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Geothermal district heating in the city of Kecskemét

MLEI GeoKec – City of Kecskemét (HU)

Contract number: IEE/12/064. SI2.645706

FINAL PUBLISHABLE REPORT

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Co-funded by the Intelligent Energy Europe Programme of the European Union

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1. Executive summary

Resolution 125/2012. (IV.26.) KH passed by the General Assembly of the Municipality of Kecskemét decided on the submission of a tender titled "Geothermal district heating in the city of Kecskemét / MLEI GeoKec – City of Kecskemét (HU)" to the call for proposals stimulating local energy investments in the Intelligent Energy - Europe programme (IEE) with the participation of EU-FIRE Kft. and Kecskeméti Termálrendszer Beruházó Kft. (Kecskemét Thermal System Investment Ltd) in a consortium partnership. The ratio of grants in the project is 75%, which, considering the total budget of the project amounting to EUR 379,295, corresponds to EUR 285,000.

The objective of the project is the preparation of the planned geothermal system investment, under which the provision of the up and running district heating system of the City of Kecskemét with geothermal energy, as well as the partial replacement of the current gas furnaces will be achieved. Hence, cost efficient, local and environmentally friendly heat energy will be used instead of the current natural gas, thereby significantly reducing CO2 emission.

The geothermal system will be achieved in several phases, in the first phase one production and one reinjection well will be implemented by reinjecting the entire quantity produced. In the later phases of the investment, the system will be expanded by drilling additional wells.

During the GeoKec preparation project, tasks undertaken in eight work packages have been carried out; project management, preliminary studies, licensing and permitting, technical and financial engineering, procurement, financing, communication and EACI circulation activities. As a result, the project management and EPCM agreements have been concluded, professional works required for the preparation of the feasibility study have been carried out and the theoretical water legal license as well as the environmental protection permit of the planned investment have been acquired. The financing of the project is facilitated by the professional and financial investment agreements, as well as the business plan prepared.

As a part of the communication work package a municipality meeting, two workshops have been organized with the participation of the decision makers and businesses of the city and its surrounding areas, a leaflet was prepared in six languages and the website of the project is also up and running.

In summary it can be established that the objectives set during the GeoKec project have been achieved, the work completed during the project ensures the comprehensive preparation and feasibility of the planned investment project, which will positively impact both local residential and business consumers.

2. Introduction and objective of the IEE MLEI GeoKec project

In the beginning of 2013, the Municipality of the City of Kecskemét, EU-FIRE Kft. and Kecskeméti Termálrendszer Beruházó Kft. (Kecskemét Thermal System Investment Ltd) received funding through the Intelligent Energy Europe — Mobilising Local Energy Investment Programme supported by the European Commission for the preparation of the geothermal investment related to the city´s district heating services.

Programme name: Intelligent Energy Europe – Mobilising Local Energy Investment
Project title: Construction of a geothermal heat production system in Kecskemét (**GeoKec project**)
Name of body in charge: the Municipality of the City of Kecskemét
Project partners:

- EU-FIRE Kft., Hungary
- Kecskeméti Termálrendszer Beruházó Kft, Hungary

Term of the Project: March 21, 2013- March 20, 2016
Budget: EUR 379,295
Percentage of funding: 75% (EUR 285,000)
Website: www.iee.kecskemet.hu

The objective of the project to be co-funded by the Intelligent Energy Europe Programme is the technical and legal preparation of the investment project supplying the district heating system in Kecskemét with geothermal energy source. Following successful completion of the GeoKec preparation project and the implementation of the geothermal development, instead of the current natural based energy source, a major percentage of the up and running district heating system will be supplied with energy originating from the heat of the earth, which is clean, free from smoke and CO_2 emission and available locally. The connection of further consumers to the new system will also become possible.

It is a step on the path to increased utilization of renewable energy resources in Hungary with a sustainable emission free energy providing increased standard of living at a lower cost compared to present fossil fuels.

The project will contribute significantly to the increased use of geothermal energy for district heating, benefiting both the general public and private companies. Many of the buildings in Kecskemét are currently heated with individual gas furnaces, which are more expensive and less environmental friendly than geothermal district heating. After extension of the geothermal district heating system, it will be possible to connect additional residential, commercial and industrial users.

The project co-funded by the Intelligent Energy Europe (IEE) programme provides funding for the preparation works of the geothermal investment planned to be developed in Kecskemét.

During the GeoKec project which ran for 36 months from spring 2013, the geological and geothermal parameters of the surrounding areas of the city and the various possibilities to re-inject the hot water produced have been explored. The designs and licensing documentation for the later development have also been prepared, as well as a business plan, which provides a guideline for preparing the financing of the development.

The following results have been achieved during the preparation project:

- Mapping the geothermal resources of Kecskemét
- Selection of appropriate reinjection technology
- Assessment of investment options
- Technical preparation related to the planned development
- Licensing and Permitting required for implementation
- Preparation of a clear financing plan
- Distribution of information to the involved parties

Data used for the GeoKec project was provided by the Municipality of Kecskemét or originate from public and private sources. The well database (basic parameters, geology of drilled layers, hydraulic data, well log data, etc.) was gathered at the data room of the Hungarian Mining and Geological Authority (www.mbfh.hu), the Mining Property Utilization Company (www.bvh.hu) from the final well reports and from hydrogeological diaries stored at the Environmental and Hydrological Research Institute (VITUKI) and Hungarian Oil and Gas Company (MOL).

3. General background

3.1. Hungary's renewable and geothermal objectives

The Hungarian government has published the 'National Energy Strategy until 2030', which defines geothermal utilization as a prioritized renewable energy source. According to the strategy, geothermal energy is a valuable contribution to increase the share of renewables in energy consumption. The project is in line with EU´s 2020 objectives as well as Hungary´s targets of cutting CO2 emissions by 5.65 million tons/year and increasing the use of renewables to 14,65% of total energy consumption by 2020. Hungary has prioritized the increased use of geothermal resources in their National Energy Strategy[1], and in the 'Renewable Energy Action Plan[2]' geothermal energy is highlighted for direct use in district heating systems. The project is in line with 2009/28/EC Directive on the promotion of the use of energy from renewable sources.

Increasing the proportion of renewable energy in district heating is one of the key targets of the domestic energy policy. Increasing the energy production based on renewable energy sources, within that the stimulation of energy production based on decentralized, local heat utilization was designated as one of the key objectives of the National Energy Strategy (NES). NES considers renewable energy based heat production as one of the most efficient ways to reduce unilateral natural gas dependency and to increase secure supply.

