

On the Renewability of Geothermal Resources in Turkey

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ABSTRACT

Turkey has more than 600 hot water springs, with surface temperatures ranging from 40-100 °C. Those hot springs are mainly situated along the major grabens at the Western Anatolia, along the Northern Anatolian Fault Zone, Central and Eastern Anatolia volcanic regions. Some surface manifestations of these resources such as Pamukkale/Denizli white travertine terraces, Kangal/Sivas psoriasis fishy treatment centre are well known throughout the world. Inhabitants of Anatolia used those thermal waters for their healing and medicinal properties for centuries. There were 226 spa centers in Turkey earlier than 1963 in which the first well was drilled in Turkey for the utilization of geothermal energy. It is therefore a vital issue to hand over those resources to the next generations along with the contemporary applications of geothermal energy.

In this paper the importance of the renewability of geothermal resources is emphasized.

1. INTRODUCTION

Geothermal energy is considered as renewable because of the heat emanating from the interior of the Earth is essentially limitless and continuously regenerates through natural geologic processes (Rybäck, 2007). The lifetime of natural geothermal systems depending on geological process ranges from a minimum of perhaps 5,000 years to more than 1,000,000 years (Wright, 1998). Hydrothermal systems with natural fluid/heat flows created the natural geothermal features such as geysers, fumaroles, hot springs, sinter terraces and mud pools with their dependent ecosystems (geothermal plants and animals). These surface features have been used by human beings since the Bronze Age, about 5000 years ago in Asia (Lund, 2005) to meet community needs including; bathing, spiritual and therapeutic. As well, geothermal plants, microorganisms and animals associated with geothermal discharges show the environmentally friendly nature of geothermal fluid. Those plants and animals also make significant contributions to: biotic diversity, intellectual stimulation, the gene pool, scenery, and aesthetic enjoyment with intrinsic values (Leod, 1995). Use of these surface features by human beings for centuries and the buffering ability of geothermal resources show that they are not new but renewable and environmentally friendly resources.

Geothermal energy can also be considered as the ability to do work of geothermal fluid or to produce power. The history of the geothermal power production goes back to 1904 when the geothermal steam was successfully used to generate power in Larderello. After that geothermal energy was seen as the power of the future and the utilization has been increased worldwide. However, in some cases, the

utilization of geothermal energy caused some negative effects such as (i) the extinction of geothermal features with their ecosystem and (ii) hydrogeochemical (such as B, Hg, As, Pb, NH₃, Li) and thermal impacts into receiving streams and soils plus geochemical impacts of CO₂ and H₂S into the atmosphere (Brown ve Webster-Brown, 2005). Some of these effects are either minimized or totally removed by reinjection but still some precautions must be taken to protect the geothermal systems from those adverse effects.

Protection of geothermal resources has legislative, financial, political and sociological aspects. In that respect, some geothermal fields used for touristic and balneological purposes could be considered more valuable than the commercial development as the energy resource. However, the difficulty that arises at this point is the determination of the geothermal resources to be protected.

2. GEOTHERMAL RESOURCES IN TURKEY

The General Directorate of Mineral Research and Exploration Directorate (MTA) of Turkey started the exploration studies for geothermal energy in 1960's. Prior to that 226 spa centers were active in Turkey for bathing and medical treatment. The geologic map of Turkey (Figure 1) indicates a very active geothermal regime shown by the many natural surface manifestations of hot springs along the major grabens at the Western Anatolia, along the Northern Anatolian Fault Zone, Central and Eastern Anatolia volcanic regions. After the drilling of first well in Balçova geothermal field, use of geothermal resources has expanded rapidly in the last 46 years from electric generation to district heating, greenhouse heating and modern balneology. Up to now about a thousands of wells were drilled to seek not only high-temperature fields, but also to develop low and medium enthalpy applications. The first geothermal electricity generation and district heating started in Denizli/Sarayköy (1984) and in Gonen (1987), respectively. Direct use applications (residential heating, greenhouse heating and thermal facilities) during 1990's and electricity generation in the last 5 years were increased rapidly.

Natural geothermal features generated by geothermal fluid at the surface are not common everywhere and shows significant differences from place to place. Some of those features in Turkey are unique such as Pamukkale/Denizli white travertine terraces, a World Heritage Site and Kangal/Sivas psoriasis fishy treatment spa centre. Geothermal spas related to hot springs have also a long history often stretching back to old times, such as Ayas/Ankara thermal baths by Hittites, Cermik/Diyarbakir by the Seljuks, Ilgin/Konya by the Romans and Seljuks, and Yalova thermal bath by Romans, Byzantines and the Ottomans etc. (Avsaroglu, 1968). Many of these springs are also related to historical sites such as Bergama/Izmir-Allianol, Gure/Balikesir-Astyra etc.



