GeoFund - IGA Geothermal Workshop "TURKEY 2009"
GEOTHERMAL ENERGY IN ECA REGION COUNTRIES
February 16-19, 2009 , Istanbul, Turkey

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LIFE AND ENERGY IN CARPATHIAN BASIN
Social and Environmental Mission with Geothermal Power Generation

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SUMMARY

Hungary and some territories of its neighboring countries, like Slovakia, Romania, Serbia, Croatia and Slovenia in the Central Europe, are located in the Pannonian Basin. The Pannonian basin is a Neogene extensional setting formed between the Carpathian and Dinaride thrust belts within the mega-suture zone of the African and European plates with a relatively thin crust; 25 to 35 km thick. The basement of the basin consists of higher thermal conductivity Precambrian-Paleozoic-Mesozoic rocks. The basin is filled with lower thermal conductivity Cenozoic sediments, the thickest sequences formed during the upper Miocene, Pannonian age. The Pannonian sediments are multilayered and composed of sand, shale, and silt beds. While the lower Pannonian sediments (e.g. clay, silt, marl) are impermeable, the upper Pannonian and Quaternary formations contain vast porous, permeable sand and sandstone beds formed by the upper Pannonian aquifer.

Hungary and its neighboring countries have different primary energy structures but the common feature of those is the critical hydrocarbon dependency.

Social life is getting worse because of the increasing energy prices hat has mayor impact on different industries as well, utilizing high portion energy in related technologies. The year by year returning gas crisis makes this socio economic life unsustainable. There is a high demand of alternative energy sources for all segments of human life.

PANNERGY Plc. launched a giant program three years ago, to explore and utilize the proven geothermal power of the Pannonian basin, to provide sustainable renewable energy for the countries.

1. THE MISSION

The mission of Pannergy will be to build nearly 45 geothermal power plants in Central Europe. After about two hundreds meetings with the municipalities, Pannergy had to recognize that this process is much more than simple power plants construction. The life of the people in this region dominantly depends on energy and as the hydrocarbon primary energy is getting more and more expensive the people and the industry cannot tolerate this price increase anymore. They need something more acceptable and secure, they need a sustainable energy supply. In Carpathian basin geothermal power is the real answer to that request, the real alternative energy.

Fulfilling the mission started with a nearly one year interpretation process of the existing databases from the hydrocarbon, coal, uranium and water explorations of the past 45 years, performed in the Carpathian basin. It was a giant work, as the relevant and useful information have to be collected from dozens of resources. By the end of this complex process, the feasible areas for geothermal explorations have been determined.

Taking into account the complex character of the process, Pannergy has made strategic alliance with the largest Icelandic engineering firm Mannvit in order to create the appropriate and effective cooperation model on the fields of geosciences, drilling technology and geothermal power plant technology.

[16] PANNERGY Plc.

2. EXPLORATION METHODOLOGY

As electromagnetic methods allow the imaging of the resistivity structure, we selected magnetotellurics as the method of choice for reconnaissance. In combination with gravity we anticipate to find zones of increased fluids and higher temperature.

MT: The magnetotelluric method comprises a frequency domain electromagnetic tool that utilizes natural variations in the Earth's magnetic field as a source. Variations in the Earth's natural magnetic field supply frequencies ranging from nearly DC (direct current) to many kilohertz.

For the AMT/MT application on hand, we use a broad band (7 decades) to study of the electric substructure of the Earth from near surface to great depth. The large frequency range also means that the method is not hampered by the presence of a conductive overburden or sampling frequencies that do not allow for deep penetration. A major advantage of the MT method is that it measures simultaneously the electric and magnetic fields in two perpendicular directions. This provides useful information about electrical structure in an area. It is also considerably cheaper (approximately 10 times) than reflection seismic surveys.

The high frequency portion of MT is named the audio magnetotellurics (AMT) method. It is an extension of the MT sounding technique into audio-frequencies from 1 Hz to 20 kHz, which permits achieving moderate exploration depths to about 2,000 m depending on the terrene conductivity. AMT surveys carried out in about 40 known geothermal areas in the western United States generally show low restivities, which in many cases appear to correlate with hydrothermal convection systems of high temperature and large stored heat capacity.

