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GEOTHERMAL GREENHOUSING IN TURKEY

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Abstract
Use of renewable energy resources should be brought forward to reduce heating costs of greenhouses and to minimize the use of ever-depleting fossil fuels. Geothermal energy not only provides the heat required throughout plant growth, but also allow a year-long production. Geothermal resources with several other benefits therefore play significant role in agricultural activities. With regard to geothermal potential and implementation, Turkey has the 7th place in the world and the 1st place in Europe. Majority of country geothermal resources is used in greenhouse heating. The size of geothermal greenhouses increased 5 folds during the last decade and reached to 2500 decare. In this study, current status of geothermal greenhousing of Turkey was presented; problems and possible solutions were discussed..

Keywords: Geothermal, greenhouse, geothermal energy, Turkey

1. INTRODUCTION

Turkey is quite rich in renewable energy sources. Therefore efforts have been directed to this huge resource. However, current uses or interests in these resources are still at low levels. Fossil fuels still constitute about half of primary energy production of the country. Now, more emphasis is placed over strategy, plan and policies for proper and healthy use of renewable energy resources.

Annual energy production of Turkey is equivalent to 109 266 million tons petrol. Of these energy demands, 26.7% is met by oil, 31.9% by natural gas, 30.7% by coal and 10.9% by renewable resources (Kılıç and Kılıç, 2013).

It is envisaged that fossil fuels will deplete in near future and they will then be replaced by renewable energy resources. More emphasis should be placed over renewable energy resources to prevent fossil fuel-originated environmental problems. Geothermal energy has a great potential to be used in agricultural sector.

As it was in most parts of the world, population of Turkey is continuously increasing and nutritional demands are also increasing accordingly. Current land and water resources will not meet such increasing demands in the future. Therefore, alternative methods, like geothermal greenhousing, are searched fort o improve yields and productions.

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Geothermal energy is a renewable energy and used in power generation, agriculture, medicine, tourism and various other industries. Geothermal energy resources are continuous renewable resources with quite lower exploring and operational costs than fossil fuel resources. They also don't require advanced technology and have quite shorter investment return periods. Geothermal energy resources can provide sufficient energies without creating any carbon dioxide emission and air pollution. Thus, they have quite low negative impacts on environmental.

Geothermal energy is commonly used in greenhouses in Turkey. It is usually used to provide heat required for plant growth year-long. Thus, besides various other uses, geothermal resources are considered as a great resource for agricultural activities. Low temperature geothermal resources can also be used greenhouse heating and they can provide quite economic heating in greenhouses.

Greenhouses supply proper environmental conditions for plant growth during the periods in which open culture is not possible. Greenhouses should be heated especially during the winter months to provide optimum conditions for plants. Heating constitute the greatest cost-item in greenhouses. Therefore, heating is not regularly practiced in Turkish greenhouses and mostly practiced to prevent plants from freezes. Then, low yields and quality are evident. Natural energy resources, especially geothermal resource, are used for economic heating of greenhouses. Availability of hot water resources greatly reduces the heating costs. Geothermal hot water resources are available in various parts of Turkey and such resources have a great potential to be used in greenhouse heating.

2. GREENHOUSING IN TURKEY

The ratio of greenhouses in agricultural production activities are continuously increasing in Turkey. About 6.6 million tons vegetables and fruits are produced in greenhouses of Turkey and such a production corresponds to about 16 billion TL production income. Majority of greenhouse products are consumed in local markets and about 15% is exported (İlbay et al., 2015). Turkey has a significant place in world fresh vegetable and fruit production and has the fifth place (with 663 621 decare under production sites) in world under-cover production. Of this amount, 12% (79976 da) is glasshouses, 47% (306 429 da) plastic greenhouse, 17% (112 673) is high-tunnel and 24% (161 541 da) is low-tunnel (TÜİK 2015).

3. GEOTHERMAL ENERGY IN TURKEY

Turkey is located over the Alpine-Himalayan orogeny and has more than 1500 hot and mineral water resources in different parts of the country with young tectonics and active fault lines. Existence of grabens (depressions formed by young tectonics), widespread volcanism, natural vapor and gas releases indicate the significant geothermal potential of Turkey (Güler and Çobanoğlu, 1997).

