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The Use of EAHEs: 2015 Turkey Review

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ABSTRACT

This paper reviews the studies conducted on the EAHE (earth to air heat exchanger systems) in Turkey as of the beginning January 2015. It is well known that EAHEs make it possible to evaluate passive geothermal resources (low enthalpy geothermal resources). It is expected that the review presented here will be very useful to the investigators, policy makers, etcetera, dealing with passive building heating and cooling applications, especially EAHE systems. Authors believe that these results will hasten the commercialization of these environmentally benign EAHE alternatives to CFC and HCFC based vapor compression geothermal or ground source heat pump systems in Turkey.

1. INTRODUCTION

To transport shallow geothermal heat from earth to an end use, an energy transport is used. It consists of pipes and fans. In most shallow geothermal utilization process considered in, e.g., Ozgener and Ozgener (2010), Ozgener et al. (2011), Ozgener and Ozgener (2012), Ozgener et al. (2013), standard circular pipes of steel, galvanized, special alloys, plastics, etcetera, are used to transport heat in the form of energy in the circulated air.

The thermal behavior of the ground (near the surface) as a function of depth and time is difficult to simulate from one point since there are many parameters such as short term weather variations, seasonal variations, moisture content of soil, and thermal conductivity of soil, etc., affecting the ground temperature (Ozgener et al., 2013), but it is well known that shallow earth temperature is approximately a sinusoidal function of time. The design and analysis of EAHE (earth to air heat exchanger) systems are based upon this well-established engineering knowledge.

One of the first steps in the consideration of an EAHE system is a characterization of the site in terms of geology. Information concerning aquifer (or aquifers) available at the site, their ability to produce water, depth to water, lithology, depth to bedrock and the nature of the soil and rock (hydraulic and thermal properties) are key issues (Ozgener, 2011).

After these steps, engineers and architects can design their projects as follows: (i) open loop EAHE system for space heating/cooling and (ii) closed loop EAHE system for space heating/cooling purposes.

This paper reviews the studies conducted on the EAHE (earth to air heat exchanger systems) in Turkey up to the beginning January 2015.

2. A BRIEF HISTORICAL BACKGROUND OF EAHES IN TURKEY AND PRESENT STATUS

The concept of EAHE is not new. However, the utilization of EAHEs in residential and agricultural buildings is new in Turkey, although they have been in use for years in developed countries and the performance of the components is well documented. The study on EAHE in Turkey is only carried out by university research studies. In addition, solar and EAHE building technologies commercially available are not yet well known by the architects, so EAHEs have not been introduced to the Turkish market. There are no Turkish EAHE's designer and manufacturers yet (Ozgener, 2011).

3. STUDIES CONDUCTED ON EAHE AND RELATED SUBJECTS IN TURKEY

Up to date, in the Turkish universities, limited experimental studies have been performed on EAHEs (Ozgener et al. 2011; 2012, 2013). The studies conducted on subjects related to EAHEs in Turkey may be summarized as follows: (a) studies performed on the base of Science Citation Index (SCI) publications, shortly called SCI studies, which are limited to the years 2010 to 2014, and (b) research studies (RSs). In Turkey, during the last 3 to 4 years, the number of conferences, symposiums, and meetings, related to renewable energies has also significantly increased. Papers presented and published in these scientific activities are not included in this classification.

3.1. SCI studies

These studies may be classified in five groups as follows: (i) EAHE modelling: Ozgener et al.(2011), Ozgener and Ozgener (2011), Yildiz et al. (2011), Ozgener et al. (2013b); (ii) EAHE performance assessments for both heating and cooling, (iii) EAHE monitoring studies: Ozgener and Ozgener (2013a), (2013b), Ozgener et al. (2013a); (iv) solar-shallow geothermal hybrid systems: Yildiz et al. (2011), Yildiz et al. (2012), Ozgener et al. (2013a,b), and (v) some other studies including policy and future perspectives of EAHE as well as a brief review among the renewable energy sources (Ozgener and Ozgener, 2010a-d; Ozgener and Ozgener, 2011; Ozgener, 2011). The SCI studies have been mostly focused on the determination of EAHE performance evaluation.

