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Geothermal Development in Slovenia: Country Update Report 2005-2009

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ABSTRACT

Direct use of geothermal waters continues to be the only type of use from geothermal reservoir sources in Slovenia, at 29 localities at present. A small progress was achieved in geothermal development during the last five years with four new users appearing in the north-eastern part of Slovenia, belonging to the Pannonian Basin geothermal region. Two of them, still in a testing phase, use thermal water from metamorphic and carbonatic basement rocks respectively, the other two (thermal leisure resort, orchids greenhouses) use the same Upper Miocene-Pliocene aquifer as other users in vicinity. Beside, new reinjection well has been drilled there for a doublet system in Lendava. Due to newish legislation thorough reports on geothermal conditions and present utilization are demanded from the users in recent years, which slowly provoked the monitoring introduction. The installed capacity amounts to 66 MW_t and the annual energy use to roughly 773 TJ. Most localities comprise installations that include centralized heating units, thermal spas combined with space heating, and with district heating and greenhouses in a few cases. In addition, ground source heat pumps are also increasingly used, especially in residential applications. There are roughly 3440 ground-coupled heat pump and ground water heat pump units of about 40 MW_t capacity removing additional 379 TJ/year in energy use while 13 TJ/yr are rejected to the ground in the cooling mode. The investments were directed for some basic research, but even more for feasibility studies and project implementation with new drillings. Drilling activity reached incredible 23.8 km of new wells, both production and exploration, including the temperature gradient boreholes. Of course, not all wells were successful. For the future prospective geothermal options may include: the adaptation of some abandoned oil wells, small size heat pumps and also groundwater heat pumps of greater capacity, some clusters of ground heat exchangers used for heating or cooling, hopefully some more reinjection wells, and probably multipurpose integrated system.

1. INTRODUCTION

The electricity production in Slovenia amounting to 13,640 GWh/yr, is based, as of December 2007 (Table 1), on domestic and only partly imported fossil fuels (35.3 %), domestic hydropower (20.6 %), nuclear power (39.8 %), and other renewables (4.3 %). Of these, small hydropower plants predominate, with PV solar units following and certain number of other biomass facilities. We believe that at present any production from geothermal even by 2015 is not realistic. Owing to a lack of natural steam reservoirs geothermal energy in Slovenia cannot be converted in Dry Steam or Flash Steam power plants into electric power. Only binary technology is promising, but it is also disputable, temporal as well as geologically. The government supports in principle the direct use of geothermal energy through different projects where few lead agencies are involved in geothermal development, such as "Ministry of the Environment and Spatial Planning, Dept. of Efficient Energy Use and Use of Renewable Energy Sources", "Ecological Development Fund of Slovenia" (EKO Sklad) which invites public tenders for regional ecological development and supports initiatives for private investments, and "Public Fund for Regional Development". Two ministries are basically involved: 1. "Ministry of the Environment and Spatial Planning" (MOP) for the water permits and concessions for thermal water usage for touristic purpose and heat extracting, and 2. "Ministry of the Economy" (MGO) for concessions for geothermal energetic source. The water permits, important for water source geothermal heat pumps, are regulated by the MOP. First concession for geothermal energetic source was given by MGO this year for the district heating doublet system in Lendava. Some private companies are active in demonstration projects for greater geothermal heat pump development. The target of appropriate ministries is also to raise the awareness of the general public to deal more carefully with energy consumption. Lead companies and institutes involved in geothermal development are: Nafta-Geoterm Co., Geological Survey of Slovenia, and several small business enterprises.

2. GEOLOGY BACKGROUND, GEOTHERMAL RESOURCES AND POTENTIAL

A description of geology, resources and potential is given in the previous country updates (Rajver et al., 1995; Kralj and Rajver, 2000; Rajver and Lapanje, 2005). Only few important points are repeated here, and some new discoveries mentioned. Slovenia has quite a complex geology and is subdivided into different geotectonic units, which more or less differ in their hydrogeological properties and geothermal conditions (Fig. 1): the NE part belonging to the Pannonian basin, while the Eastern Alps (incl. magmatic rock complex), the Southern Alps, the External and Internal Dinarides and Adriatic foreland represent parts of the Adriatic microplate. More information on geological aspects is described by Ravnik et al. (1995), Placer (1998) and references therein. The 24 thermal (natural and captured) springs have constant temperature close to or above 20°C with 36°C as maximum, however, there are several drilled localities where no surface thermal manifestations existed before. Details about the geothermal field of Slovenia and geotectonic background can be found, for example, in papers of Ravnik (1991), Ravnik et al. (1995) and Rajver and Ravnik (2002). Geothermal resources in the Pannonian and Krsko basin have been studied in more detail (Rajver et al., 2002; Rajver and Ravnik, 2003).

