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Geothermal Energy Use, Country Update for Cyprus

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ABSTRACT

This manuscript summarizes the use of geothermal energy in Cyprus. Cyprus is an electrically isolated island in the Southeastern Mediterranean Sea, being the easternmost member state of the European Union. Geothermal energy has been in use in Cyprus only during the last ten years. As there is no high or low enthalpy geothermal potential, the use of geothermal energy is restricted to ground source heat pump installations. Today there are about 170 installations with total estimated energy use of 19 GWh/a.

1. INTRODUCTION

The use of geothermal energy in Cyprus is very limited. The main reason is that in Cyprus there are no geothermal fields of low and/or high enthalpy; thus the only way to use geothermal energy locally is by installing geothermal heat pumps.

The installation of geothermal (ground source) heat pumps in Cyprus has only started in the last ten years. Today the installed capacity of these systems is estimated at 10 MW_t. The most common application of ground source heat pumps in Cyprus is for space heating and cooling in residential buildings. There are also a few installations in public buildings as well as some hotels. The majority of the existing systems were constructed between 2009 and 2010, while during the last two years the design and construction of new systems is almost absent.

This manuscript is the first ever completed review study concerning geothermal energy activities in Cyprus. It focuses on the past and present situation of geothermal energy in the island and comments about the possibly of further penetration of geothermal energy in the Cypriot energy market in the coming years.

2. ENERGY CONSUMPTION AND RES PENETRATION

Cyprus has a small and isolated energy system that is not interconnected with any other energy networks (oil, natural gas or electricity). There are no fossil fuel reserves on the island at present. However the exploration of hydrocarbons in the Exclusive Economic Zone of Cyprus has recently shown significant offshore reserves of natural gas. Gross inland energy consumption amounted to 2.22 Mtoe in 2014, 23.2% lower in comparison to 2008, where the peak value was observed. Figure 1 presents the gross inland energy consumption by fuel type in the period 1990-2014. Despite the economic recession since 2009, the trends in fuel shares have remained unchanged due to the fact that the transportation sector is responsible for more than half of total final energy demand.

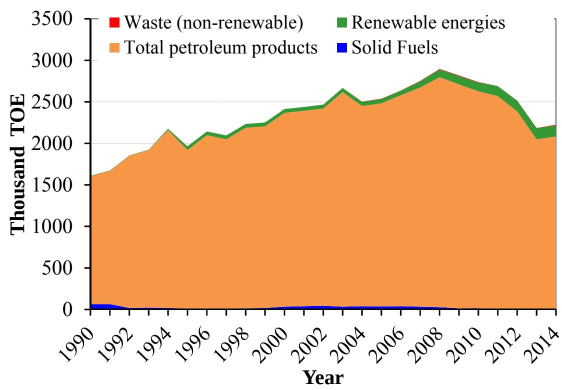

Figure 1: Gross inland energy consumption (in ktoe) by fuel type for the period 1990-2014 (source: Eurostat, 2016).

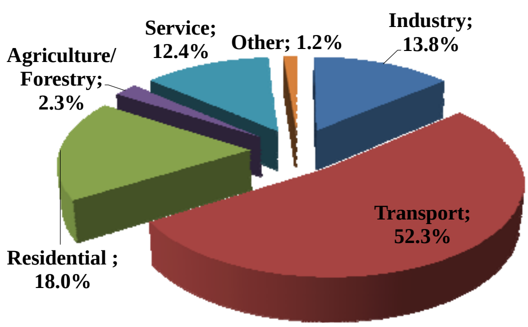

Figure 2: Distribution of final energy consumption by sector in Cyprus in 2014 (source: Eurostat, 2016).

A breakdown of final energy consumption by sector in Cyprus in 2014 is presented in Figure 2 (Eurostat 2016). Transport was the main energy consuming sector with a 52.3% share, followed by the residential, industry and service sectors with 18%, 13.8% and 12.4%, respectively.

Renewable energy sources (RES) accounted for 8.95% of gross energy consumption in 2014, compared to 3.07% in 2004 (Eurostat 2016), indicating a 190% increase within a decade. The corresponding figure for the electricity production from RES was 7.39% in 2014, while in 2004 contribution of RES was only 0.01%. It should be noted that by the end of 2014 the installed capacity for electricity production from biomass/biogas units was 9.7 MW_{el}, of wind parks 146.7 MW_{el}, and there was also 45.7 MW_{el} of PV systems (CERA, 2016). Moreover the share of RES in heating and cooling sectors reached 21.8% in 2014, based primarily on solar thermal installations for water heating (Eurostat 2016; Kitsios et. al., 2015). Table 1 illustrates the RES balance in Cyprus in 2014. Geothermal energy has a very low share that is estimated at 1.6 ktoe or 1.2% of total RES production.