3.2. Research studies

In Turkey, although various studies were undertaken to evaluate the performance of underground air tunnel as described previously, to the best of author's knowledge, no studies on the energetic, exergetic, and exergoeconomic analysis of an EAHE with a 47 m, 56 cm nominal diameter, U-bend horizontal galvanized ground heat exchanger for greenhouse heating/cooling have appeared in the open literature for Turkey's conditions (Ozgener et al., 2011). In addition this project was enhanced with solar photovoltaic cells in 2010. Currently, investigations are carried out monitoring the performance of a solar photovoltaic cells (PV) assisted earth to air heat exchanger (underground air tunnel) system for greenhouse heating/cooling (Ozgener et al, 2012). A schematic diagram of the constructed experimental system is illustrated in Fig. 1. This system mainly consists of six separate circuits: (i) the converter, (ii) the 0.9 kW PV cells, (iii) the inverter, (iv) the fan (air blower) circuit for greenhouse cooling, (vi) the ground heat exchanger (underground air tunnel or EAHE), (vii) greenhouse. The main characteristics of the elements of the system are given in Ozgener and Ozgener (2010a-d), Yildiz et al, (2011), (2012), Ozgener et al (2013a,b). The PV assisted EAHE system studied was installed at the Solar Energy Institute of Ege University, Izmir, Turkey. Solar greenhouse was positioned towards the south along south-north axis. Table 1 shows studies conducted on subjects related to EAHE in Turkey between 2009 and 2015.

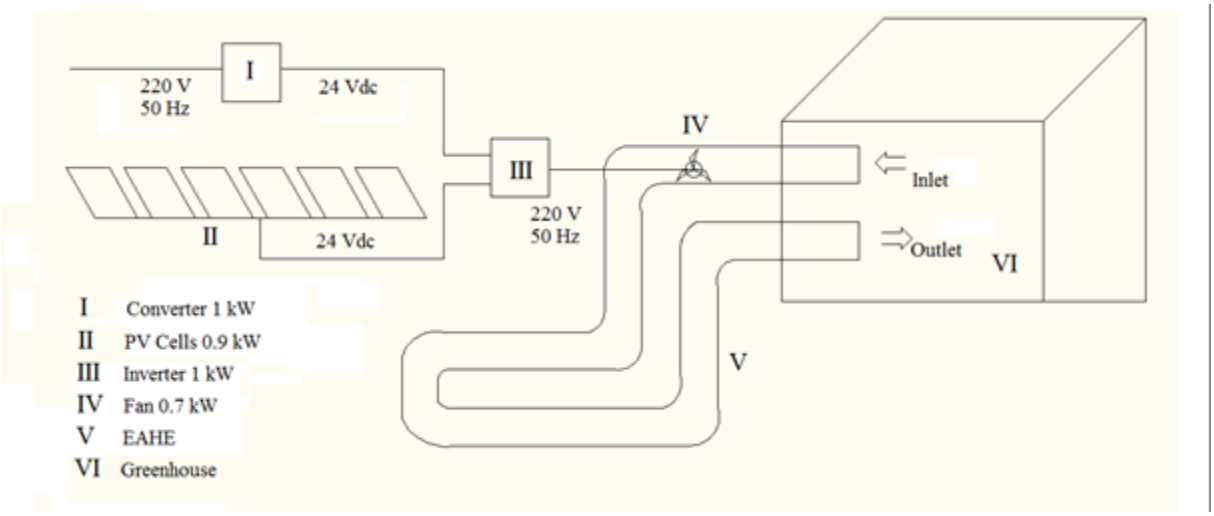

Fig.1. Basic simplified PV assisted EAHE system schema Ozgener and Ozgener (2010a-d), Yildiz et al, (2011), (2012), Ozgener et al (2013a,b).

Table 1 shows studies conducted on EAHE related subjects in Turkey between 2009 and 2015.

Item no	Classification of EAHE studies according to subject matters	Number of M.Sc. theses	Number of Ph.D. theses	Number of Research projects	Number of SCI studies
1	Experimental	1	-	2	14
2	Modeling and design	1	-	2	4
3	Application in buildings	1	-	2	14
4	Cost analysis	-	-	1	3
5	Policy	-	-	-	1
6	Hybrid	1	-	1	5
7	Others	-	-	-	2

4. POTENTIAL OF EAHE IN TURKEY

Turkey has a land surface area of 774,815 km^2 officially. It is surrounded by the Black Sea in the north, the Marmara and the Aegean Sea on the west and the Mediterranean Sea in the south, giving it very long seashores. All the land area of Turkey is suitable for the installation of EAHEs due to a topographic structure. Progress in renewable energy technologies in recent years has raised the attention of the private-sector to this system.

5. CONCLUSIONS

It is well known that Turkey has a considerably high level of geothermal energy resources that can be utilized to satisfy a part of the total energy demand in the country. Present geothermal power plants and geothermal district heating applications have rapidly increased in Turkey. Authors believe that EAHE systems in Turkey are a promising alternative.

New funding mechanisms are needed to promote investment in the utilization of low enthalpy geothermal resources or evaluation of shallow geothermal resources, which will support the development of EAHE systems in Turkey. The strong development of EAHE in Turkey is expected to continue in the coming years.

It should be underlined that is already confirmed and proven that EAHE systems can be commercially competitive compared to other air-conditioning systems in Turkey. Currently, by using EAHE systems, shallow geothermal utilization development has been relatively low in Turkey. However, EAHEs are economically preferable to the conventional space heating/cooling systems used in Turkey.

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