OPERATIONAL PROGRAMME SLOVENIA-HUNGARY 2007-2013

REVIEW OF GEOTHERMAL ENERGY UTILIZATION IN NORTH-EASTERN SLOVENIA AND SOUTH-WESTERN HUNGARY

in the scope of project

Screening of the geothermal utilization, evaluation of the thermal groundwater bodies and preparation of the joint aquifer management plan in the Mura-Zala basin

T-JAM

REPUBLIC OF SLOVENIA
GOVERNMENT OFFICE FOR LOCAL SELF-GOVERNMENT AND REGIONAL POLICY

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Report prepared by:

Andrej Lapanje

Dušan Rajver

Edgár Székely

Project co-workers:

Špela Kumelj

Simon Mozetič

István Juhász

Péter Bányai

Laura Tóth

István Hamza

Director GeoZS:

doc. dr. Marko Komac

Director NYUDUKÖVIZIG:

István Nádor

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Content

Review of geothermal energy utilization in north-eastern Slovenia and south-western Hungary

1 Introduction

Direct use of geothermal waters continues to be the only type of a use from geothermal reservoir sources in Slovenia (Rajver et al., 2010) and it is performed at 29 localities. In Hungary geothermal energy is also utilized only for direct heat use at many locations; at least on 10 main localities and at more than 400 other, mostly smaller spa or bath centres (Toth, 2010). Direct use of geothermal energy is one of the oldest, most versatile and also the most common form of utilization of geothermal energy.

1.1 Preparation of questionnaire on geothermal direct use

Special questionnaire in tables on utilization of geothermal energy have been prepared and sent together with their short description to all direct heat users of geothermal energy in T-JAM project area in north-eastern Slovenia (Prekmurje and Podravje regions) and in south-western Hungary (Zala county and Vas county). These are standard tables sent by geothermal specialists to the geothermal users in other countries with the aim to follow the trend of geothermal energy use and to be acquainted with new developments in geothermal use worldwide.

The first Table 1 – "Utilization of geothermal energy for direct heat (other than heat pumps)" demands from each user to fill in some measured values for every locality. These are: flow rate at maximum utilization (from one or several boreholes), inlet and outlet temperatures at maximum utilization (so the capacity (MW_t) of all production boreholes can be calculated at each locality), average flow rate during annual utilization, as well as inlet and outlet temperatures, if they differ from those at maximum utilization. There from the annual energy used (TJ/yr) can be calculated.

The second Table 2 - "Geothermal (ground-source) heat pumps" shows an approximate number of all geothermal (ground-source) heat pump units that are installed in the T-JAM project area of both countries as water source (W), horizontal ground coupled (H) or vertical ground coupled (V) type, their typical heat pump rating or capacity, some other relevant data and annual thermal energy removed from the ground or water. Information on heat rejected to the ground or water in the cooling mode is poorly known.

The aim of the third Table 3 – "Summary table of geothermal direct heat uses" is to show distribution of utilized geothermal energy by category (types) of use. The users in north-eastern Slovenia utilize geothermal energy for these categories:

- Individual space heating (other than heat pumps) (H)
- Bathing and swimming (including balneology) (B)

- District heating (other than heat pumps) (D)
- Air conditioning (cooling) (C)
- Greenhouses and soil heating (G)

The users in south-western Hungary utilize geothermal energy for 2 categories only:

- Bathing and swimming (including balneology) (B)
- District heating (other than heat pumps) (D)

Every user should show the geothermal fluid flow rate distribution, both the flow rate at maximum utilization as well as the average flow rate at annual utilization, for all types of use individually. In this way the user can show how much geothermal energy is used for each type of use and what the capacity for each type of use is.

2 Geothermal utilization characteristics in the Slovenian project area

Tables 1 and 3 have been sent to the following direct heat users in north-eastern Slovenia:

1. Moravske Toplice, Terme 3000 d.o.o.
2. Grede Tešanovci d.o.o.
3. Moravske Toplice, Terme Vivat, Počitek-užitek d.o.o.
4. Murska Sobota, Hotel Diana d.o.o.
5. Murska Sobota, Komunala, Javno podjetje d.o.o.
6. Lendava, Terme Lendava d.o.o.
7. Lendava, Nafta-Geoterm d.o.o.
8. Mala Nedelja, BioTerme Mala Nedelja, Segrap d.o.o.
9. Banovci, Terme Banovci d.o.o.
10. Radenci, Terme Radenci, Zdravilišče Radenci d.o.o.
11. Dobrovnik, Ocean Orchids d.o.o.
12. Ptuj, Terme Ptuj d.o.o
13. Maribor, Terme Maribor d.d.

