Geothermal Communities

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RES INTEGRATION CONCEPT PAPER

D5.1 – Final version

WP Leader: P9 – University of Szeged.
Key Contributors: P1, P2, P8
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CONCERTO

SEVENTH FRAMEWORK PROGRAMME

WP5 - Technological Research / WP5.1 Integration with other RES

The main scope of this sub-WP has been to outline ways of integrating geothermal energy in energy systems in Central-Eastern Europe. In this WP available experience of integrating geothermal energy into a cascaded facility with a view to environmental improvements and extending the utilization time and spectrum of uses of such facilities has been be studied.

Researchers at the University of Szeged looked at the economic and environmental factors of geothermal systems operating in the South Great Plain Region, outlined potential project sites and developed a number of project plans presented here in brief. We collected data from GeoCom project partners too regarding utilization in other CEE countries. This volume presents the first concise study of actual and potential geothermal projects in the South Great Plain of Hungary, with project concepts developed entirely by our researchers and contracted experts. Our work is complemented by data provided by our partners from Serbia, Slovakia, FYROM and Poland.

As projects in renewable energy use differ greatly from one-another we did not intend to formulate general conclusions regarding economic or environmental factors of RES integration. Rather, we present the RE potential of the target region, showcase our development proposals, and provide a tool (GIS model) to assist future project development.

As stated in *Annex 1* the main scope of this sub-WP has been to outline ways of integrating geothermal sources in energy systems, including those with other RES. However, as WP5.4 deals specifically with integrated utilization of waste gases of thermal wells in this phase we focused on GE system layouts and their integration with wind and solar energy, and present outputs related to waste gas integration under WP5.4.

Solar and wind energy as well as biomass provide the context of integration for geothermal. We assessed the potential of these three sources and forms of energy use in the target region, and summarized our analysis by developing and hence publishing an interactive tool that enables a multiple input evaluation of potential project sites. Our model is intended for large scale assets assessment and decision makers on all levels may make use of it. Designed primarily for an expert target group in mind as it was, our model may also be used in education while case studies and project plans can serve as blueprints for future developments.

The following activities had been planned and were carried out:
1) Investigation of the economic factors that influence the integration of GE in energy systems.
2) Investigation of other factors that influence the integration of GE in energy systems.
3) Identification of integrated systems potential layouts.
4) Studies for the improvement of geothermal energy utilization in CEE.

Partner participation
P2/P8: Data collection for case studies on RES integration in Italy; (as Italy is not CEE, these data were not included in the final document)
P4: Data collection for case studies on RES integration in Slovakia;
P5: Data collection for case studies on RES integration in Poland;
P7: Data collection for case studies on RES integration in FYROM;
P14: Data collection for case studies on RES integration in Serbia

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Contents

EXECUTIVE SUMMARY

The objective of the current study is the comprehensive presentation of geothermal energy utilization in the CEE partner countries of GeoCom with a focus on RES integration. In the following chapters, we present the current situation of geothermal, solar, wind and biomass utilization in the target region, focusing on communal geothermal and integrated heating systems, and development concepts in the scope of our study. In the case of the three counties of the South Great Plain region we determined potential development locations and possibilities, and carried out assets assessment, heat market evaluation, took into consideration all relevant financial factors and developed pre-feasibility study level concepts, published here in brief. Our study is summarized by a geothermal – solar – wind integration model for the target region that is there to provide assistance in assets evaluation in project development.

The European Union assistances provide a significant resource for alternative energy developments in CEE; however, earlier experiences show that their utilization is quite difficult due to the lack of knowledge of possibilities and know-how. A solution to these problems is a comprehensive study on the potential, projects and plans that summarizes the existing and planned investments utilizing thermal energy in a region with some of the best geothermal features in CEE.

During the elaboration of the study, we aimed to develop project plans, present project summaries, outline investment concepts with the most relevant financial and environmental indicators, and, most importantly, to develop a tool that help decision making. We present the existing systems of the regions of our partners, the projects in planning and implementation phase, and we also defined the expected parameters of several potential investments in the South Great Plain region, with the geothermal – solar –wind integration model being the most relevant output of this activity.

During the presentation of the projects, we outline the environmental indicators and the problems concerning geothermal energy utilization, and we determine the connection possibilities that can successfully integrate the industrial, research-development, administrative and civil organizations concerned in the utilization of RES. The synergy is needed, since the parties concerned in the utilization of thermal energy, more often than not, cooperate only to very small extent during the developments, there is no uniform opinion in questions concerning renewable energy utilization, thus the capacity of CEE to defend its own policy interests is low.

In the study, we present the situation of geothermal and integrated energy utilization in the concerned CEE regions. In excess to the main focus of our research, we certainly hope that, this study is a good start to a series of works that present as well as plan integrated energy projects of the region every two or three years – as a kind of manual – by reviewing projects, actual resources for developments, and the situation of legal regulations and practical experiences.

INTRODUCTION

The utilization of alternative energy sources to a larger extent has become a strategic task in CEE. The following factors and processes initiated the necessity of utilization of renewable energy systems:

The drastically growing energy demand of the Earth's population,
The climate change caused by CO_2 from fossil energy sources,
The dependence on gas import

The stimulation of utilization of renewable energy sources is a matter of life and death on a long term: The growth of energy consumption is parallel to the drastic growth of the Earth's population (according to pessimistic forecasts it even exceeds that). The recovery of fossil energy sources is becoming more and more complicated and expensive, the demand will not cover the supply, and thus the total energy demand will not be satisfiable. Accordingly, the spreading of alternative energy systems is one of the most important strategic tasks on a long term. This is especially true for countries with outstanding indicators for one of the alternative energy sources.

The renewable geothermal energy potential is one of the most significant alternative energy sources on Earth with a theoretical output of 5000 EJ/year (this is 75% of the total, extractable energy), thus a development worth of USD 30 billion is forecasted for the geothermal sector for the next 10 years. Geothermal energy is used for electric power production, direct heat recovery, and operation of pump systems with geothermal energy.

Currently there are 24 countries – mainly by oceanic plates – with geothermal power stations. The total amount of produced electric power is estimated at 60 TWh, the production shows a continuously growing tendency. The five most important capacities of the world built on thermal water are: USA: ~18 000 GWh/year, the Philippines (~9 000 GWh/year), Mexico, Indonesia (~6 000 GWh/year each), and Italy (~5 000 GWh/year).

Thermal energy systems with direct thermal utilization are currently used in 72 countries, with a heat production of 270 TJ/year. The most important countries regarding direct energy utilization are China (~45 000 TJ/year), Sweden (36 000 TJ/year), USA (31 000 TJ/year), Turkey (25 000 TJ/year), Iceland (~25 000 TJ/year). The biggest geothermal development potential of CEE is the direct heat utilization built on medium-enthalpy geothermal resources.

The number of low-enthalpy geothermal pump systems has increased significantly in the past years. There are around 900 000 systems in the USA, and 50 000 new systems are put into operation every year. In Europe there are around 500 000 heat pump systems, Sweden is on the top of the list (~40 000 pieces), followed by Germany (~29 000 pc.) and France (~20 000 pc.). In CEE a significant development is expected in this field.

The drastically growing energy demand is satisfied mainly by burning of fossil energy sources. The CO_2 from fossil energy sources is one of the main anthropogenic factors causing the global climate change. Accordingly, beside the economic aspect, the environmental indicators have become important aspects for alternative energy systems. Alternative energy systems are practically emission-free, thus the greenhouse gas emission can be significantly reduced by their utilization.

Geothermal energy emits 91 g of CO_2 during the production of 1 kWh of energy, thus it is practically emission-free, while fossil energy sources emit 6-11 times as much CO_2 during the production of 1 kWh of energy (natural gas: 600 gCO2/kWh; crude oil: 900 gCO2/kWh; coal: 1000 gCO2/kWh) (Mádlné et al., 2008).

The majority of EU states are not able to cover the energy demands from their own resources, thus they are depending on significant, mainly Russian resources. The Ukrainian-Russian gas disputes of past years have indicated the extent of energy import dependence of CEE. Although this situation cannot be terminated, it can be moderated through the utilization of alternative energy. Heating systems operating with alternative energy sources were not competitive with fossil energy sources so far. Due to the continuous increase of gas prices and the complex modification processes of the energy structure, the alternative energy systems have recently become competitive, but their spreading requires central aids. Geothermal energy provides local resources, the local governments dispose of them, it terminates the necessity to import, and can promote job creation.

The purchase anomalies of fossil energy sources, the alteration of the world market price, and the dependence of the Middle-Eastern Region in the field of energy supply necessitate the utilization of alternative, local energy sources. The challenges of the climate change and the protection of the environment in the 21st century require the improvement and expansion of the use of renewable, environmentally friendly energy sources. Our aim is to present for the participating member states the possibilities of a combined use of the available renewable energy sources. This shall be realized by helping the change of paradigm in energetics, and in compliance with the EU directives on energy supply based on own resources.

The transformation of the tasks to a local level serves the fulfilment of the objectives much better than the detailed description of monumental ideas. Based on consultations with the local management, it is expedient to design and implement the urban energy rationalization tasks along a rational and long-term energy strategy. The two pillars of the strategy: the cheapest energy is the unused energy, and the local energy demand shall be based on local energy bases.

The suggested energy management steps are:

- Thermal renovation of public institutions
- Improvement of the efficiency of heat supply (and lighting) systems
- Discovery and use of local renewable energy sources
- Switching to green sources in electricity generation

For the different renewable energy sources, the methods of use shall be the ones with the best cost/social benefit rate based on economic analyses concerning the given field. The external costs, reimbursement and prevention of environmental damages, shall be considered during the selection of the method. The region's geological and hydrogeological features and the parameters of the available heat market determine the applied technology.
Geothermal energy is at hand, it imposes a minimum threat to the environment, so it can be an optimum source of heat. The favoured way of utilization for geothermal energy shall be a complex multistage utilization that enables the use of a bigger heat quantity of the produced thermal water. However, geothermal energy is not always enough. The system is often dimensioned to allow the completion of the peak demands on the coldest days with other energy sources. In these cases, the ways to complete the missing amount of energy with other renewable energy sources shall be examined.

THE GEOTHERMAL FEATURES OF CEE

THE GEOTHERMAL FEATURES OF HUNGARY

Hungary is a country with excellent geothermal characteristics. The countries with the best geothermal values in the world are the ones situated at oceanic and continental crusts, since the values of the geothermal gradient are far higher on active volcanic areas (Italy, Iceland, Indonesia, the Philippines, Japan, and U.S.A.). Hungary is situated in the Carpathian Basin, on a 5-6-km thick Pannonian sediment. The reason for the favourable thermal energy values can be explained with the development history of the Pannonian Basin. The value of the geothermal gradient of 50C/100m is significant on both the European and world levels, the density of heat flux is of 90-100 mW/m2 compared to the continental value of 65 mW/m2. This is a consequence of the tailing of the lithosphere during the Middle Miocene. As a result, the asthenosphere got closer to the surface, thus the value of the geothermal gradient and the heat flux increased as well.

The heat flux shows significant differences at different points of the Carpathian Basin. The density of heat flux is lower than the average, approx. 50 mW/m2, in the Transdanubian Central Range, in the karst area of the Bükk Mountains and the area of Aggtelek-Gömör. The surface water leaking into the seamy carbonate rocks of this area is continuously decreasing the value of the heat flux. The value of the heat flux is lower than the average on the Little Hungarian Plain as well, which can be explained with the defervescent effect of the 7-8-km thin encrustation. The heat flux is lower than the average on the Great Plain, in the Makó-Trough and the Békés-Depression. The geothermal features are outstanding on other areas of the Great Plain, in Southern Transdanubia, and in areas of Northern Serbia, which belong to the Great Plain from the point of view of hydrogeology.

The South Great Plain is Hungary’s most important thermal water reservoir, since the quaternary and Upper Pannonian water-bearing formations are the thickest in this area. The average temperature in a depth of 500 metres is of 35-40oC, 55-65oC at 1000 metres, and 110-120oC at 2000 metres. In the Mecsek Mountains and its surroundings, the Battonya-Ridge, and on the north-eastern part of the Great Plain, the average temperature is of 70oC at a depth of 1000 metres, and 130-140oC at 2000 metres.

Most estimations on the geothermal resources of Hungary show an extractable thermal wealth of 250-300 PJ/year. On the contrary, the proportion of the geothermal energy utilization of Hungary’s total energy production from renewable sources of 55 PJ/year is only of 6% (3.6 PJ/year). If we compare this data with the target value of 10.5 PJ/year planned for 2020 in the energy strategy elaborated for the compliance with the EU directives, we can state that geothermal energy has high development potentials among renewable energy sources.

The Hungarian Thermal Water Cadastre (HKK) keeps count of more than 1200 thermal water wells, 60% of which can be found in the Great Plain. One third of those are non-producing wells (temporarily closed, observation or reinjection, or dry well). 36% of the productive wells serve baths, 27% drinking waterworks, 25% agricultural plants, 12% industrial and communal energetic needs. Geothermal energy is used for heating purposes mainly for buildings with traditional energy scale (70/50oC), and for building with floor and wall heating.

GEOTHERMAL FEATURES OF THE SOUTH GREAT PLAIN REGION

The temperature at the level of the Upper Pannonian substratum is higher than 50 0C in the biggest part of the South Great Plain (fig. 2). The geothermal utilization locations of the region with significant operational experience and tradition are well-known all over Europe.

There are 330 thermal well registered in the South Great Plain region's three counties, 250 of which are operating. The quantity of the extracted thermal water reaches 20 million m3. 75% of the extracted water was utilized in Csongrád County, 15% in Békés County, and 10% in Bács-Kiskun County. This shows that Csongrád County is the first in the utilization of geothermal energy, at the same time, Békés County has better geothermal features (fig. 2) and could significantly increase its geothermal energy production.

One third of the extracted water was used for agricultural purposes mainly in Csongrád County (the areas of Szentes and Szeged). Almost 24% of the utilized thermal water is used in baths and spas, 6% for communal geothermal heating, mainly in Csongrád County. 28% of the extracted water is used for other purposes (drinking water, agricultural, industrial and domestic hot water (DHW) supply). The remaining 7.5% is used at the 14 observation wells and 5 reinjection wells.

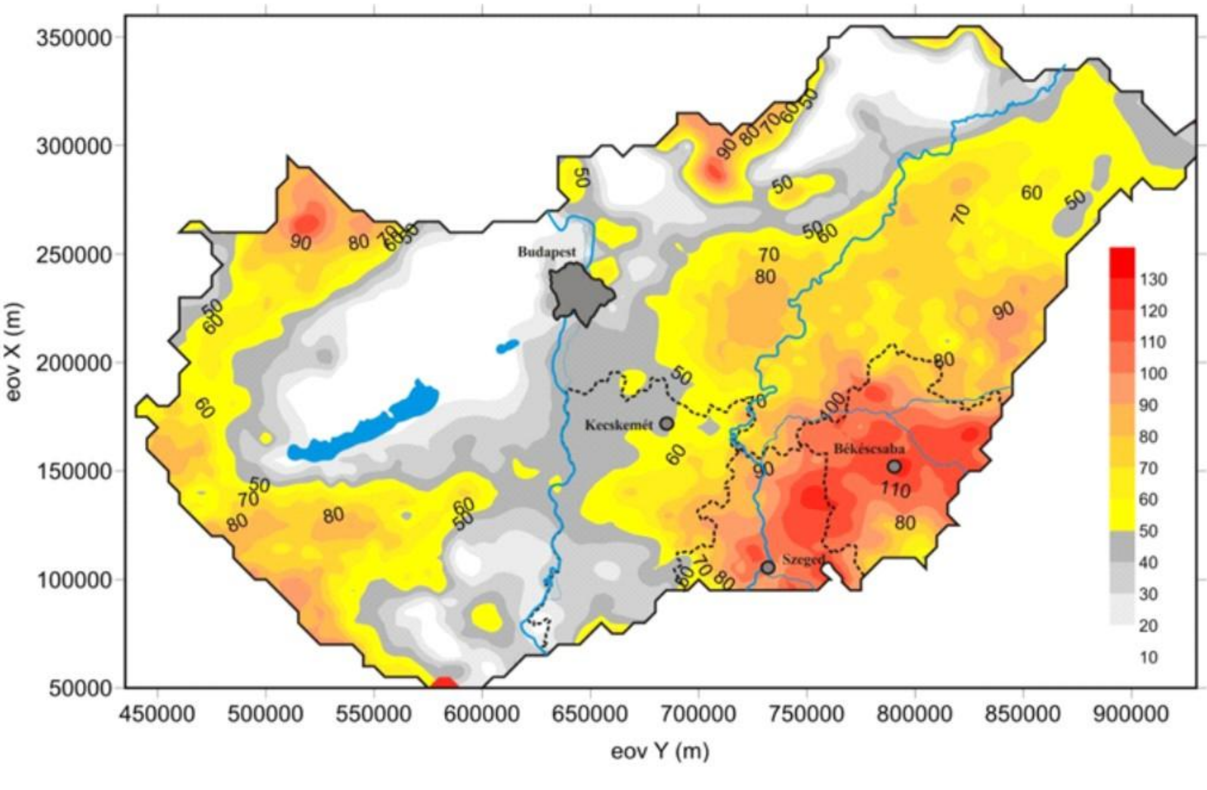


Fig. 1. Water temperatures measured on the Upper Pannonian substratum

The utilization of thermal water is present in three important segments:

Agricultural utilization of thermal water: The majority of waters warmer than 50°C on the Great Plain are used for heating cultivations and stock-farms. The majority of the total 170 ha of glasshouses and of more hectares of heated greenhouses can be found in this region. The centres of agricultural use of geothermal energy can be found in Csongrád County, mainly in the areas of Szentes and Szeged, but there are also smaller users in the region (e.g. Szarvas, Tiszakécske etc.). The agricultural agglomeration using thermal water in the Lower Tisza Valley uses the heat energy of 8-10 million m3 of water with a temperature of 70 -

100°C, becoming one of the world's leaders in this respect. Among agricultural plants using the most thermal water (ÁRPÁD-AGRÁR Zrt. of Szentes and FLORATOM Kft. of Szeged), the Árpád-Agrár Kft. is annually exploiting 550 GJ thermal energy by abstracting 2-3 millions m3 of water of 78-97°C from its 14 wells. This energy is used the heating of a 21 ha greenhouse and a 23 ha polytunnel for vegetable and flower cultivation, as well as for the heating of stock-breeding plants, industrial, and social buildings. (With traditional energy sources, the production of this amount of energy would require either 18.3 million m3 natural gas or 14,775 tons of oil fuel).

Utilization in tourism and for therapeutic purposes: The used thermal water is mainly extracted from wells with low water temperature (30-50°C) and shallow bottom depth (400-500 m). Some of the most important baths and spas can be found in Gyula, Szeged, Hódmezővásárhely, Orosháza-Gyopáros, Szentes, Csongrád, Kalocsa, Dávod, Soltvadkert, Kiskunmajsa. One of the most important touristic feature of the region is the growing number of spas with excellent water quality. The Hungarian spas have a history of more decades, currently, there are several ongoing spa developments with significant EU assistance (Makó, Mórahalom, and Gyopárosfürdő). The region's tourism is mainly based on these spas. It is important to mention that these spas and baths could become the end-users of the cascade systems to be constructed, since the thermal water used in the public institutions leaves the system at a temperature of 30-40°C, which can be utilized for the filling and heating of thermal baths (cascade systems of Hódmezővásárhely and Csongrád), and in case of newly built spas, this temperature is ideal for the floor heating of buildings (cascade systems of Makó and Mórahalom).

Thermal energy utilization for heating: The building and operation of remote geothermal heating systems was started in several settlements of the region in the 1960s. The first settlements with such systems were Szentes, Szeged, Hódmezővásárhely, Makó, Csongrád, Szarvas, and Tiszakécske. The majority of these systems are providing heating for medical institutes, hospitals and community buildings (schools, administrative institutions). It is a general fact that these systems do not meet the modern economical and environmental requirements and they are technically outdated as well. The majority of production wells have a low water output and a low thermal water temperature due to the improper construction of the well. Accordingly, the short-term geothermal developments must concentrate mainly on the optimization of these systems and the operation according to the modern efficiency. It is only the geothermal cascade system of Hódmezővásárhely from the listed systems that produces energy by using the total heat of the extracted thermal water. A further important direction of the developments using the energy for heating is the construction of cascade systems, which enables the utilization of the total extracted thermal energy, the increase of the return of the investments, and the decrease of operating and maintenance costs.

There are several industrial sites that use thermal water for the heating of their buildings and for technological hot water supply (e.g. KONTAVILL of Szentes, the porcelain factory in Hódmezővásárhely etc.). The struggling or closed hemp factories used lukewarm thermal water for unique technological purposes – mainly retting (e.g. in Szegvár, Nagylak, Eperjes etc.). Thermal water was used during the mining of hydrocarbon fields in the South Great Plain (e.g. in Algyő, Dorozsma, Ásotthalom) for water reinjection, readjustment of the reservoir pressure caused by hydrocarbon production.

It can be stated that every segment of potential geothermal utilization is present in the region. There are several ongoing capacity developments of new and expanding baths, spas and balneological treatment centres; their touristic significance is a priority among the revenues of the region. The number of claimants for agricultural utilization (e.g. greenhouse, glasshouse) is growing, the spreading of fully automatically controlled systems with combined utilization of biomass and terrestrial heat is expected. Parallel with the drastic decrease of national budget resources and the significant rise of the gas price, the demand from public institutions and local governments for heating-cooling with direct geothermal heating or heat-pump technology is growing. There are a great number of unused dry CH wells in the region, one of the most obvious ways of their utilization is the geothermal energy production. The thermal projects could escape the geological-hydrological risks and construction costs of new wells through the involvement of these dry CH wells. The geothermal features of the South Great Plain region and the development objectives of the EU are increasing the investment demand for the potential thermal power plant utilization. There is a growing demand from the side of micro regions, local governments, public institutions and entrepreneurs for planning and establishing a utilization system, in which the utilization directions mentioned above are complementing each other, combined and interlinked in a water system for effective and optimal local energy utilization.

The R+D knowledge base supporting the effective, economical and environmental friendly utilisation of geothermal energy is present in the target area as well. The majority of R+D projects are elaborated in the region's knowledge centre, the University of Szeged. The experience concerning the development, construction and operation of geothermal systems is significant in its institutions dealing with department-specific research, planning and education (Department of Mineralogy, Petrology and Geochemistry, Department of Geology, Workgroup for Regional Development, Department of Physical Chemistry, Department of Optics and Quantum Electronics etc.). A number of profit oriented enterprises are dealing with technological innovation and development related to geothermal utilization on a daily basis (e.g. Aquaplus Kft, Árpád-Agrár Zrt, GeoHód Kft, HidroGeo-Drilling etc.).

Non-profit organization forms were established, which are able to integrate organizations, companies, local governments interested in geothermal utilization, on both the user and the service side (Geothermal Innovation and Coordinating Foundation, Thermal Energy Association, Geothermal Association, InnoGeo Kft.).

THE RISKS OF UTILIZATION OF GEOTHERMAL ENERGY

Beside its obvious advantages, the utilization of thermal energy hides risks as well. One of these current and well-known problems is the issue of reinjection. According to the Hungarian legislation in force, water from a newly built thermal production well must be reinjected into the water-bearing layer. The technical problems of reinjection are currently not solved; however, the system in Hódmezővásárhely operating since decades proves that the operational reinjection of the thermal water into the water-bearing layer is possible. A complex R+D project for the solution of the problem and the development of reinjection technology is currently led by the University of Szeged (SZTE) and financed by the National Office for Research and Technology. We can state that the problem of reinjection will be solved and will not be a high risk during the implementation of thermal projects.

The risk of the realizability of the systems is low, or at best medium, since the region is practically totally known from data from wells during hydrocarbon researches, its geological and hydrological conditions are clear.

A further risk is the alteration of the world market price of other potential energy sources, since the utilization of geothermal energy can be uneconomical due to its costs. This risk is minimal, since it is only the natural gas that can compete with geothermal energy. The drastic increase of gas price of previous years justifies the construction of thermal systems, since a geothermal public-works system under the current circumstances has a return period of 10-12 years.

The investment costs of the building of geothermal cascade systems require own resources of several hundred million Forint. With the reduction of state normative, the investing local governments can hardly finance – or in most cases are not able at all to finance – the costs of such big-scale investments. Due to the economic crisis, the credit institutions have a growing number of conditions as well. Unfortunately, the financing of projects is difficult, just as in the other sectors, the period for credit appraisal and the assessment of applications is usually 5-6 months, which makes the quick implementation of geothermal investments even more difficult. Due to the economic return indicators, the financial risk of geothermal projects can be classified as a medium risk.

ENERGY STRUCTURE OF HUNGARY

Hungary is one of the countries depending on the Russian gas import, thus the long-term modification of the country's energy supply and the minimization of the dependence of import gas are of strategic importance for us. As shown by figure 1, the country's energy demand is supplied from fossil energy sources. The proportion of natural gas, crude oil and coal is of 80%, the one of the fossil atomic energy of 13.5%. The extent of the utilization of alternative energy sources is small, the majority of thermal energy is produced from geothermal energy and burning of biomass. The extent of solar and wind energy is negligible compared to the other sources. This structure shows clearly that the majority of Hungary's alternative energy developments can be and must be based mainly on geothermal and biomass energy.

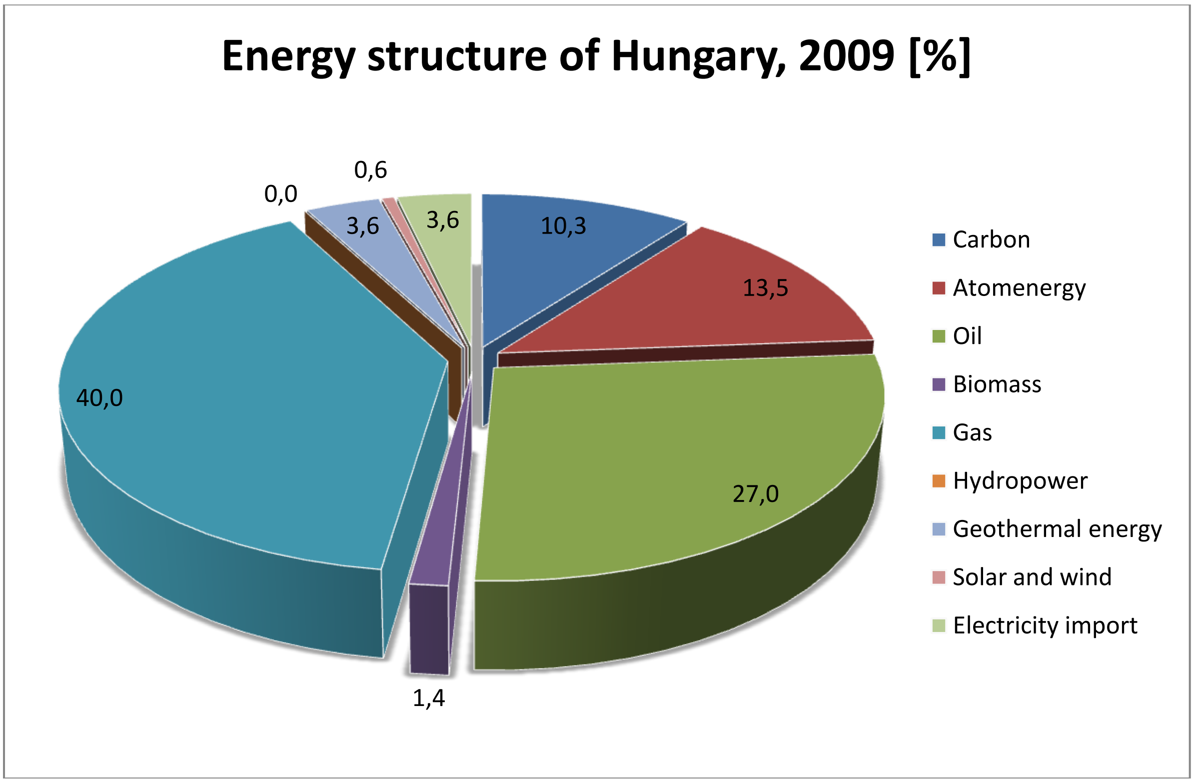


Fig. 2. Energy structure of Hungary, 2009 Source: Hungarian Energy Office

According to the data of the Hungarian Central Statistical Office (KSH), the crude oil production of the country in 1995 was of 1.8 million tons, this decreased by 2010 to 0.5 million tons. The amount of import crude oil of 6 million tons in 1995 increased by 2010 to 6.5 million tons. The natural gas production in 1995 was of 5 million m3, which decreased by 2010 to 0.5 million m3 due to the drastic decrease of our resources. Our natural gas import is continuously increasing. Our gas import in 1995 was of 6.8 million m3, by 2010 this amount increased to 12 million m3. Thus, the dependence on crude oil and natural gas import of our country increased by 2010 to approx. 90%, thus the energy market is almost totally depending on the exporting countries. Furthermore, the third most important energy supplier beside natural gas and crude oil, the Paks Nuclear Power Plant is also importing the uranium fuel, thus the only Hungarian energy sources are the geothermal and biomass energy.

HUNGARY'S ENERGY POLICY

Hungary's energy policy is in compliance with the EU directives. According to the regulations of the directive No. 2008/29/EC, Hungary must increase its utilization of renewable energies to 13% by 2020. Due to the economic crisis, the slowing of the development enables different scenarios that forecast an energy utilization of 992-1036PJ/year by 2020. Accordingly, the amount of energy from renewable sources in Hungary must reach 129-135 PJ/year by 2020. By estimating positive economic processes, the highest value of this interval should be set at 135 PJ/year. Accordingly, the 50 PJ of alternative energy produced in 2005 must be increased by 2.7 times by 2020. The renewable energy sources produce mainly thermal energy and electric power.

Hungary fulfilled the EU's expectation concerning the share of electricity produced from renewable sources for 2010, the 2008 share of the total electricity production was 1.8% higher than the required 3.6%. According to the documents of Hungary's renewable energy strategy 2008-2020, the production of green current would be increased by the starting of geothermal plants that would produce 65 GWh of electricity by 2015, and 422 GWh by 2020. The geothermal heat production was of 4 PJ in 2008, this must be increased to 7 PJ by 2015, and 9 PJ by 2020. The production of electric power and thermal energy based on geothermal energy must increase from its value of 4 PJ of 2008 to 7.23 PJ by 2015, and to 10.52 PJ by 2020. This means that almost 8% of the energy from alternative sources will be supplied from geothermal energy by 2020.

Due to the technical and hydrogeological conditions, the construction of a geothermal electric plant is quite risky, despite the fact that there are several operating systems all over the world (e.g.: Iceland, New Zealand, U.S.A. etc.). Accordingly, the direct geothermal heat production offers a big development potential for the next decade. The South Great Plain region is considered as one of the best regions from the point of view of geological features for geothermal heat production; however, the significant potential remains unexploited until there is a comprehensive picture on the utilization, technical, financial and environmental conditions, and a well-defined development concept is elaborated. In the following chapter, we present the geothermal features of the South Great Plain, the current utilization locations, and we define the potential development locations.

THE GEOTHERMAL FEATURES OF SERBIA

INTRODUCTION

Mineral and thermal waters of the Pannonian Plain have been known for centuries. Records indicate that they were used by Ancient Romans and later by the Turks. The first drilling of Artesian Wells in the more recent history started in Banat. The drilling of Artesian Wells in Pavliš near Vršac is mentioned as early as 1848. The depths of first wells were as much as 400 m, and some of them have been used ever since. These are in: Bezdan, Temerin, Zmajevo, Bečej, Senta, Ada, Iodine Spa in Novi Sad and the like. At the beginning of the 20th century, there was a temporary halt in drilling in order to intensify again in the period from 1910 to 1914. The full prosperity occurred between the two World Wars. In that period almost 600 wells were drilled of which 384 are in Banat, 153 in Bačka and 54 in Srem. The basic purpose of these wells is to supply with drinking water although they are used for balneal purposes.

Geothermal Potentials of Vojvodina

More complete knowledge about geothermal potentials of drills has started to accumulate since 1949. In the period from 1969 to 1996, 73 hydrothermal drills were bored with the overall depth of 62,678.60 m. Drilling was financed and carried out by the Company "Naftagas". The most intensive researches were implemented in the 80s of the last century when 45 drills were bored with the total depth of 34,840 m or approximately 56% of all drills.

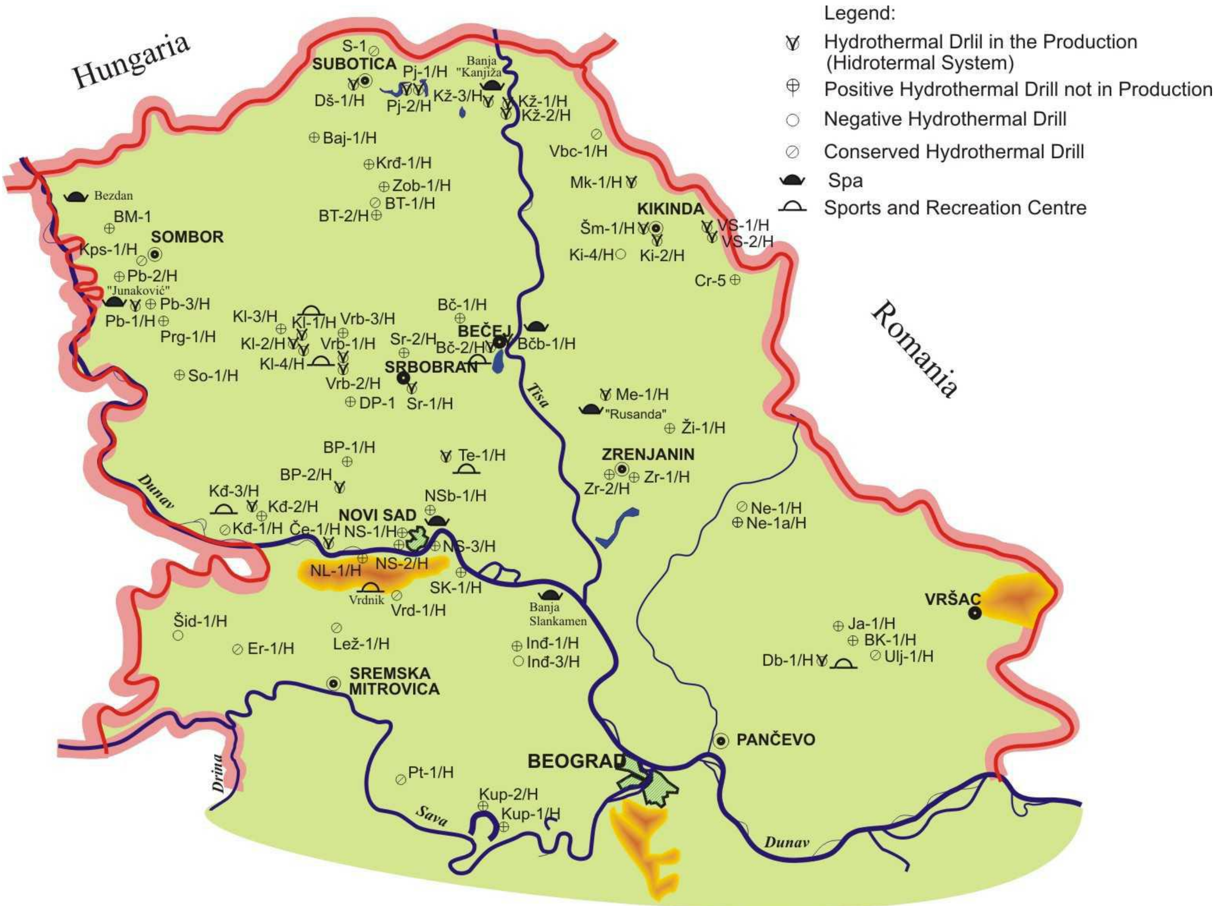


Fig. 3. Distribution of Hydrothermal Drills in Vojvodina

The territory of Vojvodina as a part of the Pannonian Basin belongs to the large European Geothermal Zone which has favourable conditions for researches and utilization in the field of geothermal energy. For the time being, hydrothermal energy is investigated and utilized. This concerns thermal waters of natural springs and waters in rocky masses which can be accessed by drilling. In Vojvodina, four hydro geological systems are recognized and classified. Their basic characteristic are investigated and defined: lithological composition, stratigraphic references, type and quality of rock collectors, temperature and hydro dynamic features, physical and chemical features of thermal and thermo-mineral waters and accompanying released gases. Generally speaking, geothermal waters suitable for use are accumulated in all systems. However, their temperature, profusion, collector properties, chemical composition, gaseous factor and other characteristics are decisive for determining future prospects and particular conditions for exploitation. This is the reason why each drill should be individually investigated in detail when making a decision concerning the choice of exploitation manner and the most suitable equipment. Overall heat energy of hydrothermal drills with water cooling to 15o C according to information from the year 1997 which included 65 drills was 85,605 kW, and according to information of the Company "NIS Naftagas" from the year 2005 for 54 hydrothermal drills it is 72,579 kW. Only 15 have been triggered for the production of heat energy.

THE USE OF GEOTHERMAL ENERGY

The most important and regarding capacity the largest consumers of energy provided by hydrothermal drills are the spas:
- "Junaković", Apatin cca 150,000 m3/a
- "Kanjiža", Knajiža cca 110,000 m3/a

These are mainly consumers which use thermal waters during the whole year and in winter months for heating up of facilities. The group of consumers in Bečej are the second regarding importance:
- Youth Sports Centre OSC "Mladost",
- Health Centre "Predrag Hadnađev" and
- Hotel "Bela Lađa"

These consume totally cca 100,000 m3 of thermal waters annually. However, the most significant consumption concerns seasonal heating up of facilities. The category of similar consumers also includes swimming pools in Temerin, Vrbas and Palić. The group of exclusively seasonal consumers of the energy of hydrothermal waters is in the field of agricultural production. The most important concerns farms for pig breeding:
- Socially Owned Company "Kozara" from Banatsko Veliko Selo,
- Socially Owned Company "Mokrin" from Mokrin,-
- "Jedinstvo" from Kikinda, (stopped using it a few years ago)

And the production of vegetables in the covered facilities
- Socially Owned Company “Elan" from Srbobran (for heating up plastic houses, ceased using it).

Particularly suitable are industrial consumers: for the time being these are textile Joint Stock Company "Kulski štofovi" and Leather Factory "Eterna" from Kula, as these are year round consumers for technological requirements. When we talk about consumers suitable for using geothermal waters energy it invariably concerns heat consumers requiring the lowest possible temperatures and, if possible, continuous application. Therefore, geothermal waters energy is traditionally utilized for: base heating in radiators or complete heating with the system of floor heating, i.e., heating of air, preparation of sanitary hot water and heating of pools or fish ponds. The existing consumers prove this and it seems that some significant changes are not expected to occur for the time being. In all mentioned combinations, the use of heat pump seems to fit in perfectly as it enables supplementary cooling of geothermal water and a more complete use of its energy potentials. Gas motor is suitable for the combustion of gases extracted from geothermal water with an additional use of natural gas. In any case, to meet peak demand it is necessary to provide for a peak boiler.

CURRENT PRICES OF DRILLS AND ENERGY

Current prices of energy from active geothermal drills in Vojvodina, based on water prices, depend on discharge water temperature and vary within the range: (0.1-0.24) €/m3.

Based on known prices of existing drills, a current range of prices has been calculated relevant to the drill depth as follows: (220,000 -500,000) € for drill depths of (600-1,100) m.

For the purpose of comparative analyses in the study, current average prices of competitive energies in relation to the energy of geothermal waters in Vojvodina have also been determined. These are as follows:
- Natural gas price 2.0 c€/kWh,
- Electricity price of 3.5 c€/kWh and
- Thermal Power Plants price of heat energy 4.4 c€/kWh.

MODERN TECHNOLOGIES FOR UTILIZING GEOTHERMAL ENERGY

Considered opportunities for applying modern technologies in the exploitation of available resources of our geothermal waters (GTW) include conventional solutions, which are proved in practice, but also other available possible solutions. Implementation of technologies is considered within the context of resolving 4 global objectives:
i) Cogeneration of heat energy and electricity,
ii) Energy preparation for cooling of buildings,
iii) Energy preparation for heating of buildings, and
iv) Preparation of sanitary water and swimming pools water.

The choice has been made on the basis of three criteria:
- Recommendations for utilization of GTW potentials (according to a so called Lindal Diagram),
- Review of the potentials of our GTWs and
- Review and analysis of potential users (consumers) of available resources.

Energy potentials of our GTWs are predominantly with low temperatures. Conventional or dual (according to Lindal categorization) thermal energy plants with exclusive resources of our GTWs are not acceptable as investments and they are not profitable from the standpoint of commercial production of mechanical (that is, electric) energy. This is the reason for possible acceptance of GTWs only as: Possible alternative to the exploitation of other (conventional) recourses, that is, as their potential substituent. The strategy of analysis of possible utilization of GTW potentials has been structured in such a manner to find answers for questions related to:
-Theoretical possibilities for exploitation,
- Practical implementation of possible solutions at the level of conventional technologies,
- Consequences of the concrete choice, theoretical and practical possibilities within environmental surroundings, and
- Technical and economic aspects of the given choice adequacy in the sense of achieving the largest possible profit within the given limitations.

In relation to the integration of GTW potentials in plants for cogeneration of productive mechanical (electric) and heat energy (SPETE), the choice which imposes itself is that of a gas internal combustion motor. Namely, assuming that there are consumers of heat energy with a relatively low level, that an acceptable repayment period (without interest) of a plant is the one of 6-8 years, it will be justifiable to install the gas motor of up to max 5 MW of mechanical power. Installation is profitable after repayment and practical reasons relevant to procurement, mounting, exploitation and maintenance justify such a choice in relation to other available possibilities. It is important to point out that only cases of cooling facilities above 0o C have been taken into consideration here with two vitally different cooling solutions. First, if the use of GTW potentials is an imperative request, it can be acceptably resolved only by the use of absorption refrigeration machines (ARM). Second, if the use of other resources is allowed, then the application of compression refrigeration machines (KRM) with the electric current drive from the commercial grid is in all respects superior solution in relation to other possibilities. Then, however, GTW potentials are completely excluded from preparations of cooling energy. At the same time, both solutions are even more acceptable for the case when there are consumers of heat from the condenser of refrigeration machine. In relation to the preparation of energy for heating facilities by using GTW resources, standard solutions have been considered here. These include complete exploitation of GTW heat potentials for required, however achievable, level through heat exchangers with the installation of "peak supplementary heaters" in order to meet possible energy shortage. Common solutions imply installations with gas boilers as peak supplementary heaters, which is the cheapest yet thermodynamically worst solution. As opposed to that, we have suggested here that the function of peak heaters should be executed by plant coolers of the corresponding level, for example, cogeneration plants for the production of heat and mechanical energy, then condensers of refrigeration machines, or condensers of heat pumps. An argument for such an attitude can be found in possibilities for the sale of "waste" heat (within the heating context – utilization of this heat for heating purposes), which significantly improves their technical and economical performances. It is, of course, clear that the final measure of acceptability of each solution concerns technical and economical indicators. However, as an option, the worst thermo-dynamical solution cannot be avoided – which refers to peak supplementary heating by fuel combustion – gas boilers. Undoubtedly, all above stated facts indicate that the best solution is to install combined or multipurpose plants. In addition to those mentioned above, there is another reason in favour of the combined schemes proposal. Namely, it is necessary to take into consideration the fact that heating demand is to a certain extent complementary with cooling demand of the same buildings: heating and cooling seasons are different in a calendar and do not coincide. Therefore, from the standpoint of complete exploitation of GTW potentials, depending on the state of surroundings (ambience) once it can be totally acceptable to install a heat pump and under different circumstances completely the opposite – installation of the refrigeration machine.

The problems related to the exploitation of our GTW resources in the sense of sanitary water preparation and swimming pool water are outlined only broadly for the following reasons. First, when in GTW applications mixing is not allowed, or chemical and technological preparation of GTW is a priori excluded, then available GTW is only energy (heat) resource and the preparation of sanitary water and swimming pool water is reduced to the problem of heating the facilities Second, depending on the chemical composition of GTW it is possible to directly use it (substantial resources), but more often, special preparations of GTW are needed. Technologies for preparation vary significantly from case to case to such an extent that it is almost impossible to analytically follow a typical "common" feature. This is the reason why the exploitation of these “substantial” resources of GTW is not considered here. Also, our GTWs are not categorised from the aspect of this application a special study would be undoubtedly needed with an aim to prepare guidelines for the utilization of substantial potentials of our GTWs).

ECONOMIC OVERVIEW

The concrete economic analysis, which respects the most recent guidelines concerning ecological requirements (the need to drill and equip a reversible drill), shows that the drills above 40o C and with strong discharge (around 60 m3/h) are profitable assuming that the consumer is capable of employing the overall potential of the drill of over 6,000 h/a. The term “the overall potential" means that geothermal waters are cooled to around 15o C during exploitation. This is achieved only by building in of heat pump. Such a volume of exploitation of the drill can be employed only by a consumer which will in addition to a heating season for the purpose of heating the building use available capacities in transitional periods (spring and autumn), but also during night in the heating season. This significantly reduces the choice of real consumers and thus the application of geothermal waters for energy purposes. A special and some sort of a “semi-economic” analysis is necessary for existing drills which are not used at all. Considerable amount of money was invested in them long time ago and nobody is repaying that (economically, their geothermal energy does not have any value at all). In order to launch their exploitation, it is necessary to make additional investments in the construction of a potential consumer of heat energy at that location. As the choice of these consumers is very small, the possibility of selling geothermal waters at very low prices (even free of charge) should not be excluded at least not in the initial period of business development and mastering of the market.

CONCLUSIONS

- In the previous period, geothermal waters at the territory of Vojvodina were investigated in detail by boring at 75 locations of which 65 were active. Also, a large number of drills, 27, are technically equipped with hydrothermal systems for exploitation, and only 15 springs were or are still used. Thus, this region ranks very high regarding the scope of investigations at the European continent and conclusions about its resources can be made with adequate reliability.

- Investigated resources are from the energetic point of view modest, particularly regarding temperatures of geothermal waters at the discharge. There are only few springs with the temperature over 60o C at the depth of around 1,000 m, and only 3 are between 70-82o C. It is not probable that further investigations and expensive drillings will produce higher temperature potentials. Therefore, overall potentials are below 90o C, which is the bottom limit at the generally accepted Lindal Diagram for utilization in the production of mechanical (electrical) energy by using still rare binary plants at temperatures below 150o C for utilization in standard thermal energy plants. In other words, there are only theoretical possibilities for transformation of Vojvodina’s geothermal water potentials into mechanical, i.e., electric energy.

- For this type of geothermal waters the only existent possibility for utilization is transformation in heat energy for heating with a relatively low temperature level (in majority cases below 60o C). This is another much more complicated part of utilizing geothermal energy. Namely, for quite some time, low temperature heat consumers have been sought unsuccessfully for various alternative sources of heat supply (solar energy, waste heat from industrial plants, and etc.). It is obvious beforehand, that this application will be profitable in a small number of industrial consumers which will operate 7,000 h/a under full capacity and satisfied with this temperature level. Unfortunately, these are only few.

- The largest number of consumers of this type of low temperature energy is in the field of technologies for heating of buildings which are of seasonal character. They are only used in winter periods and with typical breaks during the night. This provides exploitation of the constructed plant up to 3,200 h/a in a so called base heating power. Due to a small number of very cold winter days, the base power of low temperature heating is not sufficient and it is necessary to install an additional peak plant of a significantly larger power which will practically be out of operations all the time but incur maintenance costs.

- Based on the above stated, we conclude that before decision making regarding the construction, it is necessary to study in detail economic (and ecological) aspects of various alternatives of heat schemes for each given case. In doing so, possibilities for expanding the duration (season) of envisaged installation use should be carefully investigated which will have a decisive impact on economical operations. At the present moment, available options for extending the exploitation season of these geothermal springs are swimming pools, fish ponds, green houses and plastic houses in agriculture. These facilities do not require large investments; however, in the period of exploitation their energy cost will be very low. But, the main problem regarding these facilities is good organization and finding out safe and reliable markets.

- The final conclusion is that on the territory of Vojvodina there are geothermal potentials which are respectable from the standpoint of small and medium size consumers. These are not energy sources of great importance for the Province which could have considerable effects on overall energy supply. This does not mean that the Province should not be involved in their inclusion into regular exploitation. On the contrary, each envisaged project of this type should be supported by low interest rates the same as it is done in developed countries for all cases of utilizing “green energy".

- However, for the time being it is not recommended to undertake new drillings except at individual requests of consumers which have considered their projects comprehensively. More investments should be made into heat consumers at locations of existing drills with larger energy potentials even if this is accompanied by intensely subsidised price of geothermal waters.

THE GEOTHERMAL FEATURES OF SLOVAKIA

According to Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 (2009), each member state shall adopt a national renewable energy action plan and notify them to the Commission by 30 June 2010. Slovak national overall target for the share of energy from renewable sources in gross final consumption of energy in 2020 shall make 6.7% in 2005 and 14% in 2020. The highest potentials on renewable energy production have biomass with 46.7%, geothermal energy with 17.5% and solar energy with 14.5% (Decree of the Slovak Government No. 282/2003). The renewable energy sources for electricity production targets are 31.0% for 2010; however, no electricity is expected to be produced from geothermal energy sources.

GEOLOGICAL BACKGROUND

The Western Carpathians are the Alpine mountain range stretching across the Slovak territory. According to the age of development of the Alpine nappe structure they are classified as the Outer – with Neo-Alpine nappes and the Inner with Paleo-Alpine – Pre-Paleogene nappe structure. The Klippen Belt marks the boundary between the two (Figure 1). The structure of the Western Carpathians is characterized by zoning. The Outer Carpathians are made up of Tertiary series of rootless nappes with the typical flysch-like character. The Klippen Belt, a dividing unit between the Outer and the Inner Western Carpathians, has a typical klippen-fashioned tectonic pattern represented by lenses of Jurassic-Early Cretaceous limestone which penetrate the Cretaceous and Paleogene marlstones and flysches. The formations of the Inner Western Carpathians, arrayed in a series of arcuate belts, are vertically stratified into a nappe complex (consisting mostly in a Paleozoic crystalline rock basement, Late Paleozoic formations and Mesozoic complexes) overlain by post-nappe Cretaceous to Neogene sedimentary and volcanic formations (Biely Ed. 1996). The geological structure and favourable geothermic conditions create a suitable setting for the occurrence of geothermal energy resources in the Slovak territory. However, the geological setting is favourable for the occurrence of geothermal waters with temperature higher than 20 oC only in the Inner Western Carpathians. Geothermal waters are largely associated with Triassic dolomites and limestones of the Krizna and Choc nappes (Fatricum and Hronicum units), less frequently with Neogene sands, sandstones, conglomerates, andesites and related pyroclastics. Lately, geothermal aquifers were proven also in Mesozoic nappe structures in the Silicicum unit occurring in the southern parts of Slovakia.

GEOTHERMAL RESOURCES AND POTENTIAL

Geothermal research on the territory of the Slovak Republic started in 70-thies of the last century. Results gained during more than 20 years were for the first time evaluated and summarized in the Atlas of geothermal energy of Slovakia (Franko, Remsik and Fendek eds., 1995). Knowledge on geothermal resources of selected parts of Slovakia became a part of the Atlas of geothermal resources in Europe (Hurter and Haenel eds., 2002). The latest graphical review of geothermal and mineral water occurrence in Slovakia was published in 2002 as a map in the scale 1:500,000 under heading “Geothermal and mineral water sources” (Fendek et al., 2002), which is a part of the Landscape Atlas of the Slovak Republic (Landscape atlas, 2002). The map shows geological structure of the area, main geothermal aquifers, prospective areas or structures of geothermal waters, yields and temperatures of respective sources, as well as thermal power of geothermal waters in respective areas.

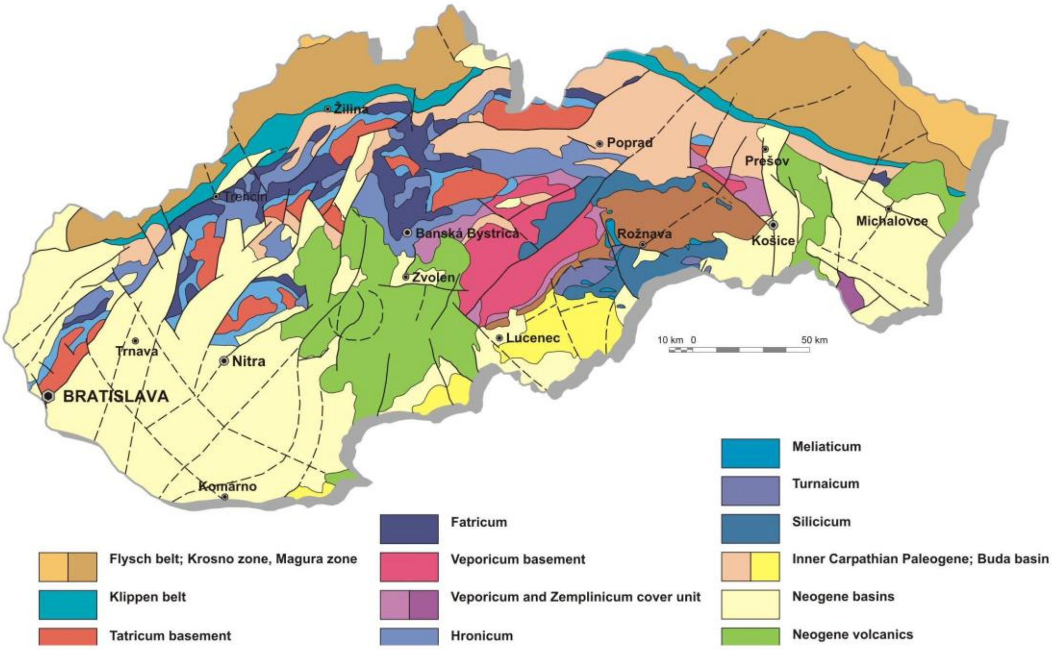


Fig. 1. Tectonic sketch of the Slovak Republic (Biely Ed., 1996)

GEOTHERMAL UTILIZATION

The total amount of thermal-energy potential of geothermal waters in prospective areas (proven, predicted and probable) represents 6,653.0 MWt (Table 1.). This amount consists in 708 MWt of geothermal resources and 5,945 MWt of reserves. Geothermal energy utilization is distributed non-equally on the territory of Slovakia. The highest number of geothermal installations is located in the Nitra County (southwest of the central Slovakia), where 19 localities in utilization are placed (Table 2). The total amount of 382.1 l/s of geothermal water is used in the Nitra County, which is equivalent to 39.65 MWt of geothermal energy. The highest utilized thermal power is used in Trnava County (Western Slovakia) in 13 localities, represented by 199.7 l/s of geothermal water and 45.84 MWt of geothermal energy. The smallest number of geothermal installations is located in the Eastern part of Slovakia – in Kosice County, where geothermal energy is used only in 5 localities representing 44.9 l/s of geothermal water with the thermal energy potential of 1.24 MWt. On the other hand, the Kosice depression is one of the most prospective areas of Slovakia with possibilities to accumulate geothermal waters with the highest temperature to be used for electricity production in the future. In Slovakia, geothermal water is not used for electricity production (Summary tables – Table 1.). It is utilized for direct use in agriculture (G), for individual space heating (H) and district heating (D), for fish farming (F) and for recreational purposes (B). Geothermal water in agriculture provides possibilities to heat greenhouses and glasshouses, as well as the soil, enabling early production of vegetables and flowers out of the normal vegetation season. All together, 11 localities use the geothermal water for agricultural production (Summary tables – Table 3.). The geothermal heat with the capacity of 17.59 MWt, which is equivalent to energy use of 461.11 TJ/yr, is primarily used for greenhouses in nine localities. In the rest of localities, greenhouses are heated in the end of the cascade heating system (Summary tables – Table 3, 5). Lately, an important increase was reached in utilization of geothermal energy for space heating – either for individual (19 installations) or for district heating (2 installations). Geothermal energy is used for space heating in 21 localities (Summary tables – Table 3, 5), among them for heating of blocks of flats and hospital in Galanta, for hotels in Besenova, Podhajska, Sturovo and Velky Meder, for dressing rooms and air heating in brown coal mine in Novaky, and for service buildings heating in many localities. The majority of localities where geothermal water is utilized, are oriented on utilization of geothermal water for bathing in open-air and/or indoor swimming pools. In Slovakia, there are 59 localities using geothermal water for recreational purposes. In some of them, the combined utilization for greenhouses, district heating and bathing has been developed, for instance in Topolniky and Podhajska (Summary tables – Table 3.). Geothermal water is utilized for fish farming in Vrbov, and in Turcianske Teplice.

FUTURE DEVELOPMENT AND INSTALATIONS

At present, hydro geothermal investigation is being done in Handlova area, belonging to the Upper Nitra Basin and in Rimava Basin. A lot of individual projects, funded from the private sector financial sources, are ready, or under preparation, to find and utilized geothermal waters for district heating (Velky Meder, Sered, Sala, Trstena, Dolny Kubin, Michalovce, and Presov). Some of the projects are oriented on the new bathing and swimming facilities construction (Bardonovo, Zuberec, Bobrovec, Fiacice, Demanova, Liptovska Kokava, Velka Lomnica and others).

THE GEOTHERMAL FEATURES OF POLAND

Geothermal use for heating purposes in the country was initiated in the last decade of the 20th century. The experimental stage of the first geothermal plant was opened in the Podhale region in 1992 (Sokolowski et al., 1992). Since that time five other plants have been launched, including one of them in the reported years 2005 – 2009. Space heating is a key sector for geothermal. It is also worth to notice a growing interest in recreation and balneotherapy what has been expressed by seven new centres open in recent years. Wide-ranging use adequate for the reservoir potential would permit to locally limit reliance on fossil fuels and mitigate the GHGs and other emissions. Over the last several years some general documents related to the energy policy of the country were introduced, e.g. the Strategy of Energy Policy in Poland till 2030 and in 2009 the EU Directive on RES promotion (and related documents). According to these documents the share of all RES, geothermal including, in final energy use (electricity plus heat & cold plus biofuels) shall reach 15% in Poland by 2020. These figures seem to be significant as compared to the current share of all RES in energy generation (ca. 7%). Among the main factors which hamper geothermal deployment are high up-front investment costs, weak law regulations, etc. From the other hand, as one of the main RES in Poland, geothermal should be promoted in view of the conditions the country has to meet as a member of the EU. More favourable legal regulations as well as economic and fiscal incentives shall be introduced. These would serve as the tools to facilitate the geothermal deployment. In 2007– 2009 some changes and amendments to ease geothermal investments were introduced in the proposal of new geological and mining law as well as new provisions of economic support from the public sources. They are treated as first positive signals whereas the geothermal stakeholders expect further improvements and tools, including e.g. establishing the Geological risk guarantee fund, introducing the green certificates or lower VAT for heat prices produced from geothermal/RES.

GEOLOGICAL AND GEOTHERMAL BACKGROUND

The area of the country is built of three geostructural units: Precambrian platform of North-western Europe; Palaeozoic structures of Central - Western Europe covered by the Permian - Mesozoic and Cainozoic sediments; the Carpathians (part of the Alpine system). Crystalline rocks prevail within the Precambrian platform (NE-Poland) and within the Sudetes region (SW-Poland). Sedimentary formations (known as the Polish Lowlands) dominate the extensive area stretching from the Baltic Sea coast towards central and southern part of a country. Significant thickness (up to 7-12 km) and share of sandstones and carbonates characterize large sedimentary complexes. These rock types often have good hydrogeological and reservoir parameters, creating conditions for the occurrence of ground waters, including geothermal ones. The main geostructural units implied distinguishing of three geothermal provinces (each of them being divided into several smaller units, called geothermal regions; Sokolowski, 1993). They are formed mostly by extensive sedimentary formations and contain geothermal aquifers (Fig. 1): The Polish Lowland Province (Triassic – Cretaceous); The Fore-Carpathians (Mesozoic - Tertiary); The Carpathians (Mesozoic – Tertiary). Moreover, the Sudetes geothermal region contains aquifers in some fractured parts of crystalline and metamorphic rocks (Dowgiallo, 2002).

Fig. 5. Poland, 2009: 1. geothermal heating plants in operation, 2. geothermal heating plants in realization (wells drilled or in drilling), 3. spas using geothermal waters, 4. geothermal bathing centres opened in 2005 - 2009, 5. geothermal bathing centres under construction (wells drilled or in drilling). Division into geothermal provinces after Sokolowski (1993)

The country is characterized by the heat flow values from 20 to 90 mW/m2, while geothermal gradients vary from 1 to 4°C/100 m. Generally, at the depths from 1 to 4 km the formation temperatures vary from 30 to 130°C, while the TDS are from 0.1 to 300 g/dm3. The proven geothermal water reserves amount from several l/s up to 150 l/s. The best geothermal conditions are found in the Polish Lowlands (Gorecki [ed.], 2006) and in the Podhale region (Inner Carpathians) (Sokolowski 1993).

