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# Macedonia - Country Update 2010

Sanja K.Popovska-Vasilevska, Kiril Popovski, Eftim Micevski

Dame Gruev br.1-3/16, 1000 Skopje, Macedonia

pvsanja@yahoo.com, kpopovski@mac.com

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## ABSTRACT

In comparison with 2005, situation with proven hydro-geothermal resources is minimally changed with introduction of one bigger (60 l/s – 75ºC) and several small boreholes (5 – 15 l/s , 30 – 55ºC), the reinjection system of one third of the waste water flow in Kocani has been completed, introduction of indirect system of use instead the previous direct one has been introduced in one of greenhouse complexes of the Kocani district heating system, privatization process of existing spas was finalized, reconstruction of heating installations in Negorci Spa finalized and process beginning of the reconstruction is in progress at Bansko Spa. There were no new exploration and investigation activities. However, increase of interest of small investors could be followed. About ten concessions for investigations have been issued and initial steps of investigations organization are in progress. The government issued very convenient feeding price for electricity of geothermal origin but it is not of practical value due to the absence of proven convenient resources. On the other hand, the existing tariff system for selling heat of geothermal origin is still in place, even though it was clearly proven that it doesn't influence positively the development of this renewable resource because it artificially presses down the selling price and doesn't include the development component. The process of introduction of ground heat pump systems began with several smaller installations.

A review of the geological background, known hydro-geothermal resources and their potential, present geothermal utilization and main characteristics of the projects is given in the paper. Finally, a prediction of development that can be expected in the period of the next ten years is given, too.

## 1. INTRODUCTION

Macedonia has been one of the leading European countries in direct uses development during the 1980s. Even rather modest, the state investments in geothermal explorations gave opportunity to the scientists and economy sector to develop three successful big and several small geothermal projects. However, when positive influence had began to give results, i.e. when state planned some new larger investments, political and economy transition process from the beginning of 1990s resulted in a complete collapse of the state economy and, with that, lost of interest for any further investments in the geothermal energy development. Even more, thanks to the collapse of the heat users, some of the existing projects have been abandoned.

When present state policy to geothermal development is in question, it can be clearly stated that it practically doesn't exist. Even under pressure of EU to define a consistent policy and strategy of all renewable energy use in order to achieve defined targets until 2020, government continues to neglect the problem. If present, rare projects and activities are pushed by different EU agencies and developed EU countries. The recently prepared "Strategy for Energy Development" and "Strategy of Renewable Energies Development in Macedonia", prepared by the Macedonian Academy of Sciences, are a good illustration for such a relation to this problem. Incomplete, based on insecure data and suppositions, without proper relation to real influencing factors and economy of the country, without participation of any of proven national or international experts, it results in provisions and recommendations that are wrong and unusable. Obviously, a great change is necessary but nobody can predict when it shall finally come.

Key players in geothermal development are:

- Ministry of Economy - Department for Energy: The Department is weak and neither has somebody understanding the problematic of RENEWABLE ENERGY SOURCES Development nor has it built collaboration with national and international agencies and experts;
- Energy Agency of Macedonia: It is founded three years ago with support of the World Bank but is still neither equipped with necessary personnel nor rooms or facilities. Up to now, no single project or concrete activity has been initiated by it.
- Macedonian Geothermal Association (MAGA): It is a NGO, working in geothermal development in the country and worldwide. Even very active and continually present with different initiatives, it is completely neglected by the government, as a part of the general policy towards NGOs in general. The Government doesn't support their activities if not being completely accommodated to its defined policy or activity in progress.

Recently, first signs of the recovery of some users resulted with several investments in the geothermal projects reconstruction and optimization (Popovski, 2009). There is interest of the others to do the same, and new candidates are trying to get concession for development of new projects. However, the process is very much slowed due to the list of constraints, mainly in the legal and financing sector. Existing "pressure" of WB and EC to work more on the environmental protection can have a positive influence for removing the constraints but it can be predicted that the process shall last at least 4-5 years, according to the experience with the other legislative changes and improving the possibilities for financing new developments.

