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HOW TO DO GEOTHERMAL PROJECTS IN HUNGARY? DREAMS AND REALITIES

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ABSTRACT

Due to the abundance source of low temperature geothermal in Hungary, hot waters are widely used for heating purposes. The relative richness is, however, not in direct relationship with the success of geothermal projects being either before, under or after implementation. This paper presents the almost 15 year long history of a geothermal project in the town of Szarvas, where a new geothermal heating system has been running for 5 years without technical difficulties. However, in the last three years a number of non-technical problems have surfaced. The reader will see the main technical solutions and experience of the operation both technically and economically.

1. INTRODUCTION

Szarvas means deer in Hungarian. That is the name of a little town in the heart of the great Hungarian Plain. (See the map on Figure 1.) Once there was in that town the geographical centre of the Hungarian Kingdom. Nowadays there are some 18,000 inhabitants in the city located on the banks of Körös dead channel. The basically agricultural town has, among others, two research institutes, two high schools, an interesting museum, and a famous arboretum.

2. GEOTHERMAL HISTORY IN SZARVAS BEFORE 1993

From the geothermal point of view Szarvas is very lucky: from the Upper-Pannonian sandstone reservoirs, at the maximum depth of 2200 m, almost 100°C (outflow) low TDS water can be gained. The first deep well for energetic use of geothermal was drilled in 1965 at Dózsa Agricultural Co-operative. After that 3 other wells were developed for agricultural purposes.

The idea of space heating by geothermal arose only in 1985, when a national programme for replacing energy from fossil fuels by renewable energy sources started. The town council applied to the government for a non refundable financial contribution to implement a geothermal heating system, and proved to be successful. Financial support had, however, been contracted to strict obligation for energy replacement. It was in 1986 when new production and reinjection wells were drilled, and surface equipment, pipelines, heat exchangers, etc. were installed. The operation start up was at the end of 1986 with heat supply for three consumers: a camping ground and two holiday homes, which loaded the well capacity by only appr. 20%.

Why was it so and how could it be?

Well, the town council had a promise from the high politics to build up an immense health centre with spa hotel and thermal bath, which could have also been a consumer for geothermal energy. The site for well drilling was already subordinated to that totally unrealistic aim, as it become evident during the coming years. Consequently wells were, unfortunately, placed rather far away from the city's large heat consumers. If the town council had not forced the idea of the health centre, wells could have been drilled much closer to the possible consumers.

Anyhow, the geothermal heating system at very low capacity had already been running for three years when the political changes in Hungary swept away all the councils and, by the end of 1990, democratically elected self-governments were formed. The new Szarvas local government, as regards to geothermal, was confronted with the following difficulties:

- the idea of the health centre was without any principle
- production was being utilised with low efficiency
- as the assign of the former town council, it would not be able to fulfil its obligation pertaining to the energy replacement, therefore
- it might have been required to pay the financial support with interest back to the state.

To make matters worse, the biggest heat consumer, i.e. the camping-ground disconnected from the geothermal system and begun its own heating supply by natural gas boilers. In order to solve the problems the self-government decided to establish a limited liability company called M. Thermal. It was the new firm's task to manage matters related to geothermal and find the proper technical and financial solutions. Shortly afterwards a great number of crazy ideas and irresponsible offers to M. Thermal were sent by different natural and legal persons both from Hungary and abroad. Those proposals had, however, a mutual feature: all of them would have required the investment being financed by the local government. Having noticed that the self-government made a decision that it would not provide any financial contribution to any geothermal investment unless a professional company would take both the technical and financial risk of the investment, our firm, the Porció Co. Ltd. undertook development.

3. IMPLEMENTATION OF THE FIRST HUNGARIAN GEOTHERMAL UTILITY

By May in 1993 negotiations between the local government and the future heat consumers on one side, and Porció on the other side had been finished, and all agreements were signed. The construction of agreements is showed in graphical form on Figure 2.

There were basically two types of contracts between the local government and Porció:

A. agreement for the implementation of a geothermal heating system in Szarvas based on the well owned by the town.

B. energy supply agreements to heat three public buildings, i.e. Town Hall, Sport Hall and Town Clinic.

The contract "**A**" has the main topics as follows:

- Porció builds up a geothermal utility by its own financing without any financial contribution from the city.
- Local government allows Porció to utilise the production well free of charge for ten (10) years.
- After ten (10) years operation of heat supply system, Porció will hand it over to the town without payment.
- Porció must lay down a larger diameter pipeline to the Town Hall in order to implement the second part of investment.
- Porció has the right to sell energy to any consumer connected to the supply system.
- All the costs related to the geothermal system will be the responsibility of Porció within the first ten (10) years.