THE GEOTHERMAL FEATURES OF FYROM

Macedonia has been one of the leading European countries in direct uses development during the 80-ies of the last century. Even rather modest, the state investments in geothermal explorations gave opportunity to the scientists and economy sector to develop three successful big and several small geothermal projects. However, when positive influence has began to give results, i.e. when state planned some new larger investments, political and economy transition process from the beginning of 90-ies resulted with a complete collapse of the state economy and, with that, lost of interest for any further investments in the geothermal energy development. Even more, thanks to the collapse of the heat users, some of the existing projects have been abandoned. When present state policy to geothermal development is in question, it can be clearly stated that it practically doesn't exist. Even under pressure of EU to define a consistent policy and strategy of all RES use in order to achieve defined targets until 2020, government follows to neglect the problem. If present, rare projects and activities are pushed of different EU agencies and developed EU countries. Recently prepared Strategy for Energy Development and Strategy of Renewable Energies Development in Macedonia, prepared by the Macedonian Academy of Sciences, are good illustration for such a relation to this problematic. Incomplete, based on insecure data and suppositions, without proper relation to real influencing factors and economy of the country, without participation of any of proven national or international experts, it results with previsions and recommendations which are wrong and unusable. Obviously, a great change is necessary but nobody can predict when it shall finally come. Key players in geothermal development are: - Ministry of Economy - Department for Energy: Department is weak and neither has somebody understanding the problematic of RES Development nor built collaboration with national and international agencies and experts; - Energy Agency of Macedonia: It is founded three years ago with support of the WB but is still neither equipped with necessary personnel nor rooms or facilities. Up to no, no one project or concrete activity has been initiated by it. - Macedonian Geothermal Association (MAGA): It is a NGO, working in geothermal development in the country and worldwide. Even very active and continually present with different initiatives, it is completely neglected by the government, as a part of the general policy to NGO in general. Government doesn't support their activities if not being completely accommodated to its defined policy or activity in flow. Recently, first signs of the recovery of some users resulted with several investments in the geothermal projects reconstruction and optimization (Popovski, 2009). There is interest of the others to do the same, and new candidates are trying to get concession for development of new projects. However, the process is very much slowed due to the list of constraints, mainly in the legal and financing sector. Existing "pressure" of WB and EC to work more on the environmental protection can have a positive influence for removing the constraints but it can be predicted that the process shall last at least 4-5 years, according to the experience with the other legislative changes and improving the possibilities for financing new developments. The country update gives information about the present state of geothermal investigations and use in Macedonia, with identification and comments about possibilities to remove the negatively influencing factors.

GEOLOGY BACKGROUND

In the territory of Macedonia rocks of different age occur, beginning with Precambrian to Quaternary ones. Almost all lithological types are represented. The oldest, Precambrian rocks, consist of gneiss, micaschists, marble and orthometamorphites. The rocks of Paleozoic age mostly belong to the type of green schists, and the Mesozoic ones are represented by marble limestones, acid, basic and ultrabasic magmatic rocks. The Tertiary sediments consist of flysch and lacustrine sediments, sandstones, lime-stones, clays and sands. With respect to the structural relations the territory can be divided into six geotectonic units: The Cukali- Krasta zone, West Macedonian zone, Pelagonian horst anticlinorium, Vardar zone, Serbo-Macedonian massif and the Kraisthide zone. This tectonic setting is based on actual terrain and geological data without using the geotectonic hypothesis (Arsovski, 1998). First four tectonic units are parts of Dinarides, Serbo-Masedonian mass is part of Rodopes and the Kraisthide zone is part of Karpato- Balkanides distinguished on the Balkan peninsula as geotectonic units of first stage.

GEOTHERMAL BACKROUND

The territory of the Republic of Macedonia belongs to the Alpine-Himalayan zone, with the Alpine sub-zone having no contemporary volcanic activity. This part starts from Hungary, across Serbia, Macedonia and North Greece and stretches to Turkey. Several geothermal regions have been distinguished including the Macedonian region, which is connected to the Vardar tectonic unit. This region shows positive geothermal anomalies and is hosting different geothermal systems. The hydro-geothermal systems, at the moment, are the only ones that are worth for investigation and exploitation. There are 18 geothermal known fields in the country with more than 50 thermal springs, boreholes and wells with hot water. These discharge about 1.000 l/s water flow with temperatures of 20-79 0C. Hot waters are mostly of hydrocarbonate nature, according to their dominant anion, and mixed with equal presence of Na, Ca and Mg. The dissolved minerals range from 0.5 to 3.7 g/l. All thermal waters in Macedonia are of meteoric origin. Heat source is the regional heat flow, in the Vardar zone is about 100 mW/m2 and crust thickness 32 km. Subsection headings should be capitalized on the first letter.

GEOTHERMAL RESOURCES AND POTENTIAL

Out of the seven geothermal fields identified in the east and northeast part of the country, four of them have been found to be very promising and three of them have been investigated to the stage where practical use is possible. Except for the springs in Debarska banja and Kosovrasti, which are in the West Bosnian-Serbian-Macedonian geothermal zone, all the others are located in the Central Serbian-Macedonian Geothermal Massif, Central and Eastern Macedonia. It’s necessary to underline that the total available flow of exploitable sources is 922.74 l/s, which is less than the estimated 1,000 l/s 5 years ago, and differs from the previous values (1.397 l/s), which are the maximal measured short lasting flows. The difference is due to the more precise data for long lasting capacities of all the flows, after many years of exploitation and measurements. Temperatures of the flows vary in the rank of 24-27°C (Gornicet, Volkovo and Rzanovo) up to 70-78°C (Bansko and Dolni Podlog). Total average temperature is 59,77°C. The biggest potential is in the Kocani geothermal field, with a total maximal flow of up to 350 l/s and temperatures of 65°C (Istibanja) and 75-78°C (Dolni Podlog). Next is the Gevgelija geothermal field, with about 200 l/s and temperatures of 50°C (Negorci) and 65°C (Smokvica). The list of the others is: Debar geothermal field with 160 l/s and temperatures of 40°C (Debarska banja) and 48°C (Kosovrasti), Strumica geothermal field with 50 l/s and 70°C and Kratovo/Kumanovo geothermal field with 70.71 l/s and temperatures of 31°C (Kumanovska banja) and 48°C (Kratovo). The real energy potential of the geothermal resource in Macedonia is in direct correlation with the technical/technological feasibility of its application, in accordance to the newest know-how in the country and in the world. A simulation, according to different outlet temperature, is made for all the exploitable geothermal resources in Macedonia. A total available maximal heat power of 173 MW is obtained, which suggests the possibility of annual maximum production of 1,515,480 MWh/year. This is of course only a theoretical indication considering that each project has different range of exploited temperature. In any case this maximum potential cannot be fully exploited, because it is strongly dependent from the utilization factor and from the type of application. For instance, the geothermal system in Dolni Podlog (Kocani) has a maximal flow of about 300-350 l/s with temperature of 75°C. If a maximal use of the source could be reached (i.e. effluent water of 15°C), its heat power could increase up to 75-85 MW. However, the applied technical solutions by the users, result with temperatures of the effluent water during the winter weather conditions of 40-45°C. That practically means lowering of the heat power of the source to 37.7-44.0 MW, i.e. 40-50% of the maximally possible one. For the same geothermal system and composition of users, it is technically and economically feasible to lower the temperature of the effluent water to 30°C during the first phase of development (Popovski, 1991), and 25°C during the second phase of development. Such an optimization should allow a reduction of losses for 25% and 17% respectively, which is in the acceptable limits even for the countries with longer experience in geothermal energy application. Therefore, depending on the reached average outlet temperature of projects using available geothermal resources, following orientation figures for total heat power can be taken: 172,9 for 15şC, 153,7 for 20şC, 134,3 for 25şC, 115,6 for 30şC, 97,2 for 35şC, 78,9 for 40şC and 68,2 for 45şC. According to the presently applied solutions, average outlet temperatures between 30 and 40 can be taken as representatives.

GEOTHERMAL FIELDS IN MACEDONIA

There are 18 localities where geothermal fields occur and geothermal energy is in use for different proposes. The most known areas are listed below: Kochani valley (Popovski, 2002): The main characteristics of the Kochani valley geothermal system are: presence of two geothermal fields, Podlog and Istibanja, without hydraulic connection between them. The primary reservoir is build by Precambrian gneiss and Paleozoic carbonated schists and the highest measured temperature in Macedonia of 790C is obtained by drilling to it. Predicted maximum reservoir temperature is about 1000C (Gorgieva, 1989). Kocani geothermal system is the best investigated system in Macedonia. There are more than 25 boreholes and wells with depths of 100-1.170 m.(Popovski, 2009) Strumica valley (Popovski, 2002): The main characteristics of this field are: the re-charge and discharge zone occur in the same lithological formation-granites; there are springs and boreholes with different temperature at small instances; maximum measured temperature is 730C; the predicted maximum temperature is 1200C (Gorgieva, 1989); the reservoir in the granites lies under thick Tertiary sediments. Bansko geothermal system has not been examined in detail apart the drilling of several boreholes with depths of 100- 600m. (Gorgieva, 2002) Gevgelia valley (Popovski, 2002): There are two geothermal fields in the Gevgelija valley: Negorci spa and Smokvica. The discharge zones in both geothermal fields are fault zones in Jurassic diabases and spilites. These two fields are separated by several km and there is no hydraulic connection between them, despite intensive pumping of thermal waters. The maximum temperature is 540C, and the predicted reservoir temperature is 75-1000C (Gorgieva, 1989). Geothermal system in the Gevgelija valley has been well studied by 15 boreholes with depths between 100-800 m. (Gorgieva, 2002). Skopje valley (Popovski, 2002): There are two geothermal fields in the Skopje valley: Volkovo and Katlanovo spa. There is no hydraulic connection between them. The main characteristics of the Skopje hydro-geothermal system are: maximum measured temperature of 54.4 0C and predicted reservoir temperature (by chemical geothermometers) of 80-1150C (Gorgieva, 1989); the primary reservoir is composed of Precambrian and Paleozoic marbles; big masses of travertine deposited during Pliocene and Quaternary period along the valley margins. There are only five boreholes with depths of 86 m in Katlanovo spa, 186 and 350 m in Volkovo and 1.654 and 2.000 m in the middle part of the valley. The last two boreholes are without geothermal anomaly and thermal waters because of their locations in Tertiary sediments with thickness up to 3.800 m. (Gorgieva, 2002)

Process of stagnation of geothermal development in Macedonia is still the main characteristic of recent 5 years. Government follows to neglect good natural possibilities. If something starts to change with other RES, like solar and wind energy, it is more organization of smaller development projects under pressure of EU lobbies than a defined orientation, and there is no such a lobby for geothermal energy. According to the present atmosphere, when all the attention is orientated towards the “big” energetic due to the big gap of local production, it is not possible to expect important changes during the next 5 years.

THE GEOTHERMAL FEATURES OF ITALY

The geothermal potential in Italy to a depth of 5 km is approximately 21 exajoule (21x1018 joule), which is equivalent to 500 million tons of oil-Mtoe. Two thirds of the resources have a temperature higher than 150 ° C. The areas with a temperature of 80-90 ° C represent a competitive alternative for electricity production. However, this is only possible in areas with strong heat flow anomalies. Such areas are for example the Tuscany-Latium-Campania pre-

Apennine belt and some volcanic islands on the Tyrrhenian Sea. (Figure 6) On the other hand, medium and low-temperature resources (T<80-90° C) are suitable for direct utilization, not only in the above-mentioned areas, but also in several other areas too. Moreover, heat pump utilization allows the exploitation of low-temperature resources (T <30 ° C) at smaller depths all over Italy. These facts indicate that Italy is rich in directly usable geothermal resources at accessible depths, of any temperature, and on large territories. Italy has a great geothermal potential that could be exploited more intensively than ever before. These are sustainable, environmentally friendly resources renewable at the human time scale, and cost-efficient at any temperature.

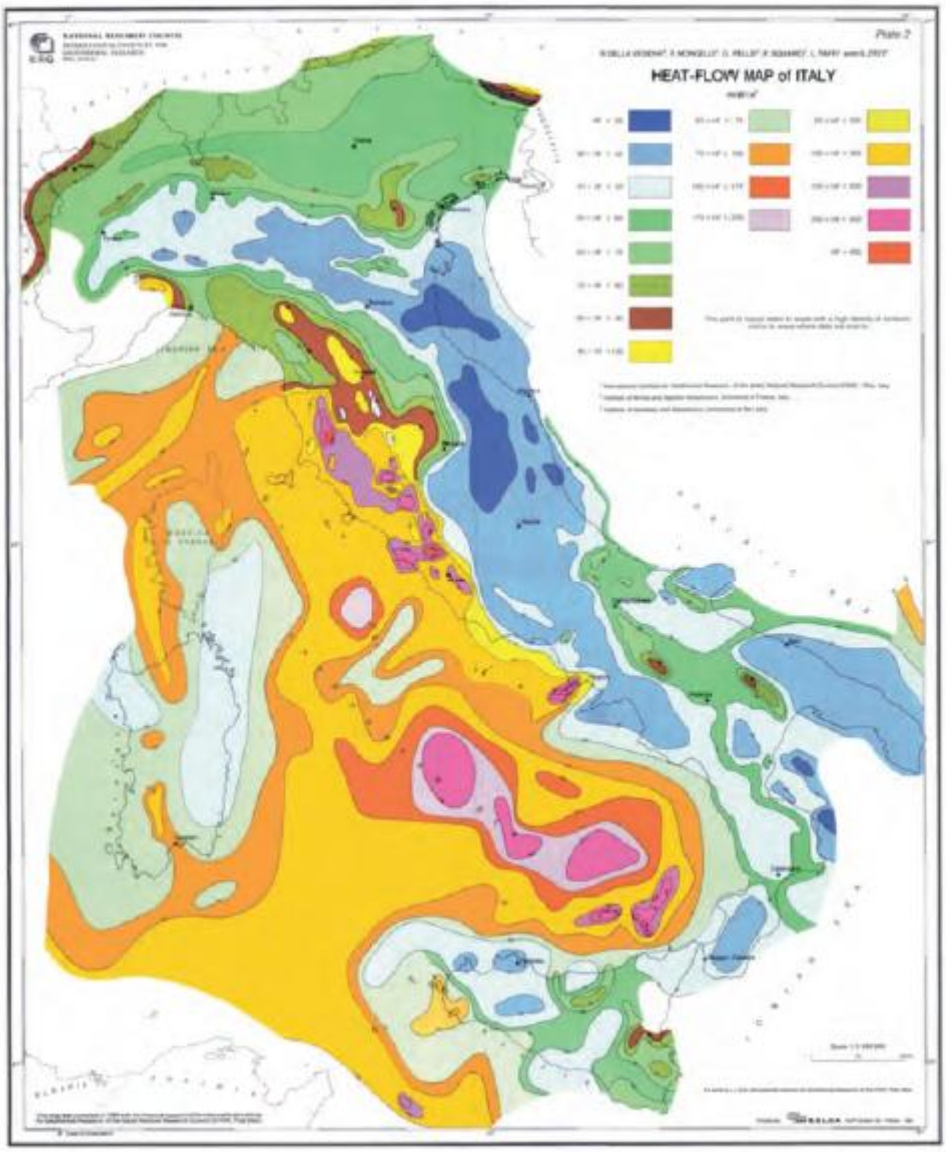


Fig.6. Heat flow map of Italy

In 2010, the shares of different resources in the total gross energy consumption of Italy were as follows: 83% from fossil fuels (oil, gas, coal), 5% imported electricity, and 12% from renewable, non-conventional energy sources (mainly water, wind, solar energy, biomass and geothermal energy). The share of the alternative resources between 2005 and 2010 increased from 7 to 12% (198 Mtoe in 2005-185 Mtoe in 2010) thanks to the dynamism of their development in the past years. In particular, geothermal energy grew from 1.19 Mtoe in 2005 to 1.32 Mtoe in 2010. Accordingly, the share of geothermal energy in the country's total energy consumption increased from 0.6% to 0.71% in the examined period. This growth can be seen in the direct use of natural heat, this grew from 0.2 Mtoe in 2005 to 0.3 Mtoe in 2010. The yearly average increase was 8.5%. Despite of the dominancy of geothermal energy production, its direct utilization grew in the same period from 0.99 Mtoe to 1.02 Mtoe, thus only by 0.6% per year. Accordingly, the geothermal utilization between 2005 and 2010 is relatively weak compared to Italy's great geothermal potential, especially for direct utilization. Figure x shows the distribution of the different types of geothermal utilization.

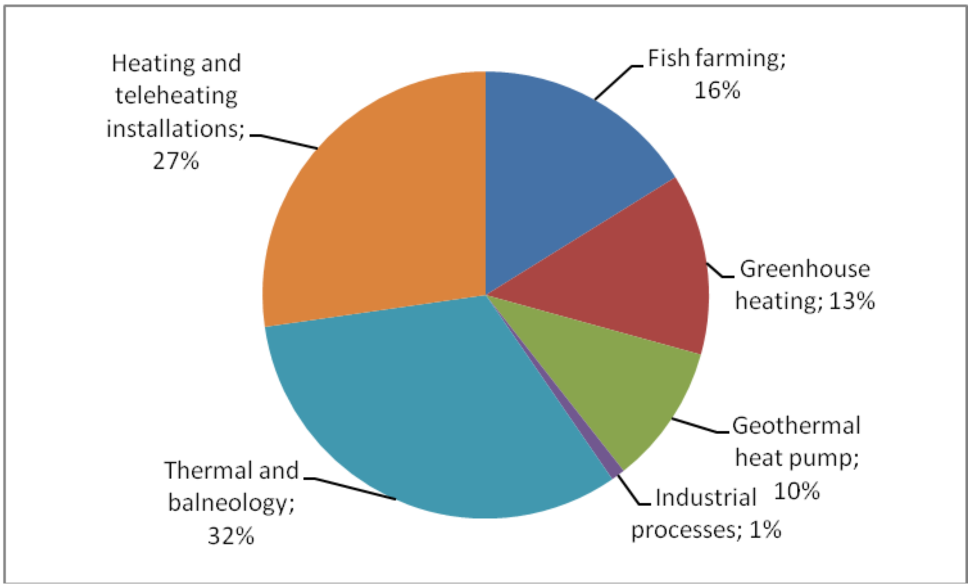


Fig.7. The different types of geothermal energy utilization in Italy

The future of the Italian geothermal research. In 2011, the Italian government started a project for the estimation of the country's energy demand by 2030, by examining the periods by 2012, 2015, 2020 and 2025. The final objective was to analyze the current facts and the possible medium-term investment possibilities to a wider scale than the UGI study dated 5 years earlier. The support of developments is justified by the excellent geological and geothermal parameters of Italy, and the fast increase of fossil energy prices. Two development scenarios were elaborated. The first shows that the price of crude oil will increase to USD 205/bbl by 2030, three times higher than the current price, considering the current economic trends and production technologies. The second scenario indicates that the economic trends are influenced by powerful environmental policies, thus the price of crude oil is estimated to grow to USD 300/bbl by 2030 due to the production with the current and newly developed technologies. The tables below show the growth of production and the emission values by 2030, according to the two scenarios.

Year	2010	2020	2030
SCENARIO I			
Installed capacity (MWe)	822,5	1 080	1 500
Gross generation (TWh/y)	5,343	6,9	9,4
Oil saved (kTOE/y)	1 020	1 310	1 790
Avoided Co2 emissions (kTonnes/y)	3 200	4 140	5700

SCENARIO II			
Installed capacity (MWe)	822,5	1 080	1 500
Gross generation (TWh/y)	5,343	6,9	9,4
Oil saved (kTOE/y)	1 020	1 310	1 790
Avoided Co2 emissions (kTonnes/y)	3 200	4 140	5700

Table 1.

UTILIZATION OF SOLAR ENERGY

The amount of solar radiation reaching the Earth
The energy formed inside the sun is radiated into the space with a constant intensity according to human scale, and this radiation reaches our planet as well. The solar constant is the numerical value indicating the amount of energy reaching the upper boundary of the atmosphere for a surface unit perpendicular to the propagation direction of the radiation during a time unit and at an average Earth-Sun distance. Its current value is 1,353 W/m^2. Since the Earth's orbit around the Sun is elliptical – one focal point is the Sun – the distance between the Sun and Earth constantly changes, thus the solar constant changes throughout the year between the values 1307 W/m^2 and 1398 W/m^2. The beams considered as parallel until the boundary of the atmosphere change into diffuse radiation in the atmosphere. For equipments using solar energy, calculations are made with the sum of direct radiation and diffuse radiation = total radiation, which is called global radiation. These data are related to clean atmosphere.

In the real atmosphere, the direct radiation decreases due to the natural and the civilization's pollution. The radiation-decreasing feature of the atmosphere is characterized with the opacity factor providing the value of radiation let through by the atmosphere. The average value in an industrial environment is 0.4-0.6, while in a clean, sea environment it is only 0.2. The solar wind activity is also important to mention (periodic, high-speed solar plasma flow), this however cannot be used for energy purposes, but it can cause serious problems in the communication systems.

The history of solar energy utilization
The development of energy-conscious architecture was forced by the lack of combustibles in the 5th century in Greece. A typical Greek house had a south-facing portico with outwork roofing held by pillars. The roof did not allow the summer sun to warm up the rooms, the low winter sun could enter into the building and heated the rooms behind the portico.

The greenhouse horticulture spread quickly in Western Europe from the 16th century. By the end of the 18th century, new solutions were found for the storage of the heat in greenhouses. The heat of the sun was stored in brick walls for the cooler night-time, or the warm air was stored in an extra chamber and fed back into the greenhouse by convective flow during the night. South-facing glasshouses attached to the houses became popular in the 19th century England, where people kept their ornamental plants. Occasionally, these were attached to the residential building through doors and windows. They could significantly contribute to the heating of the residential building during spring and autumn.

The energy-conscious architecture of the ancient times reappeared in the 19th and 20th century, but these were rare occasions and served only for demonstration or experimental purposes.

The largest solar energy programme started in 1938 and lasted until 1962 with a few years of pause. The main reason of the programme was the immense energy consumed by the US residential buildings, exceeding the energy consumption of the complete industry. The partial replacement by solar energy could have a huge economic importance.

The first south-facing solar house had a collector area of 40 m^2 on its roof. The water heated by the collectors was pumped into the 70 m^3-tank in the basement. The air heated by the tank was led into the living area by ventilators. The pump and the fans were operated from the electric network. When the water temperature of the collectors dropped under the temperature of the tank, the system would automatically empty. This eliminated the risk of the collectors to frost, and there was no heat loss due to the cold temperature outside.

Edmund Becquerel, the father of Nobel Prize winner *Henri Becquerel* discovered the Becquerel effect (1839). He discovered that when one of two electrodes immersed in an electrolyte is illuminated, a potential difference arises between the electrodes. The effect can be used – in theory – for transforming light energy into electricity. *Charles Fritts,* an American inventor made the first solar cell at the end of the 1880s, Its efficiency was lower than 1%. After the discovery of quantum physics and photoelectrical effect, some inventors began to produce solar cells at the beginning of the 1930s, but the bad efficiency of the selenium solar cell did not motivate further researches.

The oil industry started to boom after World War II all over the world, while the solar energy industry began to develop in some energy-poor countries (e.g. Israel, Japan). Luz International built 8 solar energy plants in California between 1984 and 1990. These were parabolic trough plants with a total capacity of 355 MW.

The flat solar collectors are the most common means of solar energy utilization, these are used for hot water production and auxiliary heating of private houses and public buildings. The EU member states have a leading role in the construction of solar collectors, the leader being Germany (becoming No. 1 in the world in the construction of wind power plants). The use of solar energy is a government objective in Germany, the Netherlands, Denmark, Switzerland and Austria.

The integrated, “complete building” approach is gaining more and more ground in solar architecture. This means that active building equipments are used beside passive architectural elements for a better use of solar energy in order to minimize or eliminate the traditional energy supply demand. Multifunctional use of certain elements, facilities is a common feature of these buildings. For example, the heat of flat collectors is used for hot water production and for auxiliary heating purposes in the low-temperature central heating system. Solar collectors can serve as a protecting roof, roof covering or sunblind as well.

Solar energy potential

The amount of usable solar radiation is influenced by the inclination angle and orientation of the equipment, and by the intensity and quantity of total solar radiation. The intensity and duration of solar radiation is measured at weather stations. The radiation intensity is measured in units, for radiation energy of 1 joule on a 1-m² surface perpendicular to the Sun's rays in 1 second. Its unit is W/m^2. The irradiance is the product of the intensity and duration measured in J/m^2.

Global radiation maps can be made in three ways. The first traditional method is the interpolation of values measured at the weather stations; the second is the analysis of METEOSAT satellite images; and the third is the numerical modelling. The duration of radiation or insolation is a measure of solar radiation energy recorded during a given time (hour, day, month or year). The threshold of solar radiation is 200 W/m^2 of direct radiation. Insolation is recorded with the Campbell-Stokes recorders.

Winter and summer usability varies due to the geographical situation of the countries (an external temperature below frost-point comes with a relatively high radiation energy yield, fact that influences the efficiency of solar collector equipments). Accordingly, solar energy can be used only to limited extent during the winter.

Passive utilization of solar energy

The passive utilization of solar energy does not imply any special equipment. This method can be exploited in the architecture.

Every building uses the energy of the incoming solar radiation at different efficiency levels. This aspect was more or less considered during the placement of buildings into the environment. An important aspect of passive utilization is the climate of the actual area. An area with tropical climate close to the equator enables better energy utilization than northern countries, where heating is necessary during the summer, or e.g. in Hungary, where there is only a small amount of solar energy available in the winter, but a high amount in the summer. The architecture of past decades did not exploit this possibility, resulting in badly oriented buildings and small window surfaces, and a small amount of usable solar energy and higher heating costs. At the same time, some buildings are overheating in the summer, reducing the comfort of the owners. (Kuba & Gyurcsovics, 1994)

The aim of passive solar energy utilization
The facts mentioned above show the aim of passive energy utilization: the building shall not overheat in the summer, but it should be able to use the solar energy in an ideal way by the given climate conditions. The following figure shows that the quantity of energy collectable with solar collectors and cells depends on the orientation and the inclination settings of the equipments. South orientation is the most favourable for energy utilization. The ideal inclination value depends on the time of operation. In case of an operation during all year, by considering the average radiation data for Hungary (N. 48˚), the ideal angle is 43.5 ˚. In the summer, this value is 18.5 ˚ due to the different altitudes of the sun, and 76.2 ˚ in the winter. The generally used angle is 30-60°.

Conditions of passive energy utilization:
• High number of sunny hours
• Solar radiation shall reach the building
• The building shall be able to utilize the radiation
• It is important for the building to be able to store the heat and to transfer it back into the space to be heated.

In case these conditions are not fulfilled, the building cannot be design for passive solar energy utilization. (Húsvéth, 2007)
The following points shall be considered in the design phase from the point of view of passive solar energy utilization:
• on rural level
- the ideal route of roads for the proper orientability of the buildings,
- consideration of insolation during the definition of distances between buildings,
- proper plants for shading that can protect the buildings from strong radiation in the summer,
• on building level
- the favourable orientation,
- design of a proper layout and mass form according to orientation and for the minimization of heat losses,
- ideal dimensioning of glassed surfaces,
- consideration of passive utilization during the selection of the materials for the building structures (e.g. proper heat storage of walls)

Possibility of passive energy utilization
Its primary task is the use of solar energy in buildings for heating purposes in “energy poor” seasons. Winter is quite long in the variable zone, thus the passive utilization of solar energy is of importance during spring and autumn seasons. The simplest method is the placement of well-sized insulating windows on the southern side of the building, and to design the living areas for the southern side. This solution is available for everyone during the construction of a new house, without extra costs. It is important, that passive energy utilization is quite expensive and difficult in case of existing buildings. (Szabó, 2005)

The design of passive solar energy utilization

The most important aspects are the proper choice of the lot, the ideal size and form of the house, the proper orientation, the good placement of interior spaces and the proper technical parameters of structural elements (walls, roof, ceiling, doors and windows), the good heat storage of structures, and finally, the proper use of the building.

Solar radiation modifies the external structure and the energy circulation of doors and windows. The primary source of passive utilization is the energy coming through the frontal windows. This can reduce the energy loss of wall structure by 25%. According to experiences and measurements, the common simple solutions (thick curtains, blinds, shutters) can significantly reduce the energy loss of windows during the night (25-50%). Solar radiation can affect the energy flow of glass structures on average cloudy winter days as well. The heat loss of northern windows on a sunny day can be reduced by 15%. Southern windows have mostly a positive energy balance, in some cases, the energy gain exceeds the energy loss of the same period. The alternatives for the reduction of heat loss mentioned above (curtains, blinds etc.) can shift the balance towards positive values. Windows with modified optical and thermal features can have a different energy flow and balance, a potential low heat transmission coefficient can result in a negative balance even on a south façade due to the lower solar factor of the glass. Accordingly, northern windows are generally the reason for significant heat losses. This can be twice or five times higher than the heat loss of well-insulated structures. The relevant parameters of eastern and western windows are almost similar to properly insulated walls. Southern window structures gain definitely the most energy of buildings. (Szabó, 1986) The building service and energy literature suggests the proportions and orientation of windows for energy saving purposes. The suggested window surface for northern windows is of 5%, 60% for western and eastern, and 35% for southern windows. (Szalay:2006). Unfortunately, the architects do not yet subordinate design to the protection of the environment and energy efficiency, thus these values are often not considered. In case of external doors and windows, the proportion of differently orientated window and wall surfaces is of great importance from the point of view of the total heat loss of the building.

The quality of doors and windows is the second most important aspect. The energy flow of window structures is the result of three independent physical processes. Heat transmission, transmission of solar energy, and filtration. The energy flow resulting from the solar radiation through the windows and glass surfaces and the difference between the interior and exterior temperature can be calculated without considering the energy demand of the heating of supply air.

This can be a positive or negative number; positive values indicate a gain, and negative values a loss of energy. The technical parameters of doors and windows are important as well from the point of view of the passive utilization of solar energy. The U-value of traditional doors and windows is 2.8, their solar energy transmittance is of 77%. Modern, 3-layer windows have a better heat insulation capability - k= 1.1, but their g-value is only of 57%, or they are filled with gas between the layers (e.g. argon) k=0.7. Winter insulation can be improved in different ways, such as the soft metal coating of glasses that does not modify significantly the transmittance (allegedly), or the reflective surface coatings for summer thermal protection that can reduce the transmittance of the glass to 10%.

In order to keep the thermal energy that arrived in the building through the windows, and to utilize it when the sun is not shining, the building must have a heavy structure and a higher heat storage capability. From the point of view of energy efficiency, a heavy structure is advised for thermal insulation in winter, and heat storage in winter and summer. Light structures have a lower heat storage capacity even by good thermal insulation, thus they warm up very quickly in the summer and increase the energy demand of air conditioning. The interior masses and their heat storage capacity define the usability of the gained energy. Some structural solution eliminate the interior structural mass from the thermal mechanism of the building, its effect on the heating energy consumption and the interior summer temperature values can be unfavourable. Experience shows that a 2-cm thick wooden floor or a 1-cm fitted carpet eliminates the surface from the heat storage capacity. Window structures with proper sizes and orientation increase the energy gain, but the utilization of the energy outside the sunny period is carried out by the structures and coverings inside the building. These store the majority of the solar energy and eradiate it during the night.

Active utilization of solar energy
The passive utilization of solar energy described above is a simple and cost-efficient solution. The active utilization of solar energy requires technological solutions that were conceived specially for the trapping and utilization of solar energy. These systems operating with building engineering equipments are called active solar energy applications. The two main types are solar cells and solar collectors.

Solar cells
Solar cells or photovoltaic cells (PV cells) convert the energy of the Sun into electricity by the photovoltaic effect.

The photovoltaic effect is a physical process that occurs only in semiconductor materials. When the photons hit the surfaces of semiconductor materials, they transfer their energy to the material's electrons displacing them from their orbit. If the semiconductor is coated with proper materials, the electrons are attracted to the surface, and an electric charge is set up which forms the basis of an electric current.
90% of solar cells are made from silicon. The silicon must have the right quality for a solar cell. Earlier, the solar cell industry was based on the waste of the semiconductor industry. Today, there is not enough waste to satisfy the demand, since the producers have to produce 1000-100,000 m² of solar cells. This is called silicon scarcity.

Three possible solutions can be considered: own sources, reduction of the number of solar cells to be produced, or search of other technologies with other raw materials. The solar cell industry created semiconductor factories. Silicon can be produced from very fine quartz (SiO_2). (Bathó, 2010)

Solar cells return the energy invested in mining and production, this is the energy payback time. Solar cells are considered as environmentally friendly green energy sources; however, the production of the large quantity of energy for the production of solar cells is carried out in coal-fired power plants and nuclear power plants. Unfortunately, the energy balance of the process is negative in many cases (Németh et al. 2008)

Operational principle of solar cells
A solar cell is a semiconductor diode, with a semiconductor layer doped with an n-type and a p-type material. The photons of the light hitting the solar cell actuate electrons with the photovoltaic effect and push them from one semiconductor layer into the other. The produced electricity is proportional with the intensity of the solar energy. (Horváth Á., 2006)
As mentioned earlier, the PV cell/solar cell is mostly made of silicon. Due to its stability, silicon remains unaltered for an unlimited time, thus it is very suitable for such applications.
The n-type semiconductors in monocrystalline Si-based solar cells are made of crystalline silicon that is doped with a small amount of phosphorus. Due to the doping process, the material will have redundant electrons and it will become a negative semiconductor. The p-type semiconductors are also made of silicon that is doped with a small amount of boron, creating an electron shortage, thus it will become a positive semiconductor (due to the majority of positive charges). An electric field is created between the semiconductors with unlike charges and this causes the particles with unlike charges to flow in opposite directions. The light hitting the solar cell consists of particles with energy called photons. When the light with the proper wavelength hits the solar cell, the photons transfer their

energy to the electrons of the material, these will have a higher energy level and will be able to move.

The excited electrons become free and carry the current through their migration. The “holes” generated in the material are able to migrate in a way that they are filled by other electrons. When the photons excite the electrons, the electrons and holes go in opposite directions – electrons towards the positive charge – and this generates electricity. PV cells are able to generate a voltage of 0.5 V and a current of up to 2.5 A = 1.25 W.

Similarly, to the galvanic cell, in the case of the solar cell we talk about short-circuit current and open-circuit voltage that can be measured with a current meter with small internal resistance and a high-resistance d.c. voltmeter. (Nemcsics, 2001)

The energy of the electrons of regular crystals is characterized by a band structure. A valence band form part of the valence electrons of certain atoms in the crystal, and a conduction band of the first empty atomic orbit. According to the laws of physics, the energy of the electron is in these bands. The semiconductor is located halfway between the conductors and the insulators. The band separating the valence and conduction bands is small, 1-2 eV depending on the material. The average energy of 1/40 eV of the thermal motion is not enough for the electrons to move from the valence band to the conduction band, but in the distribution of the particle motion there are always particles with bigger energy – even if by a small number – that reach the conduction band. There is no free charge carrier in the semiconductor, if it is clean and defect-free. When voltage is fed to it, only small amount of electricity can flow on it. The photons with energy of 1-3 eV of visible light are enough to lift the charges into the conduction band.

The most important feature of the semiconductor (diode) is that it is a rectifier. An electric field strength is formed between its two parts (p- and n-type semiconductors). This helps the transition of electrons flowing in one direction, but stops those coming from the other direction. The voltage on solar cells does not depend on the intensity of the sunlight, it is 0.7 V in case of silicon. For a higher voltage, several cells must be connected in series (module).

Production of silicon solar cells

The cleaned silicon is pulled to monocrystal, or turned into graphite or ceramic forms in case of polycrystalline structures, and then it is sliced. The layer separating the charges is created with usual diffusion processes, and the current plugs are created with vacuum and screen printing processes. The best efficiency is created with an optically fit antireflection coating and/or more reflection or through surface texturization.

Solar cells are usually mounted in bigger units, modules, in which the elements are connected very close to each other. The general nominal voltage of solar cell modules is 12 V, but there are modules with lower or higher voltage that match the standard chain of potentials or can be switched over. Its nominal capacity varies between a few watts and a few hundred watts. The size of solar cell modules varies between a few hundred square centimetres and a few square metres.

Different producers usually produce modules with different sizes and construction. In the modules, the solar cells are hermetically closed from the environment, and durability is a priority option during the selection of materials.

Heat-treated, high-strength glasses with low iron content are used for the front side, and glass, aluminium or special plastic materials for the protection of the rear side. The solar cells are embedded between the front and rear sides in special, optically fitted and durable plastic called EVA (ethylene vinyl acetate) and PVB (polyvinyl butyric) or special silicone resin.

The modules are usually closed into an aluminium profile frame, which is mounted to the supporting structure through boreholes or connection elements. There are modules without aluminium frames as well, such as roofing elements (shingle, tile). The fastening of these requires flexible bonding or other technologies as indicated by the producer.

The electric connection of modules is carried out through the hermetically closable connection box on the rear side, the electric wire can be connected with clamps or directly with screws. There are modules without connection box; either with connection cable, or contacts that can be connected with counterparts or directly.

We must mention that there are solar cells produced from other materials and with other technologies. The solar cells made of amorphous silicon are produced with modern thin film technology and can be applied to curved surfaces (see: solar shingle). A bigger active surface is necessary for the achievement of the energy transformation efficiency of crystalline silicone solar cells. Other solar cells can be made of gallium arsenide, copper indium selenide and cadmium telluride.

Installation of solar cells
There are two ways to install solar cells by considering the choice of the equipments and the integration into the surrounding infrastructure: isolated (stand-alone) systems and grid-connected systems. Isolated systems are not connected to a network, they consist of photovoltaic modules, a charge regulator and an accumulator system. The latter one guarantees the current supply, in case the lighting is weak or there is dark.

In case of grid-connected systems, the equipments are connected to the electric network. One advantage of this system is that when the solar cell is not able to generate the required amount of electricity, the network supplies the energy, and the produced extra energy can be fed back into the network.

Compared to traditional gauges, solar cell systems are equipped with gauges that rotate in both directions, thus they deduct the fed energy from the used energy. The current supplier is obliged to buy the produced and unused energy, and to provide the necessary gauge for the solar cell.

For the utilization of the solar energy, solar cells require auxiliary appliances, such as inverters that convert the variable direct current output of the cell into a utility frequency alternating current that can be fed into the network.

Storage of the produced energy
The storage of the produced energy is an important issue, if there is not enough solar radiation to satisfy the energy demands. This is the task of the accumulator. The energy production of a solar cell exceeds the necessary energy demand from June until the end of September. The accumulator is completely charged, and in case the solar cell is charged, the produced surplus of energy is lost. The accumulator supplies the energy from October, but will be recharged only at the end of next September. (Barótfi, 2000)

Orientation and efficiency of solar cells
In order to obtain enough energy and to use the incoming solar radiation, the angle of solar cells must be perfectly adjusted. The proper direction and angle of the cell allow a maximum energy production throughout the year. Those living in the northern hemisphere shall place their collectors towards south, those living in the southern hemisphere, towards north. For systems operating throughout the year, a perpendicular installation is advantageous, since this allows a better collection of the winter radiation from the sun's lower altitude. The best efficiency of a solar collector is achieved, when the sunbeams hit the surface at right angles. The geographical coordinates, especially the latitude, of the house must be considered

during the selection of the angle. The installation angle can differ from latitude by +/- 10°. The ideal angle is 30-60˚ (43.5˚ for an operation throughout the year, 32.4˚ from May until September, and 63.5˚ from November until March). (Barótfi, 2000)

The efficiency of the solar collector is given by the ratio of the used thermal energy and the incoming solar radiation. The thermal energy used by the solar collector is the thermal energy lead away with the heat carrier. In case the incoming solar radiation is 100%, 16 % of it is reflection loss, 2 % absorption loss of glass, 13 % convective loss, 6 % radiation loss, and 3 % loss of thermal insulation. Accordingly, there will be 60 % of solar radiation used. These are average values, they depend on collector types) (www.naplopo.hu) The values depend on the temperature of the ambient air and of the collector.
The efficiency is calculated with the following formula:

$$\eta = \eta_0 - a_1 \frac{\Delta T}{G} - a_2 \frac{(\Delta T)^2}{G}$$

where: η = efficiency, η_0 = optical efficiency of collector, a_1 = linear loss coefficient, a_2 = quadratic loss coefficient, $\Delta T = T_{collector} - T_{air}$, G = incoming global radiation.

The efficiency curve can be given in two ways: as a function of the variable x = ΔT / G, or as a function of the difference of collector temperature and air temperature. Since the efficiency of collectors vary (depending on the temperatures), the data of the efficiency curve concerning a specific mode of functioning is usually given as the specific efficiency. This is at a radiation of 800 W/m^2, and a temperature difference of the collector and the air of 40 °C. The value of the variable x = 0.05.

The maximum efficiency of solar collectors is at X = 0, thus the temperature of the collector is the same as the temperature of the ambient air. This is called optical efficiency, since there are only optical losses and no thermal loss. Optical losses depend on the light permeability of the glass covering and the absorption capacity of the absorbing plate. The (total) efficiency of quality collectors is approx. 60%.

The efficiency of solar cells is low (2), the improvement of which is strived with new materials, production processes and the development of the electronic systems.

Table 2. The efficiency of the most popular solar cells

Solar cell	Efficiency (%)
Monocrystalline silicon	14-18
Polycrystalline silicon	13-15
Amorphous silicon	8
Triple-junction amorphous silicon	10.4

Solar collectors
Solar collectors are the means of thermal utilization. They heat a given medium by converting solar radiation into heat. They can be used for domestic hot water production, auxiliary heating, heating of pools and air cooling.

The working temperature of solar collectors can vary depending on the scope of utilization between 20°C and 200 °C. The uncovered collectors are made of black plastic or metal, they can have the form of a plate, carpet, pipe or hose. These are cheap and simple equipments using *maximum 40 °C* of the solar energy, and can be operated only in summer. They can be used for the heating of pool water or as energy collector of heat pumps.

A higher efficiency can be guaranteed with insulation, a quality light-absorbing coating, and light transmission covering. These equipments are called flat solar collectors and are the most common equipments of solar energy utilization.

Types of solar collectors

There are five main groups of solar collectors. The first is the group of uncovered solar collectors without thermal insulation. It is operated with liquid (water) heat carrier, it can be placed anywhere do to its specific weight and easy mountability, and can be produced at home. The most modern one is the so-called EPDM rubber mat (absorber) that can be installed on the ground and the roof, it is insensitive to chemicals (the chemically treated water of pools), cannot be damaged by frost, thus it can be used in the winter as well. They operate similarly to the black barrels or black sprinkler hoses filled with water that are heated by solar radiation. Their disadvantage is their big heat loss and that they quickly cool down after the sunshine disappears.

Selective solar collectors have a selective absorbing surface, their optical efficiency is high. They are sold with single glazing. The vacuum tube collectors are different from other flat collectors. Their glazing is closely supported, and a vacuum pump exhausts the air from the collector house from time to time. This collector has a circular cross section, it is perfectly closed, and the absorbers are in glass vacuum tubes that are filled with an evaporative medium. The heated and evaporating medium condenses in the heat exchanger in the upper part of the vacuum tube and heats up the heat transfer liquid circulated in the upper tube of the collector.

There are so-called vacuum flat collectors – high optical efficiency and low heat loss – that mix the features of vacuum tube and normal flat collectors. The vacuum is created after the mounting of the collector housing.

Selective solar collectors are not the ones with the worst features. These are mostly homemade collectors covered with glass or polycarbonate, they have no selective layer on the absorbing surface, and thus they lose much heat.

According to the heat transfer medium, solar collectors have to main groups: air and liquid collectors. Air solar collectors are mainly used for agricultural purposes (e.g. crop driers, drying facilities). The most commercial solar collectors operate with liquids. These can be single-circuit (the water circulates in the system), and dual-circuit systems, in which the antifreeze solution circulates in the collector and transfer its heat through the heat exchanger of the hot water tank.

From the point of view of the transport of the operating medium, we can speak about gravity thermosiphon solar collectors that operate without pumps, and pump solar systems.

Fig. 8. Thermosiphon solar collector (Source: www.nyf.hu)

Its working principle is based on the density fluctuation of the heating liquid. The density of the fluid heated by the solar collectors becomes lower, thus it flows downwards towards the tank. In the tank, it transfers its heat to the domestic hot water, cools down, its density becomes higher and flows down to the bottom of the collector, where it warms up again.
There is a double-shell tank above the thermosiphon collector, the domestic hot water to be heated is in the interior tank, and the heat-carrying medium heated by the collector is in the exterior tank.

Another type of solar collectors is the parabolic trough solar collector. The material of the collector reflects the sunbeams and focuses the heat on a glass pipe containing the circulated heat-carrying fluid. The solar furnace and the parabolic mirror solar collectors are similar to these.

THE SOLAR FEATURES OF HUNGARY

Hungary lies in the middle of a Carpathian Basin, on a relatively flat surface surrounded mainly by mountains. Accordingly, it has favourable solar conditions compared to other European countries.

The number of the annual sunny hours is 1,900-2,200, and the average annual total of the incident sunshine is 1,300 kWh/m^2. (Fig. 9) The country's middle and southern regions are favourable for power generation and domestic hot water production with solar energy.

The theoretical energy potential from the point of view of solar energy is 1838 PJ, actual potential 4-10 PJ. The current use is about 0.1 PJ which means around 70,000m^2 surface area.

There is no database available on the installed solar capacity, therefore only estimates can be made. Adequate potential for low intensity solar energy has been identified. There are approximately 1500-1600 kW of electric power produced by photovoltaic installations throughout the country. The performance of the biggest system is more than 100 kWp, but the most common ones have a performance of 10 kWp. The largest PV system in Hungary was completed in 2005, and it is located outside of Budapest in Gödöllő. The 10-kWp plant is a producing power for the Szent István University. The system has 3 different units.

The most common collector used in Hungary is the flat-plate collector; however, demand for flat-plate, vacuum, and unglazed collectors has been strongly increasing.

About 3/4th of the applications are independent and used for electricity generation at highway emergency phones, meteorological stations, safety equipments, public lighting, and farmhouses.
Despite not having many applications using solar power itself, Hungary has a manufacturing plant that is a subsidiary of a solar PV company.

Hungary has also developed a national PV sales market with national and international contributing companies such as Dunasolar Rt, Helio Grid Magyarország Napelemgyártó, Sanyo Hungary Kit, and Genesis Energy Nyrt. (Urbschat, 2009).

In Hungary, the takeover of electric power produced with solar energy has been obligatory only for a few years, but there is no long-term guarantee for the takeover and the takeover price. The takeover price is very low, thus the driving force for the installation of photovoltaic facilities is missing.

According to the EU directive approved in 2008, the EU member states have to cover 22.1% of the total energy consumption from renewable energy sources by 2020. The member states contribute according to their own values. The accepted value for Hungary is 13%. (Source: Hungarian Energy Office,www.eh.gov.hu)

In Hungary, the industrial solar energy production began with a few small steps, the installed capacities are hard to measure on an economic level.

The installation of solar collectors has one of the biggest potential to create jobs among renewable energy sources. The installation of a capacity of 449 MW envisaged by the Hungarian Solar Energy Association by 2020 could create 1,500-1,600 new jobs. This capacity would provide 1.1 % of the total electricity consumption in 2020. Since solar collectors can be installed in a decentralized way, the losses of the power network could be decreased.

Currently, the installed power generating capacity of Hungarian solar systems is of 1.5 MW, the majority being the result of an investment implemented in 2011. (www.alternativenergia.hu/)

The following figures provide global horizontal irradiation values for Hungary. As shown, a majority of the country has low intensity solar resource.

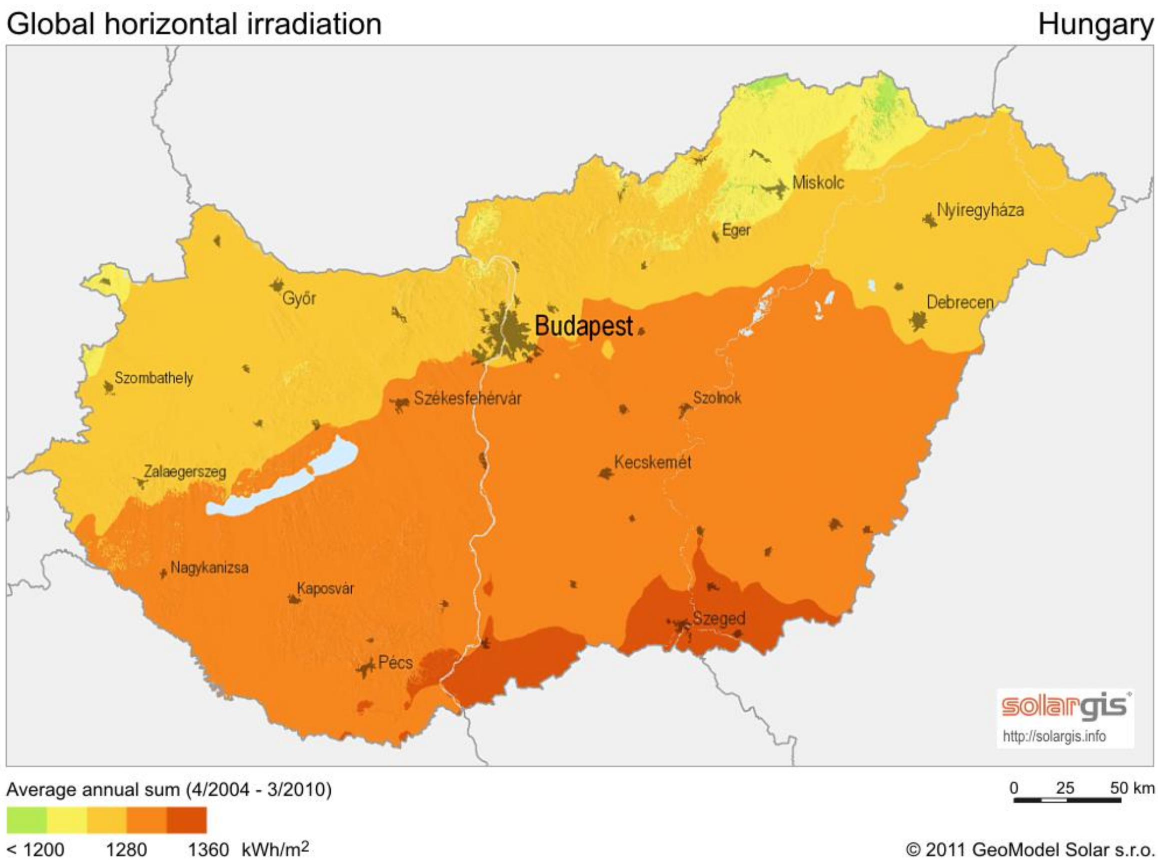


Fig. 9: Global horizontal irradiation incident on optimally inclined south-oriented PV modules in kWh/m^2 for the territory of Hungary. (Source: http://solargis.info/doc/_pics/freemaps/1000px/ghi/SolarGIS-Solar-map-Hungary-en.png)

THE SOLAR FEATURES OF SERBIA

Solar energy potential

The average solar radiation in Serbia is about 30% higher than the European average, but the use of solar energy for electricity generation is far behind the EU states. The economic incentives are of great importance in creating conditions for development and functionality of solar energy production, and for the safety of the PV energy market.

The annual average radiation intensity reaches 1,400 kWh/m^2, and 1,700 kWh/m^2 in the south-eastern parts of the country (Fig. 10). The lowest measured values of solar radiation in Serbia are comparable to the highest values in the leading countries in solar utilization such as Germany and Austria (average 1,000 kWh/m^2). Average daily energy of global radiation for flat surfaces during winter ranges between 1.1 kWh/m^2 in the north and 1.7 kWh/m^2 in the south, and during the summer period between 5.4 kWh/m^2 in the north and 6.9 kWh/m^2 in the south. (Ministry of Science and Environmental Protection, Belgrade, 2004;).

Policy support for solar power in Serbia

The energy policy of Serbia was promoted in the Energy Law in 2004. Its objective, in accordance with the policy of joining the European Union, is to create a legal harmony, to establish qualitatively new conditions, and regulatory background for the development of energy production and consumer sectors. Accordingly, in 2005 the "Long-term development strategy of the Serbian energy sector by 2015" was adopted, and in 2007, the "Program to achieve the strategy by 2012”, which sets the strategic objectives of the country until 2030. (www.jeffersoninst.org/)

So far, utilization of RES in Serbia is limited to micro and mini hydro-power-plants. It must be outlined that the country has great unexploited production possibilities in the field of renewable energy sources (biomass and biogas, geothermal energy potential, wind energy, unused hydropower potential, solar sources).

72% of electricity is produced by traditional fossil energy sources (mainly coal), the remaining 28% is generated with hydropower plants. The proportion of RES – except hydropower – is less than 1%. Despite of the great natural potentials for unconventional energy sources, and the incentive measures of the government, a development in the production with RES cannot be experienced in Serbia. The wind, solar and biomass resources are not exploited for the production of thermal energy and electric power, and neither are the geothermal resources (Serbia is rich in geothermal features).

The country has a higher number of sunny hours than any other European country (more than 2,200 hours per year). Unfortunately, this shows that the high number of sunny hours and the high intensity values are not enough for the solar energy production to have a more significant role.

There are several solar collector system networks in Serbia. These satisfy mainly the local demands by thermal and PV production (independent supply), and only a small proportion of the produced energy is transferred into the supply system. (Dusan Z. D., 2011)

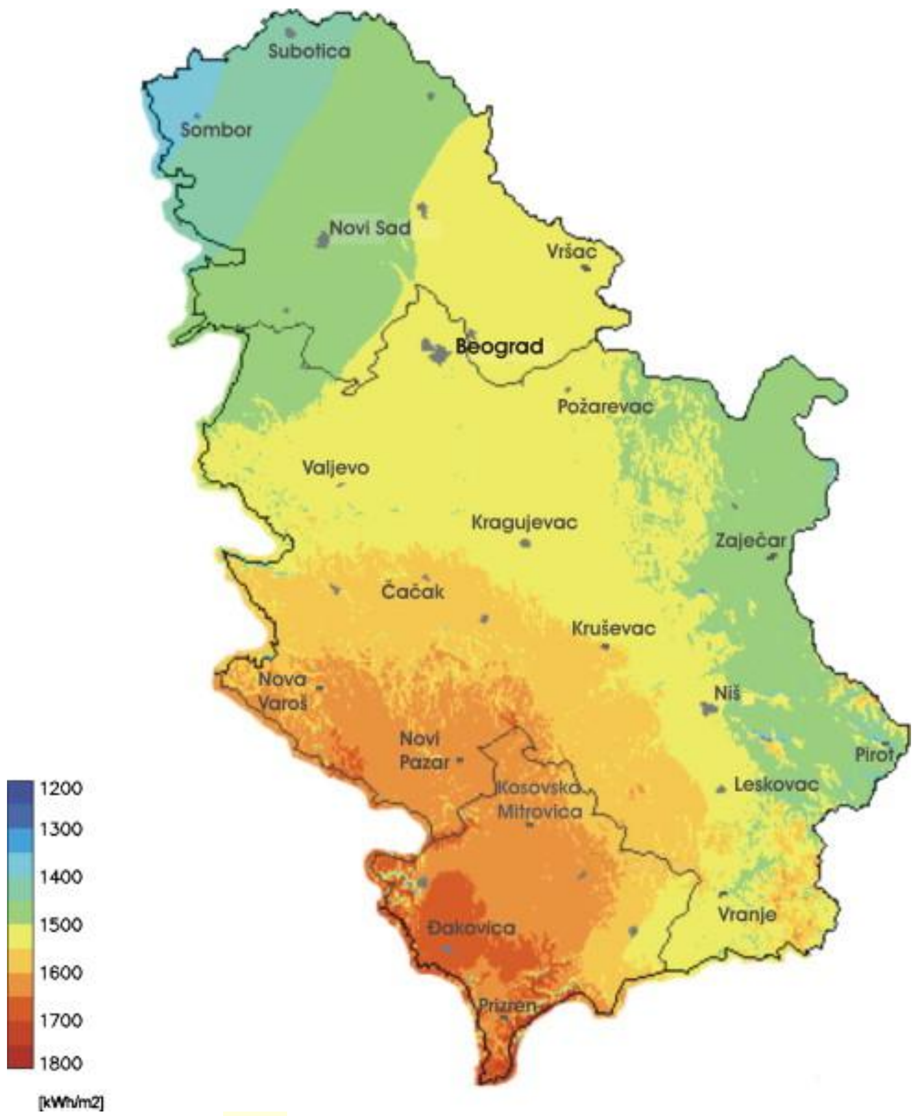


Fig. 10: Yearly sum of total solar irradiation incident on optimally inclined south-oriented PV modules in kWh/m^2 for the territory of Serbia. (Source: http://ec.europa.eu)

THE SOLAR FEATURES OF SLOVAKIA

The electricity production of Slovakia is built mainly on hydropower and nuclear plants, and thermal stations with coal, natural gas and oil. The proportion of renewable energy sources is insignificant, hydropower being the most important one.

The Slovak Republic is situated between latitudes 48 and 50. Solar radiation flux achieves a maximum of 1,050 kWh/m² per year, the maximum flux in the winter is of 80 kWh/m^2, which is a low value (Fig 11). PV energy has been given little attention in Slovakia so far. This is reflected by the negligible national RTD&D activities, and the near-zero installed power. Some parts of the country have the proper feature for PV energy production, but this would require a significant support from the government in order for solar energy to become part of the Slovakian electric power energy production. In case of realization of these objectives, and by similar solar energy and consumer energy prices, solar energy would become a priority and its proportion would increase between 2015 and 2020 compared to its current insignificant status. (http://www.skrea.sk/)

Crystalline solar cells 10x10 cm are usually integrated into so-called solar modules and/or panels with an output of 100 - 130 W/m², which is a low efficiency indicator.

There were 40 pairs of solar panels installed by a 400 kV transmission line between Slovakia and Poland in 1998. The modules provide energy for the public lighting during the night. Every panel consists of 36 cells of 75 W each. Furthermore, passive solar systems are architectural solutions that supply the heat for the heating of internal spaces using sunrays. (http://ebrdrenewables.com/)

The county has sufficient potential for the establishment of thermal solar energy systems for district heating purposes; however, no such investments have been implemented so far.
The electricity network of Slovakia covers 98% of the country, photovoltaic (PV) technology is a promising solution in areas that currently have no electricity supply.

Recently, the government of Slovakia set a goal to produce 10 GWh of power using PV installations by 2015. (Slovak Spectator, 2009).

Solar electricity production by means of photovoltaic modules is negligible, and constitutes less than 0.05 GWh.

This is not a statistically exact value because it relates to very small systems that are mostly not connected to the electric network, they are spread all over the country, and they use a part of the energy for local lighting and supply only a proportion of the electricity into the electric network. (http://www.euroqualityfiles.net/)

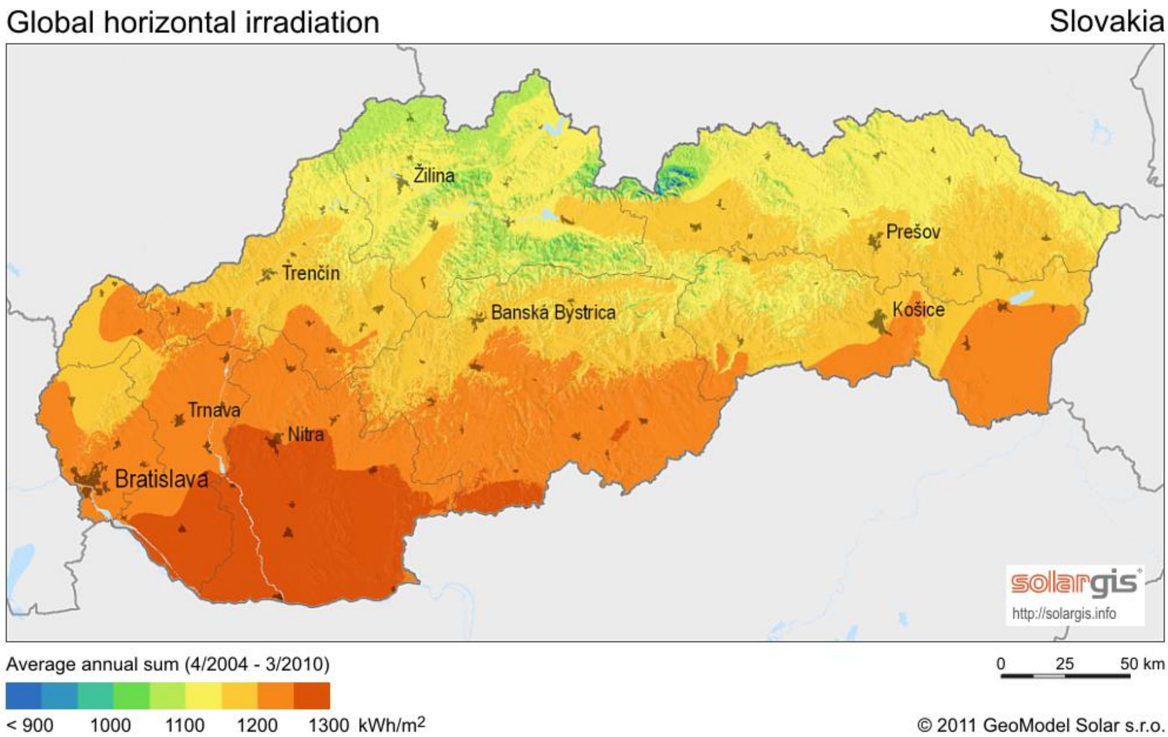


Fig. 11: Global horizontal irradiation incident on optimally inclined south-oriented PV modules in kWh/m^2 for the territory of Slovakia. (Source: http://solargis.info/doc/_pics/freemaps/1000px/ghi/SolarGIS-Solar-map-Slovakia-en.png)

THE SOLAR FEATURES OF POLAND

Solar radiation intensity in Poland is the most favourable in spring and summer months, with around 80 percent of the annual radiation intensity occurring during this period. Practically, there is no installed solar photovoltaic capacity. Despite the lack of solar installations and programs, Poland has two different sales branches for solar PV located in the country (Siemens and System PV).

Some liquid and air solar heat collectors are used in Poland. Air units are primarily used for grain drying, while liquid units are generally employed for space and hot water heating in homes and other buildings.

The estimated potential of solar energy in the country is 370 PJ/year. The annual potential solar energy values were very different, the highest being 1,340 PJ/year. This number varies greatly in different studies. It is obvious that a countrywide extensive research on the technical and economical feasibility of solar energy is needed. The map shows the global horizontal irradiation values for Poland The country has little solar resource throughout the country (Fig 12).

Although the reserves of solar energy in Poland are relatively high due to the low utilization rate, their utilisation is not easy because of high irregularity of solar radiation.