This country update gives information about the present state of geothermal investigations and use in Macedonia, with identification and comments about possibilities to remove the negatively influencing factors.

## 2. GEOLOGY BACKGROUND

### 2.1 Geological Framework and Tectonic Settings od Macedonia (Micevski, 2003)

In the territory of Macedonia rocks of different age occur, beginning with Precambrian to Quaternary ones. Almost all lithological types are represented. The oldest, Precambrian rocks, consist of gneiss, micaschists, marble and orthometamorphites. The rocks of Paleozoic age mostly belong to the type of green schists, and the Mesozoic ones are represented by marble limestones, acid, basic and ultrabasic magmatic rocks. The Tertiary sediments consist of flysch and lacustrine sediments, sand-stones, lime-stones, clays and sands.

With respect to the structural relations the territory can be divided into six geotectonic units (Fig. 1): The Cukali-Krasta zone, West Macedonian zone, Pelagonian horst anticlinorium, Vardar zone, Serbo-Macedonian massif and the Kraisthide zone. This tectonic setting is based on actual terrain and geological data without using the geotectonic hypothesis (Arsovski, 1998). First four tectonic units are parts of Dinarides, Serbo-Macedonian mass is part of Rodopes and the Kraisthide zone is part of Karpato-Balkanides distinguished on the Balkan peninsula as geotectonic units of first stage.

### 2.2 Geothermal Background (Gorgieva, 2002)

The territory of the Republic of Macedonia belongs to the Alpine-Himalayan zone, with the Alpine sub-zone having no contemporary volcanic activity. This part starts from Hungary, across Serbia, Macedonia and North Greece and stretches to Turkey. Several geothermal regions have been distinguished including the Macedonian region, which is connected to the Vardar tectonic unit. This region shows positive geothermal anomalies and is hosting different geothermal systems. The hydro-geothermal systems, at the moment, are the only ones that are worth investigation and exploitation.

There are 18 known geothermal fields in the country (Fig. 2) with more than 50 thermal springs, boreholes and wells with hot water. These discharge about 1000 l/s water flow with temperatures of 20-79 $^0$C. Hot waters are mostly of hydrocarbonate nature, according to their dominant anion, and mixed with equal presence of Na, Ca and Mg. The dissolved minerals range from 0.5 to 3.7 g/l.

All thermal waters in Macedonia are of meteoric origin. Heat source is the regional heat flow, in the Vardar zone is about 100 mW/m$^2$ and crust thickness 32 km.

## 3. GEOTHERMAL RESOURCES AND POTENTIAL

Out of the seven geothermal fields identified in the east and northeast part of the country, four of them have been found to be very promising and three of them have been investigated to the stage where practical use is possible. Except for the springs in Debarska banja and Kosovrasti, which are in the West Bosnian-Serbian-Macedonian geothermal zone, all the others are located in the Central Serbian-Macedonian Geothermal Massif, Central and Eastern Macedonia (Figure 2).

It's necessary to underline that the total available flow of exploitable sources is 922.74 l/s, which is less than the estimated 1000 l/s 5 years ago, and differs from the previous values (1397 l/s), which are the maximum measured short lasting flows. The difference is due to the more precise data for long lasting capacities of all the flows, after many years of exploitation and measurements.

Temperatures of the flows vary in the rank of 24-27°C (Gornicet, Volkovo and Rzanovo) up to 70-78°C (Bansko and Dolni Podlog). Total average temperature is 59.77°C. The biggest potential is in the Kocani geothermal field, with a total maximal flow of up to 350 l/s and temperatures of 65°C (Istibanja) and 75-78°C (Dolni Podlog). Next is the Gevgelija geothermal field, with about 200 l/s and temperatures of 50°C (Negorci) and 65°C (Smokvica). The list of the others is: Debar geothermal field with 160 l/s and temperatures of 40°C (Debarska banja) and 48°C (Kosovrasti), Strumica geothermal field with 50 l/s and 70°C and Kratovo/Kumanovo geothermal field with 70.71 l/s and temperatures of 31°C (Kumanovska banja) and 48°C (Kratovo).