Figure 1: Map of Turkey Geothermal Resources (Simsek et al., 2005)

The health-giving properties of the hundreds of hot springs were used by the inhabitants of Anatolia since 7000 B.C (Arriaga, 2005). Using these surface manifestation for a long time show that Turkish societies knew the healing and medicinal properties of thermal waters and mud to cure rheumatic, sciatic, gynaecological, kidney and as well other physical diseases, but also to treat psychiatric problems and relaxation.

The most important examples of geothermal fields in Turkey used for touristic and health purposes are given below:

a- Pamukkale, Karahayıt and Yenice Thermal Baths: Pamukkale, Karahayıt and Yenice thermal stations situated in the North of Denizli had surface manifestations. These baths were also used in antique ages. Pamukkale white travertine terraces (Figure 2) and Yenice thermal springs are adjacent to the Hierapolis ruins and Tripolis ruins, respectively.



Figure 2: Pamukkale white travertens

The sinter terraces of Pamukkale consisting mainly of calcite have been precipitated since prehistorical time from the geothermal water. Due to the touristic and spa activities, the decline in reservoir pressure caused a decrease in the carbonate precipitation and as well caused physical damage

and discolouration of travertine terraces. International Research and Application Center for Karst Water Resources of Hacettepe University (Ankara) and the Ministry of Culture of Turkey launched a project to conserve the terraces. The project was aiming (i) determination of the optimum use of thermal springs for the travertines, (ii) to increase the available yield of natural springs and prevent further pollution (iii) to extend the white travertine zone by a more rational management of the hot waters and (iv) setting up an Administrative Working Group responsible for the overall control of thermal distribution and protection works (Simsek, 2000). After this, Pamukkale, Hierapolis ruin and thermal spa were taken under protection by UNESCO.

Karahayıt's red water and travertine, 5 km away from Pamukkale, became a focus for spa and touristic activity and the tourism activities developed very rapidly. The red water spring (29 lt/s) and Kortur water spring (5 lt/s) during 1970s dried because of unauthorized drillings within the village. Karahayıt has been taken under protection by the Special Environmental Protection Council (SEPC) in 1990 (www.karahayit.bel.tr on 21/04/2008).

b- Gönen and Balcova (Agemennon) spa resort have been famous for centuries for the therapeutic qualities of its natural hot springs. Gönen thermal baths, a district of Balıkesir, were known since the Romans and the Byzantines era. Balcova thermal springs known as the "hot springs of Agemennon" situated on the green fields facing the sea and town of İzmir. Legends tell that, the soldiers who were wounded during War of Troy were sent to these natural hot springs by Agemennon.

In Balcova geothermal field exploration drilling commenced in 1963 and first heating application was applied in 1981. A total of 27 wells (15 deep and 12 shallow wells) have been operated since 1996. The district heating system has lately reached a heating capacity equivalent to 20000 households. In addition the biggest balneological application in Turkey is active in the field.

In Gönen geothermal field first two wells were drilled in 1976. The district heating facility was started in 1987 and was expanded to 2500 households by 2000. As the system is

enlarged, the number of wells used for production and reinjection is also increased. By 2001, first signs of insufficient heat supply were observed. The situation was so deteriorated that the district heating system was shut down for a month in the midst of winter 2002 (Serpen and Aksoy, 2004).

c- Kangal/Sivas and Köyceğiz-Sultaniye/Mugla thermal stations; Kangal/Sivas psoriasis fishy treatment centre (Figure 3), a well-known touristic and spa locations, provided treatment in pool supplied by warm springs flowing around 10 l/s at 36 °C (Akkuş et al, 2005).



Figure 3: Kangal/Sivas psoriasis fishy treatment centre
(<http://www.sivas.gov.tr>)

The other most important touristic geothermal manifestation is in Köyceğiz/Mugla, well known for its natural hot springs and mud baths (Figure 4). It is believed that the spas were used by the Kaunos in 100 B.C. These thermal springs have been used to cure rheumatic and skin diseases and are also supposed to have a beautifying effect on skin. The temperatures of the springs are in the range of 34 - 41 °C.

There was no drilling activity yet on these two fields.



Figure 4: Köyceğiz/Mugla hot springs

3. DISCUSSION ON THE PROTECTION OF GEOTHERMAL RESOURCES IN TURKEY

The natural geothermal features produced by naturally dynamic fluid/heat flows were used by human beings for centuries to meet community needs including; bathing, spiritual, cultural, aesthetic, therapeutic, heating and economic. This natural fluid/heat discharge rate from geothermal reservoirs represents the minimum rate at which geothermal systems could be produced by a renewable manner for thousands of years.

Renewability and sustainability are often used or discussed how to utilize from geothermal systems. As sustainability shows men's decision on how long to maintain a constant energy production from the system renewability can be defined in two different forms: *Renewability of Natural Features* and *Renewability of Reservoir Parameters*.

