FACULTY OF TECHNICAL SCIENCES
INSTITUTE FOR POWER ENGINEERING, PROCESS ENGINEERING AND ENVIRONMENT PROTECTION
NOVI SAD

UTILIZATION OF ENERGY POTENTIALS OF THE GEOTHERMAL WATER DRILL IN BEČEJ FOR ENERGY REQUIREMENTS OF LOCAL CONSUMERS

- Summary -

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Bečej – The Spa Town

Bečej has a very long tradition as spa town. The first official beginning of the spa is considered to be the year 1904 when the famous well driller, Károly Sós, started with the construction of the bats. During years, the spa has changed severel owners until present days when it is run by the Municipality of Bečej through the Health Centre "Doctor Predrag Hadnađev". A large number of visitors has been driven by the prominence and therapeutic capacities of this health resort.

Town Hall (1907)

The town of Bečej is located slightly more to the north than the very centre of the Autonomous Province of Vojvodina. Thanks to the well developed traffic network, it is well connected with all other parts of Vojvodina. The distance by road is 130 km from Belgrade, 120 km from the Airport Surčin, 45 km from Novi Sad and 75 km from Subotica. The town is located at the bank of the river Tisa and it contains large, arranged green surfaces which are suitable for recreation. The town itself and its surroundings have a moderate continental climate with a noticeable micro climate due to the vicinity of the river and large green areas.

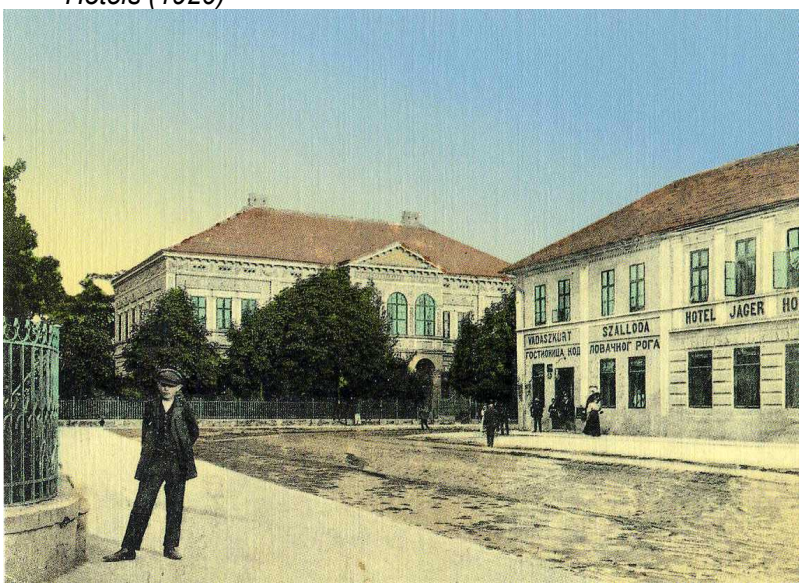
Medical Indications for which the spa is very suitable are as follows: inflammatory and degenerative rheumatism, consequences of traumas and combat injuries, conditions after bone fractures at bone joint systems, as well as dermal diseases of psoriasis and chronic eczemas. Water has positive effects on liver and spleen diseases as well as on majority stomach disorders. Very beneficial are: hydrotherapy, pelotherapy, electrotherapy, paraffin therapy, massage and kinetic therapy. All treatments are performed by professional highly-trained personnel of the local health centre. The balneal therapy is carried out in some twenty separated rooms with specially equipped tubs and three pools with different temperatures of water situated near the room for additional physical exercises. Within the spa there is a large Olympic swimming pool and three smaller pools with thermal waters.

Within the sports and recreation centre, which is in close proximity, there is a covered Olympic swimming pool, sports hall and weightlifting room.