According to the Hungarian National Renewable Energy Action Plan, the heating and cooling sector is seen as the biggest contributor with 18.9% of renewable energy sector in consumption, and electricity sector meeting about 11% of consumption with renewables.

[1] http://2010-2014.kormany.hu/download/4/f8/70000/Nemzeti%20Energiastrat%C3%A9gia%202030%20teljes%20v%C3%A1ltozat.pdf

[2] http://2010-2014.kormany.hu/download/2/b9/30000/Meg%C3%BAjul%C3%B3%20Energia_Magyarorsz%C3%A1g%20Meg%C3%BAjul%C3%B3%20Energia%20Hasznos%C3%ADt%C3%A1si%20Cselekv%C3%A9si%20terve%202010_2020%20kiadv%C3%A1ny.pdf

The Hungarian National Renewable Energy Action Plan (HNREAP) assigned a pivotal role to the district heating sector in the achievement of renewable energy utilization objectives by 2020. According to the original HNREAP, by 2020 the current renewable energy based district heat production of 5 PJ should be increased to 26 PJ.

Geothermal energy is based on the exploitation of thermal water attributed to the internal heat of the Earth, which has been used by several towns in Hungary for heating purposes. These geothermal projects have been implemented in several versions with different investment schemes and ownership structures. The current up and running district-heating systems supply approximately 650,000 households with heat and hot water with natural gas being the main energy source of district heating. A significant proportion of Hungary´s total energy needs is the quantity required for the supply of district heating-Currently in Hungary the capacity of district heating/town heating amounts to about 200 MW_{th}, which capacity includes the heating systems of a total of 21 towns. In the remaining 199 towns operating district heating systems, the opportunity to exploit geothermal energy for district heating purposes is yet to be exploited. Geothermal energy could locally generate much of Hungary's energy needs, while considerably eliminating dependence on foreign supplies of gas and the economic pressure associated with fossil fuels.

Geothermal energy has been used successfully for district heating in many parts of the world including Central Eastern Europe. Successful harvesting of the resource from various geological types of aquifers has been proven there, inclusive the Pannonian basin which Kecskemét is a part of.

3.2. About geothermal district heating in general

Geothermal energy can be exploited in several ways. In case of the right mineral layers, the opportunity is given to pump the water from the surface into the depths following the fracturing of the layer and, thereafter once the water is heated up to bring it up to the surface (EGS technology). The costs involved with the technology are quite there, for this reason EGC technology is typically rather used for the production of electricity. Domestically district heat is primarily produced directly by bringing thermal water from the depth onto the surface (hydro-geothermal systems). In this case, following the identification of aquifers below the surface of earth, the thermal water stored therein, after it is brought to the surface, supplies the energy with the assistance of a heat exchanger to the pipeline of the district heating system.

Since the Hungarian regulations in force presently do not require it clearly at the moment, following the transmission of the energy, the thermal water is typically reinjected into the reservoir concerned. Due to the unique composition of thermal waters, the storage of the exploited water is an issue to be solved, which is typically quite costly, whether it occurs in the form of surface storage or it is reinjected. This is due to the reason that because thermal water has a typically significant salt content it is high temperature, it cannot be released into surface waters without restriction.

Domestically for district heating services, the adequate thermal water is already typically located above a depth of 2500 m, thus for drilling wells, a concession is not required.

Depending on the area and method of utilization, thermal water of varying temperatures may be suitable for the supply of district heating, this temperature range in Hungary is typically between 60-90 °C.

During the design of geothermal wells, in addition to checking geological parameters, the heat demand must be mapped. In the majority of cases, geothermal wells cannot supply the entire 100 % of the annual heat demand since the peak period is generally only a few weeks each year, in addition during this period the performance of the well is somewhat lower than in the summer due to low external temperatures. Considering the above, when designing the size of the wells, it is not reasonable to calculate on the basis of heat demand during peak periods. In the majority of cases the geothermal heat production is supplemented by fossil fuel, primarily natural gas, based production during the periods of the highest demand.

The provision of district heating services does not always require a district heating license. It depends on the buildings serviced and the production unit´s ownership structure. If the buildings and the production units are in the same ownership, acquiring a district heating service provision license is not required. The water legal and environmental protection licensing is still mandatory in the above case as well.

3.3. The implementation phases of geothermal projects

One of the unique features of geothermal district heating production projects is that implementation is preceded by a long preparation phase. Hungary, even when compared with the rest of Europe is considered as a well studied and explored area. Not only its thermal water but also its various hydrocarbon rich sites have been mapped domestically since the 1950-s.

The first step of preparation is primarily the compilation of information arising out of the results of previous studies and drillings. Thereafter, with the involvement of experts, measurements and explorations are carried out, such as various seismic measurements. In certain cases the drilling of the production well may be preceded by an exploratory drilling to gather more accurate, direct data on water content, temperature and flow. The comprehensive preparatory work may be necessary in case of drilling a thermal well because of the geological and drilling risks. The geological risk arises mainly from the fact in the case of certain mineral layers, even with a long and thorough preparation, the exact locations of aquifers cannot be ascertained, such as in case of crystallized fractured layers, neither can their flow rate or temperature. The drilling risk mainly arises from the fact that even when the geological characteristics have been comprehensively mapped, certain mineral layers can contain local changes, which will only be revealed during drilling and may lead to the failure of the drilling concerned or higher expenses involved therein. The latter risk can be reduced by the adequate execution. It is important to emphasize that if on the basis of the measurement data, it is not worth starting the project, then the entire amount spent on preparation is lost, which also involves risks, however, in this case the drilling of the well involving significantly higher costs also does not take place. Thus, the loss is significantly lower than if due to trying to reduce the costs of preparation, the amount spent on the drilling of the well would be lost.

The licensing and permitting process and the acquisition of the required licenses are also a part of the preparation phase. Currently, for the establishment of the district heating production well the acquisition of at least three different permits and/or licenses would be required: Environmental Permission (preliminary or comprehensive) or unified environmental usage permit, theoretical water legal and establishment license (later water legal operation permit) and building permit.

If it is not for town heating, a district heating production system establishment permit is also required (for which it is also required to file the preliminary agreement concluded with the district heating service provider, if it is not the producer providing the services.), then following implementation, the placement into operation procedure and the test operation, it is also required to acquire the operation permit.

