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Geothermal Developments in Cyprus - Country Update 2019

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ABSTRACT

Cyprus is an isolated island country of the Eastern Mediterranean Sea, in which there are no high- and low- enthalpy geothermal reservoirs. Thus, the only use of geothermal energy is restricted to geothermal heat pump systems. The first shallow geothermal installation in Cyprus was established in 2006, indicating that Cyprus is one of the newest countries which invest in this sector. Up to now, it is estimated that there are approximately 180 geothermal heat pump installations in the country, with a vast number of them being installed in single family residential buildings. The majority of the existing systems were constructed between 2009 and 2010, while in last five years the market is static due to the consequences of the economic crisis and the lack of construction activity.

1. INTRODUCTION

The use of geothermal energy in Cyprus remains limited, as no low- or high- enthalpy geothermal reservoirs have been discovered in the region. Thus, the geothermal heat pump systems are the only used up to now technology for the exploitation of geothermal energy. The installation of geothermal heat pump systems in residential and commercial sector started in the middle of 2000s and they are used for space heating and cooling. The majority of the existing systems have been constructed up to 2011, while in the last five years the design and construction of new systems is almost absent.

The present manuscript reviews the geothermal applications in Cyprus in the last decades and attempts to comment on the future development of the market.

2. ENERGY CONSUMPTION AND RES PENETRATION

Cyprus is a small island located in the north-eastern area of Mediterranean Sea. The island has an isolated energy system as there are no interconnections (electricity, gas, etc.) with the neighborhood counties. In addition, there are no fossil fuels reserves at the present; however, significant off-shore natural gas reserves have been recently discovered in the Exclusive Economic Zone of Cyprus.

The annual final energy consumption in Cyprus has peaked in 2009 at 80,962 TJ after nineteen years of continuous increase. Figure 1 shows that between 2010 and 2013 the final energy consumption in the island decreased rapidly at the pre-2000 levels, indicating a 16.5% reduction compared to the consumption of 2009. During the last three years of available data it is shown that the final energy consumption started to increase again and by the end of 2016 it had already cover the 7.5% of its previous decrease. It is also worth mentioning that the transport sector in Cyprus is the most energy intensive one, it consumes more that 50% (2016) of the inland final energy consumption. This is attributed to the significant contribution of the air-transport activities, followed by the residential and service sectors with a contribution of 18.5% and 12.8% respectively in 2016.

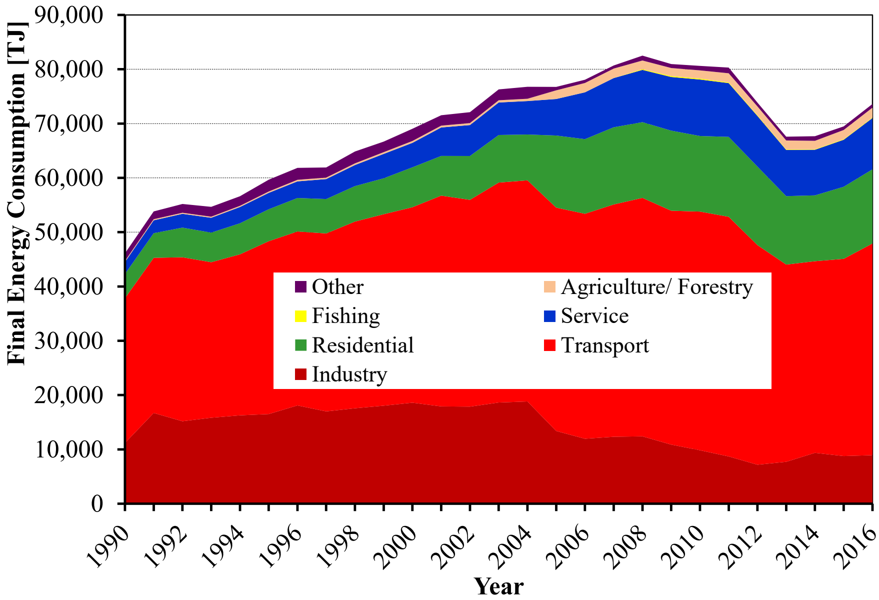

Figure 1: Final energy consumption by sector for the period of 1990-2016 (Eurostat 2019a).

