Proceedings European Geothermal Congress 2007
Unterhaching, Germany, 30 May-1 June 2007

Update of the geothermal situation in Greece

George E. Hatziyannis (on behalf of the Department of Geothermal Energy)

IGME, 70 Messogion str., Athens 11527, Greece

ghatziyannis@igme.gr

Keywords: Enter your keywords here.

ABSTRACT

In the meantime between the W.G.C. of 2005 and present day, some developments have been done in the whole sector of geothermal energy in Greece.

New geothermal fields have been located, studied and reported. In 2003 the legislation governing the exploration and exploitation of geothermal energy has been changed with a new law, followed by the signing of a number of Ministerial Decisions for its application, finalized by the 2006.

The country's geothermal potential has been increased by the location of new fields over the whole country. The new located fields are found in the Aegean islands (Chios Island), the Western Greece (Sykies Arta and Antirio fields), the Macedonia region (Kavala Akropotamos and Volvi fields), the Central Greece (Nikaia, Damasta, Aedipsos and Yaltra fields). The studied fields are of low enthalpy with the temperatures ranging between 35 and 84^{o}C.

The main advance in the new legislation was the special provision for licensing the use of Ground Source Heat Pumps. Up to now there was not any provision for it. This sector of geothermal heat/cooling is the most fast developing in the country during the last two years.

Electricity production has not seen any progress, except the actual deep drilling of Public Power Corporation (P.P.C.) in NW part of Lesvos Island for high enthalpy field.

Direct uses have not undergone any development mainly due to the new legislation which has been finalized at 2005, and some applications for district heating are still pending. GSHP have seen a rapid development due to the change of legislation

1. INTRODUCTION

Greece is one of the most favored countries of Europe regarding geothermal energy. The deep tectonic structures and the young to recent volcanism have created a large number of shallow geothermal fields both of low and high enthalpy.

According to recent national legislation, geothermal fields are divided to high enthalpy when temperature exceeds 90^{o}C and to low enthalpy when the temperature ranges from 25^{o} up to 90^{o}C. Below 25^{o}C they are considered groundwater and ground suitable for Ground Source Heat Pumps (GSHP).

Fields are characterized as 'proven' when their parameters are known with a level of confidence greater than 90% and 'possible' when this level is between 70 and 90%. The rest of the fields are considered as 'unexplored' areas or 'unknown'. The procedures for the licensing of fields are different for the three groups and for GSHP.

Twenty three "proven" and "possible" fields are known, two of which are of high enthalpy (fig.1).

Figure 1: The proven and possible geothermal fields of Greece according to law 3175/2003.

The high enthalpy fields are located in the South Aegean Volcanic Arc, and are related to Pliocene to Quaternary volcanism in the islands of Milos and Nisyros. Their exploitable potential exceeds 25 MWe of installed electric capacity and the probable potential exceeds 250 MWe. The temperatures exceed the 350^{o} C. At present they are not in use. One more prospective area is close to Argenos, Lesvos Island, where deep drilling is under preparation by the Public Power Corporation (P.P.C.).

There are twenty-one proven and possible low enthalpy fields located all over the country. The geological environments are: Tertiary volcanic areas, deep water circulation along structures in grabens, and areas with diapiric evaporites. Their potential exceeds 200.000 T.O.E. (Tons of Oil Equivalent) per year. A small percentage of those (~20% of the potential) are exploited for various uses, such as; balneology (50% of them) in more than 60 spas, heating in greenhouses, some fisheries, space heating, vegetables drying, and special aquacultures such as Spirulina algae.

The "non explored or unknown" fields are potential prospects where hot springs are known and amount to more than fifty all over the country.

One sector with fast development is the GSHP. During the years 2006 and 2007 some tens of units have been installed mainly in houses and the number is increasing rapidly.

