Interview 10 - Kleanthis Kravvaritis, Greece

Profile
Name: Kleanthis Kravvaritis
Age: 43
Education: Mechanical Engineer
Activity: CEO of «RENEWABLE - KRAVVARITIS & PARTNERS – CONSULTING ENGINEERS»
Lives in Athens
Experience in the thermogeology sector: 16 years
Geographical working area: EU

Thermogeology in Greece and in the Mediterranean Islands

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What are the main features of the Shallow Geothermal Energy in Greece?

Greece is rich in geothermal energy resources. Geothermal exploration in Greece began in the early 1970s by I.G.M.E. (Institute of Geology and Mineral Exploration, which is in fact the Greek Geological Survey) [1]. The Hellenic area is characterised by high levels of heat flow (> 80 mW/m²), mainly in the sedimentary basins of Northeastern Greece and the Aegean Sea due to the active extensional tectonics and volcanic activity.
The geothermal conditions in Greece are favourable, or even ideal in some cases, due to the country's geotectonic regime. Geothermal exploration efforts started in Greece in the early 1970s [1] and were focused on the high-enthalpy fields in Milos Island and Nisyros Island. Later in the same decade, several low-enthalpy fields in Northern Greece and on some Aegean Islands were studied. No further geothermal exploration has been carried out since 2008. However, in early 2011, international open tenders were announced (the first of this kind in Greece) for the leasing of the right to explore the geothermal potential of four promising areas: Central/Southern Chios, Nestos River Delta, Evros River Delta and Samothrace Island.
Regarding the exploitation of shallow geothermal energy in Greece, the first pilot residential GSHP vertical closed system in Greece was installed in 1993 [2]. Since then, hundreds of systems have been installed throughout the country. The available information concerning the installed capacity and annual energy output of GSHP are summarised in Table 1 [2].

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Table 1. Data on Greek GSHP market

	1999	2004	2007	2009	2012	2014
Installed capacity (MWt)	0.4	4	14	50	100	135
Produced energy (TJ / yr)	3.1	39.1	80	270	486	648
Capacity factor	0.25	0.31	0.18	0.17	0.15	0.15

The Greek GSHP sector presented a remarkable growth in the mid-2000s, with the installation of open and closed loop systems; in addition, seaside hotels operating only during the summer showed interest in cooling their facilities through the use of seawater. According to the latest data, 61% of installed capacity concerns open systems, 30% vertical closed loop systems and 9,0% horizontal closed loop systems (Figure 1).
Factors contributing to the market's development were:
a) The increase of oil prices compared to the price of electricity,
b) Awareness of public and installers of heating/cooling systems and c) introduction of the licensing process for the installation of the systems (Law 3175/2003).
The development path that the market followed during the mid-2000s peaked around 2010. Since then, the sector shows a decline due to the economic recession and the stagnation of the construction industry. Moreover, it should be noted that the GSHP market is largely dependent on the construction of new buildings, as opposed to the market of air source heat pumps, which can be installed during a simple renovation of a dwelling. Strong competition by natural gas is also a reason for the sector's recession [2].

How is thermogeology managed by Greek regulation? Is there an official cadaster of the private and public installations?

The current geothermal legislation (Law 3175/2003 "Exploitation of geothermic capacity, district heating and other provisions" and relative Ministerial Decrees) classifies the geothermal fields as "high" (T>90°C) or "low" (T<90°C) temperature fields [2]. The geothermal fields are also classified as "proven" or "probable", depending on their preceding exploration.
By the end of 2015, a total number of 32 areas had been officially characterised as "geothermal", corresponding to more than 40 'proven/probable' and 'high/low' temperature geothermal fields.
The terms, procedures and regulations for the concession of the geothermal exploration and management rights are determined in the Ministerial Decree "Geothermal Regulations" (Gazette B' 635/12.05.2005 and 1530/7.11.2005) [2]. The procedures for the exploitation of shallow geothermal energy are provided by the L3175/2003 and the Ministerial Decree published in the Gazette B' 1249/24.6.2006.
The national energy policy in Greece is regulated by the Law 3851/2010 and the National Action Plan 20-20-20.
In pursuit of accomplishing the National Renewable Energy Action Plan and the "20-20-20" target, amongst else, initiatives for the support of the heat production from the shallow geothermal energy are considered. Also, energy saving policies have been promoted, fostering new supporting (financial) instruments for the buildings

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energy saving including GSHPs as the spearhead along with the implementation of all the technical measures that are described in the “Energy Performance of Buildings Regulation” (KENAK), aiming to achieve the country’s targets. The new building regulation which is expected to act as the main market penetration tool for RES and energy savings in heating and cooling systems at the tertiary and residential sector and at the agricultural and industry as well, should be supported by promotion actions in order to encourage the end-users and SMEs to invest in GSHPs reliable technology. Furthermore, successful implementation of energy saving measures in end-use along with development of new market mechanisms (i.e. ESCOs) for both public and private sector are to be proved essential to achieve the projected RES share in heating and cooling (Ministry of Environment, Energy & Climate Change, 2010).