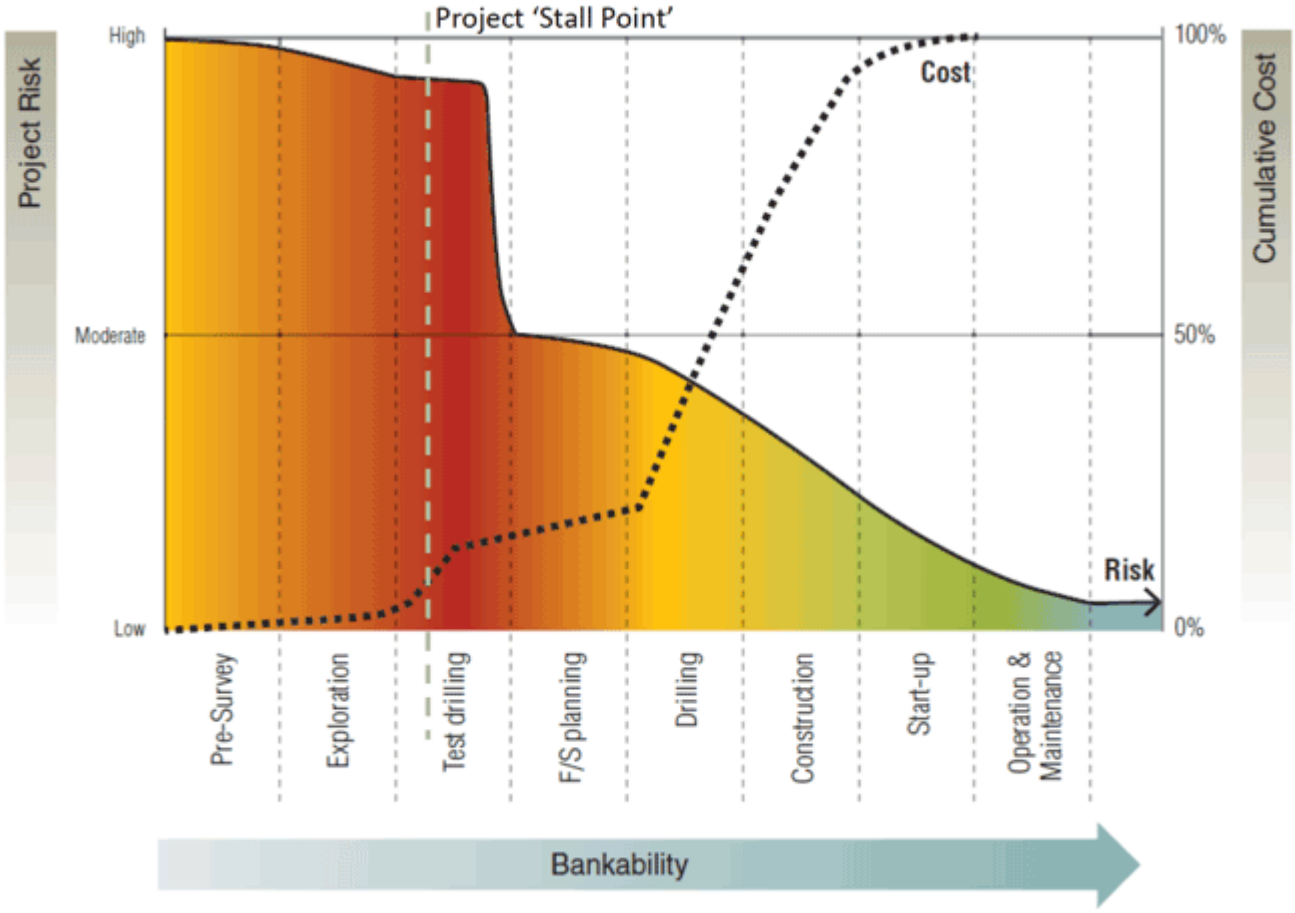
The process of obtaining the above permits and licenses is generally lengthy and difficult, according to relevant experience in the field it can even take years.

During the conclusion of the agreement with the district heating service provider, both parties significantly benefit if the town concerned has a long-term (energy) strategy. On the one hand, the heating market narrowing impact of energy efficiency developments, and on the other hand, the heating market expansion impact of potential new establishments, such as spas, kindergartens, etc. can play significant roles in setting out the details of the heat purchase agreement to be concluded, as well as in design during the potential expansion, construction of the district heating network. The licensing process pertaining to the new network is also a complicated and lengthy procedure.

The acquisition of licenses and the appropriate preparation are followed by the drilling of the geothermal production well, which, however, is already a part of the implementation phase, not that of preparation. As we already mentioned above, at this point the investor faces significant risks. These risks can be mitigated by costly preparation work, depending on the geological characteristics of the given area, either to a lesser or greater extent but they cannot be entirely avoided. Risks can be divided into two main groups; short-term risk involved in locating water with the expected volume and temperature, as well as implementation (the above mentioned geological and drilling risk) and long-term risk concerning the consistency of the supply as well as maintainable utilization potential.

In Hungary the level of risks is somewhat lower than in various other countries of Europe, which is due to the large number of wells (exceeding 10 thousand) remaining following hydrocarbon exploration and the valuable information which can be gained from them. In the areas, where the investment is „brown field", i.e., well drilling has been carried out already, the risk is significantly lower than in a „green field" case (the drilling of the first two wells in the given area takes place during the project). This risk is lower in case of certain aquifers and significantly decreases following the drilling of the first well. On the following table the fluctuations of costs and risks in relation to the progress of the project are presented.

Figure 1: Costs and risks of geothermal projects



Source: ESMAP (2012)

Following the drilling of production and reinjection wells, a test operation is carried out and if everything proceeded in order during this period, the construction of the above surface infrastructure can commence (construction of heat plant, pipelines from the well to the existing network/construction of the entire network, etc.), followed by operation. At this stage the investor faces practically no further risks, thus the financing thereof is much easier and the requirement for capital investment is significantly lower.

With respect to risk, there is a particularly high contrast between the initial phase of the development and the operation period; while until the drilling of the first two wells the investor faces high risks, the operation of the completed system is highly risk free, and its lifespan is extremely long. The lifespan of geothermal heating systems is about 30-50 years, thus completion provides production capacities for the long run.

3.4. The costs of geothermal projects

The primary cost items of geothermal developments are the following:

- Preparation (gathering previous exploration information, carrying out additional measurements, studies, design, licensing, etc.)

