 2). In reality, only 11 sites are being used (Table 3). Applications related to the usage of this energy are wide spread, due to the cheapness and unpolluting energy resource.

Table 1. Suitable sites for electricity production.

Site	Temperature (°C)
Denizli-Kizildere	200-242
Aydin-Germencik-Omerbeyli	200-232
Manisa-Salihli-Gobekli	182
Canakkale-Tuzla	173
Aydin-Salavatlı	171
Kutahya-Simav	162
İzmir-Seferihisar	153
Manisa-Salihli-Caferbey	150
Aydin-Yılmazkoy	142
İzmir-Balcova	136
İzmir-Dikili	130

3. USABLE GEOTHERMAL POTENTIAL AND ADDITIONS TO ECONOMY

When compared with fossil energy resources, the geothermal potential of Turkey can not be unified. This energy resource providing renewable, unpolluting and continuous resources has important advantages. Young tectonic and volcanic activities that have occurred in Turkey, have played big role in the formation of geothermal systems and created a rich energy potential. The West Anatolian Region, in which high temperature geothermal sites have occurred along graben systems, is the most important region of our country for geothermal energy potential. In Central Anatolia, North Anatolian Fault zone and East Anatolia, in which low heat flow occurs, low temperature zones are developed (Fig. 2).

Table 2. Geothermal Sites of Turkey, having a minimum temperature of 50 ºC, suitable for district heating (Akkus, Aydogdu, et al., 2001)

PROVINCE	SITE	PROVINCE	SITE
AFYON	Omer–Gecek	ERZURUM	Kıgıhazman
	Alaplıderesi (Uyuz Hamamı)	ESKİSEHİR	Sarıcakaya-Sakarılıca
	Heybeli (Kızılkilise)	İZMİR	Balcova
	Gazlıgol		Seferihisar
	Cobanlar		Dikili Kaynarca
	Hudai(Sandıklı)		Bergama-Dibek-Poyracık
AGRI	Diyadin-Koprucermik-Yılanlı		Bademli
AKSARAY	Ziga		Cesme
ANKARA	Kızılcahamam		Nebiler
	Ayas-Coban		Aliaga
AYDİN	Germencik-Omerbeyli	KIRSEHİR	Terme
	Aydin-Ilıcabası		Mahmutlu
	Camkoy-Bozkoy-Alangullu		Karakurt
	Salavatlı	KUTAHYA	Eynal
	Yımazkoy		Nasa-Citgol
	Ortakcı		Gediz-Abide
		MANİSA	Kursunlu
BALIKESİR	Gonen		Sart
	Hisaralan		Saraycık
	Hisarkoy		Mentese
	Pamukcu		Kula-Emir
	Susurluk-Kepekler		Urganlı
	Susurluk-Yıldız		Horzum Sazdere
	Edremit-Derman		Alasehir-K.Dere
	Edremit-Gure	NEVSEHİR	Kozaklı
	Manyas-Kızıkkoy	NİGDE	Narlıgol
	Samlı Dag Ilıcası		Ciftehan
BATMAN	Holi	RİZE	Ayder
BİNGOL	Hacıkoy		İkizdere (Ilıcakoy)
	Harur		
BİTLİS	Nemrut	SAKARYA	Akyazı
BOLU	Sarıot	SAMSUN	Havza
	Seben-Kosenozu	SIRNAK	Hısta Cermigi
BURSA	Karamustafa-Kaynarca	SİVAS	Sıcak Cermik
	Kaya-Sada (Orhaneli)	TOKAT	Sulusaray
CANAKKALE	Tuzla		Resadiye
	Kestanbol	USAK	Banaz
	Hıdırlar		Hamambogazı
	Ozancık	VAN	Hasanabdal
	Kırkgecit		Ozalp-Caybagı
CANKIRI	Cavundur		Sorkoy
DENİZLİ	Golemezli		Zereni
	Kizildere	YALOVA	Termal
	Tekkehamam		Armutlu
	Yenice	YOZGAT	Sorgun
	Karahayıt		Saraykent-Kara Magara
DİYARBAKIR	Cermik		

Table 3. Cities using Geothermal Energy for district heating in Turkey.