Petroleum products are the main energy sources in the energy system of Cyprus, as they directly cover the 71.25% of the final energy consumption in the country, as Figure 2 indicates. Actually, this percentage is higher due to the fact that petroleum products are also used for electricity production. According to the available data, in 2016 the share of RES in electricity production was only 8.4% (TSO, 2019), while for the remaining production petroleum products were used. The share of RES on the direct final energy uses was 6.32%, as Figure 2 depicts, however and taking into consideration the share of RES in electricity production, the overall contribution on the final energy consumption was 9.35% in 2016. This figure, compared to the agreed mandatory national target for 13% by 2020, indicates an obligation for at least 0.9% mean annual rate of increase in order to achieve the national target. For this reason, and according to the revised Renewable Energy Action Plan, the additional investments in photovoltaics are foreseen (MCIT, 2010).

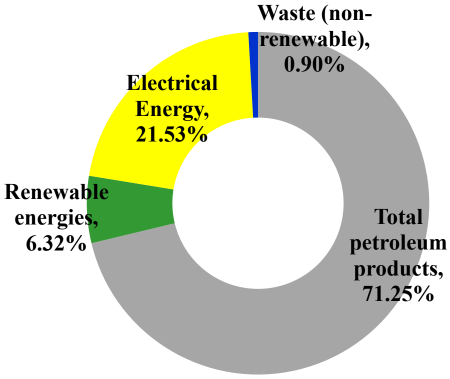

Figure 2: Share of energy sources in final inland energy consumption in Cyprus– Data 2016, (Eurostat 2019a).

Figure 3, illustrates the contribution of the RES in the total inland renewable energy production. In Cyprus, solar thermal is the leading technology in this sector due to the obligatory installation for hot-water production in building sector, following by wind, photovoltaics and biofuels. Moreover, the contribution of the geothermal applications still remains at a low level as they account for 1.02% in total RES production.

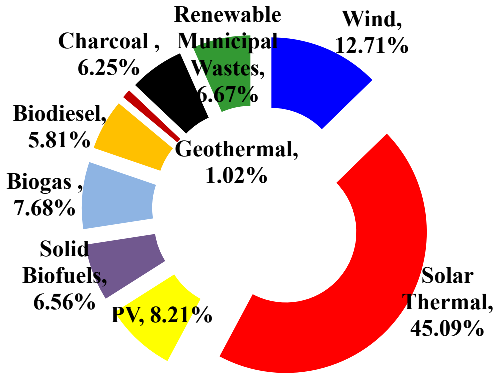

Figure 3: Contribution of different energy sources to total renewable energy production in Cyprus – Data 2016, (Eurostat 2019b).

3. GEOTHERMAL EXPLORATION

The first geothermal exploration in Cyprus has been done in the late of 1960. After 33 heat flow determinations all over the island it has been found that the heat flow ranges from 6-46 mW/m^2 with an average value of 28±8 mW/m^2 (Morgan, 1973; Cermak et al., 1979; Eckstein 1978). These values indicate a very low heat flow, without any heat generation in the earth's crust, which probably results from the regional water movement. During the following decades, and until 2010, the geothermal exploration in Cyprus seems to be absent as there are not any known references in the international scientific literature. However, starting from 2010 and by the end of 2014 two (2) independent research projects were funded by the Research Promotion Foundation (RPF) of Cyprus. In the first research the ground temperatures in specific depths and the geophysical characteristics in eight (8) characteristic locations of Cyrus were monitored and measured (Florides et al., 2011). The second research project dealt with the mapping of the geothermal characteristics of Cyprus in order to develop geothermal maps of soil's thermal conductivity, soil's thermal diffusivity, and soil's specific heat capacity (Stylianou et al., 2016). It is worth noticing that the results of the aforementioned projects confirm the findings of the 1960s that there is no direct geothermal potential in Cyprus.

