UNITED NATIONS UNIVERSITY
UNU-GTP
Geothermal Training Programme

Orkustofnun, Grensasvegur 9,
IS-108 Reykjavik, Iceland

Reports 2016
Number 12

FOSTERING GEOTHERMAL DEVELOPMENT IN HUNGARY: OPPORTUNITIES AND BOTTLENECKS

Kristof Boda
Ministry of National Development
Department of Renewable Energy
Fő Street 44-50
Budapest 1011
HUNGARY
kristofboda@gmail.com

ABSTRACT

Hungary has very good geothermal prospects and the use of geothermal energy has a long history in district heating, agricultural and balneology utilizations. After Turkey, Iceland and Italy, the country was ranked in 4th place regarding installed geothermal direct use in Europe in 2015. Geothermal resources are providing constant energy output, which is independent from weather conditions and time, utilize safe technology, which does not endanger human life and evades the possibility of huge human and environmental catastrophes, as well as having a lower carbon footprint than most other renewable energy utilizations. Therefore, geothermal energy is suitable for reaching various environmental and energy efficiency aims, energy policy targets, and also to reduce fossil energy dependency.

Hungary has very ambitious geothermal energy utilization targets to fulfil the country's EU 2020 aims, which require fast and effective development of geothermal utilization policies and projects. There are several EU and nationally supported projects, however private investors seem to be waiting to enter the Hungarian geothermal market and the number of new project inquiries has been decreasing since 2011. Therefore, strengthening of geothermal energy policy and related procedures could be a useful asset and toolkit for better enabling new investors to enter the market and help fulfilling the 2020 geothermal energy targets. Support for geothermal exploration and revision of the legislative, financial and policy interfaces and interplay of the institutional, legislative and business environment of geothermal projects in order to remove bottlenecks can have a crucial role in strengthening exiting opportunities and in reducing the barriers of future geothermal development.

In this report, current status of the Hungarian institutional, legislative and business environments related to geothermal energy utilization are analysed and evaluated from the investor perspective. Relevant good international practices are incorporated, as well as practical experiences of the first geothermal electricity-producing project of Hungary, which is expected to be online in July 2017. This should provide development recommendations and enable better geothermal development in Hungary. The report draws conclusions concerning the policy and regulatory framework, which is essential and needed to promote geothermal development.

1. INTRODUCTION

Hungary has very good geothermal prospects and internationally famous geothermal resources. The utilization of geothermal energy has a long history and several spas, medicinal waters, balneology and agricultural and district heating facilities are in use, reflecting the mostly low-temperature geothermal resources. Geothermal energy utilization has accelerated since the political transformation of 1989 mainly by spa and district heating projects and in 2015 Hungary was ranked 4th in Europe among countries utilizing most geothermal heat, after Turkey, Iceland and Italy. Geothermal development is part of Hungary's *National Renewable Energy Strategy* and has a share in fulfilling the country's 2020 EU development aims. Geothermal development is backed up by the European Economic Area (EEA), EU and national supporting schemes. During last decade, large-scale district heating systems were built and old ones were reconstructed, as well as a new EGS project being started. The year 2017 is expected to be a milestone in the history of geothermal development in Hungary, as the first geothermal energy power plant, which is also to produce electricity besides heat, will go online in July 2017.

The number of inquiries to launch new geothermal projects has increased steadily during the last decades, even during the time of the economic crisis in 2008. Hungary has no specific geothermal development strategy, but geothermal is included into the country's energy policy targets and there is a significant amount of regulations and legislation governing geothermal utilizations. Separate energy- and network operators, as well as mining-, water- and environmental authorities are responsible for permitting and licensing geothermal energy utilization projects. The number of new geothermal project inquiries has, however, been decreasing since 2013, state concessions for the utilization of deep geothermal (below 2500 m) are not advertised and not expected to start soon. Most of the geothermal projects to be implemented are either EU demonstration projects or highly subsidized projects, supported by EU or other grants. Private or public investors seem to be waiting and collecting information to introduce new projects. The institutional, legal and regulatory frameworks addressing geothermal development is constructed from a complicated set of rules that developers must follow through the development of their projects. These laws and regulations may present themselves as barriers or enabling factors to development (Kujbus, 2016; Tóth, 2010).

This research aims to provide a picture of the current status of geothermal energy production and utilization in Hungary and also to explore how Hungarian geothermal development environment can be developed and recommendations provided to better enable and foster geothermal development based on the experiences of international geothermal development facilities. The research target is reached by analysing international good practices and examples of geothermal development and apply this practice to the current Hungarian geothermal development environment. The goal is to learn from the outcomes and experience of the implementation of the first geothermal electricity power plant project of Hungary. Therefore, based on international and current Hungarian geothermal policy practices and the first Hungarian geothermal electricity and heat power plant project, this research will point out the bottlenecks and enabling factors of geothermal development in Hungary. This will be done through analysing the policy interfaces between the financial, institutional and legislative environments and creating a set of recommendations for policy and decision makers, which are responsible for geothermal development, in order to foster geothermal energy development in Hungary.

2. GEOTHERMAL DEVELOPMENT ENVIRONMENT – INTERNATIONAL EXPERIENCES AND GOOD PRACTICES

For most investments, including geothermal energy development projects, the main deciding factors about where and when to invest are the credibility, transparency, consistency and simplicity of relevant legislations. To this can be added existing institutional policies and practices, the availability of project related information, technical and financial support schemes, risk mitigation tools for project development support, the amount of time needed for project implementation, which depends on many multiple factors, and the possible profitability of the investment.

Geothermal energy resources have been identified in over 90 countries and are utilized in 78 (Lund and Boyd, 2015) and geothermal electricity is generated in 24 countries (Bertani, 2015). Most countries utilizing geothermal resources have ambitious and specialized agendas for further geothermal energy development. Kenya plans to increase its electricity production from geothermal resources, from 590 MWe in 2015 to 5000 MWe until 2030 through its Kenya Vision 2030 strategy. Many other countries in East Africa and Europe (Iceland, Turkey, Germany, Italy, Austria, Netherland, Switzerland, France, Slovakia, Slovenia, Croatia and Hungary) are planning increased geothermal development (Georgsson, 2016; Micale et al, 2015; Transenergy, 2011; Nádor, 2013). For European Union member states, the EU requires a certain increase in both renewable energy production and consumption and the introduction of related policies and planning (National Energy Efficiency Action Plans – NREAPs) in order to fulfil the policy aims of the Renewable Energy Directive (RED).

National agendas for geothermal development usually consist of various elements including geothermal resource related research and development. This includes supportive policies towards geothermal field development, institutional, legislative and regulatory framework, licensing and permitting procedures, commercially available financial sources or international and national financial supporting schemes and loans, sometimes even with state endorsement, insurance, risk mitigation tools and technical assistance as well as transparent, competitive and non-discriminatory procedures. Together these form a country specific development environment for geothermal projects and at the same time also become the main measures and tools for policy making to better enable geothermal development.

There are significant differences in the approach and practice of countries towards applying these elements in practice. These differences originate from and reflect the specific geothermal properties and country specific needs. However, there are some conditions that most countries successful in geothermal development have in common, such as:

- Clear cut, streamlined and specialized legislation: a single geothermal law, establishing the basis of geothermal developments and creation of a legislative framework reflecting geothermal needs but also ensuring environmental perspectives, the ownership and possible interference of reservoirs;
- Straightforward licensing procedures;
- One agency or institution responsible for licensing and permitting the investment and for geothermal development – an energy agency;
- Available public geothermal subsurface datasets;
- Effective financing and risk mitigation schemes: financing and insurance schemes reflecting the special needs of geothermal investments;
- Strong interaction between geothermal research, financial schemes and policymaking;
- Continuous transfer of knowledge and information between the various state actors and strong institutional capacity building;
- Available geothermal information for the public, awareness raising;
- Thoughtful and consistent national geothermal policy for the creation of legilative and institutional frameworks.

2.1 Geothermal legislation

Governments can provide support to geothermal project developers in various ways. This can be done through policies, programmes and legislation, institutional structures and streamlined administrative procedures, increasing the consistency of legislations, providing geothermal data and financial support, financial and risk insurance schemes or technical assistance.

2.1.1 Complexity of legislation

Geothermal energy utilizations are usually regulated by a set of legislations. The consistency, emphasis and simplicity of these legislations are crucial factors in the implementation of geothermal development. A supportive and enabling legislation, which is concise, simple and does not have numerous additional regulations, is a key factor for creating a solid foundation for geothermal development, thus encouraging greatly development.

In numerous countries (Germany, France, Hungary, Romania, Switzerland), geothermal energy is regulated by several separate legislations, mining law, water management law, environmental law, concession law and other related regulations and additional rules (France – Decree 77-620 – Low temperature geothermal deposits, Rybach. 2003; Transenergy 2011, Geothermal ERANET, 2013). These legislative areas are targeted for their respective areas, so a mining law is more focused on utilization of underground resources, while the water management law is more focused on preservation of surface and underground waters. The different scopes of these legislative areas often result in contradictions between each other and cause inconsistency in licensing and other procedures related to project implementation. Also, the separate legislative areas then usually belong to different administrative bodies or authorities, which will have different views and interests, as well as separate and independent procedures. This might cause inconsistencies in licensing and permitting procedures, resulting in loss of time and the need to cooperate with multiple authorities (Geothermal ERANET, 2013, Fraser / Geoelec 2013).

In numerous countries, a specific geothermal law or complete legislation has been introduced such as in Iceland, many African and Central Asian countries and in the US. The aim of these regulations are to provide one concise framework for the regulation, licensing, permitting and all other bureaucratic procedures, related conditions, deadlines, participating authorities, which then serves as the legal basis and guideline for all stakeholders of the development to evade time consuming and repeated procedures.

Haraldsson (2012) states that there is a great diversity of definitions of geothermal resources and geothermal energy between different countries. Several international studies show that these definitions are the underpinnings of legislative and regulatory frameworks for geothermal development (Geothermal ERANET 2013, Transenergy 2011, Haraldsson 2012). It is of primary importance that they are clearly cut. The diversity of legislative aspects may be seen as a barrier for national or international geothermal developers who need to get acquainted with the different legislative frameworks. According to Haraldsson (2012), regulatory frameworks of various countries should be consistent, so developers do not have to adjust to new legislations when operating in different countries.

Another aspect of consistency of legislative frameworks is that legislations are made of several rules, procedures and laws of a certain country. As developers must follow the legislations of the country they operate in, the consistency within the national frameworks and the complexity of regulations are also influencing factors. The importance of consistency and clearness within a single regulatory framework and between administrative procedures cannot be underestimated as a concise and optimised set of legislation and transparent procedures can make the difference if a certain development can start.

In some countries, geothermal development has its separate legislation, which is often a single geothermal act. This legislative structure certainly has its advantages for collecting all related information and regulations about the conditions of a geothermal development. So investors or administrative bodies have a reference point and can act accordingly, which creates a business situation where decision-making can be more efficient, providing crucial benefits for launching and monitoring geothermal projects (Fraser, 2013).

Appendix I presents an excerpt from the Transenergy (2011) research, showing the number of laws and regulations related to geothermal energy in Hungary and Slovakia for comparison.

2.1.2 Resource and reservoir ownership

An important element of legislation and institutional practice is how the ownership of a geothermal reservoir is regulated and how it is ensured that new projects do not interfere with or endanger the productivity of other projects in the same area. In most countries, geothermal energy belongs to the state. This is the case in Germany, France, Netherlands, Slovakia, Slovenia, Austria, Romania, Hungary (Rybach, 2003, Transenergy 2011, Századvég Gazdaságkutató Zrt, 2013) as well as on most other continents, even if the utilization area is owned by a private entity. After the state and the owner or the investor, who made a contract with the landowner, has started geothermal energy production, it is of crucial importance that other new geothermal projects do not influence the existing ones. A straightforward and clear definition of the reservoir and a regulation for entering new users creates an opportunity for the prevention of cross influence or interference between projects. This is crucial when initiating new projects and highlights the need for straightforward definition of the reservoir and legal guarantees, as the land owned does not necessarily cover the area of the reservoir.

It is important that the definition of resource ownership and the role of relevant geothermal institutions be efficient and capable. The legislative and administrative practices of most EU countries show that this question is either not or only partially solved. According to the general practice (Geothermal ERANET, 2013), the new investor needs to prove by an Environmental Impact Study and reservoir model of the new investment that it is not interfering with other projects. This methodology passes the main responsibility to the firm preparing the EIA and relies on the knowledge and information of the permitting authority, as the authority has to check and accept the results and grant the permissions for the new project. If any actor makes a mistake causing interference, the question will arise of who has to bear the responsibility for the damages.

One possible solution to prevent and resolve conflicts between projects is the development of institutional capacity, so decision makers are able to evaluate geothermal data, which is backed up by reliable geothermal information. This needs to be backed up by a straightforward definition of resource ownership and clearly defined reservoir boundaries. A unique solution to this question was implemented in Iceland. The territory of the country was divided into five bigger areas, which have been awarded to single investors (energy companies) to carry out research, exploration and utilization of energy. ÍSOR - Iceland GeoSurvey had prepared 3D models of the areas, which served dual purpose: by using the 3D models, it was possible to estimate the productivity of the geothermal fields, which was needed to effectively advertise the concessions, and also to make it possible to prevent interference of projects (Orkustofnun, 2016). Therefore, geothermal developers have useful and reliable information about the prospects of the planned investment (possible energy output) as well as being ensured that new projects do not interfere with the old ones.

2.2 Institutional arrangements

The institutional frameworks for development of geothermal resources show a great diversity across countries. However, two main paths can be identified, with different levels of complexity or clarity.

In some countries' policies (Germany, France, Netherlands, Austria, Slovakia), licensing procedures, permitting and financial support related to geothermal utilization are overseen by several different institutions or authorities, such as the mining office, environmental authority, water directorates, building authorities and municipalities. For this approach to work, responsibilities and knowledge of the different institutions must be ensured by very transparent and concise legislation and bureaucratic procedures. In order to overcome the challenge of multiple authorizing entities, in many states a national authority for energy or specifically for geothermal energy development, either a company or a single institution, has been appointed or founded ("a champion"). Thus, geothermal development related issues are brought together and supervised by one institution. In many countries, among them the USA (EPA), Iceland (Orkustofnun) and El Salvador (LaGeo), this authority, agency or ministry is the only authority in charge of geothermal energy development. It evaluates applications for geothermal utilizations, issues licenses and permissions and their experts also oversee the conduction of works. Ethiopia, the US, Iceland, Germany, Austria are a few of the countries where either a National Energy Agencies was founded and put in charge of researching, licensing and permitting geothermal facilities, or dedicated geothermal authorities were created (Geothermal ERANET, 2013; Fraser / Geoelec, 2013; Orkustofnun, 2016; Nador, 2013; and Montalvo, 2014).

By this methodology and division between institutions, the legislative, regulatory, permitting, licensing, utilization and operational/energy production rules are kept in one house, so the flow of information and knowledge for shaping the legislation is not fragmented and individual institutional interests have less influence on the procedures. Consequently, the fulfilment of other overall development aims such as protection of the environment could be endangered. But this is prevented as environmental impacts, procurements, tendering and many other development aspects are strictly regulated by national laws that are applied to energy development and the geothermal authority has to act accordingly as is being done in the US, Iceland or the Philippines (Gehringer and Loksha, 2012; Orkustofnun, 2016).

If such an institution or national authority is responsible for all energy related development, the knowhow and good practices of various renewable energy solutions are more likely to be transferred between different institutional departments and more knowledge can be collected to form suitable legislations and administrative procedures. The quality of decisions will be increased so that failures or administrative hurdles are reduced.

A unique example of institutional cohesion and clear cut regulatory framework can be observed in Iceland, where Orkustofnun - the National Energy Agency has been appointed as the leader of energy development, as described in Section 2.2.1. The building where Orkustofnun is located also hosts other geothermal energy related institutions, such as ÍSOR – Iceland GeoSurvey and the United Nations University Geothermal Training Programme (UNU-GTP), ensuring the countinous flow of information and know-how between the geothermal actors.

In countries where legislations and institutions are fractured, the areas of responsibilities and procedures are more complex to adjust and the flow of information is more limited. The developers often need to negotiate with several institutional partners at different locations, which all represent their individual interests and have their own way of bureaucratic procedures as they have their own sets of laws. This proposes an additional challenge to both the investor and the legislators as they constantly need to monitor and comply with a huge set of, often contradictory, laws.

2.2.1 Orkustofnun – the National Energy Authority of Iceland – in practice

Orkustofnun (National Energy Authority of Iceland) is a central hub of licensing and permitting procedures. In the current Icelandic institutional system, Orkustofnun is overseen by the Ministry of Industries and Innovation, which works in close cooperation with the Ministry for Environment and Natural Resources. The legislations governing the two ministries are closely related. The Ministry for Environment and Natural Resources is responsible for EIA and SEA legislations, for municipal planning and nature conservation. The Ministry of Industries and Innovation formed the Electricity Act, Energy and Mineral Resources Act, Water and Hydrocarbons Acts as well as the Act regulating the functions of Orkustofnun. Orkustofnun cooperates with both ministries and follows their legislations during its activities in order to ensure the aims of both legislations and ministries. Orkustofnun also considers regulations related to the Planning and Building Act.

The general activities of Orkustofnun include issuing research, utilisation and power plant licenses as well as considering transmission, distribution and municipal planning and building regulations. Therefore, the whole spectrum of licenses needed from exploration phase until energy production is the responsibility of this single agency. In 2012, the Parliament of Iceland further extended the licensing powers of Orkustofnun, which became fully independent in its decision-making (Orkustofnun, 2016).

