Geothermal Energy Use, Country Update for Hungary

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ABSTRACT

In Hungary geothermal district-heating and thermal-water heating cascade systems represent a major part of direct use available in 23 towns representing about 223.36 MW_{th} installed capacity and 635.66 GWh_{th}/y annual production. Major new projects have been established in Győr and Szeged. Individual space heating (mostly associated with spas) is available at nearly 40 locations representing an estimated installed capacity of about 77.2 MW_{th} and 83.1 GWh_{th}/yr production. The agriculture sector is still a key player in direct use, especially in the S-ern part of the Hungary, where heating of greenhouses and plastic tents have long traditions. These account for about of ~ 358 MW_{th} installed capacity and ~ 803 GWh_{th}/yr production. Balneology has historical traditions in Hungary, more than 250 wells yield thermal water, sometimes medicinal waters which represent a total installed capacity of 249.5 MWt with an annual use of about 745.5 GWh_{th}/yr..

The first Hungarian geothermal power plant project has been implemented in Tura, with a 3 MW_e capacity.

The shallow geothermal sector unfortunately does not show real development and due to the lack of registers it is hard to assess the real number of GSHP-s. In the family house market and in other official and industrial applications the air-based heat pumps became dominant. The majority of the new applications are installed in new office buildings.

1. INTRODUCTION

The Pannonian basin in Central Europe is one of the European areas with well-known positive geothermal anomaly, where the rich geothermal resources have been utilized mainly for direct use purposes for a long time. The last country update (Nádor et al. 2016) was based on data from 2014-2015 of about 850 active thermal water wells (those having outflow temperature higher than 30 °C). Despite continuous efforts of merging and harmonizing existing databases available at mining authorities, research institutes and water management organizations, the very high number of thermal water wells (around 800-1000) and the different registers tailored to their specific needs and purposes of the above organizations still impede the establishment of a fully harmonized and up-to-date national geothermal database. In this paper we collected, assessed and presented data from 2017 (the latest available at time of preparing the manuscript). Due to the heterogeneous datasets some discrepancies (e.g. differences between actual flow rates and reported well-data, lack of information on the real temperature gradients, abstracted amount of thermal water and type of utilization, changing data due to seasonal operations of wells, etc.) impede exact calculations. The reported numbers represent the author's own calculations based on data submitted by users and datasets from the various databases, and should be considered as best estimates. The reported numbers show realistic growth compared to the numbers of the previous country update reports (Tóth 2015, Nádor et al. 2016).

The steady increase of new wells in each year (Table 1) demonstrates how the geothermal sector is developing in Hungary, which is partly associated with the expansion of previous projects, partly related to new projects.

	2016	**2017**
agriculture	3	6
space heating and district heating	2	2
spa	2	5
other / unknown purpose	1	3
Total number of new wells	**8**	**16**

Table 1: New thermal water wells in Hungary drilled in 2016-2017

2. GEOTHERMAL POTENTIAL OF HUNGARY

The outstanding geothermal potential of the Pannonian Basin is manifested in elevated heat flow density (50-130 mW/m^2 with a mean value of 90-100 mW/m^2) and a geothermal gradient of about 45 °C/km. This is a result of the Early-Middle Miocene formation of the basin, when the lithosphere stretched and became thinner (the crust is "only" 22-26 km thick), and the hot astenosphere got closer to the surface (Horváth and Royden 1981).

There are two major types of geothermal reservoirs. The first types is the so called *basement reservoir,* associated with the main tectonic zones and the uppermost weathered-karstified zones of the deeply buried Palaeozoic-Mesozoic carbonates and crystalline rocks forming the basement of the Pannonian Basin. At a depth of 2000 m or more, where temperature can exceed 100-120 °C these zones with increased secondary porosity form favourable geothermal reservoirs. The second type is the *basin-fill reservoirs*. These lie within the several thousand meter thick multi-layered, porous Upper Miocene-Pliocene "Pannonian" basin fill sequence, where the main geothermal aquifers are associated with regionally extended 100-300 m thick sand-prone units. They are found in a depth interval of ca. 700-2000 m in the interior parts of the basin, where the temperature ranges from 60 to 90 °C. These reservoirs have an almost uniform hydrostatic pressure.