In Bečej, different forms of cultural programmes take place such as: federal review of children's theatres "The Games of May", numerous folklore gatherings of nations and nationalities, representatives from the whole country and from abroad. Bečej can also be called the town of sports as different sports are very much present there. The town itself and its surroundings are increasingly becoming an attractive tourist destination which is very suitable for the development of health, hunting fishing, rural, congress and recreational tourism. The present centre does not have own accommodation capacities and therefore it uses the services of a nearby hotel "Bela Lađa". The Rehabilitation Centre and all other segments of the tourist offer can be used during the whole year. The basic groups of tourists are as follows: guests for rehabilitation and recreation, sportsmen of all profiles, businessmen, participants of various seminars and the like.

Particularly interesting is the building which is very close to the town and concerns the Hotel "Fantast". In the past, it used to be the castle of the former local landlord, Bogdan Dunđerski.

Hotels (1920)



The Town is rich with a variety of restaurants with national cuisine that may offer exceptional gastronomic delights to visitors. Therefore, it is absolutely certain that with some investments and a lot of work Bečej can become: the spa town, and the town of tourism, similar to other well known spas in the country and aboard. The quality of water, climate and the position provide all requirements for success and implementation of these plans.

The Mayor of Bečej:

Đorđe Predin

Spa and Therapeutic Use of Geothermal Waters in Bečej

The first person who noticed energetic and therapeutic values of geothermal waters abundant in the area of Bećej was Károly Sós. At the very beginning of the 20th century, he built the spa with closed and open pools as chemical analyses of that time, which were also confirmed later, indicate that thermal waters are rich in oligo-elements particularly sulphur and iodine. Water also contains gas methane with very high purity which is used as fuel.

The news about healing properties of water was quickly spread across Bačka and Banat and there were always too many users of the spa's services. In 1933, the Iodine Spa obtained a certificate for healing chronic rheumatic, dermatological and degenerative bone and joint diseases, as well as for curing bone and joint injuries and some cerebrovascular accidents.

Healing properties of the water are also useful for healthy population with an aim to prevent bone and joint troubles and to revitalize body after hard work. A hygienic importance has been particularly important for the citizens of Bečej.

Summer conditioning of players of the Football Club "Partizan" from Belgrade in Bečej in the period (1956 – 1966) expanded the spa's indications and healing springs started to be used after strenuous and demanding trainings.

The Decision of the Ministry for Health of the Republic of Serbia proclaimed the Iodine Spa Bečej in 1963 as health institution with a built dispensary for curing the most serious patients.

The construction of the Sports Centre in Bečej close to the Spa has enabled sportsmen from all continents to benefit from positive healing characteristics of water during sports conditioning and various competitions.

After consultations with competent authorities of the Autonomous Province of Vojvodina, the local Self-government of the Municipality of Bečej has made a decision on the preparation of the Project Bečej Spa with the focus on the construction of the rehabilitation centre for cardiovascular patients containing modern diagnostic devices and intervention methods of medical treatment, as well as on the centre for rehabilitation and treatment of sportsmen. In addition to the medical part, it is also anticipated to construct: aqua centre, wellness centre, hotel centre, sports centre and similar facilities provided by modern spas.

Professor Đurica Stojšić, D.Sc.

Introduction

Mineral and thermal waters of the Panonian Plain have been known for centuries. Historic 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 in 1848. At the beginning of the 20th century, there was a temporary halt in drilling only to be intensified 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 has been the supply of drinking water although they have been used for balneal purposes.

More complete knowledge about geothermal potentials of the Drill has started to accumulate since 1949 in the process of oil and natural gas resources investigations on the territory of Vojvodina. The investigation of geothermal potentials of Vojvodina was fully recognized in the 80ties of the last century. The large scale exploitation of this natural resource dates back from this period primarily in the spas and on agricultural homesteads. In this period, the Drill Bč-2/H was also bored in Bečej with energy potentials which have been used ever since.

Energy Potentials of Drills in Bečej

In Bečej, there are two drills of hydrothermal waters (marked with Bč-1/H and Bč-2/H). These drills have the following basic characteristics.