2. HISTORICAL BACKGROUND

The Institute of Geology and Mineral Exploration (IGME) haw started the exploration for geothermal energy in Greece since the seventies. With its efforts the whole of geothermal fields have been discovered, studied and some of those are used today in direct uses. The geological environment of the country favors the development of relatively shallow geothermal fields both high and low temperature. Most important is the young volcanic activity mainly along the South Aegean volcanic arc (fig. 2) where the known today

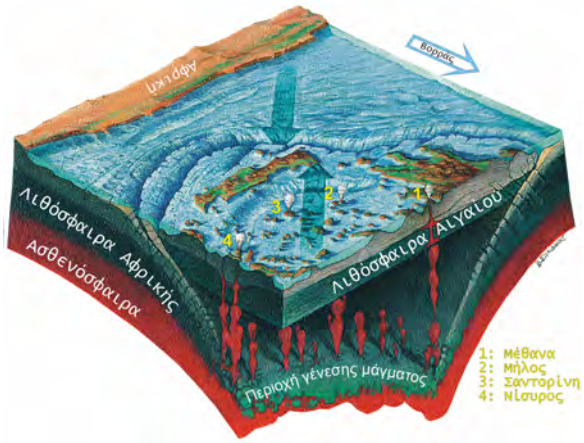

Figure 2: The South Aegean volcanic arc and the geothermal fields associated with it. (Vougioukalakis, G., 2000).

high temperature fields of Milos and Nisyros islands lie. Moreover a number of low temperature fields have been located along the arc which is a back arc area of the subduction zone of African plate under the Eurasian plate. The older Oligocene to Miocene volcanism is responsible for some important low temperature fields in middle to north Aegean Sea and Thrace area.

The deep water circulation along big structures in grabens all over the country has created a big number of low temperature fields. A few fields are related to diapiric movement of anhydrites in western Greece (Epirus and west Peloponnesus).

During the years 2002-2007 the geothermal exploration has been financed by the Third Community Support of E.U. and the Greek Government. Exploration has been carried out in ten (10) prospective areas of the country based on the favorable geological and geothermal conditions. Nine new fields have been discovered and added to the exploitable geothermal potential of the country.

The exploration of geothermal energy has not changed significantly since the last country's update. The high temperature fields are not used and the low temperature ones are exploited in direct uses. Most important is the balneological use, quite widespread in Greece since the ancient times. More than 50% of geothermal potential is used in more than 60 spas all over the country. Last year the legislation of balneology has changed (law 3498/2006) in order to accelerate the development of this important type of alternative tourism. The heating uses of geothermal energy are the second important application, applied mainly in greenhouses, aquacultures and district heating. (Fig. 3).

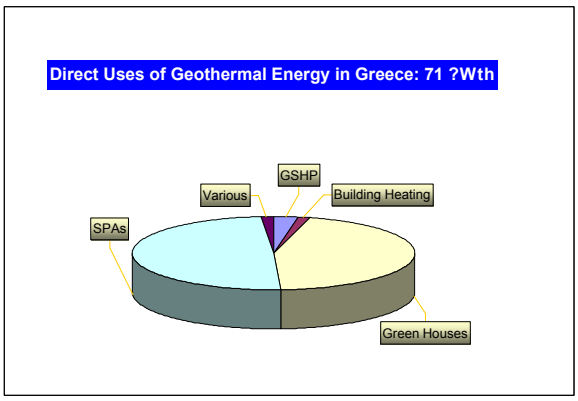

Figure 3. Direct uses of geothermal energy in Greece.

3. EXPLORATION

The Institute of Geology and Mineral Exploration (IGME) is responsible, by the law 3175/2003, for the exploration activities. Geothermal exploration is carried out with modest intensity, during the last 15 years by the co-financing of E.U. and Greek government. Especially for the period 2002 to 2008 a budget of 4 million € has been devoted to exploration. Up to now 10 fields of low temperature have been located and studied in order to provide the necessary quantitative and geometrical data for their classification in proved and possible fields.