Some high-enthalpy reservoirs also exist in Hungary. They are related to deep-lying (3500-4000 m), overpressured fractured rocks (dolomites). In addition, deeply-buried granitoid rocks with high in-situ rock temperatures (≥ 200 °C) and favourable seismo-tectonic settings (extensional regime, low level of natural seismicity) provide promising settings for future EGS project developments.

3. NATIONAL GEOTHERMAL ENERGY POLICY AND REGULATORY FRAMEWORK

The regulatory and policy framework of deep geothermal have been summarized in the previous country updates (Tóth 2015, Nádor et al. 2016), so in this paper we highlight only the most important changes since 2016.

Hungary depends on energy imports, with 83% of its hydrocarbons and about 20 billion m^3/year of natural gas imported mainly from Russia. This threatens the country's energy security, especially in the heating sector. Hungary's National Renewable Energy Action Plan target is 14.65% RES by 2020 with a 17% share of geothermal in total RES. The geothermal target numbers by 2020 are 5.99 PJ (GSHP), 16.43 PJ (direct use) and 57 MW$_e$ (power production).

There has been a delay in the implementation of the NREAP targets in the case of both shallow and deep geothermal capacity and production, especially in power production. The Government expressed many times its strong intention to support geothermal energy in Hungary. The EU2030 targets, including the 32% RES proportion at EU level, are also taken into consideration.

The newly established (in 2018) Ministry of Innovation and Technology coordinates developments of the entire energy sector, thus also geothermal energy. An important action was the establishment of the Energy Innovation Council in 2018 with the aim to provide expert inputs to the review of the Energy Strategy of Hungary. The Council has several thematic sub-groups, one dedicated to Renewable Energy, where geothermal energy has an important role, including the review of the subsidies and supports.

A new feed-in tariff system has been issued. This system follows the related EU regulations and ensures a competitive takeover price for geothermal power plants.

The 1345/2018. (VII. 26.) Governmental Decision on the Action Plan of the Utilization and Management of Energetic Mineral Resources is an important piece of recent legislation as it sets up concrete tasks with deadlines and responsible ministries concerning deep geothermal energy. It states that during the development of national RDI programs and funding schemes geothermal power production without water abstraction and reinjection technologies should be treated as priorities. The other important point is that it addresses geothermal risk mitigation: it calls on the Minister for Innovation and Technology and the Minister for Finances to make a joint proposal on introducing financial tools for the mitigation of high upfront risks for geothermal projects (i.e. a risk insurance scheme) by June 2019.

4. SHALLOW GEOTHERMAL

There are still no reliable GSHP registers available in Hungary, because the systems shallower than 20 metres do not require a license, not even a notification to the authorities. Therefore the numbers reported in Table E are the best estimates of the authors.

The increase of GSHP numbers has continued over the last several years. In the family house market and in other official and industrial applications, air-based heat pumps represent a significant part. The majority of the new applications such as communal heating/cooling are installed in new buildings by new companies. The cooling function makes GSHPs more competitive in the greenfield constructions market.

In the case of shallow geothermal systems, the system sizes continue to increase. A 1650 kW heating and 720 kW cooling capacity heat pump system was developed and began operation at the NATO base in Pápa in 2018.

According to the national geothermal potential assessment (Zilahi-Sebess et al. 2012) the GSHP potential of Hungary is as much as 23 PJ/year. The 2012 estimation of the Hungarian Heat Pump Association forecast a 3.6 PJ/year by 2020. Unfortunately, this goal will not be met.

Currently there are two types of incentives:

- The eco tariff ("H tariff") provides a preferential tariff for the electricity consumption of heat pumps and other renewable energy heating equipment (e.g. thermal solar collectors, circulation pumps, etc.) used for the heat supply of buildings from renewable energy sources. This is a national and obligatory scheme, introduced in a ministerial decree (70/2009 (XII.4) KHEM) and is available for all consumers eligible to use the countrywide electricity service [Electricity Act Art. 3(7)]. The subsidized tariff is available only in the heating season.