Research on thermal and thermomineral waters with stress on chemical composition has been done by Lapanje (2006) for the whole country, and by Kralj and Kralj (2000) for the north-eastern Slovenia. Within the bounds of the project TRANSTHERMAL analysis and representation of the geothermal capacity of the area encompassing northern Slovenia together with Carinthia and Styria in Austria (Goetzl et al., 2008; Lapanje et al., 2007) was made as an important step towards delineation of the cross-border aquifer extension and mutual influences. Only deeper geothermal potential focused on hydrothermal potential was included, and shallow geothermics was not tackled in the project.

With some new deep wells the existence of geothermal potential has been proved at some localities where success was more or less expected, such as at Dobrovnik, Janežovci and Korovci in the Pannonian basin area. On the other hand, following the exploration drillings in the 1970’s, when the highest geothermal gradient in the Tertiary layers was determined in this part of the country, the 1.9 km deep well at Benedikt has been drilled below 760 m into Paleozoic metamorphic rock series with fractured dolomitic marbles as the main aquifer. Thermomineral water with temperatures of almost 80°C at wellhead has been found. At Mislinjska Dobrava in the northern Slovenia, within the Eastern Alps geotectonic unit, the 1.3 km deep borehole has proved the existence of geothermal aquifer in the Tertiary dolomitic conglomerate, but the borehole is not yet in production.

3. GEOTHERMAL UTILIZATION

There is no electricity generation from geothermal resources in Slovenia up to date. Geothermal utilization is still firmly based on direct use, implemented at 28 localities, while at 3 more localities direct use has been stopped for some time due to economic reasons or reconstruction, as at Rimske Toplice (Tables 3 and 5). Four new direct users emerged, and all are located in the north-eastern Slovenia (Fig. 1 and 2). Three of them use the same regional Upper Miocene-Pliocene sand and loose sandstone aquifer, while the production well at Benedikt, that has been finished into Paleozoic metamorphic rocks (Kralj, 2005), is still in a testing phase.

In Slovenia geothermal energy is estimated to currently supply for direct heat uses and geothermal ground-source heat pumps 1,153 TJ/yr of heat energy. The corresponding installed capacity is 105.4 MWt. Of these values direct use is 773 TJ/yr and 65.8 MWt, and the remainder (39.7 MWt and 379 TJ/yr) are geothermal ground-source heat pumps. The main type of use turns out to be now geothermal ground-source heat pumps, followed by resort and spa use for bathing and swimming and by space heating (Fig. 3). It should be noted that the values for capacity and energy supplied by the geothermal ground-source heat pumps are approximate since it is difficult to determine the exact number of units installed.

3.1 Bathing and swimming

With the exception of geothermal ground-source heat pumps this is still the most important type of direct use of geothermal energy. There are 20 thermal spas and health resorts, and additional 5 recreation centres (4 of them as part of the hotels’ accomodation) where swimming pools with a surface area of about 44,090 m^2 and volume of 59,550 m^3 are heated by geothermal water directly or indirectly through heat exchangers or geothermal heat pumps. Since 2004 new swimming pools have been constructed in Murska Sobota under the Komunala authority and at Moravske Toplice for Terme Vivat, while enlargements of the swimming pools have been accomplished at Laško health spa (Wellness park) and Moravske Toplice (Terme 3000 resort). Wellhead water temperatures in thermal spas range from 23 to 62°C. The total geothermal energy used for bathing and swimming is estimated at 311 TJ/yr in comparison with 221 TJ/yr in 2004. At some localities improvements were achieved by better temperature range utilization, first of all at Moravske Toplice (Terme 3000), and at Banovci using the heat exchangers, while at Dobrna using the geothermal heat pumps. It must be noted, however, that direct use at Radenci wasn’t considered in the 2005 update at all, as their data were not available. In Maribor the flow rate at Terme Maribor slightly decreased. More exact numbers from some users are still expected to be gained. Direct use of geothermal for swimming pools is temporarily suspended in the LifeClass hotel in Portoroz, probably due to too low flow rate, and at Rimske Toplice owing to general reconstruction of swimming pools and resort center.

3.2 Space heating and air conditioning

Space heating is implemented at 14 localities, predominantly thermal spas, at some of them directly (Moravske Toplice, Banovci), at others through heat exchangers (Terme Lendava, Cerkno) or geothermal heat pumps (Hotel Diana in Murska Sobota). The heating of sanitary hot water is included at many localities. The GHP units are installed only in the case of too low thermal water temperature for this type. At Moravske Toplice there is a new user, the Terme Vivat. The total geothermal energy used for space heating is about 306 TJ/yr as compared with 213 TJ/yr in 2004. Air conditioning (cooling) from geothermal energy is in operation presumably only at Terme Vivat, contributing about 2 TJ/yr of extracted energy, compared to 23 TJ/yr in 2004.