Another unique aspect of the Icelandic institutional system is that decisions of Orkustofnun, such as issued licenses and permits, can be revised by the two ministries. Therefore, in case of any issues, there is an option for investors or for locals to have decisions of Orkustofnun revised either by the ministries, or the Committee for Environmental and Resource Matters. First stage issues stay within the bureaucracy, and the administration has simple methods for controlling and protecting local interests, while, as both Orkustofnun and Ngugi (2014) suggest, investors account this as a favourable condition for development. According to Ngugi (2014), all investments will inherently result in various business transaction and contractual relationships. Potentially, all these transactions and relationships could give rise to disputes necessitating arbitration or court adjudication. Therefore, investors and financiers would be concerned whether justice will be served and enforced by evaluating institutions and national policies. Ngugi's argument is also valid for bureaucratic and tendering procedures, licensing, permitting and reservoir ownership conflicts. For this case, a national champion for energy development or a legal and administrative reform can provide a solution.

This institutional system is also in place in numerous other countries besides Iceland. Several countries have appointed a single institution for geothermal energy development, such as the Geothermal Development Company - GDC in Kenya, and in Tanzania, the Geothermal Development Office in Djibouti, Environmental Protection Agency (USA), Energy Development Corporation (Philippines) and CFE – the state power company in Mexico (Gehringer and Loksha, 2012).

2.3 Geothermal research and capacity

Available information about prospective areas and geothermal resources is the first key element of supporting projects during their development as available and relevant information is a key factor in development decisions. Governments play an important role in providing resource related surface and underground information such as seismic, deep drilling and ground water data for project development. This requires surface and subsurface explorations financed by the governments. In Iceland, a governmental agency is responsible for these works (ÍSOR). According to the ESMAP Handbook (Gehringer and Loksha, 2012), in an ideal scenario this information is formulated into 3D reservoir models. The collected information should be available for geothermal project developers, providing information and reducing time for development.

In case of the Philippines, an inventory of prospective geothermal areas and initial surface investigation results are available from the Bureau of Energy Development (BED) of the Department of Energy (Dolor, 2005; 2006). In Iceland, Orkustofnun makes this information available.

Governments should facilitate data and information sharing between public agencies and fee-paying private developers with a specialized data system to reduce exploration risks. In the short term, such a system can attract potential investors as they have basic data about geothermal opportunities, while long term, the database can help preventing possible reservoir overlaps and legal disputes about ownership (Micale and Padraig, 2015).

2.3.1 Institutional capacity building and transfer of know-how

The available information, experience, knowledge and know-how is of high importance for all stakeholders, participating institutions and authorities in case of a geothermal utilization. Education, training and technical assistance, the transfer of know-how and capacity building is essential for smooth operation of institutions, authorities and also for project owners. Geothermal knowledge and knowledge transfer play a crucial role in establishing capable geothermal institutions and authorities, by better enabling streamlined procedures, simplified, clear-cut legislation and faster, more efficient and less contradictory bureaucratic procedures by better informed decision makers and policy personnel. As geothermal energy cannot be utilized in all countries of the world, the related experience and education is limited to the utilizing countries. Specific geothermal education programmes exist only in few countries such as the USA and Iceland, who is leading in this field, however, in Hungary, El Salvador, Kenya and Japan there are several postgraduate or certification programmes as well (Tóth, 2013).

The best known geothermal education program, benefitting from more than 80 years of geothermal experience in Iceland, is the United Nations University Geothermal Training Program (UNU-GTP), which has been in operation in Iceland since 1979. UNU-GTP receives its basic funding from the Icelandic Government, but its organization is through the United Nations University and Orkustofnun. It also receives funding from other sources. The six-month training programme is aiming at assisting experts of developing and EEA program participant countries with significant geothermal potential in building up expertise in most areas of geothermal utilizations. There are eight lines of study, including: Geothermal Geology, Geophysical Exploration, Reservoir Engineering and Borehole Geography, Chemistry of Thermal Fluids, Environmental Science, Geothermal Utilization, Drilling Technology and Project Management and Finances, which represent nearly all aspects of a geothermal exploration and development. These are the areas needed by institutions, which are responsible for geothermal development, to increase their geothermal know-how. In cooperation with the University of Iceland (UI) (since 2000) and the Reykjavik University (RU) (since 2013), UNU-GTP fellows can extend their studies to MSc and PhD levels (Georgsson et al., 2015a).

The UNU-GTP can also offer short courses about geothermal utilizations in interested countries within the framework of the UN Millennium Development Goals – now modified into the UN Sustainable Development Goals. The annual short courses series were started in Kenya in 2005, and in El Salvador in 2006. Since then participation has been extended to many East-African and Latin American countries. The latest capacity building service of the UNU-GTP are customer-designed short courses or trainings on offer for partner countries, which was started in 2010. The customer specifies the outline of the programme, while the contents are defined in detail and guaranteed by UNU-GTP. This form of education was introduced for countries planning fast geothermal development and their need for training and capacity building, which at the same time had the necessary financial resources (Georgsson et al., 2015b).

Capacity building and transfer of information is also ensured through one of the most relevant open-access geothermal knowledge and publications database, prepared and maintained by the UNU-GTP. Since the early 2000s, the older and current publications of workshops and short courses, reports of 6-month programme fellows and other experts have been published in open access pdf-versions at the UNU-GTP website (*www.unugtp.is*) (Georgsson et al., 2015a).

2.4 Financing geothermal projects

Within the ESMAP handbook (Gehringer and Loksha, 2012), eight different models are described for state participation in geothermal development projects. The two extremes of the model are that a single national entity is realizing the project, the other extreme is that the complete investment is outsourced or tendered to a private company. The main difference between the two extremes and the other forms in between is the entity or entities participating, and who has to bear and in what proportion the risks associated with geothermal development as well as the total cost of the investment. The possible formulas for state participation include various versions of public-private partnerships or involvement of multiple national entities. Another possible approach is that the state participates only before or after a certain stage of project development such as build-operate-transfer (BOT).

According to ESMAP, energy developers naturally prefer support through state participation, when high initial risks and financial needs are associated with exploration and collection of data at early project stages, but with independent power producers (IPPs) performing the middle and later stages.

2.4.1 Investments and financing

Geothermal energy utilizations require different financing methods and tools compared to other renewable energy sources, as there is a limited amount of information from surface exploration measurements about the properties of the geothermal reservoir and its energy production capabilities available before making the expensive investments related to subsurface researches and exploration drilling. Therefore, the size of the investment or the power plant cannot be fixed at the beginning of the investment. As investors, at this stage, cannot describe a totally valid business plan, it is less likely that the project can attract outside investors (Kreuter, 2008; Gehringer and Loksha, 2012). From the investor perspective, the most crucial information are the availability, quality, amount, flow rate and temperature of the geothermal fluid, as these provide the basis for the estimations of final energy output and therefore profitability of the project. In case of geothermal utilization, this information becomes available and reliable only when the majority of surface and underground exploration works are finished and some exploration and production wells have been drilled and approximately up to 30-40% of the total investment costs are spent (Gehringer and Loksha, 2012; Micale and Padraig, 2015). Therefore, a huge initial investment has to be made, before the results are fully ensured, and the feasibility of the project is not known. Before the exploration phase is completed, the bankability of the project is low as there is no reliable information about how much energy can possibly be produced. In most cases, this requires the investor to take all related financial risks as finding appropriate public or private financial resources, loans, supports or grants represents a unique challenge. Therefore, financial supporting schemes should reflect the unique properties of geothermal development by providing early stage financing (Hólm, 2016).

Providing geothermal information can be used as a financial tool for geothermal development as the presence of good geothermal surface and subsurface data greatly reduces the risk, time and cost of project planning, thus creating more favourable conditions for development. Therefore, the availability of previous geographical information is of significant importance for reducing exploration costs and attracting outside investors.

Regarding financial support schemes, two types of financing instruments are widely used for energy related development, which can also be further differentiated. One is *investment support,* which includes loans, insurance and investment support programmes and aims at reducing the initial risk. The other scheme is *operational support*, which consists mostly of tax incentives or exemptions and Feed-in-Tariff systems provided for operational projects. Its goal is to increase feasibility downstream and thereby to increase risk willingness through a better risk-reward profile for the project.

Rybach (2010) and Haraldsson (2014) recommend that governments should finance the exploratory and preferably also the pre-feasibility phases of geothermal development. At later stages of the investment, investors should bear the risks. It is easier for them to receive financing for a project that is backed up by relevant information after the exploration drillings. This methodology is also in line with the past approach of the Icelandic government, which funded geothermal exploration activities for decades for the benefit of the public (Rybach, 2010; Haraldsson, 2012). This practice reflects the need of geothermal development and provides effective tools to deal with the high initial costs and the late appearance of reliable information about the possible size of the power output and development.

Investment support can be provided in numerous ways. A basic difference between various types of investment support, is in who bears the financial risks of a failure. In case of loans or grants, the investors or project owners are responsible for financial damages in case of a failure, which is followed by various possible difficulties and naturally has a negative effect on investments. Insurances or loan guarantees for loans overcome this challenge but still require the investment to be made by the investor or project owners. In case of a failure, the insurance can cover the losses, which is beneficial for both the investor and financial provider, as insurances require less financial resources. Therefore, overall policy costs can be reduced compared to grant programmes only.

Regarding policymaking, grant and insurance programmes play important roles and they have to be applied if necessary, preferably providing both.

Providing funding and insurance for the early stages of project development is the practice by both public and private re-insurance companies in Germany such as Axa, Swiss Re, Goathaer, R&V, Marsh & Willis and Münich RE (Münich Reinsurance Company) which have expertise in financing and insurance for geothermal projects. The German company provides geothermal risk insurance specialized for each stage of geothermal projects, mostly in Germany and Turkey. The insurance schemes usually cover up to 70-80% of the investment costs and it is possible to insure only certain parts of the investment, creating favourable conditions for geothermal investors (Münich RE, 2015; Századvég Gazdaságkutató Zrt, 201; Kreuter and Schrage, 2009).

Regarding insurance, another example of the market based geothermal project financing offered by a state owned and governed re-insurance company is the KfW Entwicklungsbank (German Development Bank) and its subsidiary, Deutsche Investitions- und Entwicklungsgesellschaft (DEG), which are owned by the German Federal Government and primarily the Federal Ministry for Economic Cooperation and Development. The KfW partially financed the Olkaria Geothermal Power Plant in Kenya and many projects in Germany. Re-insurance offered by KfW is based on direct or indirect public involvement, e.g. through funding of facilities or ownership of institutions (Századvég Gazdaságkutató Zrt, 2013; Haraldsson, 2014; Micale et al., 2015 and KfW, 2016).

In Germany, France, the Netherlands and Switzerland public and private insurances are both available for geothermal investors. In Germany, where geothermal risk insurance has a relatively long history, the grants, loans, insurances and fees are adjusted individually for projects. All drilling and exploration related works can be supported. The financing is adjusted according to the planned capacity and output of the projects and it is possible to decrease the funding according to the final production capacity if that would be lower than was planned. If the project is only a partial success, the rates of financing, fees and insurance coverage and refunded amount are adjusted accordingly (Századvég Gazdaságkutató Zrt, 2013; Rybach, 2010; Kreuter, 2008; 2009).

The practice of providing both loans and insurance or the two combined is also a practice used by some international public development finance institutions (DFIs) and agencies. These include the Climate Investment Funds, EU-Africa Infrastructure Fund or the Japanese International Cooperation Agency, Geothermal Risk Mitigation Facility, which is active in Africa and Latin-America (; Micale et al., 2015; and GRMF, 2016). Besides these private loans and insurance examples, in many cases the state itself can take the leading role and create a loan and/or insurance fund or is participating in multilateral agreements and institutions in order to provide loans and insurance through international investment banks, multilateral development banks (MDBs) or specialized development funds. Here can be mentioned the Clean Technology Fund (CTF), the Scaling –up Renewable Energy Program (SREP), GeoFund or ARGeo (Gehringer and Loksha, 2012).

The Icelandic Energy Fund was set up to provide low-interest loans to municipalities, firms or individuals for geothermal drilling, to share the risk of drilling with developers. The loans normally cover 60% of drilling costs and can be converted into grants if the development of a new geothermal field proves unsuccessful, thus also functioning as insurance for the developer (Haraldsson, 2014). Loan programmes are also in place and accessible within the United States from the federal government. The Geothermal Loan Guarantee Program grants loans for up to 75 percent of project costs since 1974 with the federal government guaranteeing the full amount. Besides, various loan programmes are available at federal and state levels. In Germany, a drilling insurance programme was introduced in 2010, where a premium is paid on a loan which is converted into a grant in the case of drilling failure. A governmental risk coverage system has been in place in France since 1981 where a short-term risk guarantee covers all or part of an investment in case of drilling failure and a long-term risk guarantee covers the risk of resource decline for up to 25 years. A risk guarantee system was also established in Switzerland in 1987. The provided guarantee extends to 50% of drilling and testing costs and in specific cases up to 80%. A new governmental risk coverage system was introduced in 2008 in which the maximum guarantee is 50% of the subsurface exploration costs (Századvég Gazdaságkutató Zrt, 2013).

The European Economic Area Grants and the Norway Grants (EEA, 2016) are supporting programmes jointly financed by Iceland, Liechtenstein and Norway for EU member states. Among other aims, the EEA and Norway Grants are supporting development of renewable energy sources by providing funding for various energy projects from environmental awareness raising to drilling costs. The EEA recognized the special needs of geothermal development; therefore, it is possible to receive support only for parts of a larger project (EEA, 2016).

The European Union and the European Investment Bank are funding several scientific research programmes and mechanisms that support geothermal research and development, such as FP7, H2020, Intelligent Energy Europe, Structural- and Cohesion Funds, European Fund for Strategic Investments (EFSI) Connecting Europe Facility (CEF) or NER300 and 400 (Századvég Gazdaságkutató Zrt, 2013; EIB, 2015; 2016).

The Geothermal Technologies Program in the US was launched in 2009 with USD 400 million funding for a broad portfolio of projects including demonstration projects, research and development, innovative exploration techniques, national geothermal data system, resource assessment and classification system and ground source heat pumps (Wall, 2009).

The Global Environmental Facility (GEF), administered by the World Bank and UNEP, is financing geothermal investments in Europe and central Asia, from which, among others, a geothermal project of the MOL oil group in Armenia received an insurance grant (Gehringer and Loksha, 2012; GeoFund, 2016).

As the success rate of exploration drillings is 68% (Gehringer and Loksha, 2012), the insurance for exploration phase geothermal projects seems to be advantageous both for public and private insurance or loan providers and investors. Goodman et al. (2010) and Fraser (2013) suggest that geothermal risk insurance should extend to the whole EU. A common European Geothermal Risk Insurance Fund (EGRIF) could be a great asset in mediating geothermal financing conflicts (Haraldsson, 2012; Fraser, 2013).

Micale and Padraig (2015) state that with the right policies and financial measures, governments can drive investments that deliver the same amount of geothermal energy while providing only 15-35% of the national resources, which would have been spent if the projects had been built and operated by themselves.

Preferably, after a successful investment support and if the power plant is operational and production has started, operational support can be provided. Feed-in tariffs for geothermal electricity are currently in place in 20 countries world-wide (REN21, 2014), including Austria, Hungary, Croatia, Czech Republic, Ecuador, France, Germany, Greece, Indonesia, Italy, Japan, Kenya, Serbia, Slovakia, Slovenia, Spain, Switzerland, Turkey, Uganda and the United Kingdom (Haraldsson, 2012). However, within the EU, according to the current practice, geothermal electricity is supported but geothermal heat production is usually not, except in France (Orkustofnun, 2016).

2.4.2 Development strategies

In case of geothermal development implementation two major approaches, conventional and stepwise development strategies can be distinguished. According to the conventional development methodology, geothermal resources and production capacity are estimated by exploration and planning of the power plant and all related administrative procedures are started. During the development of the project, if something does not go according to plan, e.g. the energy output is not as expected, there is less space for adjustments as all financials and licenses are according to the original plan.

The stepwise development strategy involves starting the development at a smaller scale. When the resources are partly in use, it is possible to collect more relevant information and plan further utilization. An example of the stepwise development is the development of the Nesjavellir geothermal field operated by Reykjavik Energy in Iceland. The development started in 1982, initially as a hot water production project. A 100 MW thermal power plant was constructed in 1990 and when the reservoir was further explored and more data had been collected, electricity production was gradually added and the hot water production was extended to 150 MW and later to 290 MW (Steingrímsson, 2009). This methodology creates favourable conditions for adjustments during implementation, as development can be evaluated and adjusted according to the output capacity of the reservoir. As the amount of relevant information about the investment and the possible output increases, the investor is able to provide relevant information for collecting financial sources.

The stepwise development approach also provides additional benefits in case of low-temperature geothermal resources. By aiming for moderate utilization levels during the first phase of development instead of the possible maximum output of the reservoir, there is more space for adjustment if the temperature is lower or output of the geothermal resource is less than previously anticipated and utilization can be changed from electricity generation to direct use.

Stepwise development can also add to the sustainable use of the reservoirs by preventing over-exploitation of the resource.