4. DIRECT USES

4.1 Background

The utilization of geothermal energy in Cyprus includes only the use of ground source heat pump systems installed in building sector. There is also a pilot application in a traditional greenhouse. Today, the installed ground source heat pump capacity is estimated to 10.3 MWt spread out in about 180 installations across the island, and the annual energy use is 65 TJ.

4.2 Greenhouse

The use of geothermal energy in Cyprus for greenhouse heating is restricted at one pilot installation in the premises of the Agricultural Research Institute (ARI) in Zygi. The installation is in operation in last 5 years and provides heating and dehumidification in a 216 m^2 traditional greenhouse. The installed capacity of the system is 70 kWt and the annual geothermal energy use is estimated at 30 MJ.

4.3 Geothermal Heat Pumps

The geothermal heat pump systems are the only geothermal technology that is in use in Cyprus. The introduction of this technology in the building sector of Cyprus was due to a generous subsidy scheme forced in the middle of past decade by the central government under the promotion umbrella of renewable energy sources. It is worth mentioning that the majority of the existing installations have been constructed with the financial support of the aforementioned scheme. In the end of 2018, the author records 163 installations across the island[1] with a total installed capacity of 9.6 MWt. It is estimated however, that the actual installations was about 180 with an overall capacity of 10.3 MWt. This differentiation is mainly due to the fact that some small construction companies that partially involved to this activity had terminate their operation in last years. As the result, the actual number of the projects that they had involved is practically unknown, and partially reported by the companies that are responsible for the maintenance of such systems.

Today, the geothermal heat pump market in Cyprus is rather static. The economic recession between 2013 and 2017 had strongly influence the construction sector of the island which was shrunk up to 67% compared to the pre-crisis level. In addition, the improvement of energy performance of the competitive air-source heat pump technology in association with the higher initial installation cost that the geothermal heat pump systems introduce, results a turn back in the market preferences to such technology.

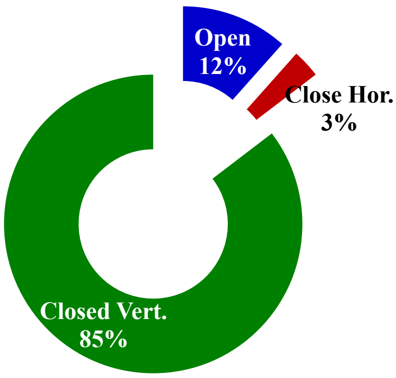

Figure 4: The share of different geothermal heat pump systems based on the capacity records.

The majority of the existing geothermal heat pump installations reported to vertical closed loop systems, accounting for more than 1,600 boreholes with an estimated total drilled length of more than 150 km. The installations of horizontal closed loop systems remain limited, there are three autonomous and three combined systems with vertical ones, introducing only the 3% of the installed capacity, figure 4. There are also open loop systems that use sea water as heat absorption/ rejection medium, and they are mainly installed in hotels placed in the southern coastal area of the island.

An interesting and promising installation that recently has been finalized and it is going to start its operation by the end of 2020 is in the new campus of the University of Cyprus. This installation is the biggest one in the island and consists of 220 vertical boreholes in the depth of 125 m. It is designed to operate in parallel with the district heating and cooling system of the campus in order to provide heating and cooling in the new premises of the Faculty of Engineering. In addition to the energy conservation, the installation will be used also for educational and training of young engineers and technicians and also as an experimental and research unit for the researchers and the academics. The energy production of this system is estimated at 9.54 TJ that is equal to 14% of the existing energy production from the geothermal heat pumps in Cyprus.

The future development of geothermal heat pump systems in Cyprus is difficult to be estimated. The main reasons behind this is the strong competition of the air-source heat pump systems, the high installation cost of the geothermal ones including the investment in land, and the absence of promotion initiatives by the state.

[1] in the areas controlled by the Republic of Cyprus

5. PROFESSIONAL GEOTHERMAL PERSONNEL

The number of professional personnel involved in geothermal activities in Cyprus has decreased during the last years. Today, in the private sector there are three (3) companies maintaining still equipment for geothermal installations, instead of fourteen (14) that existed in 2010. This situation affects also the number of employees that are working to the geothermal energy sector. In 2010 there are more than 200 employees working on fulltime or part-time basis contracts in shallow geothermal projects. Today, there is no employment in this sector, and the companies hiring seasonally employers from other sectors and only in case of a new project. In contrast, the public sector still employs three persons who, among other duties, have to assist in national geothermal activities.