The first time that geothermal energy is mentioned in the Greek legislation is in Article 2(1) of Legislative Decree 210/1973 [Government Gazette (GG) 277 A'] "Mining Code", stating that natural steams (geothermal energy sources) are included in mineral resources that are considered mining minerals or ores.

In Article 1 of Law 1474/1984 (GG 131 A') "Exploitation of geothermal potential", definitions of "geothermal potential", "geothermal energy" and "hot waters" are given, while in Article 4(2) it is stated that in the aforementioned legislative Decree 210/1973 the term "natural steams (geothermal energy sources)" is replaced by "geothermal potential".

Shallow geothermal energy, i.e. the type of geothermal energy which GSHPs uses and which according to the Greek legislation is not characterised as geothermal potential, is first mentioned in Law 3175/2003 (GG 207 A') "Exploitation of geothermal potential, district heating and other provisions".

In Law 3852/2010 (GG 87 A') "New architecture of local government and decentralised administration – Kallikratis program" the responsibilities of the prefectural administration set out in Law 3175/2003 and Ministerial Decree Δ9Β,Δ/Φ166/οικ.13068/ΓΔΦΠ2488 of 2009 are from now on responsibilities of the respective administrative region.

Law 3851/2010 (GG 85 A') "Acceleration of renewable energy sources development for the resolve of the climate change issue and other provisions on jurisdictional issues of the Ministry of Environment, Energy and Climate Change" is important for the development of renewable energy in general and particularly of GSHPs.

The first time that heat pumps, using geothermal, aerothermal or hydrothermal energy, are recognised officially as RES is in Law 4062/2012 (GG 70 A') "Promotion of the use of energy from renewable sources" which harmonises the national legislation with Directive 2009/28/EC.

Law 4122/2013 (GG 42 A') "Energy performance of buildings", which harmonises Greek legislation with Directive 2010/31/EU, states in Article 2(9) that " 'heat pump' means a machine, a device or installation that transfers heat from natural surroundings such as air, water or ground to buildings or industrial applications by reversing the natural flow of heat such that it flows from a lower to a higher temperature. For reversible heat pumps, it may also move heat from the building to the natural surroundings.". The aforementioned law replaces the definition given for a "heat pump" by Law 3661/2008 (GG 89 A') "Measures to reduce energy consumption in buildings and other provisions" [81], through which the Greek legislation was harmonized with Directive 2002/91/EC.

The degree of regulation of shallow geothermal energy usage should be appropriate to the scale of use. ‘Large scale systems’ could be regulated through existing local

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planning laws when necessary. In the case of open loop geothermal systems, a groundwater pumping flow rate threshold could be used to define projects requiring a groundwater abstraction/exploitation license in accordance with national legislation. A capacity threshold could be applied in the case of large multiple borehole collector arrays. The licensing authority could set minimum and maximum water temperatures for re-injection from geothermal systems for geothermal and aquifer management purposes.
Small sized closed loop domestic systems should be registered through a simple information submission form to a nominated government agency. These systems should require no exploration licenses or planning permission.

Financially, is thermogeology competitive with other renewables?

Heat pumps typically produce 3-5 times the amount of energy they consume in the form of electricity. Thus shallow geothermal energy is a competitive renewable energy source with large potential for reduction in CO2 emissions. The energy extraction from the ground can be based on either open loop systems or closed loop systems. In open loop systems, groundwater from a production well is used directly as source for the heat pump and subsequently recharged to the same aquifer via an injection well. In closed loop systems, a carrier fluid (water with antifreeze) is circulated in the ground in high density polyethylene or PEX-a pipes and act as a heat exchanger. They can either be installed horizontally in a depth of >1,25m (horizontal closed loop systems), or vertically in a borehole, a so-called borehole heat exchanger or vertical closed loop borehole.
Geothermal energy not only draws the natural heat of the earth and produce energy but it is also more reliable than other energy sources. Other clean energies, such as solar and wind energy need appropriate sun or wind to produce energy, which makes them weather dependent energy sources. In terms of solar or wind energy, it is necessary to meet the specific natural conditions, which means a perfect location where enough sun or wind present. But the geothermal systems are less constrained by natural topography. It does not require as much as land to produce energy compared to other green energy power plants.

What are the main obstacles faced by thermogeology in Greece?

- Financial obstacles related to the costs and benefits of investing in shallow geothermal energy installations. Installers and end users of RETs need access to capital in order to purchase, install and use such renewable energy systems. Lack of investment also results from lack of understanding of the investment profiles and life-cycle costs for such systems, which are characterised by higher up-front cost but with longer-term benefits.
- Lack of support incentives.
- Lack of knowledge about technologies, lack of information on the potential for installing GSHP systems, including the low dissemination of data from running operations.

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How would you improve the diffusion of thermogeology in your country?

Through changes regarding the legislative framework involving permission process for the installation of GSHP systems, concerning:
a) system definition,
b) installation specifications,
c) clarification of responsibilities of involved departments,
d) technical issues and
e) simplification of the process.

The exploitation of shallow geothermal energy in Greece is considered necessary — primarily due to the economic recession of the country— as GSHP systems provide heating, cooling and domestic hot water in several types of applications, with clear economic, environmental, energy, social and aesthetic advantages compared to available non-conventional or conventional systems.

Literature cited

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