3.3 District heating

There are only 2 geothermal district heating systems in Slovenia at present. In Murska Sobota about 300 dwellings under Komunala authority are heated geothermally through heat exchangers, especially from October to April, and in Lendava downtown several buildings (school, kindergarten, dwellings) under the Nafta Geoterm Co. authority use geothermal heat. In Lendava also snow melting system using geothermal heat is close to be finished. At Benedikt, district heating is in a trial phase as the well is still in the testing phase. The total geothermal energy used for district heating is 44 TJ/yr, and is higher compared with 17 TJ/yr in 2004.

3.4 Greenhouses

In eastern Slovenia the heating of greenhouses using geothermal water began in 1962 at Catez. It is performed there by the Flowers Catez Co. on 4.5 ha for cultivation of flowers mostly for domestic market. At Tesanovci near Moravske Toplice, the Grede Agricultural Co. uses the already thermally spent water flowing from Moravske Toplice (Terme 3000) with 40°C to heat 1 ha of greenhouse for tomato production. At Dobrovnik, new greenhouses with 1.4 ha have been constructed by Ocean Orchids Co. for orchids cultivation, both for domestic and foreign markets. The total geothermal energy used in the greenhouses is 95 TJ/yr, which is slightly lower compared with almost 100 TJ/yr in 2004, and much lower than in 1999 (137 TJ). At Catez, both users, Terme Catez and Flowers Catez, have production boreholes closely spaced and exploit the same fractured Triassic dolomitic aquifer. The average annual flow rate at Flowers Catez is only 20 kg/s. The active period of Flowers Catez is during colder months, while that of Terme Catez during warmer months, consequently they hopefully do not interfere much with each other.

3.5 Industrial process heat

Industrial use of geothermal energy at Vrhnika is no longer active since Jan. 1, 2009, when the Leather Industry Co. (IUV) went to bankruptcy. It is not foreseen that the production there will commence in short term again. At Trbovlje thermal water from two shallow boreholes is used for cooling the Lafarge Co. cement works, and therefore, is not considered as geothermal energy use. Small winter swimming pool that used thermal water before within the cement works was closed more than 3 years ago.

3.6 Geothermal heat pumps

At five health resorts and at Hotel Diana in Murska Sobota, the GHPs, tipically of greater capacity (1.3 MWt altogether), are used in open loop system for raising the thermal water temperature for further use in swimming pools and space heating or just to maintain the water temperature in swimming pools. Their contribution in used geothermal energy is about 16.5 TJ/yr.

According to new numbers geothermal energy use for space heating in small decentralized units is becoming more popular and widespread in Slovenia. The market penetration in larger scale began obviously during the last 5 to 10 years following some »lazy« period in the 1990's, when there was low interest in GHPs owing to high initial costs, high price of electricity and low prices of oil and gas. The ubiquitous heat content within the uppermost part of the Earth crust is available practically everywhere in Slovenia except in the mountainous region. Many technical, environmental and economic incentives, described by Rybach and Gorhan (2005), can be considered advantageous for more rapid introduction of GHP systems also in Slovenia. This is also backed by support programs from utilities and from the government through subsidies, and through credits. Depending on local conditions these units consist of ground-coupled closed loop heat pumps (horizontal heat collectors, vertical heat collectors), or groundwater open loop heat pumps.

The exact number of GHP units presently installed in Slovenia is difficult to achieve, since no national statistics are available. The numbers of heat pump sales give almost all the quantity for their estimation, despite that few domestic producers and merchant agents of imported units are not willing to fork over such numbers. Beside these numbers and previous updates, a care has been taken not to duplicate them with much smaller numbers of granted credits and given subsidies, as well as water permits (since 2005) that are granted by the Ministry of the Environment and Spatial Planning and its Environmental Agency of the Republic of Slovenia.

Currently there are about 3440 GHP operational units that extract 379 TJ/yr of geothermal heat. Of these, we estimate that 47% are open-loop systems that extract annually about 190 TJ from shallow groundwater, 49% are horizontal closed-loop (159 TJ), and 4% are vertical closed-loop systems (30 TJ). Closed-loop units together remove 189 TJ/yr from the ground, while 13 TJ/yr of heat is rejected to the ground in the cooling mode, presumably by vertical systems (Table 4). This is a great step ahead, and we assume our numbers from previous updates need some revision. Approximately 400 GHP units were mentioned by Rajver et al. (1995) extracting some 40 TJ of heat in 1994. This number reflects the activity in the 1980's and early 1990's. Then a pace of installed units became slower, showing about 700 GHP units and roughly 70 TJ of extracted heat in 1999, with water source type as prevalent, followed by horizontal and vertical types. Therefore, it is believed that in 2004 estimated 1400 GHP units (of them ca 750 water-source type) were already installed in Slovenia and not only 300, as proposed by Rajver (pers. comm.) and mentioned by Lund et al. (2005). Thus, suddenly, this direct use type became the most advanced one. There are also greater capacity GHP units (>30 kW) among them installed in public buildings such as schools. One of the obstacles to the positive trend is higher cost of electricity for the GHPs owners who fall into higher tariff group for running the pump. This is contrary to what people have in Germany, for example, where for the used electricity for heat pumps the owners get lower price of electricity. This should be soon regulated by the state.