The real energy potential of the geothermal resource in Macedonia is in direct correlation with the technical/technological feasibility of its application, in accordance to the newest know-how in the country and in the world. A simulation, according to different outlet temperature, is made for all the exploitable geothermal resources in Macedonia. A total available maximum heat power of 173 MW is obtained, which suggests the possibility of annual maximum production of 1,515,480 MWh/year. This is of course only a theoretical indication considering that each project has different range of exploited temperature. In any case this maximum potential cannot be fully exploited, because it is strongly dependent on the utilization factor and on the type of application. For instance, the geothermal system in Dolni Podlog (Kocani) has a maximum flow of about 300-350 l/s with temperature of 75°C. If a maximal use of the source could be reached (i.e. effluent water of 15°C), its heat power could increase up to 75-85 MW. However, the applied technical solutions by the users, result with temperatures of the effluent water during the winter weather conditions of 40-45°C. That practically means lowering of the heat power of the source to 37.7-44.0 MW, i.e. 40-50% of the maximally possible one. For the same geothermal system and composition of users, it is technically and economically feasible to lower the temperature of the effluent water to 30°C during the first phase of development (Popovski, 1991), and 25°C during the second phase of development. Such an optimization should allow a reduction of losses of 25% and 17% respectively, which is in the acceptable limits even for the countries with longer experience in geothermal energy application. Therefore, depending on the reached average outlet temperature of projects using available geothermal resources, the following orientation figures for total heat power can be taken: 172.9 MW for 15ºC, 153.7 for 20ºC, 134.3 for 25ºC, 115.6 for 30ºC, 97.2 for 35ºC, 78.9 for 40ºC and 68.2 for 45ºC. According to the presently applied solutions, average outlet temperatures between 30 and 40 ºC can be taken as representatives.

## 4. GEOTHERMAL FIELDS IN MACEDONIA

There are 18 localities where geothermal fields occur and geothermal energy is in use for different proposes. The most known areas are listed below:

*Kochani valley (Popovski, 2002):* The main characteristics of the Kochani valley geothermal system are: presence of two geothermal fields, Podlog and Istibanja, without hydraulic connection between them. The primary reservoir is build by Precambrian gneiss and Paleozoic carbonated schists and the highest measured temperature in Macedonia of 79ºC has been obtained by drilling to it. Predicted maximum reservoir temperature is about 100ºC (Gorgieva, 1989). Kocani geothermal system is the best investigated system in Macedonia. There are more than 25 boreholes and wells with depths of 100-1170 m.(Popovski, 2009)

*Strumica valley (Popovski, 2002):* The main characteristics of this field are: the recharge and discharge zone occur in the same lithological formation-granites; there are springs and boreholes with different temperature at small distances; maximum measured temperature is 73$^0$C; the predicted maximum temperature is 120$^0$C (Gorgieva, 1989); the reservoir in the granites lies under thick Tertiary sediments. Bansko geothermal system has not been examined in detail apart the drilling of several boreholes with depths of 100-600m. (Gorgieva, 2002)

*Gevgelia valley (Popovski, 2002):* There are two geothermal fields in the Gevgelija valley: Negorci spa and Smokvica. The discharge zones in both geothermal fields are fault zones in Jurassic diabases and spilites. These two fields are separated by several km and there is no hydraulic connection between them, despite intensive pumping of thermal waters. The maximum temperature is 54ºC, and the predicted reservoir temperature is 75-100ºC (Gorgieva, 1989). Geothermal system in the Gevgelija valley has been well studied by 15 boreholes with depths between 100-800 m. (Gorgieva, 2002).