Solar energy is used to small photovoltaic installations. Solar systems (flat collectors, parabolic collectors or heliostats) heat the water for domestic purposes and the photovoltaic installations produce electricity used for supplying telecommunications devices, lighting road signs, and a few installations are used by individual investors. (Although the reserves of solar energy in Poland are relatively high, their utilisation is not easy, because of high irregularity of solar radiation. (Lidia G., et.al. 2010)

In terms of investment attractiveness and government's incentives, photovoltaic solar power is not an attractive sector for investors, since among renewable energy sources wind energy is of priority in Poland. This fact can be noted in the value of installed capacity. According to the Photovoltaics Association, by 2011 the PV investments in Poland amounted to 1.3 MW. However, the Energy Regulatory Office states that only two PV installations function and feed into the electricity network with a total capacity of 0.104 MW.

The Energy Policy of Poland forecasts that by 2020 Poland's installed PV capacity will account for 2 MW, and by 2030 this number will reach 32 MW covering 0.0622% of total electricity production in Poland. (www.evwind.es/)

Although Poland’s photovoltaic market is still in its initial phase of development, it can be observed that the Polish solar thermal market has been developing dynamically. This fast growth is accelerated by the launch of subsidies available for solar installations. After the beginning of the system, the establishment of several high-performance PV plants is expected by 2015.

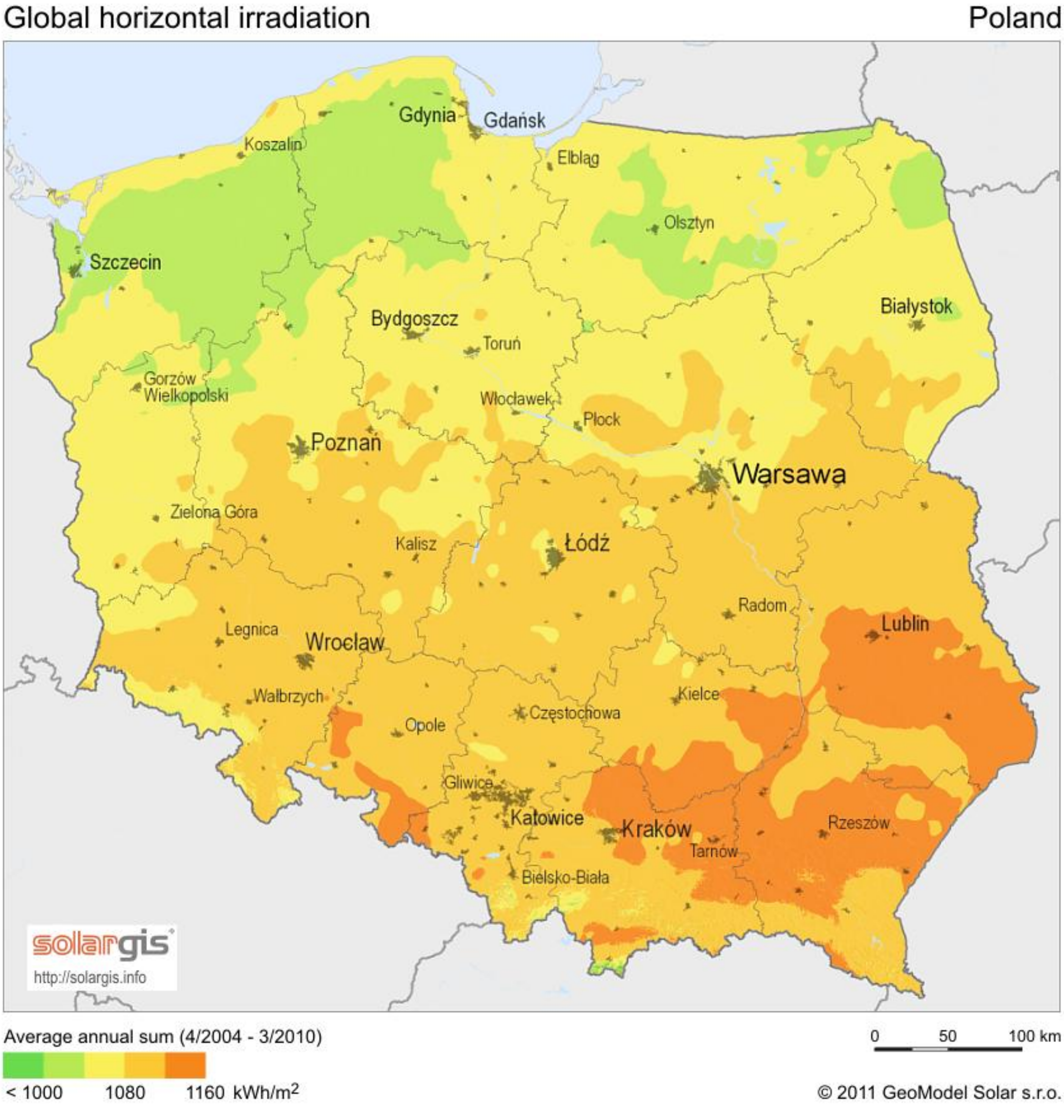


Fig 12: The global horizontal irradiation values for Poland. (Source:http://solargis.info/doc/_pics/freemaps/1000px/ghi/SolarGIS-Solar-map-Poland-en.png)

THE SOLAR FEATURES OF MACEDONIA

There is no complete data for the solar energy potential in Macedonia; however, initial indications show promising possibilities. Use of solar energy is limited to a small number of solar water heaters.

According to the energy balance in 2006, the share of solar energy in the final energy consumption was 7.4 GWh (0.6 ktoe), or 0.04%. Macedonian factor of 8 m² solar collector footprint per 1000 inhabitants shows low utilization of solar energy. There are about 16,000 m² total area of installed flat panel solar 27 collectors for heating domestic water. The solar collectors are used in residential sector, hotels, camps, and dormitories. A residential house uses about 2-6 m² of flat solar collectors which is sufficient to meet the demand for domestic water heating. There are pilot projects where solar systems are used for space heating but their space heating capacity is limited to about 30%.

Industrial solar heating water systems are currently not used in Macedonia. There are mainly local manufacturers of solar collectors in the country. Based on the current production and the level of development there are promising possibilities for the market of solar collectors. The annual rate of growth of the local market is about 10-15%, but much larger for export.

The average domestic payback time is 6-7 years. However, several issues need to be resolved as indicated by manufacturers. These are as testing/certification/labelling of solar collectors (solar key mark) in order to protect the market from bad quality solar collectors, and to provide training to installers for their proper installation.

The Government has lowered the VAT rate for solar collectors from 18% to 5%. However, the VAT reduction applies only to the solar collector, which represents about 20% of the cost for the entire system, and therefore does not provide sufficient incentive for their purchase. PV solar energy is still 300-500% more expensive than alternative fossil fuel derived sources for production of electricity. However, given the high preferential feed-in price of 46 €cents/kWh for installed capacity of maximum 50 kW, PVs are considered a safe investment. In June 2009, the first PV plant with a capacity of 10.2 kW was commissioned by a private investor nearby Skopje. (http://macedonia.usaid.gov/)

Solar radiation in FYR Macedonia as well as in Serbia, Slovenia, Croatia and Bosnia/Herzegovina are amongst the highest in Europe. Macedonia has a potential to produce 10 GWh of solar energy per year (Colovic, 2008).

The most favourable areas record a large number of sunshine hours. The yearly ratio of actual irradiation to the total possible irradiation reaches approximately 50 percent for former Yugoslavia as a whole. This ratio is approximately 45 percent for the mountainous central regions due to the prevailing weather pattern.

The primary form of solar energy and technology used are flat plate collectors for heating houses and some commercial and public premises. However, their contribution to the total energy consumption is insignificant (less than 1 percent). Additionally, it is not expected that this figure will increase substantially in the near future, as new consumption could mainly come from new entrants to the market i.e. of new buildings or installations.

Likewise, electricity production from solar photovoltaic sources will be restricted to research or remote locations, primarily for telecommunications. This is due to the difficult economics for photovoltaics.

The following figures display the direct normal and global horizontal irradiation values for FYR Macedonia. Macedonia has great solar resource in the western portion of the country. The rest of the country could also be well suited for utilizing solar potential.

The huge solar energy potential with 2000 - 2400 sunny hours during the year and generation potential of around 10GWh per year can satisfy at least 75-80 percent of the annual needs for heating and for hot water. (Fig 13) Currently its usage is limited to water heating. In Macedonia there are only 7.5m² solar panels on every 1,000 people, or 15,000m² installed solar panels. At the end of 2006 the total collector area in operation in Macedonia was 17,118 m². From 500,000 households in Macedonia only 2500 – 3000 are using solar systems for water heating. This represents only 0.5 % of the total market for solar panels. (www.analyticamk.org/)

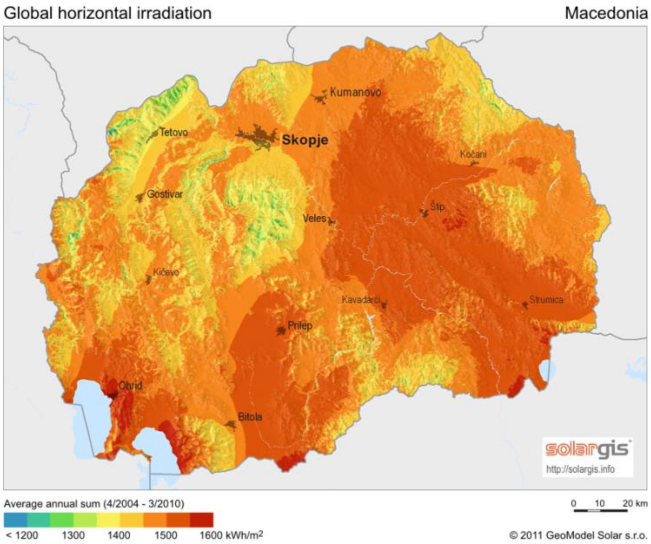


Fig. 13: Global horizontal irradiation incident on optimally inclined south-oriented PV modules in kWh/m^2 for the territory of Macedonia. (Source: http://solargis.info/doc/_pics/freemaps/1000px/ghi/SolarGIS-Solar-map-Macedonia-en.png)

THE SOLAR FEATURES OF ITALY

Photovoltaic energy production is one of the most promising renewable energy sources in Italy due to its geographical situation and the related government measures. The PV technology for energy production is widespread in the country. A significant capacity increase was experienced in 2009, Italy becoming taking the second in Europe from the point of view of solar energy utilization. This sector is currently the most attractive one for investors due to the high natural potential (Fig. 14), the economic and legal environment, and the financial support conditions.

Italy ranked among the world's largest producers of electricity from solar power with an installed photovoltaic nameplate capacity of 12,750 MW at the end of 2011 and 263,594 plants in operation at the end of 2011. Tendencies show that photovoltaic capacities tripled in 2010, and quadrupled in 2011. The total energy produced by solar power in 2011 was 10,730 GWh, while only 1,900 at the beginning of 2010. Annual growth rates were fast in recent years: 250% in 2009 and 180% in 2010 (Table 3).

The Montalto di Castro Photovoltaic Power Station is the largest photovoltaic power station in Italy, in Montalto di Castro in Viterbo province. The project was built in several phases. The first phase with a total capacity of 24 MW was connected in late 2009. The second phase (8 MW) was commissioned in 2010, and the third and fourth phases, totalling 44 MW, were completed at the end of 2010.

As of the end of 2010, there were around 156,000 solar PV plants, with a total capacity of 3,470 MW. More than a fifth of the total production in 2010 came from the southern region of Apulia.

The Archimede solar power plant is a concentrated solar power plant at Priolo Gargallo near Syracuse. The plant was inaugurated on 14 July 2010. It is the first concentrated solar power plant to use molten salt for heat transfer and storage, which is integrated with a combined-cycle gas facility.

PV installed capacity by year		
Year	**Capacity (MW)**	**Growth**
2007	87	100.4%
2008	432	396.55%
2009	1,144	164.81%
2010	3,470	203.32%
2011	12,750	267.44%

Table 3: PV installed capacity by year in Italy

Despite the favourable development conditions in Italy, solar energy to present has not been exploited adequately, some regions have unexploited potentials.

The solar heat industry reached a total turnover of approximately 200 million euro in Italy in 2007, creating more than 2,000 jobs. Solar heat production for the electricity network is not yet practiced. The most regions use solar energy for the production of hot water. The energy market is spreading towards the northern and southern part of the country very slowly.

The solar energy market is delayed compared to other EU countries. The costs of electricity generated with solar energy are by far the highest among the renewable sources, from the economic point of view, this technology is still not usually competitive.

According to the most recent data of the Manager Electric Services in Italy, in 2007 there were 8,000 plants operating for a total capacity of 83 MW. The solar cells are partially imported and partially supplied by Italian producers, such as Eurosolare and Helios Technology.

A first stimulus for the use of renewable energy sources came in 2007. Measures were taken for the support of green energies. The decisions taken make investments related to solar energy plants advantageous.

Despite these incentives, the immense potential of the exploitation of solar energy is obvious but until now has remained far behind the optimum exploitability.

The reason for that is that the first incentive measures were taken only in 2007, and an additional period had to pass until the entrepreneurial system and especially the banking and administrative systems understood its operation.

Despite these factors, the objective is the operation of photovoltaic installations totalling 3000 MW by 2016, resulting in a growth of 30% per year for photovoltaic energy and 35% for solar heat within the country. (http://www.italchamber.se/)

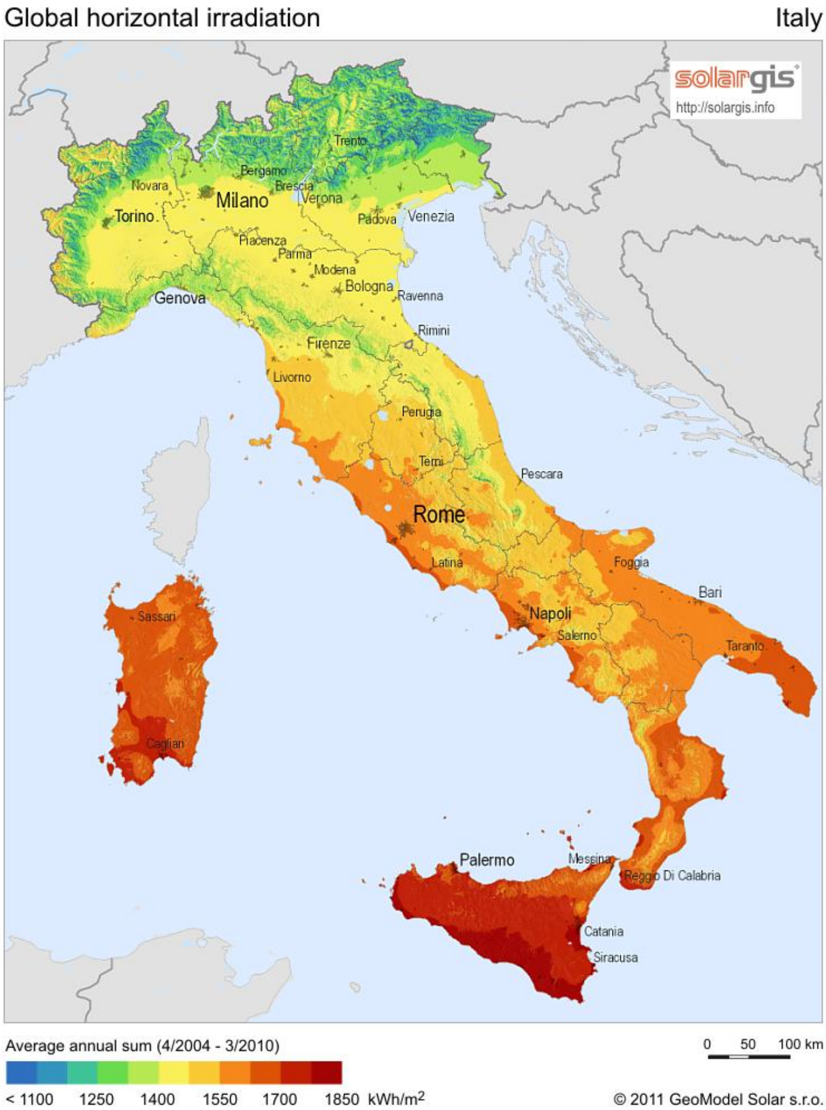


Fig. 14: Global horizontal irradiation incident on optimally inclined south-oriented PV modules in kWh/m^2 for the territory of Slovakia. (Source: http://solargis.info/doc/_pics/freemaps/1000px/ghi/SolarGIS-Solar-map-Italy-en.png

UTILIZATION OF WIND ENERGY

Wind energy the cheapest and the most dynamically developing type of renewable energy sources. It has a large literature related to the protection of the environment, technology, economy, law and meteorology. We wish to present the basics of wind energy utilization.

The characteristics of wind, as an energy source
Solar radiation is the driving force of wind energy, heating the surface of the Earth to different values, and creating a pressure difference between the air layers with different temperatures. The horizontal flow for the equalization of the pressure difference is called wind. As an energy source, wind has a low energy density; it changes in place and time; however, it is a free and clean energy.

The momentary direction and strength of the wind is defined by four forces. Pressure gradient force causes air particles to flow from areas of high pressure to low pressure areas. (Sándor, Wantuch, 2005)

Specific local wind systems are formed in the different parts of the world due to the flow-modifying effect of surfaces with different heat balances (mainland and water) and of the relief. These can be favourable from the point of view of the energy (e.g. coastal wind). It is a well-known fact, that less coarse surface, e.g. water level and mountaintops are the windiest ones. Behind obstacles (e.g. mountain, building), a weak flow creates a wind shadow, a strong flow creates turbulent flows according to the wind speed. A continuous turbulence is characteristic in the operation zone of wind turbines between 30 and 160 m. The turbulent flow varying is space and time and with changing directions and speed causes the fluctuation of the energy produced by wind power plants. The power of the plant is a cubic function of wind speed, thus the fluctuation can be significant in case of a small change of the wind speed.

Wind power plants use the kinetic energy of the flows, practically moderating the wind. The energy of the wind is a cubic function of wind speed, air density and the surface touched by the blades. A 100-% utilization of wind energy would mean that we would moderate the air flowing through the turbine to a standstill. Accordingly, extractable wind energy has a maximum value that is 53.9% of the wind’s kinetic energy (Betz maximum); the actually usable energy is much less, maximum 20-30%. (Tóth, Horváth, 2003)

The wind conditions of a given place are significantly influenced by the frictional conditions (density of buildings, flora, soil etc.). Observations of at least one decade are necessary for the statistically reliable analysis of climatic features, daily and annual cycles and extremities. Furthermore, local measurements carried out in two different heights are also required.

Weather forecast is important in the operation stage. The physical laws of forecasts of atmospheric processes theoretically limiting the accuracy of forecasts are well known in meteorology. The European Centre for Medium-Range Weather Forecasts (ECMWF) provides forecasts for 15 days. The uncertainty of the forecasts grows with time. The increase of the spatial resolution has the same effect. The forecast of the power produced by the wind power plant is a more complex issue, since local processes are influential (environmental impacts, flow around the tower, temperature etc.). The measurement of these is not available everywhere.

The history of wind energy utilization
Wind energy has been used for centuries. The Egyptians discovered sails in the 6th century B.C., and they used the nautical experiences on the mainland as well. The first windmills

appeared A.D. in the Middle East. The horizontal mills used for grain grinding can be seen in Persia. Wind generated prayer mills were used in Tibet since the 7th century. The power of wind has been used in China for 800 years for salt extraction on the seaside, and for irrigation along rivers. (Bartholy J. and Radics K, 2003)

Europe became familiar with Persian mills during the crusades, and the water and dry mills were transformed. Horizontal and vertical windmills of different shape and structure appeared during the Middle Ages, the horizontal-axis mills proved to be more efficient with time. Horizontal mills were substituted by stone tower mills with four blades in the Mediterranean Region. The lower parts of the buildings served as residential areas as well. Hollow-post wooden mills were built in the Netherlands. There were 9000 operating windmills in the golden age of windmills.

At the turn of the century, due to the industrial revolution, the windmills were substituted by steam mills.

The technical basics were taken to America by explorers, and structures were adapted to local demands with many blades mounted on iron grids and turning automatically in the wind direction. These were connected to hydraulic systems and used for drawing up water.

The discoveries in the last decades of the 19^{th} century of the American C.F. Bush and the Danish Paul la Cour made possible the use of windmills for electric power production. With the spreading of fossil fuels, the use of small mechanical power plants, including windmills and wind wheels lost ground. The shortage of the crude oil supply, the rise of costs, and the impact of air pollution from burning fossil materials on the climate generated a renaissance of wind energy utilization.

Wind power plants in our days

The utilization of wind energy for electricity production has become a leading industry. The modern wind power industry began in 1979 with the serial production of wind turbines with a capacity of 20-30 kW in Denmark. Today's turbines are capable of a capacity of 5 MW, while production costs are decreasing from year to year. The look of wind power plants has changed as well, towers can be 100 metres high, and the technical solutions (blade form, material, painting, automatic control etc.) allow a more efficient operation. Offshore farms have appeared along the seacoasts, but there are parks on the mainland with smaller wind speed as well that are closer to the utilization sites.

According to the survey of the GWEC (Global Wind Energy Council, http://zuww.gwec.net/), in 2007 the installed total capacity reached 94 GW, the number of investments is quickly growing. 86% of wind energy is produced in eight countries, the biggest producers being Germany, USA, Spain, India and China.

Thanks to the conventions on climate and the EU policy supporting renewable energy sources, the share of Europe is the largest among the continents. European wind farms produce as much electricity as 35 coal-fired power plants. In 2007, 3.7% of the total European electricity consumption came from wind energy. Denmark is the world leader in this respect, where wind power plants supply 20% (32% of the capacity) of the energy demand. The new investments of member states is surveyed and published by the EWEA (European Wind Energy Association, http://iuzuw.ewea.org/) every year. Wind parks have appeared in former socialist countries as well, the most investments being carried out in Poland, the Czech Republic and Ukraine.

The cut in wind speed of wind power plants varies from type to type (3.5-5 m/s), but they stop at 25 m/s for safety reasons. The wind speed for nominal performance is 12 m/s.

The rotor of modern plants turns automatically in the direction of the wind; however, during the installation of parks it must be considered that the strongest winds usually blow from the prevailing wind direction.

Energy estimation

The survey of wind energy resources of one country is an important task during the elaboration of authorization concepts of wind farms, and during the planning of the long-term strategy. During the measurement of the wind, we carry out point samplings according to which we estimate the values on unmeasured places and heights. This shows that the calculation of the wind energy of one country is a complex mathematical task with several estimations. (Tar et al, 2005)

At the end of 1980s, the Danish company Riso developed the WASP software (Wind Atlas Analysis and Application Program) for the uniform mapping of the wind energy potential, which is accepted and used all over the world. The model estimates the average annual wind speed according to standard meteorological wind measurements. It considers the three most important environmental factors (topography, coarseness and shadowing), and provides the most important statistical values for the given station by wind directions by using the basic physical relations of the atmospheric boundary layer.

The first analysis of meteorological wind measurements for energy purposes was recorded in 1923, and many articles have discussed the research of wind energy ever since. In the 1950s, experts suggested the establishment of institutions for the harmonization of special technical and meteorological problems for the ideal utilization of wind energy (Kakas, Mezősi, 1957).

A local wind measurement for one year carried out near the height of the rotor of the planned establishment is essential for the judgement of individual investments. This is the most exact way to demonstrate the local features and direct environmental impacts. By using these data as an input, the special models mapping the local wind conditions with a fine spatial resolution publish locally exact and reliable estimations.

The basic types and structure of wind turbines

The kinetic energy from the wind can be converted into mechanical or electric energy. At the beginning and before the century, the mechanical energy was directly used for mills, machines and other equipments. Today, mechanical energy is used primarily for pumps for filling of water reservoirs, or air compressor equipments for air tanks. The stored energy can be later used for oil engines, water turbines or other air motors.

Other wind power plants convert the kinetic and then the mechanical energy into electricity. The produced electric energy can be stored in several ways. The most common one is the accumulator storage, the electrochemical possibility by producing hydrogen through hydrolysis followed by the storage and use of the hydrogen for explosion engines and heating. A solution under development is that we produce electric energy from it once again by using fuel cells.

The devices have different names:

- *Wind engine (mechanical energy),*
- *Wind power machine (mechanical energy, rarely electricity),*
- *Wind turbine (electricity),*
- *Wind generator (electricity),*
- *Wind power plant (electricity),*

Every name is acceptable, since they express the primary function of converting the wind energy into other types of energy.

According to the position of the blades:

- vertical, perpendicular to wind direction,
- horizontal, parallel to wind direction,
- horizontal, with axes perpendicular to wind direction.

The Savonius wind turbines are the most common types of *vertical axis wind turbines*, these are similar to the ancient Persian windmills. The plate- and dish types and the Giromill are similar turbines. Darrieus wind turbines are the technically most fashioned ones; they were produced for power plants as well. Their blades are so-called aerofoils. The most common ones are similar to a parabola, but there are simply versions as well.

In recent decades, systems were developed that convert the wind energy by compressing the rare wind energy. The deflector version increases the speed of the wind by gradually narrowing from the larger cross-section, and the turbine is placed at the place with the maximum speed. The version with solar energy is a new solution, the development of which for big power plants is under way. This is a large-surface solar collector using the heat of solar radiation. The hot air under the transparent surface – due to its decreasing density caused by the warming-up – starts a strong upward flow in the solar collector in the tower. The flow is gradually narrowed, and the air reaches a high speed. The turbine powering electric generators is placed at the spot with the maximum speed The current *modern devices have a horizontal axis;* their axes are pointed to the wind. The simplest version is the one-bladed turbine that hides a simple structural form, but the equilibration of the blade can be difficult for greater devices (with high efficiency). The most common turbines of the world have three blades. Versions with more blades are usually for the production of mechanical energy. Devices with more than ten blades are called American turbines. These are used in agriculture, mainly for water pumping.

Wind generators

Small and medium-size and separate turbines are used for the charging of accumulators and heating (0.5-50 kW). These are the most profitable in places far from electric networks. Currently, there are 200,000 such wind turbines operating in the world.
The capacity of medium or larger wind turbines grew since the 1980s from 50 kW to 1500-4000 kW. Wind generators linked to a network are often operated in wind farms.

The structure of wind turbines is highly developed from the point of view of blades and related units.

The generator housings (nacelle) are placed in 30-120-m high towers. An important element is the mechanism adjusting the blades in the direction of the wind. This turns the housing on the tower around the vertical axis and enables the blade to be always perpendicular to the wind. The hub is placed on the main shaft. The brake (on the shaft) is followed by the clutch, and this is how the torque of the blade reaches the gearbox and the generator. (www.szel-mszte.hu)

The task of the regulator system is to make the available wind usable with the built-in capacity, to turn the blades in the direction of the wind, in the best angle for the wind velocity and electric load (pitch system), to operate the safety system (blade brake, shaft brake), and to optimize the output.

The main shaft is made of alloyed steel. The main bearings are mostly multi-row ball or roller bearings. The bearing takes up the load from the wind blows and vibrating masses, and moderates the load of the drive mechanism. The flexible clutch weakens the torsional vibrations generated by the changing load of the blades and generator (generator, engine, generator operation), and protects the driving mechanism and the shaft from possible overloads.

The wind power plant operates automatically by all wind conditions. When the wind speed reaches 2.5-3 m/s, the generator starts automatically. By devices with two generators, the small generator operates until a wind speed of 5-7 m/s. The main generators operated until a wind speed of 15-25 m/s. This is when the power control is activated. This can be carried out with the blade tips or with the stalling, or the full turning of the blade (pitch). The stopped wind turbine is blocked with the brake. When the wind speed is under the allowed limit, the turbine starts automatically again.

The most common utilization is the feeding of electricity to the public networks. The isolated power system is for small consumers (households, small plants).

Industrial-size electricity production from wind energy means that the generated energy is fed to the public current networks and the wind power plant becomes an integral part of the power plant system feeding the network.

A profitable fulfilment of the requirements of the network operation can be reached only with high-performance wind power plants. Specific investment costs allow a profitable network operation above a capacity of 100 kW.

Preparation and implementation of wind power plant investments

The requirements for the establishment of a wind power plant include an environmental permit, a building permit in force, a cabling right license, and an existing long-term commercial treaty on current transfer. The regulation changes in proportion with the total capacity of the wind power plant. Investors must consider that while the construction of the wind power plant takes only a few days, the procurement of official permits is a longer process.

Experience shows that the first step should be the clarification of the possibility of connection to the network, and the checking of the construction zone classification.

The consideration of the meteorological background is not a legal requirement. The essential parameter of the return rate calculation required for credit borrowing is the exact knowledge of the local wind, since wind velocity defines the result of calculations related to the return rate of the investment. The selected area shall have the most favourable wind features. The wind maps of weather services and statistics built on the observations of more decades of the nearest anemometric stations provide support. We must mention that meteorological measurements are carried out in a height of 10 meters according to international regulations. Experiences show that the logarithmic conversion of data measured close to the surface in one altitude results in some cases in underestimated values from the point of view of the rotor height of the plant. This is caused by the fact that these stations are not placed in the windiest areas (Kakas, Mezősi, 1957). Another reason is the spatial distance, since the environmental surface features between the plant site and the weather station can be very different (altitude, coarseness, density of buildings, flora etc.). The importance of meteorological data lies in their length, since a ten-year long series of data can indicate the long and short-term variability in a more reliable way. For these reasons, the German standard (www.gl-group. com) specifies the procurement of certain statistics based on the measurements of the weather service for the return calculations of the investment (e.g. monthly average data, repetition of strong winds etc.).

SODAR is the most appropriate wind profiler for wind energy purposes to measure the direction and velocity of wind every 15 metres from the reflection of sound waves from 30 inches up to 300 metres in 10-minute periods. (Varga et al, 2006)

The appropriate models provide good estimations on the expected energy production, their importance is shown by the results that become the basis for further economic calculations. The direct zone of a wind power plant is approx. 400 m^2, including the concrete foundation of the turbine, the exploration roads, and the transformer house; the tower covers 1% of the territory. The set-up of a wind power plant takes 2-3 days, which operates automatically after commissioning by regular supervision and maintenance. It does not require a permanent operator staff.

Electricity supply companies are obliged to take over a certain amount of surplus electricity, therefore, wind power plant projects a profitable investments. (Hallengara, 2004). Implementation is supported with individually assessed state aids and loans. A great number of grants can be applied for research and implementation.

Operation, legal background, profitability

Traditional energy supply is based on centralized energy production and distribution systems. In terms of modernization, the EU Commission recommended the development of a decentralized energy mix integrating the renewable energy sources, among which wind energy plays an important role. Expected global impacts are analyzed with the model of the International Energy Agency (Imre, 2005).

The major disadvantage of wind power plants is that they cause system regulation problems during the takeover of produced energy. Just like sailboats, wind power plants are standing still in no-wind conditions, but in strong wind conditions, the network is hit by a large amount of energy. International experience shows that the daily fluctuation of the energy produced by a wind farm is extremely high, it exceeds 85%, and can reach 15% for an hour. The missing energy must be supplied from other power plants or from import. Due to sudden and strong power fluctuations, the leading countries (Germany, Spain) consider only 6% of the installed capacity. Accordingly, they do not play a role in the expansion of the system, since the compensation of the energy requires the construction of a power plant with similar capacities. (Imre, 2005). Too much energy is also a risk for system operators. Despite of these facts, wind industry is dynamically developing, the investments are cheaper do to mass productions, and their prices are competitive. Wind power plants require less support year by year; however, they are not profitable anywhere without benefits and state support.

Utilization possibilities, limits and alternatives of wind energy

Due to the dependence on the weather, wind power alone is not suitable for primary current production; however, as a secondary energy source, combined with renewable sources, it can contribute to the adaptation to more environmentally friendly technologies. According to the communication of the EWEA, 7% of the current European energy consumption is supplied from wind energy. The TPWind (European Wind Energy Technology Platform) has a vision according to which wind energy could cover 12-14% of the EU’s electricity consumption by 2020, and this could increase to 22-28% of consumption in 2030.

In the not so distant future, the emission reduction agreements and the reduction of certain fossil energy sources will force humankind to use the atmospheric resources. The change to an environmentally conscious approach and the development of solutions and innovations fitting into the Earth’s sensitive ecosystem is a challenge for researchers and engineers. Hybrid systems combining the renewable energy sources can provide creative solutions. Isolated wind energy facilities together with solar collectors, solar cells, heat pumps or biomass facilities can guarantee a more constant performance. There are new categories in the energy-conscious architecture: houses with low energy, passive and zero-energy buildings; wind engines installed in the buildings or near them on posts utilize the wind energy. In the future, the feeding of the energy produced from renewable sources into the network, just as the bidirectional electric power supply making this possible, will become a general fact.

THE WIND ENERGY POTENTIAL OF HUNGARY

Hungary lies on a territory with moderate wind conditions due to its situation in a basin and the wind-moderating effects of the Carpathians and Alps. The annual average wind velocity values measured near the surface (10 metres) change between 2-4.5 m/s. The north-western part of the country is the windiest region with a wind velocity of 5 m/s at 80 metres (Fig 15:), the less windy region is the Northern mountain range with an annual average value of 3 m/s. The highest speed velocity value measured in the last 50 years by the OMSZ (Hungarian Meteorological Service) was 44.3 m/s. The highest number of hours used by wind power plants is 1500-1800 hours/year. The first part of spring is the windiest period of the year, and the first part of the autumn the least windy. During the day, wind velocity is the highest in the hours after noon, SODAR measurements show that the daily tendency changes in altitudes above 60 metres (Varga et al, 2006). The first wind maps of the country were based on the data measured in four stations together with neighbouring countries (Dobesch, H. and G. Kury, 1997). Later, these were completed with data from 29 stations (Bartholy et al, 2000).

The average potential capacity in the Great Plain is estimated at 70 W/m²/year, and maximum 180 W/m²/year in the windiest north-western region. International experience shows that a profitable operation requires a speed velocity of 6 m/s with wind turbines in an altitude of 100 metres. According to Hunyár and associates (2006), more than a half of Hungary’s current energy demand could be supplied from wind energy with wind power plants built on only 4.5% of the country’s total territory. Areas not suitable for wind power plant installation and a constant wind velocity were considered.

The creation, operation and demolition of wind power plants are in compliance with EU directives, international treaties and the Hungarian regulation. The system is developing, legislation is changing often and is in some cases contradictory, and it either stimulates or incapacitates wind power plant developments. The most controversial issues in Hungary are the connection of the energy produced by the wind power plants, the solution for the balancing energy compensation, and the amount of grants.

Current status of wind energy

Due to the poor features, the utilization of wind energy began very late compared to the other EU member states. The first wind power plant was opened in 2000 in Inota (Várpalota), the first power plant connected to the network operates in Kulcs since 2001. According to the records of the Hungarian Wind Energy Association 63 wind power plants were built in eight years with a total capacity of 112 MW, this value was of more than 300 MW by 2011. (Fig O.) The number of isolated small wind turbines and wind engines installed in an altitude of 7-10 metres, with a diameter of 2-4 metres, with more blades is also high. They are mainly used in the agriculture and can function at low wind velocity as well.

According to experts, it is not expedient to exceed the level specified in the regulations; this is why the Hungarian Energy Office introduced in April 2006 a restriction of 330 MW until 2011. The number of investors is growing; a capacity of 900-1000 MW is in the application phase.

Outlook

The period of demonstrative projects is over in Hungary; there are more and more wind energy facilities all over the country, and the international tendency shows that their number will grow in the future.

2002: 1 MW (- %)
2003: 2 MW (+100 %)
2004: 3 MW (+50 %)
2005: 17 MW (+466.7 %)
2006: 61 MW (+258.9 %)
2007: 65 MW (+6.6 %)
2008: 127 MW (+95.4 %)
2009: 201 MW (+58.3 %)
2010: 295 MW (+46.8 %)

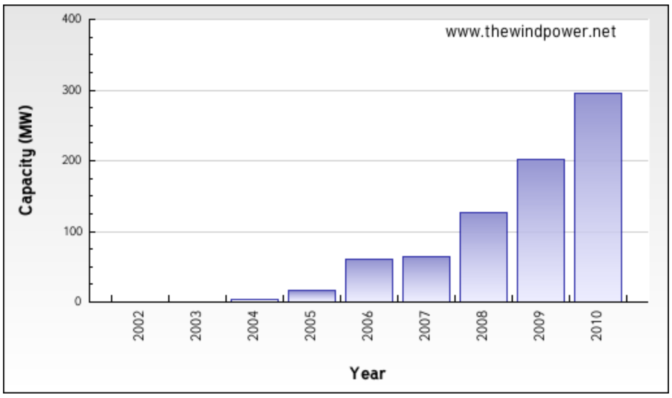


Fig 15: The wind energy production capacities in Hungary (Source: www.thewindpower.net)

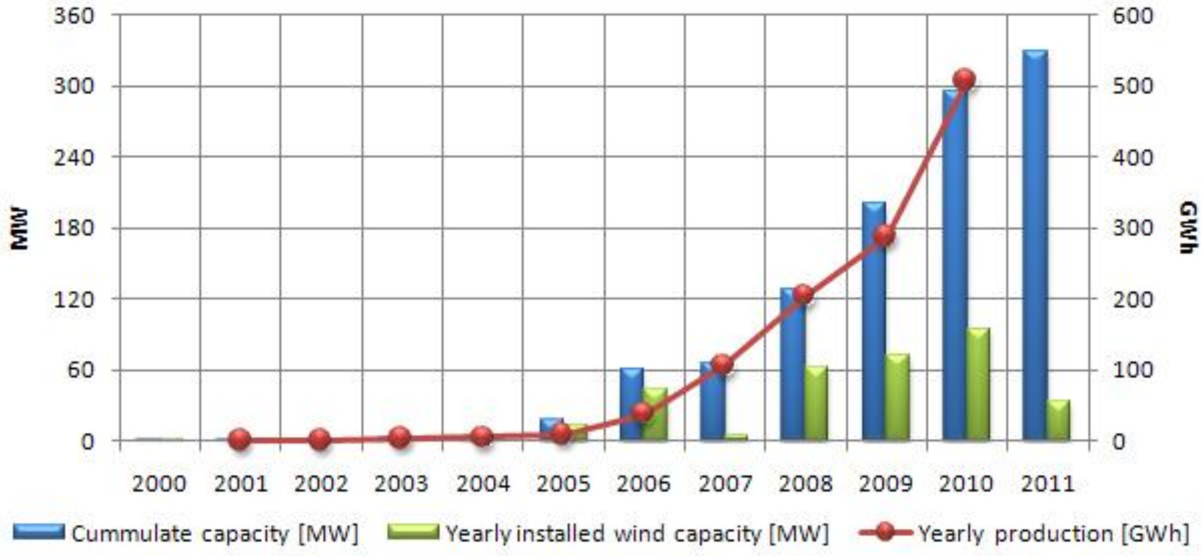


Fig 16: Cumulated wind power plant capacity [MW], capacity of annually installed wind power plants [MW], electricity produced by wind power plants GWh in Hungary (Data of the Hungarian Wind Energy Association and the Hungarian Energy Office) (Source: http://www.mszet.hu/index.php?mid=53)

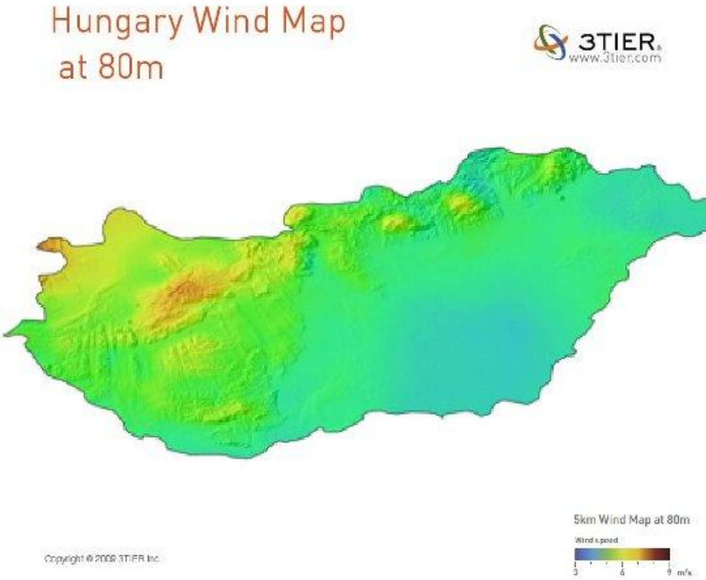


Fig 17: Wind map of Hungary at 80 m. (Source: http://ws2-23.myloadspring.com/sites/renew/countries/hungary/profile.aspx#Wind)

THE WIND ENERGY POTENTIAL OF SERBIA

The Serbian production of electric power includes power plants with a total power of 7,120 MW (lignite-operated thermal power plants with an installed capacity of 3,936 MW, hydro power plants with a total installed capacity of 2,831 MW, and crude oil and natural gas operated thermal power plants and district heating service providers). This does not include the thermal power plants in Kosovo, since it is not part of the Serbian energy production system.

The structure of electric power system in Serbia is very favourable for the construction of wind generators. Their construction should be done in phases, in the course of which it would constantly be necessary to monitor the technical efficiency and economy of already built capacities and accordingly correct the future dynamics of the construction of wind generators. The studies on the country's wind energy potential show that the wind energy potential in Serbia is about 10 000 MW (20 TWh/year) (Fig 18). The studies also show that there are many locations in Serbia where individual wind generators of medium to high power can be installed, and at least 50 good locations where wind generators farms could be installed. These farms, which would include wind generators of about 20 MW (50 × 20 MW=1000 MW), and could be realized in the next 10-15 years. One of the possible scenarios for the construction of wind generators in Serbia and Montenegro is to install 100 MW/year in the following 15 years. At the end of this period, these wind generators would provide about 10 % of the electric energy in the ecologically most acceptable way. Regardless of the chosen strategic model of the development of electric power systems, there will always be a need present and probably also an obligation for the utilization of ecologically clean sources ("green energy"). If our global objective is the integration into the European Union, then it is clear that the reform of the energy sector must be conducted in a way where all processes in the development of energy in EU must be followed. Most of the European states have had the experience that shows that it is necessary for Serbia to include wind energy in the national strategy for the energy development. Accordingly, the first step could be to determine the wind energy potential and suitable locations for the construction of future modern wind generators that will produce electricity in Serbia. (www.doiserbia.nb.rs/)

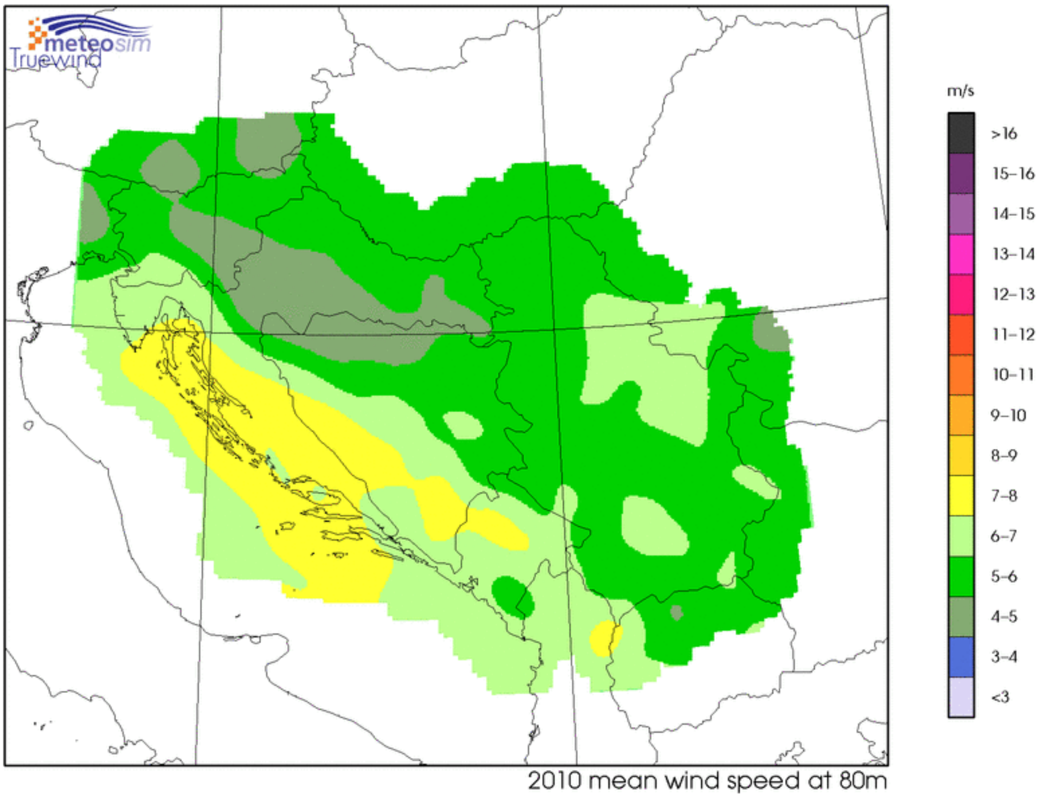


Fig. 18: 2010 annual mean wind speed at 80 m in Serbia (Source: http://windtrends.meteosimtruewind.com/wind_anomaly_maps.php?zone=BLC

THE WIND ENERGY POTENTIAL OF SLOVAKIA

Realistic sustainable wind energy potential that will not disturb the migration routes of birds and other animals in natural parks and in nature protected areas is able to substitute up to 6 % electricity consumption. Wind turbines can be built only in locations where the average wind speed reaches minimum 6 m/s in an altitude of 80 metres. (Fig. 20) Wind turbines cannot be built in natural reserves and national parks. Beyond favourable wind conditions, crucial factors are the connectivity to electric distribution network and non-interference to protected landscape and populated areas. Assuming an application of wind turbines with a capacity of 1,500–2,000 kW, the wind potential of the Slovak Republic represents around 1,100 GWh. (www.euroqualityfiles.net/)

Current status of wind energy

As of today, there are no large scale wind turbines. Yet small wind turbines with a size of one, three, and seven kW are produced locally for battery charging, water heating, and connections to the public grid. Another local manufacturer is in the process of developing a 100 kW turbine with a 20-m rotor diameter. The fact that these units exist is a clear indication of wind energy potential of the country. On the other hand, the fact that the small units reach their rated power at 6-7.5 m/s, would confirm that the average wind speeds are really in the order of 5 m/s at the usual hub-height of 10 - 20 m for small turbines.

The lack of a countrywide wind atlas, respectively of state of the art measurements makes it difficult to estimate the actual resource potential of the country. As far as the legal framework is concerned, the gradual full liberalization of the market is planned only following the privatization, although no firm timetable has been agreed upon.

Wind energy resource potential

Due to insufficient data, no statement can be made for the technical potential for wind energy development in Slovakia. Nevertheless, it would not be surprising to find wind speeds up to 6 - 7 m/s at some mountain locations. Therefore, it would be recommended to asses countrywide wind energy resources by state of the art wind measurements.

Investments with high potential for wind energy

The only indicator for the promising sites is the 2.4 MW project waiting for a new developer, which could qualify for PHARE requirements. This project is located Malé Karpaty, north of Bratislava. (Fig 19)

Barriers to/incentives for wind energy utilization

Environmental protection has become a matter of increasing public concern. In Slovakia the coming legislation will include rules specifying that there is a “duty to purchase and transmit the offered electric energy from the secondary and renewable resources for economically acceptable prices”.

The Slovakian energy policy is reported to aim at covering “the consumption increases by a suitable share of renewable and secondary sources”. Further, “to establish an economical climate in terms of financial implements, prices, tariffs, etc., which can support the rationalization activities, the realization of renewable and secondary sources...”, and also, “to encourage investments of foreign capital”. According to “Energy Concept of Slovak Republic”, a way to realize the goals is to utilize such renewable supplies as wind power. It is noted that “their importance under the conditions in Slovakia is considered mainly local”, that is, belonging to the regional energy policy.

Specific barriers to wind projects in Slovakia

The current, artificially low consumer prices. However, it should also be noted that the consumer prices have gradually increased towards real costs prices. This means that the consumers will pay a price for energy that slowly approaches that determined by the costs of production, transmission, and distribution of electricity, including operation, maintenance, and new investments.

A positive development for renewable energy sources.
The Slovak Republic has modest potential of wind energy as compared with seaside countries such as Denmark or Germany. There are only a few sites to install wind turbines, as the acceptable average wind speed of 5 m/sec is to be found at altitudes of over 1,000 m, in protected and forested areas, far away from the power lines. The country's wind potential has been estimated at 600 GWh/y. The average annual wind speed is a critical factor in site selection. (http://ebrdrenewables.com/)

2003: 2 MW (- %)
2004: 5 MW (+150 %)
2005: 5 MW (- %)
2006: 5 MW (- %)
2007: 5 MW (- %)
2008: 5 MW (- %)
2009: 3 MW (-40 %)
2010: 3 MW (- %)

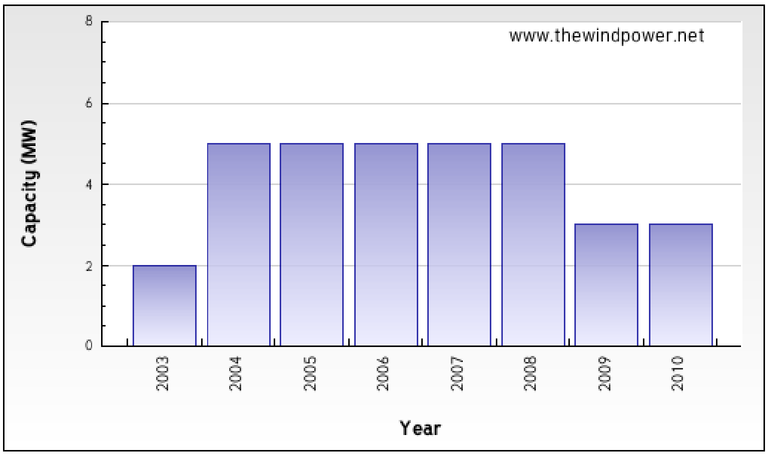


Fig 19: The wind energy production capacities in Slovakia (Source: www.thewindpower.net)

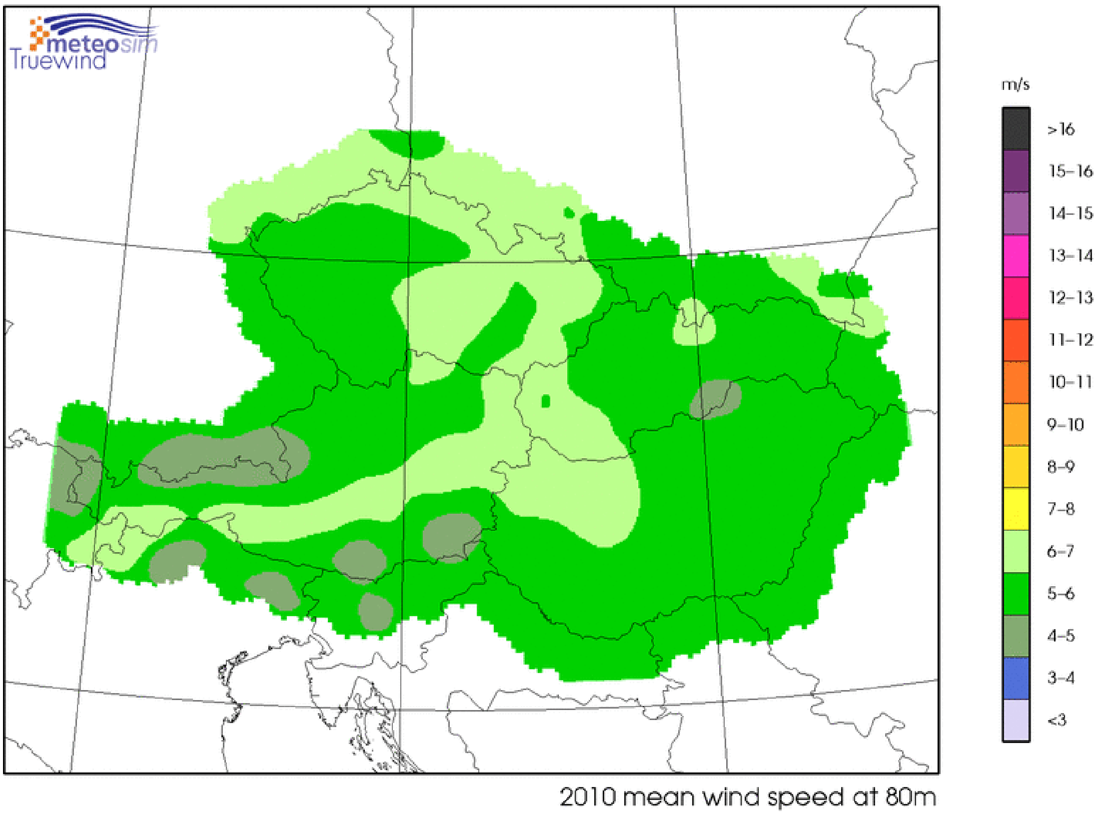


Fig. 20: 2010 annual mean wind speed at 80 m in Slovakia (Source: http://windtrends.meteosimtruewind.com/wind_anomaly_maps.php?zone=AHT

THE WIND ENERGY POTENTIAL OF POLAND

According a report published by the Polish Wind Energy Association in November 2009, 13 GW of wind energy could be installed in Poland by 2020.Wind power is the only renewable energy technology in Poland (Fig 21) ready to attract significant investment, and there is a substantial pipeline of large wind farms spread evenly over the area of the entire country.

Fig 21: Map of wind energy capacity in Poland in 2011. (Source: http://www.pwea.pl/map_of_renewable_energy_sources_in_poland.htm)

These projects could be commissioned relatively soon and will make an important contribution to meeting Poland's target mandated by the new EU Renewable Energy Directive.

Wind energy industry

Currently, there are 22 operating wind farms in Poland, and there are also single turbines or clusters of small turbines spread across the country.

Poland depends on coal for 95% of its electricity production. According to the new EU Directive, Poland needs 15% of its final energy consumption to come from renewable energy by 2020, up from 7.2% in 2005. To date, the country has renewable energy production from biomass, biogas, wind and hydropower. Poland is well suited for large scale wind power development. (Fig. 22)

1997: 2 MW
1998: 5 MW (+150 %)
1999: 5 MW (- %)
2000: 5 MW (- %)
2001: 22 MW (+340 %)
2002: 28 MW (+27.3 %)
2003: 58 MW (+107.2 %)
2004: 58 MW (- %)
2005: 73 MW (+25.9 %)
2006: 153 MW (+109.6 %)
2007: 276 MW (+80.4 %)

2008: 472 MW (+71.1 %)
2009: 725 MW (+53.7 %)
2010: 1,107 MW (+52.7 %)

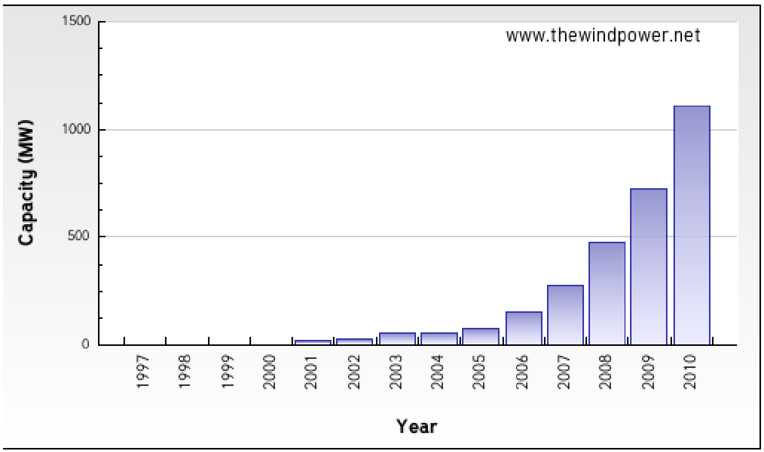


Fig 22: Wind energy production capacity in Poland (Source: www.thewindpower.net)

Average wind speeds between 5.5 and 7.0 m/s (at 80 meters height) in large areas (Fig. 23) of the country make Poland one of the most promising wind energy markets in Europe.

In 2000, the Polish government introduced a power purchase obligation for renewable energy sources, which was first amended in 2003, and again in August 2008. This requires energy suppliers to provide a certain minimum share of power generated by renewable sources.

Following this new requirement, more than 600 producers of renewable energy applied for and received licenses for producing electricity from renewable sources.

In 2009, the Polish government published a strategic document entitled "Energy policy of Poland up to 2030". The main priorities concern energy security, economic competitiveness, increasing the use of renewable energy sources and environmental protection. The document also sets out a target of 15% of RES in final energy consumption by 2020, and a 20% share by 2030. (www.gwec.net)

Obstacles for wind energy development
Some 6% of the area with the best wind conditions in Poland is situated in nature reserve areas (NATURA 2000), and while this does not prohibit the construction of wind farms in these areas, it makes it more difficult.

As in many other countries, grid infrastructure development is also an issue in Poland. The main problem is the lack of an effective mechanism which would oblige grid operators to focus their investments on increasing the operational security of the electricity system and to allow for grid access for wind energy producers.

There are also no clear and transparent rules for determining and allocating costs between grid operators and power producers.

For offshore wind energy, limitations mainly arise from the protected nature reserve areas, weak grid infrastructure in the north of the country and numerous administrative barriers.

Prospects for wind energy development in Poland
Based on the number of applications received by the Polish Energy Regulatory Office for issuing licenses for wind farms, a big increase in wind generating capacity is expected in the near future.

In the period up to 2013, support schemes currently available to investors, including EU cohesion funds (Operational Programme Infrastructure and Environment) and structural funds (Regional Operational Programmes) will help drive wind power growth.

However, the most rapid increase is predicted during the 2014-2020 period, when even more significant financing will become available from the EU funds, in particular from structural funds.

While onshore wind is expected to grow at a healthy rate, no offshore developments are foreseen until 2018, when about 500 MW will be developed. By 2020, offshore wind capacity could reach 1,500 MW.