- The voluntary preferential tariff (“B” GEO tariff) for heat pumps of COP higher than 3. This scheme is available only in those areas where the service provider (at the moment only ELMÜ-ÉMÁSZ) introduced this system; it is however accessible for the whole year.

The currently existing incentives are not enough to maintain the development of the heat–pump market experienced earlier.

There are several hybrid renewable and UTES projects being planned in Hungary. They include solar-geo hybrids for building energy-efficient development projects.

5. DEEP GEOTHERMAL

5.1. Power generation

There is one geothermal power plant in Hungary (Table A). Regulatory changes and ongoing project investigations ensure that geothermal based power production will make an appearance by the 2020s.

Since the introduction of the concessional system in 2010 (obligatory for the exploration and exploitation of geothermal energy at a depth below -2,500 m, the typical depth range for power production and CHP projects) a preliminary complex vulnerability and impact assessment (CVIA) has been prepared for over 20 potential geothermal areas, as a pre-requisite for concessional tendering. The aim of the CVIA is to provide a general overview of the future concessional area (geology, hydrogeology, geothermal conditions, etc.) and to determine those factors and areas within the planned concessional block, where future “mining activity” cannot be performed due to several restrictions (environmental- and nature protection, water management, protection of cultural heritage, agriculture, national defence, land-use, etc.). These reports are public and can be downloaded (in Hungarian) from the website of the Mining and Geological Survey of Hungary (www.mbfsz.gov.hu). So far 3 geothermal concessional contracts have been signed for 35 years that can be extended once more for a maximum of another 17.5 years: Jászberény, Battonya and Győr - the latter for heating, as discussed in chapter 5.2.

The Jászberény area has deep hydrothermal potential for CHP applications, where exploration is ongoing. The planned electric capacity of the Jászberény project is 2–5 MW_e, depending on the success of exploration efforts.

The Battonya EGS project, with a planned net electrical capacity of 9.8 MW_e. was suspended in 2018.

The first Hungarian geothermal power plant project has been implemented in Tura, although it was not part of a concession tender. This is project is located in a well-explored former hydrocarbon block, where an uplifted Triassic carbonate block was found in basement rock, in the depth range of 1700-2200 m. Due to its depth range this area does not require a geothermal concession. The production well produces 125 ºC, 6000 l/min hot water from a depth of 1500m. The total water volume is injected at 8 bar pressure into the reservoir, by means of two injection wells. The project aimed to achieve a 3.0 MW_e capacity. Actual gross electricity production is however only 2.3 MW_e, of which nearly 1 MW_e is the electricity demand of the power plant. Thus, it is capable of 1.3 MW_e net. An 11-hectare greenhouse complex is also planned.

5.2. Direct heat utilization

Geothermal “district” heating is available in 23 towns in Hungary in 2017 (Table D1), which altogether represent an installed capacity of 223.36 MW_{th} and 635.66 GWh_{th}/yr production. These are partly geo-DH systems, where geothermal energy contributes to the already existing district heating infrastructure (operated otherwise by gas) with a 30 to 100% share of geothermal (Makó, Csongrád, Hódmezővásárhely, Szentes, Vasvár, Szentlőrinc, Miskolc, and Győr). The majority of the systems are so called “thermal water heating cascade systems”, where the gas-based heating of some public buildings (town halls, libraries, schools, hospitals, etc) is replaced by geothermal. Other nearby buildings (private houses) may also eventually connect to the newly established thermal water pipelines. These systems are not currently connected to existing district heating systems, which only supply heat to a separate part of the settlement through a heat supply centre (Kistelek, Veresegyház, Bóly, Mórahalom, Gárdony, Mezőberény, Szarvas, Szeged, Barcs, Cserkeszőlő, Szolnok, Szigetvár, Törökszentmiklós, and Tamási). These local systems are commissioned on the basis of a water license and are often run by local municipalities, or municipality-owned service providers. This contrasts with the district-heating systems, where heat is provided by a trading company on a contract basis, regulated by the Hungarian Energy and Public Utility Regulatory Authority.