Name	The Drill Bč-1/H	The Drill Bč-2/H
Position	**It is within the premises of the Company "Flora"**	**It is within the wide zone of the Youth Sports Centre "Mladost"**
Completion of Drilling	**1981**	**1985**
Status	**Tested and installed eruptive device but has never been in exploitation**	**In exploitation since 1988**
Depth	**503 m**	**1,020 m**
Optimum Discharge Flow	**10.65 l/s**	**(17.2 – 28.4) l/s**
Temperature	**33° C**	**(63 – 65.3)° C**
Water Analysis	**- Sampling perform in March 1981 - Mineralization 4.47 g/l - Salinity computed to the content of NaCl 0.61 g/l - Chemical composition of gases: 91.80 CH_4, 7.11 CO_2**	**- Sampling perform in July 1990 - Mineralization 4.617 g/l - Salinity computed to the content of NaCl 2.9517 g/l - Gaseous factor (1.855 – 2.135) m_n^3/m^3 (1985) - Chemical composition of gases: 96.01 CH_4**

Note: Depending on available sources, certain data for the Drill Bč-2/H are not consistent

Heat Power of the Drill

Available heat power of the drill is determined by the following: water temperature, discharge flow and content of combustible gases and temperatures to which water

is cooled in the system for energy conversion. Cooling temperature is previously agreed and other parameters are typical for the drill. This temperature is according to the present methodology for the computation of the drill's heat power set up by the Public Company "NIS Naftagas" to 25° C. The reason for that is that at the time these systems were constructed, the available technical solutions in Vojvodina enabled maximum cooling of water up to 25° C.

If heat pumps were introduced in the system of geothermal waters utilization, it would be possible to further cool water before its release into recipients or return back to the underground area. This is convenient and desirable from the standpoint of maintaining the existing natural equilibrium as possible continuous discharge of water with 25° C in the longer period of time may disturb microclimatic conditions in the recipient and immediate surroundings.

The authors have proposed cooling of geothermal waters to 15° C and utilization of this additional energy potentials generating temperature difference between 25° C and 15° C. Therefore, the heat power of water in the Drill of hydrothermal waters in Bečej amounts to:

The Drill	Heat Power Q [kW]	
	Water Cooling to 25° C	Water Cooling to 15 °C
Bč-1/H	357	803
Bč-2/H	4,135	5,192

Both drills also contain gases which are very rich with methane and this is their additionally available heat capacity. Heat power of gases depends on their chemical composition. For presented chemical compositions of gases, top/low heat power amounts to:

- The Drill BČ-1/H 36,754/33,034 kJ/m_n^3 (45,349/40,762 kJ/kg)
- The Drill BČ-2/H 38,433/ 34,545 kJ/m_n^3 (51,138/45,965 kJ/kg

The extracted gas of the Drill Bč-2/H contains heat power of 1,761 kW (based on the top heat power) and can heat up its geothermal water slightly above 70° C. In that case, the efficiency degree of 62% in reference to top heat power and of 71% in reference to low heat power would be achieved. This would lead to energy losses if water were do be heated up by barbotage.

The Existing Heat Consumers

The system of utilizing geothermal energy in Bečej comprises of: hydrothermal drill, distribution system of hydrothermal waters, and three independent consumers with secondary installations. It has been used for 18 years and operates without peak energy sources which causes certain difficulties particularly during winter months as installations for radiator heating have been designed and constructed for temperature regime 90/70° C with anticipated construction of peak boiler room which has never been implemented. In the last heating season of the year 2004, the consumers used up around 25,000 m^3 of geothermal waters of available amount of 782,000 m^3 annually, which means only around 28.8%.