The Polish Wind Energy Association predicts very dynamic growth of installed capacity in the wind power sector, amounting to about 13 GW in 2020. The figure comprises almost 11 GW of onshore wind farms, 1.5 GW in offshore wind and 600 MW of local small wind turbines. **(**www.gwec.net)

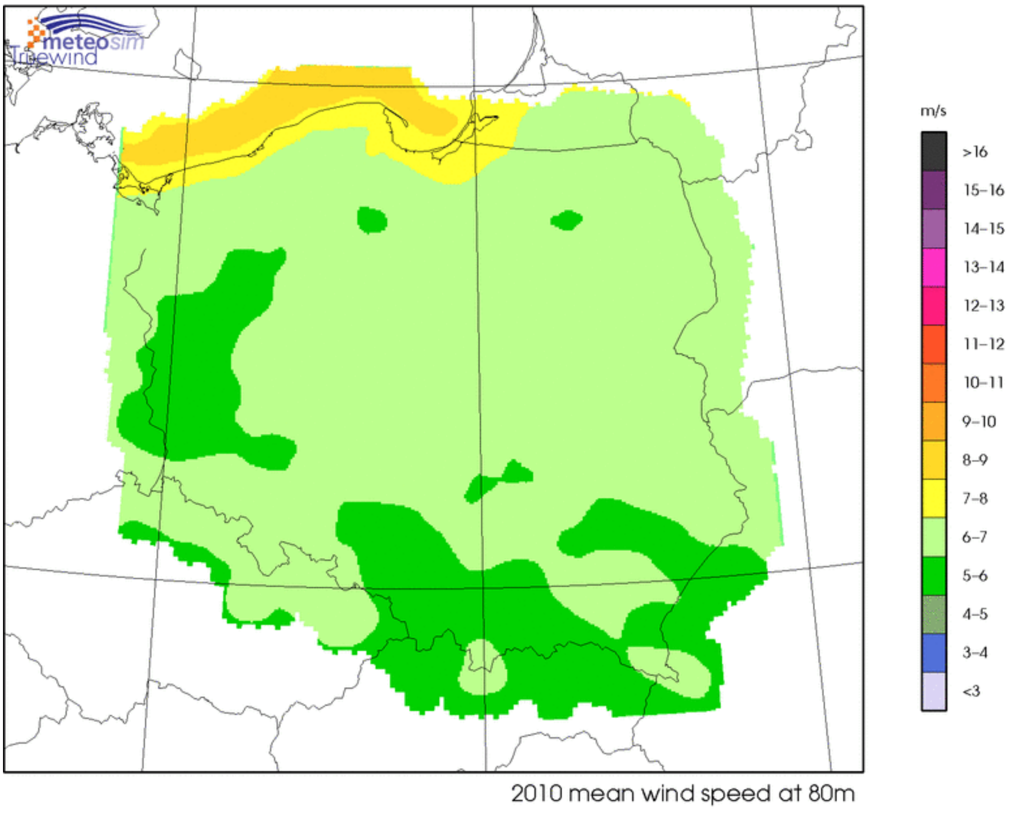


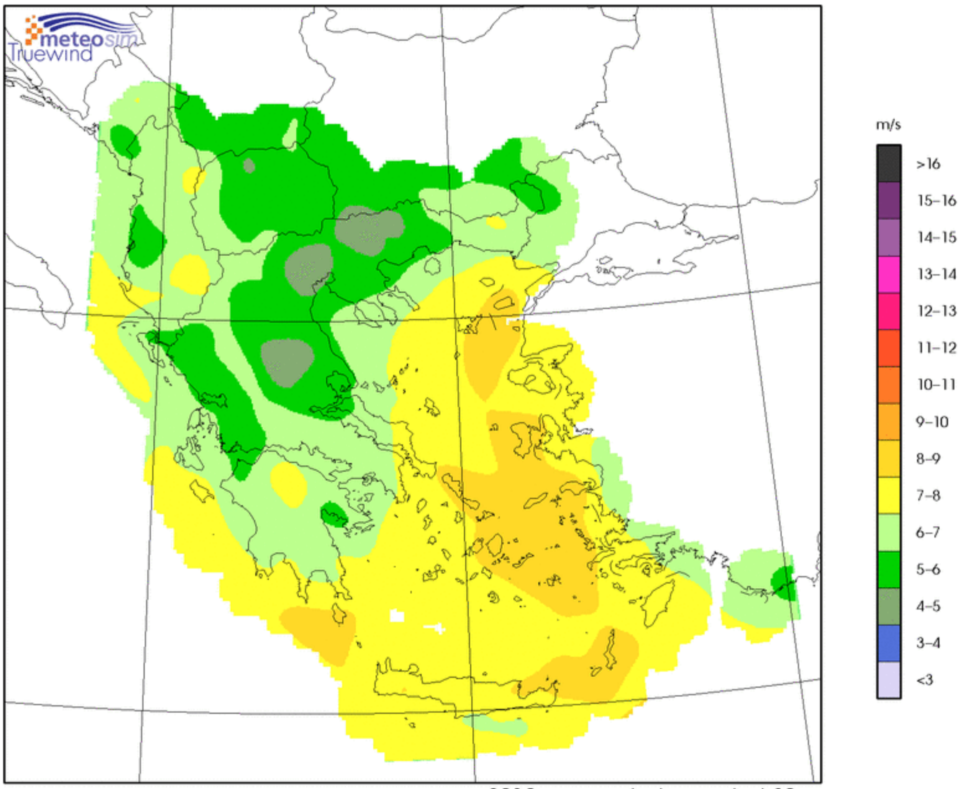
Fig. 23: 2010 annual mean wind speed at 80 m in Poland (Source: http://windtrends.meteosimtruewind.com/wind_anomaly_maps.php?zone=POL)

THE WIND ENERGY POTENTIAL OF FYROM

Currently, wind energy is not applied in this country. In the past three years, several wind measurements were executed in different areas, and feasibility studies are also in progress. With grant support by the Norwegian Government, the Norwegian company (NTE) in cooperation with ELEM has undertaken wind measurements in four sites but no further details have been published yet. In 2005, the American company AWS Truewind developed the wind atlas, which estimated the wind potential in Macedonia and determined attractive regions for use of wind power. According to the preliminary atlas, the most favourable regions are hills and mountains nearby the Vardar River and between Kavadarci and Gevgelija where the wind speed averages 7.0-7.5 m/s. (Fig. 24) Several areas have been identified to have potential for wind farms development: Kozhuf, Bogdanci, Shashavarlija, Bogoslovec, Venec, Erdjelija, and Demir Kapija. However, data from measurements are not public which hinders the process of attraction of investors interested in wind development. The wind can reach speeds of over 8 m/s only in mountainous areas, but usually the exploitation of the wind power in these areas is hard because of their inaccessibility. In Macedonia, 12,000 to 15,000 MWh of electricity can be produced with wind energy, however, currently there are no wind mills in Macedonia One of the main reasons for this is technical, since there is no atlas for the wind in Macedonia, thus the potential investors cannot find the necessary data for the country's wind capacity. There is a Monitoring programme of the Wind potential in progress, implemented by the Energy Agency, which consists of measurement and data collection of the wind parameters. (www.analyticamk.org/)

Outlook

In order to facilitate investment in wind energy development in Macedonia, the World Bank is assisting in the preparation of a wind integration study. The aim of the cooperation is to understand the importance of integrating wind farms in the energy supply and to help the transmission system operator to deal with issues relating to absorption capacity and connection requirements. (www.macedonia.usaid.gov/)



2010 mean wind speed at 80m

Fig 24: The mean wind speed in 2010 at 80 m (Source: http://windtrends.meteosimtruewind.com/wind_anomaly_maps.php?zone=GAM)

THE WIND ENERGY POTENTIAL OF ITALY

By 2010, Italy was host to 4,850 MW of wind generation capacity, an increase of more than 1,100 MW compared to 2008. The regions adding the most new capacity were Sicily, Puglia and Calabria, followed by Campania and Sardinia. Important developments are also taking place in central and northern Italy, in regions such as Liguria, Piedmont, Veneto, Emilia Romagna and Tuscany. (These regions had high wind speed. Fig. 25)

The Italian Wind Energy Association (ANEV) estimates that more than 6 TWh of electricity were produced by wind energy in 2009, bearing in mind that around 700 MW of new capacity was introduced only in the second half of the year.

The global financial crisis affected Italy's wind energy sector as well. Its impact was shown not in terms of production or employment, but in terms of tightening financing of new and running projects. Consequently, some project funding has slowed down and was rescheduled. (www.ewec2007proceedings.info/)

Policy developments
The 1999 Bersani decree provided for the gradual liberalisation of the Italian electricity market and encouraged generation from renewable sources by introducing priority grid access for renewable electricity, as well as a renewable energy quota system. This requires power producers and importers to produce a certain percentage of electricity from renewable sources.

In January 2002, Italy implemented a new support mechanism for renewable energy sources based on Green Certificates, to replace the abolished CIP6 regime and to complement the quota system

The 2008 Finance Act and the subsequent Ministerial Decree from December 2009 introduced an increase of the quota, which provides for an annual increase of 0.75% for the years 2007 to 2012. This translates into a quota of 5.3% in 2009, 6.05% in 2010 and 6.8% in 2011.

In addition, the following changes were implemented to the Green Certificate system: Characteristics of Green Certificates: From 2008, Green Certificates have a value of 1 MWh. For calculating the number of Green Certificates, the net electricity output of each plant is multiplied with a parameter, depending on the technology. For onshore wind, this parameter is 1.0; for offshore wind it is 1.1.

Under the EU Renewable Energy Directive, Italy is required to increase its share of renewable energy to 17% of its final energy consumption, up from just 5.2% in 2005.

Obstacles for wind energy development
In addition, the Italian electricity system suffers from inadequate grid infrastructure, which leads to frequent curtailment of wind power production to manage grid connection. The grid problem concerns all wind power plants in Campania, Apulia and Basilicata and some projects in Sardinia. These problems occur especially on old-fashioned 150-kV lines that are incapable of dispatching all the power produced by the wind farms.

In 2009, some wind farms operated at 30% less than their normal capacity over the course of the year due to inadequate grids. In some cases, wind farms were limited by over 70%, and in other cases, some wind farms were shut down completely.

Italy's grid issues need urgent attention, and the sector is waiting for a strong structural response to adapt the grid to accommodate both the current installed capacity and the planned wind energy capacity increase.

Wind energy sector

The wind sector is beginning to gain importance in Italy as employment grows in various sectors that are directly and indirectly connected to green energy technology development. A study on employment in the sector, jointly conducted by the Italian Labour Union and ANEV, revealed that in 2008, more than 15,000 people were employed in the Italian wind energy sector, 4,500 of whom were employed directly.

Assuming that Italy reaches its goal of 16,200 MW by 2020, the total number of jobs would rise to 66,000, of which 19,000 would be direct employment. (www.ewec2007proceedings.info/)

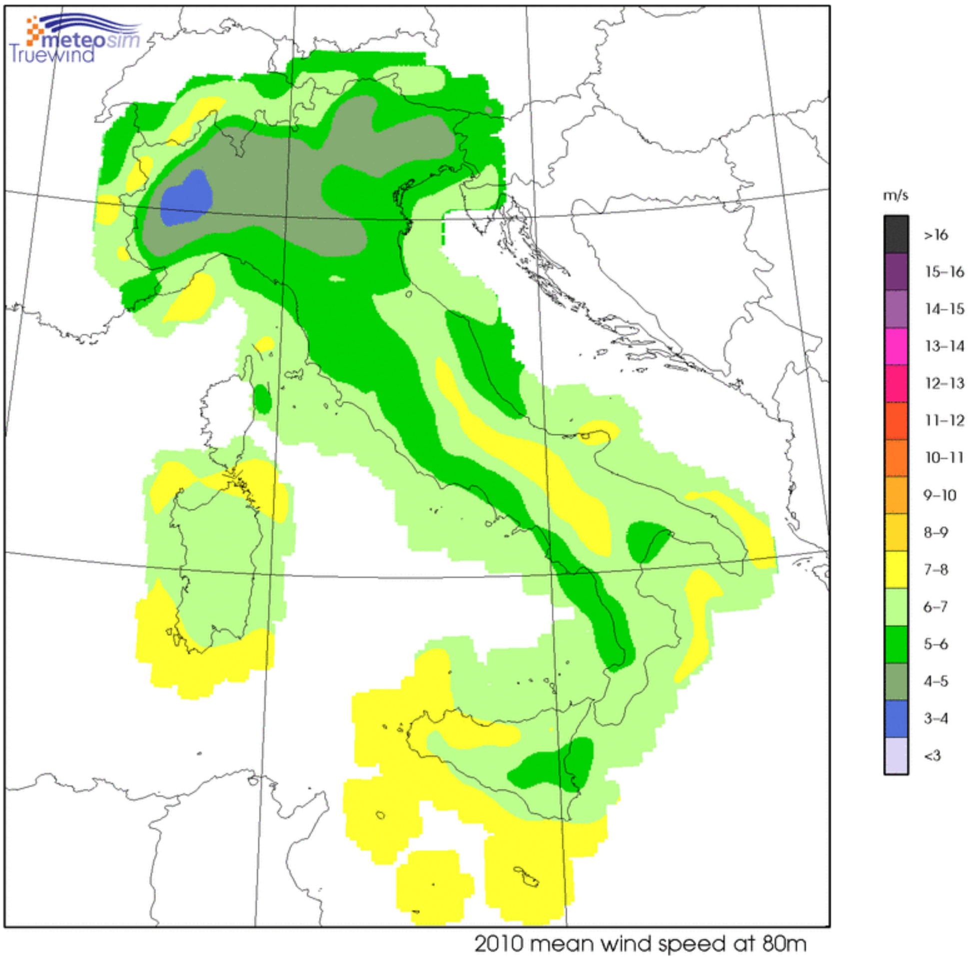


Fig. 25: The mean wind speed in Italy at 80 m (Source: http://windtrends.meteosimtruewind.com/wind_anomaly_maps.php?zone=ITM)

THE POSSIBILITIES OF BIOMASS UTILIZATION IN CEE

Biomass: A mass of organic matter of biological origin, body mass of living or recently died organisms in one biocoenosis or biome, on dry land or in water (plants, animals microorganisms), products of biotechnological industries; and any biological product, waste or residual product of the different transformers (human, animals, processing industry etc.). The body mass of humans is not included in the concept of biomass, but the biogas from the wastewater is. The primary source of biomass is the assimilation activity of plants. The process of its formation is the main topic of production biology. The plant-originated biomass is phytomass, and the animal-originated biomass is the zoomass. According to its place in the production-consumption chain biomass can be primary, secondary and tertiary. The primary biomass is the natural vegetation, crops, forests, fields, pastures, and garden and water plants. The secondary biomass is the fauna and the domesticated livestock, and the products, by-products and waste of livestock production. The tertiary biomass is the any product, by-product and waste of the processing industry dealing with biologically originated materials, and the organic materials of human settlements. The main use of biomass is food production, animal nutrition, energy-purposed use, and the production of agricultural raw material. Burning, pelleting, pyrolisation, gassing, and the production of biogas are the main utilization ways for energy production. Microorganisms proliferate very quickly during the aerobic biological wastewater treatment in proportion to the available nutrients, the oxygen content of the water, and the temperature. The biomass is the body mass of dead microorganisms, which can be removed by settling or flotation (activated sludge). Biomass formation can occur in an oxygen-free medium through anaerobic microorganisms, but at a much slower speed. Another form of biomass formation is the bloom of algae in living waters (cooling waters). (Lexicon of Environmental Protection)

History

Up to our days, the history of fuels was the history of biological fuels. Not considering the sources, the coal found at the seashores and emerging coal layers, biomass was the only heat source beside the Sun up to the 17th century. Animal and vegetable oils or tallow candle were burnt to ensure lighting.

The oldest bio-energy is the power of beast of burden that it is still used mainly in on smaller farms in developing countries. It is the most typical energy source in 80-90% of Africa and Asia. By 8 hours of work, 100 days a week, one animal is able produce 90 TWH or 320 PJ/year, and this is only a fraction of plant-generated energy. Wood was succeeded by coal at the beginning of the industrial revolution. Industrial development is usually explained with three contrary statements:

- The growing living standards provided favourable conditions for technical innovations. This led to the growing number of machines used, for which coal was a better fuel than wood.
- Scientific inventiveness resulted in broad technological changes with the use of the energy from coal. The improving prosperity was only a consequence of industrialization.
- The growth of population, poverty and the increasing costs of wood led to the advancement of coal that was available to a smaller amount. The aboveground coal supply was quickly exhausted, deep mining and deep pumping of water became necessary.

Almost the total energy demand of Nepal and Ethiopia is satisfied from biomass, 75% in Kenya, 50% in India, 25% in Brazil.

The four-billion population of the developing country uses more than 3 Gt (air-dried) of biomass. The use of bio-fuels in industrialized societies is also important, meaning a consumption of 1/3 ton/year per capita (3% of total energy consumption).

Researches on the use of renewable energy sources began at the end of the 1970s, after the second energy price shock. The developed and modern large-scale biomass firing systems were widespread in the agricultural, local industrial and communal sectors of certain countries. The development of complicated and expensive technologies stopped due to the stabilization of the energy prices at a low level on the international market. The development of related technologies started again in recent decades, due to the worsening environmental problems worldwide. Another reason for the prominence of developments was the objective to use the unused cultivation areas in Western Europe, and to retain the rural population. Currently, the European agricultural sectors use approx. 1.7 million tOE of renewable energy sources, the majority being firewood and silvicultural and forestry by-products with a quantity of 1.2 million tOE. Another energy source is the use of straw by direct firing, with 0.3 million tOE.

According to some sources, one tenth of the EU's territory could be used for energy-related biomass production. This would mean 80 million tOE per year, covering 20% of the regions current electric energy demand. In Europe, the use of wood for energy purposes shows an annual increase of 2.3%.

Theoretical background

Bioenergy: chemical energy in living organisms and organic matters after their death, which is generated from the solar energy through photosynthesis by the green plants. Bioenergy is the Earth's most important renewable energy source. It is an important mean of reduction of the greenhouse effect, since it is CO_2-neutral. Fossil energy sources have their origins in bioenergy as well, but they are not renewable. Their imminent exhaustion urges the rational and widespread use of bioenergy: biogas, thermal conversion, cellulose decomposition through bioconversion, gassing, and other methods. (Lexicon of Environmental Protection)

The total mass of the Earth's living matters, including moisture, is 2,000 billion tons. Some data related to biomass quantity according to the Open University:

Total mass in land plants: 1,800 billion tons. Total mass of forests: 1600 billion tons. World's population: 7 billion. Per capita terrestrial biomass: 400 tons. Energy stored in terrestrial biomass: 25,000 exajoule, 3,000 EJ/year (95 TW). Net annual production of terrestrial biomass: 400,000 Mt/year. 1 Exajoule (EJ) = 1 million megajoule. 1 Terawatt (TW) = 1 million megawatt. Total consumption of all forms of energy: 400 EJ/year (12 TW). Biomass energy consumption: 55 EJ/year (1.7 TW). Food energy consumption: 10 EJ/year (0.3 TW).

Only a small amount of the total solar radiation reaches the Earth, and only a fraction of it is used by the plant through photosynthesis.

Photosynthesis is the totality of processes, during which vegetable organisms and some bacteria transform the energy of light into chemical energy, and produce organic matters with the help of it.

Significance:

- The energy of light transformed during photosynthesis provides the energy for the energy-consuming processes of the whole ecosystem.
- The composition of the Earth's current atmosphere is the result of photosynthetic processes (its complete oxygen content is of photosynthetic origin, the estimated quantity of the coal assimilated through photosynthesis reaches 44 billion tons!)

Essence:

- The ability of green plants to build their own organic matters from water, minerals and carbon dioxide with the help of green plastids and sunlight. It is a redox process, during which an electron is transferred to the acceptor from the electron donor in a way that the energy required due to the redox potential differences is provided by light.

- The energy stored in plants is utilized in the plants, soil, surrounding atmosphere, living beings during several chemical and physical transformation processes, and finally radiates from the Earth in the form of low-temperature heat, except for the parts that transform into peat or fossil energy source. The importance of this cycle for us is that if we intervene and exploit a part of biomass in its state as chemical energy storage, we win one energy source. The broad scale of biofuels includes the simple burning of wood to the multi-megawatt urban incinerator power plants. The state of matter of biofuels can be: solid, liquid or gaseous; they can be originated from organic matters, industrial, agricultural, communal and domestic waste.

The basis of the utilization of biomass is burning, which results in the evolution of thermal energy. The following chemical equation contains the major steps of the burning process, through the example of methane. Every methane molecule contains one coal and four hydrogen atoms: CH_4 . During burning, the reaction partner is the diatomic oxygen molecule: O_2.

Every methane molecule reacts with two oxygen molecules during burning: oil, coal and other fuels are more complex than methane, but their burning is similar.

Biomass is the fourth most common energy source after coal, crude oil and natural gas. Biomass covers 14% of the world's utilized energy, and 34% in the developing countries.

Biomass energy sources can be:
- by-products and waste of agricultural crops (straw, maize stalk and cob, etc.)
- plants cultivated for energy purposes (rape, sugar beet, different tree species)
- biomass of animal origin (manure etc.)
- Forestry and silvicultural by-products and waste (wood chips, cuttings, sawdust, fibre etc.)

The characteristics of biomass:
- it is renewed through photosynthesis
- energy storage is realized by storing the energy of the sunshine in the form of chemical energy by the organic matters created in plants
- it can be used as an energy source without increasing the carbon dioxide level of the atmosphere
- it largely facilitates the preservation of mineral resources
- emission (CO_2, CO, SO_2, C_xH_x) is significantly lower than in the case of fossil energy sources
- lands released due to food overproduction provide realistic basis for a rational biomass production
- it has a favourable effect on rural development and job creation

Utilization possibilities:
Biomass, as an energy source, can be used in the following ways:
1. Directly:
- with burning, without or after preparation

2. Indirectly:
- after chemical transformation, as a liquid fuel or combustible gas
- fermented fuel
- biodiesel through transesterification of vegetable oils
- biogas after anaerobic fermentation.

Biomass energy sources can be used for small and medium performance decentralized heat and electric power production and as engine fuel due to its relatively low energy density.

Utilization of the solid biomass

Agriculture and forestry produce annually a high quantity of by-products. These can be used for several purposes, such as the replacement of soils in plant cultivation, livestock farming, industrial purposes, and energy production.

Unfortunately, less than 10% of the produced quantity is used for burning/energy production purposes. Straw and wood wastes are the most appropriate for energy production, maize and sunflower stalk are rather appropriate for soil amelioration. The large quantity of cuttings at fruit tree plantations are rarely utilized, they are burnt in an energy-wasting and pollutant way, despite of the fact that there are equipments available for their cutting and burning. 22% of the logged wood material in forestry can be considered as by-products. 41% of the net wood production is fire wood, 59% industrial wood. A large quantity of by-products and waste is produced during the production of industrial wood, these could be used for energy production purposes. The produced wood chips, sawdust and bark are dried and briquetted, which can be easily used. The by-products of wood production are only partially used for energy production. They are rather used for domestic purposes, used or sold as wood chips. KACZ-NEMÉNYI

Cropping for energy production purposes can serve the alternative engine fuel production (alcohol, rape methyl ester etc.), and production of combustibles (bio-briquette, energy forest, rape oil). The net heat energy yield of biomass production in case of agricultural and forestry by-products changes between 0.3 and 1.3 tOE/ha, and between 1.7 and 2.6 tOE/ha in case of energy forests (KOCSIS et al., 1993). Cropping for energy production purposes has several barriers according to KACZ-NEMÉNYI (1998):
a) It is hardly accepted by producers and society
b) Difficult adaptability of production methods into existent agricultural technologies.
c) Small energy efficiency of transformation equipments.
d) Bad energy input/output efficiency of transformation.
e) Big investment demand of biomass utilization.

The following plants can be considered for energy production:
a) Different tree species (energy forests – poplar, willow, acacia).
b) Crops with high sugar content (sweet sorghum, sugar beed).
c) Plants with high oil content (sunflower, rape, soy).

Plants with high oil and sugar content can be cultivated with traditional technologies, while the plantation, maintenance and production of energy forests differ from those.

The objective of energy forests is to produce a well-burning combustible in the shortest possible time and at the lowest possible costs. Their planting can be considered on uncultivated territories with good production potential. Poplar, willow, maple, alder and acacia can be considered for energy forests, acacia being the most appropriate since it grows fast, it springs good, it has low water content, and can be burnt in wet condition too. Willow energy forests were researched in Denmark and Sweden, with 20,000 pc/ha planted and logged every three years. The expected lifetime of the plantation is 30 years, meaning 10 productions. Other foreign tests produced with poplar reached 10-13 t of dry material per ha with a seven year rotation.

The heating value of wood depends on:
- the water content (the higher the water content, the lower the heating value)
- the tree species (density)

The higher water content, the lower heating value, since the water evaporates during burning, and this requires heat. Biofuels are rarely burnt in their original form, they require pre-treatment based on their type, e.g.: cutting (chipping, grinding, chopping), briquetting (cubing, slugging, pelleting). Briquetting and pelleting are followed by drying, since the water content of biofuels is higher than required by the technology (should be below 20%).

Briquetting is required for the easy transportation and use of agricultural and forestry by-products.

The main types of compressed biofuels
Pellet: Diameter: 10-25 mm.
Bio-briquette: Diameter 50 mm or bigger, round, square, polygon or other profile, produced from agricultural or forestry by-products. Briquettes are produced with ram or extruder presses. Usually they are produced without adhesives. Different by-products can be mixed for solidity, e.g. sawdust or pine bark to straw briquette. Briquetting is only possible in case of materials with a water content of 10-15%, thus lower water content implies drying.

Advantages
a) Its heating value is similar to the lignite (15,500-17,200 kJ/kg), but it is cleaner than lignite.
b) Compared to the 15-25% ash content of coal, it contains only 1.5-8% of ash that can be used for soil conditioning.
c) Its maximum sulphur content changes between 0.1 and 0.17%, while coal contains 15-30 times more sulphur.

Its disadvantage is that it falls apart when wet, but it can be stored for an unlimited time in a dry place.

Main parts of firing installations according to KACZ-NEMÉNYI:
- fuel container with discharge equipment,
- fuel transport system,
- fuel and air feeding system,
- heat exchanger (boiler),
- as/slag disposer,
- fume-collecting chimney,
- regulator and safety equipment.

Advantages of the use of biomass for energy production purposes:
a) Reduction of sulphur dioxide emission. The biomass used for firing has a sulphur content of less than 0.1%.
b) Lower smoke emission.
c) Reduction of emission of polycyclic aromatic hydrocarbons.
d) Carbon dioxide emission is equal to zero, since the plant with high oil content took the amount of carbon dioxide emitted in the previous year by the burnt fuel in the atmosphere through photosynthesis. There is a certain amount of carbon dioxide emission during production, collection, preparation and transport.

Disadvantages:
a) Bigger nitrogen-dioxide emission (probably from the nitrogen of the air due to the high-temperature burning).
b) RME affects the coat of lacquer after a long time, but this can be eliminated with the proper type of lacquer.
c) There is no state aid available yet.

Utilization of the liquid biomass
Every condition is available for the cultivation, the rape seed oil can be used as fuel, lubricant, hydraulic oil and furnace oil.

The liquid energy sources produced from plant biomass can be alcohols, fats and oils that can be used as:
a) engine fuel,
b) hydraulic and brake fluid,
c) lubricant,
d) for firing purposes,
e) raw material for the chemical and food industries.

The burning of these energy sources is not yet significant, but they – and especially the vegetable oils – could play a major role in the partial replacement of fossil energy sources.

The alcohols and vegetable oils can be used as engine fuel:
a) raw
b) after chemical transformation,
c) mixed with traditional fuels,
d) dosed.

Among alcohols, the utilization of ethanol is known all over the world. Ethanol can be produced from biomass with high sugar, starch or cellulose content through fermentation or distillation after the combination of hydrolysis and fermentation. A great quantity of ethanol is being produced in Brazil from sugar cane, and in USA from corn. The most appropriate for industrial alcohol production are sugar beed, sweet sorghum, maize, corns with spikes and potato. 3000-3500 l/ha alcohol can be won from sugar beed and sweet sorghum, 2000-2500 l/ha from maize, 1000-2000 l/ha from corns with spikes, and 2000l/ha from potato (KACZ-NEMÉNYI, 1998).

The energy content of ethanol is smaller than the petrol's, 25-50% more ethanol is required for the same performance. Accordingly, the engine tanks of cars running with ethanol have to be bigger, the parameters of mixing structural elements have to be increased. A favourable fuel can be mixed from petrol and ethanol, since the octane number and oxygen content of the mixture grow and the burning conditions improve. The fuels motalco and gasohol are produced by adding 5-15% of ethanol, petrol with an alcohol content of 20-22% is used in Brazil. Methanol can be used as engine fuel as a component to be mixed with traditional fuels to a maximum quantity of 15%. Mixture problems occur when added to petrol, thus ethanol, methanol and petrol have to be mixed for a good mixture.

Rape seed contains 38-45% oil. In Germany, 1.3 tons of oil can be produced from 3 tons of rape per hectare. The half of the oil is pressed from the seed mechanically, the remaining oil is extracted from the chopped slugs with solvents (n-hexane). The waste contains only 0.5-2% oil.

Disadvantages of the use of vegetable oils:
a) higher inflammation point (difficult firing)
b) big viscosity (bad pulverizability)
c) coking tendency.

These features can be improved with chemical transformation (RME – rape methyl ester can be won through transesterification of rape oil fatty acids with methanol. 1000-3000 t of rape seed can be processed per hour in Germany's crushing mills, the annual production capacity is approx. 3.7 million tons. 1300 l of rape seed oil can be won from one hectare of rape, 1375 l of RME through transesterification, 1774 kg of rape slag with a 30% protein content that can be used as fodder.

Glycerine is produced as a by-product during the production of RME and sunflower methyl ester (SFME). The chemically pure glycerine is used for:

a) solid combustible (briquette is made from 20% glycerine and sawdust).
b) manure (mixed with liquid manure)
c) ethanol production: it is purified through neutralization, then saccharized, fermented and distilled.

The different glycerine derivatives are used for:
a) cosmetics
b) tooth paste
c) medicine
d) nutrients
e) lacquer
f) plastic
g) synthetic resin
h) tobacco
i) explosives
j) cellulose processing (KACZ-NEMÉNYI, 1998).

Modern facilities that guarantee an oil production of more than 90% are available for the production of rape seed oil. (One of the most appropriate equipments is the KOMET extruder press). These presses can process from 2-5 kg of seed per hour up to 70-100 kg/h. The oil produced with the extruder press is very clean, it contains only a small amount of impurities that can be eliminated through a 24-h settling.

Countries that export crude oil could decrease their dependence from other countries with the production of rape seed oil.

The main objective during the use of biomass energy sources:
- The use of by-products and waste shall be executed in their original form in order to avoid higher expenses,
- The preparation of burning shall contain only the main stages, e.g. chopping, cubing
- Transport shall be made for short distances.

A significant amount of ash is produced during the burning of solid biomass. This ash can be used for soil conditioning due to its potassium content. (The ash from coal is not suitable for such purposes due to its high sulphur content.)

The extent of the emission of harmful substances depends on the size, operation and performance-utilization extent of the firing equipment (machine-fed equipments have better indicators).

The utilization of biogas
Gaseous energy sources can be produced from materials generated during agricultural production.

Biogas production: Anaerobic process carried out with mixed culture – in two basic steps with a group of acid bacteria. During the first stage, acid fermentation, the micro-organisms decompose the materials into complex organic acids. During the second step, another group of bacteria decompose these materials into carbon dioxide, methane and other gases. The final product of the process is biogas for energy purposes containing mainly methane and carbon dioxide. The remaining by-product is digested sludge, which will be used as organic manure. This two-stage process is mainly realized in a reactor due to cost-reduction reasons, but the efficiency and regulability of the process can be improved, if the acidic and methane decomposition stages are carried out in separate reactors.

Biogas extraction well: These are suitably formulated, perforated pipes made mainly of plastic, installed vertically in the disposed waste layers laid in order, which make it possible to extract biogas created in the deeper layers.

Biogas production in landfills: This is biodegradation under anaerobic circumstances in communal landfills resulting in biogas rich in methane, which is extracted through vertical or horizontal pipes installed in the waste. The biogas produced with the collection network can be used for energy purposes.

Biodegradation: Aerobic or anaerobic process, during which the saprophyte microorganisms of the soil detect the biogenic elements and make them available for the plants. These elements take part in the build-up, energy storage and transport of the organic matters. Biodegradation secures the continuity of organic matter production, since it is only the degradation of organic matters and the cycle of elements in the ecosystem that enable the maximum exploitation of the limited number of elements. At the end of complex physical, chemical and biological biotransformation processes, organic metabolic products are formed instead of inorganic compounds; this process is called mineralization. The speed of biodegradation largely depends on the molecular structure (the degradation of polycyclic and halogen compounds is very slow), the environmental factors, and the quantity of microorganisms with enzymes that can decompose the actual compound. The grade of biodegradation defines the speed of the cycle of the elements within one ecosystem. Its study is very important for waste treatment and disposal, and the biological elimination of pollution. This process is often used during composting of organic communal and production wastes, biological treatment of wastewater, and cleaning of polluted air containing organic components. (Lexicon of Environmental Protection)

The types of gaseous energy sources:
- biogas resulting from biochemical processes (anaerobic fermentation)
- gases from thermochemical (pyrolytic and gassing) processes.

Biogas: Gas developing with the help of bacteria during the anaerobic decomposition of organic matters and the gassing of biomass in a closed space (fermentation, rotting). It contains carbon dioxide -30%- and methane -70%. The combustion heat of biogas developed from pig slurry is approx. 23,000 kJ/m^3. It develops spontaneously, and catches fire in swamps, marshes (ignis fatuus), manure heaps, dumps. Raw material can be communal waste, agricultural or forestry by products. 60-300 m^3 of biogas can be produced from one m^3 of waste. The fermented manure remaining after biogas production is called organic fertilizer (biohumus), which is a complete, manageable, inodorous material for fertilization of gardens and parks. Its artificial production started at the beginning of the 19th century. The first biogas generator was opened in 1856, in India. Many millions of such plants operate worldwide (mainly in Asia), the majority of them are of “family” size, but there are “power-plant-type” biogas sites as well supplying energy for complete towns. The first biogas production plant was established in 1959, in USA. Biogas can be directly used for heating, cooking (similarly to natural gas, with the same equipment), or for electricity generation, operation of vehicles, and as fuel for internal combustion engines. All kinds of organic waste, manure, domestic and food industrial waste, slaughterhouse and communal wastewater, and agricultural waste can be converted into biogas. The pathogenic organisms die during biogas formation. This is very important from the point of view of the public health. The remaining compost preserves every valuable mineral, and can be used as organic manure. Biogas can become the essence of future energy sources, it is very environmentally friendly, and can have an important role in organic agriculture (organic manure replacement). (Lexicon of Environmental Protection)

Biogas – the most important one of the two energy sources – can be produced from primary and secondary biomass sources, from primary products and by-products of plants, and any kind of natural organic matter (organic manure, excrement, food industrial by-products, waste, domestic waste, communal wastewater and their sludge).

The basis of production is the organic matter, the closed environment, and the presence of methane bacteria. This allows a spontaneous methane production. Intensive biogas production requires a constant and balanced temperature, constant mixing, appropriately chopped organic matter, and the right proportion of methanogenic and acidogenic bacteria acting in symbiosis.

During biogas formation, the organic materials decompose into simpler compounds (acidic phase), and break into their components, methane (approx. 60-70%), and carbon dioxide (approx. 30-40%), and different elements depending on the original materials (H, N, S etc.) (methanogenic phase).

The composition and heating value of biogas depends on the original organic material and the applied technology. During the use of the produced gas, the users must consider that it shall be used near the production site to a proportion of 95%. The utilization in boilers and recuperators is the most profitable way to use the gas, since it has an efficiency of around 80%.

Utilization possibilities of biogas:
a) Thermal use
- gas heaters
- gas burners
b) complex use
- electric and thermal: gas engine/turbine with generator and heat exchanger
- mechanical and thermal: gas engine/gas turbine and heat exchanger
c) mechanical use
- gas engine
- gas turbine

THE BIOMASS ENERGY POTENTIAL OF HUNGARY

Biomass can be used for energy purposes by utilizing the by-products and waste of agriculture and forestry, and within energy forestry (energy forests) and plant cultivation for energy purposes (energy plants). In Hungary, there are realistic possibilities for the use of these resources. In developed countries, the lands released due to food overproduction provide realistic basis for the establishment of energy forests, energy plant cultivation. Biomass can ease the unemployment problems of the given region, a renewable energy source is produced, and the money spent for energy sources stays in the region and helps the region's development. The proportion of areas released from food production in developed countries reaches 20%. In case of Hungary's EU accession, we can calculate with 50,000-1,000,000 ha of land released from production. The use of alternative energy sources will be an important task, since Hungary has signed the Rio Declaration, in which the member states declare that they reduce CO_2 emission to the level of 1990 by 2000, and to keep it on that level.

The amount of dry renewable plant biomass with primary and by-products reaches 55-58 million tons. 6-8 million tons of organic matter could be used for energy purposes (minimum 3-4 million t) from the 25-26 million t of agricultural and 1-2 million t of forestry by-products. In order for the use to be larger and more efficient, proper ecological, economic and technical conditions must be available. The total energy potential of the 6-8 million t of biomass is approx. 1.5-2.0 million tOE.

500,000 ha of energy forests can produce 0.8-1.0 million tOE of biofuel, the capacity of 300-400,000 ha of biofuel can reach 0.5-1.0 million tOE on a long term. In Hungary, firewood is worth 0.32 million tOE in the energy balance, other biomass resources 0.1 million tOE, representing around 0.14% of the country's total energy utilization at the beginning of the 1990s. (KOCSIS et al., 1993).

In Hungary, biomass is the most used resource among renewable energy sources. Currently, firewood is the primary resource for biomass. The main materials for heat and briquette (sold in retail trade) production are forestry waste and sawmill by-products. Around 40% of logs are used for energy purposes.

Despite the use of forestry by-products for energy purposes, only 10% of our resources are being used. The significant quantity of forestry waste could be used for electricity production, and more efficiently for domestic and industrial heat production.

Around 40% of the produced wood is used for energy production, 20% of the wood become by-products. According to these estimations, Hungary has an energy potential of 62 PJ (Ukrainian Biofuels, 2008).

The annual yield of energy plantations changes between 200 and 350GJ/ha, which is more than the double of the yield of forests per ha. Only 10-20% of the main agricultural products can be used for energy production. This means approx. 40-80 PJ/year. 40-60% of agricultural by-products cannot be used for energy purposes, meaning 90-185 PJ. The energy potential of Hungary's agriculture, including other resources, is of 296-402 PJ (Ukrainian Biofuels, 2008).

Currently, efficient programmes are aiming at the modernization of landfills, e.g. biogas production is not solved everywhere, but there are related developments.

Biomass resource type	Total production	Production density
Total land area covered by	(avg. 2006-2007, km^2)	(avg. 2006-2007, %)
Arable Land	45,945	49
Permanent Crops	1,975	2
Permanent Meadows and Pastures	10,160	11
Forest Area	19,967	21
Other Land	11,563	12
Inland Water	3,420	4
Primary crop production	(avg. 2006-2007, tonne)	(tonne /100 km^2)
Total primary crops (rank among COO)	21,865,625 (21)	23,504 (28)
Top 10 primary crops		
Maize	8,340,833	8,966
Wheat	4,182,206	4,496
Sugar beet	2,227,113	2,394
Sunflower seed	1,106,480	1,189
Barley	1,058,292	1,138
Potatoes	547,872	589
Apples	537,673	578
Grapes	532,951	573
Maize, green	513,663	552
Rapeseed	418,103	449
Animal units, number	(avg. 2006-2007, number)	(number / 100 km^2)
Cattle	705,000	758
Poultry	40,376,500	43,402
Pigs	3,920,000	4,214
Equivalent animal units	2,676,765	2,877
Annual roundwood production	(2006-2007, m^3)	(m^3 / 100 km^2)
Total	5,776,500	6,209
Fuel	3,062,500	3,292
Industrial	2,714,000	2,917
Wood-based panels	750,000	806
	(2006-2007, tonne)	(tonne / 100 km^2)
Paper and paperboard	552,500	594
Recovered paper	400,500	431
Source: Food and Agriculture Organization of the United Nations		

Table 4: Available biomass in Hungary
Source: Food and Agriculture Organization of the United Nations

THE BIOMASS ENERGY POTENTIAL OF SERBIA

The annual biomass potential of Serbia is around 2.7 M tOE. The energy potential from wood (waste from direct wood production) is around 1.0 Mtoe, the potential energy from agriculture 1.7 Mtoe (agricultural waste and by-products from plant cultivation and livestock farming, including slurry). Table No. 5 shows the data of recent researches, according to the calculation methods of the Food and Agriculture Organization (FAO). In Serbia, biomass is traditionally used for heat production, in 2008, the amount of produced biomass was of 0.3 Mtoe.

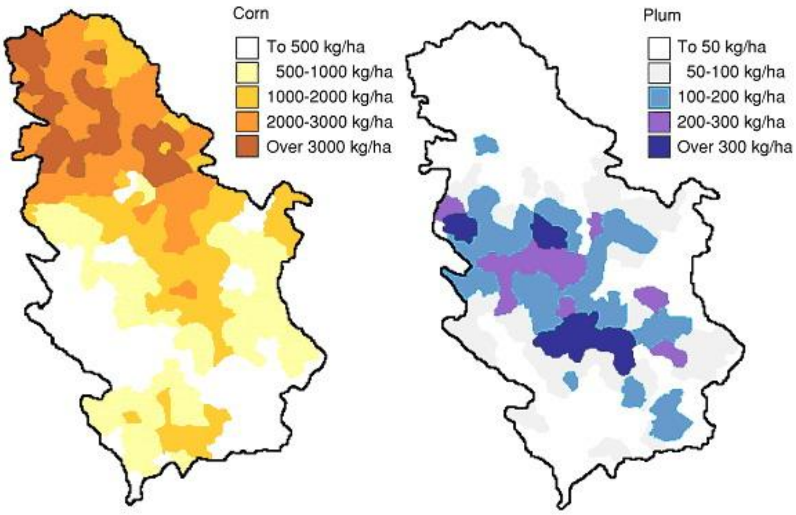


Fig. 26: Biomass potential of Serbia
Source: Food and Agriculture Organization of the United Nations

Biomass energy	Potential (toe)
Wood biomass	1,527,678*
Firewood	1,150,000
Forestry residues	163,760
Wood production residues	179,563
Wood amount outside forests	34,355
Agricultural biomass	1,670,240
Harvesting residues	1,023,000
Fruit cultivation residues	605,000
Slurry (biogas production)	42,240
Biofuels for transportation	191,305
Total biomass without transport fuel	3,197,918
Total biomass with transport fuel	3,389,223

Table 5.

The economy of Serbia is built mainly on agriculture and agriculture-related industries. The territory of Northern Serbia and Vojvodina, together with the areas of the rivers Sava and Danube, is a plain agricultural area. This region is the main resource for agricultural products, biomass, and waste from plant production. Wheat and maize are produced in the whole country. The majority of agricultural biomass comes from crops, mainly wheat, barley, maize, and industrial plants such as sunflower, soy and rape. This region has several livestock farms, thus a great amount of slurry is produced in the area. Fruit production is also significant, the most fruit being produced in the Southern territories, mainly plum, apple, cherry, peach and grapes.

Beside agricultural lands, Serbia has large forest areas as well. The total area of Serbia is 88,360 km², 30% of it is covered by forests, 55% is arable land. Southern Serbia has the most wood, but Eastern and Western Serbia have significant forest territories as well. More than 45% of 14 local governments of a total of 145 are covered by forests. 40-45% of the following nine local governments are covered by forests as well. Two thirds of forests are owned by the state, one third by private persons. About the half of forests are deciduous forests, 5% are conifers, and the 45% of the remaining forests are mixed woods. The main deciduous trees are beech and oak.

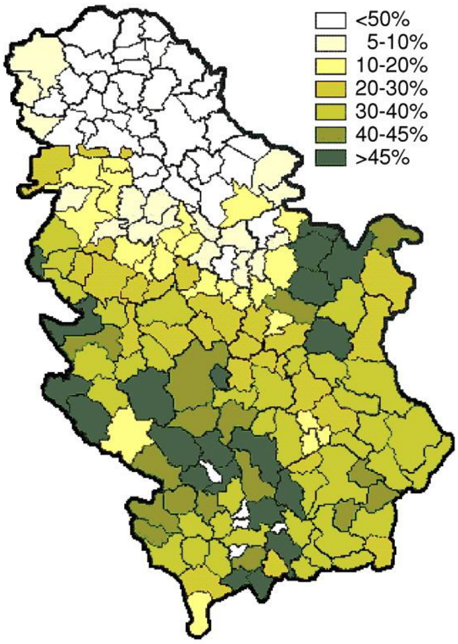


Fig. 27: Forests of Serbia
Source: Food and Agriculture Organization of the United Nations

Currently, biomass resources represent a significant energy potential in Serbia. According to a study made by the Serbian Ministry of Energy and Mining, 25% of Serbia's total energy demand could be covered from biomass. The total biomass potential is 28,000 GWh. Approx. 70% of the biomass is produced in agriculture, the remaining 30% from wood production. 20,800 km^2 of the total territory of Serbia are covered by forests.

Many households use firewood and pellets for heating. According to the Ministry of Energy and Mining, Serbia has the potential to create 15 individual district heating plants that could be operated with the available biomass, solving the heating of around 31,000 households.

Biomass resource type	Total production	Production density
Total land area covered by	(avg. 2006-2007, km^2)	(avg. 2006-2007, %)
Arable Land	33085	37
Permanent Crops	2995	3
Permanent Meadows and Pastures	14515	16
Forest Area	20834	24
Other Land	16931	19
Inland Water	NA	NA
Primary crop production	(avg. 2006-2007, tonne)	(tonne /100 km^2)
Total primary crops (rank among COO)	14,849,689 (19)	19,168 (27)
Top 10 primary crops		
Maize	4,960,795	6,404

Sugar beet	3,197,643	4,128
Wheat	1,869,573	2,413
Potatoes	836,794	1,080
Plums and sloes	618,397	798
Soybeans	366,795	473
Grapes	356,399	460
Sunflower seed	339,724	439
Cabbages and other brassicas	302,424	390
Barley	267,319	345
Animal units, number	(avg. 2006-2007, number)	(number / 100 km^2)
Cattle	1,101,093	1,428
Poultry	18,400,000	24,390
Pigs	3,605,262	5,162
Equivalent animal units	2,727,197	3,520
Annual roundwood production	(2006-2007, m^3)	(m^3 / 100 km^2)
Total	2,928,500	3,780
Fuel	1,590,000	2,052
Industrial	1,338,500	1,728
Wood-based panels	119,500	154
	(2006-2007, tonne)	(tonne / 100 km^2)
Paper and paperboard	238,000	307
Recovered paper	NA	NA

Table 6. Available biomass in Serbia

Source: Food and Agriculture Organization of the United Nations

THE BIOMASS ENERGY POTENTIAL OF SLOVAKIA

In Slovakia, biomass has the biggest potential among the renewable energy sources. Currently, there is only a negligible amount of it being utilized. The annual biomass potential is around 34,500 GWh, the technical potential is 33,400 GWh (Intelligent Energy, 2005). The available biomass resources in Slovakia are:

- forest biomass – firewood, branches, wood blocks, roots, bark, sawdust
- agricultural biomass – grain and rape straw, hemp, manure, waste
- industrial waste from wood production – trim, chips, sawdust
- municipal waste – solid combustible waste, landfill gas, sludge gas

Despite the extensive use of forestry wastes for energy production, it is estimated that only 10 percent of the potential resources are currently being utilized. The significant amount of forestry by-products could potentially be used to generate electricity on a large scale, or more efficiently used to supply heat for residential and industrial purposes.

The Slovakian government plans to develop the different areas of biomass utilization:

- Charcoal-burning (mixed with wood chips and sawdust)
- Wood gasifying plants
- Use of biogas is smaller plants
- Use of agricultural and forestry biomass for energy purposes.

Several water boiler were installed in public institutions with the support of the BIOMASA association. 45 pellet boiler were built-in with at total capacity of 13 MW. The use of bioenergy witnessed a significant improvement in case of local governments as well. Currently, there are 6 pellet and 16 bio-briquette producers in Slovakia. 20,000 tons of pellet was produced in 2005, this number grew to 120,000 tonnes in the past years (Intelligent Energy, 2005). This amount could cover 15% (800 PJ) of Slovakia's total energy demand.
The table below shows the biomass resources of Slovakia.

Biomass resource type	Total production	Production density
Total land area covered by	(avg. 2006-2007, km^2)	(avg. 2006-2007, %)
Arable Land	13,775	28
Permanent Crops	250	1
Permanent Meadows and Pastures	5,320	11
Forest Area	19,314	39
Other Land	9,441	19
Inland Water	930	2
Primary crop production	(avg. 2006-2007, tonne)	(tonne /100 km^2)
Total primary crops (rank among COO)	5,324,393 (14)	10,857 (22)
Top 10 primary crops		
Wheat	1,391,665	2,838
Sugar beet	1,113,126	2,270
Maize	756,776	1,543
Barley	668,405	1,363
Potatoes	322,367	657
Rapeseed	298,009	608
Sunflower seed	181,991	371
Cabbages and other brassicas	86,347	176
Tomatoes	61,476	125
Grapes	51,369	105

Animal units, number	(avg. 2006-2007, number)	(number / 100 km^2)
Cattle	517,855	1,056
Poultry	13,787,500	28,115
Pigs	1,106,548	2,256
Equivalent animal units	1,098,349	2,240
Annual roundwood production	(2006-2007, m^3)	(m^3 / 100 km^2)
Total	8,371,717	17,071
Fuel	361,848	738
Industrial	8,009,869	16,333
Wood-based panels	835,500	1,704
	(2006-2007, tonne)	(tonne / 100 km^2)
Paper and paperboard	901,500	1,838
Recovered paper	227,000	463

Table 7. Available biomass in Slovakia
Source: Food and Agriculture Organization of the United Nations

THE BIOMASS ENERGY POTENTIAL OF POLAND

Biomass is the most promising source of renewable energy in Poland. The technical potential of biomass amounts to 755 PJ/year, and the greatest opportunities for biomass technology implementation has been recognized in forestry, wood processing and agriculture sectors. In 2007, 2.8 billion kWh of electricity was produced using biomass and waste. (EIA, 2007).

Currently, biomass is mainly used as heat in small and medium scale boilers in industrial settings. Common fuel is wood chips, sawdust, and wood shavings. Combined heat and power (CHP) plants using organic waste from pulp and paper operations, and straw and wood-fired heating plants are also in operation.

Biogas is being produced in 23 landfill gas installations producing 22.3 GWh of electricity and 100 TJ of heat. Biogas production from landfill gas and municipal waste is also available. As of 2009, there are 30 landfill gas electric power stations; these installations have a total capacity of 11 MW. Poland also has 40 sewage fermentation plants with a total installation capacity of approximately 14 MW. Several of these were installed in 2007. Biogas contributes to Poland’s electricity production with 2.5 MW of capacity. (UDI, 2009).

The country’s two largest biogas plants were completed in 2008 (1 MW each). About 47 percent of the land area of Poland, about 14 million ha, consists of arable and agricultural lands. Nearly 9 million ha is forested, about 28 percent of the total territory. It is estimated that the total forest cover in Poland will reach 32 percent in the next 15 years.

The area with the most development in recent years has been energy generation from firewood, forestry residues, agricultural residues and surpluses. These were utilized in individual and industrial heating plants, for district heating and even CHP plants, where biomass is replacing or reducing the use of coal. Considering the age and the decreased efficiency of many of the existing plants due to age or lack of maintenance, rehabilitation and conversion into biomass plants can be an alternative

Fig. 28. Renewable energy Sources in Poland
Source: IEA

In addition, biofuels is an area that appears to be developing, especially for the agriculture. The development of biofuels is a political priority of the Polish government. Biofuels have recently been utilized in conjunction with fuel No. 2, oil, for heating purposes. In 2007, 3,500 barrels of biofuel was produced daily in Poland. (EIA, 2007).

Biomass resource type	Total production	Production density
Total land area covered by	(avg. 2006-2007, km^2)	(avg. 2006-2007, %)
Arable Land	124,350	40
Permanent Crops	3,885	1
Permanent Meadows and Pastures	32,435	10
Forest Area	92,319	30
Other Land	51,271	16
Inland Water	8,420	3
Primary crop production	(avg. 2006-2007, tonne)	(tonne /100 km^2)
Total primary crops (rank among COO)	55,815,646 (25)	17,850 (26)
Top 10 primary crops		
Sugar beet	11,266,310	3,603
Potatoes	10,101,538	3,230
Wheat	8,819,136	2,469
Mixed grain	3,838,967	1,228
Triticale	3,699,279	1,183
Barley	3,613,421	1,156

Rye	2,907,863	930
Rapeseed	1,882,063	602
Apples	1,691,996	535
Maize	1,450,179	464
Animal units, number	(avg. 2006-2007, number)	(number / 100 km^2)
Cattle	5,651,279	1,807
Poultry	141,953,500	45,396
Pigs	18,504,534	5,918
Equivalent animal units	14,472,628	4,628
Annual roundwood production	(2006-2007, m^3)	(m^3 / 100 km^2)
Total	34,159,282	10,924
Fuel	3,545,402	1,134
Industrial	30,613,880	9,790
Wood-based panels	46,395,238	14,837
	(2006-2007, tonne)	(tonne / 100 km^2)
Paper and paperboard	2,924,550	935
Recovered paper	1,486,850	475

Table 8. Available biomass in Poland
Source: Food and Agriculture Organization of the United Nations

There are very good opportunities for biomass development in Poland. The areas with the most potential for biomass / biogas projects are those in the northern and western regions, rural and mountain regions, as well as the eastern border of Belarus. The following figure shows the amount of straw available for energy production in Poland.

Territorial distribution of straw available for energy production in different provinces

Fig. 29. Available straw in the regions of Poland
Source: Food and Agriculture Organization of the United Nations

THE BIOMASS ENERGY POTENTIAL OF FYROM

Macedonia currently acquires a reasonable amount of energy from biomass fuels. The country's official energy balance shows that in 2000 the total primary production of wood amounted to 8.7 TJ having a gross energy value of 8.6 TJ. Gross inland consumption was slightly higher, about 8.9 million TJ due to small quantities of imports.

Allowing for relatively small quantities of wood as energy input in heating plants the net final energy consumption amounted to 8.55 million TJ.

By far the biggest users were households with about 7.6 million TJ. The final wood-derived energy consumption of 8.5 million TJ in the year 2002 was equal to nearly 13 percent of the country's total final energy consumption.

While the use of wood as a fire fuel in the traditional form is not likely to increase, there are prospects for a better utilization of forest output for energy purposes. Better forest practices, reforestation, planting of deserted or marginal land could make a contribution, be it relatively small, to the further development of this sector. Moreover, as burning wood in the traditional way is quite polluting, there will be pressures for switching to other cleaner sources of energy, which would release fuel wood resources. This however, will be a slow process.

As far as exploitation of the residues of field crops, fruit tree plantations and livestock activities are concerned, there should be a significant potential for their collection and utilization, along with waste, including manures from intensive farms. This could be done through incineration or anaerobic digestion technologies. Special studies and surveys will have to be carried out to determine location, logistics, size of units, economics and viability. One study estimates the technical potential of biomass in FYR Macedonia at 3.361 GWh (Colovic, 2008).

Biomass resource type	Total production	Production density
Percent of total land area covered by		
Forests	29%	
Shrublands, savannah, and grasslands	0%	
Cropland and crop/natural vegetation mosaic	68%	
Urban and built-up areas	0%	
Sparse or barren vegetation; snow and ice	0%	
Wetlands and water bodies	2%	
Primary crop production, tonne	(avg. 1999-2001, tonne)	(tonne /1000 Ha)
Total primary crops (rank among COO)	2,354,688 (27)	926 (18)
Top 10 primary crops		
Alfalfa for Forage & Silage	413,000	162
Wheat	307,606	121
Grapes	241,400	95
Potatoes	168,333	66
Maize	148,510	58
Tomatoes	129,800	51
Watermelons	120,000	47
Barley	109,167	43
Chillies & Peppers, Green	109,000	43
Cabbages	71,733	28
Animal units, number	(number)	(number / 1000 Ha)
Cattle	285,000	112
Poultry	3,344,000	1,315
Pigs	198,420	78
Equivalent animal units	397,808	156
Annual roundwood production	(1996-98, 000 m^3)	(m^3 / Ha)
Total	774	304.4
Fuel	616	242.2
Industrial	158	62.1
Wood-based panels	2	0.8
	(1996-98, 000 metric tons)	(metric tons / Ha)
Paper and paperboard	15	5.9
Recovered paper	2	0.8

Table 9. Available biomass in Macedonia

THE BIOMASS ENERGY POTENTIAL OF ITALY

In Italy, bioenergy is used for communal and industrial heating, electricity production, operation of cogeneration plants, and biodiesel production (heating and transport).

This sector represents about 30% of the Country's energy need, the use of firewood is widespread, and has been growing in recent years. Firewood is 54%, 3.9 million tons, of the total amount of wood, and is completely produced in wood production. Besides commercialized firewood, wood residues (3.5 million tons) are utilized as well. Overall, wood biomass used in later years is approximately 7.5 million tonnes, which is equivalent to 25 TWh. In addition to solid biomass, liquid biofuels, methyl ester made from sunflower oil is used for transportation and domestic heating. Around 80,000 t of biodiesel were used for heating purposes in recent years, which is 95% of total production, equivalent to a heating value of 1.16 TWh.

Industrial facilities, small and medium-size farms, agricultural facilities use firewood for the production of heat. The number of plants reaches 1,300, their heat capacity is approximately 11 TWh.

For electric power production, the plants are connected to the national network, their capacity (including solid waste and agricultural biomass) is 148 MWe and 207 MWth, equivalent to a primary energy of 2.67 TWh.

The estimated growth for the next years is of 1-2%. The heat demand from fossil energy sources is forecasted to decrease, while the energy for transportation and electric power generation to increase. The amount of estimated primary energy is 2,309 TWh.

Source	Total amount	Accessible amount	Utilized amount			
			1992	1993	1994	1995
Wood and lignocellulosics (firewood, agricultural and forestry residues, food industry residues)	151	81.4	24.4	24.2	38	38
RSU and comparable materials (paper, plastics etc.)	58	34.9	2.32	2.32	2.32	1.63
Animal excrements and sewage sludges	93	46.5	0.7	0.7	0.12	0.23
Energy crops for liquid biofuels (sunflower, rape)					1.16	1.16
TOTAL (percentage of bioenergy contribution in the gross domestic consumption of energy)	302	163	27.42 (1.4)	27.22 (1.4)	41.6 (2.1)	41 (2.0)

Table10. Annual modification of different types of biomass in Italy
Source: Food and Agriculture Organization of the United Nations

CONCLUSIONS

We concluded the analysis of the integration of renewable energy sources with a GIS method. We created five categories for every considerable energy source (best, good, average, below average, weak), and created a union of these during the integration.

The basic energy was geothermal energy, and we examined the possibility of adding solar energy, wind energy and biomass as an auxiliary energy. Since the level of survey of the energy sources is different in the examined countries, we only used indicators that are commensurable by countries. In case of geothermal energy, this is the heat flux, i.e. the temperature measured at depths of 2000 and 5000 metres.   These are parameters related mainly to the conductive heat transport. The heat flow map (figure) shows mainly the possibilities of heat pump utilization. The temperature values measured at a depth of 2000 m (figure) indicate a low and medium-enthalpy geothermal heat production mainly with water (district heating, agricultural and industrial use, hot water supply, and balneology). The temperature values measured at a depth of 5000 m (figure) indicate the possibility of electric power production from geothermal energy, especially in the case of the EGS (Enhanced Geothermal System) technology.

The heat flux map (figure) was used for solar energy as well, since this is one of the most important parameters. We have indicated the number of sunny hours during the description of the countries. Solar energy can have a role in heat and electricity production.
In case of wind energy, wind speed was the most usable parameter (figure). This indicated an energy quantity that allows the production of electricity.

The examination of the energy content of biomass in the different countries was a very difficult task. As seen in the description of the countries, the raw materials for biomass for the definition of the exploitable energy amount were considered differently by the countries. Accordingly, we could not consider this energy source for the GIS comparison.

Geothermal energy and solar energy
Solar energy can be considered as an auxiliary energy for heat pump utilization. The addition of the geothermal and solar heat flux maps results in a significant map for utilization (figure).
According to these, the most favourable areas are Italy, especially the southern part, southeast Hungary, and the Balkan countries - Serbia and Montenegro. In this case, the electricity for the operation of the heat pumps (for heating and cooling) could be generated with solar cells, and the primary water of the heat pump could be pre-warmed with solar collectors (in cold weather conditions), fact that would improve the efficiency of the heat pump! Moreover, the solar collectors can provide support in the production of domestic hot water.

The results are similar when comparing the temperature at a depth of 2000 m and the flux of solar energy (figure). In this case, the south-western part of Hungary is a favourable region as well. The connection of these two energy sources can be advantageous mainly for domestic hot water production.

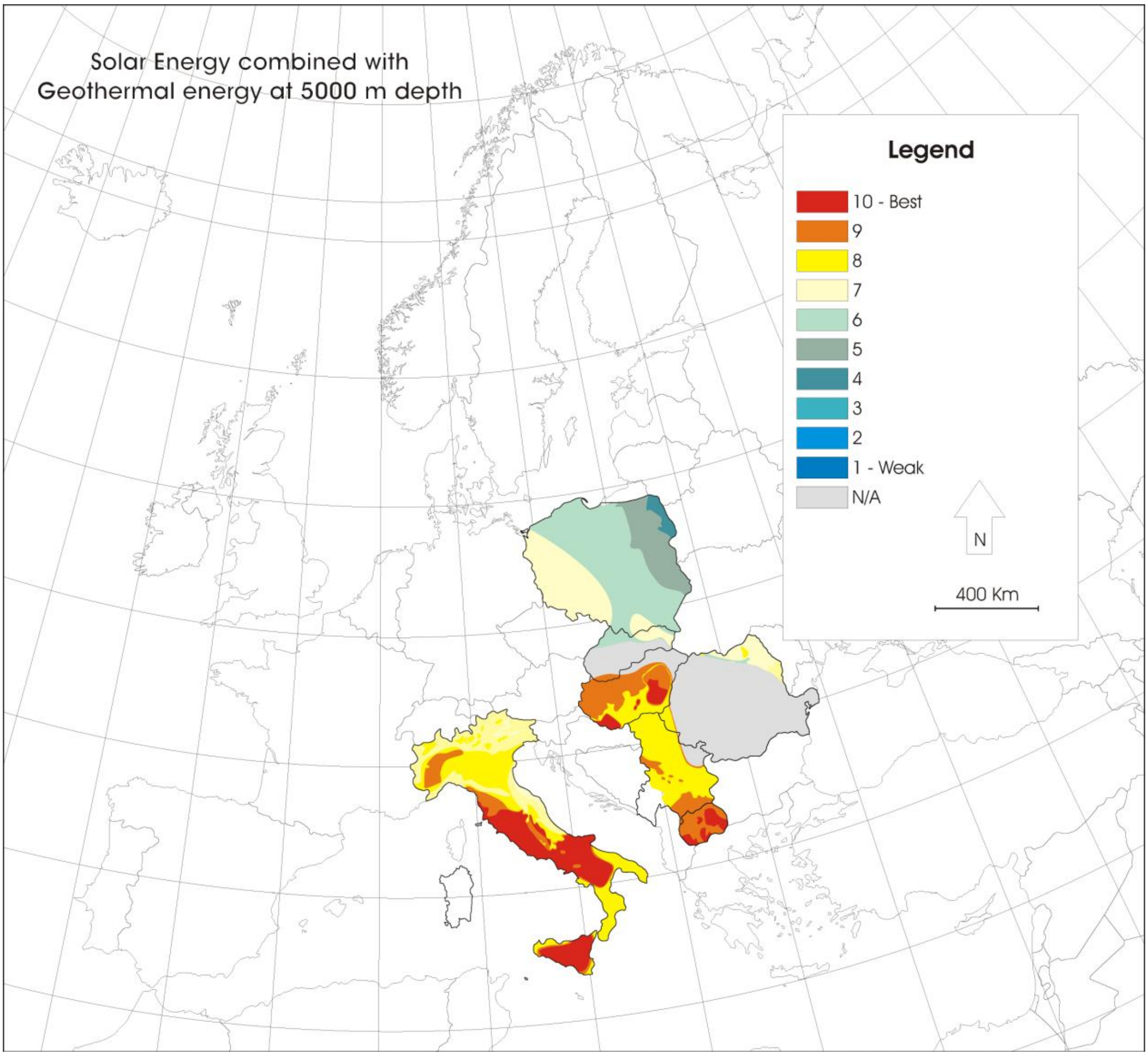
The results are almost the same when comparing the temperature at a depth of 5,000 m and the flux of solar energy (figure). The same countries can be considered as favourable. In this case, the two energy sources shall be connected, if the installation of solar cells is possible on a large area for the energy production required for the extraction of the geothermal fluid.

Geothermal energy and wind energy
The connection of geothermal energy and wind energy can be useful for the satisfaction of the electricity demands of geothermal systems. First, let us take a look at shallow heat pump

systems. For these systems, especially with pumps of several hundred kW or MW, one wind turbine could satisfy the electricity demand of one system. The map combining the two maps (figure) shows that the most favourable regions are the northern countries, especially Poland and southern Italy, and the western area along the sea. The mountain areas of Romania, Slovakia, Serbia and Montenegro, and the north-western part of Hungary have favourable features.