- Drilling (with the related preparation works, ensuring spare equipment and engineering supervision, etc.)
- construction of additional items (drill bit, filters, de-gasing equipment, etc.)
- testing of the well
- management and removal of the waste arising
- costs related to water storage (reinjection well/equipment ensuring above surface water storage, establishment of intake area, etc.)
- construction of heat exchanger and pipelines, connection to the existing system

If the entire district heating network is constructed during the project, additional costs are the following:

- ensuring backup/peak period supplementary heat production units
- construction of district heating network
- construction of measurement and operation system
- construction of heat exchangers
- ensuring protection against corrosion

The main operation costs are the following:

- operation and maintenance of wells (operation and regulation of pumps, replacement of filters at regular intervals, etc.)
- fluctuating costs related to water storage (reinjection well/equipment ensuring above surface water storage, establishment of intake area, etc.)
- continuous anti-corrosion measures (in case of both the well and the network, especially if thermal water is transmitted into the main pipeline)

4. About the planned geothermal project in Kecskemét

4.1. Location

Kecskemét is a city in the central part of Hungary, situated at 46.54° N; 19.41° E. It is the 8th largest city in the country and the shire-town of the territory wise biggest county, Bács-Kiskun. As of January 1, 2012 the city had a population of 114,226.

Figure 2: The location of Kecskemét

Kecskemét is the commercial and cultural center of the region. The most developed industrial sectors are: IT, machine industry, printing industry, plastics and food processing. During the last two decades, nearly one hundred industrial operations have settled in Kecskemét. Amongst these are international companies. The permanently settled operations are mainly focused on the production of components parts, equipment, and accessories for machine and electrical installations. German carmaker Mercedes-Benz raised a plant nearby Kecskemét. The plant was opened on 29 March 2012. The Stuttgart-based company invested €800 million to build the new plant, which has created 3000 new jobs in the region.

In the region there is a traditional industry of stock raising, vegetable production and food processing. One of Hungary's largest food manufacturing companies is based here; the Univer-Group, which has become famous for its food flavoring products and baby food. Fornetti is a market leader in Hungary for the production of frozen bakery products. Another well-known branded food product is the mineral water bottler Szentkirályi Ásványvíz.

The Action Plan of the City of Kecskemét supplementing its Environmental Protection Programme, as well as the Economic Programme also designated the transformation of the district heating system currently operated with natural gas into a renewable energy based system, thereby emphasizing the opportunity to utilize the geothermal energy sources located below the city.

The geothermal gradient in Hungary is close to double the world average, due to the highly favorable location of Kecskemét, in the area temperature may rise by 54°C per 1000 meters. The Municipality of the City of Kecskemét of County Rank had the preliminary mapping of local geothermal potential prepared, thus when preparing the local energy strategy, the preliminary geological and other technical, design parameters were available.

Twenty-six hydrocarbon wells are located in the Area of Interest around Kecskemét. Geological well database (basic parameters, geology of drilled layers, hydraulic data, well log data, etc.) has already gathered at the data room of the Hungarian Mining and

Geological Authority (www.mbfh.hu) and at the Mining Property Utilization Company (www.bvh.hu) from the final well reports. In addition, seismic data was purchased from the Hungarian Mining and Geological Authority, and temperature data was collected from the database of Geomega Kft (www.geomega.hu).

The following well data have been collected:

- Well logs
- Temperature data
- Fluid chemistry
- Hydraulic parameters
- Seismic data (velocities and reflection data)

During the development under preparation 2 km deep wells will be established, out of which thermal water of a temperature of 100 °C will be possible.

The IEE grant does not subsidize the costs of drilling. Project Company is in possession of all required data, information, thorough engineering-geological studies from the feasibility study carried out, which ensure that thermal water of the required temperature and volume is available at the location of the execution of the project, thus, the geological risks are considered to be low for the planned further project development.

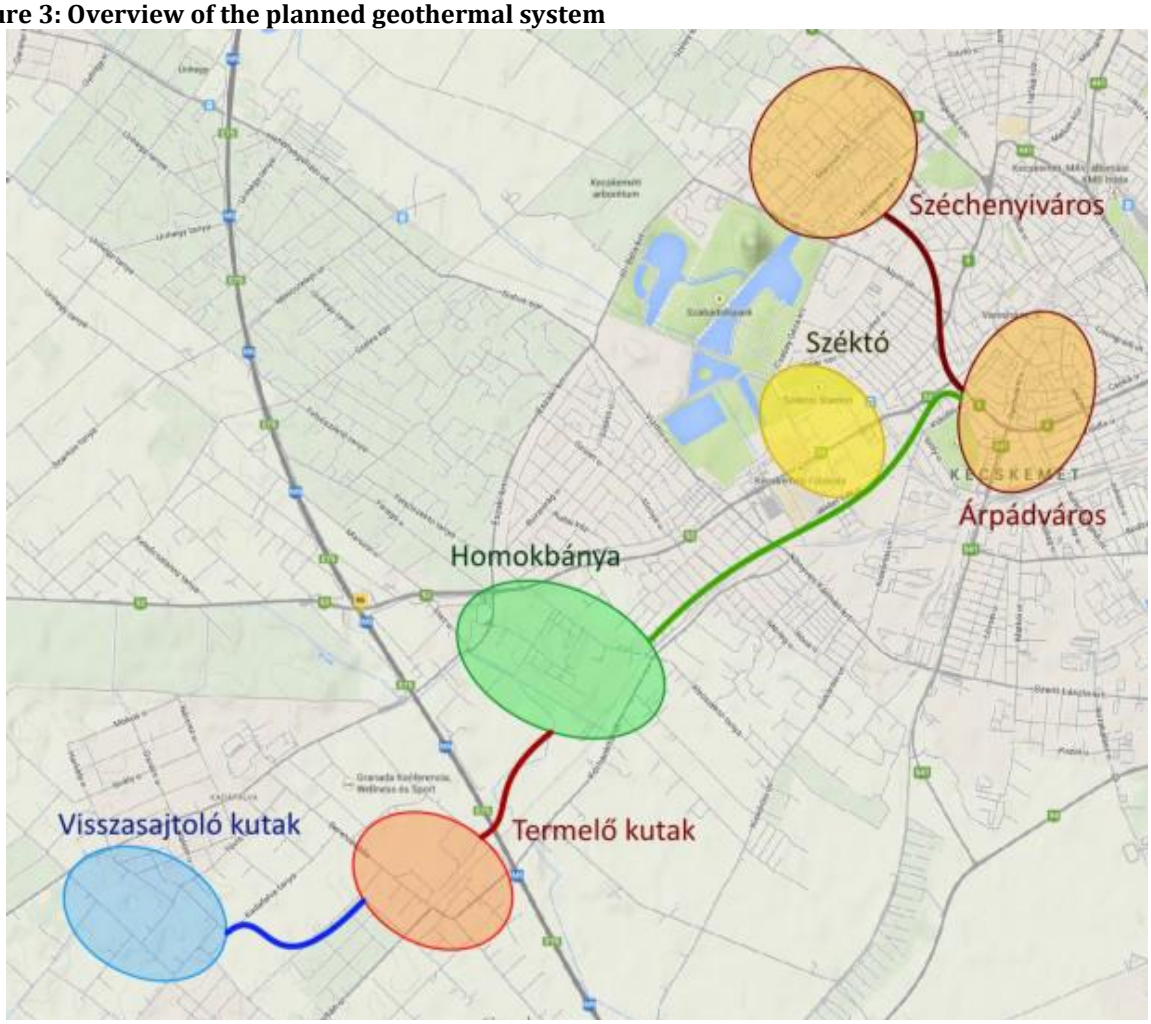
4.2. Overview of the investment prepared based on the GeoKec project