- **Natural Renewability (don't touch site)**-Renewability of *Natural Features* (Figure 5), the natural resupply of geothermal fluid, solely depend on certain continuous natural geological processes, which are beyond any men's control (Cataldi, 2001). This type renewability can enable for the protection of the natural geothermal surface features with their ecosystem. In this type of field no geothermal development like drilling activity should be allowed

- **Strong Renewability**- *Renewability of Reservoir Parameters* is attained when geothermal fluids are usually produced at rates that balance their natural recharge rates. In other words reservoir pressure (P_r) would be balanced to fluid production pressure (P_m) or dynamic water level during the exploitation life span (Ungemach, 2007). This type renewability can enable preservation of geothermal resources (really they have been used by mankind for thousands of years) for use by future generations.

Health tourism has been becoming a worldwide industry. People from all around the world are travelling to other countries to obtain medical and surgical care while at the same time touring the attractions of the countries. It is concluded that some geothermal resources is a source of heat for medicinal purposes that will contribute increasingly to the world's touristic and health demands in the future.

Traditionally, the geothermal water in Turkey has been used for medical, cooking and bathing purposes for years. However, recent developments in geothermal energy involving electricity generation, district heating, or greenhouse heating have increased the number of wells drilled to meet the demand for geothermal fluid. Some of geothermal fields have already been extensively affected by the excessive production of geothermal fluid. This caused the changes in physical and chemical characteristics of thermal springs, mud pools and natural travertine terraces. So, the protection of the renewability of thermal feature or field used as health and touristic aims in Turkey has a vital importance for future generations.

The Law "Installation of Spa Center with Exploitation of Hot and Cold Mineral Waters" acted in 1926 was insufficient to protect the renewability and sustainability of geothermal resources. Increasing public concern to protect the geothermal fields, and the insufficient law, led to some local authorities to take emergency actions during 1990's. As an example, the permission of all geothermal drilling activities had to be taken from governorship in Izmir area. Because of increasing problem in geothermal sectors a new draft geothermal law study started in 2000's.

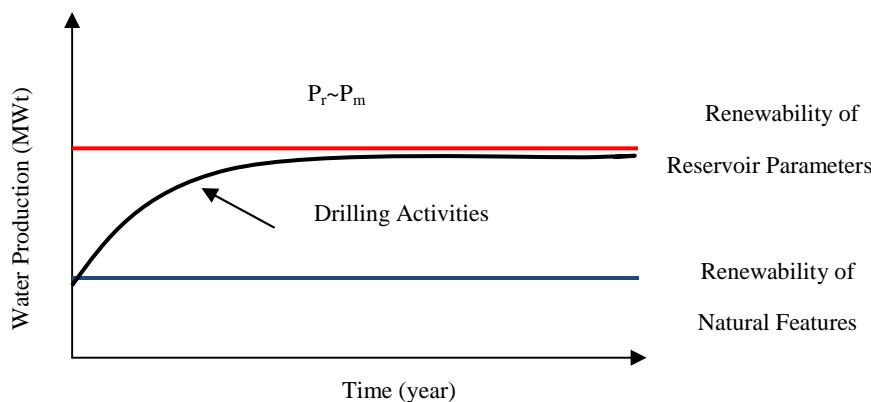


Figure 5: Renewability of Natural Features and Renewability of Reservoir Parameters (P_r = Reservoir Pressure, P_m =Measured Well Pressure or Dynamic Water Level) (adapted from Sanyal, S. K., 2005)

Geothermal Resources and Natural Mineralized Water Act of Turkey (GRNMWA) passed from Parliament in 2007, promotes the sustainable management of geothermal resources. According to this law the State owns the resource and has full control and supervision over the exploration, development and utilization of geothermal resource.

However sustainability does not guarantee the renewability of geothermal resources which is an important issue for the type of natural springs used for centuries by mankind for medicinal purposes as well as natural beauty. As well this law does not include detailed guidelines for drilling application and the geothermal monitoring programme to monitor the field to protect renewability of geothermal natural features and reservoir parameters.

To ensure protection of the site used for touristic and health purposes in the future, it can be recommended that: (a) special regulations and laws be enacted by a govermental department, to conserve the renewability of natural features and the spa area (b) The govermental department can take a leading role in renewable management of geothermal resources by producing geothermal policies which include protecting reservoir systems and natural surface features with geothermal ecosystems, (c) it can be announced guidelines for drilling and use of geothermal water in geothermal spa centre. (d) water level should be maintained by restricting withdrawal of geothermal fluid by setting up the geothermal monitoring programme to monitor the reservoir (e) all individual geothermal wells situated within geothermal area must be taken under control as soon as possible (f) the public should be better informed the fragility of hydrothermal resources used as spa centre for a long time.

CONCLUSION

1. Some geothermal areas with thermal features (like Kangal/Sivas psoriasis fishy and Köyceğiz/Mugla mud baths) should be designated as scenic reserves by the government and no geothermal drillings are allowed.
2. In the spa centers that their healing and medical properties are known, the water withdrawal must be restricted to protect renewability or reservoir parametres.
3. A geothermal renewability mechanism for some geothermal fields should be controlled with special policy and regulations by the state.

4. Increased in the public awareness and action about renewability matters should help to preserve the natural hydrothermal systems used for health and touristic purposes.

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