European Geothermal Congress 2016
Strasbourg, France, 19-24 Sept 2016

Geothermal Energy Use, Country Update for Hungary

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Keywords: Pannonian Basin, direct-heat utilization, district- and town heating, agriculture, non-technical barriers, concession

ABSTRACT

Hungary has shown a considerable increase in geothermal district heating during the last few years, which is mainly due to 2 new large projects (Miskolc and Győr). Geothermal district-heating and thermal-water heating cascade systems are available in 21 towns representing about 210 MW_{th} installed capacity and 350 GWh_{th}/y annual production. Individual space heating (mostly associated with spas) is available at 35 locations representing an estimated installed capacity of about 28 MW_{th} and 63 GWh_{th}/y annual 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 292 MW_{th} installed capacity and another 15,6 MW_{th} is for "other" agriculture purposes (e.g. irrigation, soil heating, etc). Balneology has historical traditions in Hungary, more than 250 wells yield thermal water, sometimes medicinal waters which represent a total installed capacity of 225 MW_{th}.

Power production still does not exist, however project developments are ongoing at 3 sites.

The shallow geothermal sector unfortunately does not show real development, the increase of GSHP number declined after 2010, in 2015 the estimated number of GSHP-s is 5500. 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 buildings of novel companies.

The regulatory framework witnessed some important changes: introduction of a concessional system for deep (≥ 2500 m) geothermal projects, licensing in a "one-stop-shop system" in newly established regional governmental offices, abandonment of compulsory reinjection, announcement of a District Heating Development Action Plan.

Hungarian companies and institutions have been active in various national and international research and innovation projects delivering key developments in various fields of geothermal applications.

1. INTRODUCTION

The last country update (Nádor et al. 2013), was based on data available in 2011 from 595 active thermal water wells in Hungary. The country update of Tóth (2015) provided a summary based on a data available from 672 wells. Since that time the register and database of thermal water wells (those having outflow temperature higher than 30 °C) significantly improved due to changes in legislation (Chapter 3) and combined efforts of the Geological and Geophysical Institute of Hungary and the Hungarian Office for Mining and Geology merging their databases with different contents and formats. The resulting national geothermal database now consist data from ~850 active thermal water wells and is annually updated. Despite the significant efforts, this database still has some discrepancies with several factors (i.e. seasonal operations, substantial 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 in numerous cases) impeding exact calculations. The reported numbers are based on the latest available datasets from 2014/2015, and represent the best expert estimates of the authors, which show a realistic growth compared to the numbers of the previous country update reports (Tóth 2010, Nádor et al. 2013, Tóth 2015). Unfortunately, Hungary does not yet have an official government authority which can absolutely and unequivocally vouch for the data given above.

The steady increase of new wells in each year (Table 1) demonstrates the developing geothermal sector in Hungary, partly associated with the expansion of previous projects, partly related to new district heating projects and a moderate development in the agriculture sector. The increase of new reinjection wells is a positive progress, although the majority of them are targeting the basement carbonates and reinjection into the porous aquifers is still facing technical challenges.

	2012	2013	2014	2015
reinjection	5	3	0	4
agriculture	1	3	2	1
space heating and district heating	3	1	0	5
spa	3	4	0	3
other / unknown purpose	3	5	6	5
Total number of new wells	**15**	**16**	**8**	**18**

Table 1: New thermal water wells in Hungary

2. GEOTHERMAL POTENTIAL OF HUNGARY

The geothermal potential of the Pannonian basin is outstanding in Europe, as it lies on a characteristic positive geothermal anomaly, with heat flow density ranging from 50 to 130 mW/m^2 with a mean value of 90-100 mW/m2 and geothermal gradient of about 45 °C/km (Dövényi and Horváth 1988). This increased heat flux is related to the Early-Middle Miocene formation of the Pannonian Basin, when the lithosphere stretched and thinned (thus the crust is "only" 22-26 km thick) and the hot astenosphere got closer to the surface (Horváth and Royden 1981).