The „**B**" type contracts contained the following:

- Porció installs the necessary equipment at the consumers heat centres using its own financing.
- Porció supplies geothermal energy at a 5-15% cheaper price than the cost of fossil fuel previously used (natural gas or oil) for ten (10) years.
- Consumer is obliged to take the geothermal energy.

These types of agreements were signed with the other five (5) Porció consumers, namely MOHOSZ, DATE, ÖKI, Pedagogical High School and 118 Private Flats.

Right after that Porció appealed to the water authority for permission and prepared a feasibility study and, on the basis of it, elaborated its application for a long term loan. In the meantime, Porció was commissioned by M. Thermal to prepare a feasibility study for a second phase implementation aimed at eight (8) more consumers.

After having the water permissions and loans from banks, in June 1994, the implementation started. Plans were designed by Porció, and implementation was carried out by local companies. All together more than four (4) km of transmission and distribution double pipelines were laid down for seventeen (17) geothermal substations in the existing heat centres. The site plan of the whole geothermal utility is shown on Figure 3.

The system was, both financially and from the operational point of view, separated into two parts. The first part was in the funding of Porció from the geothermal well to the Town Hall building (consumer No. 8), where the second part begun funded by M. Thermal. The main technical parameters for the heat consumers of both investors are listed in Table 1.

Implementation lasted for four (4) months for the first part and the operation started on 1st of November 1994. Consumers of the second part were step by step connected on to the geothermal network between November 1994 and January 1995.

The first Hungarian geothermal utility started to work in silence, without any puffery or fireworks. It was only the mayor of Szarvas who pointed out: "The geothermal project has been a success story."

4. TECHNICAL DESIGN AND OPERATION EXPERIENCES

This chapter contains a brief technical description of the geothermal process and, review of system operation experiences.

4.1. Geothermal well

Main parameters for the production well are as follows:

- Bottom: 1,790 m
- Perforations: four intervals between 1,570 and 1,750 m
- Production rate: 65 m^3/h (at 6 m wellhead pressure)
- Production type: artesian
- Outflow temperature: 98 ^oC (at maximum flow rate)
- Water chemistry: see table 2.
- Gas-water ratio (GWR): 0,83
- Gases in water: CH_4, CO_2, N_2.

At the time of well completion in 1986 the maximum outflow rate reached appr. 90 m^3/h at "0" wellhead pressure, which decreased slightly by the time of restart in 1994. Since then productivity of the well has practically not changed, or even, in recent time, some increase was detected. Flow rate can easily be raised by additional airlift into the well as became evident during the last heating season.

4.2. Water treatment

Degassing

In accordance with the Hungarian laws all kind of waters containing methane over 0,8 Nl/m^3 must be degassed. Degassing at such a high temperature can be solved with no difficulty by an atmospheric water tank settled near to the wellhead. (Utilisation of the gas containing mostly methane is under examination.) The only problem that may occur is scaling because of unavoidable removal of the CO_2 from the water.

Scaling

Calcite scaling might cause serious problems in geothermal systems. In the case of the Szarvas system a small amount of inhibitor is injected into the water still in the well. The inhibitor in use is Hungarian made and added to the water proportionally with the flow rate.

Sand

It is well known that geothermal waters from sandstone aquifers contain more or less sand. Diameter of particles in the Szarvas geothermal water is 90% 200-300 µm by weight. So in the case of proper design and operation sand can settle out in the degassing tank. After 5 years of operation the following experience have been collected:

- sudden changes in the flow rate should be avoided
- slow changes of the heating demand allow the use of a relatively small capacity water tank
- quantity of the sand settled down in the tank is quite insignificant while no sand has been observed in the system after the tank
- amount of sand decreases year by year, so the well cleans itself.

4.3. Geothermal water supply

Geothermal water is pumped into the pipeline network by a PLC regulated, speed controlled block of centrifugal pumps, which provides significant saving of electricity. A pressure curve as function of the outside temperature had first been calculated by computer program and was supplied as input parameter to the PLC device.