Table 1: Contribution of different energy sources to total renewable energy production in Cyprus in 2014 (Eurostat, 2016)

Energy Source	Energy Production (ktoe)	% share
Wind	15.6	11.8
Solar Thermal	66.8	50.4
PV	7.2	5.4
Solid Biofuels	12.1	9.1
Biogas	11.3	8.5
Biodiesel	9.8	7.4
Geothermal	1.6	1.2
Charcoal	8.1	6.1
Total	132.5	100.0

Cyprus, as a member state of the EU has a specific target to increase the share of RES in gross final energy consumption to 13% in 2020. Moreover and taking into consideration the fact that between the years 2004 and 2014 the increase of RES share was 5.88% it seems that in the forthcoming six (6) years an additional increase of 4.05% is required. As the electricity network is almost congested by wind parks and PVs, the contribution of heat pumps and especially of geothermal ones should be of high importance as they present higher efficiencies than the alternative air-source heat pump systems in the warm climatic conditions of Cyprus (Michopoulos et. al., 2016).

3. GEOTHERMAL EXPLORATION AND POTENTIAL

The geothermal exploitation in Cyprus started in the late 1960s. 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 four decades, and up to roughly 2004, the geothermal energy exploration in Cyprus seems to be absent as there are not any known references in the international scientific literature. However, starting from 2010 and until the end of 2014 two (2) independent research projects were funded by the Research Promotion Foundation (RPF) of Cyprus. In the first project 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 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 ground source heat pumps applications. There is only one (1) pilot installation in a greenhouse while all other ones are basically placed in residential buildings.

4.2 Greenhouse

The use of geothermal energy for greenhouse heating in Cyprus is limited and there is only one pilot and experimental application in the facilities of the Agricultural Research Institute (ARI) in Zygi. The installation consists of ten (10) vertical double u-tube boreholes up to 100 m in depth, total borehole length 1 km, which serves the heating and dehumidification needs of a 216 m^2 experimental greenhouse. The installed capacity is 70 kW_t, and the annual use of geothermal energy is estimated at 30 MJ/a.

4.3 Ground source heat pumps

The ground source heat pump (GSHP) system is the only geothermal system that is currently in use in Cyprus. The first ever recorded installation was in a single-family house in Lakatamia, a suburban area near the capital city, in 2006. Until now, it is estimated that after a decade and according to early 2016 investigations, there are about 160 installations in operation with a total installed capacity of 9.5 MW_t. The majority of the installations have been constructed in the period 2009-2010, when a very generous subsidy scheme was in place. During the last three (3) years the economic recession affected also the market of ground source heat pumps due to their high initial construction investment compared to air-source heat pump units. In addition the improvement of the efficiency of the competitive air-source systems, resulted in a market 'turn back' to such technologies. The expected recovery of the Cyprus economy, however, is likely to affect the GSHP market and a gradual recovery to pre-crisis levels is foreseen.

The authors in collaboration with the national authorities and local constructors have recorded two (2) open loop GSHP systems, three (3) horizontal closed loop GSHP systems, three (3) systems that combine horizontal and vertical closed loop installations, one combination of vertical closed loop and open loop, and over 151 vertical closed loop ones. It is estimated that about 10 to 15 systems were not able to be recorded, thus the overall estimated installed capacity is of 10 MW_t. The majority of the installed systems are found in residential buildings, mainly in single-family houses, while three (3) are installed in hotels, four (4) in office buildings, two (2) in multi-space buildings, one (1) in a private school and one (1) in a clinic.

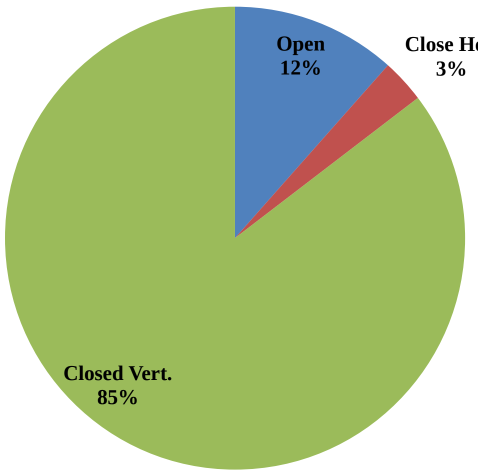

Figure 3: Share of the GSHP systems in Cyprus: Total recorded installed capacity 9.5 MW_t.

About 12% of the recorded installed capacity involves open loop systems as shown in Figure 3. This capacity can primarily be found in two (2) hotel installations, the first one located in Limassol area, and the second one in Protaras area, which both use sea water for space heating and cooling.

The horizontal closed loop systems represent today only the 3% of the country's installed capacity, Figure 3, accounting for about 4.8 km of pipe installation. The main reason is that in residential areas, where the GSHP systems are mainly installed, the investment in land is high, thus the penetration of a horizontal loop system remains limited.