Present consumers of geothermal energy in Bečej are:

Youth Sports Centre "Mladost"		
Radiator and air heating	1 exchanger	1,600 kW
Heating of pools and water	1 exchanger	350 kW
Preparation of hot consumption water	1 exchanger	50 kW
Health Centre "Doctor Predrag Hadnađev"		
Radiator and floor heating	1 exchanger	800 kW
Hotel "Bela Lađa"		
Heating of air and preparation of hot consumption water	1 exchanger	1,500 kW

Potential Heat Consumers

The temperature of the thermal dill Bč-2/H and its abundance make it suitable for utilization for the following purposes: heating of sports and recreation centres, the spa, hotels, industrial facilities, houses and apartments and other objects, for the preparation of hot water supply, for farming and vegetables growing, for heating of greenhouses and plastic houses, in cattle and poultry breeding, for heating up of farm houses and preparation of sanitary hot water, in fishery for heating up of fish ponds, in some factories for low temperature technological requirements for which hot water is used and for sanitary purposes and in spas and sports and recreation centres for balneal purposes, heating of pools and preparation of sanitary hot water. Each of such newly constructed consumers would be gladly welcomed by the present owner of the drill, „NIS Naftagas" (The Oil Industry of Serbia).

Conditions for Rational Utilization of Geothermal Energy

A Consultant Engineer may be faced with two requirements when making a decision regarding the utilization of geothermal potentials. The first one concerns the choice of equipment for rational and energetically economical utilization of geothermal energy for a completely defined and know consumer, if it exists. And the second one enables much more creativity as it concerns the possibility of choosing the most favourable consumers for rational utilization of this energy. There is no need to say that both these requirements are limited by the request to prepare the project which is economically feasible and profitable.

In order to achieve the greatest possible extent of utilization of available potentials, it is necessary to provide for cooling of geothermal waters to the lowest possible temperatures and consumers with demands lasting closest to 8,760 h/a. The present potential of the drill Bč-2/H is used within the amount of (25-40) %. If combustible gases exist, as in this case, they should be used with minimum losses and in the most rational way.

Techno-Economic Analysis of Proposed Solutions

Taking into consideration present consumers and the plan to construct on the same location the complex encompassing balneal, hotel, sports and recreational,

congress, tourist, cardiovascular and sports and reanimation facilities, the feasibility and advantages of utilizing the existing geothermal potentials have been analyzed from the standpoint of meeting energy requirements of this structure of probable users. As the capacities have not been determined yet, the authors have a certain amount of freedom in forecasting and estimating duration and dynamics of utilization. The following probable consumers are anticipated: radiator heating, heating of air, floor/wall heating, heating up of sanitary consumption water, heating up of swimming pools water or fish ponds water, direct utilization in pools and for therapeutic purposes. The analysis has encompassed two solutions. The first, improvement of the present heat diagram with small investment costs for the following:

a) Building in of a heat pump for additional cooling of geothermal water to 14^{o} C,
b) Building in of a heat pump and a small boiler for the combustion of occurring gas and
c) Building in of a heat pump and a peak hot water boiler for meeting presently deficient peak requirements.

The second implies consolidation of the plant as a centralized one for the whole complex and secondary distribution towards certain consumers. In this case, the following solutions have been analyzed:

a) The diagram with the system of exchangers, two heat pumps and hot water boiler for the utilization of occurring gases as base and peak additional heater and
b) The diagram with the system of exchangers, two heat pumps, gaseous motor and hot water boiler again as base and peak additional heater

Introduction of the heat pump has dual importance: additional cooling of geothermal waters to 14^{o} C and utilization of the plant for the function of air conditioning during summer months. Hot water boiler in both cases has a primary function to heat up and the gaseous motor is intended for better valorisation of gas energy in the cogeneration of heat and electric energy.

The analyses have been prepared for the following costs: investment, exploitation, maintenance and capital (loan with the repayment period of 10 years and interest rate of 10%). The calculations have been made with actual prices of geothermal and electric energy and natural gas as well as with present, actual costs required for the construction of the plant and its exploitation. The option with expected electricity prices growth in the next period to 6 c€/kWh has also been prepared. Also, three alternatives for the utilization of geothermal energy have been prepared.

A) Purchase (or financing construction of both drills – production and reversible) or payment of geothermal waters as if both drills already exist,
B) Purchase of only production drill or purchase of water under presently contracted price with “NIS Naftagas” and
C) Drills are treated as if they have been already repaid or obtained as grant. In addition, operations are considered with and without utilization during night.