MT-measurements are extensively used to estimate the resistivity with depth. If implemented properly it is possible to obtain the resistivity in two-dimensional sections along a line or lines. A water saturated uniform rock formation has in general lower resistivity, and if the temperature of the fluid is higher the resistivty is reduced further.

The formation most likely to give enough fluid for geothermal utilization is below the Pannonian formations. Because of the high and rather uniform temperature gradient observed for Hungary, the thicker the Pannonian layer is, the higher is generally the temperature in the underlying water bearing layer in the basement. For the proposed study it has been assumed that the optimal temperature for electrical productions is between 120° and 170°C corresponding to a depth of between 2000 m and 3000 m.

In other words the required temperature is most likely present in the layers that will be drilled into, but the permeability is, however, not known. It is assumed that the permeability, or the ability of the formation to pass flowing water through it, is rather low. It is therefore essential to look for some tectonic features that could provide greater permeability. In case there are some water carrying fissures present, it is very likely that the hot water will rise up through the fissure and may be detected by MT-surveying. It is also assumed that permeability means higher water/rock ratio thus giving greater resistivity contrast for the MT/gravity survey to detect.

Gravity surveying methods are useful in detecting fault systems below the surface. The fault system information can be used to analysis and understand groundwater channels and water flow directions. At the same time, gravity data may be used to analysis volcanic rock distribution and help find out the heat source. The gravity data are normally displayed on a contour map, and can identify large and deep fault and shallow fault systems. They do, however, have a lower vertical (depth) resolution unless constrained by seismic data, log data or other information.

Gravity based geophysical methods are usually, applied in order to provide additional support for the definition of the geological structures at a regional scale. With deep penetration the resolution is lower. In this situation the gravitational survey offers significant benefits in the interpretation of the MT measurements at a low additional cost, costing only about 10% of the MT survey.

The intrinsic ambiguity of the gravity data is reduced by the high level of redundancy of the acquired data set and integration with other data. This detailed density information can be successively utilized in conjunction with conventional MT data performing integrated inversion procedures.

These models will be automatically and reciprocally consistent because they represent the simultaneous solution of a joint minimization process honouring observed MT and gravity data at the same time.

In this project densely spaced gravity data along several 2-D MT lines with selective 3D will is acquired. This is done in order to perform cooperative (no direct link of model parameters) and joint (overlapping model parameters) inversions of MT and Bouguer anomalies and an as needed basis.

2.1. MT and gravity survey

All available data were used to outline the most prospective areas for geothermal electrical production and space heating in Hungary. Before locating wells to be drilled for geothermal utilization more data was needed. It was decided to use integrated MT and gravity survey in additional to the existing data in an attempt to further

strengthen the possibility of drilling successful wells. Survey lines were proposed on the geosciences data and optimized for the clients concerns. The spacing for the 2-D MT lines was 1000 m, but 250 m for the gravity points. When the surveying was finished for a given line the geological cross section is derived and used for constraints on the MT and gravity interpretation.

2.2. Results

Three survey lines were finished before the end of of 2007 and the geological cross sections were made available soon after. Figures 1 and 2 show 2 of these cross sections with the interpretation. In all three sections are pockets where the density is low (high porosity) and the resistivity is low (higher temperature, more fluid). These pockets indicate the geothermal reservoirs and potential drilling targets. Next further 3D and/or controlled source measurements are planning to defined specific targets.