Site	(*)Installed Capacity (House Equivalent)	(*)Present Heating (House Equivalent)	Potential (MWt)	Fluid Temperature (ºC)
Gonen (Balıkesir)	4.000	3.400	24,9	80
Simav (Kutahya)	3.200	3.200	126,7	120
K.Hamam (Ankara)	2.500	2.500	20,92	80
Narlıdere+Balcova (İzmir)	19.300	15.500	118,55	98-115
Sandıklı (Afyon)	5.000	2.000	69,52	70
Kırsehir	1.800	1.800	42,36	57
Afyon	4.500	4.500	220,2	95
Kozaklı (Nevsehir)	1.300	1.000	57,65	90
Diyadin (Agrı)	400	400	87,04	70
Salihli (Manisa)	24.000	3000	47,96	94
Denizli-Saraykoy	5000	1500	221,29	147
Edremit(Balıkesir)	7500	500	9,82	60
TOTAL	**78.500**	**39.300**	**1046,91**	

(*)Geothermal Society of Turkey (Personal Communication Bakir, 2004)

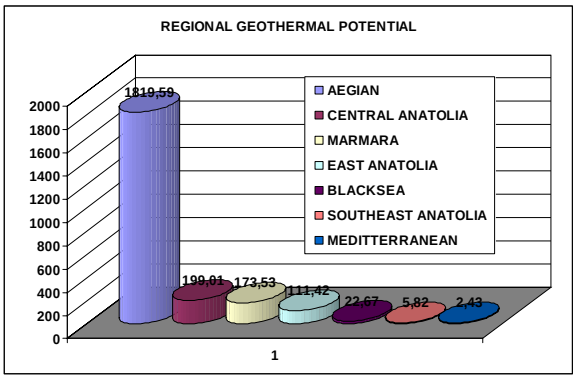

Fig. 2. Distribution of Geothermal Potential with respect to Regions.

According to the natural discharges of the hot water springs, the potential in total is of 600 MWt. Apparent thermal capacity, including 380 wells, is of 3293 MWt. Petroleum equivalent of the 2693 MWt of the mentioned potential, added by means of the wells, is of 2.028 x 10^6 tons. The addition of this equivalency to the economy is 1.095 x 10^9 US$/year. Taking into consideration the energy problem survived in our country, it is possible to see the importance of this addition of the geothermal energy. The usage of this energy during 20 years would provide more than 40 x 10^6 tons of petroleum saving. Possible geothermal heat potential of Turkey is expected to be of 31,500 MWt, which would provide 20 x 10^9 US$ of supplementary budget for the Turkish economy. This was declared at the European Desk of the International Geothermal Association in October, 2001. According to the evaluations of the Geothermal Society of Turkey(2004), this equals to district heating of 5 million houses from the geothermal energy. This data also equals to 9.3 x 10^9 US$/year of fuel-oil, 30 x 10^9 m^3 of natural gas and an decrease of CO_2 emissions in 30 x 10^6 motorized auto cars (Mertoglu, 2000). Unfortunately, only 1 x 10^6 houses are possible to be heated when market conditions and usability are considered.

3.1. Usable Potential in Electricity Production

There are 11 sites suitable for electricity production in Turkey. Potentials corresponding to these sites, with the expectance of single – flash usage, are given in Table 4. It is known from the literature that 20 – 25% of increasing potential could be gained with the double – flash method.

Table 4. Sites appropriate for electricity production and usable potentials.

Site	Temperature ° C	Available Potential MWe	Installed Capacity MWe	Present Production MWe
Denizli-Kizildere	200-242	34	20	12
Aydin-Germencik	200-232	50,97	-	-
Manisa-Salihli-Gobekli	182	0,6	-	-
Canakkale-Tuzla	174	1,12	-	-
Aydin-Salavatlı	171	7,2	-	-
Kutahya-Simav	162	3,51	-	-
İzmir-Seferihisar	153	0,18	-	-
Manisa-Salihli-Caferbey	150	0,04	-	-
Aydin-Yılmazkoy	142	0,54	-	-
İzmir-Balcova	136	0,01	-	-
İzmir-Dikili	130	0,01	-	-
TOTAL		**98,18**	**20**	**12**

3.2. Usable Potential in District Heating

It is seen that 55% of the geothermal sites in Turkey are adequate for district heating. 92 sites, at a minimum temperature of 50 ^{0}C, have been discovered. Drilling studies have been realized on 61 of these sites. According to the production data, the total potential obtained is 2131.29 MWt. The usable potential of the sites in which appropriate fluid for heating is obtained and determined according to the well – data, is given in Table 5.