There are 2 major types of geothermal reservoirs in Hungary. (1) The several thousand meter thick multi-layered porous sediments (Upper Miocene-Pliocene "Pannonian" basin fill sequence) have low heat conductivity and are composed of successively clayey and sandy deposits. Within this thick basin-fill sequence the main thermal-water bearing aquifers are those 100-300 m thick sand-prone units (former delta-front facies deposits) which are found in a depth interval of ca. 700-1800 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 and are widely used for direct heat purposes. (2) The other major reservoir type is associated with the uppermost karstified zones of the deeply buried Palaeozoic-Mesozoic basement carbonates, as well as the fractured-weathered zones of the crystalline rocks, characterized by high secondary porosity. At this depth (on average 2000 m or more) temperature can exceed 100-120 °C and may provide favourable conditions for development of medium-enthalpy geothermal systems (e.g. CHP plants).

Some high-enthalpy reservoirs also exist in Hungary related to deep-lying (3500-4000 m), overpressured fractured rocks (dolomites), as was proven by a steam-blow-out at a pressure of 360 bars and 189 °C lasting for 47 days in Fábiánsebestyén. 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.

The chemistry of the Hungarian thermal waters is quite varied. Thermal groundwater of the porous Upper Miocene-Pliocene (Pannonian) reservoirs generally has an alkaline $NaHCO_3$ character. Where thermal water of the carbonate basement aquifers has an active recharge, it is characterized by a $CaMgHCO_3$ composition. Deep basement reservoirs without direct hydraulic connection (supply) store brines with high salinity, usually NaCl-type. High dissolved content and/or gas content of some thermal waters may cause operational issues (scaling, need of degasification).

Regarding the geothermal potential of the country, several assessments have been done over the last 10 years. According to the latest survey the heat in place down to a depth of 10 km was estimated to be as much as 375 000 EJ, the prospective resources between 0-5 km depth 105 500 EJ, with inferred/indicated resources (according to the AGRC 2010 terminology) of 60PJ/y for the porous and 130 PJ/y for the basement reservoirs (supposing full re-injection) (Zilahi-Sebess et al. 2012).

3. NATIONAL GEOTHERMAL ENERGY POLICY AND REGULATORY FRAMEWORK

Due to the significant energy-import dependency of Hungary (83% of hydrocarbons, about 20 billion m^3/year gas mainly from Russia) makes the country security of supply vulnerable, especially in the heating sector. Therefore Hungary's National Energy Strategy for 2011-2030 (Ministry of National Development, 2011) looks at how the country could use better its own resources, in which the increased share of renewables is an important pillar. Hungary's NREAP 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 57MW_e (power production).

Geothermal power production still does not exist (3 projects are under development (Chapter 5.1), there is a moderate growth in the GSHP sector (Chapter 4), the only considerable expansion happened in the direct uses (Chapter 5.2), however the share of geothermal in the total RES is still below the optimal growth rate (7,2 % in 2013).

The regulatory and policy framework of deep geothermal have been summarized in previous country updates (Nádor et al. 2013, Tóth 2015), therefore in this paper we highlight only the most important changes since 2013.

During the past few years the Hungarian government has significantly reorganised the public administration in order to make the system more efficient and cheap. By the establishment of the so called "regional governmental offices" (altogether 20, one for each county equivalent of a NUTS-3 region, and one for the capital Budapest) all thematic – previously separate and independent – authorities (e.g. environmental and water protection-, construction-, mining inspectorates, etc.) were integrated into these regional offices in

2015, so the "one-stop-shop" concept (i.e. applying and getting all necessary permits at one place) was realized. Although this made the acquisition of necessary licences easier (in theory less time due to the integrated management of the different permits for the same project), but did not reduce the number of permits, which are quite numerous for a geothermal project. The licences for district heating pipelines as well as for the supply of district heating itself are still issued by the Hungarian Energy and Public Utility Regulatory Authority, being independent of the regional governmental offices.