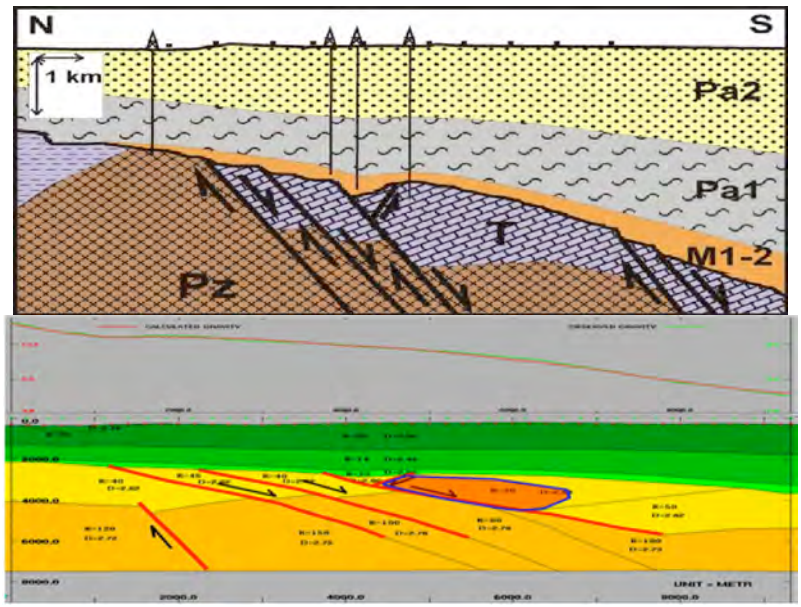

Figure 1: Top: Geological model; Bottom: Using integrated inversion result of MT & gravity, & local geology to obtain basement resistivty & density, and then interpreted basement fault system.

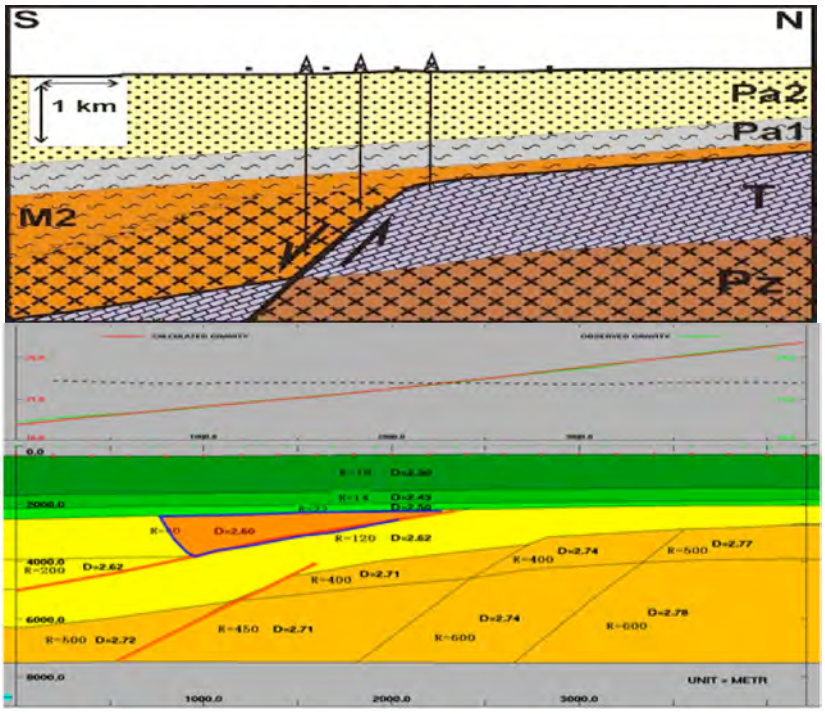

Figure 2 Top: Geological model; Bottom: Using integrated inversion result of MT & gravity, & local geology to obtain basement resistivty & density, and then interpreted basement fault system.

3. PLANNING AND DRILLINGS

The complex geophysical exploration with the interpretation of the relevant seismic databases resulted the drilling sites selection and exact three dimensional positioning of the production wells. With hydrodynamic modeling the reinjection well positions have been positioned.