According to the well – data, the total potential of the sites, in which geothermal fluid exists at a temperature of 35 – 50 ^{0}C and which are used apart from electricity production and district heating, is 106.76 MWt (Table 6).

As a result of the studies realized up to date on geothermal energy, economic additions of electricity production, heating and balneology application usages can all be seen in Table 7. Only the petroleum equivalencies were considered in calculating the economic gains. Given values are expected to increase when employments and similar parameters are considered. The integral reusage of the potential after electricity production is also planned.

4. APPLICATIONS AND ECONOMICAL GAINS

4.1. Electricity Production

In Turkey there is only one power plant in which electricity is produced from geothermal energy. During 19 years of production, the economic gain of the power plant is 175 x 10^6 US$.

The amount of power produced by the plant, during 19 years (1984-2002), is 1,343,049,400 kWh. When determining the economic gain for the country, approximations have been thought through such as; calculation of petroleum equivalency with respect to the produced electrical power by the plant. Our constraints are; 0.241 lt of petroleum is required to produce 1 KWe of electricity, which leads to 323,674,905 lt of petroleum for 1,343,049,400 kWh of elecricity. Taking into account the price of petroleum as 0.54 $/lt (market prizes of Turkey, 2002) the total amount of petroleum neccesary equals to approximately 175,000,000 $.

According to the information obtained from the plant management directorial, the capacity declared as 20.4 MWe is to be of in reality 15 MWe and that 2.5 MWe is to be used by the compressor, and for this reason the plant can only produce 12.5 MWe.

4.2. Applications Apart from Electricity

The total apparent geothermal potential of Turkey is 3293 MWt. Direct usage of this potential is 1077 MWt, which means 444 x 10^6 US$/year (Table 8).

5. EXPECTED GEOTHERMAL POTENTIAL

As known, demands on geothermal energy usage have become denser in the last years. Sufficient finance transfers were not realized before, due to the disinterestedness in the usage of geothermal energy. This situation unfortunately affected exploration studies, which resulted in the determination of lower potential values from the expected real ones.

According to the parameters affecting the occurrence of geothermal systems, geothermal energy resources are such that they have the opportunity of potential improvements, depending on depth of formation and developing technology. Sufficient amount of production wells have to be drilled in order to determine the site's potential, reservoir parameters and manageability. Due to deficiencies in the mentioned studies, an increase in the potential values presented is expected, as well as future projections and planning.

5.1. Electricity Production

Kizildere (Denizli) and Germencik (Aydin) sites are locations, which are expected to be developed both to the east and west. If improvement studies were realized for the next 10 years, the enhancement of the present potential to three times the known seems possible. In case, the number of wells drilled in other sites reaches the number of wells drilled in Kizildere and Germencik, the expected potentials for these sites are given in Table 9.

Table 5. Potentials of wells drilled in sites appropriate for district heating and petroleum equivalents.