Geothermal utilization is still firmly based on direct use, implemented in north-eastern Slovenia at 13 localities (Figure 2). In north-eastern Slovenia geothermal energy is estimated to currently supply for direct heat uses 382 TJ/yr of heat energy, excluding geothermal (ground-source) heat pumps (GHP's), but including few geothermal heat pumps of greater capacity at one locality (see below). The corresponding installed capacity at all 13 users is 38,8 MW_t. On the other hand it is very difficult to predict what is the share of geothermal energy use with GHP's in north-eastern Slovenia from the total geothermal energy use with GHP's in Slovenia which is 49,9 MWt for capacity and 244 TJ/yr for geothermal energy used. We assume that there are about 600 installed GHP units of all types (W, V, H) together in both Prekmurje and Podravje regions with very approximate capacity of 8 MW_t which extract probably some 40 TJ/year of geothermal energy from the shallow subsurface. The latter values are very rough estimates because it is difficult to apprise the real number of operating GHP units.

2.1 General characteristics

Other than heat pumps the use for bathing and swimming and for space heating at our thermal resorts and spas are the main types of geothermal direct heat use, followed by greenhouses and district heating (Tables 1a and 3a). Four new direct users emerged in north-eastern Slovenia in the last 6 years. Three of them (Moravske Toplice-Vivat, Tešanovci, Dobrovnik) use the same regional Upper Miocene-Pliocene sand and loose sandstone aquifer (so called Mura formation aquifer), while the production well at Benedikt, that has been finished into Palaeozoic metamorphic rocks, is still in a testing phase.

TABLE 1a. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT AS OF 31 DECEMBER 2009 (other than heat pumps)

1) 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)

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.

northeastern SLOVENIA (Prekmurje and Podravje)

	Locality	Type[1]	Maximum Utilization					Capacity[3]	Annual Utilization		
			Flow Rate	Temperature (°C)		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, Terme 3000	HB	87	61,2	15			15,65	29,7	124,5	0,25
2	Tešanovci	G	27,8	40	30			1,16	8,3	11	0,30
3	Moravske Toplice, Terme Vivat	CHB	12	60	29			1,56	3,8	14,54	0,30
4	Murska Sobota, Hotel Diana	HB	12	43	22			1,05	10	21,37	0,65
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	BH	23	41	29			1,15	14	21,4	0,59
13	Maribor	B	1,5	39	13			0,16	1,5	5,14	1,02
	Benedikt (*not considered*)	D		testing phase							
	TOTAL		**294,6**					**38,82**	**123,8**	**381,24**	**0,31**

2.1.1 Bathing and swimming

There are 6 thermal spas and health resorts, and additional 4 recreation centres (3 of them as part of the hotels' accommodation) where swimming pools are heated by geothermal water directly or indirectly through heat exchangers or geothermal heat pumps. Wellhead water temperatures in thermal spas range from 39 to 72°C. The total geothermal energy used for bathing and swimming (incl. balneology) is estimated to 176,5 TJ/yr. At some localities in reference with year 2005 improvements were achieved by better temperature range utilization, first of all at Moravske Toplice (Terme 3000), and at Banovci using the heat exchangers.

2.1.2 Space heating and air conditioning

Space heating is implemented at 6 localities, predominantly thermal spas, at some of them directly (Banovci), at others through heat exchangers (Moravske Toplice, Terme Lendava) or geothermal heat pumps (Hotel Diana in Murska Sobota). The heating of sanitary hot water is included at many localities. The geothermal heat pump (GHP) units are installed only in the case of too low thermal water temperature for this type. At Moravske Toplice a new user, the Terme Vivat, emerged during the last 5 years. The total geothermal energy used for space heating is about 133,9 TJ/yr. Air conditioning (cooling) from geothermal energy is in operation presumably only at Terme Vivat, contributing about 2 TJ/yr of extracted energy.

2.1.3 District heating

There are only 2 geothermal district heating systems in Slovenia at present. In Murska Sobota about 300 dwellings under the Komunala authority are heated with geothermal energy through heat exchangers, 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.