4.4. Pipelines

Pre insulated cast iron pipes for forward and, partly, for return are used to get the water along to the consumers and back to the well. However, over 1 km long of polypropylene pipe on the return side was laid down in order to keep the costs of investment lower.

4.5. Geothermal substations

Geothermal substations were located in the boiler stations of the consumers. Connection of the geothermal and former fossil fuel equipment allows secondary heating of water by conventional boilers in peak load periods or in the case of geothermal break down. Main geothermal components of a substation are: heat exchanger, control valve, regulation device, heat meter, pressure and temperature meters.

Heat exchangers

Stainless steal plate heat exchangers, designed for different heating load capacity, are used depending on heat demand of the consumer and parameters of the secondary water circuit. A problem to be mentioned, which has been observed since the second heating season is the appearance of bacteria on the plates reducing the heat transfer. By using soft acids approximately twice in a heating season can solve this problem. In the latest time, however, bacteria seems to disappear for the reason we do not exactly know.

Controlling

Substations are equipped with pressure compensated motor drive control valves built in the geothermal circuit. Signals to the valves come from the programmable heating regulation devices. Due to the up to date equipment and the continuous operation consumers are able to save energy. If energy consumption of the former “fossil fuel times” and geothermal times are compared than some 10-15% reduction can be detected.

A diagram for the energy sold by Porció Ltd. and M. Thermal Ltd. has been worked out and is shown on Figure 4.

4.6. Spent geothermal water discharge

Cooled geothermal water from the consumers returns back to the well and is sent to a small cooling pool. After cooling from an average 40-42^{o}C down to 15-20 ^{o}C, water is discharged into the river Körös through a five (5) km long pipeline.

Some words about reinjection

It is quite clear that reinjection of spent geothermal waters back to the reservoir would, in far the most cases, be the best solution for water discharge. It is especially true for Szarvas where a shallower well was drilled for reinjection in 1985. Despite that, the reinjection well is not in use for either reinjection or production. The reason for it is that in 1988 a reinjection test was carried out and results proved hair-raising. Although the well was very good at production, during the reinjection experiment the wellhead pressure was increasing unexpectedly rapidly. So, the well was pronounced unfeasible for reinjection.

Since then, some efforts by different state or private companies have been made to reinject into argillaceous sandstone, like the Upper-Pannonian formation in Hungary. Results are, however, still rather weak. The only site in town of Szeged, which could have been sort of a reference for reinjection, was stopped after three years of operation in 1998. Altogether some 750.000 m^3 water was reinjected at gradually decreasing yield and increasing wellhead pressure, while the injectivity index dropped down. The experiment should be continued, as far as everyone agrees, but an important question has not been answered yet: how is the financial source.

Unfortunately, water authorities are getting stricter and stricter with geothermal consumers when forcing reinjection. It can be pointed out that the obligation for reinjection, like a big gap, blocks the harnessing of geothermal energy in Hungary.

4.7. Summary of operation experiences

Probably the best outcome of the Szarvas geothermal heating network is that people have acknowledged a previously unknown kind of energy. Consumers are satisfied with the service and are thinking of the possibilities to save even more energy and costs. It could, however, have been totally unimaginable if the geothermal system had not been running smoothly. It can not be by accident, that DATE, the biggest consumer (No. 3) has ended its agreement for natural gas service with gas service company and took the heating solely on to geothermal base. Already this is an indication of trust in geothermal.

5. ECONOMIC RESULTS

In the case of proper technical design, good quality implementation and exact operation, economic results only depend on input economical conditions. This has so far been absolutely true for the Szarvas situation.

In the heat supply contracts with the consumers Porció undertook to supply heat at a reduced price comparing those fossil fuels’ prices that had been used before the geothermal system. Given discount rate by Porció to the consumers is, as an average, 10%. The company’s revenues from selling the heat are, consequently, in direct correlation with prices of fossil fuels (natural gas and oil). The same conditions are available to M. Thermal Ltd. as well.

As the Porció obtained a long term loan in order to finance first part of the Szarvas geothermal investment. Therefore, in the first 3-5 years, the interest to be paid because of the loan has been the most significant cost. For example, in 1995 and 1996 it reached 87% and 71% of the total costs, respectively.

Focusing on the economic outcome of Porció from the Szarvas geothermal system, two factors have had the main influence on it: energy prices and interest rates. Both have been increasing but not equally. As a percentage of the previous year energy prices reached 107%, and the interest rate 127% in 1995. (Prime rate was 22% at the beginning of implementation, and went in two steps up to 28% by middle of January 1995.) That effect caused considerable loss for Porció in 1995, although balance had previously been calculated to "0" in the feasibility study. The situation has, fortunately, been changing and the operation has been profitable since 1996.