4. DISCUSSION

The distribution of capacity and annual updated energy use for various direct-utilization types as presented in Table 5 are based on data from the users and best estimates of the missing data. The total thermal capacity currently installed for direct use of geothermal energy in Slovenia amounts to roughly 66 MWt, including GHPs at thermal spas, but without numerous mostly small ground-source GHPs. The annual energy use at 29 localities amounts to 773 TJ, which is by 7% higher than in 2004, and is a consequence of new direct heat users. Otherwise, no dramatic changes in the last 15 years can be seen. Annual energy use is higher for bathing and swimming, space heating and district heating, and lower for air conditioning (perhaps just temporarily). The use for industrial process heat is suspended. Somehow strange are numbers for greenhouse heating as installed capacity has jumped from 8 MWt in 2004 to 13.6 MWt today, but the annual energy use with 95 TJ is slightly lower compared to 100 TJ in 2004. One of the possible reasons is that the average flow rate at Tesanovci greenhouses is no more as high as reported in 2004.

High enthalpy geothermal resources in Slovenia are still not in use. However, considerations have been initiated whether there are possibilities for such production in the north-eastern part (Pannonian basin) where the highest temperatures at depths of 3.5 to 4.5 km are encountered. The capacity of deep wells, also existing ones, is yet to be determined and tested, or new deep wells have to be drilled at appropriate localities, which have to be previously confirmed by better geophysical (seismic, microseismic) investigations with a goal to create an Enhanced Geothermal System.

Doublet scheme is in preparation to be put in use in Lendava downtown. In the north-eastern Slovenia the localities are the most vulnerable to overexploitation of thermal water as most users capture water from the same aquifer, but the problem is not yet tackled with needed care.

As mentioned in introduction, both Ministries (MOP and MGO) are not harmonized, and consequently due to different laws there are problems with the supervision (monitoring) of utilization and actual state in the field of localities.

The total number of professional personnel in geothermal activities in the period 2005-2009, is approximately allocated (Table 7) as five years before, except for adding few technician-engineers at thermal spas. The investments in geothermal (Table 8) do not present complete numbers, as some users don't report such data. Nevertheless, they show domination of private sector, and increase of investments due to augmented exploration and production drilling, and construction of new buildings and swimming pools at thermal resorts.

For the past 5 years drilling activity has been higher compared with earlier periods. To our knowledge 24 wells have been drilled with a total depth of 23.8 km (Table 6). Of these, 3 are geothermal gradient boreholes, 6 wells are production oriented with a total depth of 8.85 km, and one well is dedicated for reinjection in Lendava downtown. This one is still in a testing phase. The remainder 14 wells with a total depth of 13.3 km have been drilled for the exploration purpose. Some of them were drilled almost without any previous surface investigations or pre-feasibility studies, and consequently, their result was worse than expected. To our opinion 9 wells, both deep and shallow ones, are qualified as negative, but soon after new positive wells were drilled at 2 of these localities, thus improving the situation. The deepest new production well (2.2 km) is located in north-eastern Slovenia, and exploration well (2.1 km) in the central eastern part. Of five production wells drilled, four wells are already in use at Dobrovnik, Ptuj, Moravske Toplice and Mala Nedelja.

5. FUTURE DEVELOPMENT AND INSTALLATIONS

Few projects for further geothermal direct use development are planned or under way. According to Gejzir Co. the whole district system at Benedikt will have capacity of 3.3 MWt, and planned annual heat production is 14.4 TJ. In the same region the Nafta Geoterm Co. from Lendava have improved few old oil wells into geothermal ones for aquaculture or greenhouses, as for example near Turnisce with a plan to raise fish farming of african sheatfish. The exploration wells at Janezovci near Ptuj and at Mislinjska Dobrava are currently waiting for appropriate financial support to be able to develop the site and start producing. The exploration well near Metlika is available for potential use despite lower temperature encountered than expected, but infrastructure is missing.