Stepwise development can also be suitable for smaller investments at local levels. Smaller projects can be presented in the form of a programme or portfolio and developed accordingly. The European Union supports numerous energy related large scale demonstration projects through various programmes, such as European Fund for Strategic Investments (EFSI), Connecting Europe Facility (CEF) or NER300 and 400. While these developments are necessary, geothermal development can also be fostered at a smaller scale, especially in low-enthalpy reservoirs such as the Pannonian-basin, which could be an area for national or local governments to act. Small scale, local district heating, electricity systems and heat pumps could be also supported, promoting local improvements and keeping the benefits of the investment in the local communities. Small-scale geothermal projects (0.5-5 MW according to ESMAP (Gehringer and Loksha, 2012)) could be suitable to provide a reliable base load power or heat, which is constantly available. Geothermal energy can also be successfully combined with other renewables, which have stronger environmental footprints. In such cases, the electricity does not need to be transferred over long distances by national networks, evading some of the transmission development costs.

The idea of stepwise development and methodology should also be considered, for development of existing projects. In case of existing utilizations, careful planning of further development should be carried out to avoid unnecessary capacities.

2.4.3 Tax incentives and fees

Another area of possible state support for geothermal development are tax incentives. The international practice is mostly aiming to ease the tariff duties on imported machinery and equipment for geothermal power plants or provide accelerated depreciation. In El Salvador and the Philippines, the governments supported geothermal investments extensively using these tools (Haraldsson, 2014). In some EU states such as in Hungary, large companies will be able to receive corporate tax incentives or reductions starting in 2017, if a company makes energy efficiency investments related to its own facilities (Soltész, 2016). The Philippine Renewable Energy Act of 2008 provides various fiscal and non-fiscal incentives for renewable energy developers. These include income tax holiday for the first 7 years of commercial operation of renewable energy facilities, special realty tax rates on equipment and machinery, net operating loss carry-over, accelerated depreciation, 0% VAT rate for the sale of renewable power, tax exemption of carbon credit sales, and tax credit on domestic capital equipment and services (Haraldsson, 2012).

Geothermal energy projects are also required to pay license fees and mining royalties for the use of geothermal energy or for the extraction of hot water. By reduced fees and royalties, governments can also effectively support sustainable geothermal investments. However, tax incentives are not considered as efficient for speeding up geothermal development as risk mitigation schemes (Gehringer and Loksha, 2012).

3. GEOTHERMAL ENERGY PROSPECTS IN HUNGARY

3.1 Geology

Hungary is located in Central Europe (Figure 1), the area is 93,000 km^2 and its population is 10 million. Hungary's excellent geothermal potential is well-known and the country has a long history and tradition of utilization of thermal waters for direct heat supply. The country is most famous for its low-temperature utilizations, which are mostly internationally recognized thermal baths and spas and district heating systems.

Hungary lies in the Pannonian Basin, which is encircled by the Carpathian Mountains. The crust below Hungary is relatively thin (approx. 25 km) due to sub-crustal erosion. This thinned crust has sunk isostatically. The basin that formed is filled mostly by multi-layered tertiary sediments, which are composed of sandy, shaly and silty beds. Lower Pannonian sediments are mostly impermeable. The upper Pannonian and Quaternary formations contain vast porous, permeable sand and sandstone beds. The thickness of the individual sandy layers varies between 1 and 30 m and most of them are

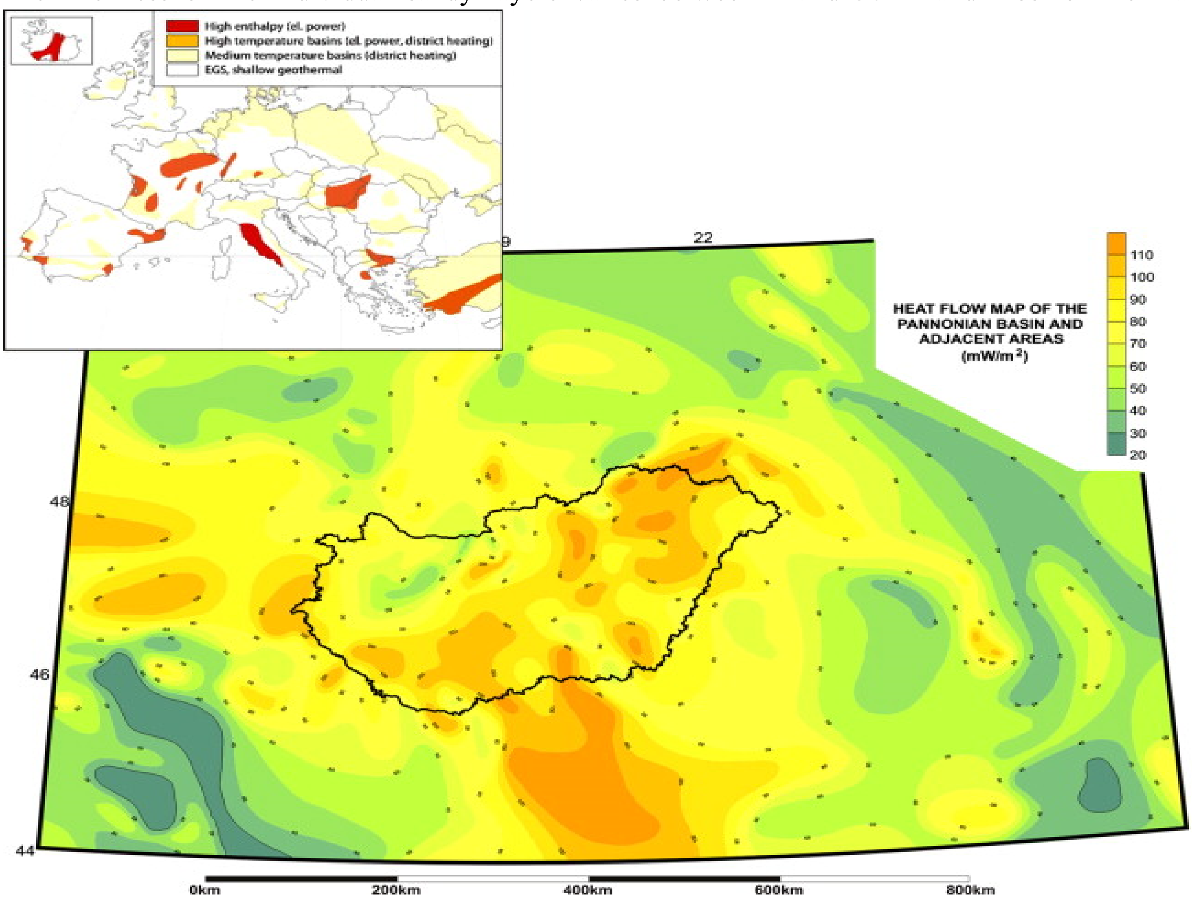

FIGURE 1: Heat flow map of the Pannonian basin and adjacent areas, based on Dövenyi et al. (2002); inset (top left) is a geothermal thematic map of Europe, based on Antics and Sanner (2007) and Szanyi and Kovacs (2010)

interconnected. These form the upper Pannonian aquifer, which is the most important thermal water resource in Hungary. This aquifer has an area of 40,000 km^2, an average thickness of 200-300 m, a bulk porosity of 20-30%, and a permeability of 500-1,500 mD. Another type of geothermal reservoir is found in the carbonate rocks from the Triassic, which have secondary porosity. These can be fractured or karstified rock masses with continuous recharge and important convection. About 20% of the Hungarian geothermal wells draw fluids from such carbonate rock formations, mainly in the western part of the country (Tóth, 2015).

The underground natural conditions in Hungary are very favourable for low- and medium-enthalpy geothermal energy production and utilization. The sedimentary layers provide heat insulation for the permeable sandstone layers below. The surrounding mountains and fractured structures provide substantial supply and flow of water The main areas of good geothermal prospects are located on the western and southeastern side of the country, but the anomalously high terrestrial heat flow (~0.09 W/m^2) and the high geothermal gradient (~0.05°C/m)also provide good prospects for low- and medium-enthalpy utilizations. This applies to most of the country, except for the mountainous areas ranging from the west part of the county to the north-east areas (Tóth, 2015). Individual and relatively small fracture zones and other anomalies can be found in various parts of the country, such as at the town of Tura in central east Hungary, Fábiánsebestyén in southeast Hungary and Miskolc-Mályi (northeast Hungary) which are providing much higher than average temperatures and flow of geothermal fluids.

3.2 Short history and current status of geothermal utilization

The history of geothermal utilization dates back to the Roman Empire when spas and public baths were built. During the medieval times, this development was continued by the Hungarian Kings and by invading regimes. These utilizations made use of the existing geothermal surface manifestations. Exploration of geothermal resources began in 1877, when the deepest well in Europe at that time (971 m) was drilled in Budapest overseen by the drilling engineer V. Zsigmondy (Geothermal ERANET, 2013). Between the two World Wars, exploration for oil and gas was begun. However, in most cases only huge thermal water reservoirs were discovered. District heating developments were started at the Budapest Zoo and some surrounding apartments, as the nearby Széchenyi Spa could provide excess water. After World War II, during the 1950s and 1960s, hundreds of geothermal wells were drilled, mostly for balneology, greenhouses and for other agricultural purposes (Tóth, 2010).

In the late 1950s, district heating projects were started in southeast Hungary in Hódmezővásárhely, Szeged, Szentes, Makó and Kistelek. The technical level of these geothermal heating systems was varying. In some cases, there are well-designed and well-controlled sophisticated systems, where dozens of geothermal wells could supply a cascade of sub-systems with greenhouses, plastic tunnels and soil heating all connected in series (e.g. Hódmezővásárhely), while in other cases, a single well provided thermal water directly to greenhouses. The peak of geothermal activity was in the late 70's when a total of 525 geothermal wells were registered and the thirty best wells had a production temperature exceeding 90°C. Total thermal power capacity of these wells was 1,540 MWt, but utilization was seasonal and the efficiency was rather low (Tóth, 2010; Ádok, 2016, Kurunczi, M., and Ádám, B., 2016).

Since the 1980s, hundreds of the agricultural wells have been shut down, mostly due to the political transformation of 1989. Since then, a continuous but slow development and research of geothermal resources is ongoing. In 2014, 672 wells produced thermal water warmer than 30°C. However, 179 wells are abandoned and 220 are temporarily closed (MFGI, 2013).

Since the 1990s and onwards, the development of geothermal energy sources has been slow but continuous. In many cases the former agricultural wells became private property or are owned by agricultural investors. Geothermal development since then is characterized by three main development domains. One is the development of the spa industry, the second is agricultural use and the third is heat production.

Spa development has taken place at several locations during the last decades. It has been financed either by private funds or EU development projects, such as Zalakaros, Sárvár, Hévíz, Bük, Budapest, Visegrád, Baja, Szeged, Eger, Miskolc-Tapolca, Hódmezővásárhely, Hajdúszoboszló, Gyula and additional places. Altogether 295 thermal wells and 132 natural springs produce water for sport and therapeutic purposes. The outflow temperature typically ranges from 30 to 50°C. These wells mostly discharge the porous sedimentary sandstone reservoirs, which lie at an average depth of 500-1500 m. About 50 wells have higher outflow temperature than 60°C, many of them discharging the fractured basement aquifers. The hottest ones are at Zalakaros (SW-Hungary, 99°C) and at Gyula (SE-Hungary, at the Romanian border, 91°C). The estimated amount of thermal water used for bathing and swimming is about 41.18 million m^3, or 352 MWt / resp. 3,912 TJ/year (Tóth, 2015).

Agricultural use is another major area of geothermal energy utilization. Various vegetables are grown on more than 70 ha. in greenhouses and on more than 250 ha. in soil-heated plastic tents. Heat and water are supplied by 181 operating thermal wells, which produce 10.97 million m^3 of thermal water (Tóth, 2015). Further, more than 50 farms utilize geothermal energy for animal husbandry. The major agricultural users are the Árpád-Agrár Zrt. in Szentes and Flóratom, Bauforg Ltd.-s. in Szeged, Bokrosi Ltd. in Csongrád, Primőr-Profit Ltd. in Szegvár and many smaller users, especially in SE-Hungary. Fish ponds near Szarvas and Győr are also heated with low-temperature geothermal water. In 2013, the total installed capacity in the agriculture sector was 306 MWt and the estimated annual use was 3,414 TJ. National and EU funds also support development of these areas.

The development of existing independent small district heating projects is also ongoing, as well as several new projects that were also started in recent years. Mayor reconstruction and development of geothermal heating systems were performed at Hódmezővásárhely, Miskolc-Mályi, Eger, Makó and other places. The technical level of development of these geothermal heating systems is varying. Some are very sophisticated and well-controlled systems such as in Hódmezővásárhely, where large number of wells (12) supply a cascade of sub-systems, and excess heat utilized for greenhouses. In other cases, a single well provides thermal water directly to greenhouses with the excess heat not utilized and water not reinjected, sometimes causing environmental problems. In 2013, individual space and district heating capacity was 186.58 MWt and actual use was 2,026 TJ/y for all of Hungary. Hódmezővásárhely is the city with the most developed geothermal district heating system with a capacity of 21 MWt (Tóth, 2015).

The mayor geothermal heat developments in Hungary are often joint projects of local governments or assemblies of neighbouring towns. The investments are funded by various supporting programmes, some of them in collaboration with Iceland within the framework of the EEA and Norwegian financial mechanisms (EEA, 2016), the EEA FM (Geothermal ERANET, 2013) and various EU grants, such as the NER300 and NER400 initiatives. Others are financed by various national supporting programmes such as Environment and Energy Operative Programme and the latter Environment and Energy Efficiency Operative Program and their sub-programmes and predecessor-programmes since EU accession in 2004. These programmes provided funding for direct utilization, but also for exploration and cooperation regarding geothermal energy utilization. As funding was available for scientific and exploration projects as well, several research and exploration projects took place both on national and international (Hungary and its neighbours) levels. However, the majority of current geothermal development has become dependent on and characterized by EU grants, as local governments are lacking funding and the existence and involvement of private investors are rare.

Between 2010 and 2014, about 24 deep geothermal projects received EU and/or national support with grants totalling 27.2 million Euros. The Szolnok hospital, the Szeged heating system, and the Gyopárosfürdõ Thermal Bath are three main examples. In addition, two large district heating projects were begun in 2010 by Pannergy Ltd., in Szentlőrinc and in Miskolc-Mályi, and finished in 2013 (Pannergy, 2013; 2016). Many other projects are also currently underway which are focusing on geothermal power plants, CHP, district heating and GSHP incentives, for example in Mosonmagyaróvár, Szolnok, Győr, Battonya and Tura.

Hungary's largest geothermal based district heating system is in Miskolc, which is the first large scale district heating project in Hungary. The aim of the project is to heat the several hundreds of apartments at „Avas" housing estate at Miskolc, the second largest city in Hungary. The project was started in 2013 when the first phase of the system began operation and the development has been continuous since then. Heat is supplied by the unique high-temperature wells in Miskolc-Mályi, where a total of 5 wells were drilled. Two production wells went to a depth of 2,305 and 1,514 m, respectively, yielding 6,600-9,000 l/min flow with a temperature between 90 and 105°C from a karstified-fractured Triassic limestone reservoir (Tóth, 2015). Three reinjection wells were also drilled and a 22 km long pipeline constructed. The planned heat capacity is 55 MWt and the heat demand is 695,000-1,100,000 GJ. To use the run-off water in a future project, 10 ha. of greenhouses are under development. Another project is planned in Szentlőrinc, where the town's heating system is planned to become 100% geothermal energy based. Both projects are supported by the EU and/or national grants and owned by PannErgy PLC, which is a private investor. As reported by the investment firm, the investment cost was 25 million EUR of which the EU support was more than 5 million EUR. In both projects, the contracted off-take partners are local government-owned companies (PannErgy, 2013; 2016). Some other private investment firms, such as CBA and EUFIRE, have become involved in geothermal energy production and utilization. Such firms have signed contracts with local governments, e.g. in Mosonmagyaróvár, Kecskemét and Eger, to create geothermal district heating systems.

Hungary is about to make a significant step forward in geothermal based electricity production which is not yet existing in Hungary. The first geothermal energy based electricity power plant is expected to be operational in the middle of 2017 with 2.7 MWt capacity at Tura, central E-Hungary, the project will be described in detail later in this report. Another project for geothermal based electricity production is on the way at Jászberény, Central-Hungary, where a 2.5 MW power plant is to be built.

Crucial development regarding high-enthalpy reservoirs are also on the way. Recent national and EU funded surface and underground studies have proven the existence of deep high enthalpy geothermal reservoirs, most of them located in SE-Hungary. The obtained undisturbed temperature of the rock is 252°C at 6,000 m depth. These areas have good prospects for high-enthalpy utilizations and are targets for future EGS development projects. They also provide the basis for geothermal electricity production, as there is no geothermal electricity production in Hungary yet. The first EGS power plant in Hungary is to be launched at the end of 2019 according to the project developer (EU-FIRE, 2016a; 2016b).

The European Commission has awarded over 1.2 billion Euros to 23 highly innovative renewable energy projects all over the EU in 2013 through the NER300 Programme. This program provides support for Hungary's first Enhanced Geothermal System (EGS) project, run by EU-FIRE and Mannvit Ltd, at Battonya, Hungary. The project, which was awarded almost 40 million Euros of the NER300 funding, has an estimated total investment cost of €116 million and an expected capacity of 11.8 MWt. Other institutional and private investors will fund the project's remaining costs (Kovács, 2013; Energiainfo.hu, 2012, Askjaenergy.com, 2013).