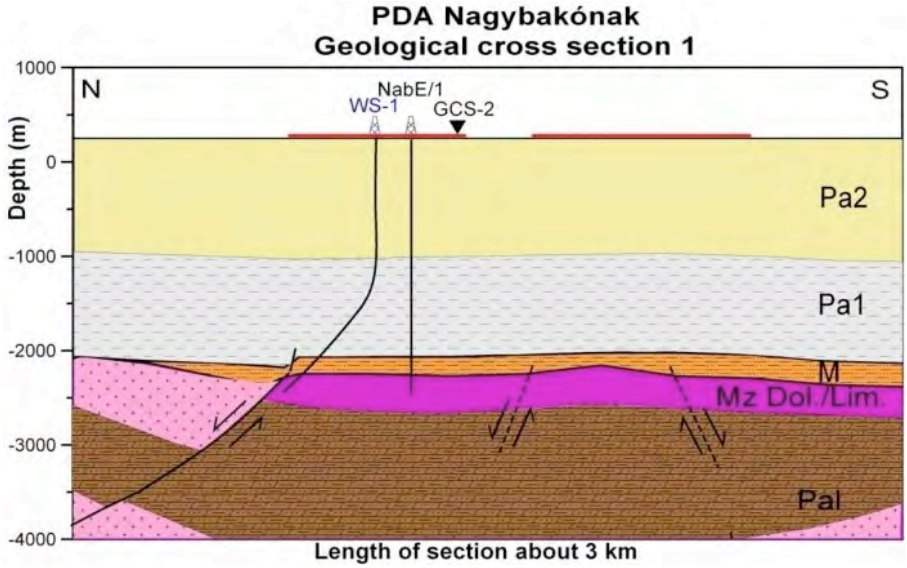

Fig.3. Geological cross section of the location

Up to these days 70% of the exploration tasks have been performed and based on their results overall 62 drilling positions selections and hydrodynamic modeling will be done by June this year. Second phase of exploration will start in July this year.

4. MUNICIPALITY BUSINESS MODEL

After the selection of the feasible areas, within their barriers, Pannergy has approached the Municipalities with the developed cooperation model. Under the legal frame of this model, Pannergy and Municipality found joint energy company with the features:

- 400.000.- Euro initial capital
- Ownership ratio:10% Municipality, 90% Pannergy
- PANNERGY gives loan without interest for 10%
- Municipality redeems from the business result

. PANNERGY provides full project financing
. JOINT COMPANY on the result of the feasibility study
. JOINT COMPANY purchases land for the power plant
. JOINT COMPANY applies for required licenses

Up to these days thirty one contracts have been signed in Hungary, additional 16 contracts will be signed in Slovakia, Romania, Serbia, Croatia and Slovenia in the upcoming half year.

5. TECHNOLOGY AND UTILIZATION OF THE GEOTHERMAL POWER

Municipalities will utilize the generated geothermal heat for their district heating systems. The capacity range will supply 1000-40000 flats, connected to the networks in each town, providing affordable priced and sustainable heat to the people. In underdeveloped regions where district heating systems do not exists, the industrial parks and the agriculture will utilizes the geothermal heat for different applications and technologies.

In those projects where the reservoir provides the higher heat amount, Kalina power plants will be built in cogeneration mode.

With this approach the underdeveloped regions and massively underdeveloped regions will have local energy generation and the country electricity network will get base load capacity.