Hungary’s largest geothermal district heating project, developed by Pannergy Plc. is in Miskolc, and was commissioned in 2013. This site has 2 production and 3 reinjection wells producing thermal water from karstified-fractured Triassic basement carbonates at a depth of 1500-2300 metres, with a total installed capacity of 55 MW_{th}. The system supplies the district heating and domestic hot water for the large panel blocks of the Avas housing estate in Miskolc, Hungary’s 3rd largest city. The main heat center is found in Kistokaj, about 1 km north of the production wells, with the secondary heat center in the city of Miskolc itself.

After the completion of the Miskolc project, Pannergy Plc. accomplished its next large direct use project near Győr in NW-Hungary, where the system was commissioned in 2015. The exploration targeted the fractured Triassic dolomite basement at a depth of 2300-2850 m, which provided a very high yield (150 l/sec) and outflow temperature (100-105 °C). The technology supplies heat to a large industrial user (Audi Motor Hungary) in the town's suburbs as well as to the town's district heating system. Its heat capacity is 52 MW_{th}. There are three production wells with 101-102 °C outflow temperature at the well-heads.

In Szeged, a city of nearly 163,000 habitants at the Hungarian-Serbian-Romanian border, an ambitious project recently began, with the aim of introducing geothermal energy into the district heating network. Presently, two triplets are operating, with one production well (at a depth around -2000 m) and two injection wells (at a depth range of -1400 to -1700 m) targeting porous basin fill reservoirs. The systems have 4.4 and 4.5 MW_{th} capacity. Another nine triplets, with similar layout and a capacity of 3 – 5 MW_{th} each are under development: 4 triplets already have licenses; the other 5 triplets are under permitting.

In Tótkomlós a 22 MW_{th} capacity geothermal project is currently being developed. The depth of the wells is 2200 m, and the planned well head temperature is 135 °C. About 1000 private heat consumers and a 13 hectare greenhouse park will be supplied by geothermal heat. If the project succeeds, a 3 – 5 MW_e electricity may also be produced.

The implementation of the Zsana-Kiskunhalas geothermal district heating project is going to be launched soon. The depth of the reservoir is 2000 – 2500 m, and the water temperature is over 120 °C. The municipality buildings in Zsana and Kiskunhalas towns and also a 10 hectare greenhouse will be heated.

The Mosonmagyaróvár geothermal district heating project has begun. The depth of the production well is at -2200 m, and well-head temperature is 82 °C. The brine will be reinjected at production depth.

The technical plans of the Mátészalka district heating has been prepared, with implementation planned for 2019. The depth of the wells is 1200 m, and the water temperature is 60 °C. The planned heat capacity is 2.5 MW_{th}.

The city of Tamási is a good example of effective utilization of low enthalpy resources. The temperature of the thermal water is 47 °C, but the municipality institutes are heated by a production-reinjection doublet.

In addition to district and thermal water town heating cascade systems, a significant number of individual space heating is being used, mostly associated with spas (Table D2). These represent altogether an installed capacity of 77.2 MW_{th} and 83.1 GWh_{th}/yr production.

The major sector for direct heat utilization in Hungary is still agriculture. Heating of greenhouses and plastic tents and other energy purposes (e.g. heating for animal husbandry) represents an installed capacity of ~358 MW_{th} and about 803 GWh_{th}/yr production. The major users are Árpád-Agrár Zrt in Szentes, Flóratom and Bauforg Ltd-s. in Szeged, Bokrosi Ltd. in Csongrád and Primőr-Profit Ltd in Szegvár, but there are many others, especially in SE-Hungary.

A large proportion of the wells are used for balneological purposes. The outflow temperature typically ranges between 30 and 50 °C. The hottest ones are at Zalaegerszeg (SW-Transdanubia, 95 °C) and at Gyula (SE Hungary at the Romanian border, 89 °C). The estimated installed capacity of the wells used for balneology is about 249.5 MW_{th} with an annual use of about 745.5 GWh_{th}/yr (Table C).

In the "other" category (reported together with balneology in Table C), thermal water for "public water supply" is mostly considered to mean drinking water. "Drinking thermal water" is a concept specific to Hungary, where 90% of the drinking water supply is provided from groundwater. In areas where the shallow aquifers are contaminated (such as SE-Hungary, where there is a naturally high arsenic content) lukewarm thermal waters with low TDS from slightly deeper confined aquifers are used.