Trends in geothermal are focused on enhancing the cascade direct use, lowering emitted thermal water temperature, promoting higher efficiency of installed capacity for direct use, effective problem solutions, regarding thermal water scaling and degassing, as well as performing new research for potential geothermal sites. As the number of users increases, interference between them has already been noticed. Problems that are already indicated are: reduction of cold drinking or technological water due to overpumping of thermal water, which represents its recharge. Moreover, the problem can be expressed in the opposite direction – lower recharge of deeper thermal aquifers due to overexploitation of shallow groundwater. Besides, increased demand for thermal water from the same aquifers causes negative quantitative trends, and potential disputes between nearby users. Therefore, users and national authorities should as soon as possible approach to unified and objective monitoring of geothermal resources in Slovenia, by controlling groundwater level, temperature, yield, and chemical composition of thermal water. If doublet system in Lendava proves to be effective, it should represent a demonstration project for other similar sites in Slovenia. Reinjection should then become nationally supported and (eventually) demanded in order to preserve the existent capacities of thermal water.

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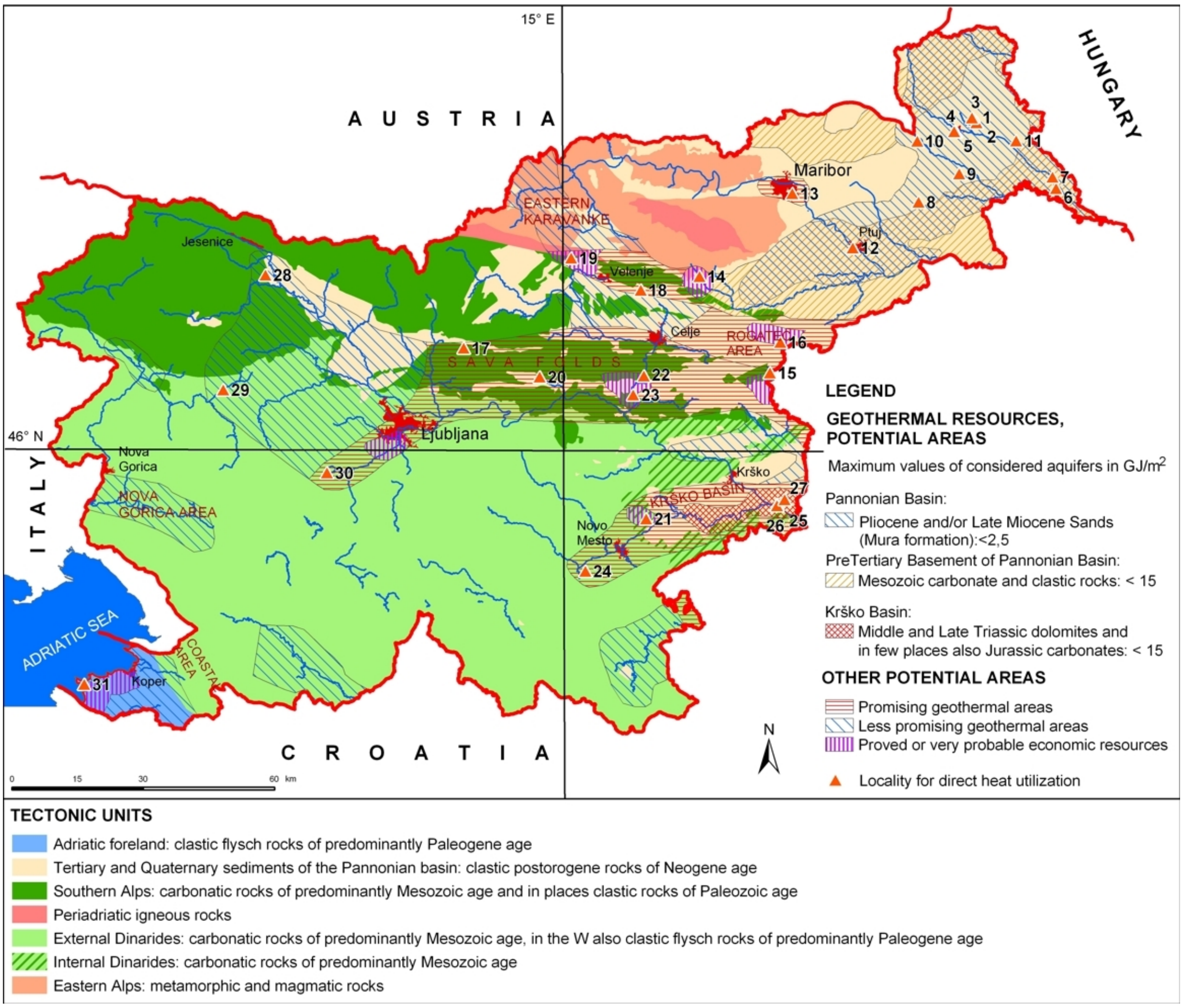

Figure 1: The main geotectonic units of Slovenia, and geothermal resources with potential areas. Numbers refer to localities in Table 3.