Ground source heat pumps (GHPs) or shallow geothermal heat utilization have increased from 2000 to 2010, but the economic crisis in 2008-2009 caused a setback. In order to foster development, the installation of a shallow heat pump no longer needs formal permission (since 2013) and does not even require a notification before drilling (Kujbus, 2016, Nádor, 2013, Haehnlein et al., 2010). The estimated installed capacity of GHPs is about 40 MWt. The actual number of installed units is more than 4,200, the average obtained COP is 4.0, but the relevant data is incomplete because installed devices do not have to be reported. The biggest Hungarian heat pump systems (around or over 1 MW capacity) are significant in the European market. Many international companies operating in Hungary made major investments in heat-pump systems in the recent years (e.g. Telenor Office at Törökbálint, central Hungary and TESCO). The average size of individual units ranges from 10 kW to 14 kW for residential use. In many cities and towns with good geothermal prospects, new investments for condominiums and apartment houses are commonly planned for GHP heating only, or GHP is used as additional source of heat additional to natural gas due to financial, environmental and energy efficiency constraints (Tóth, 2015). The installed capacity and annual energy use for the various geothermal energy applications in Hungary are (Lund and Boyd, 2015):

- 33.02 MWt or 326.05 TJ/yr, for individual space heating;
- 153.56 MWt or 1,700.26 TJ/yr, for district heating;
- 271 MWt or 3,024.12 TJ/yr, for greenhouse heating;
- 6 MWt or 61.51TJ/yr, for fish farming;
- 4 MWt or 31.34 TJ/yr, for animal farming;
- 25 MWt or 297.13 TJ/yr, for agricultural drying;
- 19 MWt or 220.62 TJ/yr, for industrial process heat;
- 352 MWt or 3,912.03 TJ/yr, for bathing and swimming;
- 42 MWt or 695 TJ/yr, for geothermal heat pumps.

The total installed geothermal energy capacity and annual energy use in Hungary are 905.58 MWt and 10,268.06 TJ/yr, respectively (Tóth, 2015; Lund and Boyd, 2015).

After Turkey, Iceland and Italy, Hungary is ranked at 4th place regarding installed geothermal direct use in Europe (Geothermal ERANET, 2013; Lund and Boyd, 2015).

4. GEOTHERMAL DEVELOPMENT ENVIRONMENT IN HUNGARY

4.1 Current energy and geothermal policy development

The current renewable energy development are backed up by the country's renewable energy targets, which are based on the EU 2020 and 2030 renewable energy goals. The National Energy Strategy 2030 was introduced in 2011 and the measures are aiming at the security of energy supply, competitiveness and environmental protection and integration to the common European structures as well as the creation of decentralised energy systems and fostering renewable energy production in Hungary (National Energy Strategy 2030, 2010). The strategy also states, that such policy and institutional reforms have to be introduced that result in a predictable investment climate in order to increase supply security and also to avoid the lack of essential energy investments, such as reduction of bureacracy, opening up the space for decisionmakers to act in favour of renewable energy sources, including geothermal. The strategic environmental assessment of the National Energy Strategy 2030 emphasizes the importance of geothermal electricity and heat utilizations (Pálvölgyi et al., 2011; MND, 2011).

According to the Hungarian National Energy Strategy 2030, the proportion of renewable energy resources of the energy consumption should reach 14.65% of the gross annual energy production in 2020 (National Energy Strategy, 2010). The total share of renewable energy sources was 9.61% within the GFCoE in 2014 and 5,2 PJ out of 65 PJ of the annual renewable energy consumption comes from geothermal resources (MEKH, 2015).

The aims and commitments of the National Energy Strategy 2030 are supported by the National Renewable Energy Action Plan 2010-2020 (NREAP) of Hungary (MND, 2010; NREAP, 2013). According to the renewable energy development path described in the NREAP, electricity production from geothermal resources should be increased from none in 2010 to 57 MW (2015) and to 410 GWh of the gross energy consumption until 2020. Heating and cooling from geothermal resources should grow 3,5 times between 2010 and 2020, from 101 kTOE to 357 kTOE, as well as the total geothermal energy utilized that should be increased 3.8 times from 4.23 PJ in 2010 to 16.43 PJ in 2020 (NREAP, 2010; Geothermal ERANET, 2013).

In 2010, geothermal energy was responsible for 8% of the gross annual renewable energy production (55.25 PJ) of Hungary. According to the NREAP, until 2020 the amount of geothermal energy will provide 14% of the gross annual RES production (120.57 PJ) (Fancsik, 2013) (Figure 2).

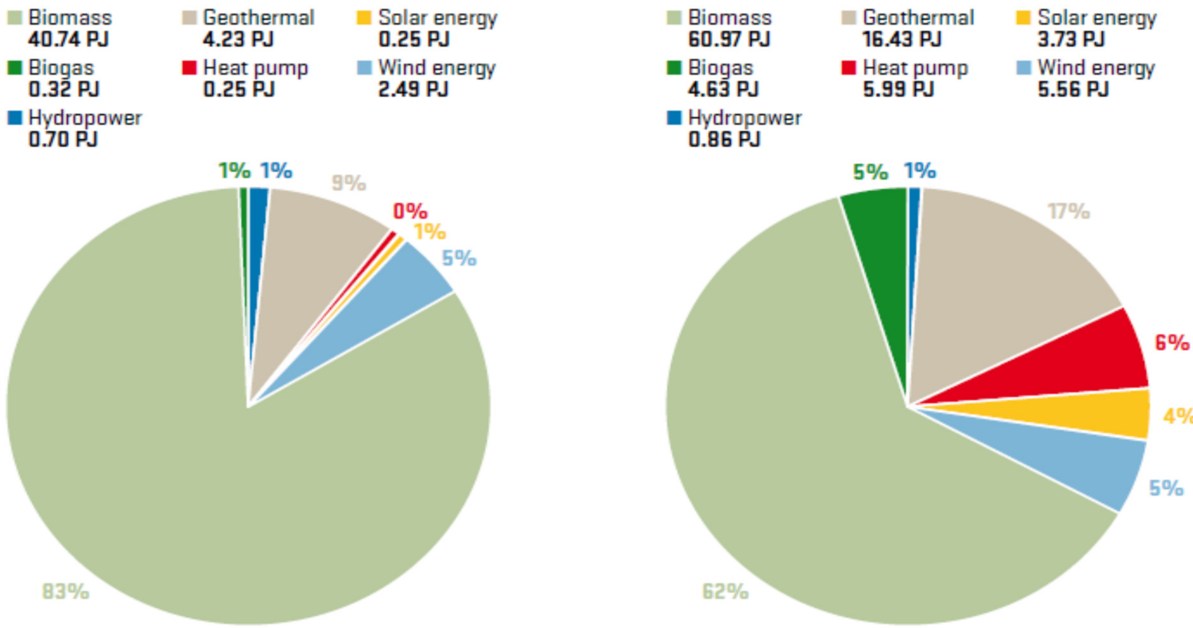

FIGURE 2: Distribution of renewable energy sources used in the electricity, heating and cooling sectors (2010 and 2020) in the NREAP of Hungary

Despite the ambitious geothermal targets of the NREAP of Hungary and the new development, the overall number of geothermal energy utilization permits issued by the relevant authorities have been decreasing continuously since 2008, from 15 to 20 new permits per year, to 2 to 6 permits. According to Attila Kujbus (2016), the current development and the ongoing projects are at least partially if not fully supported and fuelled by the EU or other international sources. Private investors and local governments tend to stay in the background due to the economic crisis and because of the lack of own resources, but most of all, as EU projects are usually providing support for complete projects, not for certain phases of geothermal development. They also have only a 1 or 2 years' timeframe, which is not enough to plan and complete a new geothermal investment. Therefore, current EU and nationally supported projects have the leading role in showing the path and initiate new projects. However, the introduction of new national and international supporting schemes, geothermal research and updated legislation should be enhanced to push development to the next level (Kujbus, 2016).

Both the National Energy Strategy 2030 and the National Renewable Energy Action Plan 2010-2020 are general strategies that describe the country's energy and renewable energy development priorities and provide a roadmap of development and production of energy until 2030 and 2020, respectively. Geothermal energy development aims are represented by the planned amount of geothermal electricity and heat produced between 2010 and 2020, but no specific geothermal strategy or policy recommendations are described.

The Mineral Resources and Resource Utilization Action Plan of 2013 is aiming at fostering mining and the mining based industries in Hungary including geothermal. The Action Plan contains the estimation of energy potentials of mining industries including geothermal potential. It states, that the increasing geothermal energy utilization is key to decreasing energy dependency and enforces the measures of related to geothermal energy development (Jávor, 2016, MFGI, 2016.)

Related to the renewable energy aims of Hungary, large companies that are performing energy efficiency related investments in order to optimize their production procedures or reduce their energy consumption, are eligible for corporate tax reduction for a certain period after their investments had been finalized. The regulation is expected to come into force in 2017 (Soltész, 2016).

Besides the EU and national energy targets, there are some other unique geographical conditions and properties of Hungary, which are also influencing the future geothermal development and policy. One is that the Pannonian reservoir extends beyond the state borders, therefore interstate agreements, the common policies, planning of development and monitoring of the cross-border reservoirs should be enhanced, as neighbouring countries such as Slovenia, Croatia, Romania and Slovakia are showing a growing interest in geothermal energy utilization (Transenergy, 2011). The existing transboundary agreements with all neighbours of Hungary should be further developed regarding future geothermal development. The other is that nearly all of the rivers and other surface waters in Hungary, which are one of the main sources of subsurface geothermal reservoirs, are originating from neighbouring countries. Therefore, the cooperation with our neighbours for the prevention of pollution of reservoirs and interference between projects, the preservation of good quality of the natural resources and reservoirs and the future public and private projects have a crucial role in maintaining the long term sustainability of the Pannonian reservoir.

4.2 Legislation related to geothermal energy

Utilization of geothermal energy and licensing procedures for geothermal investments in Hungary are regulated by the Mining Act. However, when water extraction is involved, provisions of the environmental and water management legislation should also be considered (Tóth, 2015). No single geothermal legislation or geothermal act exists. The only activity related to geothermal energy utilization, which does not require a permit or license, is surface exploration work, as for this only an agreement with the owner of the land is needed, while the mining authority should be informed 30 days in advance about the start of exploration (Dumas et al., 2013). Besides surface exploration works, the regulation applied for geothermal investments is dependent on two main factors:

1. The depth of the targeted geothermal resource;
2. Whether geothermal exploitation requires water extraction.

The legislation and authorities involved in procedures, depend on if the resource is found in an open area (at a depth from 20-30 to 2500 m), and if groundwater extraction is involved or not (Nádor, 2013). If no groundwater extraction is involved, the Regional Mining Inspectorate is competent to issue an exploration license and a license for the exploitation and utilization of geothermal energy, including construction and setup of related underground and surface facilities. On the other hand, if groundwater extraction is involved, which is usually the case, the Regional Directorates for Environment, Nature and Water are the competent authorities to issue a license for the utilization of thermal groundwater found between 30 and 2500 m ('water permit'). Simultaneously, this is considered a license for prospection, exploitation and utilization of geothermal energy and the Regional Mining Inspectorate intervenes in the procedure as a co-authority, notably by delivering a technical-safety license for drilling. However, the National Directorate General for Disaster Management (NDGDM) is also involved in giving permission to construct energy production facilities (Dumas et al., 2013).

The relevant legislative framework governing geothermal development in Hungary is made up by three different legislative areas: energetics, mining, and environment and water. These three areas cover an exceptionally big area of legislations consisting altogether of more than 118 regulations that relate to geothermal energy utilization. As Mádlné (2008) states, this amount of regulation is not transparent for investors and project owners. Different institutions are also responsible for the separate areas, so contradictions and legal gaps are frequent.

A good example of contradictory regulations are the Mining Act and the Ministerial Decrees related to water management (Ministerial Decree 101/2007 (XII. 23) and 96/2005 (XI. 4)). Each of the regulations give different values for the depth that acts as division line for determining if the drilling requires a permit or not. The Mining Act does not define any depth in connection with permit requirements. One Ministerial Decree set the depth to 20 m, the other to 30 m (Transenergy, 2011). Another possible example for contradictions could be that the necessary documents for handing in geothermal license inquiries and building permits for water facilities are not well defined and the Environmental Authority and the Land Use Office are partially free regarding what kind of documents they require. Therefore, it can happen that one authority is requiring the permission of the other authority, which requires the permission of the first authority to issue the permit to be granted by itself (Mannvit, August 2016, personal communication).

The legislation is also unbalanced and often contradictory. For example, the Mining Law states, "Geothermal energy exploited with thermal water is not geothermal energy, because it entails thermal water production". Therefore, it is not subject to the Mining Law, but is subject to the Water Management Law, which does not include the terms of geothermal energy and its utilization (Rybach, 2003).

The Act on Water Management 2005 establishes a ranking for geothermal resource utilization, and energetic utilization is ranked low. The Water Management Act also states that waters extracted for geothermal energy only need to be reinjected, however, this differs depending on the circumstances according to Ministerial Decree 101/2007. Also, geothermal energy is subject both to mining and water resource fees, however agricultural use is only subject to water resource fee (Tóth, 2015).

The overall aims of the three legislative areas are also different. The Water Management Act is aiming at water protection, while the Mining Law aims at responsible use of geothermal resources.

In April 1st 2015, the Act VI of 2015 came into force, targeting more efficient state administration. The Regional Mining Inspectorates and the Regional Directorates for Environment, Nature and Water were integrated into a new national administrative system and into a new institutional structure (Kormanyhivatal.hu, 2016). The aims of the reform was to simplify administrative procedures. However, the reorganization of licensing authorities and relocations, in practice means one address to communicate with (the Regional Governmental Offices), but with the same legislation applied. Hence, multiple licenses are still required for geothermal utilizations, and while the authorities are unchanged, the investors still need to negotiate with each involved authority, separately.

Legislative and expert questions can arise if the reorganization of the authorities related to geothermal development is challenged concerning know-how and capacities of the new institutions. An example from Hungary is that the construction permits related to some of the power plant buildings and equipment are to be granted by the National Directorate General for Disaster Management, Ministry of the Interior (NDGDM). This authority has the task to protect the lives and properties of the population living in Hungary, ensuring the safe operation of the national economy, and protecting the elements of the critical infrastructure by preventing disasters. This is done by carrying out rescue operations in civil emergencies, organizing and controlling protection activities, eliminating the negative consequences of emergencies and performing reconstruction and rehabilitation. These are highly important public safety tasks and not geothermal energy utilization specific, which raises the question of capable institutions and smooth administrative and permitting procedures.

In Hungary, different legislations are applied for geothermal energy utilizations targeting geothermal resources above or below 2500 m depth. If the resource is above this depth (open area), a licensing procedure is applied, but if the resource is below 2500 m depth, then utilization can only be enabled by a state concession procedure and licensing. Currently there is no area in Hungary, which has been tendered out for geothermal concession (Dumas et al., 2013) and according to Kujbus (2016), none is in planning yet. Only one EU EGS project has been started, an EU demonstration project, where exceptional rules are applied and no concession was involved (Pannergy, 2016). As there is no concession contract or call for proposals yet, exploration and development of geothermal energy in more than 2500 m depth or licensing procedure for exploration cannot be started (Table 1).

TABLE 1: Legislative distinction according to depth and main actors in licensing procedures and participating authorities in Hungary for geothermal projects

Depth (m)	Area	Energy extraction	Licensing authority	Consulting/licensing co-authorities	
0-20	No licensing, but the well should be reported.				
20-2,500	Open area	Closed loop, no water production (GSHP)	Regional Mining Inspectorates		The Hungarian Energy and Public Utility Regulatory Authority (electricity production, FIT)
		Extraction of thermal water	Regional governmental offices (environmental concerns)	Regional mining Inspectorates (implementation of deep-drilling)	The Hungarian Energy and Public Utility Regulatory Authority (electricity production, FIT)
Below 2,500	Closed area (concession procedure)	Extstraction of thermal water	- Regional Mining Inspectorates (concessional procedures) - Regional Governmental Offices (environmental concerns)		The Hungarian Energy and Public Utility Regulatory Authority (electricity production, FIT)
		Extraction of thermal water (EGS)	Regional Mining Inspectorates (concessional procedures)	Regional Governmental Offices (EIA)	The Hungarian Energy and Public Utility Regulatory Authority (electricity production, FIT)

4.2.1 Reservoir ownership

The ownership of the reservoir and the limitations for competitors to prevent the simultaneous exploitation of the same reservoir is not guaranteed by the current legislation. Several competitors and projects can use the same reservoir (Fraser, 2013). The legislation about the *Intervention into underground reservoirs and the requirements for drilling of wells* (Kvvm 101/2007 3 § (4) states, that during the planning of the drillings and wells, the connecting of separate underground waters or reservoirs is prohibited, but if there is no danger of cross-pollution, the Environmental Authority may grant an exception. Also, according to 5 § (2), the Environmental Authority may grant an exception from geophysical measurements if the design engineer of the project provides a statement that there is enough data available for relevant measurements.

Therefore, the exclusive usage of a reservoir is not guaranteed (Transenergy, 2011). The new investor can get a license if he provides a study proving that the new drilling will not interfere with the other utilizations and the authority grants the exception. This has happened in West-Hungary (Sipos, 2011), where a new well was drilled between two other wells, which were several kilometre from each other, but the utilization of the third well reduced the flowrate, temperatures and recharge of all three wells. This should be prevented by capable institutions and personnel at the authorities because separate projects utilizing the same reservoir can change the reservoir and well properties, which highly influences the success of both projects and creates a barrier for investors.