6. GEOTHERMAL EDUCATION

The University of Miskolc is the only institution in Hungary which offers Geothermal Engineering programs, and has done so since 2008. This 4-semester program covers twenty curricula topics. Its students can receive the equivalent of a BSc or an MSc in Geothermal Engineering. In partnership with the University of Colorado, the University of Miskolc has also brought together international professors and geothermal experts to create an up-to date geothermal curriculum for e-learning undergraduates. E-learning students can choose from the following courses (credit numbers are in brackets): Elements of Renewable Energy (5), Advanced Geology (6), Advanced Geophysics (6), Fluid Dynamics (6), Hydrogeology (5), Drilling Well Design (6), Geothermal Reservoirs (5), Geothermal Water Production (5), Geoinformatics (5), Geothermal Chemistry (5), Geothermal Heat-Transfer Systems (5), Geothermal Power Production (5), Geothermal Direct Uses (5), Geothermal Heat Pumps (5), Geothermal Environmental Impacts (5).

7. RESEARCH AND INNOVATION

Of late, Hungarian institutes, universities and companies have coordinated or participated in several research, development and innovation projects. The scope of these projects covers

- geothermal district heating
- reinjection of brines into sandstone reservoirs
- extraction of minerals from thermal water

- mitigation of technical risks in geothermal energy exploration and production activity
- geothermal risk insurance
- assessment of transboundary geothermal reservoirs

University of Miskolc and University of Szeged are partners in the H2020 project CHPM-2030, which aims to develop a novel technology that will serve the basis for combined heat and power use and strategic metal extraction by converting ultra-deep metallic mineral formations into an "ore body-EGS". This project finishes in June 2019.

The Mining and Geological Survey of Hungary is the lead partner of the DARLINGe project (funded by the Danube Transnational Program) which aims, together with Mannvit Hungary, InnoGeo Ltd, the Hungarian Ministry of Foreign Affairs and Trade, and other partners from 5 neighbouring countries, to assess the transboundary geothermal energy resources of the Southern part of the Pannoninan basin.

The Eötvös Loránd University at Budapest was granted a 3 year program (ENERAG) to strengthen research and innovation capacity in the field of subsurface fluids, taking advantage of international networks of excellence. The knowledge of subsurface water, geothermal and hydrothermal fluids and their interrelationships determines the possibilities of water management, geothermal energy utilisation, as well as the exploration and use of mineral raw materials.

Funded by the Economy Development and Innovation Operation Programme, a large scale exploration project has been performed, with the goal of studying the geothermal potential south of the Mecsek Mountians led by Mecsekérc Ltd. The project also targets a future geothermal (power) plant supplying green energy to the city of Pécs.

The Hungarian Energy and Public Utility Regulatory Authority requested in 2016 that a study be made to analyze and summarize the geothermal potential of every one of the country's 19 counties. 1622 thermal wells and in addition, more than 70 abandoned hydrocarbon wells were also analyzed. To make it easier for the average user, five different isothermal maps of Hungary were created, showing the different depths at which a particular temperature was attained. Those temperatures were 90 ºC, 70 ºC, 60 ºC, 50 ºC and 90 ºC. In addition to creating a solid informational basis where none had existed before, the study was valuable as a means of showing all 19 Hungarian county governments how they might profit from their geothermal potential.

8. CONCLUSIONS

Although Hungary has favorable natural conditions for geothermal energy production, production and utilization has lagged behind expectations. Nevertheless, there are promising signs. For the Hungarian geothermal industry to progress, it needs a well-considered energy policy together with a framework of supportive legal and financial conditions.