Site	Potential (MWt)	Site	Potential (MWt)
Afyon-Bolvadin	15,44	Eskisehir-Sakarılıca	2,16
Afyon-Cobanlar	7,16	İzmir-Aliaga	20,43
Afyon-Gazlı Gol	6,31	İzmir-Balcova	118,55
Afyon-Omer Gecek	220,2	İzmir-Cesme-Ilıca	11,7
Afyon-Sandıklı	65,81	İzmir-Dikili	0,04
Agrı-Diyadin	87,04	İzmir-Seferihisar	6,25
Ankara-K.Hamam	20,92	Kırsehir-Karakurt	0,85
Aydin-Germencik	437,05	Kırsehir-Terme	42,36
Aydin-Salavatlı	89,25	Kutahya-Gediz	36,9
Aydin-Yılmazkoy	14,44	Kutahya-Simav-Eynal	121,05
Aydin-Alangullu	0,54	Manisa-Caferbey	0,96
Aydin-Ilıcabası	1,14	Manisa-Alasehir-K.Dere	7,57
Balıkesir-Bigadic	31,83	Manisa-Kula-Emir	16,74
Balıkesir-Derman	5,33	Manisa-Kursunlu	47,96
Balıkesir-Edremit	10,33	Manisa-Saraycık-[illegible]	10,06
Balıkesir-Gonen	24,9	Manisa-Urganlı	2,39
Balıkesir-Kızık	1,82	Nevsehir-Kozaklı	57,65
Balıkesir-Pamukcu	3,91	Nigde-Acıgol	6,33
Bursa-Dumbuldek	3,68	Nigde-Ciftehan	0,26
Bursa-Kaynarca	11,09	Rize-Ayder	3,6
Canakkale-Tuzla	35,33	Rize-İkizdere-Ilıca	1,24
Canakkale-Hıdırlar	0,1	Sakarya-Akyazı-Kuzuluk	56,52
Canakkale-Etili	0,9	Samsun-Havza	10,6
Canakkale-Kestanbol	4,19	Sivas-Susehri-Akcaagıl	0,14
Cankırı- Cavundur	3,74	Usak-Hamambogazı	14,55
Denizli-Kizildere	320,7	Tokat-Sulusaray	2,09
Denizli-Tekkehamam	10,67	Van-Ercis-Sorkoy	13,56
Denizli-Golemezli	52,87	Van-Ozalp	6,53
Denizli-Yenicekent	20,6	Yalova-Armutlu	2,83
Diyarbakır-Cermik	1,41	Yozgat-Sorgun	0,67
TOTAL (MWt)			**2131,24**
PETROLEUM EQUIVALENT (TEP)			**1.605.000**

5.2. Applications Apart from Electricity

Drilling studies in unexplored sites and enhancement studies in explored sites have to be completed. In this way, an important increment in the known potential is expected for sites suitable for district heating and other applications.

6. PRESENT APPLICATIONS REALIZED IN GEOTHERMAL SITES AND POSSIBILITIES OF USAGE IN TURKEY

Various means of applying geothermal energy are realized in Turkey. District heating applications have rapidly spread in the last years. Similar conditions are also mentionable for the power plant constructions for electricity production. The reason for the applications to increase is the amortization of the expenses spent for exploration and production studies as well as the cheapness and unpolluting property of the used fluid. It has been calculated as an addition of 1.452×10^9 US$/year to the national economy. Besides the gain for the economy, continuous optimum production conditions and clean environmental energy resources, have to be considered in the selection of the energy type.

The direct usage potential of geothermal energy of Turkey is 1077 MWt (Table 10). According to this total amount; 545.2 MWt part is used in district heating equivalent to 39300 houses, 73.6 MWt part is used in thermal base heating equivalent to 9499 houses, 131 MWt part is used in greenhouse heating equivalent to 16959 houses and 327 MWt part is used in 195 therapeutic baths (Fig. 3). With this potential, Turkey is the fifth in the world's classification.

In our country, geothermal energy is mainly used for heating (district, greenhouse, and thermal base), electricity production, industrial applications, thermal tourism and balneology applications (App.1).

Table 6. Potentials of wells drilled at sites appropriate for usages between 35 – 50 °C and petroleum equivalents