The current natural gas based district heating system in Kecskemét is operated with two networks connected to one another, which are supplied with heat energy by one main heating furnace each with the operation of gas boilers and engines. The system in Árpádváros provides 3,763, while the one in Széchenyiváros provides 7,471 households, that is altogether 11,234 households with heat energy.

Termostar Kft. is the local heating company and it is owned by the municipality (69,5%) and the EDF DÉMÁSZ Zrt. (30,5%) since 1995.

The objective of the municipality is that the energy supply of the town become independent from natural gas and fossil based fuels to the highest possible extent, in order to actually reduce the price set for the end consumers. The objective of the geothermal investment project planned is to supply the up and running city district heating network of the City of Kecskemét with renewable geothermal energy, as well as to partially replace the current gas boilers, thereby reducing carbon dioxide emission. The geothermal system primarily serves the up and running district heating network but the supplying the part of the city in Homokbánya with heat is also among the targets of the city´s municipality. Additional consumers can also be connected to the network, in particular primarily the public institutions in the parts of the city in Felső and Alsószéktó. The planned geothermal investment may facilitate the achievement of these goals by supplying two thirds of the annual energy demand by reliable, locally available energy sources. The construction of the geothermal system also increases the performance level of the up and running district heating system, thereby the connection of additional households, public institutions and industrial plants becomes possible.

Figure 3: Overview of the planned geothermal system



Market Size

Characteristic Data of the Heating System:

- Volume of the heated residential space: ~ 1,500,000 m3
- Volume of the heated non-residential space: ~ 500,000 m3
- Supplied amount of heat: ~ 540,000 GJ
- Supplied hot water: ~ 300,000 m3

Geothermal reservoir characterization

The area of Kecskemét area s located in the central part of the Pannonian Basin which is a young sedimentary basin formed since Middle Miocene until Quaternary.

The target reservoir is a hot, likely fractured, crystalline rock body belonging to the Mórágy Complex. The targeted rock body at Kecskemét mostly consists of granite and migmatite. The reservoir rock is an elongated granitic body stretching along a NE-SW direction forming a syncline approximately 200 km long and 25-30 km wide. The top of the reservoir starts at 1000 m depth below sea level and sinks deeper down below 3000 m.

Project implementation in phases

The implementation of the geothermal system is carried out in three phases. In the first phase one production well (with a 2160 m3/day average capacity and an annual 788500 m3 planned water use) and one reinjection well will be established, by reinjecting the entire quantity produced, which system is capable of producing 7,5 MW heat energy. The heat energy is transmitted by the district heating system through the geothermal heat plant to be constructed during the project (primary network) into the return part. The primary cycle is operated as an independent pipeline network, separated from the geothermal cycle by heat exchangers.

The primary network transports geothermal energy to the area of Homokbánya from the planned geothermal heat plant to the heat furnace in Árpádváros. In the heat furnace the transformation of the existing, remaining gas boilers is not planned, they will continue to remain in operation, only their exploitation will decrease due to geothermal energy.

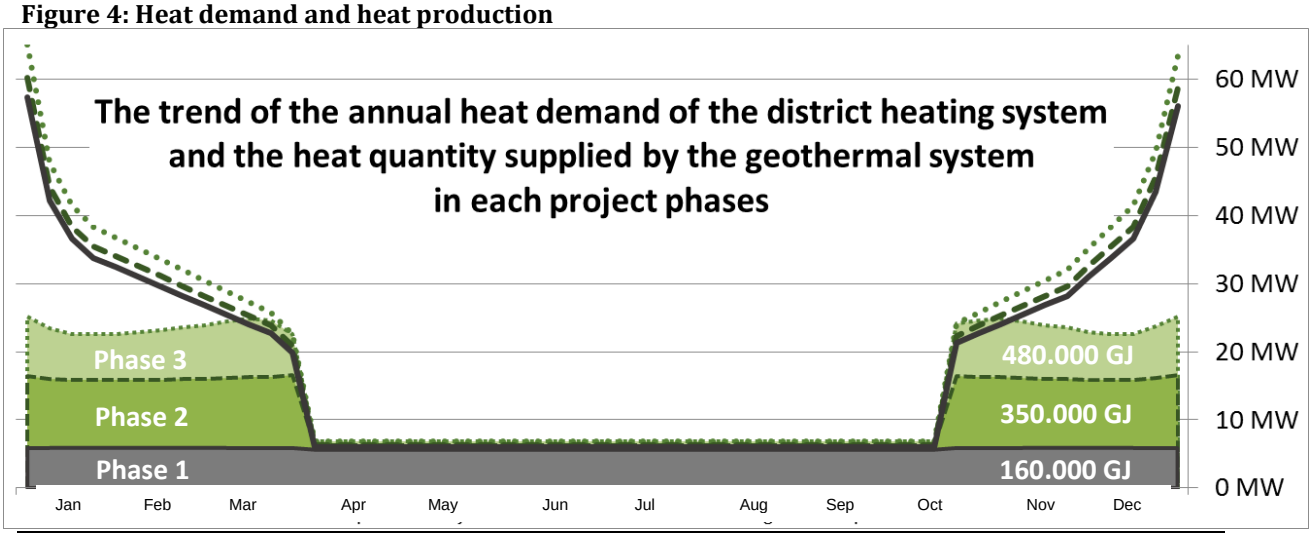
Following the implementation of the first phase, the planned geothermal system is capable of satisfying heat demand on the consumer side of up to 180,000 GJ/year.

The thermal water produced and used for energy purposes will be reinjected fully considering local conditions.