It is no doubt that consumers are unambiguous winners of the project. They enjoy better energy service at lower price without any technical and financial risk. Good experiences after the second heating season led DATE (consumer No. 3) to reconstruct its secondary heating system converting all the steam heating applications to hot water ones. In this way they could stop the low efficiency steam boilers and consume cheaper geothermal energy.

6. FUTURE POSSIBILITIES

Occasionally, ideas of enlargement for the geothermal heat service in public and industrial buildings have come up in the past three years, but development has not materialised. The main reason for that is neither technical nor financial. Possibilities for the future, i.e. the buildings where geothermal is not yet used, are as follows:

- Lutheran Church
- Székely Mihály Technical College
- Vajda Péter Grammar-school
- Sports field near the geothermal well
- Plastolus Plastic Works
- Szarvas Metallurgy Works

New efforts could also be made for utilising of the return geothermal water. By using of low temperature heating circuit in for example a greenhouse some additional 1 MW capacity can be extracted from the water. In spite of the fact that, time by time, demands occur for geothermal heat mostly from scientific institute, financing has so far been an insoluble problem.

7. CONCLUSIONS

We think that implementation of the Szarvas geothermal utility is really a success story. It has proved technically feasible and economically viable. It is a pity that legal actions have impaired the generally nice picture and additional developments have not been able to be implemented. Anyhow, the geothermal system has been running for already five (5) years without technical problems. The Szarvas story made clear for us that solution of all the technical and economical problems is still insufficient for our satisfaction.

So, how to do geothermal projects in Hungary?
Basically the same way we have done it so far.