*Skopje valley (Popovski, 2002):* There are two geothermal fields in the Skopje valley: Volkovo and Katlanovo spa. There is no hydraulic connection between them. The main characteristics of the Skopje hydro-geothermal system are: maximum measured temperature of 54.4 $^0$C and predicted reservoir temperature (by chemical geothermometers) of 80-115$^0$C (Gorgieva, 1989); the primary reservoir is composed of Precambrian and Paleozoic marbles; big masses of travertine deposited during Pliocene and Quaternary period along the valley margins. There are only five boreholes with depths of 86 m in Katlanovo spa, 186 and 350 m in Volkovo and 1654 and 2000 m in the middle part of the valley. The last two boreholes are without geothermal anomaly and thermal waters because of their locations in Tertiary sediments with thickness up to 3.800 m. (Gorgieva, 2002)

## 5. GEOTHERMAL UTILIZATION

Thermal waters utilization consists of 7 geothermal projects and 6 spas. All were completed before and during the 1980s. The present state of the projects is as follows:

*Istibanja (Vinica) Geothermal Project:* Project consists of 6 ha greenhouse complex heating in combination with a heavy oil boiler for covering the peak loadings. It has been one of the worst completed projects before the crisis, however after the privatization in 2000 it has been reconstructed and optimized with Austrian and Dutch grants and now properly covers the heat requirements of the roses production for export. The owners are interested to follow investigations in order to enable geothermal heating of additional 6 ha of greenhouses but cannot reach a common language with the municipality, who is owner of the concession rights.

*Kocani (Podlog) Geothermal Project ("Geoterma"):* This is the presently largest geothermal project in Macedonia, consisting of 18 ha greenhouse complex heating, and space heating in the center of the town. Due to the economic crisis in the country, paper industry, vehicle parts industry and rice drying have been lost as consumers of heat during the last 10 years. However, thanks to two Austrian grants, three additional boreholes have been drilled, partial reinjection of outlet water completed and monitoring system introduced in the system. Presently, activities to finalize the completion of the reinjection and connection of public buildings in the center of the town are in progress. Project works as a public utility and its organizational structure is well covered by the existing team. The only problem in work is the price of supplied heat, which is kept very low by the State Regulatory Committee and doesn't include funding for all necessary maintenance works and system development. By the use of EU funding, beginning the deeper explorations (up to 1000-1200 m) is planned for 2010.

*Bansko Geothermal Project:* The bankruptcy of ZIK "Strumica" and the slow process of its privatization resulted in the collapse of the organizational structure and proper use of the system. That was used (existing and new users) with increase of "agreed" geothermal water flows. Some years ago, when the greenhouse heating started to work again, a trial for introduction of new organizational structure has been made but without success because of not including centralized governing of the system exploitation. Introduction of a centralized system and new exploitation boreholes are an absolute need for its proper working, due to the increased number of users and resulting failure to cover peak loadings. Also, a number of reconstructions and optimizations are necessary in order to put it in proper technical order. A trial to improve the situation by organization of Italian/Macedonian project is in progress.

*Smokvica (Gevgelia) Geothermal System:* Once the largest geothermal system in Macedonia, covering the heat requirements of 22.5 ha glasshouses and about 10 ha plastic-houses is now out of exploitation. Improper privatization resulted with division of the property to 10 entities and they couldn't find a common language for covering the costs of the system exploitation. Meanwhile, also the biggest exploitation borehole has been lost. Renewal of the system exploitation is impossible because the distribution system was meanwhile destroyed. The new owner still doesn't declare what he is planning to do with the energy source.

*Negorci (Gevgelia) Spa:* Reconstruction of the heating installations has been finalized and now all the hotel and therapeutical projects are heated with geothermal energy. Project is in a process of continual step by step modernization.