In the later phases of the project, via the geothermal system implemented, with the mechanical expansion of the heat plants as needed within the building and the drilling of additional production and reinjection wells, the quantity of transmittable geothermal heat can be significantly increased, leading to the achievement of additional heating cost and CO_2 emission reductions. The connection of consumers located in the area of Felsőszéktó to the system and supplying them with direct geothermal heat from the return network concurrently with the expansion constitute additional cost reductions.

In the second phase, by the establishment of additional wells, the quantity of energy supplied by the geothermal system can be further increased, and the connection of the consumers located in the areas of Homokbánya and Széktó to the system can be achieved. In the third phase, with the drilling of additional wells, the system achieves its full capacity, supplying nearly 85% of the annual demand of the district heating system.

Figure 4: Heat demand and heat production



The below table summarizes the quantity of geothermal energy which can be produced in the later phases by the expansion of the system:

Table 1: The quantity of energy to be produced depending on the number of production wells

Number of production wells	Heat capacity [MW]				Quantity of heat produced [GJ]	
	Geothermal		Gas boilers		Geothermal	Gas boilers
	General	Max.	General	Max.		
1 production well	6.1	8.3	52.3		180 000	380 000
2 production wells	10.9	11.0	49.1		300 000	300 000
3 production wells	13.4	14.1	46.6		350 000	250 000
4 production wells	15.9	17.1	44.1		400 000	200 000
5 production wells	18.3	20.1	51.7		450 000	150 000
6 production wells	19.8	23.1	39.2		490 000	110 000
7 production wells	23.3	26.0	36.7		510 000	90 000

4.3. Expected results of the geothermal investment project upon completion

The benefits of the new system, in case the planned geothermal development is implemented, contribute the following results to the energy production of the City of Kecskemét:

- The replacement of fossilized energy sources with locally available renewable energy source. The use of a clean, smoke free energy source instead of a heating system based on fuel
- Exploitation of local energy source without the need of transport
- The economic expansion of the district heating system, the connection of new private and industrial consumers
- The utilization of geothermal energy is more economic than the utilization of other energy sources, the costs of heating are reduced compared to the prices based on the currently used natural gas.
- Reducing dependency on import and raw materials
- Termination of air pollution characteristic of fossilized energy sources
- Significant reduction of the emission of greenhouse gases (the implementation of the first phase of the project results in the reduction of about 11,300 ton/year CO_2 emission).
- Using relatively simply, easy to maintain heat technology installations with a long lifespan.
- Long-term high security supply.

5. Summary of the results achieved during the GeoKec project preparing the development

5.1. Fulfilling the steps of implementing the project

5.1.1. WP1 – Project management

As part of the progress reports of the project, the project management reported to the execution agency on the progress of the tasks to be implemented. The beneficiaries submitted the following reports and documents:

- technical progress report
- interim technical implementation report
- Interim financial statements
- Final technical implementation report
- Final financial statements

5.1.2. WP2 – Preliminary studies

For this work package the preliminary environmental impact study, the geothermal site report, as well as the reservoir model have been prepared and submitted.

The objective of the preliminary study is to facilitate the acquisition of the official Environmental Permission for the implementation of the geothermal heating system investment project by preparing the licensing documentation and in accordance with the Hungarian legal regulations in force. According to the authority, based on the preliminary study it is not required to conduct a comprehensive environmental impact study.

The document reporting on the drill area contains the identification and description of geological parameters and mineral layers expected in the vicinity of the target area, the interpretation of geological data, the analysis of potential drill areas, the potential depth of drillings, as well as the expected temperature values.

The reservoir model presents the physical characteristics of the geothermal reservoir and the forecast of the impact of production and reinjection on the reservoir.

5.1.3. WP3 – Licensing and permitting

On January 11, 2013, the Regional Environmental and Water Management Authority granted the Theoretical Water Legal License for the implementation of the project in its resolution. The license contains the theoretical consent to the completion of the entire geothermal system including the production and reinjection wells, pipelines and the heat plant.

During the GeoKec project we obtained the Environmental Permission for the implementation of the geothermal heating system investment project on October 20, 2014.

5.1.4. WP4 – Technical and financial engineering

This work package contains the expert work needed to prepare a comprehensive feasibility study; drilling, well testing, well design, licensing documentation, technical documentation, as well as a comprehensive business plan have been prepared.

The above listed experts´ documents have been used and summarized in the Feasibility Study prepared.

We present the major findings of the prepared business plan below.

Planned costs of the investment project

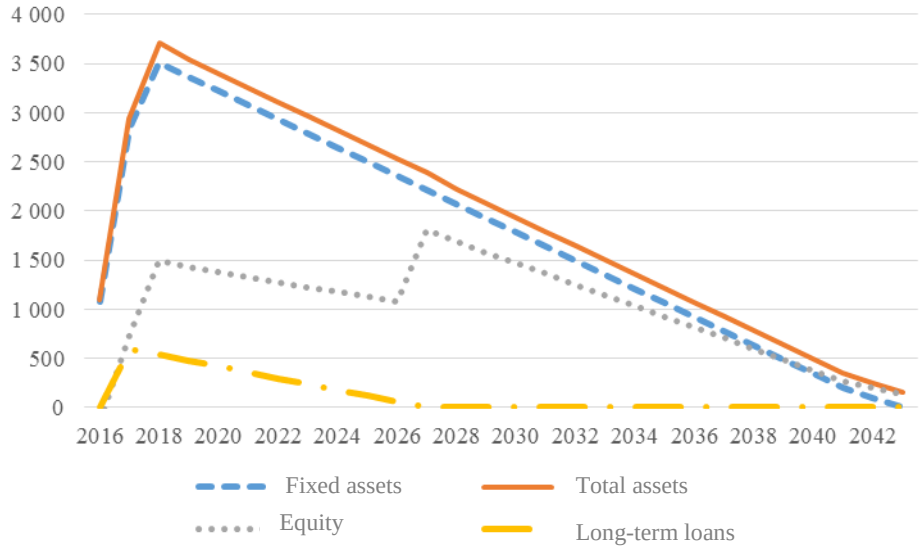
The total investment cost of the fully completed geothermal is EUR 30.375 million (approx. HUF 9.4 billion), which consists of the below planned investment phases:

Phase 1: EUR 11.375 million
Phase 2: EUR 10.8 million
Phase 3: EUR 8.2 million

Business model and Financial Plan

The financial model is based on the presumption of completing the first phase of the project to be started in 2016, which corresponds to the development of 1+1 wells, i.e., heat production capacity amounting to 161 GJ. (After two years of distant heating system development, the total level of production will be achieved in 2019.) The development will start in 2016 and the plan extends to an additional 25 years of operation, which corresponds to the expected lifespan of key components.