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Tables A-G

Table A: Present and planned geothermal power plants, total numbers

	Geothermal Power Plants		Total Electric Power in the country		Share of geothermal in total electric power generation	
	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (MW_e)	Production (GWh_e/yr)	Capacity (%)	Production (%)
In operation end of 2018	3.0*	0*	8,617*	32,700*	0.035*	0
Under construction end of 2018	0	0	est. 150	est. 240	0	0
Total projected by 2020	3.0	20	8,900	34,000	0.034	0.059
Total expected by 2025	12	80	9,200	36,000	0.130	0.222
In case information on geothermal licenses is available in your country, please specify here the number of licenses in force in 2018 (indicate exploration/exploitation if applicable):					Under development: 1	
					Under investigation: 2	

* If 2017 numbers need to be used, please identify such numbers using an asterisk

Table B: Existing geothermal power plants, individual sites

Locality	Plant Name	Year commis-sioned	No of units *	Status	Type	Total capacity installed (MW_e)	Total capacity running (MW_e)	2018 pro-duction (GWh_e/y)
Tura	Tura	2018	1 (RI)	under setting into operation	B-ORC	3.0*	0	0
total						3.0	0	0

Key for status:		Key for type:			
O	Operating	D	Dry Steam	B-ORC	Binary (ORC)
N	Not operating (temporarily)	1F	Single Flash	B-Kal	Binary (Kalina)
R	Retired	2F	Double Flash	O	Other

* In case the plant applies re-injection, please indicate with (RI) in this column after number of power generation units

Table C: Present and planned deep geothermal district heating (DH) plants and other uses for heating and cooling, total numbers

	Geothermal DH plants		Geothermal heat in agriculture and industry		Geothermal heat for buildings		Geothermal heat in balneology and other	
	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)
In operation end of 2018	223.36*	635.66*	358.12*	803.1*	77.2*	83.1*	249.5*	745.5*
Under constru-ction end 2018	0	0	3	6,75	2	2	2	6
Total projected by 2020	240	700	365	832	80	83	253	757
Total expected by 2025	300	850	380	867	90	95	263	787

* If 2017 numbers need to be used, please identify such numbers using an asterisk

Table D1: Existing geothermal district heating (DH) plants, individual sites

Locality	Plant Name	Year commis-sioned	CHP	Cooling	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2018 produc-tion * (GW_{th}/y)	Geoth. share in total prod. (%)
Barcs	TH	2014	No	No	2	2	6.04*	100
Bóly	TH	2002	No	No (RI)	2.5	2.5	4.75*	100
Cserkeszőlő	TH	2001	No	No	2	2	3.8*	100
Csongrád	DH	2012	No	No	4.3	4.78	13.53*	90
Hódmezővásárhely	DH	1994	No	No (RI)	18.0	18.66	22.5*	90
Kistelek	TH	2005	No	No	3.39	3.39	10.41*	100
Gárdony	TH	2010	No	No (RI)	1.8	1.8	7.28*	100
Győr	DH	2015	No	No (RI)	52	52	190*	100
Makó	DH	2012	No	No (RI)	9.01	9.01	10.13*	100
Mezőberény	TH	2014	No	No (RI)	1.6	1.6	0*	100
Miskolc	DH	2013	No	No (RI)	55	55	241.17*	100
Mórahalom	TH	2004	No	No	1.5	1.5	5.58*	100
Szarvas	TH	n.a.	No	No	11.28	11.28	10.34*	100
Szeged	TH	2014	No	No (RI)	8.9	n.a	23.68*	est 3
Szentes	DH	1958	No	No	27.2	27.2	30.27*	97.4
Szentlőrinc	DH	2009	No	No (RI)	3.1	3.1	7.36*	100.0

Table D1 (continued): Existing geothermal district heating (DH) plants, individual sites

Locality	Plant Name	Year commis-sioned	CHP	Cooling	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2018 produc-tion * (GW_{th}/y)	Geoth. share in total prod. (%)
Szigetvár	TH	n.a.	No	No	1.5	n.a.	1*	n.a.
Szolnok	TH	2012	No	No	1.2	n.a	4*	n.a.
Tamási	TH	2015	No	No (RI)	1	1,42	2,26*	70
Törökszentmiklós	TH	2014	No	No (RI)	1.86	2,7	3,6*	n.a
Újszilvás	GSHP	2010	No	Yes	0.46	0,46	0,07*	100
Vasvár	DH	1975	No	No (RI)	1.76	14,67	5,89*	15
Veresegyház	TH	1993	No	No (RI)	12	12	32*	100
total					223.36		635.66*	

* If 2017 numbers need to be used, please identify such numbers using an asterisk

Table D2: Existing geothermal large systems for heating and cooling uses other than DH, individual sites