Reservoir ownership causes another problem related to the sustainable use of reservoirs in Hungary. Many of the reservoirs are located on country borders and there are well-documented cases of independent geothermal utilization projects in Hungary and its neighbours that are influencing each other and can cause reduction of production capabilities on both sides of the border. This had happened both in East- and West-Hungary (Oradea (RO) –Gyula (HU), Lutzmannsburg (A) –Bük (HU)) (Sipos, 2011) which clearly points out the importance of trans-national solutions.

4.2.2 Reinjection

Reinjection is a sensitive topic in the Hungarian geothermal industry. According to the relevant legislation, which was modified in 2013, reinjection is not compulsory for balneology and agricultural uses, but for energy related utilizations. However, the Environmental Authority can grant an exception (Geothermal ERANET, 2013). Consequently, energy related projects are less competitive compared to the agricultural utilizations, and higher initial investment is needed.

Reinjection is essential for sustainable use of the reservoirs and therefore in the interest of the project owner as the Geoelec project suggests. Considering the structure of the Pannonian basin and the recharge of the reservoirs, the Geological and Geophysical Institute of Hungary has found that the duration of the water cycle of the reservoirs is approximately 10,000 years (Sipos, 2011), making sustainable use essential.

According to the relevant legislation, reinjection is only possible if the produced water is not polluted in any way during its utilization. Practically, this means that only the heat content of the thermal fluids can be utilized. As the majority of the produced thermal waters is used for balneology, most of the thermal waters cannot be reinjected. This results in the continuous decrease of fluids in certain reservoirs as only 2% of the produced thermal waters are reinjected (Kujbus, 2012a; 2012b). The low rate of reinjection highlights the need for more efficient utilizations and the need for reconstruction of old geothermal systems.

Reinjection in Hungary is challenging as most reservoirs consist of porous sedimentary rock and sandstone. Experiences show that reinjection into these reservoirs often causes the degradation of the reservoir as changes in fluid directions and new fractures cause a lot of floating particles, which decrease the permeability and finally the production capacity of the reservoir. This problem has been realized by well owners and geothermal companies. Scientific research projects have been started within the Economic Development and Innovation Operational Programme of Hungary to develop an efficient and sustainable reinjection methodology to avoid the permeability decrease (GEOSZ, 2016). Therefore, it would be important to provide more support for the development of new geothermal technologies and research projects to avoid technical challenges and reduce environmental effects (Jávor, 2016). Research and development also provide new jobs, which are of high value.

4.2.3 Environmental Impact Assessment

As a general rule, an Environmental Impact Assessment (EIA) has to be prepared and submitted as a part of the application package for the water license if groundwater abstraction is exceeding 5 million m^3/year or reinjection is more than 3 million m^3/year for the generation of electricity or direct heat. Same applies in all cases where groundwater exploitation from karstic aquifers exceeds 500 m^3/day or 2000 m^3/day from porous aquifers. Also, if energy production of more than 20 MW is aimed at or the project location is within the protection zone of mineral, medicinal or drinking water resources or on nature protection areas, an EIA should always be prepared (Nádor, 2013).

The EIA is evaluated and checked by the Regional Inspectorate for Environment, Nature and Water, which issues the environmental license for the applicant (Nádor, 2013). Based on the legislation and the current practice, an EIA should be prepared for nearly all utilizations.

As a part of the EIA, environmental monitoring and reporting of well data are compulsory for the well owners. The regulation (101/2007) related to the planning, construction and utilization of geothermal wells describes the necessary expertise, appropriate planning, usage, monitoring and reporting of the wells. Furthermore, the project owner has to report about water usage and well monitoring data under the Mining Act and Water Management Act (Fraser, 2013).

4. 3. Institutional arrangements and licensing

Hungary introduced the single administrative points, which are governmental offices with universal authorizations. Geothermal developers have to hand in inquiries and documents at these offices. However, the experts and decisions makers are still at the authorities, which had been formally put under the guidance of the governmental offices (Kormanyhivatal.hu, 2015).

Due to the separate legislative areas, responsibilities related to geothermal utilizations are distributed among separate authorities, namely the Mining Office and the Water and Environmental Directorate. If energy or heat production is involved, investors need to negotiate with the local service providers, the national distributor and balance circle manager as well as the office for Hungarian Energy and Public Utility Regulatory Authority. The construction of buildings, if a power plant is built, is overseen by the National Directorate General for Disaster Management, Ministry of the Interior (NDGDM), which is a public safety authority, as well as by local authorities and land use offices, which might lack the necessary geothermal knowledge for permitting The grid connection and for participation of the FiT Systems, the permission and agreement of the balance circle manager (MAVIR Zrt.), the grid operator, the renewable electricity market (HUPIX) and the local service provider are all required.

In case of *open area projects*, the most crucial permits are the three types of water permits, namely the planning (preliminary) permit, the construction permit and the operation permit. During the permitting procedure, production and reinjection wells have to be handled separately.

In general, application for water permits (planning, construction and operation) has to be submitted to the Regional Inspectorate for Environment, Nature and Water. The planning permit issued by the water and environmental authority describes the general water management objectives and basic technical parameters of the planned activity and determines the amount of water to be used in the future but it does not authorize the drilling of wells or any kind of water utilization (Fraser, 2013). The drillings are licensed by the Mining Authority.

Among other documents and plans, the application for a water planning permit shall include the aim of the planned water use, the quality and quantity of the water to be abstracted, the time schedule, the planned methods for water treatment, the technology of the acquisition and the results of preliminary investigations if available. Furthermore, it should include a location map of the area affected by the well and other water uses in the vicinity. Most of these factors are unclear at the planning phase of a geothermal project, therefore countinous cooperation between the project owner and licensing authorities during project preparation could be essential, instead of a not fully funded permit, which needs modifications later.

The construction permit is the one necessary for drilling, reconstruction or abandonment of a well. The application for a water construction permit shall notably include the documentation relating to the property rights, information on the category of water use (public, private), the utilization purpose, the type of the targeted aquifer and the groundwater temperature. Furthermore, it should include the exact location of the drilling, technical parameters of the operation, technical parameters of the well, a geological description of the location, a hydrogeological model, potential contamination sources and measures of protection (Fraser, 2013).

The water operation permit is the one, which authorizes the execution of water use within a given period of time. The application for an operation permit shall notably include the name of the operator, results of testing, the conditions, rights and obligations of operation and a hydrogeological report.

If the energy or heat produced is to be sold through the national networks or local heat systems, legislations, licenses and permissions related to the construction of buildings, grid connection and sales of electricity and heat are also required. These licenses are not directly related to geothermal energy but rather to general construction, environmental, safety hazard and sales of electricity. The authorities involved in the process are also focused on these areas and not on the specialties of geothermal utilizations.

If energy production and sales of electricity are involved in the project, a set of licenses, permissions and contracts related to energy production, participation in the Feed in Tariff system, electricity off-take to the local and national grids are also required. The procedures to obtain these permits can start simultaneously with the construction of the power plant. The most crucial procedures are to obtain the permission to sell electricity to the national grid, which is assessed by the Hungarian Energy and Public Utility Regulatory Authority (MEKH) and to establish a contract with the local service provider for the electricity offtake to the local grid. Due to the limitations of the electricity grid capacity to adjust the production to the demand, these negotiations are usually expected to last between 3 months up to 1.5 years, which can possibly cause a delay of projects. The fulfilment of all the requirements of the legislation and rules to be applied for energy production and the FIT System can be challenging due to the high number of regulations and amount of time needed to work out the agreement. Therefore, the investor needs to apply for various licenses and permits, in some cases to authorities, which are lacking specific geothermal knowledge for granting a well-funded permit or license. This might cause delays and inconsistencies between the separate administrative procedures of those involved and separate licensing authorities, causing an increase of time and financing for projects. The institutions and authorities have a crucial role in removing these kind of barriers for developments, by introducting specific legislation (geothermal law) and reducing the interface between the investor and the authoritities by creating an energy authority acting as the only interface.

4.4 Financing geothermal projects

4.4.1 Fees related to geothermal utilization

Geothermal energy production requires both a mining and a water resource fee, while abstraction of water for balneology, medicinal or water supply only requires a water fee (Geothermal ERANET, 2013; Transenergy, 2011). This multiple taxation disadvantages energy utilizations over other uses.

4.4.2 Project financing

Regarding available public financial resources, geothermal investments in Hungary can be supported from numerous EU, other international and national supporting schemes. Best-known are the GeoFund Geothermal Energy Development Program, the European Economic Area (EEA) Grants, EU Funds and the Environment and Energy Efficiency Operative Programme, which already provided support for some projects. Most of these supporting schemes are aiming at supporting complete projects, such as construction of a complete geothermal district heating system. Also, due to the financial requirements and general project guidelines of EU Funds, usually supported projects are to be implemented in a relatively short period, 1 or 2 years. These two constraints, support of complete projects and the short time for which support is available, limit the support opportunities for new geothermal investments. This has to do with them having long implementation timeframes, because planning, licensing, exploration, drilling and testing of the wells can take up to 10 to 12 years (Icelandic Generic Plan of 1982) and designing, permitting and the construction of the power plant and its facilities takes up to 2-5 additional years (Steingrímsson, 2009). Therefore, providing financial support to implement complete projects in 1 or 2 years' time does not meet the requirements of geothermal project financing, especially not of new projects. On the contrary, it only fulfils the requirements of certain reconstructions of existing systems. In order to better enable the initiation of new geothermal projects, these EU and national state governed supporting schemes need to be able to reflect the unique necessities of geothermal project financing, and also provide an effective tool for supporting geothermal development by providing financing for certain project phases instead of complete projects.

There are good examples of implemented geothermal projects, which present a possible solution. One is the GeoFund – Geothermal Energy Development Program, which is funded by the GEF trust fund and the International Geothermal Association (IGA) and is administered by the World Bank GeoFund coordination office. Implementation is done by the IFC. The fund aims at removing barriers to geothermal energy use in Central Asia and Europe. It provides low cost loans, contingent and outright grants as well as short and long term cover geological risk insurance (GRI) for project developers. The fund also provides technical assistance for developers. GeoFund supported and provided insurance for one Hungarian project in 2006, the drilling of a new well at Iklódbördőce, Zala county, SW-Hungary, operated by the MOL Hungarian Oil and Gas plc.. The GRI grant covered 85% of the drilling costs (USD 3.72 million), provided technical assistance and related technical assistance grants of USD 810.000. MOL signed an agreement with the World Bank with the endorsement of the Hungarian Government (GeoFund, 2016).

Another good example is the Economic Development and Innovation Programme (EDIP/GINOP), which supports geothermal research projects with short timeline (development of reinjection to porus reservoirs) and the EEA Grant, which supported EUFIRE Ltd. in their geothermal district heating project at Kiskunhalas, Hungary. In this project, the planning and drilling of the first well and related well tests are financed. These were only parts of a larger investment and had a shorter (1 or 2 years) timeframe, and not the complete geothermal development project. The support of the project for drilling the first well and testing is 34% of the total cost, so the financial risks of the investor are significantly reduced (EUFIRE, 2015; 2016a) by providing support for certain parts of a geothermal investment instead of complete projects (Nádor, 2013).

Only some of the international public or private development funds are accessible in Hungary due to its economic status. These funds are the GeoFund, EU development funds, World Bank loans and EBRD loans as well as several international renewable energy investments funds and bank associations that are providing loans for geothermal investments. The Hungarian state itself currently does not provide geothermal development loans or supports, bank guarantee, endorsements etc. For receiving international development funds, the government would need to participate and bear some of the financial risks.

The availability of traditional capital markets is limited for geothermal project developers (Münich RE, 2015). Private loans or bank loans for geothermal energy investments are also limited. Banks in Hungary do not have geothermal institutional practices and specific knowledge about geothermal investments, therefore, external expertise is needed for decision making which creates additional costs and prolongs the time for business negotiations. According to Münich RE (2015), the geothermal risk insurance (GRI) is effective in reducing financial risks of a project by providing backup in case of a failure. Therefore, it provides an advantage for obtaining other loans (Münich RE, 2015).

4.4.3 Availability of geothermal surface and subsurface data

Providing geothermal data for prospective investors also supports investors by reducing the pre-feasibility cost. The creation and maintenance of public geothermal databases can also help in ensuring the countinous development of institutional capacity. The Geological and Geophysical Institute of Hungary has participated in international projects to develop a database of geothermal wells in Hungary (MFGI GeoBank, 2016). The map provides a lot of data about the wells, however in case of private wells or waters that are not used for energy, the data is provided on a voluntary basis and it is not monitored by an independent entity. The database also contains only limited amount of information such as depth of wells but no production rates or ground water levels. Therefore, the data is not accurate enough to decide about a geothermal development, meaning that no concise public database exists (Nádor, 2013). Private investors and geothermal companies are preparing their own databases that they do not share for obvious reasons. Here the state needs to interfere by conducting research and collect geothermal data in order to be able to provide this information to all investors to achieve better results from geothermal concessions.

5. TURA GEOTHERMAL PROJECT: THE FIRST GEOTHERMAL POWER PLANT IN HUNGARY PRODUCING ELECTRICITY

The geothermal power plant at Tura will be the first power plant utilizing geothermal energy for electricity production in Hungary, as geothermal resources are currently used only for heat production and other conventional utilizations. Due to its pioneering role in geothermal electricity generation, the Tura geothermal project represents a high value in terms of the experience and know-how collected which could be utilized by the relevant institutions, decision makers or investors. Being the first of its kind in Hungary, the project also has a unique interface with the country's geothermal development environment, which is also to be explored by this research.

5.1 Short history of the Tura geothermal project

The Tura geothermal project aims at developing and operating a geothermal heat and electricity production plant in the town Tura in Pest county, 30 km east of Budapest. Tura is well-connected through a motorway close by and the national train network. It is developing rapidly with 8,000 habitants. The main source of income at Tura originates from agricultural activities, but spa development is also on the way, utilizing the geothermal resources near the town of Tura.

The first geothermal well of the area (TU-4) has been in production since 1969. Since 2002, the project area has been under continuous development and 3 other wells have been drilled with very good results. Based on this new resource with unexpectedly high temperature, the overall aim of the Tura geothermal project became the building of a geothermal „Organic Rankine Cycle" (ORC) power plant with a capacity to produce 2.7 MW of electricity, and to utilize the cooled fluid from the power plant in surrounding greenhouses as a secondary heat consumer. The operation and sale of electricity is planned to start in the middle of 2017. If the project can keep its timeline, this will be the first example of electricity production from geothermal resources in Hungary. Therefore, it might be useful to collect and analyse the major factors influencing and enabling the success of this development.

The geothermal resource in Tura has been well known for decades. The geothermal reservoir rock is fractured limestone of Triassic age. There are several tectonic structures in the vicinity of Tura area. The primary reservoir rock is 700-1000 m thick, but together with the overlying and underlying carbonate rocks the theoretical thickness of all subsequent carbonate rocks might exceed 3 km. The geothermal gradient in the overlying sediments varies between 50 and 53°C/km. In the project area one well was drilled in 1963 as an agricultural well of the collective farm. The water gained was used for balneological purposes as the area of Tura is mostly an agricultural area, supplying vegetables for the neighbouring towns and Budapest. Following the political changes of 1989, the collective farm as an agricultural enterprise was outdated and the land became private property. This was the time when the municipality of Tura became the owner of some of the agricultural areas and the geothermal wells on them.

The area/property where the well is located is owned by the municipality of Tura. The municipality formed a legal firm, Tura-Therm Ltd., to utilize the wells and the heat of the geothermal waters by building a 2-5 ha. of greenhouses to grow cherry-tomatoes. The municipality needed an investor to bring in know-how, deal with the risks and cover the investment costs of this development. In 2002, the municipality found the investor, Turawell Ltd. As a result of the business negotiations, the ownership rights of the wells were held by the original owner, Tura-Therm Ltd., while the production rights were given to the new investor. Turawell Ltd. had attained 80% of Tura-Therm Ltd. (the original investor) while 20% is still owned by the municipality of Tura. Turawell Ltd. (the new investor) is a Hungarian firm and its majority owner is Mr. László Miszori, while the minority is owned by his colleague, Mr. László Szántó. As a result of the business transaction, Turawell Ltd. bought the majority of Tura-Therm Ltd. and the lands needed in Tura to execute a greenhouse project to grow cherry-tomatoes. The greenhouse project was launched by drilling two reinjection wells in 2011, as reinjection was compulsory according to the relevant legislation. The testing of the two new wells provided much better results than previously anticipated. In well V-1, 126°C hot geothermal water of 91 l/s flow rate was found, which was later verified by well tests. Therefore, the TU-4 well, which was scheduled to be a reinjection well, was turned into a production well. With these new and promising results, the project scope was changed significantly and the target became building of a power plant to produce electricity for the national network and heat for the greenhouses.

The first well, TU-4, drilled in 1963, was used for agricultural purposes and became the basis of the greenhouse development in the area, when a workover was carried out in 2000. Two new wells, T-1 and V-1, were drilled in 2011. T-1 is located close to the old TU-4 well and was originally planned as a production well of the greenhouse project, while the other new well, V-1, located 1.0 km to the southwest from the other two, was originally planned as a reinjection well. The two areas are connected by a 1.1 km long pipeline. Results of the drilling indicated that well V-1 has better outflow parameters than expected and even better than the other two wells, as 126°C hot water with a flow rate of 91 l/s was produced from 1400 m depth. Therefore, the project scope was significantly changed from heat production to heat and electricity production. The licenses of the wells have been modified to allow production from V-1 and reinjection into T-1 and TU-4. Besides these three wells, a standard shallow, cold water production well (HV-1) was also drilled at the power plant site to supply cold water for the cooling tower. The production index of the well is up to 8 l/s for 2 bar drawdown. The arrangement of the project area and the location of the four wells utilized by the project is shown in Figure 3.