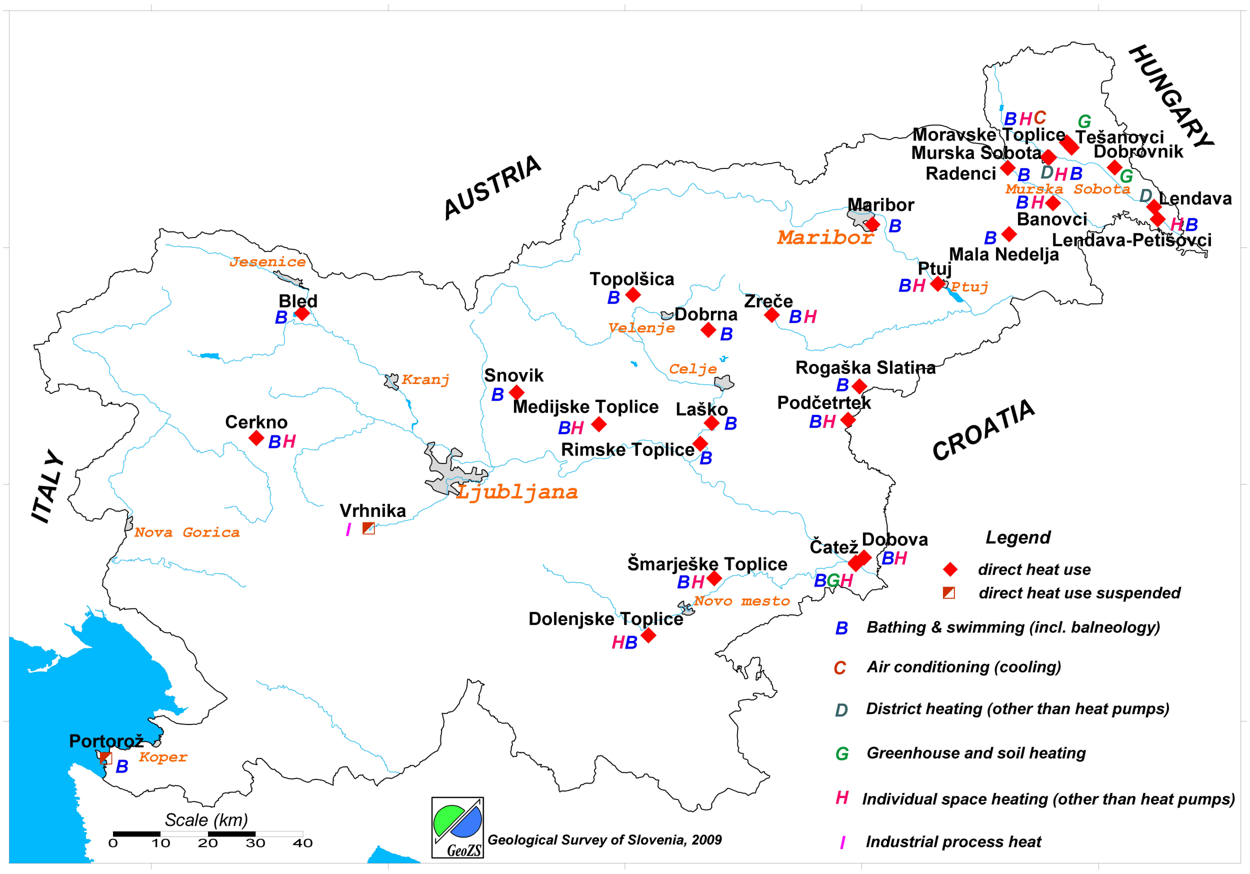

Figure 2: Localities with geothermal direct heat use in Slovenia (December 2009).