*Other Spas in Macedonia:* Even planned, reconstruction of heating systems and their orientation towards geothermal energy use in Macedonian spas has not been realized due to their undefined property and the absence of funds. Now, when the process is finalized, activities to find possible investors are in progress in Katlanovo Spa, Kezovica Spa and Bansko Spa. However, it is not possible to expect quick results, due to the absence of capital in the country and real interest of foreign investors.

## 6. DISCUSSION

A process of stagnation of geothermal development in Macedonia is still the main characteristic of the recent 5 years. The Government continues to neglect good natural possibilities. If something starts to change with other renewable energy sources, like solar and wind energy, it is more organization of smaller development projects under pressure of EU lobbies than a defined orientation, and there is no such a lobby for geothermal energy. According to the present atmosphere, when all the attention is orientated towards the "big" energetic due to the big gap of local production, it is not possible to expect important changes during the next 5 years.

## 7. FUTURE DEVELOPMENT AND INSTALLATION

"New Strategy for Renewable Energy Development" is still indifferent to geothermal energy, as a prospective energy source for Macedonia. Practically, it doesn't include any development until 2020. However, there are some private initiatives, which shall probably change the situation. Most important is the ones for renewal of the Smokvica geothermal system, reconstruction and enlarging the Bansko geothermal system and foundation of a new one in Dojran. Final completion of the reinjection system in Kocani should be realized during the next two-three years, too. Probably, some reconstructions and orientation towards geothermal energy use in other spas shall be made but, up to now, there is no data for such intentions. Unfortunately, still there are no signs that something will be done with the very prospective geothermal field in Kratovo-Zletovo, Skopje and Kumanovo regions.

## ACKNOWLEDGMENTS

Taking into account that already for 20 years there are no geothermal investigations in Macedonia, the basic source of data is still the work of Prof. Mirjana Gorgieva on evaluation of geothermal potential of the country, made during the last years of the past century. She died 5 years ago but her work is still alive.