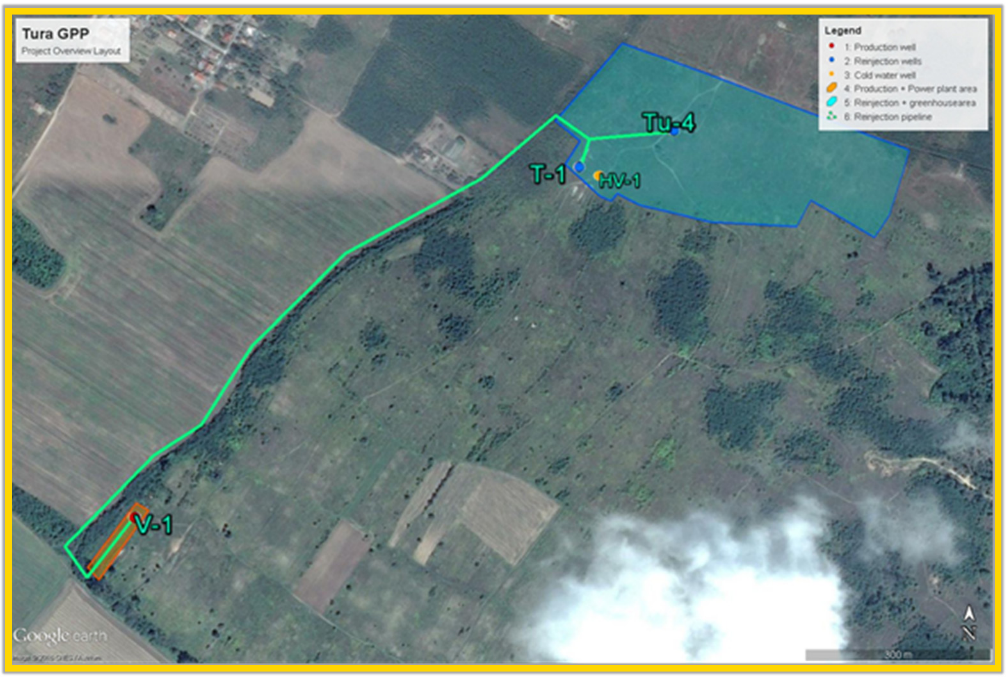

FIGURE 3: Overview of the area of the Tura geothermal project

Tura-Therm Ltd. was not a power production company, therefore in order to start the development of the project, a new investor was needed who had the necessary experience and know-how to implement such a new kind of investment in Hungary where only partial technical, licensing, permitting, legislative and policy experience weas available for a geothermal based electricity power plant. In 2012, KS Orka Singapore Ltd. purchased the majority of Tura-Therm Ltd. and became the investor and majority owner of the project. KS Orka Singapore is well-known in the geothermal industry and has significant experience in geothermal power plant constructions and related technology. KS Orka is a joint venture between Hugar Orka ehf, an Icelandic company, and Zhejiang Kaishan Compressor Co., Ltd. (Kaishan), which is listed on the China Shenzhen stock exchange. KS Orka combines Hugar Orka's geothermal and project development expertise with Kaishan's power plant technology and manufacturing expertise to form a vertically integrated geothermal and waste energy company, KS Orka, in 2016. Mannvit Budapest Office is providing the project management, specific local knowledge and technical assistance for the project implementation (Mannvit Budapest Office, 2016).

In 2012, the new project was launched, called Tura geothermal project. KS Orka, which bought a 51% stake in the Tura geothermal project, will be building the power plant at an estimated cost of HUF 3.4 billion (USD 11.9 million) with an additional preparation cost of HUF 2.1 billion (USD 7.3 million) (KS Orka, 2016). Figure 4 shows the schematic plan of the scheduled Tura power plant.

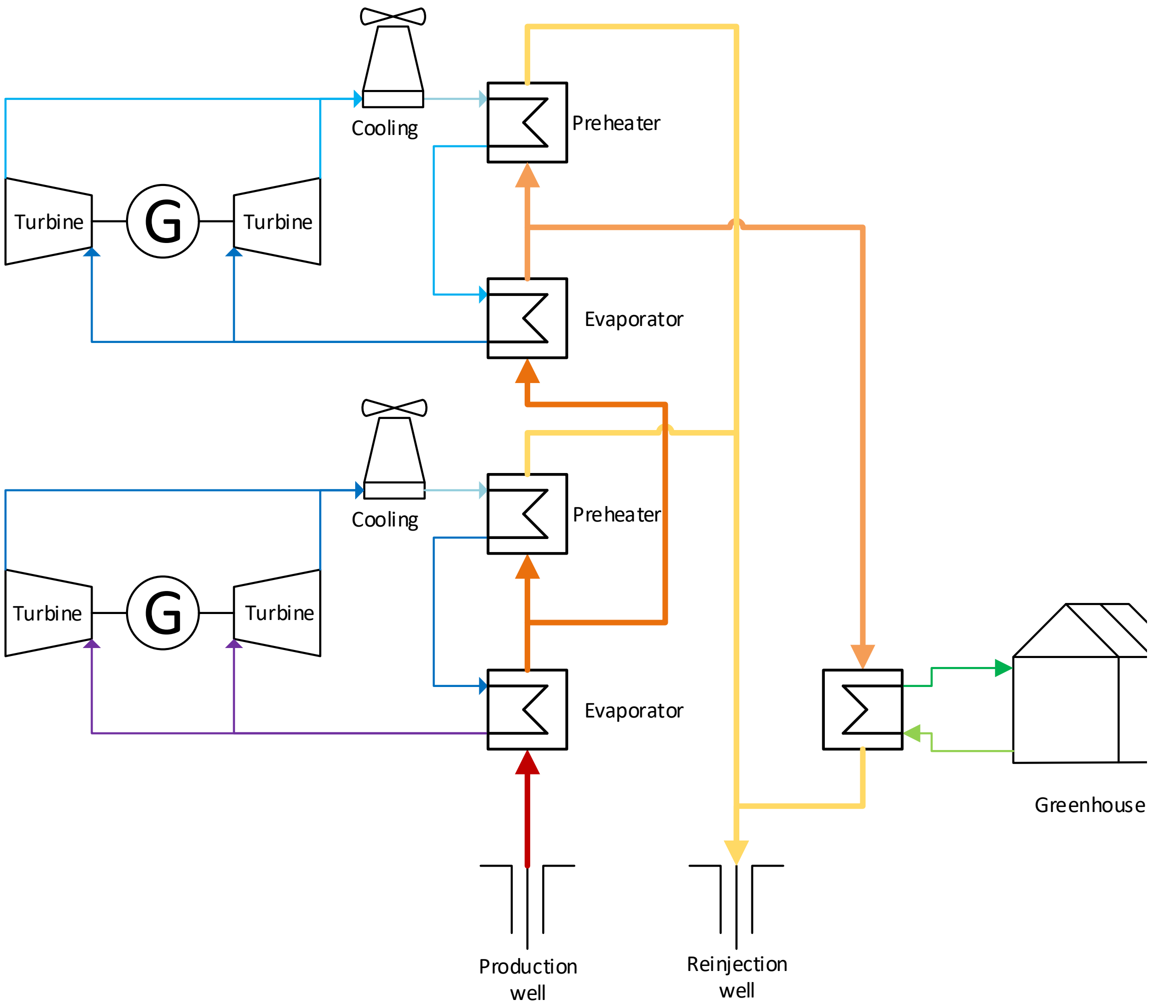

FIGURE 4: Schematic plan of the planned geothermal power plant at Tura

The design temperature of the power plant system is 125°C with 91 l/s (86 kg/s) outflow rate. The total production capacity is 2.7 MW. The excess water of the power plant is 75/78°C hot water, which will be utilized by a greenhouses covering 5-7 ha. The greenhouses will later be extended to 11 ha. and a total annual production capacity of 6300 tons of cherry-tomatoes.

Since 2012 until 2016, the project team of the Tura geothermal project has been working on the modification of existing licenses, permissions, reworking of the wells, the power plant design and construction and electricity and heat production.

On July 15th 2016, at a ceremony in Tura, KS Orka and its partners officially kicked-off the Tura geothermal project and the foundation stone of the first geothermal power plant in Hungary was laid at the project site. The construction of the power plant will be finished and all licenses and permissions have to be obtained by the middle of 2017, when the power plant will go online and production will start (Think GeoEnergy, 2016, Mannvit, 2016).

When this report is written, the construction of the power plant has started and most of the licenses, permissions for the wells and pipelines are in place and the land ownership rights are settled as well. Most licenses and permissions affected by change of project scope and electricity production have been obtained but modifications of these and the final permissions have to be obtained during and after the construction has finished. Simultaneously, new negotiations and licensing procedures need to take place due to electricity production. Permissions and agreements are needed to establish the connection to the electricity grid and related to the sales of electricity, including participation in the Feed in Tariff System have to be obtained. The experiences of this period is explored in detail in this research.

5.2 Advantages and bottlenecks of the project implementation

The project was well developed in many aspects, providing the new investors with a good base to start with. This provided multiple advantages for the investor and for project generation and implementation from various planning, preoperational, financial and management perspectives.

The resource was known and tested. The geothermal capacity of the area had been known since 1963, when the first well of the area was drilled. Also there was no need for extensive and time consuming surface exploration and other tests, previous geographical and other geothermal data was available. In addition, information on the structure of the town and land ownership questions had been solved.

Tura-Therm, Ltd. covered initial project cost, such as exploration and drilling cost of two new wells in 2011. This eliminated most of the initial financial risks of the new investor with the high-temperature resource having been discovered through these drillings, creating favourable conditions for project development. This is a crucial point for any investor in geothermal project development because geothermal development, compared to other renewable energy sources, have high initial costs due to surface exploration, land purchase costs, drilling costs and well testing costs. These costs have to be covered before the actual productivity of the resource can be established and with it the profitability and size of the power plant determined. This makes geothermal projects cost intensive and high risk until the resource size is finally determined. It can be hard to find financial sources willing to cope with this risk. Naturally the investor needs to cover all other costs emerging after becoming owner. However, this could be done by utilization of its own financial resources, therefore the need for further investors or national or EU support had also been evaded.

According to Steingrímsson (2009), market opportunity, knowledge and technical skills, time, financing and luck are the main factors, which will determine the success of a geothermal project. At the beginning of a project, important and costly decisions have to be made, when the resource and expected profitability of the project is not yet known. The original project owner had definitely benefited from this factor in 2011 when the decision was made to drill two wells for reinjection purposes and the productivity of the new wells exceeded the original production well. When this unique geothermal resource was found, the project could be extended to electricity production in addition to the heat production. In this case, luck proved to be essential for the development of the Tura project.

The area of drilling and the power plant site was also owned by the original investor, Tura-Therm Ltd., therefore, no ownership questions emerged with the land owned by the project company proving suitable for the execution of the project.

Regarding the reservoir ownership, the project is in an advantageous position. According to the relevant Hungarian legislation, the ownership of a geothermal reservoir is not consistently regulated. According to the mining law, reservoirs have an underground volume of 2 km^3 size which is covered by the owner's license for utilization. However, in practice reservoirs tend to extend, at least partially, beyond this volume. In order to avoid two projects influencing the productivity of each other, the Mining Authority performs a licensing procedure which includes the estimation and testing of the reservoir by the new project. If this study shows that the new project will not affect the older one and the Mining Authority does accept this argument, the new project can be started. If later the findings of the study are shown to be wrong and production is affected, no responsibility can be established as it can be argued that the results of the exploration were misleading.

Due to its location, the Tura geothermal project is currently not and probably will not be endangered by other projects. The Tura area consists of small size agricultural lands with several owners and families, and inhabited town areas, so there is no space for other energy production geothermal development. However, development of spas has started in the area.

Many of the licenses and permits for wells and pipelines were already in place when the new investor joined the project. However, modifications were needed for many of these licenses and permits at later stages, during the power plant development due to the change of project scope and to adjust to new and previously unknown circumstances. For example, the construction of a geothermal pipeline was needed to connect the wells and the power plant. The original investor had prepared plans and obtained a preliminary permission for construction in order to make the project more advantageous for finding an investor. When the new investor revised the project and the permit for the geothermal pipeline, it became obvious that at numerous locations the pipeline would be crossing roads and other underground installations such as other pipelines and cables. Therefore, the whole permitting procedure had to be restarted and new permitting documentation and plans were needed. This issue highlights the importance of capable geothermal institutions and authorities. If the authority responsible for granting the preliminary permission for the pipeline had noticed that the documentation for the permit was insufficient, the project implementation could have been more efficient.

Local municipalities and their population are also supporting the project, as it is expected to create between 50 and 60 job opportunities. The project and the power plant were designed taking environmental and sustainability aims into account, as the power plant outlay and design were prepared after the relevant regulations and decades long experience of the investor, considering both social and environmental aims. Reinjection and sustainable use of the reservoir are also ensured, minimizing the effect on the environment.

Time is a very important factor in project implementation and profitability of an investment. The Tura geothermal project has an advantage in that respect that no previous surface and underground exploration was needed, neither test nor exploration drillings. Besides enormous cost savings (up to 45% of the total investment), this also saved a lot of time. Typically, a geothermal development from the initial idea until the power plant is online takes usually between 7 to 10 years or even 10 to12 years (Steingrímsson, 2009; Steingrímsson et al., 2005; Ármannsson et al., 2014). The drillings of the wells usually take place after the surface exploration and initial environmental impact study and feasibility studies had been prepared and evaluated. Drilling usually takes 3-4 months per well. It is interesting to calculate how long it takes to implement the Tura geothermal project. The period between the original investor purchasing the area and onset of development was 8 years (2002-2010). The drilling of the wells, including receiving permissions, took 2 years from 2009 to 2011. Then the project scope was changed and the new investor started the development in 2012. The power plant is expected to be online in 2017. Hence, the development period lasted from 2011 to 2017, even though no exploration and drillings of wells was necessary.

Licenses needed for the construction of the original project, the greenhouse heated with geothermal energy without the electricity production, are in place. However, with the significant change in the project scope, with the power plant being added to the originally planned greenhouse, a series of modified or new permissions were needed and other legal steps to be performed in order to launch and implement the project. These changes are due to the changes in the size of the greenhouses and the completely new power plant for electricity production:

- The necessary licensing for the construction of the pipeline to connect the wells and the power plant is in place and the extent of that license is expected to be appropriate for the construction. However, there is some risk that the construction license for the pipeline has to be modified due to unknown prescriptions of potentially affected local utilities operators, and unclear status of agreements with land owners which may be affected by the pipeline construction.
- Operation licenses for water facilities can be requested only after the construction of the complete system (i.e. wells and pipeline).
- Construction license for the building of the power plant is already obtained. However, if the design of the power plant is to be changed a licensing modification will be needed.
- The most critical group of the licenses are the permits for the electric network connection. Due to the planned capacity increase, the licensing process including negotiations with the local system operator (ÉMÁSZ) has to be re-started. This could be a relatively long process (from 3 months up to 1.5 years).
- The licenses of the planned technology are already in place, due to the unique rules of procedures, with the license having to be changed only after instalment of modified equipment.

Concerning the water permit of the geothermal pipeline between the project sites, the issuing authority (Environmental and Water Authority) requires the verification of the property rights and the right of way for the project owner for issuing the water construction permit. This means that the investor has possibly to pay all affected landowners a fee before the granting of the water construction permit. The property rights and the right of way have to be issued by the Land Registry Authority, which requires the water construction permit as verification of reason, before the property rights and the right of way can be issued. This contradictory situation between the two authorities and legislations can cause significant delays for the investor and the project until the authorities and the project owner can settle the ownership questions and licenses. As land ownership and property rights are challenging, and are usually time consuming to settle, a legislation is needed to better enable project owners to obtain and keep permits for a longer time to settle challenging situations and avoid delays (Mannvit, 2016).

It should be mentioned that a water construction permit is valid for 2 years, meaning that the construction should be finished within 2 years. However, in case of building constructions in which water is not involved, the local authorities issue the building permit, which is valid for 5 years, leaving more space and time for the investor to start the construction (Mannvit, 2016).

The construction of the geothermal power plant, pipelines, cooling tower, grid connection and all other facilities requires a regular construction permit, which generally is issued by the local municipality.

However, the National Master Builder Office (part of the Ministry of Internal Affairs) intervenes if the aim of the project is the sales of energy.

The National Directorate General for Disaster Management (NDGDM) intervenes in the process of issuing the construction permit of the power plant facilities and some of the machinery and equipment related to power production (heat exchangers). As the original mission of NDGDM is to provide physical help and rescue for people in case of natural disasters and catastrophes, the question of institutional capacity arises if a decision is needed about a specific construction and safety solutions of a power plant when the processes and equipment to be used are related to thermal waters.

Besides network capacity issues, the experience of the Tura project also shows, that institutional capacity and knowledge on geothermal electricity utilization is crucial, both for authorities and investors. In case of the Tura geothermal project, the capacity (3 MW) of the generators and transformers that are installed and connected to the local grid, exceeds the maximum possible production capacity of the production well and the power plant (2.7 MW), as the supplier does not produce this equipment with less than 3 MW capacity. The local service provider and the permitting authority questioned the installation of the planned generator and transformer setup on the basis of that their capacity exceeding the amount that is to be loaded to the grid according to the application of the investor for electricity production and this is may endanger the grid and distribution systems. This is of course impossible to happen because the resource itself is unable to deliver that much energy for electricity and the electricity output of the systems is adjustable. Such a case highlights the need for capable institutions, where know-how and expertise can benefit the institution itself by making well-funded decisions and also shorten the time for the investor to obtain the licenses (Mannvit, 2016).