2.1.4 Greenhouses

At Tešanovci 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, greenhouses with 1,4 ha (recently increased to 3 ha) have been constructed by Ocean Orchids Co. for orchids cultivation, both for domestic and foreign markets. The Ocean Orchids Co. uses 3 heat pump units to regulate water temperature for use in the piping system for greenhouses but this is not tackled extra here. Therefore, total geothermal energy used in the greenhouses is 25,6 TJ/yr.

2.1.5 Geothermal (ground-source) heat pumps

At Hotel Diana in Murska Sobota, the heat pumps, typically of greater capacity (0,26 MWt altogether), are used in open loop system for raising the thermal water temperature for further use in swimming pools and for space heating. Their contribution in used geothermal energy is about 4,75 TJ/yr and it is already included in the category “bathing and swimming”.

TABLE 2a. 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. (°C) - outlet temp. (°C)] x 0.1319
or = rated output energy (kJ/hr) x [(COP - 1)/COP] x equivalent full load hours/yr

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Locality	Ground or water temp (°C)[1]	Typical Heat Pump Rating or Capacity (kW)	(MWt)	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	8 to 16	8 to 14 on average	4	360	W	2.4 to 6.0	900-2520	20	
closed loop:									
ground coupled	0 to 12	3 to 25	2	200	H	2.9 to 4.5	1200-2520	13	
ground coupled	2.5 to 14	2 to 40	2	40	V	3 to 4.8	1800-1900	7	2
TOTAL		total	8	600	W,H,V	2.4 to 6.0		40	2

According to the recent numbers the 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 geothermal GHP's 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's crust is available practically everywhere in Slovenia except in the mountainous region. Depending on local conditions these units consist of ground coupled closed loop heat pumps (horizontal heat collectors, vertical heat collectors), and groundwater open loop heat pumps.

The exact number of operational GHP units presently installed in north-eastern 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 in north-eastern Slovenia in Pomurje and Podravje region there are approximately 600 GHP operational units that extract ca 40 TJ/yr of geothermal heat. Of these, we estimate that more than half are open-loop systems that extract annually roughly about 20 TJ from shallow groundwater, the rest are horizontal closed-loop (perhaps 13 TJ), or vertical closed-loop systems (perhaps 7 TJ of extracted energy). Thus suddenly, this direct use type became the most advanced one (Table 2a).

There are also greater capacity GHP units (>30 kW) among them installed in public buildings such as schools, but perhaps this is more the case in other parts of Slovenia, not so much in the Pomurje and Podravje region.

TABLE 3a. 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. (°C) - outlet temp. (°C)] 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. (°C) - outlet temp. (°C)] 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
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

($TJ = 10^{12}$ J)
($MW = 10^{6}$ W)

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] ($TJ/yr = 10^{12}$ J/yr)	Capacity Factor[3]
Individual Space Heating[4]	11,86	133,91	0,36
District Heating [4]	3,29	43,98	0,42
Air Conditioning (Cooling)	0,13	2,04	0,5
Greenhouse Heating	7,06	25,59	0,11
Fish Farming			
Animal Farming			
Agricultural Drying[5]			
Industrial Process Heat[6]			
Snow Melting			
Bathing and Swimming[7]	16,49	176,52	0,34
Other Uses (specify)			
Subtotal	38,83	382,04	0,31
Geothermal Heat Pumps	8	40	0,16
TOTAL	**46,83**	**422,04**	**0,29**

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

2.2 *Possibilities for geothermal electricity production*

There is no electricity generation from geothermal resources in Slovenia up to date. Geothermal power plant is very hardly realizable project at this moment in Slovenia. There are not (yet) proved deep aquifers with high enough temperature and high enough flow rate for economic operation of geothermal power plant. We may speak perhaps only about potential high temperature geothermal aquifers in the area of Petišovci and Murski gozd. The next problem that decreases the economic warrant (justification) of geothermal power plants is the necessity for utilizing thermal water with binary systems and with reinjection into geothermal reservoir owing to unfavourable chemical composition of thermal fluid even in case of proven geothermal potential in Slovenia (Rajver and Lapanje, 2010). The investigation on possibility to apply the Enhanced Geothermal System technology in those parts of north-eastern Slovenia with the highest geothermal gradient would be much welcome.