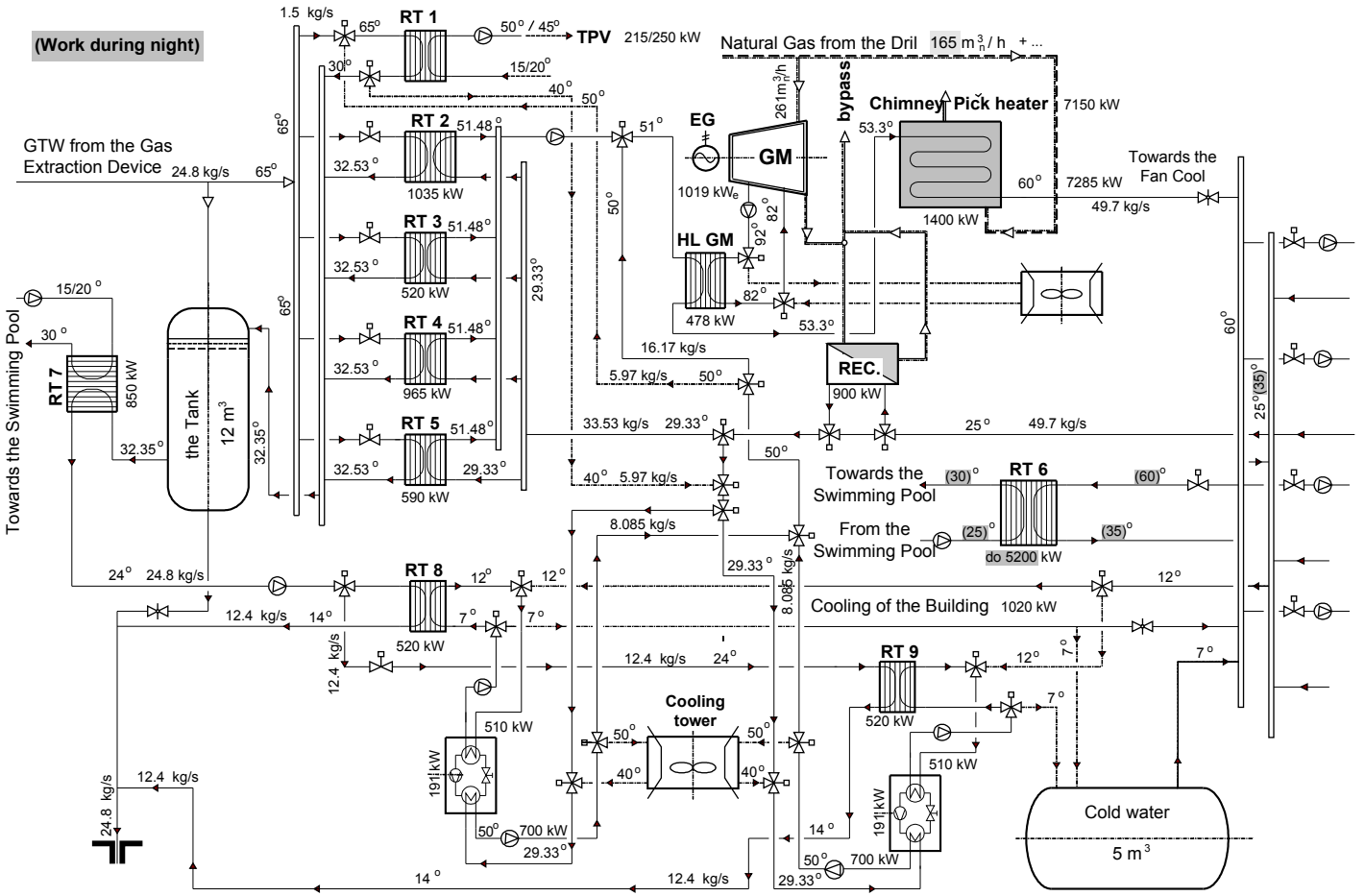


Diagram of the Plant with Gaseous Motor

The longest repayment period for the most expensive alternative (two drills in operation and the plant consisting of: two heat pumps, gaseous motor, and hot water boiler, as peak heater) presented in the following diagram is less than four years. Profit in the fist ten years of operations, when the loans is also to be repaid, for all alternatives with actual energy prices varies between 530,000 and 805,000 €/a, and with the increased electricity price to 6 c€/kWh, it varies between 684,000 and 846,000 €/a. After that period, in almost all alternatives, it exceeds 1,000,000 €/a. Profit is also attainable in the case of reduced load to 80%, and even to 60%. In that case, the lowest profit is 4,585 €/a calculated with the present price or 63,450 €/a calculated with the increased price of electricity.

The supply of the same consumers with the full capacity without summer air conditioning from the modern standard hot water boiler run by the natural gas will provide profit of 165,000 €/a for the lower price of electricity or of 140,000 €/a for the higher price of electricity. Therefore, it can be unambiguously concluded that a well conceived energy exploitation of the drill Bč-2/H is a superior technological solution in comparison to a classical one.

Conclusions

- The Bečej Drill Bč-2/H is energetically one of the most beneficial drills at the territory of Vojvodina. It has natural, eruptive flow between (17.2 - 28.3) kg/s (data are not consistent). The existing plant has been planned with the flow of 24.8 kg/s. The temperature of the discharge flow is 65^0 C, and its particular value concerns the high gaseous factor which is around 1.85 m_n^3 per m^3 of the discharge GTW. This means that with the design discharge flow around 165 m_n^3/h of combustible gas with a relative high energy quality can be separated at the outlet.

- The design outflow has a thermal power of 4,153 kW if we count together with water cooling to 25^0 C. However, by building in of a heat pump this power of GTW can be increased to 5,192 kW. This power should be increased for the power feasible due to standard combustion of separated gas to the figure of around 1,425 kW with around 90% efficiency in the combustion process.