The bufferability of the wind energy is a very important factor when considering the combination of wind energy and the geothermal features at greater depths. This is important since the extraction of thermal water, both for heat and electricity production, requires a significant amount of pumping and reinjection energy. Buffer reservoirs, in case their construction is possible, can allow the moderation of the biggest disadvantage of wind energy utilization, namely the unstable network load due to the dependence on temperature. Compared to the depth of 2000 metres, the most suitable areas are almost identical with the regions defined above (figure). The comparison of the geothermal features at the depth of 5000 m and the wind energy is different (figure). The mountains, especially the Carpathians, cannot be considered as favourable regions.

MAPS


Solar Energy combined with
Geothermal energy at 5000 m depth
Legend
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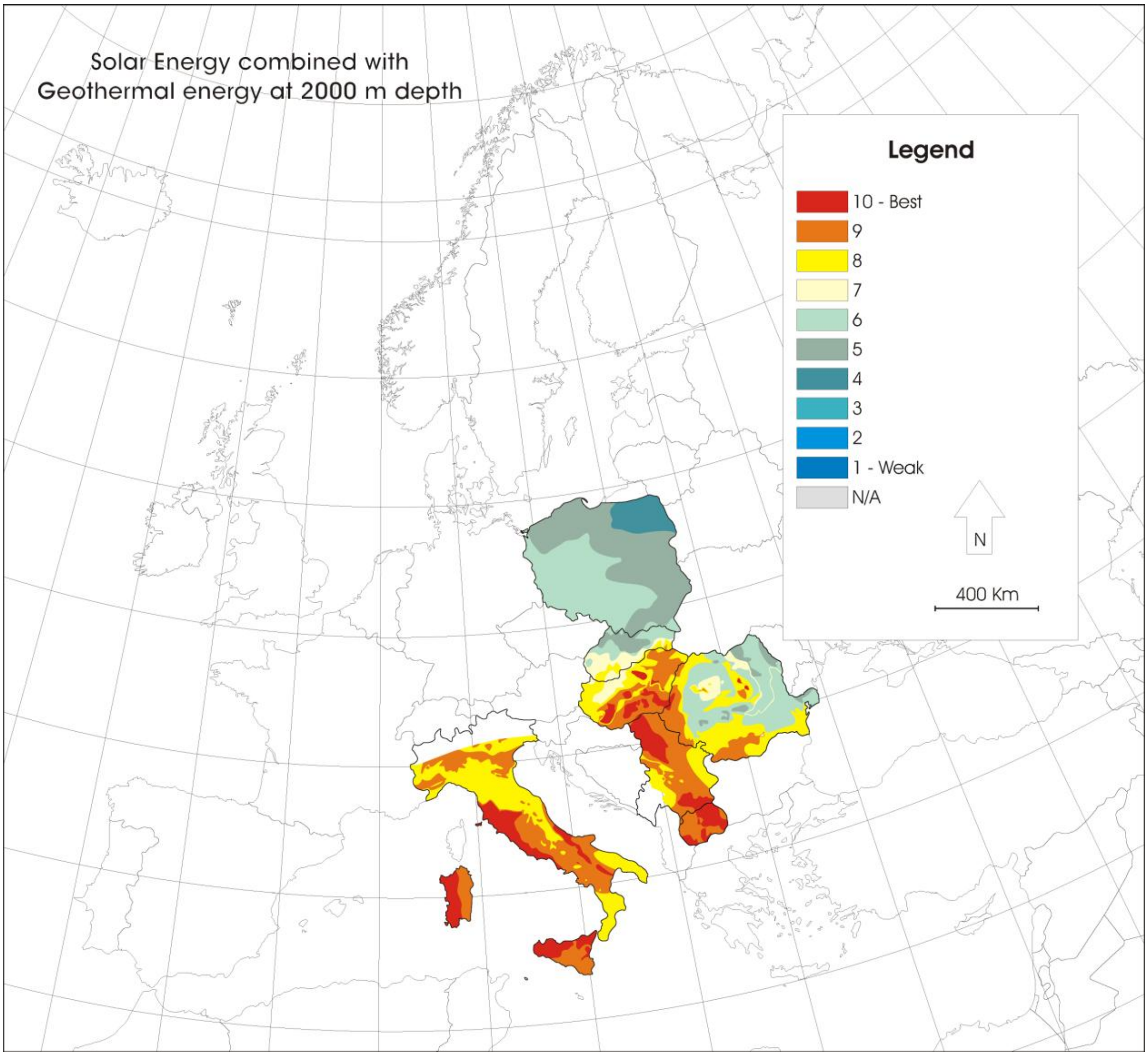
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Geothermal energy at 2000 m depth
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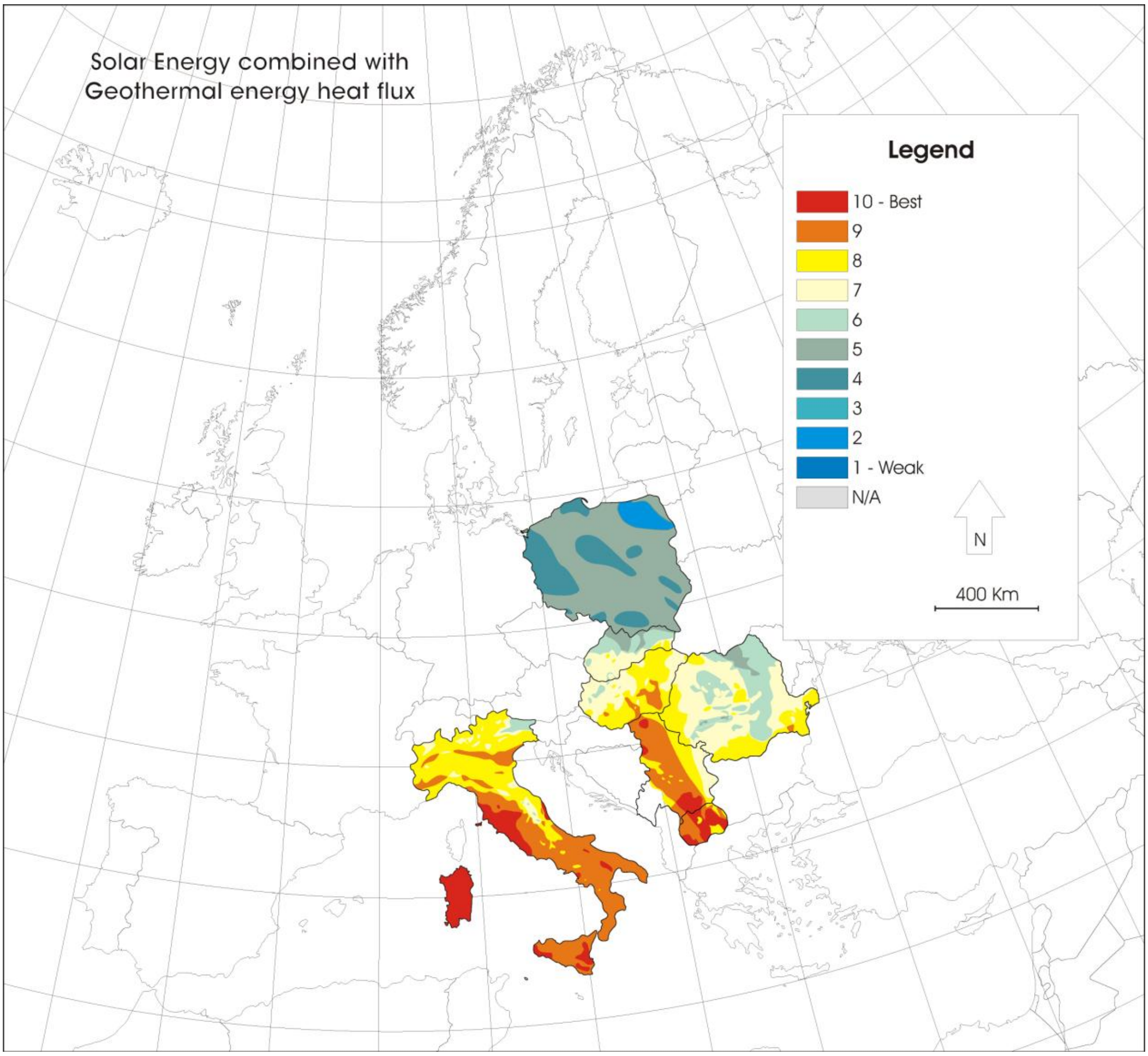
Solar Energy combined with
Geothermal energy heat flux
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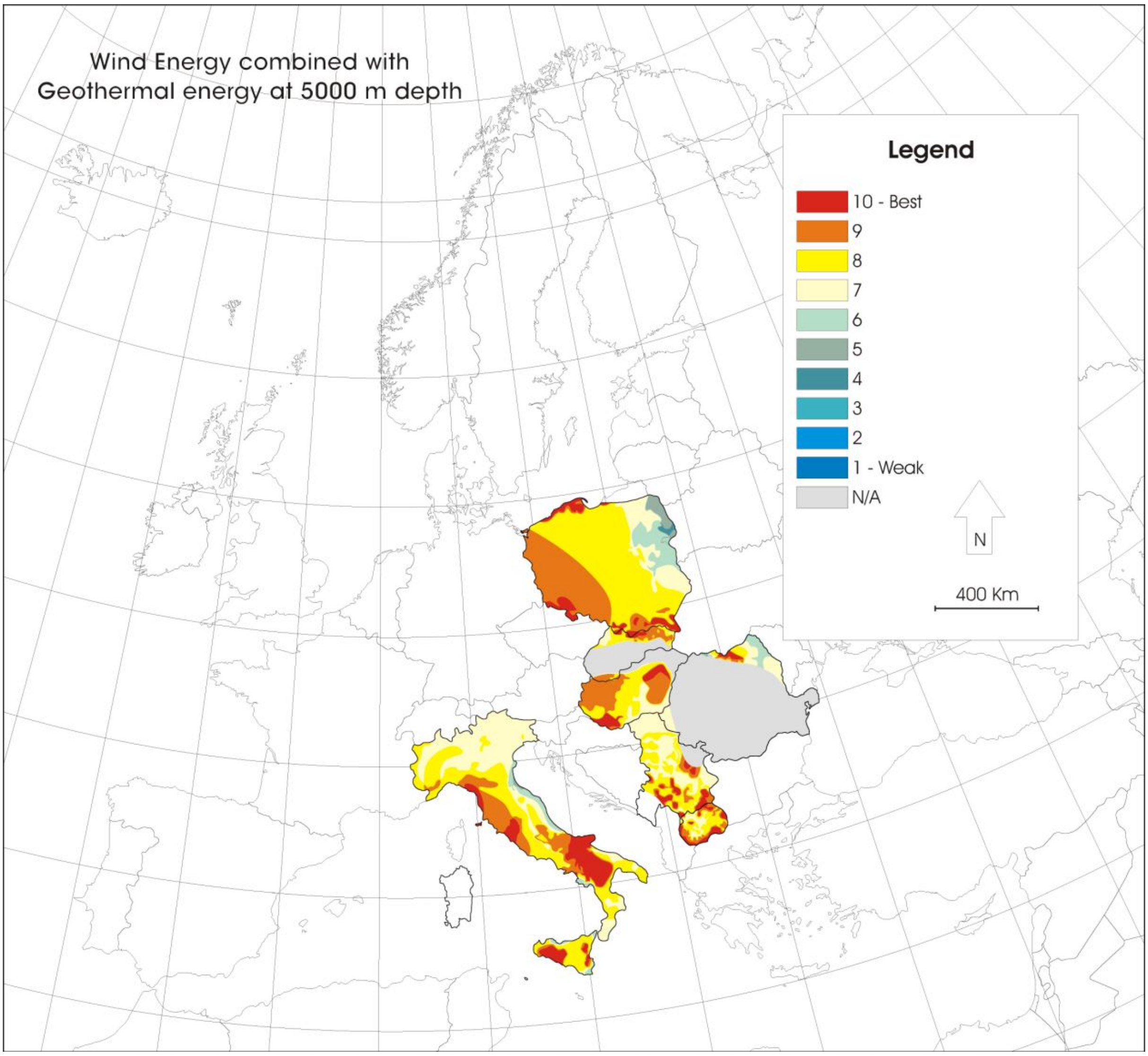
Wind Energy combined with
Geothermal energy at 5000 m depth
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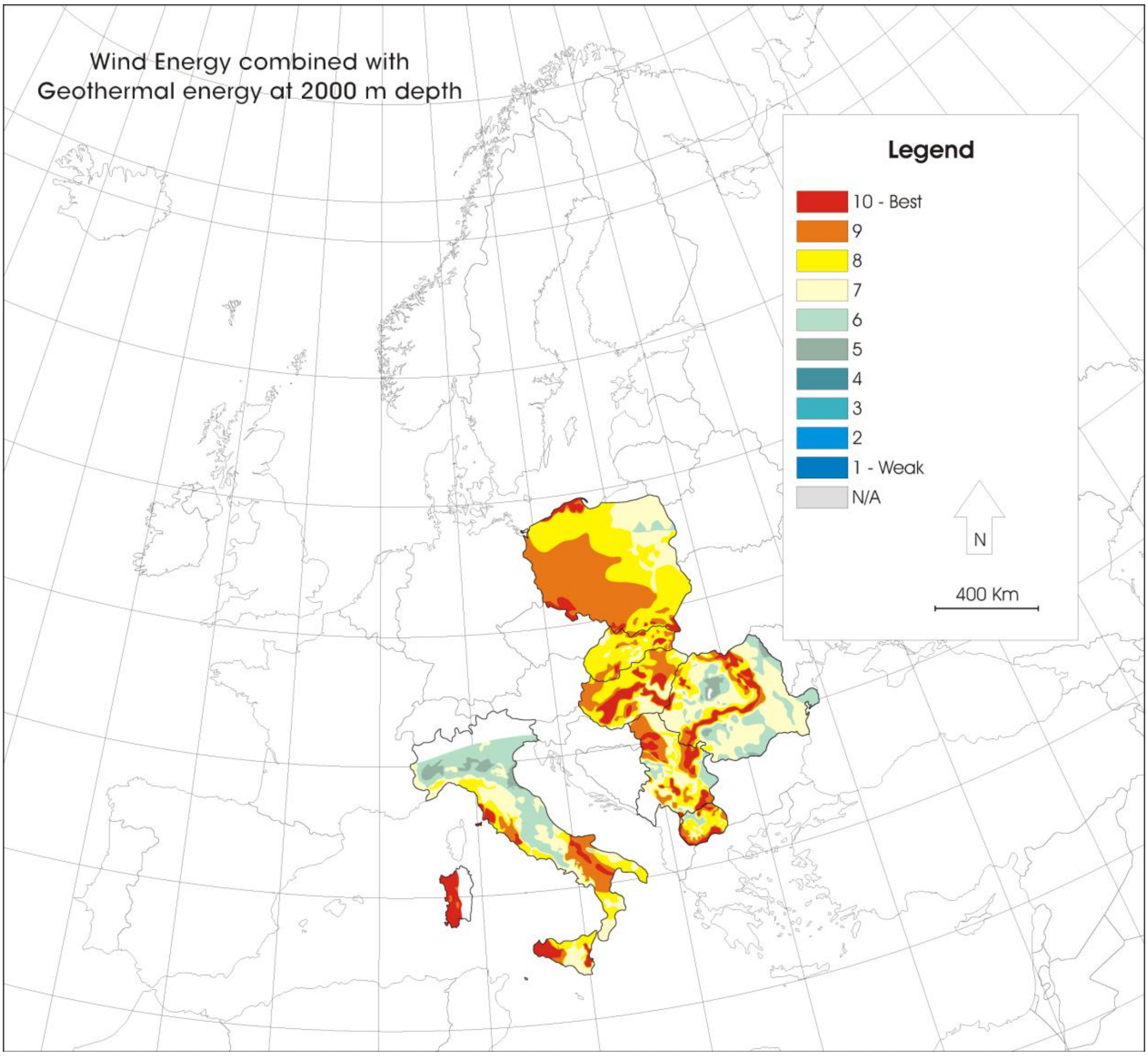
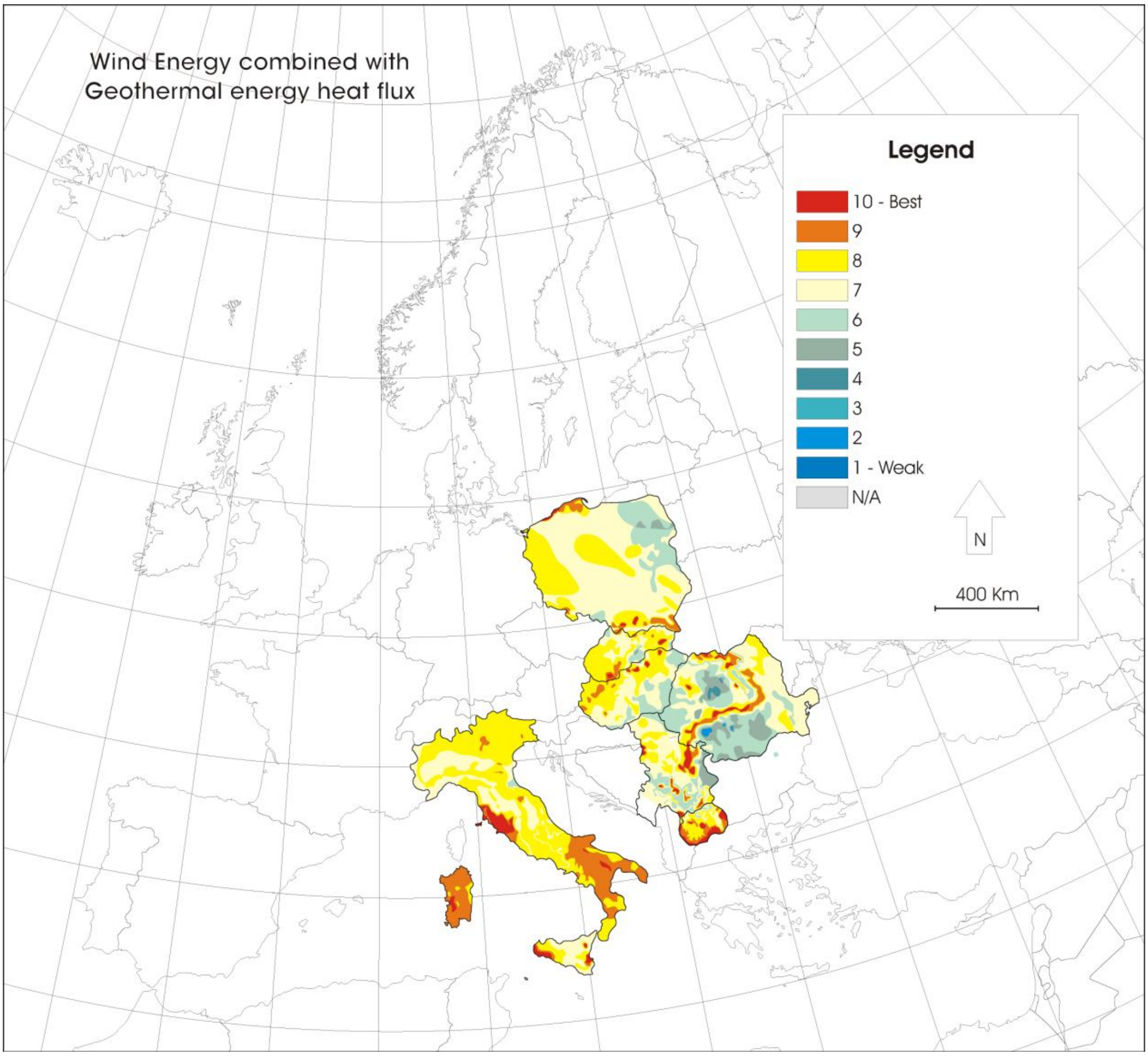
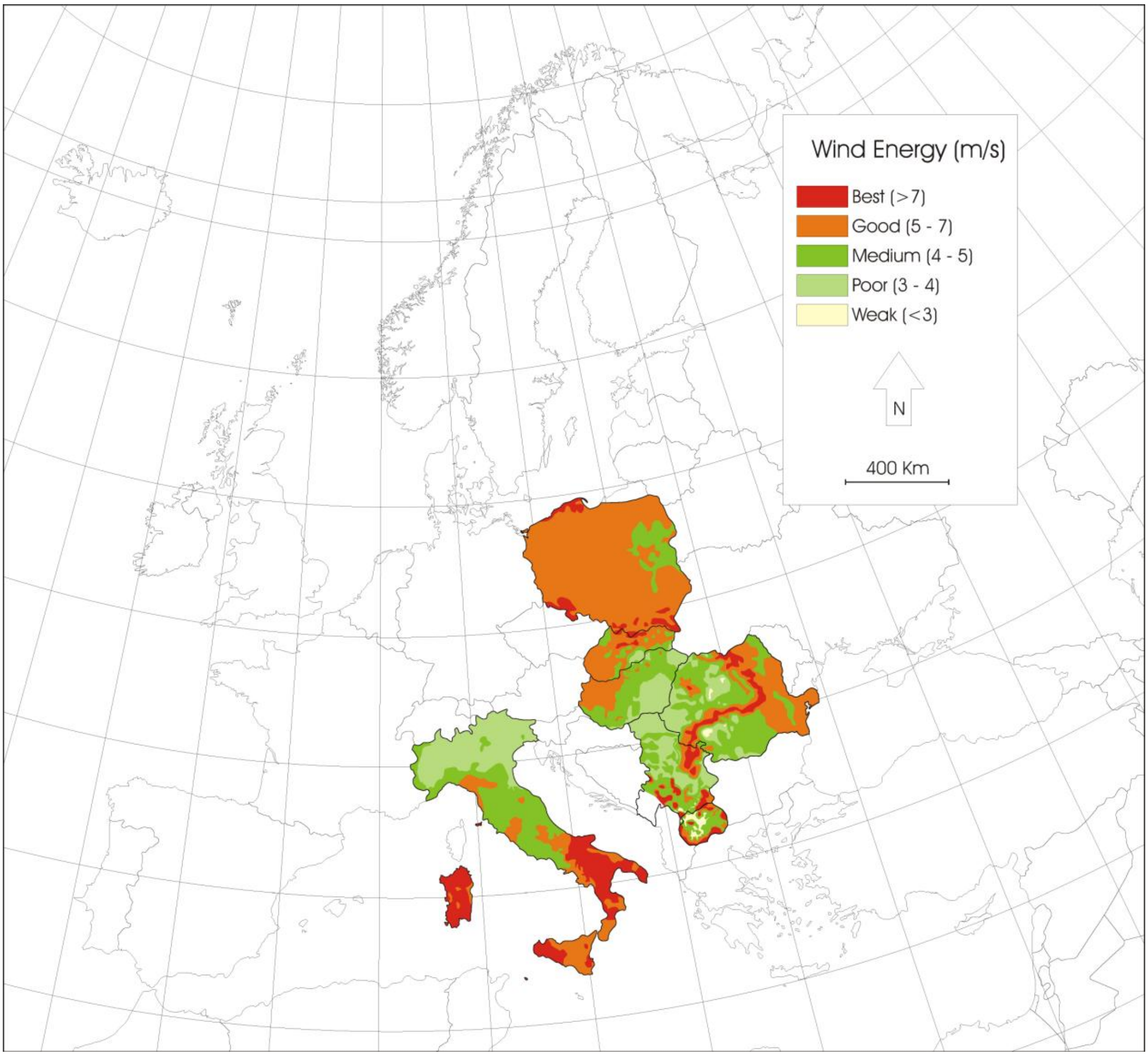
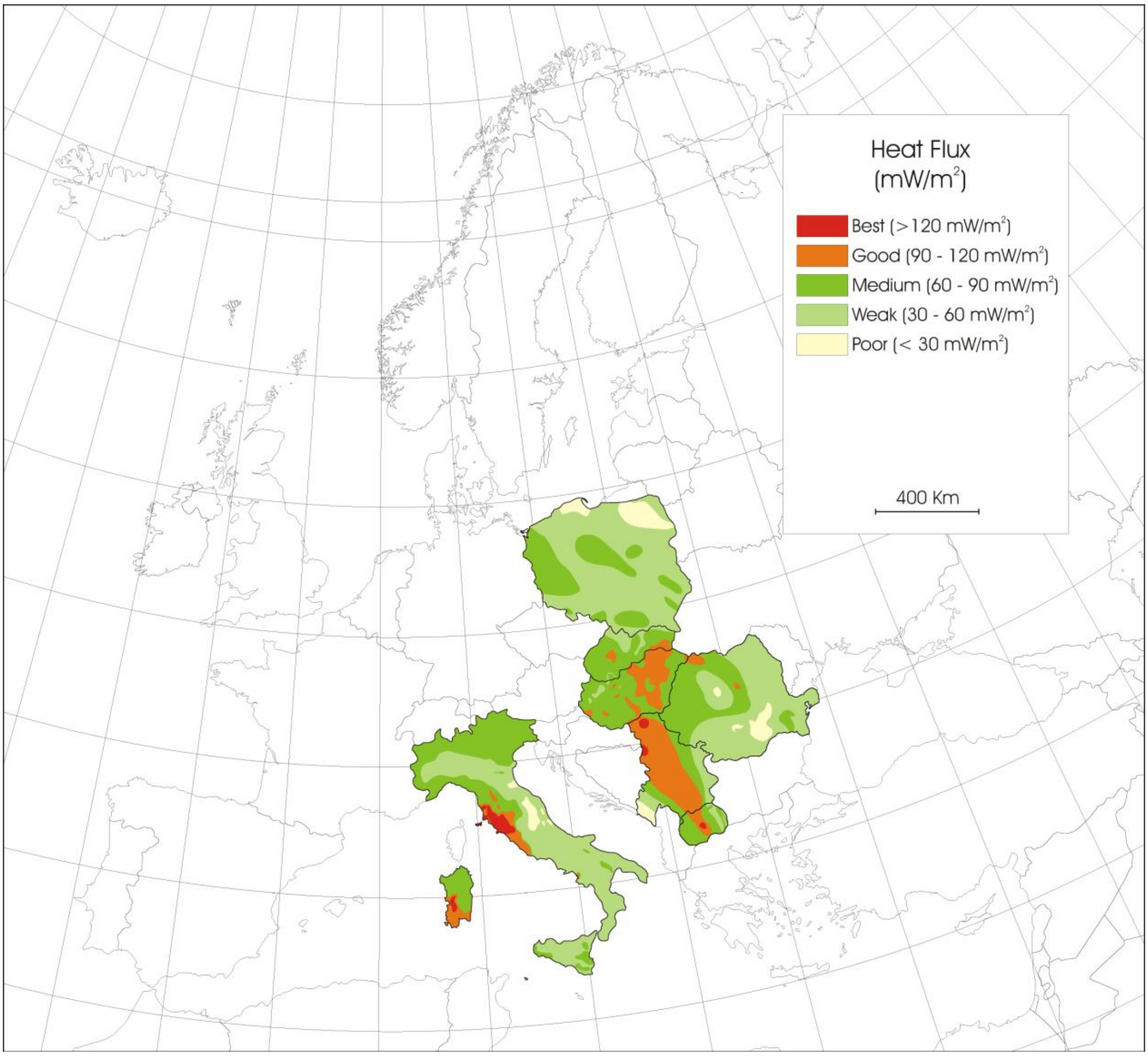
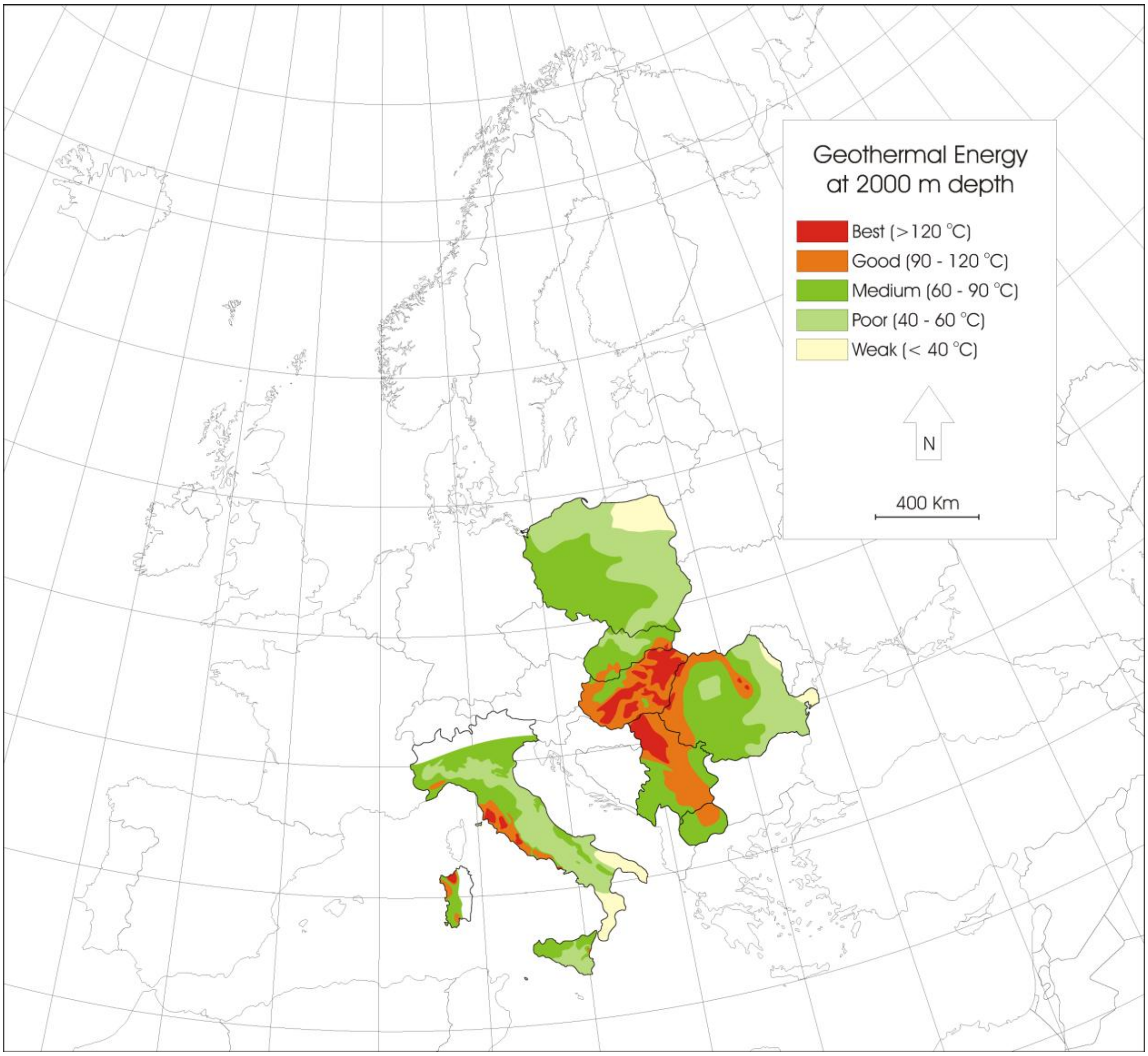
N
400 Km

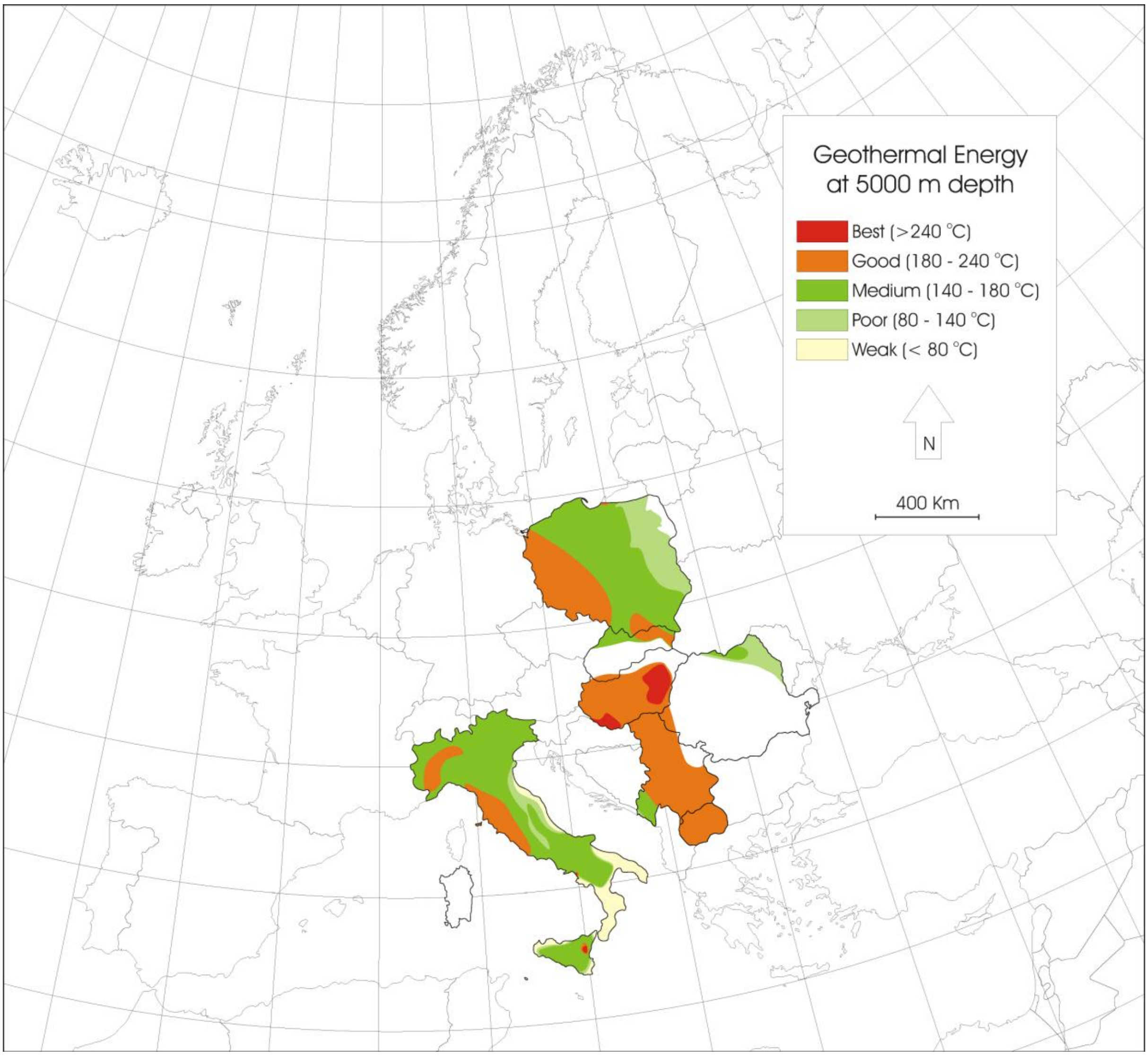

Wind Energy combined with
Geothermal energy at 2000 m depth
Legend
10 - Best
9
8
7
6
5
4
3
2
1 - Weak
N/A
N
400 Km


Wind Energy combined with
Geothermal energy heat flux
Legend
10 - Best
9
8
7
6
5
4
3
2
1 - Weak
N/A
N
400 Km


Wind Energy (m/s)
Best (>7)
Good (5 - 7)
Medium (4 - 5)
Poor (3 - 4)
Weak (<3)
N
400 Km


Heat Flux
(mW/m²)
Best (>120 mW/m²)
Good (90 - 120 mW/m²)
Medium (60 - 90 mW/m²)
Weak (30 - 60 mW/m²)
Poor (< 30 mW/m²)
400 Km


Geothermal Energy
at 2000 m depth
Best (>120 °C)
Good (90 - 120 °C)
Medium (60 - 90 °C)
Poor (40 - 60 °C)
Weak (< 40 °C)
N
400 Km


Geothermal Energy
at 5000 m depth
Best (>240 °C)
Good (180 - 240 °C)
Medium (140 - 180 °C)
Poor (80 - 140 °C)
Weak (< 80 °C)
N
400 Km

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CASE STUDIES AND PROJECT CONCEPTS OF GEOTHERMAL AND INTEGRATED RES PROJECTS IN CEE

PROJECTS IN THE SOUTH GREAT PLAIN REGION, HUNGARY

In the following chapters, we present the operating or planned geothermal and integrated projects of the region. We present the locations for thermal energy utilization for agricultural, heating, industrial, electric power production or touristic purposes. Our priority systems are the communal medium-enthalpy cascade systems (80-100°C) with direct heat utilization, since tendencies of the past years indicate the most intensive development for these systems. Beside the operating thermal energy projects, we determine and present the locations of the three counties, where the conditions for the construction of cascade systems are already available.

The definition method of potential development areas included several steps. We have considered that a successful project implementation requires thermal water with high temperature and output, and a proper buyer market. The temperature of the thermal water for direct heat utilization must reach 50°C, a lower value does not enable an cost-effective project. The construction of a cascade system, a multi-level geothermal heating system, requires water of at least 65-70°C. The Upper Pannonian layer of sand is the most appropriate for the extraction of thermal water in the South Great Plain. The whole territory of counties Csongrád and Békés is suitable for the construction of such systems, the cascade projects can be successfully implemented in both counties. Bács-Kiskun County has least favourable features due to the thin Upper Pannonian layer of sand, which enables the extraction of a thermal water of maximum 60°C. Accordingly, direct heat utilization geothermal projects cannot be economically implemented in areas west from the line of the towns Kecskemét-Soltvadkert-Kecel-Kiskunhalas. This does not mean that no geothermal heating systems can be installed in these areas, since heating can be successfully solved with integrated uses, heat pumps and by appropriate building energetic conditions.

Another essential condition for the successful implementation of projects for direct heat utilization is the existence of a heat market on the investment area. It is rational to mention locations, where public institutions are concentrated (within an area with a radius of maximum 3 km), and/or where a significant agricultural utilization is possible (heating of glasshouses or stalls), and/or where there is a demand for balneological utilization. Accordingly, the potential locations are mainly the towns of the region, since there are a great number of public institutions, and the majority of agricultural and/or balneological activities can be found in the areas surrounding these towns. Based on the number of population, there are 10 settlements in Csongrád County, 21 in Békés County, and 7 in Bács-Kiskun County suitable for the construction of geothermal systems for direct heat utilization (table 1). By comparing figure 2 and table 1, we can see the reason for Csongrád County being a leader in geothermal energy utilization: beside the appropriate hydrogeological features, it has a concentrated heat market as well. Considering the fact that a geothermal cascade system will be constructed in Mórahalom, which has a low number of population of only 6000 persons, we can state that every settlement, except Csanádpalota and Medgyesegyháza, is theoretically suitable for the realization of direct geothermal heat utilization. For detailed analyses, see the latter chapters.

Table 1. Towns in the South Great Plain region

Town	Micro-region	Population (persons)	Territory (km2)
CSONGRÁD COUNTY			
Szeged	Szeged	169,030	281
Hódmezővásárhely	Hódmezővásárhely	47,258	483
Szentes	Szentes	29,117	353
Makó	Makó	24,403	229
Csongrád	Csongrád	17,686	174
Sándorfalva	Szeged	8,042	56
Kistelek	Kistelek	7,318	69
Mindszent	Hódmezővásárhely	7,031	59
Mórahalom	Mórahalom	6,007	83
Csanádpalota	Makó	3,286	78
BÉKÉS COUNTY			
Békéscsaba	Békéscsaba	64,784	194
Gyula	Gyula	32,055	256
Orosháza	Orosháza	30,032	202
Békés	Békés	20,465	127
Szarvas	Szarvas	17,557	162
Gyomaendrőd	Szarvas	14,375	304
Mezőberény	Békés	11,241	119
Sarkad	Sarkad	10,463	126
Szeghalom	Szeghalom	9,465	217
Dévaványa	Szeghalom	8,273	217
Vésztő	Szeghalom	7,656	126
Mezőkovácsháza	Mezőkovácsháza	7,026	63
Battonya	Mezőkovácsháza	6,747	146
Tótkomlós	Orosháza	6,638	125
Füzesgyarmat	Szeghalom	6,542	127
Mezőhegyes	Mezőkovácsháza	6,355	156
Csorvás	Orosháza	5,765	90
Elek	Gyula	5,583	55
Újkígyós	Békéscsaba	5,537	55
Kőrösladány	Szeghalom	5,129	124
Medgyesegyháza	Mezőkovácsháza	3,891	64
BÁCS-KISKUN COUNTY			
Kiskunfélegyháza	Kiskunfélegyháza	30,523	256
Kiskunhalas	Kiskunhalas	28,997	227
Kiskőrös	Kiskőrös	14,452	102
Kiskunmajsa	Kiskunmajsa	11,707	222
Tiszakécske	Kecskemét	11,504	133
Kecel	Kiskőrös	8,892	114
Soltvadkert	Kiskőrös	7,597	109

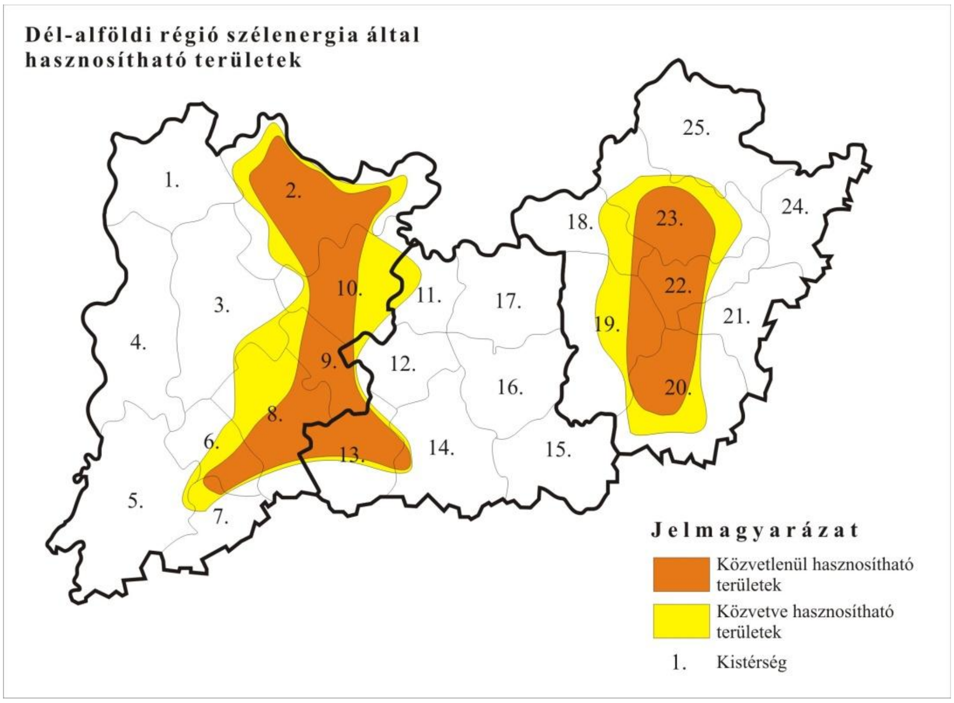
Systems with direct heat utilization can be found in the South Great Plain region in Szeged, Hódmezővásárhely, Csongrád, Makó, Szentes, Kistelek, Szarvas and Tiszakécske. These supply district heating for connected public institutions, hospitals and baths. Hódmezővásárhely and Szentes have energy-efficient cascade systems, in Hódmezővásárhely with the joint utilization of thermal water in the Town Hospital and Bath and Spa, in Szentes with the heating and water supply of the Town Hospital and Spa, the Vegetable Crops Research Institute, and the Public Bath. The systems in Csongrád, Makó and Szarvas are currently under modification, the shift to a modern cascade system is necessary due to their bad water output, and environmental and economic indicators.

The renewable energy treasure of the South Great Plain

Wind energy

The wind energy usable for industrial purposes can be found only in the higher areas of the region. Small-performance wind turbines (of a few kW) can be useful local energy sources (e.g. for water pumping or production of electric power) in places with no electricity networks, but they cannot be used for the energy supply of institutions with higher energy demand (e.g. local government buildings).

The following table presents the areas for the location of possible wind-power plants in the region by wind exposure and height.



Possible areas for wine energy utilization in the South Great Plain region (Chamber of Commerce and Industry of Békés County - BMKIK)

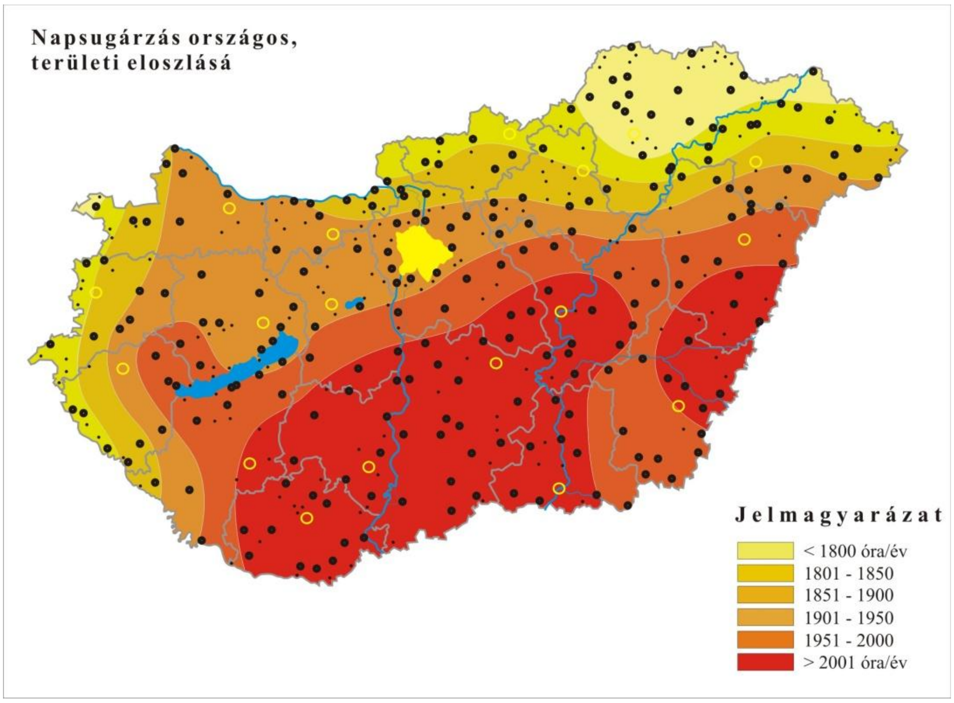
Legend
Orange: Directly usable areas
Yellow: Indirectly usable areas
1. Micro-region

A further problem is that despite of investor intentions the wind-power plants installed mainly in the windiest area of Transdanubia by 2010 in Hungary have a total performance of only 330 MW. Authorities refer to regulation problems of electric power systems, and the related authorisations were already issued. The establishment of further wind-power plants has mainly administrative obstacles (the Hungarian Energy Office does not issue building permits). Currently, there is not only a capacity limit referring to wind-power plants in Hungary; there is also a production limit in force for operating plants. Depending on its type, one wind-power plant can transfer only a certain amount of electric energy to a network in one year, determined during the compulsory takeover. (Hungarian Wind Energy Association, 2005)

The disadvantages of systems using wind energy are well known. Wide fluctuations in performance (weather-dependent), requiring significant extra expenses and charges from other sources; “wind-farms” are not attractive to the eye, and the noise could disturb people living in the area; furthermore, the energy sector is characterized by high reparation and maintenance costs. Furthermore, we must mention that only certain areas of the South Great Plain, especially with wind turbines built in high areas, are suitable for the effective utilization of wind energy.

Solar energy
The South Great Plain region has the most favourable features in Hungary from the point of view of global radiation. The expected total energy from global solar radiation reaches in the northern parts approx. 450 kjoule/cm²/year, in the southern parts 480 kjoule/cm²/year.

The diagram for the territorial distribution of solar radiation in Hungary made according to exact, satellite measurements shows the annual sum of global radiation coming in to a horizontal surface.

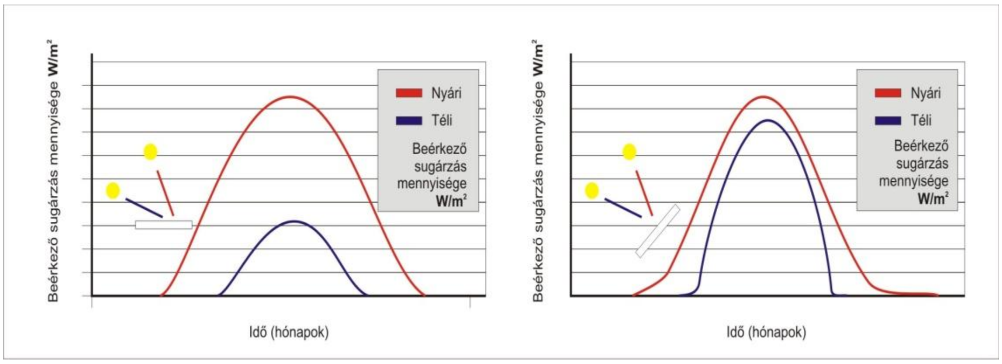


National, territorial distribution of solar radiation (Gy. Péczely 1998)

Legend
-less than 1800 hours/year
-1801-1850
-1851-1900
-1901-1950
-1951-2000
-more than 2001 hours/year

The diagram shows that the southern parts are the sunniest ones. It is important to mention that from the point of view of solar radiation, the percentage difference between the most and least favourable area in Hungary is only 8%. 8%. This means that from the point of view of solar radiation there are no significant differences of major influence on the operation of solar energy utilization systems.

The following diagrams show the strength of solar radiation on horizontal and south-oriented surfaces of 45° by sunny weather, in winter and summer. With the proper orientation, in winter we can reach 66% of the summer radiation amount. The limiting factors are frequent the cloudy winter days.



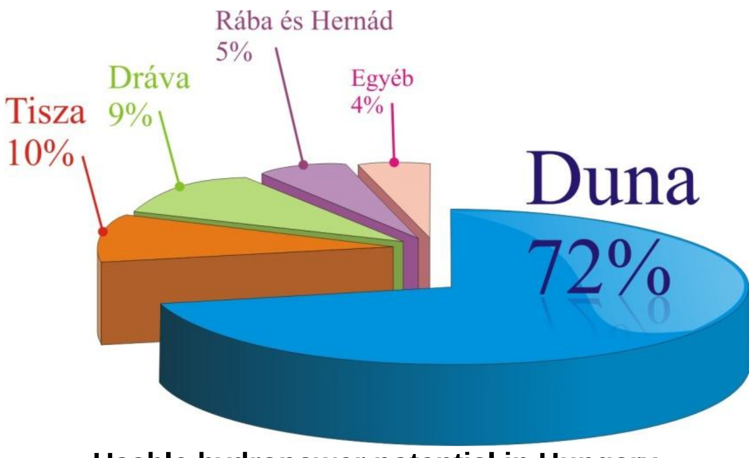
Amount of solar radiation in winter and summer in case of a horizontal, absorbing surface of 45°

Legend
Red: Summer
Blue: Winter
Beérkező sugárzás mennyisége W/m² - Amount of solar radiation W/m²
Idő (hónapok) - Time (months)

Despite the fact that solar energy utilization is the “most evident” of all energy sources, it does have some disadvantages. There are numerous technological barriers in its utilization, the problem of the use and storage of unused heat surplus is not properly solved yet, EU regulations regarding its utilization are only in process yet, some applications are quite expensive. A further unpredictable factor is the degree of environmental problems caused by the “worn-out” waste of collectors is yet unclear. Due to the small number of Hungarian applications, there is no adequate practical background available.

Accordingly, solar energy does not offer an adequate solution for the energy demand of larger buildings, which is caused mainly by its weather-dependence, beside its other disadvantages.

Hydropower
The technically usable hydropower potential of Hungary is approx. 1000 MW, which is far more than the hydropower potential actually used or usable for electric energy production. The rough percentage distribution can be seen below:



Usable hydropower potential in Hungary

The exploitable power by total utilization is 25-27 PJ, which is 7000-7500 million kWh per year. The truth is that the utilization of the hydropower potential of the rivers Danube, Tisza and Dráva is not a current task.

The Hungarian features allow only a difference of levels of 10-15 metres from the point of view of drop height. The majority of small and midget hydropower plants are operating in areas with favourable hydrological and topographical features, the South Great Plain region is not one of those.

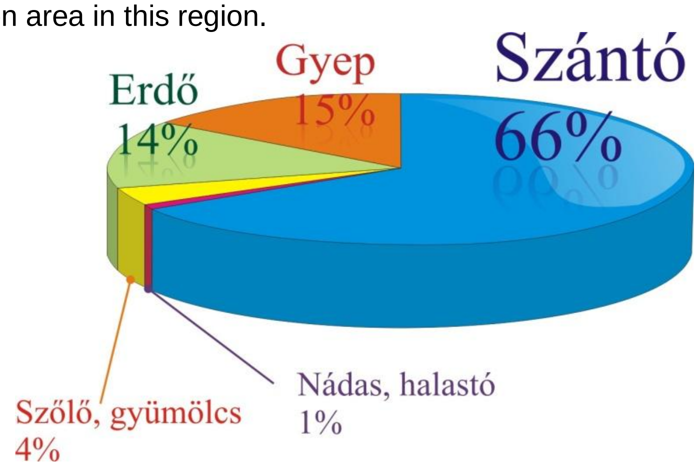
Another disadvantage is that it damages, at least it transforms the ecological environment, it impedes the natural migration of fishes, it decreases the oxygen content of the water due to slack water of the dam lake, and the lack of rise influences the eco-system of the flood area. The construction of dams transforms the environment, heavy metals and other toxic compounds are accumulated behind the dams, and a part of nutrients settles down.

The obstacles of its spreading in the South Great Plain region are mainly the unfavourable hydrological and topographic features.

Bioenergy
The total biomass reserve of Hungary is estimated at 350-360 million tons, 105-110 million tons are regenerated and reutilized. The annual amount of the primary biomass is 54 million tons (in dry material), 46 million tons of which are produced in agriculture, 8 million tons in forestry. Plant products contain 30.4 million tons of coal, four times the amount of the coal produced in Hungarian coal mines. This potential can be further increased with the amount of forestry and timber industry waste products, 4.9 million tons of dry material with an approximate energy content of 30 PJ. (BAI and partners 2002)

The total weight of the annually renewing surface biomass in the South Great Plain region is 9,454 million tons, the gross energy content of which is 180 PJ. The biomass directly usable for heating is the most adequate for energy purposes. The heating value of the so-called dry biomaterials suitable for heating is approximately identical with the one of the domestic brown coal.
The Hungarian biomass, bio-ethanol and bio-diesel production is determined mainly by crop production, both in quantity and utilization possibilities. The quantity and structure of plant biomass significantly depend on the nature of agricultural lands in the region.

The South Great Plain region has a territory of 1 848 100 hectares, 85% of which is production area. From the point of view of bioenergy potentials, the arable land is the most significant cultivation area in this region.



Production areas in the South Great Plain Region.

Legend

66% Arable land
15% Grass
14% Wood
4% Grape, fruit
1% Reed, Fishpond

In the South Great Plain region, the biggest combustible source potential is the straw of cereals, maize stalk being also a significant material. Cultures, currently of smaller importance in the region, like the energy hemp, energy grass, energy woods etc. could become perspective due to several advantageous characteristics. (BMKIK 2007).

The yields should be increase in order to satisfy the demands. In the region's areas struck by inland waters and desiccation this could be carried out only with genetically modified plants, which would harm the production areas for basic foods. Accordingly, this is a strongly weather and agriculture-dependent alternative with huge potentials; however, it does not provide a reliable solution for the regional local governments due to its manifold dependence.

Bio-ethanol is a fuel produced from annually renewing plants, and as such, it is theoretically neutral to the greenhouse effect. Just like in the case of renewable energy sources, the carbon dioxide and other greenhouse gases from bio-ethanol combustion re-build themselves into the plants growing the following year (cereals, potato, sugar beet, grass, straw). This equality is only possible if used plants are grown where there has been "nothing" before.

Another disadvantage of bio-ethanol production is the specifically high electric energy and thermal energy demand of production. The energy balance can be improved with the utilization of thermal energy generated during production, and by the use of by-products, e.g. plant waste as fodder; however, the amount of used fodder is limited.

A main concern and problem of the spreading of alternative energy is that the production of bio-ethanol and bio-diesel requires huge quantities of traditional agricultural produces – mainly maize, wheat, rape and sunflower seed.

We must add that the utilization of food plants and foods for fuel production in times when a significant part of the Earth's population is starving results in a dilemma of ethical nature.

Geothermal energy

From the point of view of its thermal water features, Hungary is a "superpower", the heat quantity in Hungarian groundwater reservoirs is 4.7 million petajoules, 250-350 petajoules of which could be utilized according to the legal background and available technologies; however, currently, there are only 3.1 petajoules utilized. From the point of view of resources, thermal energy exceeds Hungary's biomass possibilities by an order of magnitude, it costs about half as much as solar energy by current price levels, it is far more consistent to abstract than wind energy; and Hungary disposes of Europe's most significant geothermal water and heat resources.

Compared to other alternative energy sources, geothermal energy does not depend on import, it can be found in Hungary, thus it requires no transportation, and the local population disposes of it (danger of sale of the heat market!). Its utilization is emission-free, i.e. it is a completely environmentally friendly and renewable energy source with the reinjection of used water (obligatory). Its fresh supply does not depend on agriculture, like bioenergy, does not depend on weather (capacity of 6500h/year) like wind or solar energy. Its specific price (HUF 500-700/GJ) is by far more favourable than the one of energies produced from currently used fossil energy sources (e.g. district-heating HUF 2800/GJ), which continues to increase according to current world market trends.

GEOTHERMAL AND INTEGRATED PROJECTS OF CSONGRÁD COUNTY

GEOTHERMAL DISTRICT HEATING SYSTEMS IN SZEGED

The utilization of geothermal energy has a long history in Szeged and its surroundings. The growing energy demand due to the development of the region is satisfied with the increasing utilization of alternative energy sources, mainly with the significant amount of geothermal energy available. Thermal water is mainly used in agriculture and industry (Floratom Kft. – glasshouses, the well of the First Hungarian Hemp Spinnery Co. (B-370) with a capacity of 39 000 m3/year, the well of the Szegedi Paprika Rt. (B-454) with a production of 140 000 m3/year, the well of Furnér Szeged Termelő Kft. (K-482), 8 000 m3/year), and also as an additional energy source for the town's district heating systems. The thermal water from well B-415 of the Szeged Clinic was used for the heating of buildings with a capacity of 180 000 m3/year, however, this has been closed years ago due to unsatisfactory operation. The Szeged District Heating Ltd. extracts thermal water from three wells mainly to complement the natural gas energy supply. The well "B-650" in the part of the town called Felsőváros produces 54 000 m3 water per year for heating (the total water quantity was reinjected into the water bearing layer for a long time, the reinjection stopped due to the blocking-up of well B-651). Well B-384 produces 330 000 m3 of thermal water per year. 54 000 m3 of water is produced for the partial supply of the district heating plant in the part of the town called Újszeged.

Due to the strong gas lobby and the failure of most attempts at reinjection, 75% of the town's district heating system supplies natural gas for the heating of buildings and dwelling-houses despite of the fact that 50% of the energy demand of district heating could be supplied by geothermal energy.

UNIVERSITY INTEGRATED SYSTEMS

As the first step of the construction of the town's integrated cascade system, in 2007, the researchers responsible for this current FP7 project of the University of Szeged (SZTE) with the co-ordination of the Geothermal Innovation and Coordination Foundation, by INTERREG II financing, have elaborated the feasibility study for the integrated system of the SZTE's institutions in Újszeged and downtown. SZTE is probably the town's biggest natural gas user. The change to geothermal heating as well as solar power for HDW production of a part of the university institutions seems to be practical and exemplary investment. As a multiplicator effect, the construction of exemplary intergated systems planned within the project – with the extraction-environmental monitoring system protecting the water resources – is an innovative energy utilization initiative in the South Great Plain region, thus their principle and technology can be disseminated in similar areas of the Pannonian Basin. The production and reinjection wells, the technological solutions of the heat centres, the heat-pump systems as well as the solar collectors could serve as practical education locations and presentation plants for production and utilization for the university training of technicians and engineers started in 2008, thus the experiences could become part of their education.

The development's objective is to supply certain SZTE buildings with geothermal energy, as well as solar power for DHW production thus switching partially or totally from natural gas supply to renewable and locally available energy. The energetic analysis of buildings, the hydrogeological analysis of the area and the planning of the systems have been carried out from support funds, both projects include a valid water rights implementation permit and feasibility study.

The project realizes the establishment of two separate cascade circles. The buildings to be heated with geothermal energy within the downtown thermal circle (fig. 3):
József Attila Study and Information Centre (TIK),
the buildings of the Faculty of Arts on Egyetem street,
the building of the Faculty of Arts on Petőfi Sándor avenue,
the Rector's Office on Dugonics Square
the main building of the Faculty of Pharmacy on Eötvös street,
the István Apáthy Student Hostel,
the Medical Clinic No. I on Tisza Lajos blv.
the Ságvári Endre High School,
and the central boiler plant of the University Clinic.

Fig. 3. The downtown thermal circle of the university geothermal project

The primary target area of the planned project phase is the university area in the downtown of Szeged: the total and partial supply with thermal energy of the Information Centre (TIK), the buildings of the Faculty of Arts, the Rector's Office, the Faculty of Pharmacy, the Medical Clinic, the Ságvári High School and the Clinic Heating Plant, for the replacement of the fossil energy source (natural gas) to the largest possible extent. A 2 200 m deep thermal well will be drilled on the empty area near the TIK during the implementation of the project, which will produce 60 m3 of thermal fluid per hour of 90°C. The heat centres of the above mentioned institutions will be "strung" on the 3 600 m-long NA 200 pre-insulated pipe network, which will be installed below the surface. The well's water will supply heat to the institutions through this network, through modern plate heat exchangers; the used thermal water will be reinjected through the 1 700-m-deep reinjection well to be drilled near the last consumption location. Institutions towards the end of the circuit that receive cooler thermal water will be equipped with solar collectors for DHW production.