3 Geothermal utilization characteristics in the Hungarian project area

Tables 1 and 3 have been sent to the following direct heat users in south-western Hungary:

1. Zalaszentgrót, Szentgróti Víz- és, Fürdő Kft
2. Letenye, ÉKKÖV Kft.
3. Hévíz, Tóforrás
4. Hévíz, Szent András Állami, Reumatológiai és, Rehabilitációs Kórház
5. Hévíz, Hotel Aquamarin
6. Hévíz, Hotel Helios
7. Hévíz, Danubius Health, Spa Resort
8. Hévíz, DRV Zrt.
9. Alsópáhok, Kolping Családi, Hotel Kft
10. Lenti, Gyógyfürdő Kft.
11. Zalakaros, Gránit Gyógyfürdő Zrt.
12. Zalakaros, Karosinvest Idegenforgalmi, Szolgáltató Kft.
13. Bázakerettye, Önkormányzat, Szolgáltató Kft.
14. Nagykanizsa, Kanizsa Uszoda Kft.
15. Galambok, Castrum, Gyógykemping Kft.
16. Kehidakustány, Kehida Termál, Gyógyfürdő Üzemeltető, és Szolgáltató Kft.
17. Gelse, Gelse Termál, Vagyonkezelő és, Szolgáltató Kft.
18. Zalaegerszeg, Thermál Plus Kft.
19. Pusztaszentlászló, termálfürdő, Eurowild Kft.
20. Mesteri, Mesteri Termál Kft.

21. Szentgotthárd, Gotthárd Therm Kft.
22. Vasvár, Vasi Triász Kft.
23. Vasvár, Vasi Triász Kft, fűtés
24. Borgáta, Borgáta Forrás Kft.
25. Celldömölk, Termálfürdő
26. Sárvár, Termálfürdő
27. Sárvár, Danubius Hotel
28. Sárvár, Spirit Hotel
29. Szombathely, Termálfürdő

3.1 General characteristics

The project involves the area of the south-western Hungary that means the whole Zala County and Vas County. The geothermal heat is used by 29 users mainly for bathing and swimming including balneology in the spas in this examined area (Figure 2). District heating is applied in one location only out of total 18 localities. Spreading of geothermal heat pumps increased in the last few years but their number is still low.

3.1.1 Bathing and swimming

Following the questionnaire results 29 thermal water utilization sites are registered in 20 localities in the examined area. The water users operate 38 thermal wells for the purpose of thermal bathing and balneology. The annual average water flow rate is 107 l/s produced from 38 wells and the annual geothermal (heat) energy use is 226 TJ/year.
A natural lake-spring can be found in Hévíz where 400 l/s of thermal water comes to the surface as annual average flow giving 422 TJ/year of energy use. Altogether 507 l/s of thermal water from the thermal wells and the lake-spring is used for bathing giving the annual energy use to 648 TJ/year (Tables 1b and 3b). Nowadays more enterprises plan further utilisation of the big quantity run-off water of the lake-spring.

3.1.2 District heating

Thermal water is used for district heating only in one locality in Vasvár where a housing estate is heated with thermal water of 72^{o}C. The used heat energy is 12,4 TJ/year. There is no obligation for reinjection of thermal water. It is planned that a hospital and some public institutions will be heated by thermal water in Zalaegerszeg. Construction of the reinjection system is not finished yet.

TABLE 1b. 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. (°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

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

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 (kg/s)	Temperature (°C)		Enthalpy[2] (kJ/kg)		(MWt)	Ave. Flow (kg/s)	Energy[4] (TJ/yr)	Capacity Factor[5]
			Inlet	Outlet	Inlet	Outlet				
Zalaszentgrót Szentgróti Víz- és Fürdő Kft K-37 kút	B	26	32	30			0,22	1,66	0,44	0,06
Letenye ÉKKÖV Kft. K-59 kút	B	8,5	48	30			0,64	0,19	0,45	0,02
Hévíz Tóforrás	B	400	38	30			13,30	400,00	422,00	1,00
Hévíz Szent András Állami Reumatológiai és Rehabilitációs Kórház B-14 kút	B	35	38	30			1,17	10,70	11,30	0,30
B-32 kút	B	33	40	30			1,38	4,60	6,00	0,14
Hévíz Hotel Aquamarin B-4/a. kút	B	5,6	42	30			0,28	1,70	2,69	0,30
Hévíz Hotel Helios K-11 kút	B	11,5	37	30			0,33	7,70	7,10	0,68
Hévíz Danubius Health Spa Resort B-15 kút	B	14	41	30			0,64	3,20	4,60	0,23
Hévíz DRV Zrt. B-33 kút	B	13	37,5	30			0,40	4,10	4,00	0,32
Alsópáhok Kolping Családi Hotel Kft B-7 kút	B	10	38	30			0,33	1,10	1,16	0,11
Lenti Gyógyfürdő Kft. B-33 kút	B	13	70	30			2,17	3,30	17,40	0,25
K-23 kút	B	17,5	35	30			0,37	3,80	2,50	0,22
K-12 kút	B	5,7	56	30			0,62	2,00	6,80	0,35