Figure 5: Key figures of the planned balance sheet for Geothermal System in Kecskemét (m HUF)



Financing

Kecskeméti Termálrendszer Beruházó Kft. (Kecskemét Thermal System Investment Ltd) will finance its operation primarily from three sources in addition to its own revenues. Beside the capital contribution of the founders, investors, such as development companies and venture capital funds, as well as long-term bank loans will be required. The plans are based on the presumption that the founders make their entire capital contribution at the beginning of the development phase and that during the process a co-owner will join. The planned sources for equity are shown in Table 2.

Table 2: The planned financing structure for the Geothermal System in Kecskemét

Source	%
Non-refundable grants (EEA and Norway Grants)	**24%**
Lilly Media (financial investor)	**37%**
Mannvit Ltd. (professional investor)	**16%**
Own contribution of EU-Fire Ltd.	**6%**
Additional sources (e.g., bank loans)	**17%**

5.1.5. WP5 – Procurement

In the work package the following documents have been prepared and used: Tender Call and Guidelines for the Feasibility Study, public award contract for the Feasibility Study, Tender Call and Guidelines for the EPCM contracts, as well as the EPCM contract itself. The tender call and contract for the procurement of construction and testing operation works have also been prepared, as well as a summary on investment and the evidence available.

In the framework of the GeoKec project the following contracts have been prepared:

Conclusion of contracts

In 2012 EU-FIRE concluded the syndicate agreement with the Municipality of the City of Kecskemét, in which the parties set forth that they shall mutually cooperate in the implementation of the geothermal project.

On July 2, 2013, the Municipality of the City of Kecskemét concluded a contract for the provision of project management services with CAM Consulting Szolgáltató Kft.

Thereafter, the Municipality of the City of Kecskemét entered into an agreement with threenine companies for carrying out the preparation expert work; Aquasoft EHF (preparation of Feasibility Study), Stapi ehf (exploratory geological analysis and designation of well site), GEOEKS D.O.O (provision of hydrogeological and water base model preparation services).

On October 17, 2014 the Project Company entered into a professional investment agreement with Mannvit Ltd headquartered in Iceland.

After EU-FIRE Ltd entered into an agreement with P&L Ltd on July 1, 2014 on the conclusion of the procurement process with respect to the EPCM and the development agreement, on September 7, 2014 the EPCM agreement was signed with Mannvit Ltd.

Kecskeméti Termostar Kft. stated in its declaration of intent dated March 16, 2016 that it shall undertake negotiations with the Project Company for the sales of geothermal heat.

Due to the results of the Feasibility Study (FS) and the declaration of intent signed by Termostar Kft., on February 5, 2016 the Project Company signed the binding financial agreement with Lilly Media Ltd.

After the procurement process pertaining to the implementation was concluded, on March 17, 2016 Kecskeméti Termálrendszer Beruházó Kft. entered into a project execution agreement with EB Hungary Ltd.

Based on the above prepared agreements, implementing the geothermal investment project became possible, which EU-FIRE is expected to commence in the summer of 2016.

5.1.6. WP6 – Financing

In this work package two agreements were prepared and concluded with a finance and a professional investment expert each. In these agreements the investors undertake that in exchange for ownership ratio in the Project Company, they shall contribute to the financing of the later investment project.

The declaration of intent, in which the district heat supply company of the City of Kecskemét (Termostar Kft.) ensures the Project Company that it intends to purchase geothermal energy at terms and conditions to be set forth later also constitutes part of the work package.

5.1.7. WP7 – Communication

During the project we maintained consistent contact and communication consciously with the relevant residents, the institution systems participating in the implementation, the partner organizations, the controllers, investors and other involved parties. In the preparation phase of the development (GeoKec projekt), the primary objective was to raise awareness; we attempted to primarily present the objective of the development and the benefits to be achieved to the involved parties, as well as to provide the involved parties with information on the establishments to be implemented based on the results of the Feasibility Study, such as what parts the system will be composed of, how it will operate, etc.

The following partial tasks were implemented in the work package:

- communication plan
- project website
- municipality meeting
- 2 workshops
- project leaflet in six languages
- agreement templates, as well as
- a public report prepared for the general public informing them of the signed agreements
- a result oriented public report (final publishable report)

Communication was maintained by following the preliminary communication strategy prepared and according to the communication plan prepared in the framework of the project. During this process we organized various meetings and presentations, as well as a public meeting. We have prepared and distributed a project publication (information leaflet) and placed advertisements, leaflets at the municipality. We established cooperation with higher education institutions, social organizations and held a workshop on geothermal energy for the regional municipalities. In relation to the investment, we created an internet based website, which we are continuously updating.

On July 9, 2014, a workshop was held in Budapest on geothermal energy as a great opportunity to utilize affordable renewable energy. The representatives of EU-FIRE, KTRB, the University of Nevada Mining and Metallurgical Engineering, the Geological and Geophysical Institute of Hungary, Mannvit, the Hungarian Oil and Gas Company (MOL) and the University of Miskolc participated at the workshop.

A workshop in the city hall of Kecskemét took place on January 12, 2016, where the majors and company leaders of the surrounding area had the opportunity to get acquainted with the project background and to ask questions.

Figure 6: Kecskemét, January 12, 2016

5.1.8. WP8 – EASME dissemination activities

This work package contains the information material required at the potential request of EASME. The table of Common Performance Indicators has been prepared and submitted.

5.2. Main Project Deliverables

Name of Deliverable	Description	Language versions	Target group
Preliminary Impact Study	Compiling a licensing report according to the prevailing Hungarian regulations	Hungarian	Municipality
Well site report	Geological, well data gathering and evaluation to estimate expected well parameters	English	Municipality
Reservoir model	Data collection in connection with underground water base, evaluation of the data, calibration and running of the model	English	Municipality
Feasibility Study	Professional conceptional design of the geothermal system to be implemented	Hungarian, English	Interested economic business sector