Reinjection witnessed many legislative changes and heated debates within the geothermal and water management sector over the last 10 years in Hungary: from being compulsory (with exemptions till a certain deadline) to non-compulsory. Due to the modification of the Water Act in 2013, the reinjection of thermal waters used for energetic purposes is not obligatory, but being assessed and authorized on individual basis (depending on the local reservoir conditions). Nevertheless the largest recently established Hungarian geo-DH projects are all designed and operate with full reinjection, and the already existing systems are complemented with new reinjection wells, too.

Regulations related to data management have significantly improved: the amendment of the Mining Act in 2014 entitled the Hungarian Office for Mining and Geology to establish a register of all facilities utilizing geothermal energy, including the amount of produced and utilized amount of geothermal energy. This includes all those facilities, too which use thermal water, however do not pay mining royalty after utilization, therefore a more complete register became available. Since 2013 the Geological and Geophysical Institute of Hungary is authorized to manage and operate the national well cadastre (including all thermal water wells). This also includes the register of new wells drilled each year. These two new "databases" and their joint assessment significantly contributed to a more complete evaluation, presented in this paper.

An important policy development related to geothermal district heating was the finalization of the so called District Heating Development Action Plan in 2015-2016, as part of the National Energy Strategy. The Action Plan emphasizes the role of renewables – especially biomass and geothermal – in modernizing the Hungarian DH sector. Presently a governmental decision is under preparation about the execution of this Action Plan (expected to be launched in September 2016). A separate paragraph of this decision (Act 4) deals with potential geothermal development possibilities (i.e. assessment of settlements and their environs which already have a district heating infrastructure fed by gas, although favourable geothermal conditions would make possible to - at least partly - replace it with geothermal energy).

4. SHALLOW GEOTHERMAL

As reported earlier (Nádor et al. 2013, Tóth 2015), unfortunately there are no reliable GSHP registers available in Hungary, because the systems shallower than 20 m do not require a license, nor even a notification to the authorities. Therefore the numbers reported in Table E are the best estimates of the authors.

The increase of GSHP number declined after 2010. 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 as communal heating/cooling are installed in new buildings of novel companies. The cooling function makes GSHPs competitive in the greenfield constructions.

According to the latest national geothermal potential assessment (Zilahi-Sebess et al. 2012) the GSHP potential of Hungary is as much as 23 PJ/year. The 2012 estimate of the Hungarian Heat Pump Association forecasted a 3,6 PJ/year by 2020, also considering economic factors, which is far below the theoretically available geological potential.

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 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.

- Voluntary preferential tariff ("B" GEO tariff) for heat pumps of COP higher than 3. This scheme is available only on those areas, where the service provider (at the moment only ELMÜ-ÉMÁSZ) introduced this system, however it is accessible for the whole year.

The currently existing incentives are not enough to maintain the development of the heat–pump market experienced between 2000-2010.

5. DEEP GEOTHERMAL

5.1. Power generation

Geothermal power plants are not yet in operation in Hungary (Table A), however regulatory changes and ongoing project developments are promising.

Since the introduction of the concessional system in 2010 (obligatory for the exploration and exploitation of geothermal energy from a depth below -2,500 m, typical depth range for power production and CHP projects) a preliminary complex vulnerability and impact assessment (CVIA) has been prepared for 17 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 Hungarian Office for Mining and Geology (www.mbfh.hu).

Out of the 17 potential areas, tenders were announced in the EU official journals only for 3 areas in 2013. For the Jászberény area (deep hydrothermal potential for CHP applications) 2 proposals were submitted, the winner was Cege Plc (daughter company of MOL Plc, Hungarian Oil Company). The planned electric capacity of the Jászberény project is 2–5 MW_e, depending on the exploration success. Another tender for the Battonya area (EGS potential) was published in 2014, the winner was the EU-FIRE EGS Hungary Ltd. The South-Hungarian EGS Project was supported earlier by NER300 EU Program with 39.3 million € and was also selected as a Significant Hungarian Governmental Project. The planned net electric capacity of the ORC-based EGS project is 9,8 MW_e.