Geothermal heating was initiated in Turkey in 1964 with the heating of a hotel in Balıkesir-Gönen. Following the research and development activities, the first geothermal power plant was constructed in 1984. Direct use of geothermal resources was initiated in 1987 again in Balıkesir-Gönen with heating 2 000 m^2 greenhouse (Yıldız, 2014; Serpen, 2005).

Geothermal resources don't exist in several countries. Turkey has about 8% of world geothermal potential. With about 31 500 MWt heat potential, Turkey has the seventh place in world and has the first place in Europe. Turkey has a geothermal potential able to meet about 30% of country heating needs (Anonymous, 2013). Of the potential geothermal resources of Turkey, 79% is located in Western Anatolia, 8.5% in central Anatolia, 7.5% in Marmora region, 4.5% in Eastern Anatolia and 0.5% in other regions (Figure 1). About 94% of geothermal resources has low and medium temperature and available for direct applications (heating, thermal tourism, mineral processing and etc.) and 6% is available for indirect applications (power generation) (MTA, 2015). Previous studies

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identified more than 225 geothermal fields which can be useful at economic scale and about 2 000 hot and mineral water resources (springs and wells) which have temperatures ranging from 20 to 287 °C. Up to now, nearly 1 200 geothermal exploratory, production and reinjection wells have been drilled in Turkey. At present, there are 16 geothermal district heating systems in operation some using water as low as 40 to 45^{o}C, without the use of heat pumps. These systems serve 77 453 residences (Mertoglu, et al., 2015). Number of wells opened up to now is 5 046 and total depth is 252 515 m. Total geothermal electric potential of Turkey is 2 000 MWe (16 billion kWh/year) and direct heat energy use potential is 2 886.3 MWt (Table 1). Total thermal installed capacity is 2886.30 MWt, direct use is 45126.00 TJ/year and 12536.00 GWh/year and the capacity factor is 0.50. All these values indicate that Turkey has a great potential in geothermal resources (Hasdemir et al., 2014; EIE, 2015. IGA, 2015; Lund and Tonya, 2015).

Figure 1. Geothermal resource map of Turkey

Table 1. Heat energy potential of geothermal energy

Type of use	*Amount (MWt)*	*Amount (TJ/yr)*
Individual space heating	*420*	*4635*
District heating	*805*	*8885*
Greenhouse heating	*612*	*11580*
Agricultural drying	*1.5*	*50*
Bathing and swimming	*1005*	*19106*
Geothermal heat pumps	*42.8*	*960*
TOTAL	*2 886.3*	*45216*

Turkey has extensive geothermal resources that have been utilized for heating of residences, district heating, greenhouse heating, and for spas. There is also a liquid carbon dioxide and dry ice production factory integrated with a power plant at Kizildere. Greenhouse heating has increased substantially in the last three year with installations in six major areas covering 230 ha. About 16

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million local and 10 000 foreign visitors are benefiting from the balneological uses of geothermal water in Turkey, with investments growing in recent years. Geothermal heat pump installations have grown, with large installations in the Metro Meydan M1 Shopping Center/Istanbul; the Terme Maris Facility in Dalaman; The Titanic Hotel in Antalya; Antalya Terra city, and the Sabiha Gokcen Airport in Istanbul (Mertoglu et al., 2010; Mertoglu et al., 2015; Lund and Tonya, 2015).
The targeted geothermal electricity production was announced by Turkish Government as 1500 MWe by the year 2023, the 100th Anniversary of Turkish Republic. Between 2010-2015, a total of 320 geothermal exploration, production and injection wells for electricity production and direct use purposes were drilled in Turkey with a total depth of 570 km by MTA and the private sector. Especially in the Buyuk Menderes Graben and Gediz Graben geothermal systems, new geothermal fields have been explored by MTA and Turkish private sector. Nearly 80% of the geothermal exploration wells have been drilled in the Western Anatolia region of Turkey (Mertoglu et al., 2015).
Just because of supports provided for energy investments in Turkey, use of geothermal resources has been oriented toward to use for energy sector. The other uses, like in greenhouse heating, haven't been sufficiently developed, yet. Turkey, even with that great source (more than 1500 resources) is not able sufficiently benefit from geothermal resources. Based on water temperature, geothermal energy is primarily used power generation, residence heating, thermal tourism-treatment, greenhouse heating and various other industries. With the full capacity in use, the total value-added potential of geothermal resources is around 80 billion $. However, Turkey is using only 12% of that capacity (Anonymous, 2013; EIE, 2015). There are technical, financial and methodological reasons of such low capacity use. Another significant reason is the lack of investments in geothermal energy.