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## FIGURES


**Figure 1: Geological settings and geothermal regions in Macedonia (Arsovski, 1997)**

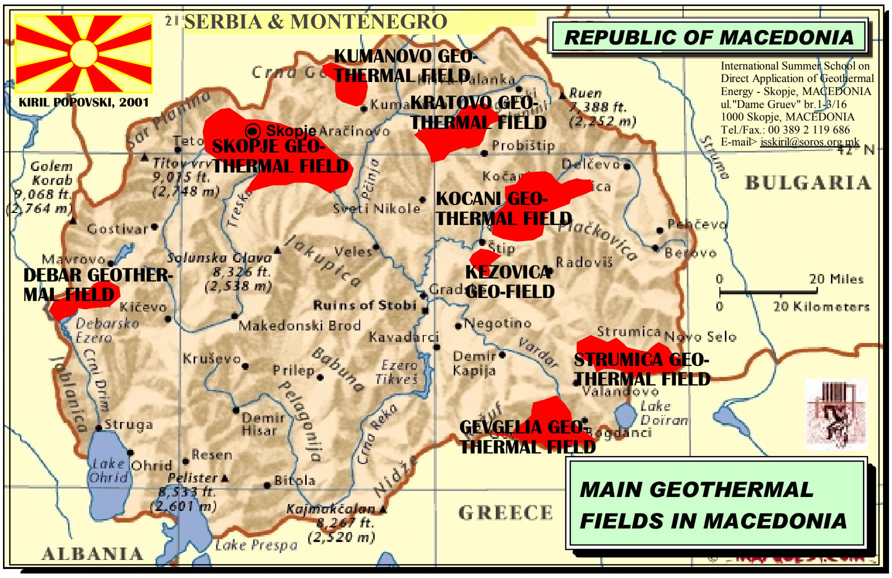


**Figure 2: Main geothermal fields in Macedonia (Popovski, 2001)**

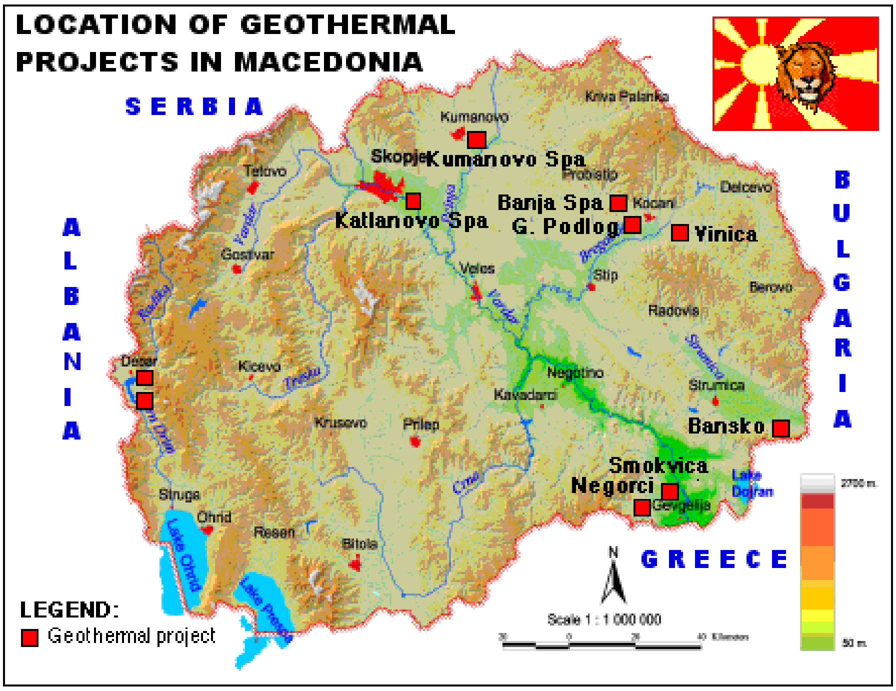


**Figure 3: Location of geothermal projects in Macedonia**

**TABLES**

**Table 1: Utilization of geothermal energy for direct heat**

| | | |
|---|---|---|
| | **AS OF 31 DECEMBER 2009 (other than heat pumps)** | |
| 1) | I = Industrial process heat | H = Individual space heating (other than heat pumps) |
| | C = Air conditioning (cooling) | D = District heating (other than heat pumps) |
| | A = Agricultural drying (grain, fruit, vegetables) | B = Bathing and swimming (including balneology) |
| | F = Fish farming | G = Greenhouse and soil heating |
| | K = Animal farming | O = Other (please specify by footnote) |
| | S = Snow melting | |
| 2) | Enthalpy information is given only if there is steam or two-phase flow | |
| 3) | Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. (°C) - outlet temp. (°C)] x 0.004184 | (MW = $10^6$ W) |
| | or = Max. flow rate (kg/s)[inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001 | |
| 4) | Energy use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. (°C) - outlet temp. (°C)] x 0.1319 | (TJ = $10^{12}$ J) |
| | or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.03154 | |
| 5) | Capacity factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 | |
| | Note: the capacity factor must be less than or equal to 1.00 and is usually less, | |
| | since projects do not operate at 100% of capacity all year. | |