Locality	Type[1]	Maximum Utilization					Capacity[3]	Annual Utilization		
		Flow Rate	Temperature (°C)		Enthalpy[2] (kJ/kg)			Ave. Flow	Energy[4]	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5]
Zalakaros										
Gránit Gyógyfürdő Zrt.										
K-11 kút	B	19	47	30			1,35	4,20	9,40	0,22
K-14 kút	B	26	53	30			2,50	6,30	19,10	0,24
K-5 kút	B	24	96	30			6,60	1,50	13,00	0,06
K-8 kút	B	36	106	30			11,40	1,14	11,40	0,03
Zalakaros										
Karosinvest										
Idegenforgalmi	B	9	53	30			0,86	1,43	4,34	0,16
Szolgáltató Kft.										
K-18 kút										
Bázakerettye										
Önkormányzat										
Szolgáltató Kft.										
K-1 kút	B	2	32	30			0,02	0,14	0,04	0,07
Nagykanizsa										
Kanizsa Uszoda Kft.										
B-62 kút	B	12	50	30			1,00	2,20	5,80	0,18
Galambok										
Castrum										
Gyógykemping Kft.										
K-7 kút	B	7,5	43	30			0,41	1,74	3,00	0,23
Kehidakustány										
Kehida Termál										
Gyógyfürdő Üzemeltet										
és Szolgáltató Kft.										
K-8 kút	B	25	51	30			2,20	3,17	8,80	0,13
K-12 kút	B	17	51	30			1,50	0,00	0,00	0,00
Gelse										
Gelse Termál										
Vagyonkezelő és										
Szolgáltató Kft.										
K-5 kút	B	8	42	30			0,40	0,28	0,44	0,04
Zalaegerszeg										
Thermál Plus Kft.										
K-193 kút	B	8	41	30			0,37	0,95	1,38	0,12
K-249 kút	B	10	43	30			0,54	0,00	0,00	0,00
K-286 kút	B	28	98	30			7,97	1,05	9,40	0,04
Pusztaszentlászló										
termálfürdő										
Eurowild Kft.										
K-2 kút	B	2,7	48	30			0,20	2,00	4,74	0,76
Mesteri										
Mesteri Termál Kft.										
K-8 kút	B	7,2	64	30			1,02	1,42	6,37	0,2
Szentgotthárd										
Gotthárd Therm Kft.										
B-44 kút	B	16,6	32	30			0,14	1,36	0,36	0,08
Vasvár										
Vasi Triász Kft.										
K-10 kút	B	1,00	72	30			0,18	0,86	4,76	0,84
Vasvár										
Vasi Triász Kft										
K-10 kút	D	10	72	30			1,76	2,25	12,46	0,22
Borgáta										
Borgáta Forrás Kft.										
K-6 kút	B	50	48	30			3,76	0,00	0,00	0
K-2 kút	B	12	48	30			0,90	0,95	2,26	0,08
Szombathely-										
Termálfürdő										
Vasvíz Zrt.										
B-46 kút	B	5,6	34	30			0,09	2,5	1,32	0,46
B-108 kút	B	9,5	34	30			0,16	1,42	0,75	0,15

Locality	Type[1)]	Maximum Utilization					Capacity[3)]	Annual Utilization		
		Flow Rate	Temperature (°C)		Enthalpy[2)] (kJ/kg)			Ave. Flow	Energy[4)]	Capacity
		(kg/s)	Inlet	Outlet	Inlet	Outlet	(MWt)	(kg/s)	(TJ/yr)	Factor[5)]
Sárvár										
Gyógyfürdő Kft.										
B-7 kút	B	12,5	44	30			0,73	5,5	10,15	0,44
B-35 kút	B	9,1	44	30			0,53	3,5	6,46	0,38
Sárvár										
Danubius Sz. Zrt.										
Thermál Hotel										
B-44 kút	B	13,3	48	30			1,0	1,36	3,22	0,1
Sárvár										
Spirit Hotel										
Thermal SPA										
K-53 kút	B	8,6	46	30			0,57	5,57	11,75	0,65
Celldömölk										
Városgondnokság										
Vulkán Fürdő										
K-45 kút	B	3,6	51	30			0,32	2,0	5,53	0,54
K-46 kút	B	6,6	33	30			0,08	2,2	0,87	0,35
K-60 kút	B	3,3	44	30			0,19	2,4	4,43	0,74
TOTAL		995,9	46,9	30			70,60	503,44	647,97	0,29