The institutions, buildings to be connected to the second thermal circle in Újszeged are (fig. 4):
the buildings of the university's Biological Centre in Újszeged,

the ten-storey building of the Ottó Hermann Student Hostel,
the Ferenc Móra Student Hostel,
the Biological Research Centre of the Hungarian Academy of Sciences,
the SZTE ÁOK Children's Hospital,
the Town Bath and Sports Hall,
the Medical Clinic of the Hungarian State Railways Company,
the SZTE Faculty of Health Sciences and Social Studies.

The objective of the planned project phase is the total or partial supply with thermal energy of the university buildings in Újszeged – the Biological Centre, the Biological Research Centre of the Hungarian Academy of Sciences, the Town Baht and Sports Hall, the Children's Hospital and the Faculty of Health Sciences – for the replacement of the natural gas supply. A 2,200-m-deep thermal well will be drilled near the Biological Centre during the implementation of the project, the 1,700-m-deep reinjection wells will be located near the Children's Hospital and on the yard of the old nurse training school. The pipeline (NA 150, 1 500 metres long) will connect the institutions mentioned above below the surface. The transfer of the heat will happen through the modern plate heat exchangers constructed in the institutions' heating centres. The used thermal water is suitable for the clearing of frost and snow from the pavement, parking lots and public areas around the bath and sports hall with the plastic worm pipes installed below the pavement. Not unlike in the case of the downtown circle, institutions towards the end of the circuit that receive cooler thermal water will be equipped with solar collectors for DHW production.

Fig. 4. The "Újszeged thermal circle" of the university thermal project

With the realization of the project proposal and the operation of the thermal system, the natural gas and thermal energy balance of consumers will show the following figures:

Institution / Building	Natural gas			Thermal energy utilization
	Consumption	Replacement		
	m3	m3	GJ	GJ

Downtown thermal circle, total:	1,883,612	1,479,535	50,304	43,424
Újszeged thermal circle, total:	261,250	1,452,975	49,401	43,384

Short financial summary of the development:

Investment costs (net thousand HUF)	1,886,650
Expected KEOP fund (net thousand HUF)	943,325
Own contribution (own resources or loan) (net thousand HUF)	943,325
Operating prime costs of the thermal system (without amortisation) (net thousand HUF)	65,000
The extent of reduction of heating costs (thousand HUF/year)	188,961
Specific investment costs (HUF/KW)	141,000
Specific historic costs (HUF/GJ)	718
Project lifetime (years)	25- 50

Simplified project payback period: 18 years.
Anticipated payback period with state aid: 9 years.

51% of the current heating costs of the institutions can be saved by current gas prices. Furthermore, the realization of the project enables a reduction of greenhouse gas emission of 6,289 tons/year, significantly reducing the air pollution of the project area.

IMPLEMENTATION

The researchers responsible for the current FP7 project have been trying to push this agenda for 4 years, without much success. While the plans for an integrated system are ready, feasibility studies are completed and all expertise is at hand, the administration of the University is not at all interested in the implementation of such project at the moment. Being the single largest consumer of gas in the city political motives as well as a general reluctance to accept ideas coming from “below” hinders any breakthrough in this case, despite the apparent economic advantages and PR value of such development.

THE GEOTHERMAL CASCADE SYSTEM IN THE FELSŐVÁROS AREA

Several thermal wells supply thermal energy and thermal DHW in the outer and inner areas of the town. The unsuccessful operation of several wells in the past years, the spreading of gas-engine heat supply technologies supported by the state, and the “demonizing” of the technical-economical difficulties of thermal plants pressed geothermal utilization back, which resulted in the shut-down of well plants (pair of wells in Felsőváros, clinical thermal well, thermal wells supplying DHW for housing areas Észak I/A and I/B, and the cultivation wells in Újszeged etc.). The currently operating wells are the 1000-m-deep wells for public baths, the famous Anna-well, and the central well on Székely sor with reduced operation.

The Local Government of Szeged plans the construction of a new, roofed swimming pool on Etelka sor, near the existing gymnasium. The building could fit functionally and architecturally into the group of buildings of the existing "Tisza Center" and the recently built "Tisza Palota". Natural gas supplies the heat of the existing buildings, but the gas heating of the swimming pool would represent an unsustainable burden for the town budget.

These facts, as well as the growing number of anomalies of the resources, supply security and service fees of fossil energy sources, and the harmful emission effects of gas plants motivated the leadership of the Local Government to examine the possibilities of thermal energy utilization. The Local Government of Szeged commissioned the experts carrying out this present research project to make the feasibility study of the project. The main objectives of the thermal project are the best possible utilization of the heat capacity of the thermal water through the “linkage” of heat consumers, a further utilization of the used fluid for the clearing of frost, and the reinjection of the waste water on the lowest possible temperature into the layers close to the extraction layers.

The adjustment (into a cascade system) of heating systems with high temperature demands, and, the low temperature difference heating systems represents, a major difficulty, especially if these systems stagger in the thermal network.

The current project wishes to order three systems into one cascade system:
The first element is the group of buildings of the Gymnasium-Tisza Center-Tisza Palota with similar operational temperature difference of 80/60, 75/55oC (by partial thermal utilization);
The second element is the indoor swimming pool with a temperature difference of 68/30oC (by total thermal energy utilization); The third element is the clearing of snow and frost from the public areas near the swimming pool (below 30oC).

The cost of the project – by current price level – is estimated at HUF 373 454 thousand, and the system can be operated by an annual cost of HUF 35 463 thousand. A new renewable thermal capacity of 3.55 MW can be started at a - very favourable – specific market price of 105,198 HUF/kW.

The economic profitability of the proposed system is determined by the product's market, the marketable amount of heat (and the amount of the replaceable natural gas), and the proportion of consumed DHW. Therefore, we carried out extensive analyses, and tried to screen the complete micro-environment concerned. The project cash flow and the computed return indicators show that the payback period can reach approx. 8.4 years, which is acceptable on the energy investment market. By a KEOP fund of 15 % – confirmed to be be granted – the payback period of the own contribution is of approx. 7 years. The lifetime of the investment is of min. 25-50 years.

SUMMARY, THE CURRENT PHASE OF THE PROJECT:
The thermal project for Felsőváros was stopped, the local government stopped the works on the bath due to the economic crisis.

GEOTHERMAL PUBLIC UTILITY SYSTEM OF HÓDMEZŐVÁSÁRHELY

The geothermal cascade system of Hódmezővásárhely was realized as a model investment in several phases. The project successfully proves that reinjection into Pannonian sandstone, considered as difficult if not impossible by professional circles, is indeed possible, and economically sound. The reinjection system has been successfully operating for 10 years, a significant amount of operational experience has been gathered, which will enable the operable utilization of new reinjection systems within geothermal projects.

History

The first thermal well in Hódmezővásárhely was bore in 1954 to supply thermal water for the town's public bath. This was followed by the construction and operation of the 1 800-m-deep well for the heating of the town hospital. According to the experiences of more decades, the town decided to extend the utilization of the local terrestrial heat at the beginning of the 1990s.

The construction of the geothermal public utility system was started in 1994 in a joint investment of the Financial Trust and Service Provider Co. of Hódmezővásárhely and a professional investor, and under the leadership of Geohód Kft. set up by the two parties in 1993.

The project had two objectives. On the one hand, to replace the domestic hot water produced from cold drinking water with natural gas in the local district heating plants by utilizing the thermal water of 43-50°C extractable from a depth of 1000-1 300 metres. On the other hand, to replace the natural gas through the utilization of the thermal water of 80°C extractable from a depth of 2000 metres (not requiring special treatment), and to reinject the unusable, cold fluid into layers close to the extraction layers.

Accordingly, the investment consisted of two separate parts: a system for DHW, and a heating system. The project was realized in more phases, the DHW-well of Hódtó in 1994, the well for heating in 1996, the reinjection well No. I and the other DHW-well on Oldalkosár street - thus the complete first part of the geothermal public utility system – in 1998.

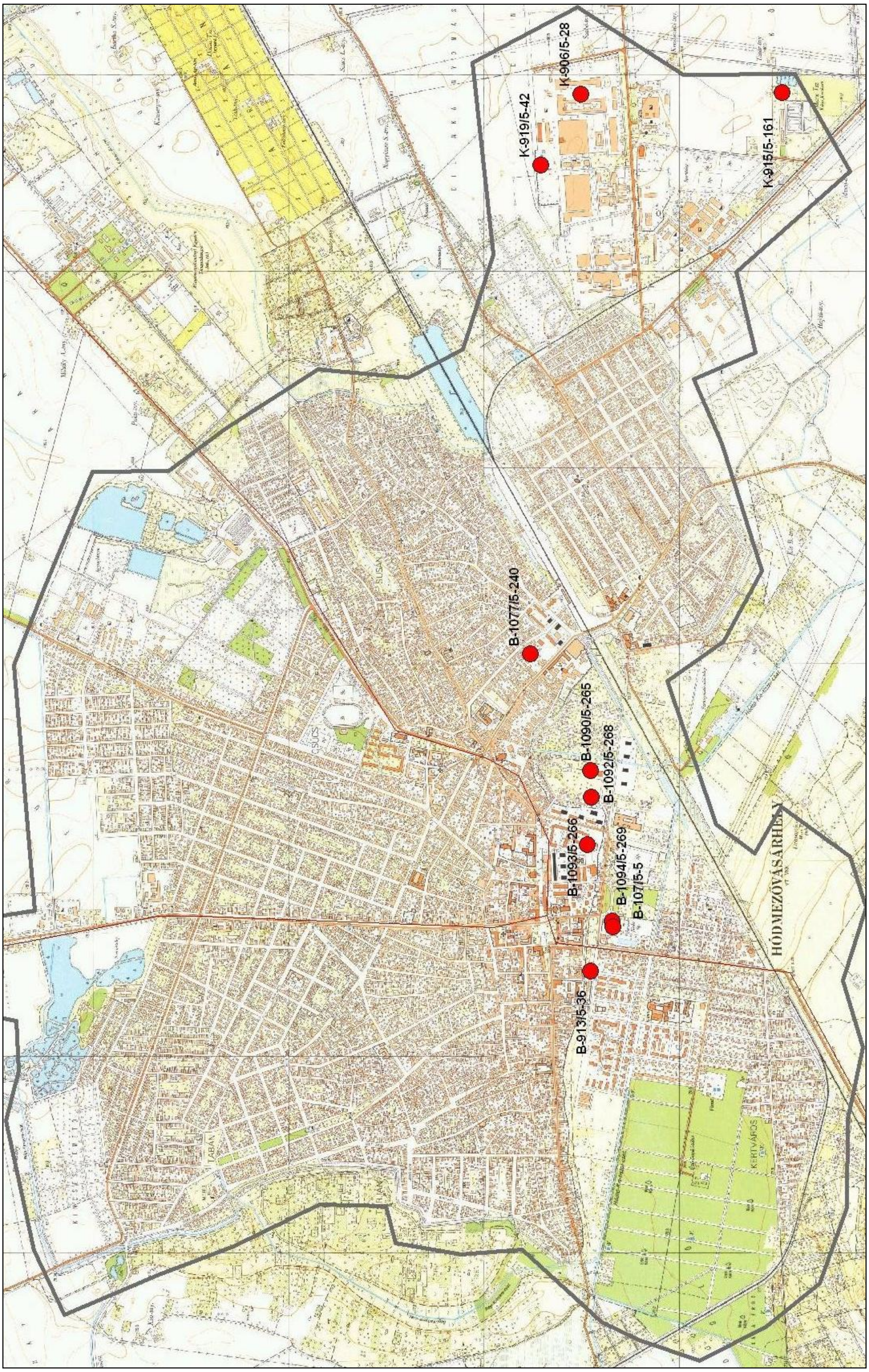


Fig. 5. The geothermal public utility system

The public utility system is an insulated pipeline network that connects four housing projects of Hódmezővásárhely with individual district heating systems (fig. 5).

The first part of the complex thermal system was constructed – and already operating – in 1998 (fig. 5). The next phase in 2003 saw the expansion of the system for the supply of the new indoor swimming pool. The previously stored water of the thermal well on Mátyás street, and the reinjected water of the heating well of Hódkút with a significant heat quantity (40 – 45oC) was utilized as a "residual" thermal energy for the heating and DHW-supply of the facility. After the clearing of the frost on the pavement around the swimming pool, the cold fluid of the thermal well on Mátyás street is directed into reinjection well No. II built in 2007 on the green area on Somogyi Béla street.

The first project phase finished in 1998 cost HUF 305 million, the second phase put into operation in 2003 HUF 147.5 million, the third phase - the construction of the reinjection well - HUF 125 million. The cost of the total project was of HUF 577.2 million, which today would reach HUF 1.5 billion.

The functioning of the thermal system

System for domestic hot water supply

It supplies DHW for residential and public consumers equivalent to 3000 flats, and 9 public institutions (hospital, bath etc.).

A pump is supplying the water from the reservoir at the DHW-well on Oldalkosár street into the pipeline connecting the four heating stations, the consumers of three housing areas (Mátyás and Oldalkosár streets, and hospital area) get the well's water boosted through the old district heating networks. The well of Hódtó supplies the housing area in Hódtó in a similar way, furthermore, it can automatically assist the pipeline supplying the other housing areas in case the capacity of the other DHW-well is too low. The used water of the DHW system is discharged into the town's sewage network.

Heating system

The starting point of one branch is the 2014-m-deep thermal well of Hódtó, which produces 60 m3/h of thermal water of 80 °C in the winter, and 25-30 m3/h in the summer.

The two submersible pumps are controlled from the surface of the 50-m3 degasser and reservoir built near the well. Pumps pump the water from the insulated reservoir into the heating station in Hódtó, where the circular heat loss of the DHW is completed. The fluid arrives into the heating station on Oldalkosár street, where the thermal energy replaces the lost heat and supplies heat for the heating system. Finally, the partially used water supplies thermal energy for the hospital area's institutions in a direct way. The final point of the system is the town swimming pool and bath, where the heat capacity of the used water (40-45ºC) can heat the sport swimming pool, and supply additional water for the thermal pools. The remaining water quantity (40 m^3/h in the winter, 25 in the summer) ends in the buffer reservoir of the old reinjection system.

The starting point of the other thermal heating network is the 2300-m-deep thermal well on Mátyás street. The well produces thermal water of 86ºC with a capacity of 60m^3/h in the winter, 3-4 m^3/h in the summer with the help of a submersible pump for the heating and DHW circular heat replacement of 600 district-heated flats with a temperature difference of 90/70 ºC. The secondary thermal water flows in a 2000-m-long insulated pipeline into the heating centre of the indoor pool, where the heat demand of 4 MW is produced with a temperature difference of 70/25ºC. The fluid used several times flows into the buffer reservoir of the new reinjection station after the clearing of the frost from the pavement near the pool.

The automatic computer control of the complete geothermal system is carried out from the dispatcher centre of the heating station in Hódtó. Every production, transmission and reinjection pump can be controlled with a frequency changer - reservoir level, maintenance of pressure and temperature, which is economical for water production and operational energy utilization, and guarantees a dynamics- and fluctuation-free well operation.

Service data, operational parameters
Quantity of produced and supplied DHW approx. 150 000 m3/year
Prime cost of DHW approx. 70 – 80 HUF/m3 (with traditional technology approx. 500 – 600 HUF/m3);
Quantity of produced heating thermal water approx. 580 000 m3/year, quantity of reinjected water approx. 400 000 m3/year;
Quantity of heat for thermal heating approx. 65 000 GJ/year;
Prime costs for production of thermal energy for heating (with reinjection) approx. 650 – 750 HUF/GJ (with traditional, natural gas technology currently approx. 2,800 – 3,000 HUF/GJ);
Quantity of natural gas replaced by heating and thermal DHW approx. 2 650 thousand m3/year;

Project results
The geothermal system of Hódmezővásárhely is a fine example for the complex utilization of one of Hungary's most significant energy sources, the geothermal energy, which complies with the directives aiming the reduction of fossil energy sources undertaken with the country's EU membership.

One of the most important results of the project is the saving compared to the costs of traditional district heating with natural gas:
The project's annual return is approx. HUF 200 - 220 million;
The simplified payback period of the project is approx. 6.5-7.5 years;
80% of the primary heat demand of the town's district heating system equivalent of 3000 flats is supplied from local geothermal energy.

Beside economic efficiency, the DHW-supply system reduces the load on the region's cold water reservoir in a depth of 200-600 metres with the utilization of the water from deeper layers.

The utilization of the local energy source – independent from external political and economic factors – replaces an annual quantity of approx. 2.7 m3 of import natural gas, and eliminates the emission of harmful substances resulting from the burning of the gas (carbon monoxide, nitrogen dioxide etc.). It is especially remarkable that the reduction of this environmental load can be felt in the most congested area of the town.

As an excellent reference for the permanent and economical reinjection into Pannonian sandstone, more than 2.3 million m³ of cooled fluid has been successfully reinjected into our reinjection well No. 1 in the last 10 years.

The software monitoring the station of the reinjection well records the characteristic operational data, thus the maintenance requirements of the well are traceable. According to maintenance experience, the compressor cleaning and regeneration unit must be serviced every 1.5-2 years (approx. when a well-head pressure of 5 bars is reached). It can be concluded that the project has fulfilled the preliminary environmental and profitability expectations.
Summary, the current phase of the project:
According to operational experience, the built system has enough heat capacity for maintaining the heat of further pools of the town bath, and for the heating of eventual new pools.

In the possession of favourable experience, the town strives to realize the “southern thermal circle” marked with blue on the attached town map (fig. 5 - where the wells marked with red are the operating wells of the above presented project phase).

A 2300-m-deep production well of the “southern thermal circle” was bore in 2008 on the territory of the town’s sewage treatment plant. As a first step, the water of 87 oC, with an output peak of 70 m3/h, supplies thermal energy for the town’s district heating in the heating station of Hódtó. The secondary thermal water supplies thermal energy for a vocational high school and a business quarter (with an INTERSPAR hypermarket). The water of 60 oC is currently discharged, but its heat capacity will be used this year for a high school dormitory, a new town cultural centre - built from a successful application – and museum buildings. Finally, the used fluid will be reinjected through the new reinjection well No. III to be constructed next year.

The preliminary feasibility plans of “northern thermal circle” (north from the “red” system with eastern-western axis) (fig. 5) are also available (the town does not have the own contribution yet).

With the realization of this project phase, and the implementation of the modernisation programme for district-heated housing blocks in Hódmezővásárhely, including the one of the thermal system, Hódmezővásárhely could become the first Hungarian town where the heat for every public institution and every district-heated flat is supplied from a local energy source.

THE UTILIZATION OF GEOTHERMAL ENERGY IN SZENTES

Szentes and its surrounding area use currently the biggest amount of geothermal energy for heating and agriculture in Hungary. The utilization of thermal wells in Szentes is very diverse. The biggest quantity of thermal water is used in greenhouse systems, the utilization in tourism, sports, medicine and district heating is also significant. There are 32 wells in the town, the temperature of the water is in every well above 60oC, 12 of them with a water temperature of 90-99oC. The thermal water in Szentes was found in 1958, during the search for crude oil. The first well was bore on the territory of the town hospital, it was 1735 m deep, and produced water of 71oC with a capacity of 1700 litres/minute. The salt content of the thermal water containing alkali-bicarbonate and fluoride exceeded 2000 mg/l, thus it was classified as medicinal water by the Hungarian Institute for Balneology in 1967. The construction of the thermal heating system begun in 1987, the thermal water was produced by thermal wells Szentes I and Szentes II. Initially, the hot water for heating was produced through heat exchangers, this was later replaced by a direct heating system. Currently, there are 1300 flats and institutions equivalent to 1500 flats supplied with geothermal energy through heat exchangers. The used thermal water is utilized for medical purposes in the spa near the town hospital. Besides public heating, a significant quantity thermal water is used by one of Europe's biggest agricultural companies, the Árpád-Agrár Zrt. for the heating of glasshouses and stalls on an area of more than 60 ha.

According to the size of the thermal system, there are several ongoing developments in Szeged for the diverse utilization of geothermal energy.

The Local Government of Csongrád County applied for and was granted an aid within a KEOP 4.1.0 programme in 2009 for the expansion of utilization of geothermal energy of the Dr. István Bugyi Hospital. The total project costs reached HUF 155 million, 44% of which – HUF 68 million – were granted by the EU.

The overall objectives of the project:
reduction of the heat supply costs on a long term
expansion of the supply security
expansion of the utilization of renewable energy sources
reduction of the utilization of natural gas
saving of thermal energy
contribution to the national energy saving and reduction of greenhouse gases.

Direct project objectives:
the renewal and modification of technological steam supply on the side of heat production
reduction of losses of energy production and distribution
optimization of the management of geothermal fluid
physical renewal of heat supply systems.

The following activities help to realize the project objectives:
installation and regulation of a submersible pump;
construction of a new primary and secondary pipeline;
partial replacement of natural gas boilers, total replacement of heating and DHW-supply of kitchens and laundries by thermal water;
installation of new, high-performance plate heat exchangers;
regulation of the central accelerating pump,
installation of a modern automatic steam generator in the laundry building.

Main results of the activities:
significant reduction of heat loss, which enables the increase of the heating temperature

the high performance of the new heat exchangers enables a total utilization of thermal water in comparison with the performance of the wells
the partial, or total, replacement of the heating and DHW-supply of the three buildings by thermal water results in a significant saving of natural gas,
this latter reduces the environmental load (CO_2 emission).

Numerical results:
an annual saving of energy costs of HUF 9.5 million after the development
a CO_2-saving of 315/year after the development
a payback period of 12.6 years (simple return)
improvement of complex energy characteristics of three buildings
a utilization of geothermal energy of plus 3245 GJ/year.

Direct target group:
673 hospital workers (environmentally friendly and comfortable work environment)
patients (adjustable temperature in the hospital rooms)
decision-making board of the hospital operator (spreading of alternative energy utilization)
hospital operator (reduction of costs)
other institutions of the Local Government of Csongrád County (stimulation of other energy projects).

Indirect target group:
visitors of the hospital
local population reached with information
partners, enterprises, professionals concerned in the project
the relevant local government (Local Government of Szentes)

The Local Government of Szentes applied successfully for the EEA and Norwegian Financial Mechanisms Programme with its project entitled “Overall heating modernization of the basic education institutes of the Local Government of Szentes, by using renewable energy sources”. The application successfully passed the first round, thus the National Development Agency gave the application the green light with a total allocation of HUF 750 million, with an own contribution of 15%. The project's main objective is the heating modernization of primary educational institutes, kindergarten, and public institutions. The gross costs of heating modernization and engineering (with the included district heating connection fees): HUF 293,012,557. The gross costs for building renovation and modernization: HUF 368,007,699. The gross costs for project elaboration, implementation, publicity, and accounting: HUF 59,666,274. Gross project costs: HUF 720,686,530. The gross own contribution (15% of eligible costs): HUF 108,102,980. Payback period compared to the own contribution: 2.47 years. The amount of own contribution: HUF 108,102,980 = EUR 421,865 (calculated with an exchange rate of 256.25 HUF/EUR defined in the project).

The Local Government of Szentes had a survey made for the utilization of the escaping thermal water as well. One objective of the project is the utilization of the residual geothermal energy of the leachate, its collection, and cooling to a minimum temperature. Another objective is the reduction of the emission of harmful substances from the burning of natural gas of the town’s heat supplier by the utilization of thermal water extracted from deeper layers of the new thermal well. The thermal water from upper layer would be utilized in the Public Bath for sporting and heating purposes. The result of the project is the heating of public buildings with geothermal energy, replacing the fossil energy sources.

The boring of the bath thermal well and construction the discharge pipe for the leachate into the Tisza River is currently in the water rights implementation authorisation phase. The capacity data of the discharge pipe enable the collection of the leachate of thermal wells owned by the Local Government of Csongrád County, thus the contamination of the Kurca Canal will be terminated.

The planning and authorisation process for the heat exchange-heat pump systems for the utilization of the geothermal energy of thermal leachate must be begun and implemented by taking into consideration the collection of waters mentioned above. The construction and operation of the technical establishments follow the application and public procurement procedures in one or more phases.

The boring of a thermal water well on the territory of the Public Bath is currently in the phase of water rights implementation authorisation. This would be a thermal well with double piping for the production from two water-bearing layers. The upper water-bearing layer could produce thermal water with low temperature, the lower layer thermal water with high temperature. The thermal water from the two layers would be utilized in tourism, sports and district heating systems. The water from the deeper layer must be fed into the district heating system in an insulated pipeline.

Currently, the leachate of 6 thermal wells could be collected for the area of the Public Bath of Szentes according to the situation of the thermal wells and existing long-distance pipelines of Szentes.

Service Provider Co. of Szentes (SZVSZ):
It can supply the leachate of 2 thermal wells to the territory of the Public Bath in an existing insulated long-distance pipeline.

Agricultural Research Institute:
It can supply the leachate of 1 thermal well to the territory of the Public Bath in an existing insulated long-distance pipeline.

Szentes Hospital and Clinic:
The leachate of 2 thermal wells collected on the territory of the hospital can be fed into the existing long-distance pipeline of the SZVSZ and led to the territory of the Public Bath. The feeding of the leachate into the existing pipeline requires technical modifications. The pipeline between the Public Bath and the heating station at the Kurca Canal must be expanded /350-400 m/, since the current pipeline is not suitable for the quantity of the thermal water due to its dimensions.

Szentes Public Bath:
The thermal water, currently in authorisation phase, is situated on the territory of the Public Bath. The treatment and further utilization of leachate would be realized on the territory of the Bath.

Estimated project costs:

Costs	Sum (HUF million)
Total project planning and authorisation	30
Construction of the heating station building	25
Construction of the heat-pump and heat exchanger system	100
Engineering of heat utilization units and construction of heat centres	35
Construction of insulated closed reservoir and insulated pipeline systems	110
Build-up of feed and transmission units	30
Boring of a dual-purpose thermal well with double piping	210
Total investment costs	540

Environmental project results:
The maximum leachate quantity of the 6 above-mentioned wells is estimated at 450m3/h. The reduction of harmful emission through the replacement of an amount of natural gas of 1,082,000 m3/year:

carbon dioxide	2391 t/year
carbon monoxide	563 kg/year
nitrogen dioxide	2,109 kg/year

The maximal water discharge of the new thermal well with double piping is estimated at 90m3/h. The reduction of harmful emission through the replacement of an amount of natural gas of 2,060,000 m3/year:

carbon dioxide	4,553 t/year
carbon monoxide	1,071 kg/year
nitrogen dioxide	4,017 kg/year

The total saving of natural gas and reduction of emission of harmful substances from the two wells:

The reduction of harmful emission through the replacement of an amount of natural gas of 3,142,000 m3/year:

carbon dioxide	7,844 t/year
carbon monoxide	1,634 kg/year
nitrogen dioxide	6,126 kg/year

The financial result and profitability of the project is determined by the value of the replaceable gas costs after deduction of operating costs, its comparison with the investments costs, and the level of return.

The utilization of the new thermal water represents a heat production of 4.2 MW, its heat capacity is of 70,000 GJ, the one of the heat-pumps a heat production of 2.4 MW, a heat capacity of 36,780 GJ, together a total of 106,780 GJ. The sales price of this heat quantity considering the current purchase price of the natural gas is of HUF 320,340,000. The expected annual operating costs of geothermal energy utilization with 1650 HUF/GJ represent HUF 176,187,000. The estimated payback period of the project is 3.8 years.

An application worth of HUF 815,000,000 of a three-level information centre for the presentation of geothermal energy utilization possibilities was submitted to the system of the Norwegian Fund, beyond the projects below. The application is currently in the assessment phase.

THE GEOTHERMAL CASCADE SYSTEM OF MAKÓ

The Local Government of Makó wishes to rationalize its district heating stations and the heat production system of the fully reconstructed Public Bath.

The medium and long-term urban planning and institution modernization concepts were reviewed and discussed together with the urban planning management of the local government.

The primary objective of the planned investment is the replacement of the natural gas of the two district heating stations (Hunyadi street, Deák square) used for the heating and DHW-supply of 722 flats by geothermal energy; and the heating of the buildings and pools of the public bath through a cascade system with the reinjection of the used thermal water. The thermal well "B-230" is available for the system, the thermal energy for district heating was partially supplied from this well until 2004, however, due to the unsatisfactory operational parameters, the well has not had a water rights permit for operation since 2004. A main task of the project is the resetting of well parameters registered at the time of the boring, guaranteeing a thermal water supply of a modern geothermal cascade system. The construction of a pipeline of 5000 m and of an energy-efficient, optimal, and modern cascade system is an important objective. A further essential task is the modification of the heat exchange facilities at the heating station on Deák square originally planned for natural gas for the acceptance and optimal utilization of thermal water. The installation of heat exchangers for the proper thermal heat transfer efficiency is essential since the utilization of natural gas will be terminated in the heating station on Deák square, which will be transformed into a 100% thermal substation.

The objective of the study made in 2009 for the grounding of the investment is the analysis of the justification and feasibility of the project entitled The Geothermal Cascade System of Makó, the support of decision-planning through the presentation of establishment and operation possibilities and conditions, costs, the analysis of profitability, and the necessary steps and period of the investment processes. The implementation, operational features, and the environmental and economic effects of the project proposal were presented in detail in this study. The project implementation period, the funding possibilities, and the legal regulation concerning thermal plants were profoundly studied as well. We summarize the main arguments and aspects of the study in order to support the work of the decision-makers.

Project history, justification of realization:
The district heating system of Makó was constructed in the 1970's. The two district heating stations on Hunyadi street and Deák square are used for the heating and DHW-supply of 722 flats. In 1986, the town was given the 2300-m-deep thermal well B-230 for use, which was integrated into the natural gas district heating system, thus geothermal energy could be partially used for heating. Due to unsatisfactory parameters – mainly the phenol-content – the well does not have a water rights permit for operation since 2004, thus it has been shut down. Well analyses showed that the renewal of the well can enable a production of thermal energy of approx. 5.9 MW on a long term. According to planning data, this quantity can supply enough energy for the two district heating stations, moreover, it would have an extra capacity for the heating of other buildings in a cascade system. Based to these opinions, the town leadership decided to use this capacity for the heating of buildings and pools of the new public bath, and to supply DHW with the environmentally friendly geothermal energy in accordance with the development directions of modern times. Beyond these facts, the following factors justify the necessity of the development s:
The drastically growing gas prices, and the growing heating costs due to the decreasing gas price subsidy (a rise in price of more than 70% since January 1, 2007),
The growing import dependence increasing the insecurity of gas supply, and the heating of private and public institutions (the events at the beginning of 2009 made clear that the

situation is uncertain due to the gas dispute between the Russian service provider and the Ukrainian transit companies and states),
The drastic decrease of local government budget, the necessity to minimize expenses,
Makó is situated on a territory with one of Europe's best geothermal features,
The town has a well-operating and developed district heating system with proper usable operational experience.
The new Public Bath to be built is one of the region's most significant tourism investment, for which the establishment of the geothermal heating system is wished to be financed from KEOP funding. The realization of the investment with a state aid of HUF 1.5 billion is in danger due to the lack of aid from applications, since the big project is not viable without the heating system.
The development of a more liveable urban environment requires environmentally friendly technologies that reduce the emission of harmful substance in compliance with EU directives. The geothermal heating systems are practically emission-free compared to the ones operated with fossil energy sources.

As an obvious solution, the Local Government of Makó wishes to establish a modern geothermal cascade system sustainable on a long term that enables a significant reduction of heating costs through the optimization of the current district heating system and the transformation of the network. The thermal energy is in place, is not import-dependent, and it is managed by the local population. The realization of the project can guarantee the heat demand of the district heating stations of Makó and the buildings and pools of the new bath from the cheap, local geothermal energy.

The initial situation, project location:
The planned location of the project is the town of Makó. The thermal pipelines and related institutions are marked with different colours on the map on next page (fig. 5), for the better transparency of investment locations.

Makó's district heating service was started in the 1970s. The natural gas boilers of the stations on Hunyadi street and Deák square supply 100% of the district heating. The thermal well "B-230" owned by the town partially supplied thermal energy for district heating between 1986 and 2004, however, due to the unsatisfactory parameters the well was shut down from the system. The insulated pipeline system between the two heating stations is currently unused. The old buildings of the public bath will be completely modified and expanded from DAOP funds. The heating of the bath buildings and pools was designed for geothermal energy supply, the system will be constructed according to the current application document.

The main locations of the planned investment:
Thermal well "B-230"
Reinjection wells I and II
District heating station on Hunyadi street
District heating station on Deák square
Public Bath of Makó

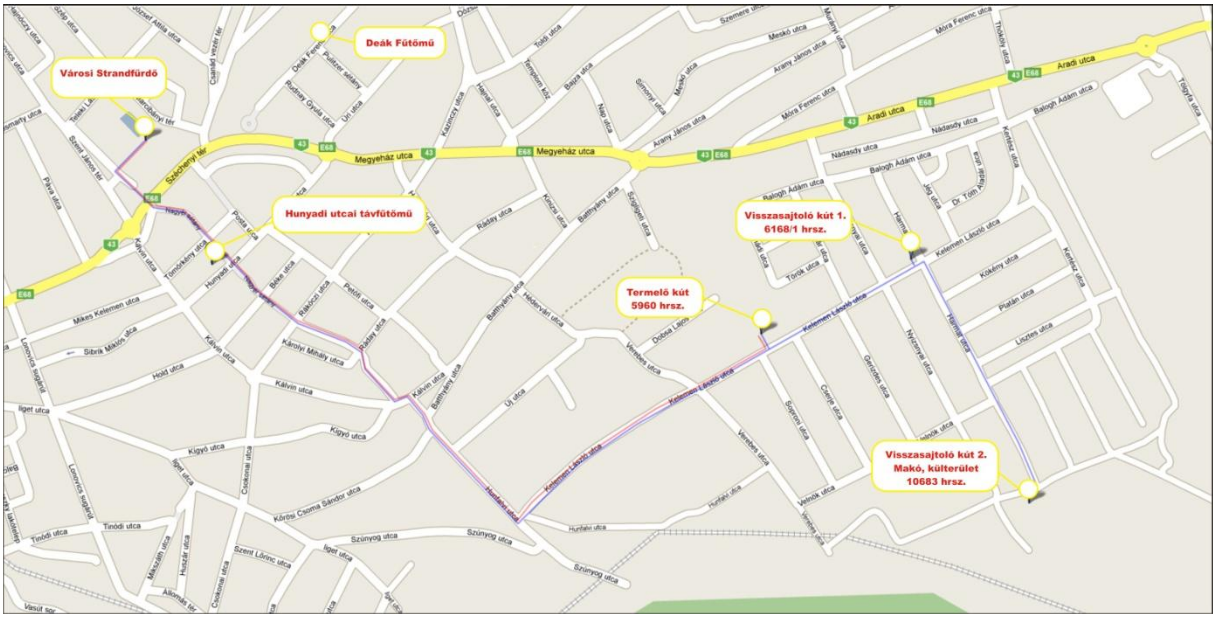


Fig. 6. The geothermal cascade system of Makó

Summary of the technical content of future developments of the project:
The current project presents a solution proposal for the modification and expansion of the district heating system of Makó, through the synthesis of presented problems and parameters, and for the supply of the new Public Bath's buildings with geothermal energy through their linking into a modern geothermal cascade system. The main operational, financial and environmental parameters of the system are presented in the following tables.

Basic data of the current phase:

Energy source	Energy utilization	Energy utilization (GJ/year)
Natural gas	2,289,941 m3/year	77,858
Electric energy utilization for heating:	82,000 kWh/year	820
Total		78,678

Main technical activities of the project:
Full and complex renewal of the existing thermal well "B-230",
Construction of a thermal cascade system guaranteeing optimal energy utilization,
Construction of a 3,100-m-long thermal pipeline network,
Transformation of the heating station on Deák square into a substation,
Renewal and development of heat centres,
Establishment of PLC system and dispatcher centre,
Building equipment modifications,
Project management,
Communication plan, fulfilment of undertakings concerning equal opportunities and sustainability.

Presentation of data after the realization of solution proposal:

Energy source	Energy utilization	Energy utilization (GJ/year)
Natural gas	97,588 m3/year	3,318
Thermal heat	269,398 m3/year	67,086

Electric energy utilization for heating:	441,840 kWh/year	4,418
Total		74,822

Savings after modernization:

Natural gas replacement (m3/year)	2,192,353
Natural gas replacement (GJ/year)	74,540
Reduction of CO2 emission	3,847

Short financial summary of the development:

Investment costs (net thousand HUF)	948,650
Expected KEOP fund (net thousand HUF)	474,325
Loan (net thousand HUF)	474,325
Operating prime costs of the thermal system without amortisation (net HUF thousand)	51,600
The extent of reduction of heating costs (thousand HUF/year)	100,811,555
Project lifetime (years)	25- 50

Simplified project payback period: 14 years.
Anticipated payback period with state aid: 7 years.

A new renewable thermal capacity of 5 MW can be started at a - very favourable – specific market price of 194, 000 HUF/kW.

Phases of implementation:
The works of renovation, pipeline construction and thermal centre establishment can be carried out within 10-11 months after the signing of the grant agreement and the contract for loan. The starting date of implementation – considering the appraisal period of four months in case of KEOP applications – is January 1 2010; the calculated final commissioning date of the system is December 31 2010. The periodical test runs of the system can be started in summer 2010.

Short presentation of the project management organization:
The town leadership examined every possibility suitable for the construction and long-term reliable operation of the geothermal cascade system of Makó. The Local Government of Makó decided to involve professional investors for the successful implementation and sustainability of the long lifetime of the investment. The presence of professional investors is a guarantee for the proper quality and lifetime of the investment. The investors have proper professional experience, and guarantee the appropriate construction and maintenance of the geothermal cascade system as operators of similar systems. Their material and intellectual investment will only be profitable, if the built system will have a long lifetime, thus the saving of maintenance and renovation costs is not in their interest. This fact is a guarantee for the system's reliable operation, thus the operational risk for the local government is minimized.
As a result of these aspects, the Local Government of Makó and the professional investor, the BRUNNEN Hőtechnika Kft, have set up MATERM Thermal System Investment, Development and Service Provider Co. for the successful implementation of the investment.

Beyond the saving of costs, the local government has a share in the project organization's profit as well. The distribution and utilization of the town's return is in the competence of the Board of Representatives: a strategy regulates the utilization of costs saved with the project for other developments.

Operation of facilities established within the project:

The MATERM Kft. is responsible for the operation of the thermal system. The majority owner and management of the company participated in the design and construction of several Hungarian thermal systems; they operated for ten years the geothermal public utility system of Hódmezővásárhely (capacity 10 MW) mentioned several times in this study.

Possible project risks:
Considering the fact that the main project objective is the renovation and expansion of the district heating system based on an existing thermal well, the investment has lower risks during both construction and operation than in case of a new well. Engineers with professional experience and practice, and comprehensive, detailed hydrogeological, profitability, sustainability, and environmental analyses guarantee the proper construction, rationalization and expansion of the system. The necessary renovation and maintenance costs of operation were included in the business plan of MATERM Kft., which guarantees a low operational risk and a high-standard service. The thermal heat will be marketed after the realization of the project in a well-working system developed along several decades: The highly qualified managements of the Makó Gyógyfürdő Kft. (Thermal Spa Co. of Makó) and MATERM Kft. guarantee the continuity of the service’s turnover. The total quantity of used thermal water will be reinjected, thus the environmental risk is minimal.

Summary, the current phase of the project:
The KEOP 4.2.0 application for the implementation of the project was accepted; the formal and professional correction of deficiencies was made, and is currently in the assessment phase.

Consequently, it can be declared that the application for the realization of a geothermal cascade system in Makó aims at the solution of a current energy problem, and is built on one of the EU's main objectives for the utilization of alternative energy, the utilization of geothermal energy. The investment reduces the heating costs of the local government with a decreasing budget, the air pollution of the town, and the import dependency.

THE GEOTHERMAL CASCADE SYSTEM OF CSONGRÁD

The Local Government of Csongrád wishes to rationalize the heating system of its public institutions. The medium and long-term urban planning and institution modernization concepts were reviewed and discussed with the urban planning management of the local government.

The primary objective of the planned investment is the renovation of the thermal well constructed long ago and operating with poor efficiency, and of the connected, partially operating thermal network, and the construction of an energy-efficient, optimized, and modern thermal cascade system.

The objective of the study submitted for a KEOP grant is the analysis of the justification and feasibility of the project entitled The Geothermal Cascade System of Csongrád, the support of decision-planning through the presentation of establishment and operation possibilities and conditions, costs, the analysis of profitability, and the necessary steps and period of the investment processes. The implementation, operational features, and the environmental and economic effects of the project proposal were presented in detail in this study. The project implementation period, the funding possibilities, and the legal regulation concerning thermal plants were profoundly studied as well. We summarize the main arguments and aspects of the study in order to support the work of the decision-makers.

Project history, justification of realization:
The thermal circle was designed and constructed based on the thermal well in the part of the town called Bökény, and extended at the end of the 1990s. The well – due to bad technological construction – can produce thermal water with low output and temperature, and has worse parameters than planned. Accordingly, it can serve only the consumers of the original system; the consumers connected at the end of the 1990s were disconnected and are currently heated with natural gas. The realization of the project is justified by following factors:
The drastically growing gas prices (a rise in price of more than 70% since January 1, 2007),
The growing gas import dependency increasing the insecurity of gas supply, and the heating of public institutions (at the time of the making of the study, the situation is uncertain due to the gas dispute between the Russian service provider and the Ukrainian transit companies and states),
The drastic decrease of local government budget, the necessity to minimize expenses,
Csongrád is situated on a territory with one of Europe's best geothermal features,
The town has an inefficiently operating district heating system with outdated technological and technical conditions, but has the advantage of a developed system of heat supply based on thermal water with proper usable operational experience.
The development of a more liveable urban environment requires environmentally friendly technologies that reduce the emission of harmful substance in compliance with EU directives.

As an obvious solution, the Local Government of Csongrád wishes to establish a modern geothermal cascade system sustainable on a long term that enables a significant reduction of heating costs through the optimization of the current thermal system and the extension of the network. The thermal energy is in place, is not import-dependent, and it is managed by the local population. The realization of the project can guarantee the heat demand of important public institutions of Csongrád from the cheap, local geothermal energy.

In harmony with the local government's intentions, an application was submitted in 2008 for the support of the investment in the KEOP 4.1 call for tenders. The application was rejected due to the feasibility study with unsatisfactory content, mentioning the unclear ownership conditions and the inappropriate energetic parameters. The second application – withdrawn later – was accepted and passed the formal control as well. The third application submitted in April 2009 was successfully accepted in the KEOP 4.2.0 call for tenders.

The initial situation, project location:
The planned location of the project is the town of Csongrád. The thermal pipelines and related institutions are marked with different colours on the map, on the next page (fig. 6) for the better transparency of investment locations.

The town already has a built thermal heating system with low efficiency (marked with the yellow line on the map). The network is located in the part of town called Bökény, near the dead branch of Tisza River. The system supplies thermal heat for a heat centre supplying 515 flats, the town's medical clinic, one high school and a social care home. The system was extended in the 1990s, however, the network was not able to supply enough amount of heat for the new consumers due to the inappropriate well construction, thus they were disconnected from the system (marked with the red line on the map). The project wishes to optimize the two systems for the maximization of the thermal water's heat capacity, and to include a third thermal circle into the thermal heat system of Csongrád (marked with the green line on the map).

The project covers the development of heating of 10 institutions with geothermal energy. The network heating the institutions will be developed in the form of a modern cascade system for the best possible heat utilization, thus the heat of the produced thermal water will be used to the maximum extent.

Institutions of the built and operating thermal circle No. I:
District heating station, Muskátli str. 13
“Dr. Ödön Szarka” Medical Clinic, Gyöngyvirág str. 5
“Mihály Sághy" Secondary School and Vocational Training Institute, Gyöngyvirág str. 18
“Aranysziget” Social Care Home, Gyöngyvirág str. 7-9

Institutions of the built but inactive thermal circle No. II:
Mayor's Office, Kossuth square 7
"Lajos Kossuth” Elementary School and Kindergarten, Kossuth square 6
“János Batsányi” Gymnasium, Secondary School, Dormitory, Kossuth square 1
"István Bársony” Agricultural Secondary School, Technical School and Dormitory, Szentesi út 2/A

Institutions of the planned thermal well No. III:
School of Singing and Music, Szentháromság square 14
Public bath, Dob str. 3-5

Fig. 6. The geothermal cascade system of Csongrád

Summary of the technical content of future developments of the project:
Through the synthesis of presented problems and parameters, the current project presents a solution proposal for the reconstruction and expansion of the thermal system of Csongrád, through the linking of the institutions into a modern geothermal cascade system. The main operational, financial and environmental parameters of the system are presented in the following tables.

Basic data of the current phase:

Energy source	Energy utilization	Energy utilization (GJ/year)
Natural gas	990,903 m3/year	33.690
Thermal heat	355,083 m3/year	27.787
Electric energy utilization for heating:	182,760 kWh/year	1.828
Total		63.305

Main technical activities of the project:
The complex renovation of the thermal well in Bökény operating with poor efficiency and low water output,
Construction of a thermal cascade system guaranteeing optimal energy utilization,
Renovation and optimization of the built and operating thermal circle No. I (connected to the above-mentioned institutions),
The renovation and optimization for the cascade system of the built but inactive thermal circle No. II (connected to the above-mentioned institutions),
Construction of thermal circle No. III, connection of the School of Singing and Music and the Public Bath to the system,

Renewal and development of 12 heat centres,
Establishment of PLC system and dispatcher centre,
Building equipment modifications,
Project management,
Communication plan, fulfilment of undertakings concerning equal opportunities and sustainability.

Presentation of data after the realization of solution proposal:

Energy source	Energy utilization	Energy utilization (GJ/year)
Natural gas	71,243 m3/year	2.422
Thermal heat	270,560 m3/year	55.931
Electric energy utilization for heating:	280,722 kWh/year	2.807
Total		61.160

Savings after modernization:

Natural gas replacement (m3/year)	919.660
Natural gas replacement (GJ/year)	31.268
Reduction of CO2 emission	1.663

Short financial summary of the development:

Investment costs (net thousand HUF)	415.176
Expected KEOP fund (net thousand HUF)	149.712
Loan (net thousand HUF)	265.464
Operating prime costs of the thermal system (net thousand HUF)	56.057
The extent of reduction of heating costs (thousand HUF/year)	30.384
Project lifetime (years)	25- 50

Simplified project payback period: 9.70 years.
Anticipated payback period with state aid: 6.21 years.

A new renewable thermal capacity of 3.3 MW can be started at a - very favourable – specific market price of 127,000 HUF/kW.

Short presentation of the project management organization:
The town leadership examined every possibility suitable for the construction and long-term reliable operation of the geothermal cascade system of Csongrád. The Local Government of Csongrád decided to involve professional investors for the successful implementation and sustainability of the long lifetime of the investment. The presence of professional investors is a guarantee for the proper quality and lifetime of the investment. The investors have proper professional experience, and guarantee the appropriate construction and maintenance of the system as operators of similar systems. Their material and intellectual investment will only be profitable, if the built system will have a long lifetime, thus the saving of maintenance and renovation costs is not in their interest. This fact is a guarantee for the system's reliable operation, thus the operational risk for the local government is minimized.

As a result of these aspects, the Local Government of Csongrád and the professional investor, the BRUNNEN Hőtechnika Kft, have set up CSOTERM Thermal System Investment, Development and Service Provider Co. for the successful implementation of the investment. In case of a successful application, the share of the local government will increase proportionally to the sum granted from KEOP assistance. Beyond the saving of costs, the local government has a share in the project organization's profit as well. The distribution and utilization of the town's return is in the competence of the Board of Representatives: a strategy regulates the utilization of costs saved with the project for other developments.

Operation of facilities established within the project:
The CSOTERM Kft. is responsible for the operation of the thermal system. The majority owner and management of the company participated in the design and construction of several Hungarian thermal systems; they operated for ten years the geothermal public utility system of Hódmezővásárhely (capacity 10 MW) mentioned several times in this study.

Summary, the current phase of the project:
The establishment of the geothermal cascade system of Csongrád is currently in the phase of contract signing, the realization - due to the extension of the application assessment and appraisal period of the bank loan – starts in May 2010.

Consequently, it can be declared that the application for the realization of a geothermal cascade system in Csongrád aims at the solution of a current energy problem, and is built on one of the EU's main objectives for the utilization of alternative energy, the utilization of geothermal energy. The investment reduces the heating costs of the local government with a decreasing budget, the air pollution of the town, and the import dependency.

THE INTEGRATED RES DEVELOPMENT CONCEPT OF SÁNDORFALVA

Sándorfalva is one of the youngest towns of Csongrád County; it is located in the north-eastern direction from Szeged. It has a population of a little more than 8000 persons, the environment has a rural character. The town does not have a district heating network, the private and public buildings are heated individually, mainly with natural gas, and in a few cases with wood. The secondary heating networks are traditional, oversized with a temperature difference of 90/70oC and 80/60 oC. According to operational experiences, they can satisfy the demands on a design exterior temperature of maximum 60/40 o C. For its long-term – mainly tourism – developments, the Local Government of Sándorfalva had the possibilities of the utilization of potentially usable renewable energy sources examined. In 2009, the local government commissioned the the professionals carrying out this present FP7 project to make the relevant analyses, to elaborate the modernization proposals, to analyze the results and their effects, to present the technical-economic processes of RES integration, and to compile the necessary documents. The feasibility study provides a detailed analysis on the town's heat market possibilities. According to the study, the construction of heating systems built on integrated alternative energy sources is possible in more phases. The first step is the energetic modernization of the examined buildings. According to the study, the burning of biomass and the introduction of geothermal energy would be the most economical way of heating of the town's buildings in the current conditions.

Fig. 7. The geothermal cascade system of Sándorfalva

The local utilization of geothermal energy has two possible versions (Fig. 7):
Utilization of geothermal energy from a depth of 1,400 metres with an own well;
Utilization of geothermal energy from a depth of 2,200 metres with an own well;

Project proposal on the technology with an own well (point 1)
The heat demand of institutions on the territory of the Local Government - after the thermal modernization – is of 708 kW.

A 1,400-m-deep production well could produce a thermal water of 60oC with a production capacity of 60 m3/h, the reinjection of which would require two reinjection wells with the same depth. The capacity of 708 kW can be guaranteed with a quantity of 30 m3/h, in systems with a temperature difference of 60/40oC, this amount could be safely reinjected with one reinjection well.

The suggested location of the production well is the yard of the Pallavicini School, or the yard of the Castle, for a 100% supply of the biggest consumers. The suggested location for the reinjection well is the territory of the currently closed public bath, or a near-by local government territory. The thermal circle between the wells would connect the public buildings and other important potential consumers located rationally from a logistical point of view on a pipeline network. This geothermal system would have a capacity of approx. 1 MW (30oC delta T). It would replace the institutional natural gas utilization; furthermore, it would have a free capacity of 300 kW, and a further capacity of 700 kW with heat pumps for consumers with low temperature difference (40/30oC) (e.g. heat supply of the central football training facility, heating of the open-air football pitch, heating of the public bath's dressing room, maintaining the temperature of the circulated pool water).

The estimated costs for the construction of the thermal well: HUF 400,000,000. The estimated operating costs (according to experiences with similar systems): calculating with 1,200 HUF/GJ – after the current institutional heat demand of 4,533 GJ/year – 5,493,600 HUF/year. The income of the thermal project is the value of the replaced natural gas, without the basic rate (for the reserve energy source or potential additional heating): 12,429,486 HUF/year (the price for gas of the institutions modernized with insulation). Accordingly, the simplified payback period of the project (400.000.000 / (12.429.486 – 5.439.600)) is of approx. 60 years, thus this version is not viable due to the very long payback period.

The salt content of the thermal water according to previous estimations (1,000-1,500 mg/l) forecasts the utilization of the water for medicinal purposes. A capacity of 60 m3/h can be targeted in this case, the half of which would be placed into the medicinal pool, after the first step of heat utilization. Peak periods could be covered by biomass burners installed at the heat stations. This would represent an extra capacity of 700 kW. In case of the "marketing" of the water of 60 oC and a capacity of 60m3/h, covering a heat capacity of 1.8 MW, on a correct heat market and in the heating season by the Hungarian weather conditions and heating habits, that is 14,000 GJ of thermal heat, and if the fluid of 30m3/h already used once could be placed in the medicinal pool, the payback period would be of approx. 14 years. The project proposal can be implemented and financed in this form. This requires a training facility with a heat demand of approx. 300 kW, and a small public bath and educational swimming pool with a demand of 800 kW.

Project proposal on the technology with an own well (point 2)
A 2,200-m-deep production thermal well can produce thermal water of 90 oC with a capacity of 60 m3/h, with a much higher salt content than the previous one; the procedure of certification as medicinal water of this would be harder and riskier.

This well would provide a heat capacity of approx. 4 MW in a temperature range of 90/30 oC by direct utilization, a water of 38 oC by a capacity of 30 m3/h for the medicinal pool, and a further capacity of 1.4 MW in the lower secondary temperature range of 50/30 oC. The estimated investment costs of the project: HUF 655,000,000. A reinjection well is necessary in case of no balneological utilization, which significantly increases the costs.

Current phase of the project:
The Local Government of Sándorfalva had the possibilities of its heat market to be examined. The town has good geothermal features and a concentrated heat market. The analysis for the utilization of RES has been carried out; results indicate that an integrated project is profitable and realizable only by the connection of new, bigger heat consumers. The energetic modernization of the buildings is necessary, which could be followed by the planning of the construction of a public heating system operating with biomass and geothermal energy.

The energy balance and costs of the current system
The summarized main thermal data of public institutions:

	Institution	Calculated max. heat demand (kW)	Annual gas consumption (m^3)	Gas meter size
1.	Pallavicini Elementary School	276	58.206	G 40
2.	Arany János School	75	16.013	G 10
3.	“Építők” School	40	7.899	G 4
4.	Kindergarten Kis Blv.	55	8.392	G 6
5.	Kindergarten Iskola Str.	42	7.339	G 6
6.	Kindergarten Rákóczi Str.	25	4.633	G 4
7.	Kindergarten Kölcsey Str.	58	10,965	G 6
8.	Day-care centre	42	7,353	G 6
9.	House of Health A	30	5,241	G 4
10.	House of Health B	44	7,254	G 6
11.	Retirement Home	42	7,287	G 6
12.	Cultural House	74	12,633	G 10
13.	Mayor’s Office	58	9,636	G 10
14.	Events Hall	26	3,855	G 6
15.	Fire Department	41	6,549	G 4
16.	Urban Management Co.	14	2,177	G 6
17.	Multipurpose building	69	11,682	G 10
	Institutions total:	**1,011**	**186,939**	
18.	New training centre (plan)	300	108,618	G 40
19.	New spa (plan)	800	216,412	2 x G 40

The cumulated utilization and costs of the ***natural gas for heating*** of the facilities concerned by the project can be summarized as follows. The annual net cost of gas consumption at current level of the institutions was defined under consideration of the universal service tariff.

The energy content of natural gas utilization is 34 MJ/m^3, the base rate depending on the installed gas meter according to the relevant tariff (under a performance of 20 m^3/h – HUF 12,000/year and HUF 2,859/GJ; in a performance range of 20 – 100 m^3/h – HUF 19,068/ m^3/h and HUF 2,276/GJ; above 100 m^3/h approx. HUF 1,000/MJ/h fixed price and the open-market price approx. HUF 1,764/GJ), other fees include the import correction factor (HUF 92/GJ) and the security stockpiling fee (HUF 60.50/GJ), the energy fee is HUF 88.50/GJ (recoverable in case of household customers).

Institution	**Natural gas** GJ/year	**Base rate** (HUF)	**Total gas price** (HUF)	**En. tax** (HUF)	**Total costs** (HUF)

Pallavicini Elementary School	1,979	762,720	4,806,001	175,141	5,743,862
Arany János School	544	12,000	1,638,256	48,144	1,698,400
"Építők" School	269	12,000	810,093	23,806	845,899
Kindergarten Kis Blv.	285	12,000	858,277	25,222	895,499
Kindergarten Iskola Str.	250	12,000	752,875	22,125	787,000
Kindergarten Rákóczi Str.	156	12,000	469,794	13,806	495,600
Kindergarten Kölcsey Str.	373	12,000	1,123,289	33,010	1,168,299
Day-care centre	250	12,000	752,875	22,125	787,000
House of Health A	178	12,000	536,047	15,753	563,800
House of Health B	247	12,000	743,840	21,859	777,699
Retirement Home	248	12,000	746,852	21,948	780,800
Cultural House	430	12,000	1,294,945	38,055	1,345,000
Mayor's Office	328	12,000	987,772	29,028	1,028,800
Events Hall	134	12,000	403,541	11,859	427,400
Fire Department	223	12,000	671,564	19,735	703,299
Urban Management Co.	74	12,000	222,851	6,549	241,400
Multipurpose building	397	12,000	1,195,565	35,134	1,242,699
Institutions total:	***6,356***	***954,720***	***18,014,437***	***562,506***	***19,555,469***
New training centre (plan)	3,693	762,720	8,968,450	326,830	10,058,000
New spa (plan)	7,358	1,525,440	17,868,903	651,183	20,045,526

Net specific institutional purchase price: 3,077 HUF/GJ.

The utilization and costs of the ***electric power for heating***, and the maintenance costs of facilities are insignificant, they are omissible.
In case of DHW production of the institutions, the measurement of used quantities and consumed electric power is impossible. The annual sum for electric power of the 17 institutions can be determined at ***HUF 1,628,812*** according to the following assumptions: average heating performance of electric equipments = 1.3 kW; 5 hours of operation; daily consumption value of 17 institutions = 111.5 kWh; total quantity = 40,720 kWh; unit price = HUF 40/kWh.

Accordingly, the current net heating energy cost of the institutions is HUF 21,160,475.

With the assumed gas costs of the new establishments, it adds up to a net sum of HUF 51,287,807.

EVALUATION OF ALTERNATIVES

The basic approach of the study is that the cheapest and less pollutant energy is the unused energy. Accordingly, we cannot put aside the thermal renewal, which will improve the energy efficiency of the institutions and moderate the losses of buildings. In this chapter, we present and examine the primary energy source alternatives that will complement and replace gas utilization.

Evaluation of alternatives

<u>Analyses for the specification of final versions</u>

The steps of the analysis of possible alternative solutions are as follows:
1. Specification and description of alternatives
2. Presentation of indicators of project solutions

a./ Solution lifetime (years)
b./ Simplified payback period (years)
c./ Extent of energy saving (+-%, zero)
d./ Benefit-cost rate (%)
e./ Cost efficiency (HUF thousand /kW)
f./ Sustainability risk of energy source (low, medium, high)
g./ Emission changes (+-%, zero)
h./ Live labour demand (change persons)
i./ Change in service comfort (improve, worsen, unchanged)

3. Other aspects, strengths, weaknesses, subjectivities

Methodology of the evaluation

The alternatives are presented according to the steps presented in chapter one, and to the extent and necessity of analysis correctitude and relevancy.

At the beginning, the irrelevant technological solutions are filtered out after the consideration of basic aspects. The remaining alternatives are evaluated one by one according to the comparison of their general features.

During the comparison of alternatives, we choose the “multi-aspect” evaluation, which provides proper assistance for the determination of the alternative to be chosen.
The alternatives are ranked according to point 2 of chapter 6.1.1, then weighted according to point 3, and finally, the final version is specified in a summarizing evaluation.

The “do-nothing” version

Should the planned and proposed project not be realized, the current heating structure will remain in the town’s institutional heat supply, and the development for health tourism and training centre will not be implemented.

The technical content, the operational costs of this version, and the out-dated condition of facilities are detailed in chapter 5 of this study; the missed results and the emission indicators of remaining pollutants are presented in the Executive summary (chapter 1).

Project alternatives

The current natural gas boiler systems of the establishments are serviceable, and they can operate for several more years after renovation and the development of modern control. It is a well-known fact that the world's natural gas reserves are finite; it is probable to remain a significant energy source for decades on both national and local government level. The increase of the purchase price to the level of world market price, the termination of the price support on national level, the uncertainties and political dependences of the international gas supply, and its role in the generation of the global climate change significantly intensify the “will to replace” gas.

The fact that the change to other fossil energy sources (e.g. oil, coal, fossil fuel-based electric power) is non-sense and expensive and atomic energy will remain an issue of political debate. There are efficiency-improving solutions (see previous chapters), such as

- minimization of losses;
- use of condensing boilers;
- cogeneration;
- trigeneration;

or the use of alternative energy sources, such as

- solar energy;
- wind energy;
- hydropower;
- biomass;
- geothermal energy.

The combination of renewable sources could be an optimum solution as well.

The aim of this chapter is the analysis of the possibility of the local use of environmentally friendly renewable sources, which are cheaper on a long term. The basic objective is the introduction and analysis of possible alternatives, and the elaboration and confirmation of an optimum solution proposal.

Three renewable energy sources can be taken into consideration for heating energy in the South Great Plain region. These are solar energy, biomass, and geothermal energy.

Presentation of alternatives

A.) IMPROVEMENT OF ENERGY EFFICIENCY

Modernization of institutions:

The Pallavicini School and Gym: almost complete replacement of doors and windows, and complete insulation of the external façade. After the demolition of building “A”, a twice as big school wing will be built on its place with modern thermal parameters (heat demand of approx. 80 kW). The other two buildings (building "B" and gym) require the installation of modern plastic windows of 400.3 m^2 (k=1.1 W/m^2K). The wall of building “A” is built with a 5-cm thick NC (EPS) insulation, its heat transmission coefficient is 0.65 W/m^2K, instead of the allowed 0.45; this however, is a very small difference, which does not justify the application of external facade insulation. The posterior insulation of the ceiling (with 10-cm thick rock wool) is recommended on an area of 575.3 m^2. For the gym, the posterior insulation of the external façade (with 10-cm thick Nikecell (expanded polystyrene) and patent plaster) on a surface of 407 m^2 is recommended. After these works, the total heat demand of the institutions will decrease to **195.7 kW** for heating, and **20 kW** for DHW production, i.e. to 215.8 kW.