Regarding the vertical closed loop GSHP systems, which represent the 85% of the recorded installed capacity, it is worth noticing that the minimum and maximum borehole's depth is recorded at 22 m and 235 m respectively, while the majority of the installations are in depth of 90 m to 110 m. The overall recorded length of the vertical geothermal heat exchangers is about 125 km, mainly served by a single u-tube construction, using a Φ 25 mm or Φ 32 mm polyethylene pipe.

An interesting and also promising fact is that at the beginning of 2016 there were five (5) new projects, two (2) of them being under construction and three (3) under design, in which the installation of vertical ground source heat pump systems are foreseen. Based on the latest available information the projects being under construction are located in the premises of public universities of Cyprus, namely the University of Cyprus and the Cyprus University of Technology. They involve 2.9 km of new boreholes, with a capacity of about 1.2 MW_t, and will also be used for experimental and educational purposes.

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 14 that existed in 2010, with six (6) employees – compared to more than 200 employees in 2010. Besides, the public sector employs three persons who, among other duties, have to assist in national geothermal activities. These are employed by the Ministry of Energy, Commerce, Industry and Tourism and the Ministry of Agriculture.

In the last ten (10) years, two (2) 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, no more than five (5) people continue working on the topic. Finally, it should be added that during the past years a relevant Ph.D. thesis has been completed in Cyprus, while another one is in progress.

6. LEGISLATIVE ISSUES

Cyprus adopted 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 2014 and late 2015. It is expected that the first certified installers will exist by the end of this year, while the minimum number of certified specialists for the installation and maintenance of shallow geothermal energy systems was estimated to reach 105 until 2020 (Build-up Skills, 2012). In the same Directive's framework and according to the National Renewable Energy Action Plan, the country aims at an energy consumption of 2.97 ktoe from heat pumps for space heating and cooling in 2020 (MCIT, 2010). Unfortunately this is a horizontal target without any specific target for GSHP systems.

Following the adoption of 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, two (2) financial subsidy schemes have been in force since December 2014 and March 2015 respectively. The first scheme is addressed to the commercial sector while the second one to the residential sector. These schemes offer a financial support for more than 30 different interventions in buildings. The installation of ground source heat pump systems is an eligible investment that can be subsidized by both schemes (MCIT, 2014; MCIT, 2015).

7. CONCLUSIONS

Geothermal energy is used in Cyprus only for heating and cooling of interior spaces and mainly applied in residential buildings. The current level of utilization of geothermal energy represents a small fraction of the total energy use. The ground source heat pump market was mainly developed between 2007 and 2010, while in the last years it has rapidly shrunk. Installed geothermal capacity by the end of 2015 is estimated at 10 MWt.

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Table A: Present and planned geothermal power plants, total numbers

	Geothermal Power Plants		Total Electric Power in the country		Share of geothermal in total electric power generation	
	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (%)	Production (%)
In operation end of 2014	-	-	1,478	4,013.4	-	-
Under construction end of 2015	-	-	-	-	-	
Total projected by 2018	-	-	-	-	-	-
Total expected by 2020	-	-	-	-	-	-
In case information on geothermal licenses is available in your country, please specify here the number of licenses in force in 2015 (indicate exploration/exploitation, if applicable):					-	

Table B: Existing geothermal power plants, individual sites*

*Geothermal power plants are not available in Cyprus

Table C: Present and planned geothermal district heating (DH) plants and other direct uses, total numbers

*Geothermal district uses are not available in Cyprus

Table D1: Existing geothermal district heating (DH) plants, individual sites

* Geothermal district heating plants are not available in Cyprus

Table D2: Existing geothermal direct use other than DH, individual sites

* Geothermal district uses are not available in Cyprus

Table E: Shallow geothermal energy, ground source heat pumps (GSHP)

	Geothermal Heat Pumps (GSHP), total			New (additional) GSHP in 2015 *		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2015	170[(1)]	10[(2)]	19	1	0.05	n.a.
Projected total by 2018	10	1.5	2.9			

(1) estimate, reported 160; (2) estimate, reported 9.5 MW_t

Table F: Investment and Employment in geothermal energy

	in 2015 *		Expected in 2018	
	Expenditures (million €)	Personnel (number)	Expenditures (million €)	Personnel (number)
Geothermal electric power	-	-	-	-
Geothermal direct uses	-	-	-	-
Shallow geothermal	3	6	4	6
total	**3**	**6**	**4**	**6**

Table G: Incentives, Information, Education

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D	none	none	none
Financial Incentives – Investment	none	none	DIS, LIL
Financial Incentives – Operation/Production	none	none	none
Information activities – promotion for the public	no	no	no
Information activities – geological information	no	no	yes
Education/Training – Academic	yes	yes	yes
Education/Training – Vocational	no	no	yes

Key for financial incentives:

DIS	Direct investment support	FIT	Feed-in tariff	-A	Add to FIT or FIP on case the amount is determined by auctioning
LIL	Low-interest loans	FIP	Feed-in premium		
RC	Risk coverage	REQ	Renewable Energy Quota	O	Other (please explain)