In both cases a concessional contract was signed, which is valid for 35 years that can be extended once more by max. another 17,5 years. On both areas surface exploration (together with testing of existing wells in Jászberény) is ongoing, drillings are expected to start in 2016.

A promising site for a future small-scale geothermal power plant is located at Tura, about 50 km west from Budapest. This is a well-explored former hydrocarbon block, where an uplifted Triassic carbonate block is found in the basement in the depth range of 1700-2200 m, hit by some wells producing thermal water of 100-120 °C. Due to the depth range this area does not require a geothermal concession. Singapore based KS Orka has agreed to take a 51% stake in the Turawell CHP project in which a 2,7 MW_e capacity micro-power plant and a 11 ha greenhouse complex is planned. Engineering services are contracted to Mannvit. The first phase of the project should be operational by the end of 2016.

A new feed-in tariff system is under preparation and will be introduced at the beginning of 2017. According to the expectations the system will follow the related EU regulations and ensures a competitive takeover price for geothermal power plants above 10 €cts/kWh. Until the issue of the new regulation, project developers can negotiate the takeover price individually with the related Ministry.

5.2. Direct heat utilization

Hungary's largest geothermal district heating project (Miskolc) with 2 production and 3 reinjection wells targeting karstified-fractured Triassic basement carbonates at a depth of 1500-2300 m with a total installed capacity of 55 MW_{th} was completed in 2013. The total investment cost was about 25 million euros, which was partly covered from the ERDF-sourced Energy and Environment Operative Programme with a total fund of about 9,7 million euros. The project developer, Pannergy Plc is contracted to a city-owned off-take partner for 15+5 years.

The system has an annual net heat production of 733277 GJ supplying 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, and the secondary one in Miskolc city itself. During the 2nd phase of project development (2013) a 2nd heat supply center was established within the city, which made possible to heat the historical city center and the university buildings (and provide domestic water supply). Furthermore 7000 m^2 plastic tents are also heated by geothermal (Miskolc Agrokultúra Ltd, a municipality owned agriculture company).

After the completion of the Miskolc project, Pannergy Plc accomplished its next successful large direct use project near to Győr in NW-Hungary in 2014-2015 with the drilling of 2 production and 2 reinjection wells targeting the fractured Triassic dolomite basement at a depth of 2300-2850 m providing very high yield (150 l/sec) and outflow temperature (100-105 °C), which will supply heat to a large industrial user (Audi Motor Hungary) in the suburbs of the town as well as the district heating system of the town. The estimated capacity of the entire systems is 52 MW_{th}, with an expected annual use of 340-400 TJ/yr. The ribbon-cutting ceremony of the heat center at Bőny was in November 2015. The total investment cost was about 32 million euros, partly subsidized by the ERDF-sourced Energy and Environment Operative Programme by 6,5 million euros.

In 2014-2015 a new thermal water town-heating system was established in Tamási with a drilling of a new production-reinjection doublet. The production well supplies thermal water of 47 °C from a depth of 680 m is feeding the heating of 17 public buildings connected according to a decreasing temperature demand along a 4,7 km long pipeline. The total investment cost was about 4,38 million euros, half of which was subsidized by the ERDF-sourced Energy and Environment Operative Programme.

In 2014 a new thermal water heating cascade system was completed in Szeged with two separate loops, which provide heat for various buildings of the University, the largest heat consumer of the town, as well as a some public buildings. Both loops have 1 production well that yields thermal water of 85-90 °C from a depth of 2000 m from the porous Upper Miocene-Plocene “Pannonian” reservoirs, and 2 reinjection wells (altogether 2 new production and 4 reinjection wells). The loops are complete with a 3,5 and a 3,1 km long pipeline respectively. The total installed capacity of the system is 8,9 MW_{th}. The investment cost was 10,1 million euros, partly co-financed by the ERDF sourced Energy and Environment Operative Programme by 5million euros.