- Unfortunately, at present and for quite some time only between 25 and 40 % have been utilized depending of the GTW flow taken for calculations. The group of present consumers is of too small power and duration of utilization for such a mighty drill. This example shows in a very explicit way the other side of the problem related to the utilization of geothermal springs in general. Namely, it is more difficult to form adequate consumers than to open and completely equip the drill. This is the main reason why a lot of successful drills have been out of operations, irrelevant of the fact that geothermal water, which is in some places above 45^0 C, is competitive with some classical energy sources.

- Our estimates show that on this drill with adequate consumers it will be possible to build a powerful thermal plant with the base heating power of over 7 MW with a supplementary function of heating consumers such as swimming pools and similar ponds for fish rearing. Modern plant diagram with a heat pump provides

also for summer cooling in addition to the maximum deployment of geothermal waters in the heating season.

- Therefore, future activities regarding architectural concept of contents in the vicinity of the present production drill should be focused on composing the strongest possible and during a year the longest consumer of heat energy which will remain economically affordable even after the later likely indispensable construction of the reversible drill. The existence of a slightly weaker but still acceptable drill Bč-1/H should not be disregarded as it can easily adjoin the in details analyzed drill Bč-2/H and significantly increase this resource.

- The investment in the construction of this mighty energy source is low and would amount to around 2,237,000 € when starting from the green field. However, in realty it is less for the value of the existing production drill (around 360,000 €) and for additional almost 200,000 €, which could be ascribed to the use of the remaining existing equipment. Thus, the investment would be approximately 1,677,000 € for both the consumers and the owner of the Drill. This is still a lot of money but it would pay off for around 3.5 to 4years if annual profit were to be accomplished of around 600,000 €/a even under unfavourable credit terms and conditions with effective annual interest rate of 10%.

- At any rate, present consumers should improve the existing plant by building in one heat pump and a relatively small hot water boiler which will enable present consumption in a much better way and introduce additional function of summer cooling. This is an investment amounting to less than 125,000 €.