4. GEOTHERMAL GREENHOUSING IN TURKEY

Greenhouse production activities are mostly intensified in southern sections of Turkey where climate conditions are available. The reason of less development in greenhouse activities of the regions is low winter temperatures and thus heating costs of those regions. Heating is the greatest cost item in greenhouses. In places where natural temperatures are not available, heating should be supplied for sustainable plant growth (Hasdemir et al., 2014).
Geothermal greenhouse heating has recently become quite popular in Turkey. Heated greenhouses are mostly located in western Anatolia of Turkey. Greenhouses in these regions are commonly constructed around geothermal hot water resources. Since state supports are also provided to geothermal investments, greenhouse investments have several advantages. Geothermally heated greenhouses have quite a heating cost-advantage over the conventionally heated ones.
Generally the geothermal resources with a temperature of over 70 °C are used in greenhouse heating in Turkey. With regard to geothermal resources, Aegean region is the richest and Mediterranean is the poorest region of Turkey. Thus, Aegean region should be focused on for development of geothermally heated greenhouses (Table 2). Eastern Anatolia region with terrestrial climates and several negative influences on agricultural activities has only 4.5% of country geothermal resources. Vertical limit of greenhouses is around 1100-1200 m in Turkey and these limits may reach up to 1600-1650 m in places with geothermal resources (Titiz, 2004; Çanakcı and Acerer, 2009; Serpen et al., 2010; Doğanay, 2011).
Greenhouse applications have reached three million m^2 due to satisfaction with the various operations; however, development has slowed down in the last couple years. There are six major greenhouse areas in the country, mostly in the west. Tomatoes are mostly grown in these

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greenhouses with the major markets of Russia (60%), Europe 20%, around 10% elsewhere internationally, and 10% sold domestically (Mertoglu, et al., 2015).

About 1 200 decare greenhouse is heated with geothermal resources in Turkey. Exports are made to Europe from 250 decare geothermally heated greenhouses of Şanlıurfa province of Turkey (Serpen, 2005). Greenhouses are heated annually for about 1500-2000 hours. The CO_2 content of warm and hot geothermal water (wt. 2.5%) is also used in production activities and there is about 4 000 ton/ha CO_2 production in greenhouses (Yıldız, 2014).

Table 2. Geothermally heated greenhouses of Turkey

Place	*Capacity (MW_t)*	*Area (decare)*
Dikili-İzmir	*83.7*	*775*
Salihli-Manisa	*22.6*	*350*
Turgutlu-Manisa	*15.4*	*110*
Balçova-İzmir	*10.5*	*100*
Kızıldere-Denizli	*40*	*357*
Gümüşköy-Aydın	*2.5*	*50*
Karacaali-Urfa	*3.1*	*2.4*
Diyadin-Ağrı	*25*	*170*
Sındırgı-Balıkesir	*3.0*	*200*
Simav-Kütahya	*17*	*100*
Total	*207.4*	*2104.4*

5. CONCLUSIONS

Energy is the primary resource for economy and social development. Future of mankind is totally dependent on proper use of energy resources. Limited nature of fossil fuels and dependency to foreign sources has oriented decision and policy makers to renewable resources. Environment-friendly geothermal resources with various technical and economic superiorities are quite well alternative for conventional fossil fuels.

Turkey doesn't have sufficient fossil fuel resources like petrol, natural gas or quality coal, but significantly rich in geothermal resources. Therefore, greater emphases have recently been placed over investigation and use of geothermal energy resources. Turkey has a quite well place worldwide both in agricultural activities and geothermal resource potential. Geothermal greenhousing is getting more popular in each day in Turkey.

Greenhouses provide significant contributions to local economies. Heating constitute the major cost-item in greenhouses. Sufficient attention should be paid on site selection, hot water use, worker training, marketing and environment-friendly practices in greenhouses for the sustainability of greenhouse activities nationwide. Sustainable and rational use of geothermal resources and proper implementations of the relevant policies will provide significant contribution in solving energy-related problems of the country, will reduce the dependency to foreign sources, will improve energy efficiency and diversity and will play significant roles in prevention of environmental pollution.

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