In the last decade, two research projects and a postdoctoral fellowship were funded by the Research Promotion Foundation of Cyprus (RPF), while another research grant was funded by the Government of Cyprus. Under these programmes about 18 researchers and academics worked in specific issues related to the design and installation of GSHP systems in Cyprus. Today, the academic and research personnel working in part-time base in this topic are no more than three persons. Finally, it should be added that during the past years a relevant Ph.D. thesis has been completed in Cyprus, while another one is estimated to be finalized by the end of the year.

6. LEGISLATIVE ISSUES

Cyprus adopted the EU Directive 2009/28/EC in September 2013 and based on this it is obliged to establish certification schemes for geothermal heat pump installers. The relevant Ministerial decisions and laws were adopted between early 2015 and early 2017. Although the certification scheme for the installers of geothermal heat pump systems is in force for the last two years, the interest from employers and employees is very limited. This evidence introduces the lack of certified specialists for the installation and maintenance of geothermal heat pump systems in the market.

In the framework of the same Directive, Cyprus obliged to achieve the share of RES in the final energy consumption to 13% by 2020. According to the National Renewable Energy Action Plan, the country foresees an energy consumption of 124.35 TJ from heat pumps for space heating and cooling by 2020 (MCIT, 2010). Unfortunately, this is a horizontal target without any specific target for the geothermal systems.

Following the adoption of EU Directives 31/2010/EC and 27/2012/EC, and in order to support among others the reduction of energy consumption and the increase of the energy efficiency in the building sector, three financial subsidy schemes have been in lunched in December 2014, March 2015, and March 2018 respectively. Under these schemes, a series of intervention measures was eligible for subsidization in residential and commercial buildings, and among them the installation of geothermal heat pump systems was an option. These schemes were finalized after the absorption of the available fund; however there was no interest about the installation of a shallow geothermal system.

7. CONCLUSIONS

The use of geothermal energy in Cyprus is limited to space heating and cooling applications mainly for the residential buildings. The geothermal heat pump market was rapidly developed between 2006 and 2011, however in last years it remains static. Today, the annual utilization of the geothermal energy is estimated to 65 TJ. It is estimated that these figures may remain the same in the next years as the current market trends indicate that the future expand of the market is restricted by the competition of the air-source heat pump systems and by the high associated initial construction cost that the geothermal heat pump systems introduce.

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TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2019*	-	-	1,478	4,575	-	-	-	-	289.9**	452	1,767.9	5,027
Under construction in December 2019	-	-	-	-	-	-	-	-	34.0	-	34.0	-
Funds committed, but not yet under construction in December 2019	-	-	-	-	-	-	-	-	-	-	-	-
Estimated total projected use by 2020	-	-	1,478	-	-	-	-	-	478.2	-	1,956.2	-

* Data from Dec. 2018
** PV: 122.7 MWe; Biomass: 9.7 MWe; Wind: 157.5 MWe

TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2019

1) Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.(
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.00

2) Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.13
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg) x 0.03154

3) Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171
since projects do not operate at 100% capacity all year

4) Other than heat pumps

5) Includes drying or dehydration of grains, fruits and vegetables

6) Excludes agricultural drying and dehydration

7) Includes balneology

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Individual Space Heating[4]	-	-	-
District Heating [4]	-	-	-
Air Conditioning (Cooling)	-	-	-
Greenhouse Heating	0.07	0.03	0.014
Fish Farming	-	-	-
Animal Farming	-	-	-
Agricultural Drying[5]	-	-	-
Industrial Process Heat[6]	-	-	-
Snow Melting	-	-	-
Bathing and Swimming[7]	-	-	-
Other Uses (specify)	-	-	-
Subtotal	-	-	-
Geothermal Heat Pumps	10.23	64.97	0.2
TOTAL	10.3	65	0.2