Site	Potential (MWt)	Site	Potential (MWt)
Afyon-Cay-Karaburun	0,4	K.Maras-Suleymanlı	8,36
Afyon-Omer-Gecek	1,03	Kayseri-Erciyes	1,38
Afyon-Sandıklı	0,52	Kırsehir-Terme	2,78
Amasya-Gozlek	0,24	Kırsehir-Cicekdagı	0,11
Amasya-Hamamozu	0,91	Konya-Ilgın	4,97
Amasya-Terzikoy	0,71	Kutahya-Saphane	0,14
Ankara-Haymana	2,18	Kutahya-Harlek	0,38
Ankara-Meliksah	5,02	Kutahya-Emet	1,03
Balıkesir-Bigadic	0,01	Kutahya-Simav-Nasa	0,26
Balıkesir-Gure	0,03	Kutahya-Yoncalı	3,08
Bingol-Kos	0,1	Manisa-Demirci	0,25
Bolu	0,18	Nigde-Ciftehan	0,02
Bursa-Cekirge	2,07	Samsun-Kocapınar	0,5
Bursa-Kaynarca	0,59	Samsun-Ladik-Hamamayagı	0,5
Canakkale-Can	0,92	Sivas-Sıcakcermik	44,7
Corum-Figani	0,46	Sivas-Sarkısla-Ortakoy	0,1
Denizli-Yenicekent	0,03	Sanlıurfa-Karaali	4,41
Denizli-Beylerli	0,06	Tokat-Resadiye	1,44
Elazıg-Karakocan-Golan	0,63	Usak-Ulubey-Aksaz	0,06
Erzurum Ilıca	0,67	Yalova-Termal	0,05
Erzurum-Pasinler	10,05	Yozgat-Cavlak	4,6
Eskisehir	0,26	Yozgat-Uyuz	0,5
Eskisehir-Sakarıılıca	0,07		
TOTAL (MWt)			**106,76**
PETROLEUM EQUIVALENT (TEP)			**80.390**

Table 7. Petroleum Equivalent and Economic Addition of Usable Geothermal Potential

Application	*Potential	Economic Addition	
		1000 TEP	1000 US$/Year
Electricity Production	98.17(MWe)	236	112000
District Heating (House – Greenhouses – Thermal Baths), Balneology Application	3293(MWt)	2480	1340000
		TOTAL	**1452000**

* For electricity Production; 1 ton of petroleum = 3600 kWh, for applications apart from electricity production; 1 MWt = 860000 Kcal/h is accepted.

Table 8. Economic Gains of Geothermal Energy apart from Electricity in Turkey

	Present District Heating (House Equivalent)	Installed Power (House Equivalent)	Pot. (MWt)	Petro. Equi. (TEP)	Economic Gain (1000 US$/Year)
Municipal Heating	39.300	78.500	545,2	410.535	225.083
Thermal Base heating	9.499	9.499	73,6	55.421	30.385
Greenhouse Heating	16.959	16.959	131	98.643	54.082
Balneology			327	246.231	135.000
TOTAL	**65.758**	**104.958**			
DIRECT USAGE			**1076,8**	**810.830**	**444.550**

Table 9. Expected Potentials in Sites Suitable for Electricity Production

Site	Temperature (° C)	Expected Potential (MWe)
Denizli-Kizildere	**200-242**	**120**
Aydin-Germencik	**200-232**	**150**
Manisa-Salihli-Gobekli	**182**	**30**
Canakkale-Tuzla	**174**	**50**
Aydin-Salavatlı	**171**	**50**
Kutahya-Simav	**162**	**30**
İzmir-Seferihisar	**153**	**10**
Manisa-Salihli-Caferbey	**150**	**30**
Aydin-Yılmazkoy	**142**	**20**
İzmir-Balcova	**136**	**10**
İzmir-Dikili	**130**	**10**
TOTAL		**500**

Table 10. Direct Usage Potential Apart from Electricity in Turkey

Application	Amount of Heating Realized Equivalent to house	Present Power Equivalent to house	Potential MWt
District Heating	39300	78500	545,2
Thermal Base Heating	9499	9499	73,6
Greenhouse Heating	16959	16959	131
Balneology Usage			327
TOTAL	**65.758**	**104.958**	
Direct Usage			**1077**

Resource: Geothermal Society of Turkey.