A brief description of the new discovered fields, not mentioned previously is given below**.**

3.1. Macedonia

Volvi field: it is located in Northern Greece, north east of Thessaloniki, on the west coast of Volvi lake. Exploratiob involved drilling of a small number of wells which encountered a hot aquifer at a depth ranging from 100 to 200 m. the mean temperature is 31-55^{o}C and the flowrate > 400 m^{3}/h.

Akropotamos field: exploration has been finalised with the drilling of 2 productive wells. This important field has a temperature of 83 ^{o}C and a flow rate > 150 m^{3}/h., with a high CO2 content.

3.2 Central Greece

Nikaia field: the field is located south of the city of Larissa and close to Karies and Nikaia villages. The hot aquifer is encountered at a depth of 350 m and has a temperature of 40 ^{o}C. No pumping test has been carried out yet.

Damasta field: In the graben of Sperchios a number of spas were operated since ancient times. Geothermal exploration, outside the protection area of spas, revealed a new geothermal field in Damasta village. A productive well has been opened up to a depth of 150 m and encountered a hot aquifer with a temperature of 42^{o}C and a flowrate >40 m^{3}/h.

Aedipsos and Yaltra fields: in the Aedipsos town, in northern Euboea, a large number of spas operated since last century. The geothermal exploration discovered two geothermal fields in the Yaltra and Aedipsos areas.

The Yaltra field is located close to the same name village. Two exploration and one productive well have been drilled at a depth up to 250 m. The geothermal aquifer was encountered at a depth ranging between 70 and 250 m with a temperature of 36-42 ^{o}C and a flowrate >40 m^3/h.

In the Aedipsos area a deep well was drilled (350 m deep) and encountered hot water (80 ^{o}C). Exploration will continue to greater depth with the aim to locate higher temperature (>100 ^{o}C) and high flowrates for power generation.

3.3 Western Greece

Antirio field: In the west part of central Greece the Antirio field was discovered in the past related to the diapirism of anhydrites. Exploration has ended last year with the drilling of one more productive well which encountered the hot aquifer at a depth of 200m. The temperature encountered is 35^{o}C and the flowrate >90 m^3/h.

Sykies Arta: in this area a geothermal field was discovered on 2000 and a delineation of it was carried out recently. The productive well drilled located the hot aquifer at a depth of 250 – 300 m with a temperature of 48 ^{o}C and a flowrate of 100 m^3/h.

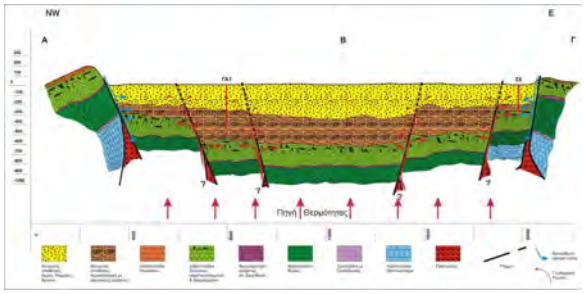

Figure 4. Model of the Sykies , Arta field (Vekios, P., 2007)

3.4 Aegean Islands:

Chios Island: The Nenita geothermal field was discovered 7 years ago. In 2005 one more productive well was drilled at a depth of 340 m which yielded ~100 m^3/h at a temperature of 80 ^{o}C .

Current exploration located the geothermal field of Thymiana close to the town of Chios. One productive well drilled and encountered an aquifer at a depth of 150 m with a temperature of 30^{o}C and a flowrate of ~100 m^3/h.

4. DEVELOPMENTS OF USES

No significant development of uses have been done during the past 3 years, despite the aim of the legislation change was to accelerate the geothermal fields uses. Instead of the development, some projects referred to previous update of Greece have not reached the stage of use (Macedonia airport heating and cooling, Imathia prefecture cultivations in greenhouses, Kimolos island desalination plant, Milos's island desalination project). The only one development in geothermal application was the accelerated use of GSHP due to the provisions of the new geothermal legislation. Licensing for installing of ESHP is given by the local governments and there are some motives in the development law.