The continuously developing thermal water cascade heating system of Veresegyház expanded with a new production well in 2015. The Vasvár and the Szentes geothermal district heating systems also enlarged with new production wells in 2014-2015. These systems were developed by Porcio Ltd.

Together with these developments **geothermal “district” heating** is available in 21 towns in Hungary in 2016 (Table D1). These are partly geo-DH systems s.str., 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, Győr). The majority of the systems are so called “thermal water heating cascade systems”, where the gas-based heating of some public buildings (town hall, library, school, hospital, etc) is replaced by geothermal, furthermore other nearby buildings (private houses) may join the newly established thermal water pipelines. These systems are not connected to existing district heating systems, mainly because these facilities do not exist there. They supply heat only to a separate part of the settlement through a heat supply centre (Kistelek, Veresegyház, Bóly, Mórahalom, Gárdony, Mezőberény, Szarvas, Szeged, Barcs, Cserkeszőlő, Újszilvás, Törökszentmiklós, 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.

In 2014 altogether 7,7 while in 2015 10,36 million m^3 of thermal water from 51 production wells supplied all these different heating systems which represent an estimated total installed capacity of 209,3 MW_{th} and production of 350,5 GWh_{th}/y (Table D1).

In addition to district and thermal water town heating cascade systems, 72 wells provided heating of individual buildings mostly associated with spas (balneological use) at 35 locations, typically with an outflow temperature around 50 °C (some of them representing significant uses of 8000-15 000 GJ/yr (e.g. Zalaegerszeg, Szolnok, Gyopárosfürdő-Orosháza, Martfű, Vácrátót, Demjén, Mezőkövesd, Bogács). These wells have a cumulative estimated installed capacity of about 28 MW_{th} (considering only the heating part) (Table C).

The growing number of projects in exploration phase (e.g. Komárom, Eger, Mosonmagyaróvár) shows that municipal mayors in Hungary recognize the value of geothermal. The main barrier for the actual development of these sites is the lack of financing. In the last 5-10 years the main driving force in deep geothermal project development was the ERDF-sourced Environmental and Energy Operative Program (EEOP), which supported the development of heating/cooling supply in local systems, as well as preparing and developing activities of geothermal based heat and electricity producing projects. Unfortunately no new calls have been launched yet in the EEOP during the new financing period (2014-2020). In addition to the EEOP, several other operative programs would also provide possible funding for various actors and segments of the geothermal sector, however these calls have not been opened yet either. Nevertheless some new wells are 100% financed by the owners (e.g. Veresegyház, Szentes).

After a more than 2 years of suspension, the EEA Grants for the support of development of new geothermal district heating systems at locations with already existing DH infrastructure became available again in 2016 spring, where 2 project proposals (Kiskunhalas and Kecskemét) were awarded.

The major sector for direct heat utilization is still **agriculture** in Hungary. For the heating of greenhouses and plastic tents and other energy purposes (e.g. heating of animal husbandries) altogether ~8,75 million m^3 thermal water was abstracted in 2014 and 7,74 million m^3 in 2015 from 146 wells, representing an installed capacity of ~ 292 MW_{th}. The reported annual use (basis of paying mining royalty) was 796848 GJ in 2014 and 723382 GJ in 2015. 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. In addition to that another 47 wells produced thermal water in 2014 for “other” agriculture purposes (e.g. irrigation, soil heating, etc) typically in a temperature range of 30-40 °C. This roughly represents 15,6MWt installed capacity and an annual use of ~60 TJ in 2014.

Thermal water of typically 40-50°C outflow temperature from 18 wells was used for **industrial purposes** representing an installed capacity of 18 MW_{th} and an annual use of about 196 TJ/y (2014), thus, this remained unimportant.