3.1.3 Geothermal heat pumps

The licensing authority of the geothermal heat pumps utilizing the heat energy of the field in the case of closed systems is the District Inspectorates of Mines. The competent District Inspectorate is in Pécs Zala County and the other one is in Veszprém Vas County in the examined area. The District Inspectorates issued 13 permits in Zala county and 3 permits in Vas County, therefore we assume with great confidence that they don't reflect the actual heat pump use. The licensing authority in the case of open systems resulting in water production is The Environment Nature Protection and Water Management Inspectorate in Szombathely.

Open system geothermal heat pump energy use has not been authorized in this area and the geological conditions are not favourable for this purpose. These open system utilizations pertain to the pebble-bed of the Danube river and concentrate in Budapest. Of course the operation of some systems installed without permission can not be excluded. Vertical type geothermal heat pumps are used mainly in the area by applying typically 50 m and occasionally 100 m deep probes.

The occasional use of heat pumps can be observed from the 1990's onward but we can talk about its spreading only in the last 10 years. The use of greater number of heat pumps can be observed only in the last few years from about 2005 on.

We determined the number of operating heat pump units by estimation on the base of the Report 2009 of the Hungarian Heat Pump Association and the country data given in the Hungary Country Update 2005-2009 of the University of Miskolc (Toth, 2010). In the examined area we estimate, that heat pump units are installed on at least 98 locations. These heat pumps use 18 TJ/year of thermal energy (i.e. energy removed from the ground or water) and reject to the ground 4 TJ/year in the cooling mode (Table 2b).

Therefore, the total installed capacity of all geothermal direct use categories (bathing with balneology, district heating without geothermal heat pumps) is 71,17 MWt and their annual thermal energy use is 659,7 TJ/year.

There is a lack of spreading of heat pumps owing to two factors essentially. One of them is lack of the right incentive significant state aid and the other hindering factor is high value of the electric power fee compared to the gas. It is not possible to achieve significant savings by operating the heat pump at the current electricity and gas fees.

TABLE 2b. 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.

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

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)

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

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

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

Locality	Ground or water temp. (°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)
Zala county								
closed loop: ground coupled	10-15	10-150	64	V	3-5	2000	12,5	2,9
open loop: water-water	10-15	10	6	W	3-5	2000	0,5	0,1
Vas county closed loop_ ground coupled	10-15	10-100	28	V	3-5	2000-4800	5	1
TOTAL			98	V, W	3-5		18	4

3.1.4 Other geothermal energy utilization

Geothermal energy is not used for heating greenhouses nor in agriculture in this area. A geothermal power plant does not operate in Hungary so far. Preparations for installation of geothermal power plant have started in some places in Hungary. Implementation of a pilot project has begun in the area of Ortaháza-Iklódbördöce. These localities are in the examined area in Zala County. Implementation started with contribution of The Hungarian Petrol Company, MOL Plc. by forming the producing and reinjection wells. The project is stopped because of the insufficient flow rate of the wells.

TABLE 3b. 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. (°C) - outlet temp. (°C)] 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. (°C) - outlet temp. (°C)] 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
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

($TJ = 10^{12}$ J)
($MW = 10^{6}$ W)

Use	Installed Capacity[1] (MWt)	Annual Energy Use[2] ($TJ/yr = 10^{12}$ J/yr)	Capacity Factor[3]
Individual Space Heating[4]			
District Heating [4]	1,76	12,46	0,22
Air Conditioning (Cooling)			
Greenhouse Heating			
Fish Farming			
Animal Farming			
Agricultural Drying[5]			
Industrial Process Heat[6]			
Snow Melting			
Bathing and Swimming[7]	68,84	635,51	0,29
Other Uses (specify)			
Subtotal	70,6	647,97	
Geothermal Heat Pumps		18	
TOTAL	**70,6**	**665,97**	**0,30**

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

4 Discussion and comparison between the regions of both countries

Comparison and differences between the regions of both countries could be drawn in several items (Table 4):