A new big project of Space Heating has been started last year with the aim to provide heating to some municipal building in the town of Polichnitos, located to the south east of Lesvos island. A consortium consisting of a big energy company, the local University, IGME, CRES and Technical University of Chalkis will carry out this project, with the financial support of E.U. and Greek government. It is expected that in two years it will be the first operating large scale space heating project in Greece.

Production of electricity has not achieved yet. The high temperature fields of Milos and Nisyros islands have not undergone any development and it is not expected that this situation will change in the few next years.

The activities of IGME during the next six years will be orientated towards the location of EGS in order to provide the fields for electricity production in other areas of the country.

Spas had a small development and their number increased to sixty. The new legislation for the development of balneology and associated tourism combined with the motives of development law is expected to further increase spas development.

5. LEGISLATION

The legislation for the exploration of geothermal energy was always a sub-division of the Mining law of Greece.

At 1984 there was a separate geothermal legislation (law 1575/84) again under the general framework of Mining law. The last change was at 2003 with the law 3175/2003 which replaced the previous one. Up to the end of 2005 a series of Ministerial Decisions were published and further specified some topics. The character of the new law remain that the geothermal energy is a kind of "ore" and the Mining law remains its main umbrella. The main new features introduced are the following:

- the concept of the " field" management is introduced
- The whole field can be hired in order to achieve the sustainable management of it.
- Selling of geothermal energy is allowed.
- Geothermal fields are classified in three categories according to the degree of their knowledge:
  a. Proven fields
  b. Possible fields
  c. Unknown or no-explored fields.
- According to the temperature of the geothermal fluid two types are distinguished:
- High temperature when it exceeds 90 ^{o}C.
- Low temperature when it lies between 25 ^{o}C & 90 ^{o}C.
- Permits for the exploitation of low temperature proven and possible fields are provided by the Regions (local governments). License for exploration of Unknown fields is provided by the Ministry of Development.

- Permits for electricity generation from high temperature fields are provided by the Ministry of Development and Regulative Energy Agency (RAE).

- Licensing of GSHPS is provided by the Regions after the submission of a complete report including all the necessary reports (geological, engineering, techno-economic and environmental).

6. CONCLUSIONS

Since the end of 2004, when the last country update of Greece was presented at the WGC 2005, some changes have taken place, in the following fields:

- New important low temperature geothermal fields have been discovered by the continuous exploration of IGME and the co-financing of E.U. (3rd C.S.F.). These fields are located in Macedonia, Central Greece, Aegean Islands, and Western Greece.

- A monitoring network has been realized aiming to contribute to the sustainable exploitation of the fields.

- The new legislation for geothermal energy development, for every use, has been finalized in late 2005.

- The GSHP have a rapid development since the new legislation solved a lot of bureaucratic barriers and more than 50 units have been licensed during the years 2006 and 2007.

- Drilling of deep exploitation wells is in progress in the area of Argennos, in the NW part of the Lesvos Island. The Public Power Corporation has the license to install a power station there.

- Another project dealing with heating of some municipality buildings of Polichnitos village is carried out now. The hot water (~90oC) will be provided by the field with the same name.

- Finally a number of applications for licensing the use of geothermal fields in east Macedonia and Thrace are pending approval by the local authorities.

REFERENCES

Hatzis, M., et al.: Geothermal exploration in the area of Aedipsos, Euboea. IGME internal report. (2007).

Kolios, N., et al.: Geothermal exploration in the area of Akropotamos Kavala. IGME internal report. (2007).

Koutsinos, S., et al.: Geothermal exploration in the area of lake Volvi. IGME internal report. (2006).

Vekios, P., et al.: The Sykies Arta geothermal field. IGME internal report. (2007).

Vougioukalakis, G.: Study of the young volcanism in Greece. IGME, internal report. (2000).

Vrellis, Gr., et al.: Geothermal exploration in the Chios Island. IGME internal report (2007).