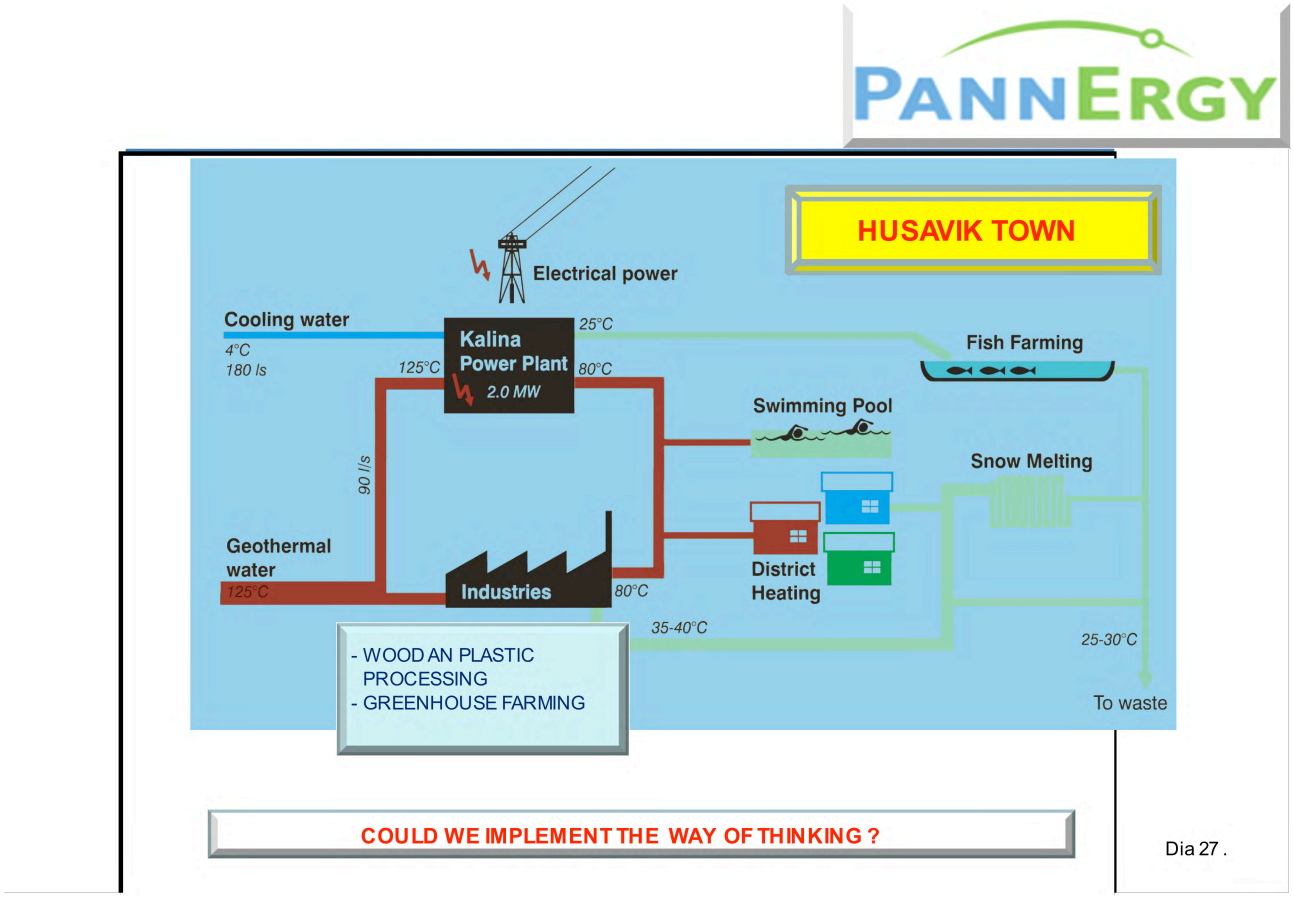

Fig.4. Overall concept of the project for multipurpose utilization

6. RESULTS AND IMPACTS OF THE MISSION

The mission will have direct and indirect impact on the life of 3 millions of people with providing alternative, low priced energy for the household and industries. The primary energy dependency in Hungary represents an unsustainable life and this is the phenomena in the neighboring countries as well.

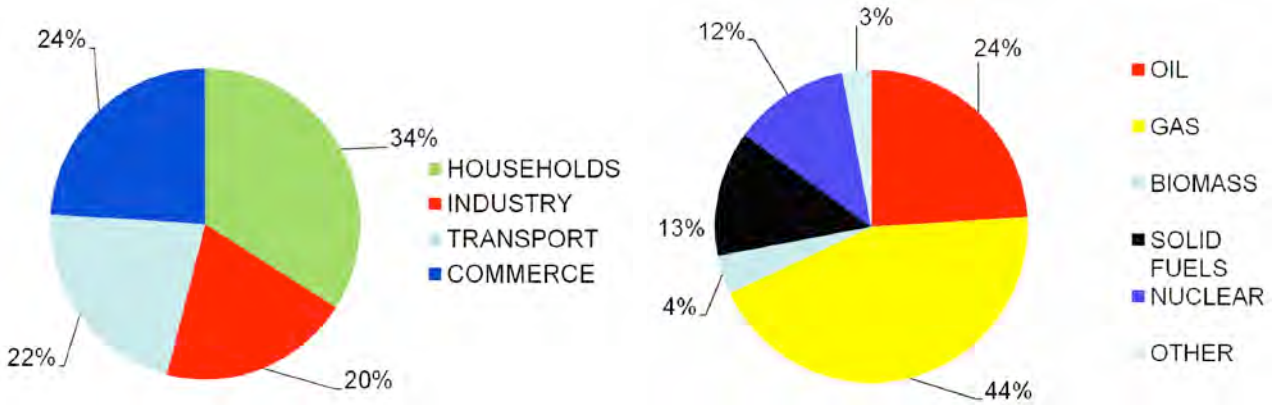

Figure 5. Illustration of the dangerous hydrocarbon energy dependency

The successful achievement of the Mission of Pannergy will result with:

- geothermal heating of around 300 000 flats connected to district heating network in 38 municipalities.
- 200 MW green electricity from geothermal power
- 27 industrial plants utilizing geothermal energy
- 800 acres new greenhouse, built around geothermal power plants resulting employment in massively underdeveloped region
- 56 tons CO2 reduction in the region

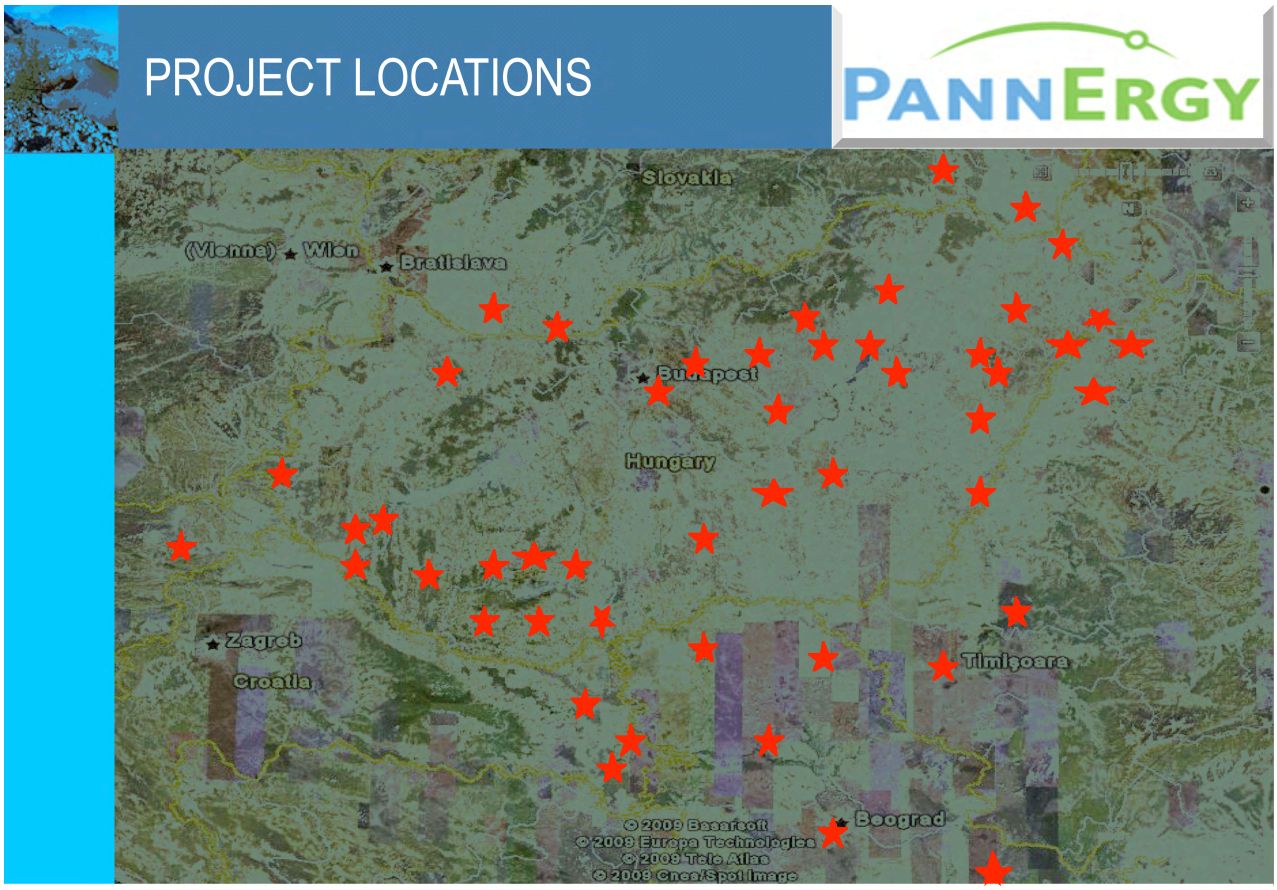

Fig.6. Planned locations of the projects

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NOTO-OSZV/SZAMALK