Table 4. Summary of geothermal utilization in the Mura-Zala basin										
Direct heat uses by category										
Use	Flow rate at maximum utilization	Installed capacity	Average flow rate	Annual energy use	Capacity factor	Flow rate at maximum utilization	Installed capacity	Average flow rate	Annual energy use	Capacity factor
	(kg/s)	(MWt)	(kg/s)	(TJ/yr)		(kg/s)	(MWt)	(kg/s)	(TJ/yr)	
	SLOVENIA					HUNGARY				
space heating	81	11,86	38	133,91	0,36					
District heating	32,2	3,29	20	43,98	0,42	10,00	1,76	2,25	12,46	0,22
conditioning (cooling)	1	0,13	0,5	2,04	0,50					
Greenhouse heating	57,8	7,06	11	25,59	0,11					
swimming (incl. balneology)	122,6	16,49	54,3	176,52	0,34	985,90	68,84	501,19	635,51	0,29
Subtotal	294,6	38,83	123,8	382,04	0,31	995,90	70,6	503,44	647,97	0,29
ground-source heat pumps*		8		40	0,16				18	
TOTAL		46,83		422,04	0,29		70,6		665,97	0,30
remarks:										
*These numbers are a best guess possible, as we do not know more exactly how many ground-source HP units of all 3 types										
(open loop-W, closed loop-V and H) are installed										
Geothermal HPs at thermal spa centers: These GHPs (usually of greater capacity) are used to raise water temperature to higher level										
for further use as swimming pools, sanitary water, etc.										
This is taken into account directly at types of use H and B (Table 1 and 3) for the Slovenian part.										

-Total flow rate at maximum utilization

As it was expected due to the greater area and longer history of utilization, the flow rate capacity of geothermal production wells in the Hungarian part of the Mura-Zala basin is much greater than that of the Slovenian part. Total flow rate at maximum possible utilization from Hungarian sources is 996 kg/s from 39 wells and one strong spring in Hévíz which gives alone 400 kg/s. The total flow rate at maximum utilization from the 25 Slovenian wells is 295 kg/s.

-Capacity of geothermal boreholes

The installed geothermal capacity which is calculated as shown in Table 1, i.e. comprising the maximum flow rate and the inlet and outlet temperature difference, is of course, also higher in the Hungarian part, showing 71,17 MWt, while in the Slovenian part it is 38,83 MWt.

-Average flow rate at annual utilization

The average flow rate at annual utilization shows among other things how productive are the geothermal aquifers and how technically efficient are the wells. For the Hungarian part this average flow rate is 509 kg/s in total (or 51,1% of the total flow rate at maximum utilization), including 400 kg/s from the Hévíz spring and in the Slovenian part 124 kg/s (or 42% of the total flow rate at maximum utilization). This shows that especially at some Hungarian localities this flow rate is much lower than that at maximum possible utilization. However, at some Slovenian localities the situation on boreholes' efficiency is not so good as well.

-Geothermal energy used at annual utilization

The annual geothermal energy used (equation in Table 1) amounts to 659 TJ/yr for both direct heat use categories in the Hungarian part (predominantly bathing and swimming including balneology and district heating at Vasvár), while in the Slovenian part it is 382 TJ/yr for five direct use categories, mostly bathing and swimming including balneology, and individual space heating at spa and thermal centres.

-Average capacity factor

For direct heat uses together the average capacity factor is similar in both countries, being 0,29 in the Hungarian part and 0,31 in the Slovenian part, without GHPs. If GHPs are included it is also 0,29 for Slovenian part because the capacity factor for GHP units is usually low which is a common feature in most countries.

-Types of geothermal energy use

In the Hungarian part of T-JAM project area there are only two categories of direct heat use of geothermal energy, while in the Slovenian part there are five (Table 4 and Figure 1), and in near future at least one or two more are in preparation (snow melting, fish farming). Probably similar future plans exist also in south-western Hungary to expand the direct heat use to some other categories. Geothermal heat pump units (Table 2a, 2b) are at the moment more spread in the Slovenian part of T-JAM project area. We assume this is due to several factors:

- favourable hydrogeological conditions on Slovenian side,
- longer history of installation (from the 1980's) in Slovenia and
- low gas prices in Hungary in the past.

In both countries it is impossible to get more exact numbers about them due to reasons explained earlier.