The complete replacement of the outdated, combined, and inefficient heating system would be recommended, if economically acceptable. From the point of view of priorities, the replacement of the old boilers by a boiler cascade of condensing wall-mounted Viessmann Vitodens boilers with a capacity of 3x80 KW. The replacement of the heating network is to be considered, if allowed by the efficiency analysis.

The Arany János School (castle building): replacement of doors and windows on a surface of 93.8 m^2, however, due to its monument classification, only a more expensive wooden structure is applicable. After analyzing the annexed energy certificates, the facade insulation is not required, only the covering of the ceiling with 10-cm thick rock wool on a surface of 463 m^2. As a result, the heat demand will decrease by almost 10 kW (14%) (**60.9 kW** for heating, and **5 kW** for DHW production).

The modernization of the complete internal heating system would be timely, the relevant aspects and priorities are similar with the ones in the previous chapter. This building would require the installation of a wall-mounted Viessmann condensing boiler with a capacity of 60 kW.

The Építők School: the complete thermal renovation is recommended, i.e. the installation of plastic doors and windows on a surface of 31.6 m^2, facade insulation on 186.4 m^2 and ceiling insulation on 235 m^2. The insulation will result in a demand of a capacity of **17 kW** for heating, and of **5 kW** for DHW production. The saved capacity is 17.4 kW (50%).

The above-mentioned actions are recommended for the internal heating system. The recommended boiler is a condensing wall-mounted combi boiler with a capacity of 19 kW.

We have a mixed picture for the kindergartens. The *unit on Kis Blv.* does not require the replacement of doors and windows, only façade insulation on a surface of 215.1 m^2, and ceiling insulation on 400 m^2. A capacity of 10.9 kW (24%) can be saved, **34.4 kW** is required for heating, and **10 kW** for DHW production. The renewal of the complete heating system is recommended by keeping the current wood-heating system. The installation of a new wall-mounted condensing boiler of 35 kW is recommended as well.

The *unit on Iskola Street* has doors and windows in good condition, façade insulation on a surface of 172.8 m^2, and ceiling insulation on 203.7 m^2 is recommended. The heat loss can decrease by 46% (14.8 kW). The remaining heat demand is **17.4 kW** for heating, and **10 kW** for DHW production. The replacement of the current gas boiler by a wall-mounted condensing combi boiler of 26 kW is recommended. The modernization of the internal heating system is recommended depending on the available financial resources.

The *unit on Rákóczi Street* requires the replacement of a few windows, i.e. the installation of modern plastic windows on a surface of 9.42 m^2. The required complete insulation parameters: 155.45 m^2 on the facade, and 148.35 m^2 on the ceiling. The efficiency can be improved by 8.4 kW (41%). The remaining heat demand is **12 kW** for heating, and **5 kW** for DHW production. The replacement of the boiler by a wall-mounted condensing combi boiler of 19 kW is recommended.

The unit on *Kölcsey Street* requires the partial replacement of doors and windows as well (34 m^2). Facade insulation is required on a surface of 242.9 m^2, and ceiling insulation on 324 m^2. As a result, the efficiency can be improved by 50% (24 kW). The remaining heat demand is **24.3 kW** for heating, and **10 kW** for DHW production. The replacement of the old boiler by a condensing wall-mounted combi boiler of 35 kW is recommended. The modernization of the internal heating system is recommended depending on the financial indicators.

In the Kindergarten the replacement of doors and windows is unnecessary, only facade insulation on a surface of 177 m^2, and ceiling insulation on 262 m^2. The efficiency can be improved by 13.5 kW (42 %). The remaining heat demand is **18.8 kW** for heating, and **10 kW** for DHW production. The replacement of the old boiler by a condensing wall-mounted combi boiler of 26 kW is recommended. The modernization of the internal heating system should be carried out as mentioned above.

Both buildings of the *House of Health* has doors and windows in good condition, the heating system is modern, no replacement is recommended. In *building "A"* the façade should be insulated on a surface of 113.6 m^2, the ceiling on 261.8 m^2, resulting in a maximum capacity saving of 11.4 kW (40 %). In *building "B"* the façade should be insulated on a surface of 280.2 m^2, the ceiling on 201 m^2, resulting in a capacity improvement of 15.9 kW (40 %). The heat demand after modernization will be of **17.4 kW** for heating and of **2 kW** for DHW production in building "A", and of **23.9 kW** and of **5 kW** in building "B".

The building of the *Library and Retirement Home* requires a complete reconstruction. Replacement of doors and windows on a surface of 34 m^2, facade insulation on 185.6 m^2, and ceiling insulation on 262.4 m^2, resulting in a capacity improvement of 13.7 kW (43 %). The remaining heat demand will be of **18.3 kW** for heating, and of **10 kW** for DHW production, for which the installation of a wall-mounted condensing combi boiler of 26 kW is required. The modernization of the old, outdated internal heating system is also necessary.

The Cultural House does not require the replacement of doors and windows; facade insulation is required on a surface of 426.6 m^2, and ceiling insulation on 529 m^2. The capacity can be improved by 30 kW (43%), resulting in a heat demand of **39.4 kW** for heating, and of **5 kW** for DHW production. The current outdated boiler of 70 kW can be replaced by a wall-mounted condensing boiler of 45 kW. The internal heating system is in good condition, its replacement is unnecessary.

The *Mayor's Office* has doors and windows in bad condition, an outdated heating system, thus a complete thermal modernization is relevant. 98.7 m^2 of plastic doors and windows will be installed; the external facade will be insulated on a surface of 298.8 m^2, the ceiling on 462 m^2. A capacity of 20.3 kW (38 %) can be saved, **32.6 kW** is required for heating, and **5 kW** for DHW production. These demands can be satisfied by a modern wall-mounted condensing boiler of 35 kW. The modernization of the internal heating system and the installation of radiators with thermostatic valves for individual control and of a weather-dependent control system are recommended.

A complete renewal of the *Events Hall* could result in changes and savings. Doors and windows should be replaced on a surface of 27.5 m^2; the facade requires insulation on 113.7 m^2, the ceiling on 132.4 m^2. This can result in an efficiency improvement of 54% (11.8 kW). The head demand in the future would be of **10 kW** for heating, and of **5 kW** for DHW production. Further saving could be achieved with the replacement of the inefficient convector system, the installation of a two-pipe radiator heating system with thermostats, and the installation of a wall-mounted condensing boiler of 19 kW.

The *Fire Department* requires thermal modernization as well. The heat demand of the building can be decreased by 41% with new doors and windows on a surface of 52.4 m^2, facade insulation on 235.7 m^2, and ceiling insulation on 108 m^2. The remaining heat demand is **21.4 kW** for heating, and **5 kW** for DHW production. The floor heating does not require any works. The old radiators must be replaced by new ones, and the outdated boiler by a new condensing one of 26 kW.

The building of the *Urban Management Co*. requires the exact same activities as the Events Hall. Doors and windows should be replaced on a surface of 12.3 m^2; the facade requires insulation on 89.3 m^2, the ceiling on 93.3 m^2. A capacity of 4.8 kW (40 %) can be saved, **7.1 kW** is required for heating, and **2 kW** for DHW production. The system could be linked to the modern main pipe of the local government's boiler room on a 20-m long pipeline with individual control.

Finally, the current *Multipurpose building* (future Community Youth Centre) requires complete renovation. According to local government plans, the interior of the building will be reconstructed – from other and own resources – into a wing complying with every thermal specification. Since these are only plans, we do not take them into consideration within this study, in order for the comparison with the current condition to be exact and justified.

According to the current conditions, the doors and windows should be replaced on a surface of 104.9 m^2; the facade should be insulated on a surface of 189 m^2, the ceiling on 494 m^2. A demand decrease of 26 kW (40 %) can be reached, **38.3 kW** is required for heating, and **5 kW** for DHW production. A wall-mounted condensing combi boiler of 45 kW could satisfy the total heat demand of the building. Instead of the convectors, the installation of a two-pipe, pump-heating system is recommended with radiators with thermostatic valves for individual control and a weather-dependent control system.

The application of floor heating is recommended during the actual reconstruction of the building to keep the internal temperature difference at a low level for the most efficient utilization of renewable energy sources.

*

The historic costs (net HUF thousand) of above-mentioned investments improving the energy efficiency and reducing the losses can be summarized as follows:

Institution	Replacement of doors and windows	Façade insulation	Ceiling insulation	Boiler replacement	Renewal of heating system	Total costs
Pallavicini Elementary School	8,006	2,360	725	6,216	11,290	28,597
Arany János School	1,876	-	583	1,720	4,629	8,808
“Építők” School	632	1,081	296	1,150	2,350	5,509
Kindergarten Kis Blv.	-	1,248	504	1,290	4,000	7,042
Kindergarten Iskola Str.	-	1,002	257	1,190	2,037	4,486
Kindergarten Rákóczi Str.	188	902	187	1,150	1,483	3,910
Kindergarten Kölcsey Str.	680	1,409	408	1,290	3,240	7,027
Day-care centre	-	1,026	330	1,150	2,620	5,126
House of Health A	-	659	330	-	-	989
House of Health B	-	1,625	253	-	-	1,878
Retirement Home	680	1,076	331	1,150	2,624	5,861
Cultural House	-	2,474	667	1,590	-	4,731
Mayor’s Office	1,974	1,733	582	1,290	4,620	10,199
Events Hall	550	659	167	1,150	1,324	3,850
Fire Department	1,048	1,367	136	1,190	1,080	4,821
Urban Management Co.	246	518	118	-	1,250	2,132
Multipurpose building	2,098	1,367	136	1,590	4,940	10,131
Institutions total:	**17,978**	**20,506**	**6,010**	**23,116**	**47,667**	**115,097**

The results of energy efficiency improvement

The loss reduction reachable with the investment – indicated by the values in the annexed energy certificate “B” – results in a moderation of the heat demand, thermal energy utilization, and gas costs of the network of institutions, as presented in the table below:

	Institution	Max. heat demand after modernization (kW)	Reduction (kW)	Reduction (%)
1.	Pallavicini Elementary School	215.7	60	21.8
2.	Arany János School	69.5	9.5	12.6
3.	“Építők” School	22.3	17.4	43.8
4.	Kindergarten Kis Blv.	44.4	10.9	19.7

5.	Kindergarten Iskola Str.	27.4	4.8	14.9
6.	Kindergarten Rákóczi Str.	17	8.4	33.0
7.	Kindergarten Kölcsey Str.	34.3	23.9	41.1
8.	Day-care centre	28.8	13.5	31.9
9.	House of Health A	19.4	11.4	37.0
10.	House of Health B	28.9	15.9	35.5
11.	Retirement Home	28.3	13.7	32.6
12.	Cultural House	44.4	30.0	40.3
13.	Mayor’s Office	37.6	20.3	35.1
14.	Events Hall	14.5	12.2	45.7
15.	Fire Department	26.4	14.6	35.6
16.	Urban Management Co.	9.3	4.6	33.1
17.	Multipurpose building	43.2	25.9	37.5
	Institutions total:	**708**	**297**	**29.3**

For the costs, we took the change of base rates into consideration. The expected institutional gas costs after modernization are presented in the table below (the maximum gas demand of the school must be contracted below 20 m^3/h – 200 kW!):

Institution	**Natural gas** GJ/year	**Base rate** (HUF)	**Total gas price** (HUF)	**En. tax** (HUF)	**Total costs** (HUF)
Pallavicini Elementary School	1,548	12,000	4,661,802	136,998	4,810,800
Arany János School	476	12,000	1,433,474	42,126	1,487,600
“Építők” School	151	12,000	454,736	13,363	480,099
Kindergarten Kis Blv.	229	12,000	689,633	20,266	721,899
Kindergarten Iskola Str.	212	12,000	638,438	18,762	669,200
Kindergarten Rákóczi Str.	106	12,000	319,219	9,381	340,600
Kindergarten Kölcsey Str.	220	12,000	662,530	19,470	694,000
Day-care centre	170	12,000	511,955	15,045	539,000
House of Health A	112	12,000	337,288	9,912	359,200
House of Health B	159	12,000	478,828	14,071	504,899
Retirement Home	167	12,000	502,920	14,779	529,699
Cultural House	256	12,000	770,944	22,656	805,600
Mayor’s Office	213	12,000	641,449	18,850	672,299
Events Hall	73	12,000	219,839	6,460	238,299
Fire Department	144	12,000	433,656	12,744	458,400
Urban Management Co.	49	12,000	147,563	4,336	163,899
Multipurpose building	248	12,000	746,852	21,948	780,800
Institutions total:	***4,533***	***204,000***	***13,651,129***	***401,170***	***14,256,299***

Net specific institutional purchase price: 3,145 HUF/GJ;

With the installation of the new combi boilers, the electricity costs of the local electric water heaters will be practically replaced (see chapter 5.2.4).

Cost-effectiveness analysis of the energy efficiency project phase

1. Current gas costs of the local government: HUF 19,555,469. According to the reduction of the heat demand presented above, almost 30% of these costs can be saved, i.e. HUF 5,299,170. Further savings are generated in the DHW production by the replacement of electric boilers (HUF 1,628,812/year). The total sum saved **HUF 6,927,982.** The costs for the improvement of the energy efficiency were presented in the previous chapter. According to that, the complete modernization would cost HUF 115,097,000 plus approx. HUF 12,000,000 for preparation, planning, and project management would add up to net **HUF 127,097,000.** Accordingly, the simplified payback period of the project phase is **18.3 years**, the annexed IRR table No. 1 shows that the **value of the internal rate of return is positive** (1.88%), the **project phase is supported by the KEOP to approx. 45%** within the call of tenders No. KEOP-2009-5.3.0/A entitled "Energetic Developments of Buildings and Modernization of Public Lighting".
2. Thermal insulation and the replacement of doors and windows can be chosen separately, their cost is net HUF 44,494,000 plus preparation and project management costs of approx. HUF 8,000,000, adding up to a total of HUF 52,494,000. The proportion of support in this case is **50%.**
3. The modernization of the internal heating system can be chosen as well, for net HUF 70,783,000, or separately, either the renewal of the heating network (HUF 47,667,000), or the replacement of boilers (HUF 23,116,000). These are completed with the costs for preparation and management, with a support of **30%.**

B.) RENEWABLE ENERGY SOURCES

<u>*Solar energy:*</u>
There is a huge amount of solar energy available, since the number of sunny hours is above 2000 in the South Great Plain. Due to its probability (shining or not shining) and the undiscovered economic way of heat storage, this energy can only be partially applied. In case of facilities, it could be excellently used for the pre-heating of returning boiler water for DHW production. The possible institutions with DHW consumption (school gym, kindergartens, Day-care Centre, and Social Care Home) should consider solar energy, since its utilization for heating is becoming more and more popular. Due to the small amount of consumed DHW, the combined utilization of solar energy has excellent prospects.

The figure among the annexes shows the connection scheme of a combined solar collector heat supply system. The annexes include the offer of an expert company for the installation of a combined system dimensioned for a collector surface of 30m^2.

The relevant technical descriptions show that it can contribute to heating in the heat supply systems dimensioned for low heating temperatures, in traditional radiator systems the preferred solution is the DHW production.

The modernization of the heating systems can be an objective in the institutions in Sándorfalva. The dimensioning and installation of larger heat-transfer appliances with lower operating temperature requirements should be considered, especially in institutions consuming a significant amount of DHW (kindergartens, day-care, school, social care home). The following vacuum-tube solar collectors systems can be applied in these institutions.

Cost-effectiveness analysis:
1. The expected annual output of the vacuum-tube collector is approx. 700 kWh/m^2/year. This adds up to 21,000 kWh/year on a collector surface of 30 m^2, i.e. an annual heat quantity of 75.6 GJ in a system with low temperature difference of 50/30 ^{o}C. The investment costs add up to HUF 4,041,000, operating costs (electricity costs of a 90-W accelerator, and maintenance costs) are approx. HUF 750 /GJ, compared to the price of HUF 2,742 /GJ of natural gas without the base rate. The simplified

payback period calculated with the saving of costs is **26.8 years.** Accordingly, it cannot overcome the level set by the KEOP call on its own.

2. In case of utilization of solar energy combined with the project improving energy efficiency described in chapter 4, by planning 7 systems with a collector surface of $30m^2$ each (1 day-care, 4 kindergartens, 1 school, 1 retirement home), and with the modernization of the heating system only in these seven institutions (contributing to the profitability of solar energy utilization), the total investment costs are estimated as follows: 222,674,000 (total insulation) + 27,294,000 (modernization of 7 networks) + 28,287,000 (7 solar collector systems) = HUF 278,255,000. The operating costs for the 7 solar collector systems (7 x 75.6 x 750) add up to HUF 393,750 /year, the sum of replaced gas costs (525 GJ x HUF 2,742 /GJ) = HUF 1,439,550 /year, it reduces the remaining gas costs of the institutions, as presented in chapter 4, with its profit (HUF 1,045,800 /year). Accordingly, it increases the result and saving of the energy efficiency improvement project by this sum (6,671,742 + 1,045,800 = HUF 7,717,542 /year). The simplified payback period of the proposal is **36 years, no KEOP support granted**!

Finally, we can state that cost-effectiveness indicators of the current technology of solar energy utilization cannot comply with the relevant KEOP specifications.

Biomass

The applicable main energy sources of biomass in Sándorfalva are the wood chips, straw, and pellet. The heating technology with straw requiring a large storage capacity can be put aside due to the situation of consumers in the downtown, and the narrow institutional environment. The purchase price of the latter – due to the high production and added value – is high, it accommodates to the price of the European natural gas, and thus its national competitiveness is currently bad. Therefore, we do not deal with pellet technology. Accordingly, *the proposed biomass alternative is the firing with wood chips* from agricultural, timber or silvicultural waste.

Presentation of the technology and heat centre modifications

The natural gas systems are available in every institution as excellent reserve energy sources, and if necessary, they serve as “heating supplement” for the capacity support of alternative heating sources during peak periods. An optimum solution for alternative energy utilization is if the production is carried out at a central place, and it is distributed to the consumer institutions through a pipeline. *(The figure among the annexes shows the connection scheme of the examined technologies.)* This requires the construction of a pipeline system, and of heat centres accepting the heat, preferably in the free spaces of the existing boiler houses. The costs of these two necessary project elements are summarized below, followed by the analysis of the alternatives of primary energy sources. We do not discuss two kindergartens (Rákóczi and Kölcsey street), due to their distance to the other institutions. The utilization of individual technologies is recommended for these two.

Heat supply pipeline:

The heat supply systems of the town institutions operate at 60/40 ^{o}C, at design temperature. On the one hand, the total heat demand of the institution will be of 708 kW after the realization of the project phase for efficiency improvement. On the other hand, the new systems will have a lower temperature difference being able to reach delta T of 30 ^{o}C. Accordingly, around 20 m^3/h pf heating medium would flow in the pipelines, so we can calculate with NA 100/200 insulated pipeline. The insulated, underground ISOPLUS or BÁCSHŐ communal heat supply pipeline would connect the two farthest institutions (Pallavicini school and the future spa), and link the others on the 2,975.m long line. The institutional NA 50/125 connecting lines are also insulated, their total length is approx. 875 metres. A pressure drop of 2 bars is generated on the pipeline network, which can be guaranteed with a pump work of an electric output of 1-2 kW.

Estimated investment costs for the pipeline network:

Planning, authorisation procedures	3,825
Construction of main pipeline of 2,950 metres	103,250
Construction of NA 50/125 connection lines of 875 metres	13,125
Commissioning, pressure test	500
Technical inspection	2,500
Total net	***119,375***

Heat centres:
The reception of the heat is carried out in the boiler house, heat centre of every institution, through the necessary modifications.

Despite the fact that the high temperature would allow the direct connection of internal heating systems as well, indirect heat exchange is recommended for these technologies as well, thus the independent accommodation of external and internal heating systems through the installation of small plate heat exchangers. The biomass of higher temperature and other low-temperature (higher mass flow) technologies have different costs. The size of the heat exchanger is bigger for the latter; we do not consider this slight difference in this study.

Considering the heat demands of peak season heating and DHW production, the following plate heat exchangers can be installed with the connected heat and hydromechanical appliances, calorimeters, and automatic control systems.

Institution	Heat exchanger (kW)	Historic cost (net HUF thousand)
Pallavicini Elementary School	220	4,800
Arany János School	70	1,650
"Építők" School	25	850
Kindergarten Kis Blv.	50	1,450
Kindergarten Iskola Str.	30	950
Day-care centre	30	950
House of Health A	20	680
House of Health B	30	950
Retirement Home	30	950
Cultural House	45	1,200
Mayor's Office	50	1,450
Events Hall	20	680
Fire Department	30	950
Urban Management Co.	10	500
Multipurpose building	45	1,200
Planning, technical inspection, commissioning		6,500
Total:	**705**	**25,710**

Total costs for pipeline networks and heat centre modifications: ***HUF 145,085,000 + VAT.***

Wood-chips boiler house
A Viessmann wood-chip firing facility of 540 kW would be installed either on the school's yard, or in the yard of the Multipurpose building on Széchenyi Street in a lightweight-construction boiler house of 20-25 m^2.

Fuel storage of 100 m^3 would be established as part of the boiler house, which would store a one-month's worth of material. This amount is estimated according to the heat demand shown in chapter 4.2, and the 10% efficiency deterioration of the boiler, for the annual use of approx. 315 t of wood chips, and the specific weight of 0.35-0.50 t/m^3 depending on the material's moisture content.

A spiral conveyor feeds the boiler from the storage, and a tractor owned by the local government orders the wood chips into the feed opening of the storage every 2 or 3 days.

Material supply
Wood product waste can be bought at the site of ÖKOHŐ Ltd. in Baja or Cegléd. The transport route Cegléd-Kecskemét-Kistelek-Sándorfalva is approx. 120 km. The current purchase price of wood chips is HUF 12,000/t, which is HUF 750/GJ. This is completed by the transport and storage costs.

The waste material from the regional silviculture could be an alternative, which could be chipped with a mobile chipping machine for the feed into the boiler. Another alternative could be the waste product of a local woodworking factory. Since none of these two is available, the current study calculates with the above-mentioned version of purchased wood material.

Construction costs for the wood-chips heating base (net HUF thousand):

Planning, authorisation procedure	1,500
One complete KOP Pyrot 540 heating system	22,500
Lightweight boiler house and storage of 20 + 40 m^2	12,000
Chimney system construction	1,000
Installation of deduster system	1,150
Heat dissipation system	1,200
Modification of fire-fighting system	850
Installation of an electric power system with control box	900
Weak-current control system	800
Commissioning, test run	250
Technical inspection, project management	1,200
Total	***43,350***

Operating costs for the wood-chips heating base (net HUF thousand):
Material costs

Electric power (15,000 kWh x HUF 36/kWh)	540
Wood chips (315 t x HUF 12,000/t)	3,780
Transportation costs (wood chips, ash, waste) (8.4 t/freight and HUF 200/km) for 315 t of wood chips and 240 km = HUF 1,824 thousand; for 16 t of ash and 100 km = HUF 40 thousand.	1,864
Maintenance of boiler system	300
Cleaning and maintenance of chimney system	100
Maintenance of heating room appliances, and heating centres (15 pc)	450
Annual costs for inspections for compliance with standards	30
Other (materials handling, telephone, insurance, reports etc.)	500
Total	7,*564*
Staff costs (use of existing labour)	-
*Other costs (*exceptional occurrences etc*.)*	*500*
Total operating costs	**8,064 (HUF 1,779/GJ);**

Cost-effectiveness analysis of wood-chip heating:

1. <u>In case of combined project </u>(efficiency improvement and biomass energy source utilization), the specific operating costs of the biomass system for the used wood chips (5,040 GJ/year) are net HUF 1,600/GJ, and for the replaced fossil energy source (4,553 GJ/year) net HUF 1,779/GJ. The specific heating costs with the use of biomass technology (3,145 – 1,779) decrease by net HUF 1,366/GJ (43%). The total annual profit of the biomass project phase: 4,533 GJ x HUF 1,366/GJ = HUF 6,192 thousand, by the above-mentioned investment costs of HUF 145,085 thousand + HUF 43,350 thousand = HUF 188,435 thousand.
Completing (combining) these figures with the main figures of the energy efficiency improvement phase, we get the following figures:
total investment costs 127,097,000 + 188,435,000 = HUF 315,532,000;
total project profit (saving of energy costs) 6,927,982 + 6,192,000 = HUF 13,119,982 (we do not consider the two distant institutions either on the investment or the profit side, since their influence on the main figures is insignificant).
Accordingly, the simplified payback period of the combined project **24 years**, the annexed IRR table No. 2 shows that the value of the internal rate of return is positive (**0.15%**), the project phase **can be supported** by the KEOP.

2. The investment costs of version No. 1 without the replacement of the gas boiler (the current boilers can be used as reserve heating systems) can be reduced by HUF 23,116,000 (HUF 292,416,000), by constant returns. In this case, the payback period is **22.3 years**, the IRR indicator increases, and the project is supported by KEOP.

3. The investment costs of the combined project in case of version No. 1 without the modernization of internal heating systems (only with the insulation works) decrease by HUF 47,667,000 (HUF 244,749). Accordingly, the simplified payback period of the project phase is **18.65** years; the annexed IRR table No. 3 shows that the value of the internal rate of return is positive (**1.77%**), the project phase **can be supported** by the KEOP to approx. **60%** within the call of tenders No. KEOP-2009-5.3.0/B entitled "Energetic Developments of Buildings Combined with Renewable Energy Utilization”.

As a conclusion, we can state that the heating with biomass – as primary energy source – is a realistic alternative. From the point of view of the local government, the rational alternatives are point 1 and 2; from the point of view of the national economy, the most reasonable alternative would be point 2.

<u>Geothermal energy:</u>
Several ways of utilization of geothermal energy are known in Hungary. One is the utilization of the high-temperature heat of thermal water from high depths (1000-3000 m) by direct utilization (between 100 and 30 ^{o}C) or by heat pumps (between 5 and 30 ^{o}C); the other is the utilization of the low-temperature heat (5-30 ^{o}C) from lower depths (10-300 m).

The region’s geological and existing well operation features, and the parameters of the heat market determine the applied technology.

Thermal energy is at hand, it imposes a minimum threat to the environment, so it can be an optimum source of heat.

The excellent geological features of the South Great Plain are well known. There are several operating thermal wells in the region of Szeged built on Upper Pannonian sandstone reservoirs – depth of 1,800-2,100 m, output of 60-70 m^3/h, and temperature of 80-100 ^{o}C. In 2008, water management expert Dr. József Török made town’s geothermal report for the Local Government of Sándorfalva. The experts’ report confirms that the 1,400-m-deep thermal well could produce a fluid of approx. 60 ^{o}C, the one of 2,200 m of 90 ^{o}C.

The local utilization of geothermal energy has four possible versions:

1. Utilization of geothermal energy with an own well;
2. Use of heat-pump technology in case of shallow depth open water;
3. Use of heat-pump technology with closed soil sampler.

On the technology with an own well (point 1)
The heat demand of institutions on the territory of the Local Government - after the thermal modernization – is 708 kW.

A 1,500-m-deep production well could produce a thermal water of 70 ^oC with a production capacity of 45 m^3/h; the reinjection would require two reinjection wells of the same depth. The capacity of 708 kW can be guaranteed with a quantity of 30 m^3/h, in systems with a temperature difference of 60/40 ^oC, this amount could be safely reinjected with one reinjection well.

The suggested location of the production well – as opposed to the expert's opinion – is the yard of the Pallavicini School, or in a worse case, in the yard of the Castle, for a 100% supply of the biggest consumers. The recommended location of the reinjection well is the territory of the currently closed public bath, or a near-by local government territory. The thermal circuit between the wells would connect the public buildings and other important potential consumers located rationally from a logistical point of view on a pipeline network. This geothermal system would have a capacity of approx. 2 MW (40 ^oC delta T), thus it would totally replace the institutional natural gas utilization, furthermore, it would have a direct free capacity of 1,300 kW, and a further capacity of 700-800 kW with heat pumps for consumers with low temperature difference (40/30 ^oC) (heat supply of the central football training facility, heating of the open-air football pitch, heating of the public bath's dressing room, maintaining the temperature of the circulated pool water).

The estimated historic costs of the above-mentioned thermal circuit (see chapter 9) = net **HUF 645,075 thousand**.

The operating costs of the thermal system (see chapter 10) with HUF 1,231/GJ – after an annual heat demand of institutions, sports centre and spa of 14,721 GJ/year – **HUF 18,121,551/year.**

The revenue of the thermal project phase is the value of the replaced natural gas and electric power for heating, as shown below:

Replacement of institutional gas costs (gas fee of institutions modernized through insulation according to article "A" of chapter 6.1.4.1, not including the two distant kindergartens)	HUF 13,041,699
Gas fee of new establishments (with universal tariff)	HUF 30,905,963
Replacement of electric power	HUF 1,628,812
Total "profit" of the alternative	**HUF 45,576,474**

The simplified payback period of the project is **23.4 years** (645,075,000: 45,576,474 – 18,121,551), **supported** by KEOP.

We must note, that the salt content of the thermal water according to previous estimations (1,000-1,500 mg/l) forecasts the utilization of the water for medicinal purposes. A capacity of 60 m^3/h can be targeted in this case, the half of which would be placed into the medicinal pool, after the first step of heat utilization. This would represent an extra capacity of 700 kW.

This requires a training facility with a heat demand of approx. 300 kW, and a small public bath and educational swimming pool with a demand of 800 kW!

Use of heat-pump technology in case of shallow depth open water (point 2)
Cold water can be used for heating; however, the heat capacity has its limits:

- auxiliary equipment and auxiliary power is required to increase the temperature;
- a cost-effective operation is reachable only by the lower secondary temperature range (a temperature difference of 46/38 ^{o}C is ideal), accordingly, special heat market conditions must be established;
- the cold water from the shallow well must be reinjected into another shallow well after utilization.

During the efficiency improvement investment of high-temperature heating systems of institutions, the size of heat-transfer appliances must be increased in order to reach the lowest possible temperature of the fluid at exterior design temperature, which enables the best possible combination with heat-pump technology. The efficient utilization of the equipment is the main principle during the selection of the heat pump. In the Pallavicini School, the selected heat pump would be a modern German 184-kW DAIKIN heat pump with frequency-converter, which could effectively supply heat for the institution by continuous operation. The primary heat source of the heat pump would be supplied from the near-by waterworks or the institutional line; the used water would flow back into the water network, or would be reinjected into the 250-m deep reinjection well on the school's yard during periods with low consumption. The advantage of the system is that it can be used in the summer for floor heating or fan-coil radiators.

System parameters

Temperature of primary circuit	24/16 ^{o}C
Maximum capacity of primary circuit	20 m^3/h
Temperature of secondary circuit	50/45 ^{o}C

Estimated investment costs (net HUF thousand):

Planning, water rights authorisation procedure, preparation	2,000
Construction of NA 100 feed pipeline of 250 m	2,500
One DAIKIN EWWD 120 MBYN – 184 kW heat pump	4,295
Installation of a 41-kW electric power system	1,500
Local heat and hydromechanical appliances (transformation of heat centre)	2,400
Thermal renewal of school (without boiler replacement)	22,381
1 250-m deep reinjection well with engineering	14,000
Technical inspection, commissioning	750
Total	***49,826***

With the properly dimensioned efficiency-improving renewal of the building physics and heating system, the heat demand will be of 1,548 GJ/year (see chapter 4.1.4.1), 90% of which can be assured with the planned heat pump.

Estimated operating costs (net HUF thousand):

Electric power costs (with average 5.5 COP, 47,374 kWh x HUF 36 /kWh)	1,705
Electricity consumption of accelerating pump of the secondary circuit (4,000 kW/year)	144
Electricity consumption of reinjection pump (15,500 kWh/year)	558
Maintenance	100
Total	***2,507***

Cost-effectiveness analysis:
The gas costs of the institution without the base rate = HUF 4,810,000, of which HUF 4,329,720 can be replaced (the payment of the base rate remains, guaranteeing the existence of a reserve energy source).

The possible cost saving is HUF 4,329,720 – HUF 2,507,000 = HUF 1,822,720 + VAT. The simplified payback period of the project is **27.33 years**, the annexed IRR table No. 4 shows that the value of the internal rate of return is negative **(- 0.67%),** the project **cannot be supported by the KEOP**.

On the technology with closed soil sampler (point 3)
It would be effective in heating systems with very low temperature, especially when combined with summer air-conditioning. The floor heating dimensioned for this low temperature range (35-45 ^{o}C) is not typical for institutions mentioned in this study, there is no wall heating, and no reconstruction works were considered for summer air-conditioning.

Considering the fact that the kindergartens on Kölcsey Street and Rákóczi Street are located far from the central systems, they would be appropriate for a model project with heat-pump technology with closed soil sampler. We have completed an estimated analysis for the kindergarten on Kölcsey Street.

The heat demand is approx. 30 kW, we wish to provide 80% of it with heat-pump technology (for the better utilization of the equipment), thus, four 120-m deep soil samplers must be installed in the yard of the kindergarten. A 24-kW heat pump will be installed in the boiler room, which will replace the gas boiler in 80% of the heating period. This requires the modernization of the internal heating system, its reconstruction for low temperature difference, and the correct realization of the insulation and efficiency improvement phases according to chapter 4.

The investment costs of the heat-pump project = approx. HUF 4,500,000; annual operating costs – with average COP of 4.5 – after an electricity consumption of 11,500 kWh = approx. HUF 344,000/year.

The annual gas costs of the institution after insulation works = HUF 603,372/year, 80% of which will be replaced with the heat-pump technology (HUF 482,700), the total saving of energy costs = HUF 138,700/year. The simplified payback period of the proposal is **32.44 years**. With summer air-conditioning, the indicator could be reduced to KEOP level; however, there is no cooling currently, so there is nothing to save from.

*

A primary energy source based on geothermal energy provides an excellent solution for the development of the town public bath into a spa. Of all heat-pump technologies, the water heat-pump technology of the school could be examined in detail, if necessary. The other institutions with low consumption could keep the modernized natural gas heating, and the Pipacs Kindergarten on Kis Blv. could keep its current wood-heating system.

THE GEOTHERMAL CASCADE SYSTEM OF KISTELEK

The local government of Kistelek (population of 7600) decided in 2002 to use the geothermal energy of the town in a cascade system. The first step was the construction of a 2,100-m-deep production well; in 2004 the town build a thermal bath based on the thermal water of 82 o C. Between October 2005 and June 2007, the Aquaplus Kft. of Sándorfalva bore a new, 1,700-m-deep well in Kistelek, which can reinject the used water into the sandstone. The construction of the new well was funded from KIOP (Environment and Infrastructure Operational Programme) funds - HUF 290 million - and from the Own Resource Fund of the Hungarian Ministry of the Interior - HUF 116 million. This was followed by the construction of the pipeline of 5 km for the supply of the public institutions with thermal water, and the modernization of the heating system of 8 institutions.

The own contribution of the local government of HUF 90 million was covered from a bank loan with a repayment period of 15 years, the development will have a return by the end of the loan period. A better return would have been possible in case of an individual undertaking by the local government with the local water supplier, without the involvement of an external company.

The project had obvious advantages for the town and the Kistelek micro-region. Its effects will be perceivable outside the region as well. Several other settlements are interested in the successful investment, the more projects realized, the bigger the contribution to the reduction of Hungary's excessive natural gas utilization.

The automatic control system continuously provides data on the operation, helping the planning of future developments. Considering the features of the settlement, the connection of further public institutions, blocks of flats and farms is possible, the connection of family houses will be too expensive.

Project activities, project results:
Produced and utilized geothermal energy: 31.25 TJ/year
Amount of replaced natural gas: 968,000 m3/year
Proportion of geothermal energy produced by the system compared to the total Hungarian production: ~1%.
Reduction of emission of harmful substances in the region:
CO_2: 5,128 t/year
CO: 30.72 kg/year
NO_x: 71.23 kg/year

Reduction of heating costs of institutions: HUF 69,000 thousand.
Net saving of expenses: HUF 16,000 thousand.

THE INTEGRATED RES DEVELOPMENT CONCEPT OF MINDSZENT

Mindszent has a population of 7,000; it is located in the northern direction from Hódmezővásárhely on the left bank of the Tisza River. The town has a rural character, and it is spread on a big territory. The most important institutions of the town to be eventually connected to the district heating system: the Mayor's Office, the Cultural House, the Office of Government Issued Documents, the Sports ground, the House of Health, the Depot of the Fire Department, the Kindergarten on Szabadság square, the institutions of the Kindergarten and Day-care Centre, the Primary School on Szabadság square, the Primary School and Sports Hall, the Guesthouse, and the Care Centre. The majority of private houses are heated with natural gas; the number of wood-heated houses is growing. There are many houses with outdated gas boilers.

The town wishes to optimize the energy indicators of its buildings due to the increasing natural gas prices and the decreasing of state budget resources, thus it commissioned the researchers carrying out the present FP7 project to make an alternatives-analysis, which deals with the possibilities of heating systems based on renewable energy sources.

The study analyzes the energetic features of the buildings and states that the building of heating systems based on alternative energy sources can be economically realized only after the insulation of the façade and ceiling of the buildings and the replacement of doors and windows. Therefore, phase I should include the energy optimization.

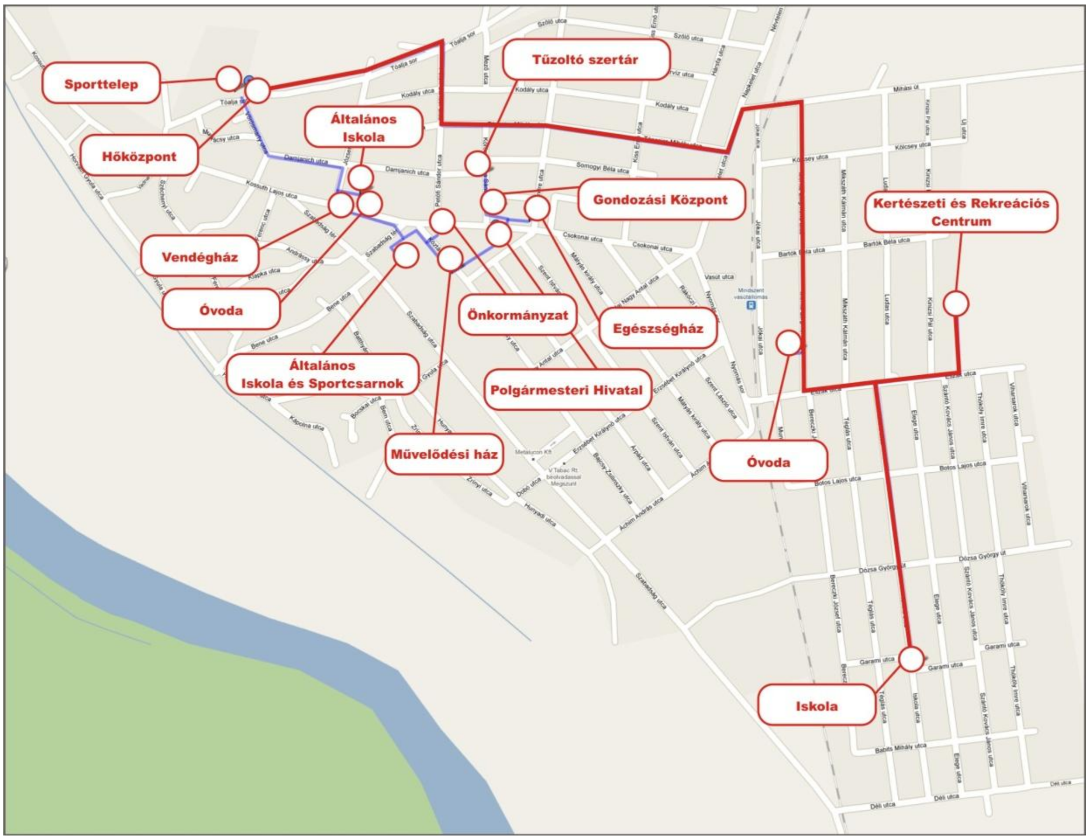


Fig. 8. The geothermal cascade system of Mindszent

The study analyzes the possibilities for the replacement of heating with natural gas by renewable energy sources. It defines that biomass and geothermal energy could be the primary alternatives. For the supply with biomass energy, the required quantity could be supplied with an own crushing machine from local forests, or by contracting an external supplier. The first version can be realized from a forest of approx. 100 ha. – currently unavailable – thus an external supplier must be contracted.

Utilization possibilities of geothermal energy in Mindszent:
There are several operating thermal wells in the region of Mindszent built on Upper Pannonian sandstone reservoirs – depth: 1,800-2,100 m, output: 60-70 m3/h, temperature: 80-100 oC. A horticulture based on a thermal spring is operating in the town's outskirts and by the Mihási road, an operating thermal well with good water quality can be found on the farm of the former Lenin producer's cooperative.

The thermal well with cadastre number 5-95 built in 1970 is 2,000 m deep, has a 7” perforated pipeline, with perforations at 1,721 and 1,943 metres. The maximum output at the time of the building was of 1.920 l/minute, its water temperature of 78 oC. Future analyses are more likely to forecast the same operational parameters. The water quality is good, non-aggressive, it can be used for balneological purposes. The well is owned by an entrepreneur of Italian origin, it currently supplies water for the heating of several buildings and offices on an insulated, outdated free pipeline.

The experts’ opinions confirm that the 1,400-m-deep thermal well could produce a fluid of approx. 60oC, the one of 2,200 m of 80oC.
The local utilization of geothermal energy has several possible versions:
Utilization of geothermal energy from a depth of 1,400 metres with an own well;
Utilization of geothermal energy from a depth of 2,200 metres with an own well;
Utilization of the well with cadastre number 5-95;
Use of complementary biomass burners in for peak periods;
Use of heat-pump technology in case of shallow depth open water;
Use of heat-pump technology with closed soil sampler.

On the technology with an own well (point 1)
The heat demand of institutions on the territory of the Local Government - after the thermal modernization – is of approx. 1 MW, by the consideration of total DHW need as well.

A 1,400-m-deep production well could produce a thermal water of 60oC with a production capacity of 60-70 m3/h, the reinjection of which would require two reinjection wells of the same depth. The capacity of approx. 1 MW can be guaranteed with a quantity of 28-30 m3/h, in systems with a temperature difference of 60/30oC, this amount could be safely reinjected with one reinjection well.

The thermal well could be located near the Sports ground, on the location of the suggested biomass project; the reinjection well is suggested to be located on a local government territory in the outskirts of the town. The most suitable location is a future public bath or swimming pool, or the current public bath owned by a private person. It is mentioned that the in case of the transformation of the bath into a spa, the used water must not be reinjected since it would be used for the medicinal pools.

The thermal circle between the wells would connect the public buildings and other important potential consumers located rationally from a logistical point of view on a pipeline network (e.g. shops, post office, pension etc.). This geothermal system would have a capacity of approx. 1 MW (30oC delta T), thus it would totally replace the institutional natural gas utilization, furthermore, it would have a free capacity of 5-600 kW, and a further capacity of 700 kW with heat pumps, for consumers with low temperature difference (40/30oC). A biomass burner would be needed to cover peak periods. The estimated costs for the construction of the thermal well: net HUF 396,000 thousand.

Calculating with the operating costs of the integrated plan (wells, biomass burners, heat pumps) – according to data of other thermal plants – of 1,000-1,200 HUF/GJ, based on the general gas purchase price of 2,482 HUF/GJ, the project proposal can calculate with a profit of 1,400 HUF/GJ. Based on these numbers, it is clear that the project based only on local government consumers does not have a reasonable payback period (35 years at best), thus it does not meet the assistance criteria.

In case of omissible reinjection (creation and winter operation of medicinal pools), the payback period would be of 21,8 years, which would enable a KEOP assistance of 60% for the concept.

On the technology with an own well (point 2)
A 2,200-m-deep thermal well would produce a heat capacity of approx. 3.5 MW in a temperature range of 80/30oC by direct utilization with a water of 80oC by a capacity of 60 m3/h, and a further capacity of 1.4 MW in the lower secondary temperature range of 50/30oC. The investment costs of this project: Net HUF 972,000 thousand.

The project concept would be viable beside the full supply with heat of the town's institutions, by the establishment of a 2-3-ha horticulture and/or a big-size public bath.

The thermal water of 80oC with a capacity of 60 m3/h from the 2,200-m-deep thermal well in the area of the Sports ground would flow into the degassing reservoir near the institution's new boiler plant. Sampling of nearby wells suggest that significant waste gas will be produced. A small scale gas engine could be used to burn the gas and the technological heat could be utilized to raise the temperature of the thermal water, while the electricity produced could be fed into the grid or used locally.

The fluid is then forwarded into the buffer reservoir of the reinjection plant from the pump station of the boiler room, with a plate heat exchanger with a capacity of 1 MW, through a 2,500-m-long pipeline of the bath built until the horticulture, and the 2-MW heat exchanger of the horticulture and 1-MW heat exchanger of the bath (fig. 9). The thermal system replaces the total gas consumption of the local government institutions, and supplies energy for the heating of the 2-3-ha horticulture, and the bath.

Due to the size of the project proposal, the only possible way is the combination with a project on energy efficiency improvement of the local government, the estimated cost of which is of net HUF 1,226 thousand, and requires KEOP assistance due to its payback period.

On the utilization of the existing thermal well (point 3)
The town's public heat consumers could be supplied from thermal well number 5-95 on the farm of the former Lenin producer's cooperative through an insulated pipeline of approx. 3,400 metres. A quantity of 22-25 m3/h of a thermal water of approx. 74oC would guarantee the heat demand of 1 MW (by the consideration of transformed heat supply systems, and a 40 oC delta T). The size of NA 100 is required due to the length of the pipeline for the guarantee of manageable pressure ratio (approx. 3,5 bar), and the reinjection of the used fluid must be solved as well, preferably at the location of the transfer of the thermal heat (near the sports ground).

The estimated investment costs of the project concept: HUF 439,000 thousand. Considering the fact hat the lower investment cost of the project in point 1 could not provide a profitable alternative, we do not present a further analysis of the concept.

Summary, the current phase of the project:

The town of Mindszent had the modification possibilities of its heating systems examined. The alternative-analysis showed that phase 1 must include the energetic modernization, the insulation of the facade and ceiling of buildings, and the replacement of doors and windows. It defines that biomass and geothermal energy could be the primary alternatives. The biomass energy supply is realizable and economically sustainable through the installation of new boilers or in a combined energetic modernization project. Despite of the good geothermal features, the realization of the town's geothermal cascade (possibly combined with waste gas utilization) system is only possible, if new consumers are connected to the system.

THE INTEGRATED SYSTEM OF MÓRAHALOM

Mórahalom is the region’s most dynamically improving town, with a population of 6,000 persons. The primary objective of the town’s leadership is the improvement of competitiveness and tourism attractiveness. According to the town’s intentions, the concept of a geothermal cascade system was formed in 2007.

The project is justified on the one hand by the necessity of instant termination of deficiencies, wasting and unused energy outflow due to outdated system, bad system sizing, and operation with bad efficiency as defined by the energy audit of the heat supply system of Mórahalom, and by the demand for a cheaper and more efficient energy system. (A preliminary analysis showed that natural gas represents 87% of the Local Government’s energy utilization, and 59% of its costs. The costs for natural gas can reach approx. 70%.)

On the other hand, from the side of possibilities, the exploitation of geothermal energy in the region of Mórahalom is an obvious solution, after reviewing every other alternative energy solution, since the geothermal potential of the South Great Plain is significant on the European level.

Mórahalom, just as other settlements of the region, has been using the thermal water for decades, despite the fact that the region's features are not common for the town - the town’s thermal bath is famous for its thermal water. The water of the bath’s wells have been used for heating for several years, thus it is unnecessary to overemphasize the advantages of thermal energy utilization.

The drastic changes of the natural gas prices, the social subsidy structure, the finite natural gas reserves, the services anomalies, and Europe’s dependence have highlighted the importance of alternative energy sources. The thermal energy is in place, is not import-dependent, and it is managed by the local government.

The town leadership had the heating systems examined in 2002 - with granted assistance, but finally it decided for the tourism developments due to the "manageable" energy expenses, the moderate investment supports and own resources.

The analysis of the replacement of natural gas was a major aspect of the audit proposals, which was justified by the anomalies of natural gas supply, the drastic increase of purchase prices, the harmful environmental effects, and the good geothermal features of the region.
The Local Government decided – as a continuation and based on the reliable data, suggestions and ideas of the audit – to have a feasibility study made for the implementation of a geothermal public utility system in Mórahalom.

The pre-feasibility study, the construction plans made according to the version chosen in the study, and the preliminary environmental impact assessment made and authorised according to the plans were finalized in October 2007 with INTERREG IIIA HUROSCG assistance. The project’s objective, beyond the making of the current project's feasibility study and plans, was for the new production and reinjection wells to serve as sampling and measuring points for the first Hungarian-Serbian cross-border water base and production monitoring system. Our partners during the making of the pre-feasibility study, planning and elaboration of the international water base monitoring were the experts of the Department of Mineralogy, Petrology and Geochemistry of the University of Szeged (SZTE), the South Great Plain Regional Office of the Hungarian Geological Service, and the Geothermal Innovation and Coordination Foundation.

The project proposal was submitted for and was granted assistance in the KEOP 4.1.0 call for applications.

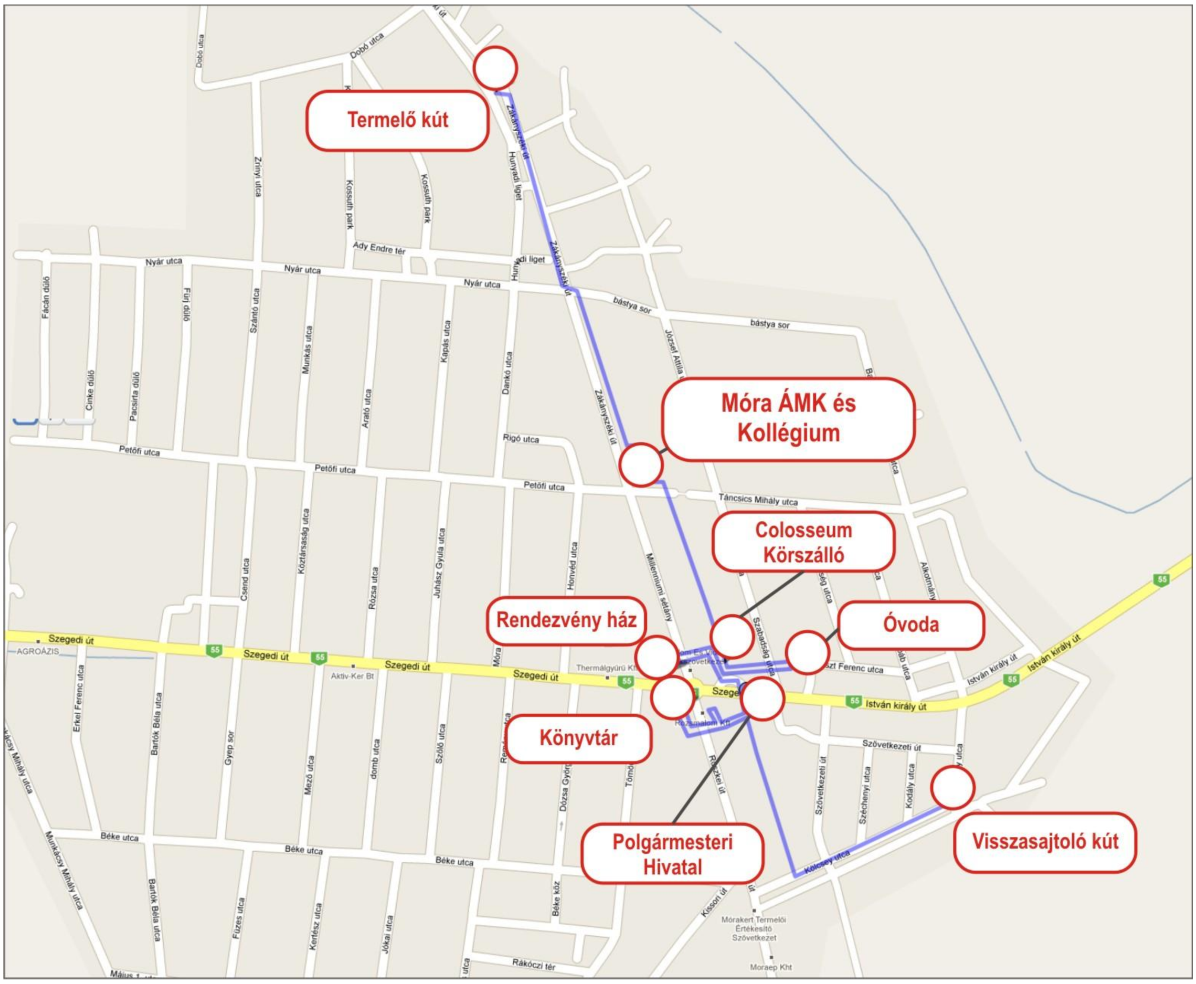


Fig. 10. The geothermal cascade system of Mórahalom

A fluid with good quality and of medicinal quality of approx. 70 oC can be produced from the 1,300-1,400-m-deep thermal well in the northern part of the town. As an optional novelty of the proposal, the extracted thermal water – after the utilization of its heat - will be used in the increasing number of pools of the local spa, and in the reinjection well, which will be bore on a Brownfield investment site, the new industrial park. (Until the water is classified as medicinal water – according to relevant regulations – the total quantity of used water will be reinjected). The most important local government buildings from the point of view of heat market are connected through a 2.8-km-long insulated underground pipeline network. As another novelty of the project, heat pumps will supply the heating of new buildings getting only a low-temperature fluid from the primary thermal circle.

The construction and operation of the geothermal cascade system of Mórahalom are the results of project activities; the proportion of renewable energy in the energy utilization of public institutions will increase from 0% to 80%, resulting in a fossil energy source (natural gas) saving of 14,441 GJ per year both on project and national economy levels.

A heat capacity of 2,620 kW will be installed in the geothermal system, at a very favourable market price of 165 thousand HUF/kW.

Throughout the system’s 25-year lifetime, an annual amount of 481,907 m3 of combusted natural gas will be replaced; the annual emission of pollutants from energy utilization will be reduced by 866 t of CO2, 318 kg of NxOx and 605 kg of CO. The system reduces the CO2 emission on a specific cost of HUF 16,636.46.

The total project investment costs: gross HUF 526,000 thousand, 50% of which – HUF 263,000 thousand – is EU assistance from the KEOP call for tenders. The operating costs of the system without amortisation: net HUF 19,200 thousand.

The public institution system will become largely independent from supply and price formation anomalies of gas import. The operating wells of the geothermal system – designed with INTERREG funding – will be part of the Hungarian-Serbian water base protection monitoring system, and will serve as practical training site for the launch of a geothermal technician and engineer training at the University of Szeged.

With the geothermal development of the public institution system and the “New Town Centre”, the emission of pollutants will be reduced by 70-80% (by an annual amount of CO2 equivalent to 1054 t of GWP). The system with cheap heating will not only be the installation factor for the spa, but for the new “Colosseum” hotel as well, which will promote the competitiveness of the service sector based on regional tourism, and will create new jobs for the system operation. The secondary target group of the project will be the students of SZTE studying geology, geography, or participating at trainings in the fields of regional development and geothermal technician.

Summary, the current phase of the project:
According to its geothermal development objective, the town of Mórahalom had the energetic condition of its buildings examined, a feasibility study made, and applied successfully for assistance for the realization of its thermal heating system. The project was carried out in 2009-2010, the production and reinjection wells are up and running, the pipeline is operating, and the heating of the public institutions has started.

Integation with other RES – the FP7 project
In the current FP7 project an exemplary RES integration development is being carried out.

First, a detailed energy audit takes place for the buildings to be retrofitted / refurbished, public lighting system with an overall estimation of energy consumption of all buildings within the Concerto area but not directly affected by project activities.

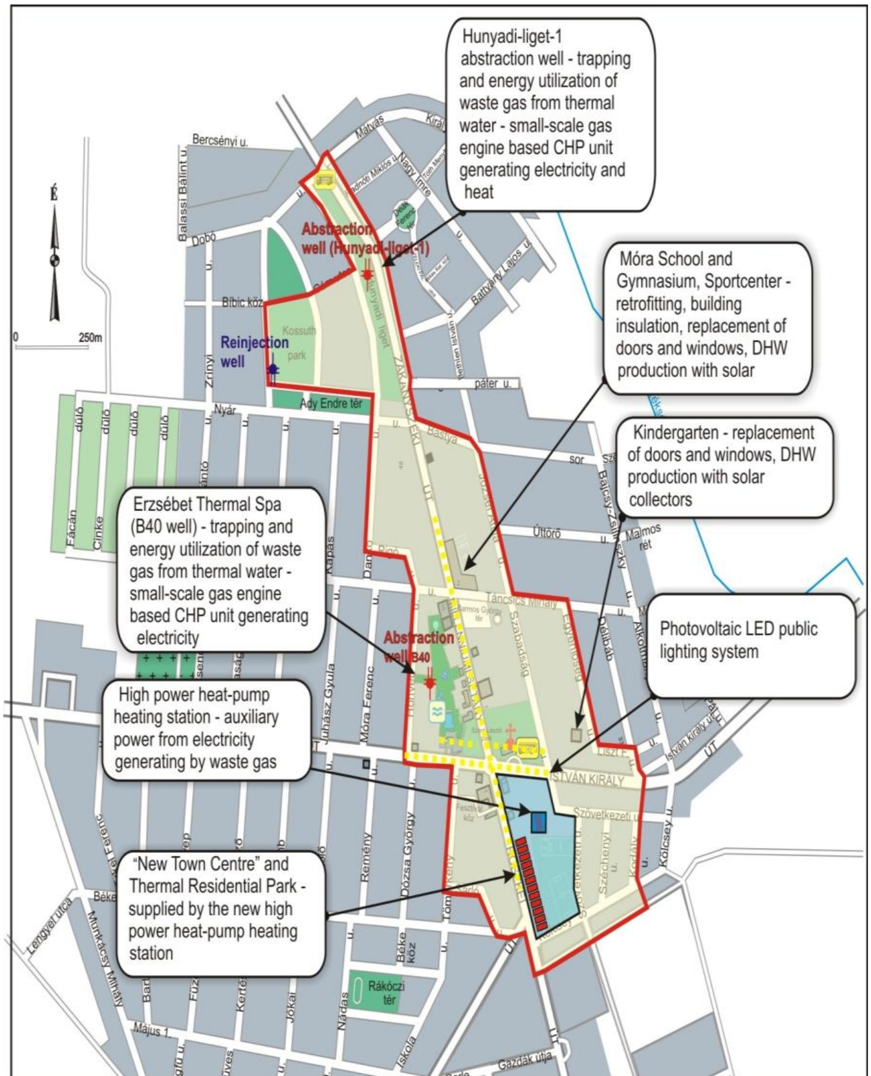
As a major part if RES integration a small scale gas engine will be planted on the new Hunyad-liget-1 well which will generate electric current and heat, and supply the high power heat-pump heating station of the “New Town Centre” with auxiliary power (60kW). It will also provide extra heating for the abstracted thermal water. According to gas sample analyses and technical feasibility studies prior the project, 2-2.5 kW electric energy and 6-7 kW thermal energy can be produced in the CHP unit from 1 m3 trapped gas. Heat from the CHP unit will used to further heat the thermal water (by ~ 4C degrees). Parallel to this development a CHP unit will be constructed on the B-40 well which will generate electric current that will suppliy the Erzsebet Thermal Spa.– heat (90-120 C) generated will be used at the DHW production and heating of the Spa. The waste gas thermal value is planned at 8.48 kWh/Nm3, the usable electric power at 35 kW (el.) and the usable thermal power at 70 kW, the total combined efficiency: 86.74%.

The modernization of the complete public lighting of the town centre (Szent Laszlo Park, Millenneum Alley, Central Bus Station, and the public transportation stops in the Concerto Area) will also take place with a changeover to solar-powered LED lighting system. The current lighting of the public area is provided by 36 W strip lights (consumption: 42W/piece), and by 70W sodium lamps (consumption: 90W/piece). We wish to replace them with 10-12W and 30W LED lighting units, with consumptions of 15 W and 38 W, the current supply is provided by photovoltaic cells.

Establishment of the heat-pump heating station for the energy supply of the “New Town Centre” and the “Thermal Residential Park” will take place in 2011-2012 to produce a thermal power of 450 kW in a heat-pump system with an average efficiency of 5 COP. The total heated ground space of the “Thermal Residential Park” to be heated by that will consist of 12 big dwelling houses (431 m2 heated floor area/estate), and will be constructed in two stages.

In order to increase the efficiency of the developments. insulation of walls, replacement of doors and windows with an expected heat demand decrease of 12-21% will take place at the Móra ÁMK as well as at the Kindergarten and Day-Care Centre

Finally, in order to guarantee the multiplier effect of the activities carried out in the Concerto area an on-line, real-time energy measuring system accessible to the professionals (including those participating in on-site practical trainings at the University of Szeged) as well as the general public will be established.



CONCERTO PROJECT DEVELOPMENT IN MÓRAHALOM
the Concerto Area equals to the operational area of the geothermal cascade system

GEOTHERMAL AND INTEGRATED PROJECTS OF BÉKÉS COUNTY

THE GEOTHERMAL DEVELOPMENT CONCEPT OF BÉKÉSCSABA

The production of thermal water, and its partial energetic and balneological utilization in the public bath has a history of many years. This year, the public bath managed by the town wishes to modernize its thermal system, increase its efficiency, and significantly moderate its natural gas utilization.

There are favourable geological and geophysical features available on the town's territory according to further subsurface drillings for the extension of thermal energy utilization, heat utilization for public institutions, and thereby, for the moderation of the town's growing heating costs.