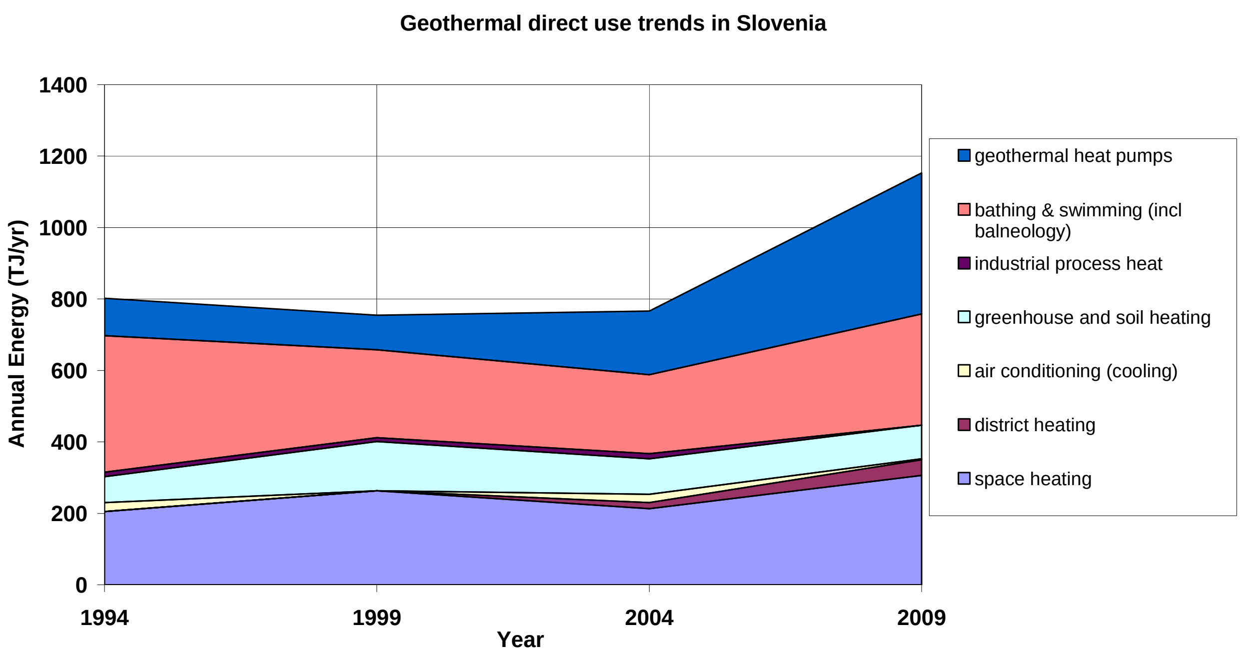

Figure 3: Geothermal direct use trends in Slovenia

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY IN SLOVENIA

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capacity MWe	Gross Production GWh/yr	Capacity MWe	Gross Production GWh/yr	Capacity MWe	Gross Production GWh/yr	Capacity MWe	Gross Production GWh/yr	Capacity MWe	Gross Production GWh/yr	Capacity MWe	Gross Production GWh/yr
In operation in December 2007			1241	4817	886	2814	696	5422	183	583	3006	13636
Under construction in December 2009					42.5	160						
Funds committed, but not yet under construction in December 2009					134 mioUS$							
Total projected use by 2015												

Other Renewables: small hydro power plants (< 10 MW), solar PV, biomass (the one not included among Fossil Fuels).
Sources: Report on situation in the energetics field in Slovenia in 2007, Agency of Republic of Slovenia for Energetics.
Ministry for Economy, Directorate for Energy (Mr. S. Škornik)

TABLE 4. GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS AS OF 31 DECEMBER 2009

This table should report thermal energy used (i.e. energy removed from the ground or water) and report separately heat rejected to the ground or water in the cooling mode. Cooling energy numbers will be used to calculate carbon offsets.

1) Report the average ground temperature for ground-coupled units or average well water or lake water temperature for water-source heat pumps

2) Report type of installation as follows: V = vertical ground coupled (TJ = 10^{12} J)
H = horizontal ground coupled
W = water source (well or lake water)
O = others (please describe)

3) Report the COP = (output thermal energy/input energy of compressor) for your climate

4) Report the equivalent full load operating hours per year, or = capacity factor x 8760

5) Thermal energy (TJ/yr) = flow rate in loop (kg/s) x [(inlet temp. (^{o}C) - outlet temp. (^{o}C)] x 0.1319
or = rated output energy (kJ/hr) x [(COP - 1)/COP] x equivalent full load hours/yr

Note: please report all numbers to three significant figures

Locality	Ground or water temp. (^{o}C)[1]	Typical Heat Pump Rating or Capacity (kW)		Number of Units	Type[2]	COP[3]	Heating Equivalent Full Load Hr/Year[4]	Thermal Energy Used (TJ/yr)	Cooling Energy (TJ/yr)
open loop: water-water	2 to 16	2 to 40 9 to 13 average	19.85	1606	W	2.4 to 6.0	900-2520	190	
closed loop: ground coupled	0 to 12	3 to 25	18.23	1698	H	2.9 to 4.5	1200-2520	159	
ground coupled	2.5 to 14	2 to 40	1.63	137	V	3 to 4.8	1800	30	13
TOTAL		MWt =	39.71	3441	W,H,V	2.4 to 6.0		379	13

TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2009 (other than heat pumps)

I = Industrial process heat
C = Air conditioning (cooling)
A = Agricultural drying (grain, fruit, vegetables)
F = Fish farming
K = Animal farming
S = Snow melting
H = Individual space heating (other than heat pumps)
D = District heating (other than heat pumps)
B = Bathing and swimming (including balneology)
G = Greenhouse and soil heating
O = Other (please specify by footnote)