5.3 Licensing procedures and involved authorities in the Tura geothermal project

The Hungarian licensing environment for almost every constructing activity is divided into to the three main phases:

I. Licenses for preparation phase;
II. Licenses for construction phase;
III. Licenses for operational phase.

During the licensing phases several areas have to be evaluated. The main ones are as follows:

- Environment;
- Water management;
- Buildings;
- Transport of electric energy;
- Power plant technology.

During the licensing process there are a few main authorities who have to approve and issue the necessary permits. These main authorities are however to a certain extent dependent on the opinion of involving/special authorities. Table 2 introduces the procedure, including relevant special permits (indicated with italic style fonts) which are prerequisites of the main licenses and the competent authorities and main steps of the licensing procedure (Mannvit, 2016).

TABLE 2: Summary of the main permitting procedures of the Tura geothermal project

	License/permit/prerequisite	Licensing authority	Scope of license
Preparation	Environmental license (Preliminary environmental assessment)	Environmental and Nature Conservation Authority	Assessment of potential environmental effects of the construction and operation of the complete system
Construction phase	Water legal license for construction	Directorate for Disaster Management of the Capital	Construction license for • production well, • injection well, • water pipeline.
	Plant and soil protection plan	*Capital and Pest County Government Office* *Plant and Soil Protection Directorate*	*Saving of fertile soil on the affected land*
	Change of land usage type	*Land Registry Office*	*Change the current agricultural usage type to industrial*
	Construction permit	Hungarian Trade Licensing Office (MKEH)	Construction of buildings • power plant • transformer
	Electric cable license	Hungarian Trade Licensing Office (MKEH)	Construction of electric transmission lines
	Contract with local electric network operator	*ÉMÁSZ Hálózati Kft.*	*Connection with existing electric network system, takeover of produced electric power*
	Consolidated permit for small power plants	Hungarian Energy and Public Utility Regulatory Authority (MEKH)	Construct power plant technology
Operation phase	Water legal license for operation	Directorate for Disaster Management of the Capital	Operation license for • production well • injection well • water pipeline
	License of commission	Hungarian Trade Licensing Office (MKEH)	Commission of the buildings • power plant • transformer
	Electric cable operation license	Hungarian Trade Licensing Office (MKEH)	Operation of electric transmission lines
	Consolidated permit for small power plants	Hungarian Energy and Public Utility Regulatory Authority (MEKH)	Operation of power plant

6. CONCLUSIONS AND GEOTHERMAL POLICY RECOMMENDATIONS

Although the existing geothermal policy frameworks and licensing systems for geothermal projects show a great diversity, it may be noted that they also share strong similarities. These similarities allow the identification of the broad outlines of a geothermal licensing system, towards which all European countries shall progress (Fraser, 2013).

Effective, clear and concise geothermal legislation or preferably a single geothermal act, streamlined administrative procedures, dedicated and capable institutional system and effective financial support schemes are essential elements to remove administrative and financial barriers of geothermal development, as we can see in case of the Tura geothermal project. There, it can be stated that there would have been no project without the EU Funds and luck with the private investor.

A good policy framework for effective geothermal development is required to reflect the unique needs of geothermal energy compared to other renewable energy sources. The long time span from surface exploration until energy production, the high initial costs and high risks must be reflected and remedied by a capable supporting system. In addition, institutional framework, legislative, legal and administrative constraints are bottlenecks that limit development, should be explored and mended by a specific legislation. Therefore, it is crucial, that a policy framework is proactive and enabling rather than restrictive.

Besides the essential existence of a geothermal resource, the ESMAP handbook (Gehringer and Loksha, 2012) identified four key elements that are inevitable in supporting geothermal development:

1. Availability of sufficient geothermal resource data and other relevant information and related research;
2. Effective, dedicated and specialized institution or energy authority;
3. Supportive policies and regulations, and preferably a single geothermal act; and
4. Access to suitable financing for the project developer, including risk mitigation.

The ESMAP handbook (Gehringer and Loksha, 2012) handbook states based on the experience of successful countries of geothermal development, that all share the following:

- Dedicated national exploration and development organization, capable of managing large scale infrastructure projects;
- Committed and adequately staffed ministry or similar governmental department;
- Committed and adequately staffed national power utility; and
- Capable regulator.

As the GeoDH study suggests, developing geothermal energy requires an enabling framework starting with clear and consistent national/regional strategies of public authorities. From the project developer's point of view, realising a geothermal project requires several authorizations and the compliance with a number of national and local regulations and legal and financial safeguards. Regulatory barriers and long-administrative procedures can result in additional costs. It is therefore crucial that a fair, transparent and not too burdensome regulatory framework for geothermal and district heating is in place, which not only protects the environment and other aims but also enables development by removing burdens and barriers to development and creates a legislation that is concise and not contradictory (GeoDH, 2016).

The current Hungarian legal, institutional and policy frameworks for geothermal energy use are rather complicated and need to be simplified. The administrative procedures related to mining, energy, environmental protection, water management, disaster management directorates and the authorities responsible for regulations and licensing procedures should be streamlined. The majority of international studies have shown that legal contradictions and time-consuming licensing procedures are still in place (Dumas et al., 2013; GeoDH, 2016; Kujbus, 2012b; Transenergy, 2011; Fraser, 2013; GeoFund, 2016;

Geothermal ERANET, 2013; Rybach, 2003; 2010; Nádor, 2013). Experts agree that reforms have been started but there will always be an area that can be further developed and optimized.

In order to strengthen future geothermal development, the question of reservoir ownership and limitations of use should be addressed and the needed institutional preventive measures and capacity building should be fostered. The main advantage of this would be the prevention of interference between projects, which is a basic deciding factor for geothermal investments. Due to the specific situation of Hungary where numerous cross-border reservoirs are existing, this issue should also be further discussed with its neighbours beyond the existing international agreements.

According to recommendations from various experts of geothermal energy development for the fulfilment of the targets of the NREAP of Hungary, a state funded supporting and risk-mediating mechanism would be a great asset. International experience indicates that public support is needed to reduce the very high upfront risk and cost elements in geothermal for starting geothermal development (Gehringer and Loksha, 2012; Századvég Gazdaságkutató Zrt, 2013; Jávor, 2016; and Hólm, 2016). When designing such supporting programmes it has to be ensured that the support is granted for the exploration and drilling phase and not for the complete project, in order to reduce initial risk and evade one of the biggest obstacle of geothermal development (Hólm, 2016).

The experience of the EEA and Economic Development and Innovation Programme previous or on-going geothermal energy related research projects shows that geothermal research and development can play an essential role in supporting Hungarian geothermal industry and it creates related jobs of high value. Therefore, more emphasis on research and development to support the geothermal industry in developing new geothermal technologies together with a geothermal specific insurance and support scheme could better enable geothermal development.

The examples of financial factors and administrative hurdles and bottlenecks at the Tura geothermal project, as well as the international studies mentioned in this report, seem to be pointing to the need for an adjustment of the Hungarian geothermal development framework in order to foster new development and to increase the annual number of new geothermal energy project inquiries.

Geothermal industry actors and experts agree that the acceleration of geothermal energy development processes is crucial to reach the renewable energy targets of the NREAP. The National Energy Strategy 2030 and the government's determination for the simplification of administrative procedures opened up the opportunity to introduce supporting changes and restructuring of all geothermal energy related areas that the state can enhance. The experiences and measures of other countries, which are successful in geothermal development, should serve as a basis for further development of the Hungarian geothermal policy framework.

ACKNOWLEDGEMENTS

I would like to express my gratitude to my supervisor, Mr. Engilbert Gudmundsson for providing me useful materials, ideas and his work for advising me during the preparation of this report. The Mannvit Budapest Office provided me with essential information and experiences about the Tura geothermal project. I also would like to express my gratitude for Mr. Lúdvík S. Georgsson and the rest of the UNU-GTP staff and lecturers for the possibility to participate in the programme and to gain geothermal project management knowledge and skills. Lastly, but not least, I would like to thank my colleagues and supervisors at the Ministry of National Development, Budapest, Hungary.

REFERENCES

Ádok, J., 2016: The geothermal heating system in Hódmezővásárhelyi (in Hungarian). Fókusz, website: geotermia.lapunk.hu/tarhely/geotermia/dokumentumok/adokjanos_cikk_hodmezovasarhelyi_geot_fut_rendszer.pdf

Antics, M., and Sanner, B., 2007: Status of geothermal energy use and resources in Europe. *Proceedings of the European Geothermal Congress 2007, Unterhaching, Germany,* 8 pp.

Ármannsson, H., Steingrímsson, B., Gudmundsson, Á., 2014: Planning of geothermal projects in Iceland. *Presented at "Short Course IX on Exploration for Geothermal Resources", organized by UNU-GTP, GDC and KenGen, at Lake Bogoria and Lake Naivasha, Kenya*, 10 pp.

Askjaenergy.com, 2013: *Mannvit Engineering awarded EU energy funding*. Askjaenergy, website: *askjaenergy.com/2013/02/04/mannvit-engineering-eu-funding/ NER300.*

Bertani, R., 2015: Geothermal power generation in the world, 2010-2014 update report. *Proceedings of the World Geothermal Congress 2015, Melbourne, Australia,* 19 pp.

Dolor, F.M., 2005: Phases of geothermal development in the Philippines. *Paper presented at "Workshop for Decision Makers on Geothermal Projects and Management", organized by UNU-GTP and KenGen in Naivasha, Kenya,* 10 pp.

Dolor, F.M., 2006: Ownership, financing and licensing of geothermal projects in the Philippines. *Presented at "Workshop for Decision Makers on Geothermal Projects in Central America", organized by UNU-GTP and LaGeo in San Salvador, El Salvador,* 17 pp.

Dövenyi, P., Horvath, F., Drahos, D., et al., 2002: Atlas of geothermal resources in Europe. In: Hurter, S., Haenel, R. (Eds.), Atlas of geothermal resources in Europe. European Commission, Office for Official Publications of the European Communities, Luxembourg, Publication No. 17811.

Dumas, P., Serdjuk, M., Kutschick, R., Fraser, S., Reith, S., and Koelbel, T., 2013: *GEOELEC deliverable 4.1 – report presenting proposals for improving the regulatory framework for geothermal electricity, final draft v. 4, Report on geothermal regulations*. GEOELEC, website: *www.geoelec.eu/wp-content/uploads/2011/09/4.1.pdf.*

EEA, 2016: *Programme areas 2009-2014 – Brochure*. EEA Grants, website: *eeagrants.org/Results-data/Documents/Publications/Brochures/Programme-Areas-2009-2014-brochure.*

EIB, 2015: *Investment plan for Europe to support renewable energy and strategic infrastructure projects.* European Investment Bank, website: *www.eib.org/infocentre/press/releases/all/2015/2015-104-investment-plan-for-europe-to-support-renewable-energy-and-strategic-infrastructure-projects.htm.*

EIB, 2016: What is the "European Fund for Strategic Investments" (EFSI). European Investment Bank, website: *bei.europa.eu/efsi/what-is-efsi/index.htm.*

Energiainfo.hu, 2012: *The EGS Hungary Consortium won 11 billion HUF for the establishment of a connected geothermal power plant in Hungary*. Energiainfo.hu, website: energiainfo.hu/cikk/tizenegymilliard_forint_geotermikus_eromure.28844.html,NER300.

EU-FIRE, 2015: *Geothermal heating system in Kiskunhalasi* (in Hungarian). EU-FIRE, website: *eu-fire.hu/pages/kiskunhalas.*

EU-FIRE, 2016a: *Our projects* (in Hungarian). EU-FIRE, website: *eu-fire.hu/pages/projektek*

EU-FIRE, 2016b: *EGS geothermal power plant in Hungary* (in Hungarian). EU-FIRE, website: *eu-fire.hu/pages/egs-hungary.*

Fancsik, T., 2013: *Transenergy, the role of geothermal energy in the energy policy of the EU and Hungary.* Transenergy, 11 pp, website: *transenergy-eu.geologie.ac.at/Downloads/Events/Public_Event/HU/energetika_FT.pdf*

Fraser, S., / GEOELEC, 2013: *A prospective study on the geothermal potential in the EU. GEOELEC, deliverable 4.1, Appendix I – Overview of national rules of licensing for geothermal*. GEOELEC, website: *www.geoelec.eu/wp-content/uploads/2011/09/D4.1-A.1-Overview-of-National-Rules-of-Licencing.pdf.*

Gehringer, M. and Loksha, V., 2012: *Geothermal handbook: planning and financing power generation*. Energy Sector Management Assistance Program (ESMAP), technical report 002/12, 150 pp.

GeoDH, 2016: *Geothermal district heating*. GeoDH, website: *geodh.eu*.

GeoFund, 2016: *Case study 10: Hungary.* GeoFund, website: *documents.worldbank.org/curated/en/255021468030285546/pdf/761080BRI0P07500Box374367B00PUBLIC0.pdf*.

Georgsson, L.S., 2016: Geothermal energy in the world – present status and future predictions. UNU-GTP, Iceland, unpublished lecture notes.

Georgsson, L.S., Fridleifsson, I.B., Haraldsson, I.G., Ómarsdóttir, M., Ísberg, Th., and Gudjónsdóttir, M.S., 2015a: UNU Geothermal Training Programme in Iceland: Capacity building for geothermal energy development for 36 years. *Proceedings of the World Geothermal Congress 2015, Melbourne, Australia,* 11 pp.

Georgsson, L.S., Haraldsson, I.G., Ómarsdóttir, M., and Ísberg, Th., 2015b: The UNU Geothermal Training Programme: Training activities offered on-site in developing countries. *Proceedings of the World Geothermal Congress 2015, Melbourne, Australia,* 12 pp.

GEOSZ, 2016: *Presentation of the project "Technological development of deployment of deep geothermal systems"* (in Hungarian). GEOSZ, website: *geosz.hu/index.php/kf-projektrol.*

Geothermal ERANET, 2013: Geoth*ermal energy status and policy review, Part A, Analysis*. Geothermal ERANET, website: *www.geothermaleranet.is/media/publications-2015/Geothermal-ERA-NET-D2_1-Geothermal-energy-status-and-policy-review-NTs.pdf*

Goodman, R., Pasquali, R., Dumas, P., Hámor, T., Jaudin, F., Kepinska, B., Reay, D., Rueter, H., Sanner, B., Van Heekeren, V., Bussmann, W., and Jones, G., 2010: GTR-H – geothermal legislation in Europe. *Proceedings of the World Geothermal Congress 2010, Bali, Indonesia*, 5 pp.

GRMF, 2016: Geothermal risk mitigation facility for East Africa. GRMF, website: *http://www.grmf-eastafrica.org/about*

Haehnlein, S., Bayer, P., and Blum, P., 2010: International legal status of the use of shallow geothermal energy. *Renewable and Sustainable Energy Reviews, 14-9*, 2611–2625.

Haraldsson, I.G., 2012: Legal and regulatory framework – Barrier or motivation for geothermal development? *Paper presented at "Short Course on Geothermal Development and Geothermal Wells", organized by UNU-GTP and LaGeo, Santa Tecla, El Salvador*, 24 pp.

Haraldsson, I.G., 2014: Government incentives and international support for geothermal project development. *Paper presented at "Short Course VI on Utilization of Low- and Medium-Enthalpy Geothermal Resources and Financial Aspects of Utilization", organized by UNU-GTP and LaGeo, in Santa Tecla, El Salvador*, 12 pp.

Hólm, S.L., 2016: *Geothermal development - a private company's experience.* Unpublished presentation, Mannvit Budapest Office.

Jávor, B. (ed.), 2016: *Alternative and sustainable energy scenarios for Hungary* (in Hungarian). Green Hungarian Foundation, Budapest, website: *zma.hu/sites/default/files/ASES_hun_20161102.pdf.*

KfW, 2016: *Our tasks and goals.* KfW, website: *www.kfw-entwicklungsbank.de/International-financing/KfW-Development-Bank/Tasks-and-goals/.*

Kormanyhivatal.hu, 2015: "*Simpler administration, faster decision making - a unified government office system is created"* (in Hungarian). Governmental offices, website: *www.kormanyhivatal.hu/hu/csongrad/hirek/ egyszerubb-ugyintezes-gyorsabb-donteshozatal-egyseges-kormanyhivatali-rendszer-jon-letre.*

Kovacs, I., 2013: *A new opportunity for geothermal energy in Hungary: a picture of a EGS project* (in Hungarian). Geothermia, website: *geotermia.lapunk.hu/tarhely/geotermia/dokumentumok/ kovacsimredr_eu_fire_eloadasa_20131030.pdf.*

Kreuter, H., 2008: Risk mitigation in deep geothermal projects - experience in Germany. *Workshop on Geological Risk Insurance, World Bank Geothermal Energy Development Program (GEOFUND), Karlsruhe, Germany,* 4 pp.

Kreuter, H., and Schrage, C., 2009: Geothermal market based insurance schemes. *Paper presented at GeoFund – IGA Geothermal Workshop "Turkey 2009", Istanbul, Turkey,* 4 pp.

KS Orka, 2016: *Tura geothermal project*. KS Orka, website: *ksorka.com*.