The research team responsible for the current FP7 project. was commissioned to make the pre-feasibility study of the town's geothermal cascade system. The objective of the study is the preparation of an investor decision through the implementation analysis of a environmentally friendly, modern district heating system based on geothermal energy, the analysis of utilization possibilities of existing thermal wells, and the presentation of economic sustainability of the project.

Aspects of implementation:
The Upper Pannonian formation including favourable water-bearing sand layers in the town's region – as in the whole South Great Plain region – reaches a depth of approx. 2,500 metres. However, a small number of unique and thin water reservoirs are present in its upper third, which is shown by the water output of wells bore into these layers. The huge water reserve in the lower part of the Upper Pannonian formation is of high temperature (see: the building parameters of the inactive thermal well "B-953").

There are only 5 thermal wells on the town's territory. Two of those are operating wells, the others are closed down. Both operating wells are owned and used by the public bath. The inactive, unused thermal wells are located in the different parts of the town, more km away from each other.

The hot water of the Árpád Bath of Békéscsaba is supplied from thermal wells No. B-282 and B-1018. The wells No. B-953 and K-1042 dispose of chemical and other parameters that would be suited for geothermal utilization. The National Directorate of Health Resorts and Spas (OGYFI) of the Office of the Chief Medical Officer classified the water of wells B-282 (decision No. 130/Gyf/2001) and B-1018 (decision No. 244/Gyf/2002) of Békéscsaba as medicinal water. The study confirms that the well No. B-953 is suitable for the supply of the geothermal cascade system due to its water output, temperature, and chemical data. The well No. B-953 is considered as a production well for the planned thermal system. The heat capacity during building forecasts a total value of 7.3 MW by optimum heat market – and by an output of 1,300 l/min, a temperature of 99 oC, and 60 o C of delta T – a primary value of 5.5 MW, and a secondary value of 1.8 MW by heat pump recovery of 20-oC-delta T.

Heat market features
Békéscsaba has a population of approx. 64,000. It is one of the settlements with the biggest green areas among towns with country rights. It can be divided into two parts: the downtown in the eastern part, built-up with housing environment. The western part is an area only with family houses. The natural gas is the main heating energy, the heating with solid fuels, mainly wood, is becoming more and more popular. The district heating (boiler plant) systems are the most common for institutions, major shops, and hotels; the family houses have different heating systems (gas convector, district heating, solid fuel). The networks are traditional, oversized with temperature differences of 70/500C, and 80/600C. The town has now district heating supply system, the buildings have their own heating stations for heating

and production of DHW. Accordingly, the current energy sources used by the public institutions are electric power and natural gas.

After reviewing the local government's and other institutions – by considering the distance from the planned production and reinjection wells and the rational connection to the thermal system from the point of view of construction and economic efficiency – the following potential network of important consumers was defined (fig. 11):

Elementary School No. 10 (A)
Elementary School No. 2 (B)
Catholic Elementary School Savio Szent Domonkos (C)
Elementary School on Szent László street (D)
Downtown Elementary School and Gymnasium (E)
Ferenc Rózsa Gymnasium (F)
Gábor Kemény Secondary School of Logistics and Transport (G)
Secondary School of Engineering and Computer Science (H)
Secondary School of Economics István Széchenyi (I)
Albert Szent-Györgyi Gymnasium, Secondary School and Dormitory (J)
Mihály Munkácsy Museum (K)
Sámuel Tessedik College, Faculty of Economics (L)
Town Sports Hall (M)
Pál Réthy Hospital, gas boilers (N)

The water of 99oC with a capacity of 78 m3/h supplies heat for institutions A-K in the first step, replacing 100% of the current natural gas utilization. This is a thermal energy utilization of approx. 26,500 GJ, considering the saving of heating plant losses as well. The second step is the heating of institutions L-N, with a secondary fluid of approx. 68oC. The rate of gas replacement in these buildings is of minimum 80%, which can result in a thermal energy utilization of 17,500 GJ. Accordingly, the existing and above-mentioned heat consumers can utilize an annual amount of 44,000 GJ of geothermal energy.

Fig. 11. The suggested route of the geothermal cascade system of Békéscsaba

Main economic and environmental energy indicators of the project:
Thermal energy utilization: 44,000 GJ/year,
Amount of replaced natural gas: 1,500,000 m3/year,
Investment costs: Net HUF 1,447,000 thousand.
Annual operating costs saved: HUF 114,000,000.
Simplified project payback period: 12.7 years,
Simplified project payback period with 40% of KEOP assistance: 7.5 years,
reduction of CO_2 emission: 2,468 t/year
reduction of NO_x emission: 3,300 kg/year

GEOTHERMAL DEVELOPMENT OF GYULA

Gyula is the second largest town of Békés County, with a population of 32,000. The town is known for its spa in both Hungary and Europe. The medicinal water of the Várfürdő (Castle Spa) is rich in alkali bicarbonate and chloride. The water is won from six deep wells, the deepest being the one with 2,500 metres. In 1969, the Ministry of Health classified the water of the bath of 72 oC as a medicinal water, the bath as a spa in 1971, and the area of the spa as a health resort in 1985.

According to our current knowledge, the geothermal developments of the town were limited to the spa only. The development of the Várfürdő began in 1999 with the rebuilding of the bubble pool No. 2, costing HUF 25 million. The reconstruction of the heating system was realized in the same year from HUF 23 million. Further developments took place in 2002. The wave pool No. 7 was rebuilt from HUF 100 million, the public utilities were rebuilt from HUF 100 million with the renovation and expansion of the water system of the spa. HUF 400 million were spent for the development of the spa in 2001. An investment worth of HUF 800 million took place in 2003. The investment was realized from HUF 300 million non-refundable state subsidy granted by the Ministry of Economy, a loan of HUF 260 million, an increase in the share capital of the Local Government of Gyula by HUF 100 million, an assistance granted by the Treasury Property Directorate of HUF 40 million, and the own contribution of the Várfürdő of HUF 100 million.

The situation of the public institutions is concentrated enough for the establishment of a geothermal cascade system. Several schools, kindergartens, the Mayor's Office, the Library etc. can be found in a circle of 1 km. The construction of a geothermal cascade system seems profitable considering the heat demand of the spa. According to our current knowledge, the local government does not plan to realize a similar investment.

GEOTHERMAL DEVELOPMENTS OF OROSHÁZA

Orosháza is the third largest town of Békés County, with a population of 30,000 The name of the town is strongly linked with Gyopáros, and the health tourism built on the thermal water. Just as in Gyula, the thermal developments of the town were limited to the spa only.

In 2008, the Local Government of Orosháza submitted an application for the KEOP 4.1.0 call for tenders. The project objective was the heating of the institutions of the Gyopáros Spa. According to the project, the buildings will be connected to the 1,560-m-deep well with a capacity of 90 m3/h and a water temperature of approx. 90 °C located on the territory of the Orosháza-Gyopáros Spa Co., and the used water will be reinjected through the two reinjection wells. The application was granted an EU assistance of more than HUF 265 million. The overall costs of the project: HUF 530 million. A closed heat exchange system will be built on the territory of Orosháza-Gyopárosfürdő, which will replace the current natural gas heating. More than HUF 30 million will be saved, and the air pollution will be reduced by 842 tons of CO_2. An expansion and modernization worth of HUF 1.9 billion will be started shortly in Gyopárosfürdő, the plans include the heating of the new spaces with thermal water.

The public institutions are rather spread on a big territory, however, the establishment of a geothermal cascade system is possible. According to our knowledge, the local government is planning the construction of a similar heating system.

THE GEOTHERMAL DEVELOPMENT CONCEPT OF BÉKÉS

Békés is the fourth largest town of Békés County, with a population of 20,000. The town has the oldest spa in Békés County. Its water was officially classified as medicinal water in 1943. It is rich in alkali-bicarbonate and iodine, and suitable for the cure of locomotor, rheumatic, certain gynaecological diseases, and for the after-treatment of injuries. The demand for a new, modern spa complex is present on the side of the population, a great number of residents of Békés are forced to commute to other settlements' spas for recovery and leisure activities. As a riverside town (the two Körös rivers), the local basic swimming education of the youth would be an important aspect. The new Thermal Bath of Békés was opened in December 2009.

The town has good geothermal features, the 29 public institutions are suitably concentrated. These institutions have a natural gas consumption of 72 thousand m3/year, thus it can be forecasted that the water quantity extracted from a 2,000-m-deep thermal water would be suitable for their heating. The following table contains the 2007 gas consumption data of the town's public institutions.

Institution	Natural gas use (m3/year)	Natural gas use (HUF/year)	Installed capacity kW
Kindergarten			
Baky	27200	2856000	208
Csabai	6100	634400	32
Hunyadi	3200	33280	30
Jantyik	6400	665600	39
Korona	3700	384800	34
Ótemető	6500	695500	39
Teleky	4200	436800	32
Móricz	6300	655200	39
Nursery	3100	322400	32
Day-care centres			
Jantyik	13000	1365000	120
Bajza	13100	1375500	120
Rákóczi	13500	1417500	118
Primary schools			
Eötvös József	98800	10868000	720
Csikós	7600	790400	32
Karacs Teréz dormitory	32000	3328000	208
Karacs Teréz school	73200	8052000	416
Rákóczi str.	18500	1979500	112
Dr. Hepp Ferenc	98100	10791000	416
Primary school of arts	14800	1583600	112
Sports hall	31000	3317000	189
Library, gallery	43200	4622400	224
Medical institutes			
Central Clinic	78500	8635000	146

Vásárszél medical practices	5800	603200	80
Medical practice of spa	38000	3952000	132
Tuberculosis treatment centre	8900	925600	40
Mayor's Office			
Mayor's Office main building	29800	3188600	188
Petőfi str. 4, Hungarian National Public Health and Medical Officer Service (ÁNTSZ)	12400	1302000	94
Petőfi str. 4, kitchen	12600	1310400	56
Piac sq. 3	10700	1112800	34
Total:	720200	77203480	4042

Currently there is a concept plan in the making in the form of a university thesis, which plans one 2000-m-deep production well and two 2,000-m-deep reinjection wells for the connection of the public institutions into a cascade system. The final points of the system before reinjection are the spa pools and buildings. The townhall shows interest for the concept.

THE GEOTHERMAL CASCADE SYSTEM OF SZARVAS

Szarvas is the fifth largest town of Békés County, with a population of 18,000. It is the only town of Békés County with an operating district heating systembased on thermal water. Several public institutions and residential heating plants are supplied with geothermal energy in the district heating system. However, due to the bad well construction and the unsatisfactory network formation the system is in a bad overally shape, and its running is not economic. Due to the drastic increase in the natural gas prices, the Local Government of Szarvas set up a project company for the transformation of the town's thermal system into a modern cascade system. The mixed-ownership SZATERM Investment and Service Co. was set up for the development and operation of the town's geothermal public utility system. The contribution of the Local Government of Szarvas in the company is the production thermal well No. K-87 (estimated value: HUF 150 million), the one of BRUNNEN Hőtechnika Kft. - as professional investor funded by the researchers responsible for the present FP7 – is a credit amount of HUF 740 million, guaranteeing an ownership share of 17% (Local Government) and 83% (BRUNNEN) respectively. The project company plans to submit an application for the KEOP call of tenders for the assistance of the planned investment.

Presentation of economic activity:
The project company completes the following activities: complete renovation of the engineering system of thermal well No. K-87 operating in the town outskirts; boring of a 1,700-m-deep reinjection thermal well; establishment of surface hydraulic engineering systems; construction of a pair of thermal pipelines of 4.5 km and of a reinjection pipeline of 2.5 km. Further tasks: Complete modification and renewal of 16 institutional thermal heat centres (90-750 kW); establishment of 11 new heat centres (70-810 kW); construction of the market's ground heating; and the creation of a remote telemonitoring control system for the complete system.
SZATERM Kft. operates the geothermal system, and supplies thermal energy for the institutional heat consumers connected to the public thermal system. The operating obligations and costs of the geothermal system are carried by the service providing company;
Investment costs: Net HUF 1,056,000 thousand.
Expected KEOP assistance: 50%, HUF 528,000 thousand;
Supplied thermal energy: 60,651 GJ/year,
Amount of replaced natural gas: 2,400,000 m3/year;
Reduction of CO_2 emission: 4,282 t/year;
Operating costs: Net HUF 119,630 thousand;
Operating costs without amortisation: HUF 56,630 thousand;
Cost of thermal service: 2,476 HUF/GJ;
Simplified project payback period: 8 years;
Simplified project payback period with 30% of KEOP assistance: 5.5 years.

Summary, the current phase of the project:
A development concept for the renewal and optimization of the town's geothermal district heating system has been developed. The project company SZATERM has been set up for the implementation of the development and the operation of the system. The feasibility study was made, the application documentation is being prepared.

OTHER SETTLEMENTS OF BÉKÉS COUNTY – POSSIBILITIES FOR RES INTERGATION

There are 16 more towns in Békés County with no development concept for investments aiming at renewable energy utilization. Beyond the above-mentioned settlements, Gyomaendrőd, Mezőberény and Sarkad have a population of more than 10,000. All three have an operating spa. Considering the number of public institutions in these towns, a successful establishment of a geothermal and possibly biomass based public utility system requires, beyond the institutions and the local spa, the establishment of a secondary user – e.g. a 2-3-ha greenhouse horticulture.

There are only a few public institutions in Szeghalom, Dévaványa, Vésztő, Mezőkovácsháza, Battonya, Tótkomlós, Füzesgyarmat, Mezőhegyes, Csorvás, Elek, Újkígyós, Kőrösladány, and Medgyesegyháza. Despite the favourable geothermal features, the establishment of a medium-enthalpy direct geothermal heating system is not possible at all, or only by a significant heat market expansion. The economical construction of heating systems based on integrated RES requires the energetic modernization of the settlements' institutions. The construction of individual heat pump systems could be a realistic and economically profitable investment despite the unsatisfactory heat market circumstances. The rural structure of these settlements enables the establishment of biomass or combined heating systems.

GEOTHERMAL AND INTEGRATED PROJECTS OF BÁCS-KISKUN COUNTY

THE RES DEVELOPMENT CONCEPT OF KISKUNFÉLEGYHÁZA

Kiskunfélegyháza is the second largest town of Bács-Kiskun County, with a population of more than 30,000. There are a great number of greenhouse horticultures utilizing geothermal energy in the town’s area. The town has a district heating system operated by the District Heating Co. of Dunaújváros. The local government mentions the utilization of geothermal energy with integration into the town's district heating system in its Regulation No. 15/2008 (III.28). In its meeting of February 2010.

It is understood that the extractable water with only 60oC is able to satisfy the heat demands of buildings only to an outside temperature of maximum +3oC. For this reason integrated systems are proposed, with biomass burners attached to the cascade system to cover peak period demands.

The local government contacted the InnoGeo Kft., a spin-off company of SZTE formed by the researchers behind the current FP7 project and discussions were initiated about the issues of demand survey, planning, application, implementation and operation of future systems.

GEOTHERMAL DEVELOPMENTS OF KISKUNHALAS

Kiskunhalas is a town at the border of the western thinning line of the Pannonian sandstone, with a population of approx. 30,000. The town has favourable geothermal features, proven by the water quality and temperature of the town's famous spa.

Presentation of the project proposal:
The geothermal base located 8 km from the town (one 1,800-m-deep production well, one 1,800-m-deep reinjection well, necessary well engineering, heat exchanger station, control system) supplies thermal energy (90 m3/h; 120oC) for the connected consumers on a 12-km-long, insulated NA-250 underground pipeline

Strategic consumers:

Consumer	Installed capacity (kW)	Used thermal energy (GJ)	Replaced natural gas (m3)
TESCO store	615	3.780	123.528
District heating plant	8.000	35.000	1.029.412
Gábor Fazekas Primary School	750	1.177	43.260
Lajos Bernáth Dormitory	600	1.611	59.233
Garbai Vocational School and Dormitory	450	2.712	99.706
Psychiatry	750	4.800	176.471
New spa and wellness centre	1.500	9.000	294.118
3-ha bio horticulture	4.500	25.000	816.993

The investment costs of this project: Net HUF 1,505,000 thousand;
Expected KEOP assistance: 50%, HUF 750,250 thousand;
Operating costs: HUF 198,000 thousand;
Operating costs without amortisation: HUF 48,000 thousand;
Simplified project payback period: 9 years;
Amount of replaced natural gas: 2,642,721 m3/year;
Reduction of CO2 emission: 4,672 t/year.

Summary, current phase of the project:
A pre-feasibility study and development concept were elaborated for the geothermal energy utilization in Kiskunhalas. The geothermal heating system will supply energy for the town's district heating system and several new Greenfield investments. The Halas-Geoterm Kft. is managing the construction of the thermal well between Zsana and Kiskunhalas, and the building of the greenhouses was started as well.

THE GEOTHERMAL DEVELOPMENT CONCEPT OF KISKŐRÖS

The Local Government of Kiskőrös wishes to replace the natural gas heating of its institutions by thermal energy, based on its geothermal features. The available geological and geophysical analyses show that the Upper Pannonian sandstone formation with a favourable thermal water reserve is situated in a depth of 950-1,000 metres, thus the extractable thermal fluid can have a temperature of maximum 52-54oC and an output of 20-30 m3/h. This fact is confirmed by the operational data and experience of the town's thermal bath with a history of more decades. A 2,500-m-deep CH test-boring is situated near the town, which stopped in a Triassic carbonate formation of a thickness of 150 m. This can dispose of a high-temperature thermal source, however, the recovery risks are too high, thus the pre-feasibility made is basing the town’s thermal utilization system on the Upper Pannonian reservoirs with a stable energy basis.

The moderate sandstone geological features are coupled with excellent heat market features. Almost every potential important public institution is situated in the downtown, in a close distance. This allows the utilization throughout the whole heating season of the total amount of the 1.3-1.4-MW heat capacity of a thermal well with the above-mentioned features.

According to the study, the location of the 1,000-m-deep production well would be the vicinity of the Bem School on Vasváry Pál street. The 1,000-m-deep reinjection well would be located on the green area between the Wattay Secondary School and its Dormitory on Árpád street.

The primary heat capacity (54/30oC) of 750 kW of the thermal fluid of 54oC, with an output of 450 l/min. would be utilized mainly in the following school-type institutions with a temperature difference of 60/40oC – through an underground two-pipe, insulated NA 100 pipeline network of approx. 1,300 m:

Bem School,
Police,
Sándor Petőfi Gymnasium and Sports Hall,
Day-care Centre and Kindergarten on Árpád str.,
Wattay Secondary School and Dormitory,
Dental surgery,
Petőfi Day-care Centre,
Petőfi Cultural House,
Pátria,
Petőfi School,
Court-house,
the building of the bank and the block of flats,
Mayor’s Office,
Kindergarten on Batthyány str.

The fluid (30/5oC) can have a capacity of 785 kW before reinjection for a future Greenfield investment.

The thermal energy will be supplied indirectly from the heating stations of institutions through modern plate heat exchangers, the existing gas boilers can serve as reserve energy sources and produce automatic support in cold seasons. According to our expectations, approx. 75-80% of the current gas utilization can be replaced by geothermal energy. The internal heating systems of several major institutions will be examined - if necessary - for the applicability of a lower temperature difference.

The main indicators of the suggested cascade system:
Investment costs: Net HUF 343,260 thousand;
Available KEOP assistance:
For local governments: 60%, HUF 205,956 thousand;
For companies: 50%, HUF 171,630 thousand;
Operating costs: HUF 39,000 thousand;
Saving of expenses: HUF 24,338 thousand;
Specific historic cost: 1,653 HUF/GJ;
Use of thermal energy: 8,700 GJ/year,
Simplified payback period: 34.4 years.

Summary, the current phase of the project:
Kiskőrös has favourable geothermal and heat market features for the establishment of a communal geothermal cascade system. The pre-feasibility study shows that the presented concept can be implemented only with a 60% KEOP assistance, and by the connection of further consumers into the system, e.g. the construction of pool heating in the local spa.

THE INTERGATED RES DEVELOPMENT CONCEPT OF KISKUNMAJSA

Kiskunmajsa is a town of 12,000, situated in the area between the rivers Danube and Tisza. It is the cultural and commercial centre of the region. There are several thermal wells in the town producing thermal energy and thermal water. Its most important well is the thermal well supplying energy for the spa of Kiskunmajsa, and the adjacent horticulture. The animal holding (former producer's cooperative) has been using the thermal water for decades.

The utilization of geothermal energy in Kiskunmajsa has a long history, the geological features of the region are well known. These facts, the growing number of anomalies of the resources, supply security and service fees of fossil energy sources, and the economic and political influence motivated the Local Government and the management of the Termál 2002 Kft. to examine the possibilities of thermal energy utilization. The Power-Energy Kft. made the energy audit of local government institutions, thus the necessary data and modernization proposals are available. The objectives of Termál 2002 Kft. were the improvement of the efficiency of the operating thermal well, the moderation of the serious natural gas consumption, and the analysis of the disposal of the used thermal fluid according to environmental regulations. The Termál 2002 Kft. and the Local Government of Kiskunmajsa commissioned the K-P Kontúr Kft. professional workshop to make the project's feasibility study.

The cost of the project – by current price level – is estimated at HUF 556,428 thousand, and the system can be operated by an annual cost of HUF 18,445 thousand. A new renewable heat capacity of 2.5 MW can be started, however, the specific market price of 222,571 HUF/kW is too high.

The economic profitability of the proposed system is determined by the product's market, the marketable amount of heat (and the amount of the replaceable natural gas), and the proportion of consumed DHW. Therefore, they carried out extensive analyses, and tried to screen the complete micro-environment concerned.

The project cash flow and the computed return indicators show that the payback period can reach approx. 24.5 years, which is unacceptable on the energy investment market. The economic sustainability of the project proposal is questionable, its internal rate of return is of -5.7%. Since the payback period of the project is of min. 25-50 years, its realization is worth considering in case of availability of sufficient own resources. However, the current KEOP call for tenders does not support the project proposal due to the negative internal rate of return.

The study also mentions that the modernization and extension of the Chicken farm's thermal heat supply, and the environmentally friendly disposal of the used fluid can be realized within an individual project, by a granted KEOP assistance of 50%. The introduction of heat-pump and biomass systems is worth considering for the town's institutional network. As a renewable energy source, the utilization of biomass, beside geothermal energy, will receive more EU and state assistances in the next years.

INTERGATED RES DEVELOPMENT POSSIBILITIES IN TISZAKÉCSKE

Tiszakécske is a town in the northern part of the South Great Plain, with a population of 12,000. A geothermal anomaly can be found on its territory, which is explained by the thin layer of the Pannonian sandstone. The town's favourable features are proven by the spa with a history of more decades, and several horticultures in the area.

The Spa was opened in 1971 – with the investment of the local producer's cooperative. At that time, the spa had two pools with thermal water, one with mixed water (thermal water + cold water), one with cold water, and a small pool for children. The plans for the covering of the cold-water pool were made in 1980, and the concept was realized in 1983. The late István Szabó rented the spa from 1984, and the family became the owner in 1999.

The following investments turned the spa into the pearl of the town and its main tourist attraction, and Kiskunmajsa became internationally famous.

The current spa has a great number of attractions for those looking for recreation. The medicinal water of 52 °C is produced from a depth of 1,344 m, it is rich in fluoride and sodium bicarbonate.

The number and outspread situation of the town's institutions does not allow the establishment of a geothermal cascade system. Heap-pump or biomass energy supply systems can be established as an alternative, as the supply with biomass could be supplied from local forests.

GEOTHERMAL DEVELOPMENT POSSIBILITIES IN KECEL

Kecel is a town in Bács-Kiskun County known for its wine production. It has a population of approx. 9,000, and good geothermal features. Its popular spa is a great proof of that. The town has a concentrated heat market similar to Kiskőrös. The Mayor’s Office, the KTKT János Arany Primary School, the Kindergarten and Day-care Centre, the Town Library, the Cultural House, the Central Kitchen, and the Retirement Home are situated close to each other. The utilization of geothermal energy is not profitable due to the small number of institutions. The connection into the system of an agricultural or balneological consumer with bigger energy demand would allow establishment of a modern communal geothermal cascade system.

INTERGATED RES DEVELOPMENT POSSIBILITIES IN SOLTVADKERT

Soltvadkert is a small town in Bács-Kiskun County with a population of approx. 8,000. The majority of the town is dealing with wine-production, and has similar good geothermal features as Kiskőrös and Kecel. However, in contrast with other settlements of the region, it does not have a spa based on these features. This fact can be explained with the Lake Vadkert, which can satisfy the needs of those looking for bathing opportunities.

The local government is planning the construction of a spa, according to the modern tendencies. The town's institutions are suitably concentrated. The Mayor's Office, the KTKT Primary School and Kindergarten, the Lutheran Kindergarten, the Kindergarten on Bocskai Road, Arany János Road, the Cultural House, the Medical Office, the buildings of the Police, Fire Department and Joint Social Institutions can be found in the downtown.

The town is currently not planning to switch to geothermal heating, since it would require a greater number of consumers with higher energy demand. Beyond its institutions and possible spa to be built in the future, the town would need for example a bigger, 4-5-ha horticulture for the communal geothermal cascade system to be economically efficient.

GEOTHERMAL AND INTEGRATED SYSTEMS IN SLOVAKIA

SALA GEOTHERMAL DISTRICT HEATING SYSTEM, MET SALA

The system was established in 2010, with a total installed geothermal heat capacity of 1,1 MW. The amount of energy production / year is 87 000 GJ/year (24 167 MWh/year). The total investment cost was 2 M EUR. The amount and heat of the water abstracted is 315 000 m3 / 26 000 GJ/year (7 222 MWh/year), reinjection is not applied. Sala is a geothermal district heating system with single production well 1800 m deep. Old district heating system was repaired and new geothermal resource was built and connected to the system, gas boiler plant is used as peak load and back up heat source. Geothermal water with temperature of 70°C and 15 l/s is exploited by submersible pump. Apartment buildings in the town of Sala are supplied by geothermal heat. Used geothermal water is drained into Vah river. 30% of annual heat production is covered by geothermal energy.

SERED GEOTHERMAL DISTRICT HEATING SYSTEM, MBP SERED

At the site drilling works were completed in 2010, geothermal system is to be finished in 2011. The amount of installed geothermal heat capacity is 0,63 MW. The amount of energy production / year is 39 000 GJ/year (10 833 MWh/year). The geothermal system is not combined with other RES, and reinjection is not applied. The total investment cost was 2 M EUR. The amount and heat of the water abstracted is 220 000 m3 / 17 000 GJ/year (4 722 MWh/year). Sered is a geothermal district heating system with single production well 1 800 m deep. Old district heating system was repaired and new geothermal resource was built and connected to the system, gas boiler plant is used as peak load and back up heat source. Geothermal water with temperature of 63°C and 10 l/s is expected to be exploited by submersible pump. Apartment buildings in the town of Sered are supplied by geothermal heat. Used geothermal water is drained into Vah river. 40% of annual heat production is covered by geothermal energy.

GALANTATERM S.R.O.

The system was established in 1995 with an amount of installed geothermal heat capacity of 7.0 MW/th. The amount of energy production/year is 70 000 GJ. The system is not combined with other RES. Total investment costs were 105 000 000 SKK // EUR 3 485 361.485. The amount and heat of the water abstracted is 59 m3/h at 77°C. Reinjection is not applied. The system consists of two geothermal wells FGG-2 and FGG-3 of the depth 2 101 m and 2 102 m respectively. The temperature of water in them is 78°C and 77°C. The recommended production is 15.8 l/s and 18 l/s. The pumped geothermal water is transported to a collector, goes through a system of countercurrent plate heat exchangers (HX-1,HX-2, HX-3, HX-4, HX-5) and gradually transfers its heat energy to the distribution systems of secondary circuit. These distribution systems supply heat to the housing estate Sever (more than 1 300 flats, community buildings, a school, a kindergarten, an old people‘s home, shops) and to the hospital. The residual energy of partly used geothermal water has been utilized by Thermal Centre Galandia s.r.o. Galanta for heating the water in swimming pools, for heating tap water and for heating the premises of the spa from the year 2007. Before discharging waste geothermal water into a seepage drain its residual heat is used by the training centre Kaskády s.r.o. The used geothermal water is piped into the seepage drain of hydroelectric power plant Kráľová nad Váhom where it mixes with percolation water and cools to acceptable levels. After that it is discharged into the recipient river Váh.

Distribution of utilized gethermal energy sources in counties of the Slovak Republic (till 30.06.2009)

County	Number of localities in utilization	Yield (l/s)		Thermal power (MWt)	
		Total yield	Utilized yield	Total thermal power	Utilized thermal power
Bratislava	1,0	30,8	12,0	4,1	1,7
Trnava	13,0	369,2	199,7	83,0	45,8
Nitra	19,0	617,5	382,1	89,7	39,7
Trencin	10,0	140,8	111,1	12,5	10,9
Zilina	14,0	388,3	268,4	39,9	32,1
Banska Bystrica	13,0	211,9	151,8	18,8	13,3
Presov	7,0	267,8	172,3	36,1	19,1
Kosice	5,0	241,6	44,9	80,8	1,2
Total amount	82,0	2267,9	1342,3	364,9	163,9

Utilization of geothermal energy for direct heat as of december 2009

Lokality	Type	Maximum Utilization			Capacity (MWt)	Annual Utilization		
		Flow rate (l/s)	Temperature (C°)			Ave. Flow (l/s)	Energy (TJ/yr)	Capacity Factor
			Inlet	Outlet				
Senec	B/H	12,0	49	28	1,05	10,5	29,084	0,875
Piestany	B	2,0	69	30	0,33	1,8	9,259	0,900
Koplotovce	B	14,5	24	15	0,55	7,8	9,259	0,538
Diakovce-2	G/H	12,0	68	26	2,11	10,5	58,168	0,875
Galanta-2	D/B	25,0	77	28	5,13	15,7	101,471	0,628
Galanta-3	D/B	25,0	80	25	5,75	18,0	130,581	0,720
Galanta-1	B	10,8	62	28	1,54	6,8	30,495	0,629
Cilizska Radvan	G	6,0	82	32	1,26	4,8	31,656	0,800
Velky Meder (Calovo)-1	G/H	10,0	79	26	2,22	9,6	67,111	0,960
Velky Meder (Calovo)-2	B	18,2	57	26	2,36	16,2	66,240	0,890
Topolniky	G/H/B	23,0	74	18	5,39	18,6	137,387	0,808
Dunajska Streda-2	B	23,0	55	22	3,18	15,5	67,467	0,674
Dunajska Streda-1	G/H	15,2	91	35	3,56	13,4	98,978	0,881
Cilistov	B/H	15,0	52	16	3,56	12,5	59,355	0,833
Belusske Slatiny	B	6,0	22	15	0,18	3,8	3,509	0,633
Trencianske Teplice	B	12,1	40	27	0,66	10,8	18,519	0,892
Banovce n, Bebravou	B	17,0	40	21	1,35	8,6	21,552	0,506
Chalmova	B	13,4	33	18	0,84	7,6	15,037	0,567
Chalmova	H	5,0	39	20	0,40	3,8	9,523	0,760

Kos	H	22,0	59	38	1,93	16,3	45,149	0,741
Partizanske	B	18,8	20	15	0,39	9,6	6,331	0,510
Male Bielice	B	8,5	40	22	0,64	7,4	17,569	0,870
Velke Bielice	G	8,3	39	19	0,69	4,9	12,926	0,590
Topolcany	B	2,0	55	33	0,18	1,5	4,353	0,750
Zeliezovce	G	13,5	18	15	0,17	6,7	2,651	0,496
Santovka	B	10,0	27	18	0,38	5,2	6,173	0,520
Kaliniakovo	B	36,0	25	19	0,90	22,7	17,965	0,630
Vlcany	G/H	10,0	68	38	1,26	6,1	24,138	0,610
Diakovce-1	B	4,0	38	18	0,33	3,6	9,497	0,900
Diakovce-3	B	15,0	19	15	0,25	13,4	7,070	0,893
Obid	B	5,8	21	15	0,15	2,7	2,137	0,465
Sturovo	B/H	70,0	40	22	5,27	53,1	126,070	0,758
Podhajska	H/B/G	53,0	80	34	10,20	33,6	203,865	0,634
Tvrdosovce	B/G	20,0	70	38	2,68	11,2	47,273	0,560
Surany	B	3,5	49	35	0,21	2,4	4,432	0,685
Patince	B	103,5	26	17	3,90	32,5	38,581	0,314
Virt	B	10,0	26	18	0,33	7,2	7,597	0,720
Virt	B	18,3	24	15	0,69	8,9	10,565	0,486
Zlatna na Ostrove	G	7,5	51	21	0,94	7,1	28,095	0,946
Oravice	B/H	65,0	56	26	8,16	52,9	209,325	0,814
Rajecke Teplice	B/H	9,0	37	22	0,56	7,7	15,234	0,855
Stranavy	B	22,0	24	18	0,55	8,7	6,885	0,395
Liptovsky Jan	B	30,0	29	15	1,76	16,8	31,023	0,560
Liptovsky Trnovec	B/H	31,0	60	28	4,17	27,8	117,338	0,896
Besenova FBe-1	B	22,0	26	15	1,01	15,4	22,344	0,700
Besenova ZGL-1	H/B	27,0	62	26	4,07	25,8	122,509	0,955
Lucky	B	35,0	32	18	2,05	31,5	58,168	0,900
Turcianske Teplice	F/H	12,4	54	18	1,87	8,5	40,361	0,685
Turcianske Teplice	B	15,0	44	18	1,63	12,1	41,496	0,806
Tornala	B	45,0	18	15	0,56	18,2	7,202	0,404
Vyhne	B	5,0	36	22	0,29	3,1	5,724	0,620
Sklene Teplice	B	16,0	57	21	2,41	12,3	58,405	0,768
Kremnica	B	23,2	47	23	2,33	11,4	36,088	0,491
Kovacova	B/H	30,0	48	18	3,77	26,4	104,465	0,880
Sliac	B	4,0	33	15	0,30	3,6	8,547	0,900
Sielnica	B	3,6	33	15	0,27	3,0	7,123	0,833
Dudince	B	9,0	28	15	0,49	7,7	13,203	0,855
Vinica	B	10,0	21	15	0,25	4,6	3,640	0,460
Dolna Strehova	B	1,5	29	15	0,09	0,8	1,459	0,526
Dolna Strehova	B	2,5	35	15	0,21	1,2	3,166	0,480
Slovenske Klacany	B	2,0	38	18	0,17	1,0	2,638	0,500
Vysne Ruzbachy	B/H	49,8	23	12	2,29	29,2	42,366	0,586
Poprad	B/H	61,2	48	15	8,45	58,4	254,198	0,954
Vrbov-1	F/B	28,3	56	22	4,03	18,3	82,068	0,646

Vrbov-2	F/B	33,0	59	15	6,08	25,6	148,572	0,775
Trstene pri Hornade	B	10,0	18	15	0,13	6,1	2,414	0,610
Trstene pri Hornade	B	14,3	21	15	0,36	7,5	5,936	0,524
Valaliky	B	11,7	21	15	0,29	6,3	4,986	0,538
Kosice (Tahanovce)	B	4,9	26	15	0,23	2,3	3,337	0,469
Sobrance	B	4,0	29	15	0,23	3,5	6,463	0,875
TOTAL		**1342,3**			**130,63**	**914,89**	**3053,770**	

Summary table of geothermal direct heat uses as of 31. december 2009

	Installed Capacity (MWt)	Annual Energy Use (TJ/yr)	Capacity Factor
Individual Space Heating	16,7	381,1	0,723
District Heating	10,8	232	0,681
Greenhouse Heating	17,6	461,1	0,831
Fish Farming	11,9	271	0,722
Bathing and Swimming	73,6	1708,5	0,736
Subtotal	130,6	3053,7	0,741
Geothermal Heat Pumps	1,6	13,5	0,267
Total	**132,2**	**3067,2**	**0,733**

GEOTHERMAL AND INTEGRATED SYSTEMS IN POLAND

During 2005–2009, geothermal energy was used in several localities mainly for heating, balneotherapy and bathing (Fig. 1, Table 3 and 5). For other purposes it was used on a semi-industrial scale in a cascaded system reported before (Kepinska, 2005) and for new application – heating up the lawn of football playground). Comparing to the data presented at WGC 2005, the installed geothermal capacity and heat sales have increased, what was caused mostly by further heat sales increase in the Podhale region, launching a new geothermal heating plant in Stargard Szczecinski as well as further heat pumps development.

Taking into account the data from particular geothermal plants, at the end of 2008 the installed geothermal capacity (heat pumps excluded) totalled 77.95 MWt and with the shallow heat pumps not less 281.05 MWt. Geothermal heat sales were ca. 501 TJ (including 456.6 TJ for space heating) - shallow heat pumps excluding - and not less than 1501.1 TJ including shallow heat pumps. Only in case of geothermal bathing facilities where waters are used to fill pools or for curative treatment, the capacities and heat production were evaluated using the standard equations. Following the equations recommended to prepare particular tables attached to this country report, at the end of 2008 geothermal capacities and heat uses would be markedly higher in some cases. In case of heat pumps, the exact data are known for the heating plants (absorption pumps) only, while for ground-source and groundwater compressor pumps only tentative data are available.

In 2009, five geothermal space heating plants were operational: in the Podhale region (since 1992/1993), in Pyrzyce (since 1996), in Mszczonow (since 1999), in Uniejow (since 2001) and in Stargard Szczecinski (since 2006). A heating installation in Slomniki (open late 2002) and reported in 2005, was not in operation.

PODHALE REGION

In that region, since 1994 the biggest in the country geothermal heating project has been underway. The main geothermal aquifer – a subject of exploitation, is hosted by the Triassic and Eocene carbonates (depths of 1 – 3.5 km). Reservoir temperatures reach up to 80 - 90°C. The maximum flow rates vary from 50 to 150 l/s of 82 - 86°C water. The TDS are 0.1 – 2.5 g/l (Kepinska, 2000). In 2008 the installed geothermal capacity was 41 MWt (not fully used yet) and heat sales amounted to 267.00TJ/y (peak gas including, it totalled 324.25 TJ). By the end of 2008, 1298 receivers were connected to geothermal heating grid (incl. 57% individual houses, 17% multi-family buildings, 17% hotels and boarding houses, 3% schools and other buildings). The target heat sales 600 TJ/y are expected to be achieved by 2011. In May 2008 a part of geothermal water cooled down in heat exchangers started to supply a new bathing centre (“Termy Podhalanskie”). Along with the heating system (operated by PEC Geotermia Podhalanska SA) the basic research and R&D works on cascaded uses have been run by the PAS MEERI. The system comprises the installations: wood drying, greenhouse, fish farming and foil tunnels with heated soil. Thanks to the geothermal heating the annual average concentrations of particulate matter PM10 and SO_2 have dropped by about 50% in comparison to the period before this heating type was put on-line. In 1998 – 2008 the CO_2 emissions were reduced by 197 000 tons.

PYRZYCE

The heating plant was open in 1996. The aquifer is situated within the Jurassic sandstones at the depths of 1.5 – 1.6 km. It is exploited by two production and two injection wells. The maximum flowrate is 100.1 l/s of 61°C water. The TDS are 120 g/l. The plant's maximum installed capacity is 48 MWt including 14.8 MWt geothermal, 20.4 MWt from absorption heat pumps and 12.8 MWt from gas boilers. It supplies heat and warm water to over 90% of users of the town's population (13,000). The network water parameters: 95°C/40°C (winter) and 60°C/45°C (summer). In 2008 geothermal heat sales was ca. 60 TJ/y including ca. 30 TJ extracted directly by exchangers and 30 MWt from two absorption heat pumps while the total heat sales was 100 TJ/y. Basically, the exploitation and technical parameters of the plant remained similar as during the past years. However, one noticed the drop in heat sales (in 2005: 72 TJ from geothermal) despite of connecting some new consumers. It was caused by lower heat demand thanks to the thermomodernisation of many buildings.

THE MSZCZONÓW HEATING SYSTEM

The Mszczonów heating system replaced 3 coal-fired plants. It supplies ca.2900 (50%) of total town population with space heating and domestic warm water. The clients are: 31 multifamily buildings (blocks of flats) and public buildings (Municipal office, kindergarten, grammar school, two secondary schools, Cultural Centre, Health Care Centre). Moreover, cooled geothermal water of TDS = 0.5 g/L is distributed as a potable one by local waterworks (mixed with Quarternary water).

Since 2008 a part of water discharged from the well has been used to pools of newly-opened recreation centre “Termy Mszczonow”). The system consists of one production well equipped with submersible pump (/the well was drilled in 1970s for oil&gas exploration, total depth 4119 m/ than reconstructed and adopted for geothermal exploitation in 1996 – 1999), 1650 m pipeline (diameter 125 mm) providing geothermal water to the heating plant building (hosting all above listed installations listed). The system in monitored in case of geothermal well exploitation parameters and heating plant’s parameters.

The system was established in 1999. Amount of installed geothermal heat capacity (MWth) is as follows: 10.2 MWt total installed capacity, including 2.7 MWt absorption heat pump (APS), 1.9 MWt high-temperature gas boiler, 4.6 MWt low-temperature peak gas boilers (2x2,3 MWt) and 0.6 MWt cooler. The amount of energy production / year is 14 500 GJ/2008 – geothermal (ca. 30% of the total annual heat sales / 48 000 GJ/ from geothermal /via APS/). The total investment cost was 10 mln PLN (2.5 mln Eur/exchange rate from Dec 2010/) – space heating plant (recreation center not included). The amount and temperature of the water abstracted is ca. 60 m3/h, 42.5°C. Injection is not applied in the system.

In 2008, maximum 16.6 l/s of 42.5°C water is produced from the Cretaceous sandstones by a single well. The plant of the total installed capacity of 10.2 MWt uses geothermal water both for heating and drinking. The heating part of the plant operates as an integrated system: the district heating water is heated to the required temperature by the heat extracted from geothermal water and gas boilers fitted with 2.7 MWt absorption heat pump and 0.6 MWt cooler. When cooled down, it is supplied to the consumers as potable water (TDS 0.5 g/l). In heating season, ca. 30% of the total heat sales come from geothermal water (14.5 TJ in 2008; Table 4). In June 2008 the geothermal bathing centre was opened (“Termy Mszczonów”). It uses a part of water stream discharged by the well and sent directly to pools.

THE UNIEJOW HEATING SYSTEM

The Uniejow heating system supplies ca. 80% of all buildings in the town. It replaced 10 local coal-fired heating plants and ca. 160 individual coal-fired ovens. Geothermal water is exploited in a triplet system (1 prod., 2 injection wells; but since 2008 some water amount disposed into a river; see above).

Main components of the system:
- geothermal wells: one production (aquifer situated at ca. 1900 – 2000 m) and two production wells);
- pumping station for geothermal water injection,
- 2 heat exchangers (for space heating),
- 2 heat exchangers (for domestic warm water),
- peak biomass boilers,
- thermal water treatment station,
- pumps for domestic water supply,
- distribution system incl. 10 km of pipelines (equipped with control and monitoring system)

The system supplies space heating and domestic warm water. The clients (ca. 180 connections): multifamily buildings (blocks of flats) and single family buildings (2 residential areas), public buildings (kindergarten, grammar school, County Cultural Centre, Health Care Centre, church, vicarage, pharmacy, Geotermia Uniejow Office).
In June 2008 the geothermal recreation centre was opened ("Termy Uniejow"). It uses a part of water cooled down in heat exchangers (ca. 28 m3/h of 42°C water) for pools, curative treatments and heating the centre's facilities. Some amount of spent water from bathing centre (ca. 20 m3/h of 28°C water) is used to heat up a lawn of football playground.
The system was established in 2001. The amount of installed geothermal heat capacity (MWth) is 5.0 MWt total installed capacity, incl.: 3.2 MWt geothermal heat exchangers, 1.8 MWt peak biomass boilers, in 2006 they replaced 2.4 MWt peak fuel-oil boilers. The amount of energy production / year is Ca. 14 000 GJ/2008 – geothermal (total annual heat sales). The amount and temperature of the water abstracted is 120 m3/h, 68°C (max. parameters). Before 2008 the full amount of water was reinjected. Since 2008 water (40 - 45°C) has been partly injected (2 injection wells), and partly used for recreation centre "Termy Uniejow" for heating the football playground and then it is disposed into a river

The heating plant was opened in 2001. Geothermal aquifer is situated within the Cretaceous sandstones at the depth of 1.9 – 2 km. The maximum production is 18.8 l/s of 68oC water (without pumps) and 33.4 l/s (using the submersible pump), and the TDS are 5 g/l. Water is exploited in one doublet system. The installed capacity of the plant is 5.6 MWt, including 3.2 MWt from geothermal and 2.4 MWt from peak oil boilers. In 2008 about 80% of all buildings in the town were supplied by this plant. In 2008 the total heat sales were ca. 14 TJ. The works on connecting new consumers are planned. In June 2008 the geothermal bathing centre was opened ("Termy Uniejów"). It uses a part of water cooled down in heat exchangers (ca. 8.4 l/s of 42°C water) for pools, curative treatments and heating the centre's facilities. Spent water from bathing centre (ca. 5.6 l/s of 28°C water) is used to heat up a lawn of football playground.

INTEGRATION WITH OTHER RES
In 2006, 1.8 MWt biomass boilers were constructed (wood cheaps, other) to replace fuel-oil boilers in geothermal plant

STARGARD SZCZECINSKI

The plant was open in 2006. It is based on a doublet of deep production (2672 m) and deviated injection (2960 m) wells. The aquifer is situated in the Jurassic sandstones. The production well discharges 27.8 l/s of 78°C water on average (max flowrate was 69.4 l/s of 87°C water). The geothermal capacity is 10 MWt and heat sales were ca. 86 TJ in 2008. Geothermal heat is extracted by heat exchangers and than sold to the nearby coal-fired municipal district heating plant (total capacity 116 MWt) serving about 75% of local population (75,000). Initially the plant was planned to distribute ca. 300 TJ/y of geothermal heat to the town's consumers via the existing municipal network. It had to cover the total heat demand for warm tap water in summer while during the heating season it would be supported by existing coal-fired plant. (However, due to economic situation mostly, in fall 2009 the geothermal plant was in liquidation).

BALNEOTHERAPY AND OTHER USES

Geothermal waters from springs or wells, with temperatures from 20°C to 62°C, have been used for medical treatments in seven spas. Some by-products, like iodine-bromine medical and cosmetic salts, and CO2 are extracted from geothermal waters. In one locality (Iwonicz), the cosmetics based on geothermal brine are produced. It is worth to note seven new geothermal bathing centers constructed in the reported years (2006 – 2008). Four of them were opened in the Podhale region (Aqua Park Zakopane, Szymoszkowa, Terma Bukowina tatrzanska, Termy Podhalanskie) and three in the Polish Lowlands: (Grudziadz-Marusza /2005/, Termy Uniejów and Termy Mszczonów /both in 2008/). Five of them use water produced mostly for heating whereas two base on waters discharged by new or reconstructed wells that supply only these centres. Some further investments are either at the final stages of realization or under projects' elaboration. Moreover, a semi-technical cascaded uses have been operated by the Mineral and Energy Economy Research Institute PAS in the Podhale region (Kepinska, 2005): wood drying, greenhouse, fish farming and foil tunnels with a heated soil. In case of Uniejow town, outlet geothermal water from the bathing centre started to be used to heat up a lawn of football playground. Even if on a small scale, this new type of use demonstrates various opportunities of geothermal applications in the so-called cascaded mode.

GEOTHERMAL HEAT PUMPS

As given before, the absorption heat pumps have been working in two geothermal plants: in Pyrzyce two pumps of 20.4 MWt total capacity produced about 30 TJ in 2008. In Mszczonów, geothermal heat production is entirely based on AHPs: the installed capacity is 2.7 MWt and heat sales were ca. 14.5 TJ in 2008. For these installations one can give the exact data on their capacities and heat production: 23.1 MWt and 44.50 TJ in 2008, contributing significantly to the total geothermal capacities and heat sales by all plants in 2008. The market for shallow geothermal heat pumps, GHPs, has been constantly growing. However, no detailed statistic data exist. On a basis of available data and market analyses (e.g. Joniec, 2007) one may very roughly assume the total installed capacity at least 180 MWt and heat production 1000 TJ/2008. About half of newly installed GHPs has capacities less than 70 kW, larger capacities (70 - 110 kW) form ca. 30% of installations while bigger ones (110 - 150 kW) are not common.

GEOTHERMAL DRILLING

In 2005 – 2009 five new geothermal wells were drilled: two production ones in the Podhale region (ca. 1.8 – 2.2 km of depth) and three exploration ones in the Polish Lowlands (ca. 2.0 - 3.3 km). They gave a total depth of ca. 12.5 km. Besides, the drilling of next deep well was initiated in August 2009. Several projects for new geothermal drillings had been issued the licenses and awaited for realisation in 2009. They were oriented at geothermal water exploitation for heating and/or recreation. Moreover, some projects on reconstruction of old wells have been prepared and expected to be executed soon.

GEOTHERMAL AND INTEGRATED PROJECTS IN FYROM

About 15 geothermal projects have been developed in the Republic of Macedonia during the period of 70's and 80's of the last century. Some of them are still in operation but others are abandoned or work below the designed capacities. Four of them are very important and have an important influence to the development and application of geothermal energy in the country. These are the Kocani eothermal project, the Smokvica and Istibanja agricultural geothermal projects, and the integrated project in Bansko.

Geothermal projects in Macedonia					
Geothermal location	Geothermal field	Applications	Thermal power		Heating systems
			Total MW	Geothermal MW	
Bansko	Bansko	* 2,9 ha glasshouses * 6 ha soft plastic covered greenhouse * 2 smallhotels * 1 medical center	6.000 3.000 1.560 250 150	6.000 3.000 1.560 250 150	* Aerial steel pipes * Vegetative heating * Soil heating * Alunimia radiators * Water heat accumulator * Plate heat exchangers
Podlog	Kocani	* 8 ha glasshouses * 2 ha soft plastic covered greenhouse	14.000 2.000	12.000 2.000	* Aerial steel pipes * Vegetative heating
Kocani	Kocani	* 12 ha glasshouses * 4 central heatings	40.700 1.000	20.500 1.000	* Aerial steel pipes * Vegetative heating * Alunimia radiators
Smokvica	Gevgelija	* 4 ha glasshouses	8.000	8.000	* Aerial steel pipes * Vegetative heating
Istibanja	Kocani	* 6 ha glasshouses	17.500	7.480	* Aerial steel pipes * Vegetative heating
Negorci	Gevgelija	* Central heating / balneology	350	350	* Steel and alunimia radiators
Total 2010			**94.510**	**62.230**	

New Strategy for RES Development is still indifferent to geo-thermal energy, as prospective energy source for Macedonia. Practically, it doesn't consist any development until 2020. However, there are some private initiatives, which shall probably change the situation. Most important is the ones for renewal of the Smokvica geothermal system, reconstruction and enlarging the Bansko geothermal system and foundation of a new one in Dojran. Final completion of the re-injection system in Kocani should be realized during the next two-three years, too. Probably, some reconstructions and orientation towards geothermal energy use in other spas shall be made but, up to now, there is no data for such intentions. Unfortunately, still there are no signs that something will be done with the very prospective geothermal field in Kratovo-Zletovo, Skopje and Kumanovo regions.

KOCANI (PODLOG) GEOTHERMAL PROJECT (“GEOTERMA”)

Basic function of the System is exploitation of geothermal water from exploitation wells, transport (distribution) to the final users, collecting of used water and re-injecting of the same in re-injection borehole. Geothermal water is produced from 4 existing exploitation wells with 500-700m depth in the area of v. Dolni Podlog, Kocani and is accumulated in a balance reservoir of 1000m3 capacity. Used geothermal water is pumped back to the aquifer in the reinjection well in v. Banja. With the ongoing project the system will be enlarged with 1 new exploitation well and 1 reinjection well (doublet system). The geothermal system with the available capacity is heating 12 ha of greenhouses ,,Dobra”, 6ha greenhouses ,,Zelena Kuka”, elementary school ,,St. Cyril and Methodius” , elementary school ,,Nikola Karev”, high school ,,Ljupco Santov”, and the court. The year of establishment is 1985, the Amount of installed geothermal heat capacity (MWth) is 110MW. The amount of energy production / year is 300 000GJ. The amount and heat of the water abstracted is 300 l/sec, at 80oC, the amount and heat of the water reinjected is 100 l/sec, at 25oC.

This is the presently largest geothermal project in Macedonia, consisting of 18 ha greenhouse complex heating, and space heating in the centre of the town. Due to the economic crisis in the country, paper industry, vehicle parts industry and rice drying have been lost as consumers of heat during the last 10 years. However, thanks to two Austrian grants, three additional boreholes have been drilled, partial re-injection of outlet water was completed and a monitoring was system introduced to the system. Presently, activities to finalize the completion of the re-injection and connection of public buildings in the centre of the town are in flow. The project operates as a public utility and its organizational structure is well covered by the professional team. However, the price of supplied heat poses a problem as it is kept very low by the State Regulatory Committee and doesn’t consist funding for necessary maintenance works and system development. By the use of EU funding, deeper explorations (up to 1.000-1.200 m) is planned from 2010.

The project is located in the region of Kocani Valley, where 18 ha of greenhouses have been heated since 1982, as well as a rice drying plant (abandoned). Weak-corrosive water permitted an initial simple technical design (direct use of the brine in heating systems of users). A subsequent successful borehole, which increased the flow rate from 300 l/s up to 450 l/s, opened the way for introduction of geothermal energy application in other sectors. Some industrial operators have expressed the intention to be connected to the system.

INTEGRTATION WITH OTHER RES

Although the problems of exploitation and further development have already been evidenced and possible solutions defined, it is necessary to underline that presently the two most important problems for the system survival and development have to be resolved. One is the need to reach a technically feasible and economically justified annual heat loading factor of the integrated system. The usage of the installed heat power seems to have a very irregular distribution over the year. High investment costs in pipelines and heating systems should be repaid by their full use only during the three winter months and a partial one during the other three-four months. Possible solution could be the introduction of cascade use of heat everywhere possible, as well as integration with other energy sources, including RES, covering the peak loads with (waste or bio) gas, heavy oil or biomass boilers and introduction of heat users with different daily and annual heat loading characteristics.

RESERVOIR MANAGEMENT

The second principal problem is the continual empting of the geothermal reservoir. By continual over-pumping, the reservoir has a water level of about 40 m below the soil surface. Introduced partial re-injection, which should stop further decrease of the water level, didn’t fulfil the expectations due to a list of unresolved technical problems of its maintenance. Completion of a new parallel reinjection of the effluent water of one of the users is in flow. However, that shall only partially resolve the problems of proper reservoir engineering. It is absolutely necessary to introduce complete re-injection of the effluent water of the system and, with that, fulfilment of obligations of legal regulations and enabling connection of new consumers. According to the present organizational state and existing system for determination of the selling price of supplied heat, temporarily it is not possible to foresee a proper technical completion of the system and, with that, guarantee for its long term exploitation.

ISTIBANJA (VINICA) GEOTHERMAL PROJECT

The town of Vinica is situated ten km from Kocani, and hosts the second geothermal system Istibanja of the Kocani geothermal field. A 6 ha greenhouse complex is heated with geothermal energy in combination with gas. Initially not properly completed, the heating system was reconstructed and optimized 10 years ago. However, the non resolved question over the property of concession rights still disturbs proper maintenance of the system, resulting in problems with regular heat supply. Further investigations and new boreholes completion are necessary to finally reach an acceptable state of geothermal system exploitation. The project consists of 6 ha greenhouse complex heating in combination with a heavy oil boiler for covering the peak loadings. The project was reconstructed and optimized with Austrian and Dutch grants and now properly covers the heat requirements of the rose production for export. Owners are interested to continue investigations in order to enable geothermal heating of additional 6 ha of greenhouses but cannot reach a common language with the municipality, who is the owner of the concession rights.

INTEGRTATION WITH OTHER RES

The project consists of 6 ha greenhouse complex heating in combination with a heavy oil boiler for covering the peak loadings. As the heating of an additional 6 ha of greenhouses is planned it is suggested that biomass boilers be introduced to the system to cover peak loads. As the area is a primarily agricultural one biomass is readily available. While initial costs would be higher, safe supply and easy access to the assets would make it an economical and green solution.

BANSKO GEOTHERMAL PROJECT

The integrated geothermal project "Bansko" is composed of agricultural users, supply of a spa centre with thermal water and central heating, heating of several small hotels and a medical centre. The system suffers from the lack of an initially defined conception, taking into account the needs and demands of different uses and users. The bad composition of the heat users (daily and annual diagrams of heat consumption of the biggest ones are practically the same), and conflicts for the availability of resources strongly hindered further improvements. Undefined rights and property of the geothermal resource resulted in a "war for water" among the already connected users, which led to unsatisfactory heat supply to all of them. This regulatory problem has been a real barrier for proper governing of the system. The system has excellent possibilities for growth due to the fact that at least two new boreholes with double capacity of the existing one are feasible and that there is a large heat market.

The bankruptcy of the ZIK "Strumica" and the slow process of its privatization resulted in the collapse of the organizational structure and led to an improper use of the system. The operation was carried out with a constant increase in geothermal water extraction. The introduction of a centralized system and new exploitation boreholes are an absolute need for the system's proper operation, due to the increased number of users and not covered peak loadings. Also, a list of reconstructions and optimizations is necessary in order to put the system in proper technical order. A trial to improve the situation by an Italian/Macedonian project is in progress.

INTEGRATION WITH OTHER RES

While the Bansko geothermal project is in need of some fundamental reconstruction work, including the introduction of a sustainable reservoir management a sound integration of geothermal energy with other res could easily add to the economic viability of the system. With a number of DHW users in the heat market, including hotels and medical facilities solar collectors may be introduced, to cover their DHW need.

SMOKVICA GEOTHERMAL PROJECT

Greenhouse complex "Gradina", which is a rather large heat consumer consisting of 22,5 ha glass greenhouses and 10 ha soft plastics greenhouses has been the largest geothermal heated complex in Macedonia. However, the complex went bankrupt 15 years ago and the geothermal system was abandoned.

During the last 2 years a new geothermal heated greenhouse complex of 4 ha has been completed nearby the geothermal field, which opens new development possibilities. Once the largest geothermal system in Macedonia, covering the heat requirements of 22,5 ha glasshouses and about 10 ha plastic-houses is now out of exploitation. Improper privatization resulted with the division of the property to 10 entities and they couldn't find a common language for covering the costs of the system exploitation. Renewal of the system exploitation is impossible because the distribution system was destroyed. There is no information on what the new owner's intentions are with the energy source.

OTHER PROJECTS

Other existing projects in Macedonia are mainly connected to medical spa uses, except in the Negorci Spa, where a primitive trial to use geothermal water for space heating has been made.

Negorci (Gevgelia) Spa: Reconstruction of the heating installations has been finalized and now all the hotel and therapeutical projects are heated with geothermal energy. Project is in a process of continual step by step modernization.

Other Spas in Macedonia: While planned, reconstruction of heating systems and their orientation towards geothermal energy use in spas have not been realized due to the un-defined property and the absence of funds. Activities to find possible investors are in progress in Katlanovo Spa, Kezovica Spa and Bansko Spa. However, it is not possible to expect quick results, due to the absence of capital in the country and the lack of interest of foreign investors.

GEOTHERMAL AND INTEGRATED PROJECTS IN SERBIA

There are no geothermal based district heating systems in Vojvodina. Geothermal power is used locally at several places, however. The following chart lists well data of the geothremal operations in Vojvodina.

	Location	Operator	Built	Use	Yield [l/s]	Heat [Co]	Energy [MW]
1	Óbecse	Local Govt.	1988	Heat supply, DHW	17,2	65	4,50
2	Petrőc	Agricult. opretaot	1987	Agricultural	6,5	46	0,94
3	Magyarkanizsa	Spa	1981	Spa and balneotherapy	1,8	41	0,19
4			1986		9,3	65	1,95
5			1999		12,5	70	2,36
6	Bácsszentiván	Spa	1983	Spa	11,8	53	2,26
7	Palics	Local Govt.	1985	Spa	5,5	48	0,53
8	Palics	Hotel Jezero	1988	Heat supply, DHW	6,3	48	1,17
9	Temerin	Komunalac KV	1987	Spa	14,9	40	1,34
10	Alibunár	Local Govt.	1986	Spa	7,4	24	n.a.
11	Melence	Spa	1985	Balneology	6,9	33	0,34
12	Homokrév	Agricult. opretaot	1984	Agricultural heat	7,0	51	1,46
13	Szenthubert	Agricult. opretaot	1987	Agricultural heat	11,2	43	0,75
14	Kúla	Industrial operator	1984	Industrial HW	5,6	53	0,85
15	Karadordevo*	Military	1978	Spa	2,17	34	n.a.
Sum:					**126,07**		**18,64**

Out of use systems:

	Location	Last operator	Built	Use	Yield [l/s]	Heat [Co]	State
1	Szabadka	Athletic Department	1984	Spa	4,83	35	Out of use since 2001
2	Dunacséb	TK Dunav	1996	Spa	5,00	31	Out of use since 2005
3	Kúla	Athletic Department	1981	Spa	9,50	50	Out of use since 2005

4	Kúla	Industrial operator	1984	Industrial HW	8,33	53	Kept on minimal yield
5	Kúla	FVT Sloboda	1985	Industrial HW	8,50	51	Out of use
6	Szenttamás	Industrial operator	1984	Agricultural heat	11,67	63	Out of use since 2004
7 8	Verbász	Athletic Department	1986 1986	Spa	3,50 4,33	39 51	Dismantle d system
9	Szenthubert	IPP Banat	1988	Heat supply, DHW	6,67	45	Out of use since 2001
10	Nagykikinda	KRO 6. oktobar	1984	Heat supply, DHW	6.17	50	Out of use since 2004
11	Nagykikinda	Agricultural operator	1985	Agricultural heat	10,1	51	Out of use since 2002