Tender Call for preparation work (Feasibility Study) and related Guidelines	Preparation for tender submission and tender guidelines, based on the aforementioned carrying out procurement and the selection of the awardee	Hungarian	Interested economic business sector
Tender Call for EPCM and related Guidelines	Preparation for tender submission and tender guidelines, based on the aforementioned carrying out procurement and the selection of the awardee	Hungarian	Interested economic business sector
Tender Call for Construction and the related Guidelines	Preparation for tender submission and tender guidelines, based on the aforementioned carrying out procurement and the selection of the awardee	Hungarian	Interested economic business sector
Construction contract	Contract of the construction of the whole geothermal system	Hungarian	Interested economic business sector
Contract with financial investor	A binding financial agreement with a private investor	Hungarian, English	Interested economic business sector
Project website	The website presents the objectives of the project in two languages, as well as contains the templates of concluded agreements	Hungarian, English	Public authorities, potential investors, the general public
Meetings, press-meeting and workshops	Events facilitating the introduction of the project to the public efficiently	Hungarian	Public authorities, potential investors, the general public
Final publishable report	A document prepared in two languages to be published for the general public in 200-200 copies, containing the summary and lessons learnt from the activities carried out during the GeoKec	Hungarian, English	Public authorities
Project leaflet	A Project leaflet printed in 1000 copies	Hungarian, English Croatian, Romanian, French, Bulgarian	Public authorities, potential investors, the general public

Agreement/contract templates	Templates of agreements and contracts concluded during the project, also uploaded to the project´s website	Hungarian, English	Public authorities, potential investors, the general public
Report on contracts	Summary report on agreements and contracts concluded during the project	Hungarian, English	The general public
Table of Common Performance Indicators		Hungarian, English	EASME

5.3. The impact of the results achieved during the GeoKec project

The results of the preliminary impact studies and geological measurement confirm the feasibility of the geothermal investment project. The GeoKec project has largely contributed to the preparation of the planned investment project, as a result of which binding financial and professional investment agreements have been successfully concluded, which ensure the future financeability of the project. As a result of the project, the commencement of the development has become possible since the licenses and permits required therefor have been acquired as well.

The events organized to provide information (such as municipality meeting, workshops, leaflets in several languages) contributed to enabling the decision makers, businesses and residents of Kecskemét and the surrounding establishments to get to know the objectives, designs and execution schedule of the planned geothermal investment project.

Consequently, it can be stated overall that the implementation and results of the GeoKec project played a pivotal role in implementing the renewable energy objectives of the area, within that the City of Kecskemét, which, by the execution of the well prepared geothermal investment project, highly impacts both residential and industrial consumers.

6. The fluctuation of project costs

The planned budget prepared in the beginning of the GeoKec project contained the planned costs of the project (the total budget of the GeoKec project is EUR 379,295). During the implementation of the project, certain items had to be redistributed compared to what was planned. One example is that changes have arisen in the accounting of travel costs, the sums actually spent on foreign trips decreased compared to what was originally planned, thus the additional sums were redistributed to activities related to the domestic project. Similarly, certain material expenses, such as the sums planned to be spent on subcontractors became irrelevant since we carried out the tasks ourselves, thus they were redistributed as wages in the final budget.

7. Difficulties experienced during the implementation of the project

Difficulties pertaining to the planning of financing

Commercial banks, credit institutions, and hedge fund companies are not willing to bear the risks of drilling and generally do not provide financing for the drilling of the geothermal well. Consequently, currently the developer of the project has to undertake the risks of drilling, which means that in practice the costs involved in the project and at least the drilling of the first well has to be financed from own capital and, whenever possible from, grants from awards. After the first two wells are successfully drilled, the execution of additional required drillings (such as for the reinjection well) and other components of the system can possibly be financed by banks and/or hedge funds.

While implementing this GeoKec project, the Project Company submitted a proposal in April 2014 for the Call for proposals entitled "Implementation of Geothermal Based District Heating Systems – Replacing Existing Fossil Fuel Based District Heating" in the framework of the Renewable Energy Programme Area of the EEA Financial Mechanisms 2009-2014. This grant was selected for the reason that it provides financing even with the above mentioned drilling risks involved, including but not limited to the drilling costs of wells.

Unfortunately, no decision has been made on the proposal submitted by the Project Company until today for reasons not attributable (force majeure) to the Project Company (suspension of the EEA grant scheme in Hungary).

This unexpected suspension of the grant scheme has caused a delay of 1.5-2 years in THE physical implementation of the project, the launching the drilling activities on-site. Since the disputes between the Hungarian and Norwegian governments have been recently resolved, we have been informed that the evaluation of the bids has been conducted and the geothermal project in Kecskemét is expected to be supported by the EEA grants. It is the project developer´s intention that the project implementation will immediately continue after receiving the awarded grant by drilling the first deep geothermal production well, expectedly in the second half of 2016.

An additional difficulty was that in 2013 at Kecskemét, as a result of municipality elections, the previous contact persons in the project were replaced by others, during which period cooperation became more difficult.

It was also a problem that the conclusion of the long-term heat sales agreement was requested in a premature phase of the GeoKec project, when the quantity of geothermal energy source, thus the transmissible quantity of heat cannot be accurately calculated.

Technical difficulties

The targeted crystallized layer is not a typical reservoir for the area´s geothermal/thermal systems. Due to the above, modelling and geological mapping requires high level qualification, an expert with extensive experience in the field and takes longer than usual.

The owner´s agreements and consents required for the well sites and eachsite along the long pipeline tracks took longer than expected (the main reason for the delay was that no final agreements could be responsibly concluded until financially securing the investment project).

Connection to the large-scale district heating system operated at high temperatures and its synchronization require a lengthy and complicated engineering work in the cooperation with the operators of the district heating system. The transformation of the up and running system, the modification of the technical parameters may become necessary.

8. Lessons and conclusion

We summarize below the lessons learnt during the project:

- The co-ordination of the project team including the employees of the different subcontractors, e.g., financial experts and engineers, is a very complex and time-consuming task, which requires relevant project management experience and commitment from all involved parties.

- Initial scheduling requires thorough consideration in order to prevent delays in the completion day of the deliverables. As a consequence, it is really important to create a well-designed schedule at the planning phase of the project proposal.

- Professional and financial investors need as much information about the project implementation as possible to be able to calculate the undertaken risks and make decision on the financing. For that purpose, they can make their binding financing decisions if all project data are available, including the verified geothermal resource. This can be confirmed after the first geothermal well is drilled.

- Negotiations with the relevant land owners are very time-consuming. Therefore, it is strongly advised to start the negotiations once the first suggestions for the track of the pipelines and for the well sites are known in order to be able to avoid delays in the project implementation, particularly in the licensing procedures.

Following the completion of the GeoKec project representing preparation, the implementation of the investment project shall continue as intended by the project partners in phases; by implementing project phases 1, 2 and 3, i.e., the completion of the project, its placement into operation and the long-term operation of the completed system.

In summary it can be established that the objectives set during the GeoKec project have been achieved, the work completed during the project ensures the comprehensive preparation and feasibility of the planned investment project, which will positively impact both local residential and business consumers.