For **balneological** purposes 255 wells produced thermal water. The outflow temperature typically ranges between 30 and 50 °C. These wells mostly discharge the Miocene porous sandstone reservoirs between an average depth of 500-1500 m. About 68 wells had higher outflow temperature (60-80 °C), many of them discharge the fractured-karstified basement aquifers. 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 225 MWt with an annual use of about 1375 TJ/year (Table C).

In the “other” category (reported together with balneology - Table C), more than 100 wells produced lukewarm (30-35 °C) thermal water for “public water supply”, meaning mostly for drinking water. “Drinking thermal water” is a country specific experience in Hungary, where 90% of the drinking water supply is provided from groundwater. On areas where the shallow aquifers are contaminated (e.g. natural high arsenic content in SE-Hungary) lukewarm thermal waters with low TDS from slightly deeper confined aquifers are used. Another 65 wells with similar characters (low TDS waters with 30-40 °C outflow temperature) are registered as “other use” with no further specifications on their utilization. These altogether represent an estimated installed capacity of 16,6 MW_{th}.

6. GEOTHERMAL EDUCATION AND TRAINING

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 2012 the university won an EU competition to continue developing geothermal post-graduate e-learning courses. 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). Most recently, geothermal professors from the University of Miskolc worked with colleagues from the University of Colorado to develop a short course in geothermal engineering. This course provided the essentials of longer degree programs, and was first offered in the summer of 2014. The course addressed the production, utilization and environmental impact of geothermal energy, and the natural conditions which geothermal energy requires. The goal of this short course was to provide students with a broad understanding of these topics and their history. In addition, the Hungarian Chamber of Engineers began working with the University of Miskolc to organize several geothermal short courses about shallow and deep geothermal direct uses (Tóth 2015).

7. RESEARCH AND INNOVATION

During the last few years several national and EU-co-funded projects with different Hungarian partners achieved significant results related to various fields of geothermal energy. Without a full list, some are listed below:

The “Kútfő” project supported by the ERDF co-funded Societal Renewal Operative Program was a hydrogeology-oriented large-scale research project at the Miskolc University looking at the sustainable utilization of groundwater resources, including thermal waters.

In the WellTech project supported by the ERDF co-funded Economy and Innovation Operative Program Mecsekérc Ltd. developed an innovative approach on well-design of reinjection wells and reinjection technology in combination with hydraulic fracturing.

New high energy laser drilling technology has been developed and tested at Szeged University together with ZerLux and has promising results in increasing well productivity not only in oil & gas industry, but in geothermal applications as well.

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 “orebody-EGS”.

In the Geo-DH project the Geological and Geophysical Institute of Hungary (MFGI) developed a web-map service showing the potential areas for future development of geothermal district heating in Europe, which was also referred in the recently launched EU Strategy on Heating and Cooling. MFGI also plays a key role in coordinating deep geothermal research and policy supporting activities in the Danube Region by preparing a geothermal report (Nádor 2014) and initiating joint projects among countries sharing the unique deep geothermal potential of the Pannonian Basin (DanReGeotherm-DATA, DARLINGe).

The South-Hungarian EGS project at Battonya is looking at innovative ways of reservoir stimulation (hydroshearing) that is expected to lower seismic risk whilst increasing effectively permeability in the deep hot granitic bodies.

In the Jászberény CHP project the utilization of an abandoned hydrocarbon well is included into the work program. The project investigates the cost saving opportunities.

In case of shallow geothermal systems, the increase of system size is the direction of development. A more than 1000 kW capacity system is under planning now (maximum achieves 1650 kW) and the raise of capacity is continuing.

The hybrid renewable and UTES projects show a rapid development. There are several initiations related to solar-geo hybrids in building energy efficiency development projects, and a market appeared in bio-geo UTES solutions.