Locality	Plant Name	Year commis-sioned	Cooling	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2018 produc-tion * (GWh_{th}/y)	Geoth. share in total prod. (%)	Operator
Alsópáhok	n.a.	n.a.	No	0.6	na.	1.04*	n.a.	Kolping Hotel
Békés	n.a.	n.a.	No	0.6	na.	0.8*	n.a.	Békés Gyógyászati Központ és Gyógyfürdő
Békéscsaba	n.a.	n.a.	No	0.7	n.a.	1.1*	n.a.	Békéscsaba Vagyonkezelő Zrt.
Bogács	n.a.	n.a.	No	0.8	n.a.	1.2*	n.a.	Bogácsi Thermálfürdő Kft.
Budapest		n.a.	No	8 (appr. 12 spas)	n.a.	12*	n.a.	Budapest Gyógyfürdői és Hévizei Zrt.
Bük	n.a.	n.a.	No	0.7	n.a.	1.1*	n.a.	Büki Gyógyfürdő Zrt.
Debrecen	n.a.	n.a.	No	2	n.a.	1.9*	n.a.	Debreceni Gyógyfürdő Kft.
Demjén	n.a.	n.a.	No	2	n.a.	2*	n.a.	Demjén Termál Fürdő Kft.
Győr	n.a.	n.a.	No	3	n.a.	2*	n.a.	Rába Quelle Kft
Gyula	n.a.	n.a.	No	2	n.a.	1.5*	n.a.	Gyulai Várfürdő Kft.
Hajdúböször-mény	n.a.	n.a.	No	0.6	n.a.	0.8*	n.a.	Hajdúböszörményi Városgazdálkodási Kft.

Table D2 (continued): Existing geothermal large systems for heating and cooling uses other than DH, individual sites

Locality	Plant Name	Year commis-sioned	Cooling	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2018 produc-tion * (GWh_{th}/y)	Geoth. share in total prod. (%)	Operator
Hajdúszobosz-ló	n.a.	n.a.	No	3	n.a.	2.3*	n.a.	Hungarospa Hajdúszoboszlói Gyógyfürdő és Egészségturisztikai Zrt.
Hévíz	n.a.	n.a.	No	1.5	n.a.	2.1*	n.a.	Hévízgyógyfürdő és Szent András reumakórház and Hunguest Hotels Zrt.
Igal	n.a.	n.a.	No	0.7	n.a.	0.9*	n.a.	Igal-Fürdő Üzemeltető és Szolg. Kft.
Jászkisér	n.a.	n.a.	No	2.5	n.a.	8*	n.a.	MÁV Építőgépjavító üzem
Karcag	n.a.	n.a.	No	4	n.a.	8*	n.a.	Berek-Víz Kft.. Nagykun Víz- és Csatornamű Kft.
Lakitelek	n.a.	n.a.	No	1	n.a.	3*	n.a.	Népfőiskola
Lenti	n.a.	n.a.	No	1	n.a.	2.5*	n.a.	Lenti Gyógyfürdő Kft.
Lipót	n.a.	n.a.	No	1	n.a.	1*	n.a.	Lipóti termálfürdő
Magyarherte-lend	n.a.	n.a.	No	0.8	n.a.	0.8*	n.a.	Hertelendi Termál Szolg. Kft.
Marcali	n.a.	n.a.	No	0.8	n.a.	0.5*	n.a.	Marcali Városi Fürdő és Szabadidőközpont
Martfű	n.a.	n.a.	No	2	n.a.	3*	n.a.	Tisza Joule Szolg.és Ker Kft.
Mezőkövesd	n.a.	n.a.	No	1.5	n.a.	1.8*		Zsóry Fürdő
Mezőtúr	n.a.	n.a.	No	1.6	n.a.	0.8*	n.a.	Mezőtúri Intézményellátó és Ingatlankezelő Közhasznú Nonprofit Kft.
Miskolctapol-ca	n.a.	n.a.	No	6	n.a.	4.5*	n.a.	MIVÍZ Kft
Mohács	n.a.	n.a.	No	0.6	n.a.	0.7*	n.a.	Mohács Uszoda Kft.
Nyírbátor	n.a.	n.a.	No	2	n.a.	1.2*	n.a.	Nyírbátori Városfejlesztő és Működtető Kft.
Nyíregyháza	n.a.	n.a.	No	0.8	n.a.	0.6*	n.a.	Szabolcs-Szatmár-Bereg Megyei Kórházak és Egyetemi Oktatókórház