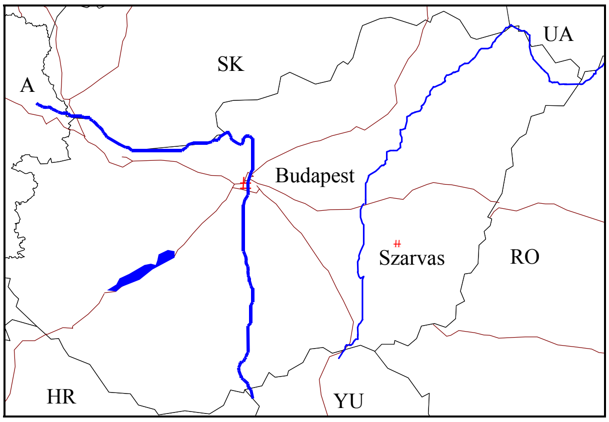

Figure 2. Location of the town of Szarvas in Hungary

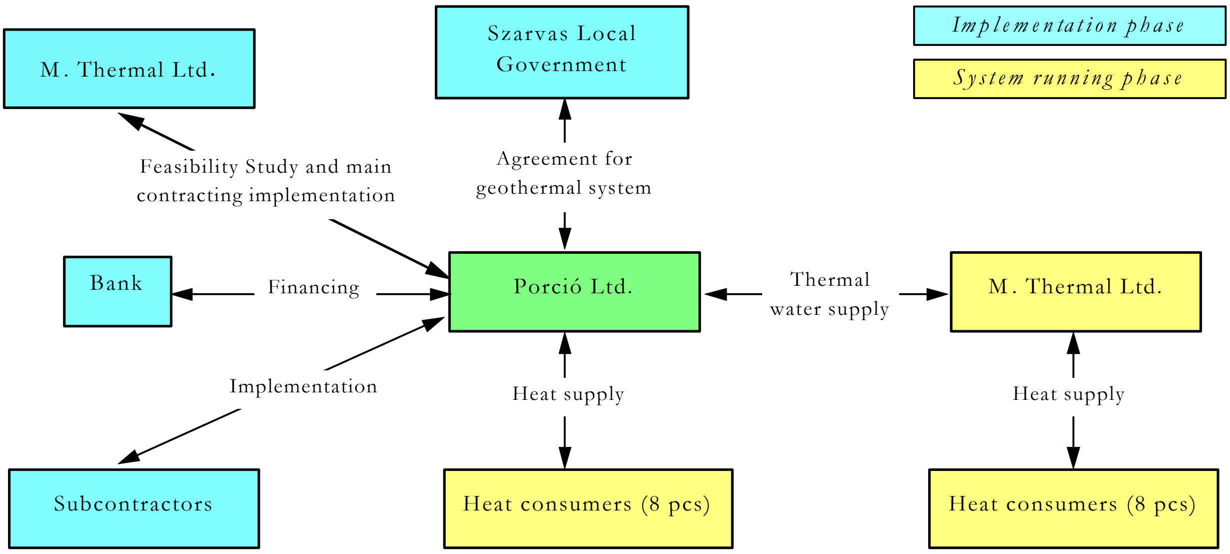

Figure 1. Construction of agreements for the Szarvas geothermal utility

Figure 3. Site plan of the Szarvas geothermal utility

Table 1. Main technical parameters of the heat consumers supplied by geothermal

No	Consumers	Heated volume	Heat demand	Previous
		m^3	kW	fossil fuel
	Porció's Consumers			
1	MOHOSZ Health Centre	3 900	100	oil
2	Sport Hall	14 000	310	oil
3	DATE, Agricultural High School	33 200	830	nat. gas
4	ÖKI, Research Institute for Irrigation	10 500	260	nat. gas
5	Brunszvik Pedagogical High School	38 200	950	nat. gas
6	118 Flats	19 300	620	nat. gas
7	Town Clinic	7 000	280	nat. gas
8	Town Hall	9 800	300	oil
	Total	135 900	3 650	
	M. Thermal's Consumers			
9	Primary School No. II.	14 100	535	nat. gas
10	Slovakian Primary School	8 100	240	nat. gas
11	Shops	4 400	180	oil
12	Culture House	7 100	290	coal
13	Hotel Árpád	6 400	260	nat. gas
14	Thermal Bath	3 300	135	nat. gas
15	Primary School No. I.	2 500	100	nat. gas
16	Szirén Clothing Co.	19 000	760	nat. gas
	Total	64 900	2 500	
	Grand total	**200 800**	**6 150**	

Table 2 Chenical composition of Szarvas geothermal water

Chemical component	**Content mg/l**
Sodium (Na^{+})	1 100,0
Calcium (Ca^{++})	8,0
Magnesium (Mg^{++})	3,3
Ammonium (NH_4^{+})	12,4
Ferrum (Fe^{++}) + (Al^{+++})	0,0
Chlorides (Cl^{-})	107,0
Hydro-carbonates (HCO_3^{-})	2 684,0
Sulphates (SO_4^{--})	53,0
Bromide (Br^{-})	0,4
Iodine (J^{-})	0,9
HBO_2	43,0
$H2SiO_3$	91,8
(K^{+})	26,0
(F^{-})	3,3
Total dissolved solids (TDS)	**4 133,0**
pH	7,6
Alkalinity (mg eq/l)	44,0
Total hardness (CaO g/m^3)	18,8
Variable hardness (CaO g/m^3)	0,0

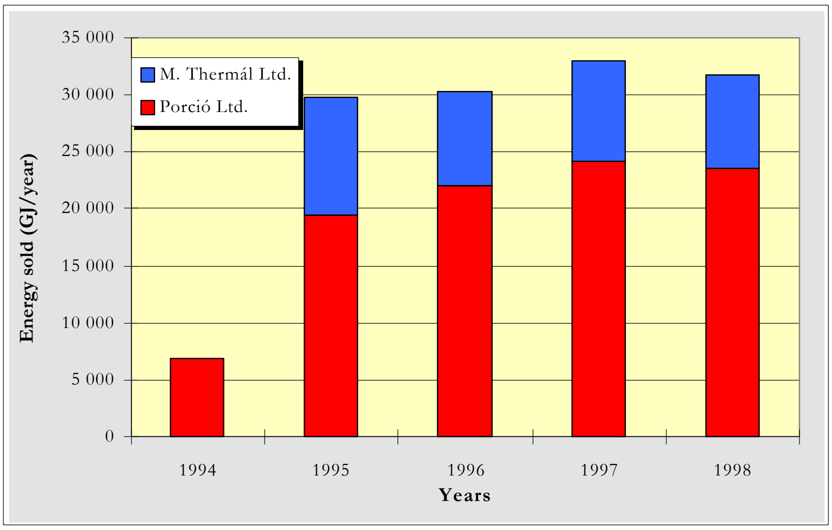

Figure 4 Energy sold through the geothermal utility (GJ/year)