Enthalpy information is given only if there is steam or two-phase flow

Capacity (MWt) = Max. flow rate (kg/s)[inlet temp. (^oC) - outlet temp. (^oC)] x 0.004184 (MW = 10^6 W)
or = Max. flow rate (kg/s)[inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

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

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					Capacity[3)]	Annual Utilization		
		Flow Rate	Temperature (^oC)		Enthalpy[2)] (kJ/kg)			Ave. Flow	Energy[4)]	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5)]
1 Moravske Toplice	HB	87	61.2	15			15.65	29.7	124.5	0.25
2 Tesanovci	G	27.8	40	30			1.16	8.3	11	0.3
3 Moravske Toplice-Vivat	CHB	12	60	29			1.56	3.8	14.54	0.3
4 Murska Sobota, HDiana	HB	12	43	22			1.05	10	23.74	0.71
5 Murska Sobota, Komunala	DB	10.3	49	30			0.82	7	17.54	0.68
6 Lendava Terme	HB	14	59	30			1.7	7.6	28.48	0.53
7 Lendava Town	D	25	66	40			2.72	15	31.7	0.37
8 Mala Nedelja	B	22	48.4	27			1.98	6	17.3	0.28
9 Banovci	HB	23.5	61.8	15			4.59	17	70.9	0.49
10 Radenci	B	6.5	42	28			0.38	1.5	2.77	0.23
11 Dobrovnik	G	30	62	15			5.9	2.4	14.6	0.08
12 Ptuj	B	23	41	29			1.15	14	21.4	0.6
13 Maribor	B	1.5	39	13			0.16	1.5	5.14	1
14 Zrece	HB	27	30.7	25.7			0.57	15	9	0.55
15 Podcetrtek	HB	36	43	28			2.3	36	71.2	1
16 Rogaska Slatina	B	8	60	28			1.07	1.2	4.43	0.13
17 Snovik	B	22	27.5	24			0.32	7.6	4	0.35
18 Dobrna	B	15	35	21.6			0.84	2	4.66	0.18
19 Topolsica	B	38.1	32	28			0.64	5.5	2.92	0.15
20 Medijske Toplice	HB	35	23	20			0.42	14	5.8	0.44
21 Smarjeske Toplice	HB	39	32.5	29.5			0.49	8.5	3.3	0.2
22 Lasko	B	10.8	33.8	31.6			0.1	10.8	3.13	1
23 Rimske Toplice	HB	22.6	39.6	32			0.72	3	2.77	
24 Dolenjske Toplice	HB	30	31.7	29.3			0.29	9.1	2.67	0.12
25 Terme Catez	HB	80	62	29			11.04	41	178.46	0.51
26 Flowers Catez	G	60	54	28			6.53	20	69	0.33
27 Dobova	HB	10	63	38			1.05	7	23.1	0.7
28 Bled G & P, GH Toplice	B	21	20	18			0.18	10	2.64	0.48
29 Cerkno	HB	30	27.6	24.5			0.39	6	2	0.12
30 Vrhnika*	I	12.4	21.9	15			0.36	0	0	
31 Portoroz*	B	0.8	23	18			0.02	0	0	
Benedikt	D		testing phase							
TOTAL		779.1					65.77	320.5	772.69	0.37
locality with*: not considered in Total numbers										

TABLE 5. 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
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. (TJ = 10^{12} J)

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] (TJ/yr = 10^{12} J/yr)	Capacity Factor[3]
Individual Space Heating[4]	22,4	306,23	0,43
District Heating [4]	3,29	44	0,42
Air Conditioning (Cooling)	0,13	2	0,49
Greenhouse Heating	13,6	94,6	0,22
Fish Farming			
Animal Farming			
Agricultural Drying[5]			
Industrial Process Heat[6]	0,36 not considered in total numbers	0	
Snow Melting			
Bathing and Swimming[7]	25,04	310,56	0,39
Other Uses (specify)			
Subtotal	64,46	757,39	0,37
Geothermal Heat Pumps	40,99	395,5	0,31
TOTAL	105,45	1152,89	0,35

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 6. 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 Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (gradient)	
Exploration[1]	(all)		14		3	13,697
Production	>150° C					
	150-100° C					
	<100° C		6			8,849
Injection	(all)		1			1,223
Total			21		3	23,769

TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with University degrees)

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Programs
(6) Private Industry

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2005		2	1			10
2006		2	1			10
2007		3	1			9
2008		3	1			9
2009		3	1			9
Total		13	5			47

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2009) US$

Period	Research & Development Incl. Surface Explor. & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999	1.94	4.08	13.33		99	1
2000-2004	2.56	4.43	45.7		96	4
2005-2009	8.5	7.89	53.1		90	10