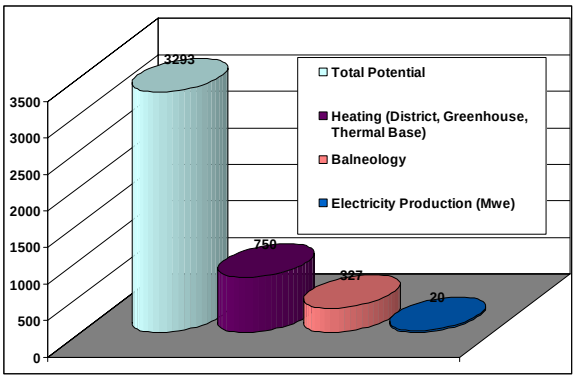

Fig. 3. Usage of Apparent Potential

6.1. Electricity Production

The General Directorate of MTA had tested a turbine of 0.5 MWe power in 1974 at the Kizildere geothermal site, which later on lead to the first and only electricity production power plant in 1984. Today, the Denizli – Kizildere power plant, having an installed power of 20 MWe, continues producing electricity at an amount of 12 MWe. According to the electricity production from geothermal energy, Turkey is located as 14th in the world classification after USA, Philippines, Mexico, Italy and Indonesia, which are the first five in the classification (Simsek, Mertoglu, et al.2001).

Investments for the construction of the power plant of a 100 MWe in Aydin – Germencik, and pre – investment studies in Canakkale – Tuzla and Manisa – Salihli – Caferbey sites are being carried out at the present day.

7. CONCLUSIONS

- Turkey's needs for energy increase day by day. The country meets more than the half of her necessity from foreign countries. In respect to this, Turkey has to develop and use geothermal energy potential resources, as an alternative energy, in order to decrease the polluting influences of fossil energy and to obtain economic savings.

- There are 170 geothermal sites in Turkey. The visible energy potential in these sites is 3293 MWt; expected heat potential is 31500 MWt.

- According to the present data, there are 92 sites suitable for district heating and 11 sites suitable for electricity production in Turkey.

- According to the well – data, the geothermal electricity potential of Turkey is 98.18 MWe, and district heating potential is 2131 MWt.

- The direct usage potential of the visible reserves is 1077 MWt, which provides an economical saving of more than 444 x 10^6 US$ per year.

- A total amount of 1.343 x 10^9 kW of electrical energy has been produced from the power plant by means of geothermal energy during 1984 and 2002. The petroleum equivalency of this production equals to 175 x 10^6 US$.

- The petroleum equivalent of the usable geothermal potential and the addition to the economy is; 112 x 10^6 US$/year for electricity production, 1.34 x 10^9 US$/year for district – thermal base – greenhouse heating and balneology applications, with a total of 1.452 x 10^9 US$/year.

- Even though 170 sites are found in Turkey, only in 105 sites were wells drilled. According to this ratio, only 2 wells correspond for each site. In this aspect, the number of wells does not seem sufficient for the determination of the real potential.

- Sufficient finance transfers have to be realized in order to undertake targeted studies in discovered sites. The targeted studies will diminish investment risks, in sites where usage of geothermal energy is planned as an energy resource.

- An important potential exists in Turkey, for district heating, for electricity production and for other applications. Usage of this potential would provide additions to the solution of the energy problem.

- Governmental and private contributors are suspicious about the variations of potentials, yields and similar parameters in time. It is an obligatory to realize studies on enhancement and potential determinations in order to eliminate the disadvantage effecting directly the investments.

- Studies dealing with electricity production have to be realized. Enhancements in sites suitable for electricity productions have to be completed and power plants have to be constructed as soon as possible.

- Geothermal Resources of our country are mainly used for thermal tourism, greenhouse and district heating. According to the well yields, temperatures and chemical compositions of the hot waters; paper production, refrigerating by ammoniac adsorption, production of hydrogen sulphate, drying wood and diatomite, whitening and chemical drying processes, plant production etc. purposes have to be investigated.