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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 2015 *	0	0	6300	29371	0	0
Under construction end of 2015	0	0	est 50	est 300	0	0
Total projected by 2018	15	100	est 6350	est 32000	0,24	0,3
Total expected by 2020	est 22	est 150	est 10000	est 40000	0,3	0,4
In case information on geothermal licenses is available in your country, please specify here the number of licenses in force in 2015 (indicate exploration/exploitation, if applicable):					2 concession for exploration and expolitation (Jászberény, Battonya), 1 water construction licence (Tura)	

* If 2014 numbers need to be used, please identify such numbers using an asterisk

Table B: Existing geothermal power plants, individual sites:

Geothermal power plants are not yet in operation in the Hungary

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

	Geothermal DH plants		Geothermal heat in agriculture and industry		Geothermal heat for individual 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 2014	157,22	353,74	325,6	732,6	28	63	241,6	724,8
Under constru-ction end 2015	52	117	3	6,75	2	4,5	5	15
Total projected by 2018	50	112	5	11,25	5	11,25	20	60
Total expected by 2020	50	112	5	11,25	5	11,25	20	60

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})	2014 production (GWh_{th}/y)	Geoth. share in total prod. (%)
Barcs	TH	2014	No	No	2	2	7	100
Bóly	TH	2002	No	No (RI)	2,5	2,5	4,32	100
Cserkeszőlő	TH	2001	No	Yes	1,2	1,2	4,78	100
Csongrád	DH	2012	No	No	4,3	4,78	14,7	90
Hódmező-vásárhely	DH	1994	No	No (RI)	15,0	18.66	22	80,4
Kistelek	TH	2005	No	No	3,39	3,39	8	100
Gárdony	TH	2010	No	No (RI)	1,5	1,7	4,23	100
Győr	DH	2015	No	No (RI)	52	52	*started test operation in Q4 of 2015*	100
Makó	DH	2012	No	No (RI)	5,3	5,3	5	100
Mezőberény	TH	2014	No	No (RI)	1,6	1,6	0,5	100
Miskolc	DH	2013	No	No (RI)	55	55	183,88	100
Mórahalom	TH	2004	No	No	1,5	1,5	2,93	100
Szarvas	TH		No	No	11,28	8	10,25	100
Szeged	TH	2014	No	No (RI)	8,9	n.a	33,5	est 3
Szentes	DH	1958	No	No	27,2	28,5	20,44	97.4
Szentlőrinc	DH	2009	No	No (RI)	3,1	3,1	6,66	100.0
Tamási	TH	2015	No	No (RI)	1	n.a.	1,2	n.a
Törökszent-miklós	TH	2014	No	No (RI)	3	n.a	2,35	n.a
Újszilvás	GSHP	2010	No	Yes	0,46	0,46	0,07	100
Vasvár	DH		No	No	1,76	14,67	2,32	12,9
Veresegyház	TH	1993	No	No (RI)	7,3	7,3	16,31	100
total					**209,29**		**350,44**	

Table D2: Existing geothermal direct use other than DH, individual sites

no systems above 500 MWth are operating in Hungary

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

	Geothermal Heat Pumps (GSHP), total			New (additional) GSHP in 2015 *		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2015 *	5500	61	122	150	2	50
Projected total by 2018	6500	72	144			

Table F: Investment and Employment in geothermal energy

	in 2015 *		Expected in 2018	
	Expenditures ** (million €)	Personnel *** (number)	Expenditures ** (million €)	Personnel *** (number)
Geothermal electric power	5	8	70	25
Geothermal direct uses	3	20	30	65
Shallow geothermal	6	55	15	175
total	**14**	**83**	**115**	**265**

Table G: Incentives, Information, Education

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D	DIS	DIS	no
Financial Incentives – Investment	DIS, FIT	DIS	yes, for enterprises, budgetary/governmental non-profit organizations
Financial Incentives – Operation/Production	no	no	reduced electricity price for GSHPs. Its rate is depending on electricity supplying regional companies (geo-tariff)
Information activities – promotion for the public	yes, in the frame of ongoing projects (compulsory element of financial supports)		some
Information activities – geological information	borehole data, interactive maps and reports, publications available at the website of the Geological and Geophysical Institute of Hungary (www.mfgi.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)