Kujbus, A., 2012a: *Current and future status of the Hungarian geothermal energy production* (in Hungarian). RETS EU project International Conference, Vesces, Hungary, website: *www.rets-project.eu/UserFiles/File/pdf/Vecses%20Seminar% 20September% 202012/2012-09-25-Semin-Hungary-present-and-future-of-geothermal-energy-production-Attila-kujbus_HU. pdf*

Kujbus, A., 2012b: *National Environmental and Energy Center (NEEC) non-profit co., and action plan for publicity of low-enthalpy geothermal energy in Hungary till 2020.* Interreg IVC, GeoPower Project, 17-22, website: geopower-i4c.eu/docs/Action%20Plan_final_hungary.pdf.

Kujbus, A., 2016: *Presentation and personal communication at the Ministry of National Development.* MND, March 29th, 2016, Budapest.

Kurunczi, M., and Ádám, B., 2016: *Hódmezővásárhely geothermal heating system: Geothermal water as an alternative energy source* (in Hungarian). Website: http://www.hoszisz.hu/tanulmanyok/24-a-geotermikus-energia-termalviz-es-foeldh-mint-alternativ-energiaforras, visited on 04. October 2016.

Lund, J.W., and Boyd, T.L., 2015: Direct utilization of geothermal energy 2015, worldwide review. *Proceedings of the World Geothermal Congress 2015 Melbourne, Australia*, 31 pp.

Mádlné, S.J. (ed.), 2008: *Geothermal energy utilization in international and domestic status and future opportunities in Hungary: Recommendations of governmental steps in support* (in Hungarian). Report to the Hungarian Academy of Sciences, Budapest, website: www.geotermika.hu/portal/files/mta-geotermika.pdf.

Mannvit, 2016: *Turawell geothermal project underway.* Mannvit, website: *www.mannvit.com/news/turawell-geothermal-project-underway/.*

Mannvit Budapest Office, 2016: *Parts of the Tura diligence report*. Mannvit, Budapest.

MEKH, 2015: *Report on the use of renewable energy in Hungary 2004-2014* (in Hungarian). Hungarian Energy and Public Utility Regulatory Authority – MEKH, website: *www.mekh.hu/download/3/f3/20000/beszamolo_a_magyarorszagi_megujuloenergia_felhasznalas_2004_2014_evi_alakulasarol.pdf*

MFGI, 2013: *Mineral resources and resource utilization action plan of 2013* (in Hungarian). MFGI, website: www.mfgi.hu/hu/node/703.

MFGI, 2016: *Public maps and databases for geothermal energy in Hungary.* MFGI, website: *map.mfgi.hu/furas/.*

MFGI GeoBank, 2016: A geological and drilling database for Hungary. MFGI, website: *www.mfgi.hu/hu/node/79.*

Micale, V., and Padraig, O., 2015: *Lessons on the role of public finance in deploying geothermal energy in developing countries*. Climate Investment Fund – CIF, website: *climatepolicyinitiative.org/wp-content/uploads/2015/08/Lessons-on-the-Role-of-Public-Finance-in-Deploying-Geothermal-Energy-in-Developing-Countries-Full-Report.pdf.*

Micale, V., Trabacchi, C., and Boni, L., 2015*: Using public finance to Attract Private Investment in Geothermal: Olkaria III: case study, Kenya*. Climate Investment Fund - CIF, website: *climatepolicyinitiative.org/publication/using-public-finance-to-attract-private-investment-in-geothermal-olkaria-iii-case-study-kenya/*

MND, 2010: *Renewable energy, Republic of Hungary, National renewable energy action plan 2010-2020*. Ministry of National Development, website: *www.kormany.hu/download/6/b9/30000/RENEWABLE%20ENERGY_REPUBLIC%20OF%20HUNGARY%20NATIONAL%20RENEWABLE%20ENERGY%20ACTION%20PLAN%202010_2020.pdf*

MND, 2011: *National energy strategy of Hungary.* Ministry of National Development, website: *www.kormany.hu/en/ministry-of-national-development/news/national-energy-strategy-2030-published.*

Montalvo E., F., 2014: Regional geothermal office for Central America. *Paper presented at "Short Course VI on Utilization of Low- and Medium-Enthalpy Geothermal Resources and Financial Aspects of Utilization", organized by UNU-GTP and LaGeo, in Santa Tecla, El Salvador,* 10 pp.

Münich RE, 2015: *Exploration risk insurance – Münich RE's experience in Turkey*. Münich RE & IRENA, website: *www.irena.org/EventDocs/S3.4GeothermalExplorationInsuranceTurkey-MunichRE.pdf.*

Nádor, A., 2013: *List of legal and economic deficiencies, non-technical barriers of geothermal development.* TransEnergy, website: transenergy-eu.geologie.ac.at/Downloads/outputs/Summary%20report%20of%20the%20supra-regional%20hydrogeological%20model/WP6/2CE124P36PR_WP6C_6.2.3_%20List%20of%20legal%20and%20economic%20deficiencies.pdf.

Nádor, A., Tóth, A.N., Kujbus, A., and Ádam, B., 2013: Geothermal energy use, country update for Hungary. *European Geothermal Congress, Pisa, Italy*, 12 pp.

Ngugi, P.K., 2014: Risks and risk mitigation in geothermal development. *Paper presented at "Short Course VI on Utilization of Low- and Medium-Enthalpy Geothermal Resources and Financial Aspects of Utilization", organized by UNU-GTP and LaGeo, in Santa Tecla, El Salvador*, 11 pp.

NREAP, 2013: "*Hungary's National Renewable Energy Action Plan*" (in Hungarian). NREAP website: www.kormany.hu/download/d/61/10000/Magyarorsz%C3%A1g%20Meg%C3%BAjul%C3%B3%20 Energia%20Hasznos%C3%ADt%C3%A1si%20Cselekv%C3%A9si%20Terve.pdf.

Orkustofnun, 2016: Geothermal policy options and instruments for Ukraine. Orkustofnun – National Energy Authority, report prepared for the Ministry for Foreign Affairs, Iceland, 132 pp.

Pálvölgyi, T. (ed.), Dönsz-Kovács, T., Kukely, G., Mészáros, G., and Enikő, E.S., 2011: Environmental assessment for the national energy strategy until, 2030, with outlook until 2050 for the strategic environmental assessment (in Hungarian). Ministry of National Development – MND, website: www.fataj.hu/2011/06/236/ESTRAT2030-Kornyezeti-Hataselemzes-20110513.pdf

PannErgy, 2013: *PannErgy Plc., preliminary information concerning business operations 2013.* PannErgy, Plc., website: *pannergy.com/wp-content/uploads/2014/02/2013q4_v5_1_9_en.pdf*

PannErgy, 2016: *Projektjeink.* PannErgy, Plc., website: *pannergy.com/projektek/*

Ren21, 2015: Renewables 2015 global status report. Ren21, website: www.ren21.net/wp-content/uploads/2015/07/REN12-GSR2015_Onlinebook_low1.pdf

Rybach, L., 2003: Regulatory framework for geothermal in Europe – with special reference to Germany, France, Hungary, Romania, and Switzerland. *Lectures on the sustainable use and operating policy for geothermal resources - Proceedings of short course for IGC2003, Sept., UNU-GTP, publicat. 1, Reykjavik,* 43-52.

Rybach, L., 2010: Legal and regulatory environment favourable for geothermal development investors. Proceedings of the World Geothermal Congress 2010, Bali, Indonesia, 7 pp.

Sipos, G., 2011: *Geothermal power at deep levels in Hungary* (in Hungarian). Origo, website: *www.origo.hu/idojaras/20110928-geotermikus-energia-tavfutes-furdes-visszasajtolas-csak-a-fold-melyen-szamit.html*

Soltész, I., 2016: *Energy efficiency investments supported by tax incentives* (in Hungarian). TERC, website: *www.terc.hu/cikk/adokedvezmennyel-tamogatott-energiahatekonysagi-beruhazasok.*
Steingrímsson, B., 2009: Geothermal exploration and development from a hot spring to utilization. *Paper presented at "Short course on Surface Exploration for Geothermal Resources", organized by UNU-GTP and LaGeo, in Ahuachapan and Santa Tecla, El Salvador*, 8 pp.

Steingrímsson, B., Ármannsson, H., and Gudmundsson, Á., 2005: Phases of geothermal development in Iceland. *Paper presented at Workshop for Decision Makers on Geothermal Projects and Management, organized by UNU-GTP and KengGen in Naivasha, Kenya,* 11 pp.

Szanyi, J., and Kovács, B., 2010: Utilization of geothermal systems in southeast Hungary. *Geothermics 39-4,* 357-364.

Századvég Gazdaságkutató Zrt, 2013: *Recommendations for designing a risk mitigation framework for geothermal investments* (in Hungarian). Századvég Gazdaságkutató Zrt, Website: *tasz.hu/files/szazadveg-tanulmanyok/NFM_201312/NFM02_TANSZ_201312_EN_free.pdf.*

ThinkGeoenergy, 2016: *Official kick-off for Turawell geothermal project in Hungary*. Think GeoEnergy, website: *www.thinkgeoenergy.com/official-kick-off-for-turawell-geothermal-project-in-hungary/*

Tóth, A.N., 2010: Hungary country update 2005-2009. *Proceedings of the World Geothermal Congress 2010, Bali, Indonesia,* 8 pp.

Tóth A.N., 2013: Hungarian-American cooperation in geothermal e-learning. *European Geothermal Congress, 2013, Pisa, Italy.*

Tóth, A.N., 2015: Hungarian country update 2010-2014. *Proceedings of the World Geothermal Congress 2015, Melbourne, Australia*, 8 pp.

Transenergy, 2011: *Transenergy - Transboundary geothermal energy resources of Slovenia, Austria, Hungary and Slovakia - overview of EU, national and regional legislation*. Transenergy, website: *transenergy-eu.geologie.ac.at/Downloads/2CE124P3_4PR_WP3%203.3.1_Overview%20of%20EU%20national%20and%20regional%20legislation.pdf.*

Wall, E., 2009: Recovers act funding for geothermal technologies. GRC - Department of Energy Update, website: *www.geothermal.org/PDFs/Articles/09MayJune21.pdf.*

APPENDIX I: Excerpt from Transenergy (2011) research. Overview of laws and regulations related to geothermal energy in Hungary and Slovakia - regulations related to grid connection, building permits and participation in FiT are not included

HUNGARY

Regulations related to mining:

1. Act XVI of 1991 on concession.
2. Act XLVIII of 1993 on mining.
3. Governmental Decree 203/1998 (XII.19.) on the execution of Act XLVIII of 1993 on mining.
4. Governmental Decree 267/2006 (XII.20.) on the Hungarian Office for Mining and Geology.
5. Governmental Decree 54/2008 (III.20) on the determination of the specific value of mineral resources and geothermal energy and the method of value calculation.
6. Governmental Decree 103/2011 (VI.29.) on the complex vulnerability and impact assessment of the natural occurrences of mineral resources and geothermal energy.

Regulations related to energetics:

7. Act LXXXVIII of 2003 on energy tax.
8. Act XVIII of 2005 on district heating.
9. Governmental Decree 157/2005 (VIII.15.) on the execution of Act XVIII of 2005 on district heating.
10. Act LXXXVI of 2007 on electric energy.

11. Governmental Decree 273/2007 (X.19.) on the execution of certain regulations of Act LXXXVI of 2007 on electric energy.
12. Governmental Decree 389/2007 (XII.23.) on the compulsory acceptance system and feed-in tariffs of electricity produced by energy gained from renewable energy resources and waste, as well as the co-generated electricity.
13. GKM/Ministerial Decree 110/2007 (XII.23.) on the calculation method to determine the quantity of the useful heat and the co-generated electricity.

Regulations related to environmental protection:

14. Act LIII of 1995 on the general rules of environmental protection.
15. Act XLIII of 2000 on waste management.
16. Governmental Decree 219/2004 (VII.21.) on the protection of groundwaters.
17. Governmental Decree 220/2004 (VII. 21.) on the protection of surface waters.
18. Governmental Decree 221/2004 (VII.21.) on certain rules of river basin management.
19. KvVM /Ministerial Decree 28/2004. (XII. 25.) on the threshold values of water contaminating materials and on certain rules of their application.
20. KvVM /Ministerial Decree 30/2004 (XII.30.) on certain rules of examination of groundwaters.
21. KvVM /Ministerial Decree 33/2005 (XII.27.) on the administrative service fees of environment, nature protection and water authorities.
22. Governmental Decree 314/2005 (XII.25.) on the licensing process of environmental impact assessment.

Regulations related to water management:

23. Act LVII of 1995 on water management.
24. KHVM / Ministerial Decree 18/1996 (VI.13) on the contents of the application form and its annexes to be submitted for granting the water permits.
25. Governmental Decree 72/1996 (V.22.) on the implementation of authority powers in water management.
26. Governmental Decree 121/1996 (VII.24.) on the establishment and utilization of public baths.
27. KHVM /Ministerial Decree 12/1997 (VIII.29.) on the degassing of the produced and supplied waters.
28. Governmental Decree 123/1997 (VII.8.) on the protection of water resources, potential water resources and water establishments supplying drinking water.
29. KHVM /Ministerial Decree 23/1998 (XI.6.) on the water management register of the water inspectorates.
30. KHVM /Ministerial Decree 43/1999 (XII.26.) on the calculation of the water resource fee.
31. EüM/ Ministerial Decree 74/1999 (XII.25.) on the natural medicinal factors.
32. KvVM /Ministerial Decree 24/2007 ((VII.3.) on the Water Safety Regulations.
33. KvVM /Ministerial Decree 101/2007 (XII.23.) on the professional requirements about the intervention into the groundwater reserves and water well drilling.
34. KvVM /Ministerial Decree 30/2008 (XII.31.) on the technical regulations related to the activities and establishments serving the utilization, protection and mitigation of damages of waters.
35. Governmental Decree 147/2010 (IV.29.) on the general regulations related to the activities and establishments serving the utilization, protection and mitigation of damages of waters.
36. Governmental Decision 1002/2012 (I.11.) on the exemption of re-injection of thermal water used for energetic purposes in agriculture.

Regulations related to heat pumps:

37. Governmental Decree 264/2004 (IX.23.) on the taking back of waste deriving from electric and electronic gadgets.
38. KTM /Ministerial Decree 10/1995 (IX.28.) on the environmental protection product fee and the execution of Act LVI of 1995 on the environmental protection product fee of certain products.
39. GKM /Ministerial Decree 96/2005 (XI.4.) on the regulations of certain building processes concerning special buildings falling within the competence of the mining inspectorates.
40. TNM /Ministerial Decree 7/2006 (V.24.) on the determination of energetic features of buildings.

SLOVAKIA

National legislation in relation to geothermal energy exploration and exploitation:

1. Constitution of the Slovak Republic, Constitutional Act. 460/1992 Coll. as subsequently amended.
2. Civil Code, Act. 40/1964 Coll., as amended.
3. Water Act. 364/2004 Z.z. on waters as amended and amending Law No.. 372/1990 Coll. on offences, as amended.
4. Geological Act. 569/2007 Z.z. on geological works, as amended.
5. Mining Act. 44/1988 Coll., protection and utilization of mineral resources, as amended.
6. Act. 92/1991 Coll. on the transfer of state property to other persons, as amended.
7. Commercial Code Act. 513/1991 Coll., as amended.
8. Trades Act. 455/1991 Coll. on trades, as amended.
9. Building Act. 50/1976 Coll., the Planning and Building Order (Building Act) as amended.
10. Slovak Republic Government Order no. 755/2004 Coll., laying down the amount of nonregulated payments, fees and details related to charging for water use.
11. Ministry of the Environment Regulation no. 51/2008 Coll. that administers Geological Act, as amended.
12. Act. 309/2009 Coll. the promotion of renewable energy and high-efficiency cogeneration and amending certain laws.
13. Act.656/2004 Coll., on energy and amending certain laws.
14. Decree of the Regulatory Office for Network Industries 225/2011 Coll. establishing price regulation in the electricity energy.
15. Act 657/2004 Coll. of thermal energy and amending certain laws.
16. Decree of the Regulatory Office for Network Industries no. 219/2011 Coll. establishing price controls on thermal energy.
17. Act. 24/2006 Coll. Assessment of environmental impact (Environmental Impact Assessment) and amending certain laws.
18. Government Order no. 269/2010 Coll., laying down the requirements for achieving good water status.
19. Ministry of Agriculture, Environment and Regional Development of the Slovak Republic no. 418/2010 Coll. for implementing certain provisions of the Water Act.

MAIN HUNGARIAN LAWS AND REGULATIONS REFERRED IN THE REPORT:

Mining Law Act: XLVIII of 1993 of Hungary.
Website: *njt.hu/cgi_bin/njt_doc.cgi?docid=19243.328105*

Water Management Act: LVII of 1995 of Hungary.
Website: *njt.hu/cgi_bin/njt_doc.cgi?docid=23855.328110*

Governmental Decree 103/2011. (VI.29.) on the Complex Vulnerability and Impact Assessment.

Governmental Decree 219/2004 (VII.21.) on the protection of ground waters.
Website: *njt.hu/cgi_bin/njt_doc.cgi?docid=86354.332598*

Governmental Decree 221/2004 (VII.21.) on certain rules of river basin management.
Website: *njt.hu/cgi_bin/njt_doc.cgi?docid=86359.298018*

Act XVI of 1991 on Concession.
Website: *njt.hu/cgi_bin/njt_doc.cgi?docid=15165.330720*

Ministerial Decree 101/2007 (XII.23.) rules of intervention to groundwater resources and guidelines to the drilling of wells. Website: *njt.hu/cgi_bin/njt_doc.cgi?docid=111083.291366*

Governmental Decree 314/2005 (XII.25.) on environmental impact assessment.
Website: *njt.hu/cgi_bin/njt_doc.cgi?docid=96394.330273.*