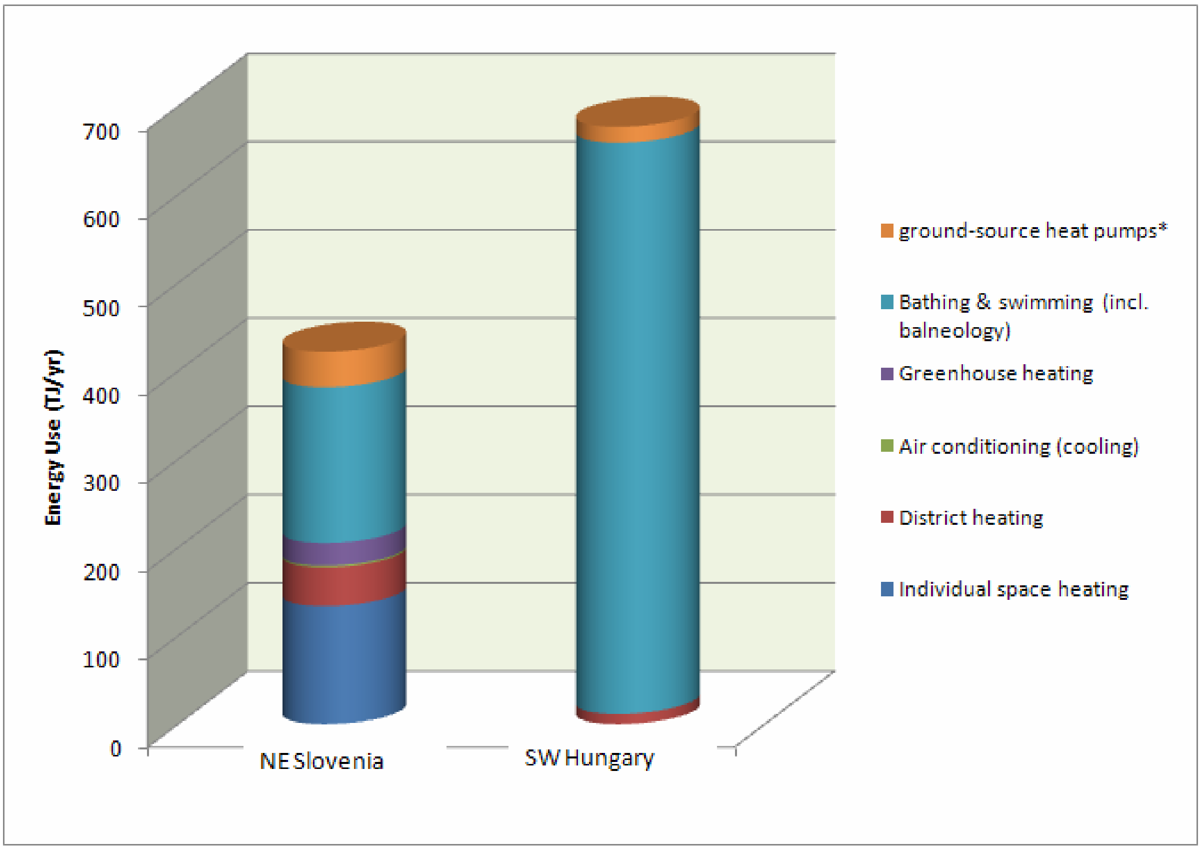

Figure 1. Annual geothermal energy use in the regions and counties of both countries as of direct heat use category.

-Maximum available temperatures at wellheads

In the Slovenian part the maximum available temperatures at wellheads are at Moravske Toplice Terme 3000 (72°C from the Mt-1, Mt-4 and Mt-5 wells), at Banovci Terme (68°C at the Ve-2 well) and at Lendava downtown (66°C from the well Le-2g). In the Hungarian part, however, wellhead temperatures are even higher; the highest are at Zalakaros (106°C from the K-8 well, 96°C from the K-5 well), at Zalaegerszeg (98°C from the K-286 well) and at Lenti (70°C from the B-33 well). This tells us something about the depth of thermal water circulation.

5 Conclusion

This report represents an overview of geothermal energy direct use as of first half of 2010. There is a great necessity for systematic data collection following the unified methodology and for improvement of the users' database with better data quality. Especially on Hungarian side it is necessary to collect additional data from the already existing users for whom no credible data have been collected so far.
It is very much satisfactory that geothermal direct heat use as well as the number of geothermal (ground source) heat pumps increases in both countries so far. Hopefully the positive trend will continue.

6 References

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Figure 2: Geothermal users in the T-JAM project area