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Appendix 1. Present Applications and Usage Possibilities of the Important Geothermal Sites in Turkey

Site	Temperature (°C)	Present Usage	Available Applications
Denizli-Kizildere	242	Electricity Production, Greenhouse heating, District Heating, Thermal Baths, CO_2 Production, Textile Industry	Electricity Production, District Heating and Industrial Usage, Drying Processes, Thermal Tourism, Thermal Base Heating, Cooling Processes
Aydin-Germencik	232	500 m^2 Greenhouse Heating	Electricity Production, District Heating and Industrial Usage, Drying Processes, Thermal Tourism, Thermal Base Heating, Cooling Processes
Canakkale-Tuzla	174	Thermal Baths, Salt Production, Greenhouse Heating	Electricity Production, District Heating and Industrial Usage, Thermal Tourism, Thermal Base Heating, Salt Production
Aydin-Salavatli	171	Thermal Tourism	Electricity Production, District Heating and Indusrial Usage, Drying Processes, Thermal Tourism, Thermal Base Heating, Cooling Processes, Greenhouse heating
Kutahya-Simav	162	Thermal Tourism, Thermal Base Heating, Greenhouse heating, 3200 house heating	Electricity Production, District Heating and Industrial Usage, Thermal Tourism, Thermal Base Heating, Greenhouse heating
Izmir-Seferihisar	153	Thermal Baths, 6000 m^2 greenhouse heating in Seferihisar	Electricity Production, District Heating and Industrial Usage, Thermal Tourism, Thermal Base Heating, Greenhouse heating
Manisa-Salihli-Caferbey	150	-	Electricity Production, District Heating for Salihli, Drying Processes, Thermal Tourism, Thermal Base Heating
Aydin-Yilmazkoy	142	-	Electricity Production + Integral Applications
Izmir-Dikili	130	1000 m^2 Thermal Baths	Electricity Production + Integral Applications
İzmir-Balcova	125	Thermal Tourism, Thermal Base Heating, Greenhouse heating, Swimming Pool	Thermal Tourism, Thermal Base Heating, Greenhouse heating, Swimming Pool
Afyon-Omer-Gecek	98	Thermal Base Heating; 3 Thermal baths, 33 Motels, 5500 m^2 of greenhouse heating, 4000 houses heated.	District Heating of Afyon, Greenhouse Heating, Industrial Heat, Farm usage, Cold Storehouses
Balikesir-Bigadic-Hisarkoy	98	Thermal Tourism, Thermal Base Heating	Thermal Tourism, Thermal Base Heating, Greenhouse heating
Kutahya-Gediz	97	Thermal Tourism, Thermal Base Heating	Thermal Tourism, Thermal Base Heating, Greenhouse heating
Izmir-Aliaga	96	-	Thermal Tourism, Thermal Base Heating
Manisa-Kursunlu	94	Thermal Tourism, Thermal Base Heating	Thermal Tourism, Thermal Base Heating, Drying Processes, District Heating for Salihli
Nevsehir-Kozakli	93	Thermal Bath, SSK Hospital Heating, Greenhouse Heating	Thermal Tourism, Thermal Base Heating, District Heating for Kozaklı
Balıkesir-Sindirgi-Hisaralan	92	Thermal Bath Application, Greenhouse heating (2000 m^2)	Thermal Tourism, Thermal Base Heating, Greenhouse heating, Industrial Usage
Van-Ercis-Sorkoy	92	Thermal Bath Applications	Thermal Tourism, Thermal Base Heating
Denizli-Golemezli	88	Thermal Bath Applications, Thermal Base Heating, Greenhouse heating	Thermal Tourism, Thermal Base Heating
Ankara-Kizilcahamam	86	Heating	Heating and other applications
Sakarya-Akyazi-Kuzuluk	84	Thermal Tourism, Thermal Base Heating	Thermal Tourism, Thermal Base Heating, District Heating for Akyazı
Balikesir-Gonen	82	Thermal Tourism, Thermal Base Heating	Thermal Tourism, Thermal Base heating, District Heating, Hot Water Processes for Tannery, Industrial Usage, Greenhouse Heating
Agrı-Diyadin	78	Thermal Bath Applications, Heating of governmental buildings	Thermal Tourism, Thermal Base Heating, Greenhouse Heating, CO_2 production
Yalova-Armutlu	77	Thermal Baths	Heating and other applications
Yozgat-Sorgun	75	Thermal Baths	Heating and other applications
Afyon-Sandikli	70	Thermal Tourism, Thermal Base Heating	Thermal Tourism, Thermal Base Heating, Greenhouse heating