Table D2 (continued): Existing geothermal large systems for heating and cooling uses other than DH. individual sites

Locality	Plant Name	Year commis-sioned	Cooling	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2018 produc-tion * (GWh_{th}/y)	Geoth. share in total prod. (%)	Operator
Orosháza-Gyopárosfür-dő	n.a.	n.a.	No	1.3	n.a.	4.7	n.a.	Gyopáros Gyógy- és Élményfürdő
Sárospatak	n.a.	n.a.	No	2	n.a.	0.8*	n.a.	PATAQUA Termálfürdő Kft.
Sárvár	n.a.	n.a.	No	0.5	n.a.	0.6*	n.a.	Sárvári Gyógyfürdő Kft.
Szolnok	n.a.	n.a.	No	1	n.a.	0.6*	n.a.	Víz-és Csatornaművek Koncessziós ZRt. (strand)
Tiszaföldvár	n.a.	n.a.	No	0.8	n.a.	0.4*	n.a.	Tiszaföldvári Városüzemeltető és Foglalkoztatási Kiemelten Közhasznú Nonprofit Kft.
Vácrátót	n.a.	n.a.	No	2	n.a.	5*	n.a.	MTA Ökológiai Kutatóközpont
Vásárosna-mény	n.a.	n.a.	No	1.5	n.a.	0.8*	n.a.	NUOVA -ATLANTIKA VÍZIVIDÁMPARK Kft.
Velence	n.a.	n.a.	No	0.8	n.a.	0.5*	n.a.	VELENCE PLUS Kft. (strand)
Zalaegerszeg	n.a.	n.a.	No	3.5	n.a.	0.6*	n.a.	AQUAPLUS Kútfúró. Építő és Termál-energetikai Kft.
Zalakaros	n.a.	n.a.	No	5	n.a.	2*	n.a.	Gránit Gyógyfürdő Zrt
total				77.2		83.1		

* If 2017 numbers need to be used. please identify such numbers using an asterisk

Table E: Shallow geothermal energy. ground source heat pumps (GSHP)

	Geothermal Heat Pumps (GSHP). total			New (additional) GSHP in 2018 *		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2018 *	6500*	72*	144*	500*	6*	50*
Projected total by 2020	8000	88	176			

* If 2017 numbers need to be used. please identify such numbers using an asterisk

Table F: Investment and Employment in geothermal energy

	in 2018		Expected in 2020	
	Expenditures (million €)	Personnel (number)	Expenditures (million €)	Personnel (number)
Geothermal electric power	5	12	5	12
Geothermal direct uses	2.5	16	2.5	16
Shallow geothermal	5	48	6	55
total	**12.5**	**76**	**13.5**	**83**

Table G: Incentives. Information. Education

	Geothermal electricity	Deep Geothermal for heating and cooling	Shallow geothermal
Financial Incentives – R&D	O (National Research Fund)	O (National Research Fund)	O (National Research Fund)
Financial Incentives – Investment	FIT	DIS	No
Financial Incentives – Operation/Production	FIT	DIS	2 types of tariffs as reduced electricity price for GSHPs
Information activities – promotion for the public	in the frame of ongoing projects	in the frame of ongoing projects	in the frame of ongoing projects
Information activities – geological information	borehole data. interactive maps and reports. publications available at the website of the Mining and Geological Survey of Hungary (mbfsz.gov.hu)		
Education/Training – Academic	Four semesters. academic engineering education at the University of Miskolc		
Education/Training – Vocational	Hungarian Chamber of Engineers in collaboration with University of Miskolc held several courses		

Key for financial incentives:					
DIS	Direct investment support	FIT	Feed-in tariff	-A	Add to FIT or FIP on case the amount is determined by auctioning
LIL	Low-interest loans	FIP	Feed-in premium		
RC	Risk coverage	REQ	Renewable Energy Quota	O	Other (please explain)