**Note:** please report all numbers to three significant figures.

| Locality | Type[1)] | Maximum Utilization Flow Rate (kg/s) | Temperature (°C) Inlet | Temperature (°C) Outlet | Enthalpy[2)] (kJ/kg) Inlet | Enthalpy[2)] (kJ/kg) Outlet | Capacity[3)] (MWt) | Annual Utilization Ave. Flow (kg/s) | Energy[4)] (TJ/yr) | Capacity Factor[5)] |
|---|---|---|---|---|---|---|---|---|---|---|
| Bansko | **D** | **53** | **69** | **30** | | | **8.65** | **35.00** | **180.05** | **0.66** |
| Bansko | G | 30 | 69 | 30 | | | 4.89 | | | |
| Bansko | G | 10 | 69 | 25 | | | 1.85 | | | |
| -Bansko | B | 8 | 45 | 25 | | | 0.67 | | | |
| -Bansko | H | 13 | 69 | 40 | | | 1.58 | | | |
| Istibanja | **G** | **21,5** | **61** | **30** | | | **2.79** | **15.00** | **61.14** | **0.69** |
| **Kocani** | **D** | **180** | **75** | **30** | | | **33.90** | **57.00** | **338.32** | **0.31** |
| Kocani | G | 170 | 75 | 30 | | | 33.90 | | | |
| -Kocani | H | 10 | 75 | 40 | | | 1.46 | | | |
| Negorci | **H** | **80** | **50** | **40** | | | **0.84** | **5** | **6,60** | **0.25** |
| **TOTAL** | | | | | | | **46.18** | | **586.11** | **0.40** |

**Table 2: Summary table of geothermal direct heat uses as of 31 december 2009**

| | |
|---|---|
| 1) Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. ($^oC$) - outlet temp. ($^oC$)] x 0.004184 | |
| or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001 | |
| 2) Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. ($^oC$) - outlet temp. ($^oC$)] x 0.1319 | (TJ = $10^{12}$ J) |
| 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 | ( MW = $10^6$ W) |
| Note: the capacity factor must be less than or equal to 1.00 and is usually less, | |
| since projects do not operate at 100% capacity all year | |
| **Note:** please report all numbers to three significant figures. | |

| Use | Installed Capacity[1] | Annual Energy Use[2] | Capacity Factor[3] |
|---|---|---|---|
| | (MWt) | (TJ/yr = $10^{12}$ J/yr) | |
| Individual Space Heating[4] | 0.84 | 6.60 | 0.25 |
| District Heating [4] | 42.55 | 518.37 | 0.39 |
| Air Conditioning (Cooling) | | | |
| Greenhouse Heating | 2.79 | 61.14 | 0.69 |
| Fish Farming | | | |
| Animal Farming | | | |
| Agricultural Drying[5] | | | |
| Industrial Process Heat[6] | | | |
| Snow Melting | | | |
| Bathing and Swimming[7] | | | |
| Other Uses (specify) | | | |
| **Subtotal** | **46.18** | **586.11** | **0.40** |
| Geothermal Heat Pumps | | | |
| **TOTAL** | | | |

| | |
|---|---|
| 4) | Other than heat pumps |
| 5) | Includes drying or dehydration of grains, fruits and vegetables |
| 6) | Excludes agricultural drying and dehydration |
| 7) | Includes balneology |

**Table 3: Wells drilled for electrical, direct and combined use of geothermal resources from january 1, 2005 to december 31, 2009 (excluding heat pump wells)**

| 1) | Include thermal gradient wells, but not ones less than 100 m deep | | | | | |
|---|---|---|---|---|---|---|
| Purpose | Wellhead | Number of Wells Drilled | | | | Total Depth |
| | Temperature | Electric | Direct | Combined | Other | (km) |
| | | Power | Use | | (specify) | |
| Exploration1) | (all) | | 1 | | | 0.55 |
| Production | >150$^o$ C | | | | | |
| | 150-100$^o$ C | | | | | |
| | <100$^o$ C | | 2 | | | 1.1 |
| Injection | (all) | | 1 | | | 0.6 |
| Total | | | **4** | | | **2.25** |

**Table 4: Total Investments in geothermal in (2009) US$**

| Field Development Including Production | Drilling & Surface Equipment | Utilization | | Funding Type |
|---|---|---|---|---|
| | | Direct | Electrical | Private |
| Million US$ | Million US$ | Million US$ | Million US$ | % |
| | 1,355,000 | | | |
| | | | | |