

DISTRICT HEATING SYSTEMS IN ORADEA, ROMANIA

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BACKGROUND

Oradea is located on the Crisul Repede River, in the northwestern corner of Romania almost due west of Budapest, Hungary. The city has a population around half a million people and can trace its origins back to the Neolithic Age. It was an urban settlement beginning in the 13th century and has been an economic and cultural center for the region. It is a geothermal city with 12 wells drilled within the city limits, six in the nearby Felix Spa and five in the Bors geothermal area to the west, with one doublet set at Nufarul. Currently, there are a variety of geothermal uses in the area, including space and greenhouse heating, domestic hot water supply, process heat, balneology and swimming pools. Wellhead temperatures range from 70 to 105°C with artesian flows of from 5 to 25 L/s. The present installed capacity is 25 MWt and the heat supply is estimated at 60,000 MWh per year (216,000 GJ/yr). With pumping, the production would double and adding four more doublets, the installed capacity could be increased to 65 MWt.

The utilization of geothermal heat in the city has reduced the air pollution caused by the two local, lignite fired co-generation power plants. The heat supplied from the geothermal sources reduces the emission into the atmosphere of about 300,000 tonnes/year of CO₂, SO₂, NO_x, particles and ash.

The uses of geothermal energy in Oradea are:

- space heating of about 3,000 flats (8,000 people);
- preparation of sanitary hot water for about 6,000 flats;
- milk pasteurization and timber drying;
- fish farming;
- heating 1.8 hectares of greenhouses (additional 7 ha at Borş); and
- electricity generation in a pilot binary plant of 500 kW which uses CO₂ as the working fluid (at the University of Oradea) (Rosca and Maghiar, 1995).

In the surrounding Bihor County, there are 71 geothermal wells serving 20,000 people. This provides about 30% of their space heating and 45% of the domestic hot water.

GEOLOGY

The Oradea geothermal reservoir is located in Triassic limestone and dolomites at depths of 2200 to 3200 m on an area of about 75 km² and it is exploited by 12 wells with a total flow rate of 140 L/s geothermal water with temperatures at the wellhead of 70 to 105°C. The water is of calcium-sulphate-bicarbonate type with mineralization below 0.9 to 1.2 g/L, and no dissolved gases. The Oradea aquifer and the adjacent one at Felix Spa (10 km away) are hydrodynamically connected and are part of the active natural

flow of water. The water is about 20,000 years old and the recharge area is in the northern edge of the mountains to the east. Although there is a significant recharge of the geothermal system, the exploitation with a total flow rate of 300 L/s generates pressure draw down in the system, that is presently prevented by reinjection. Reinjection is the result of successful completion and operation of the first doublet in the city at Nufarul, in October 1992. At present, the total installed capacity is over 30 MWt and with the installation of four more doublets, this capacity can be doubled. The Felix Spa reservoir is currently exploited by six wells, with depths between 50 and 450 m. The total flow rate available from these wells is 210 L/s. The geothermal water has a wellhead temperature of 36 to 48°C and is potable.

The Bors geothermal reservoir is situated about 6 km northwest of Oradea. This reservoir is completely different than the Oradea reservoir; even though, both are in fissured carbonate formations. The surface area is small, only 12 km². The geothermal water has 13 g/L dissolved solids and a high scaling potential. Anti-scaling solution (Romanian PONILIT) is injected at 450 m depth and some scale then forms on the pipe (Figure 1). The dissolved gasses are 70% CO₂ and 30% CH₄. The reservoir temperature is greater than 130°C at the average depth of 2,500 m. Presently, three well are used to produce 50 L/s and two others used for injection at 6 bars. The wells are producing with a temperature of 115°C at 10-15 bar. The gasses are partially separated at 7 bar, which is the operating pressure, and then the fluid is passed through heat exchangers before being injected. The geothermal water is used for heating 7 ha of greenhouses with an installed power of 15 MWt at an annual savings of 3,000 TOE.



Figure 1. Calcite scaling in Borş well.

CITY DISTRICT HEATING SYSTEM

The Nufarul doublet has been operating over three years to supply domestic hot water through four pumping stations to about 3,000 apartments for 8,000 people near the south east corner of the city (Figure 2). The production well is cased to 2630 m with the last 590 m slotted, and the injection well is cased to 2711 m with the last 426 m slotted. The initial flow rates were 12 L/s from the producer (artesian flow) and 5 L/s in the injector (3-5 bars injection pressure). After acid stimulation, the flow rates increased to 42 L/s from the producer and 8 L/s into the injector, under the same operating conditions. Both wells are vertical and separated by a distance of 950 m. The transmissivity is 72 Darcy-m for the injector.

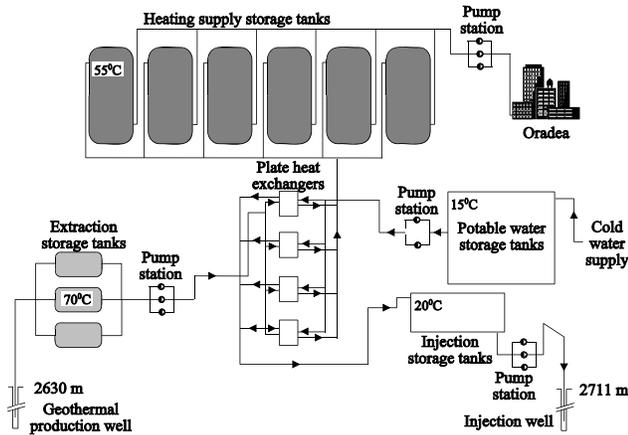


Figure 2. Nufarul doublet and Oradea district heating system.

Although the system has been designed for a geothermal flow rate of 30 L/s and an installed capacity of 5 MWt, the present heat supply is restricted by the deliverability of the production well with artesian flow. At 0.4 bar pressure, the flow rate is limited to 15 L/s (50 m³/hr) with a wellhead temperature of 70°C. At these conditions, using a 45°C temperature drop through the heat exchangers, the present capacity is 2.2 MWt producing 21,000 MWh/yr (75,600 GJ/year).

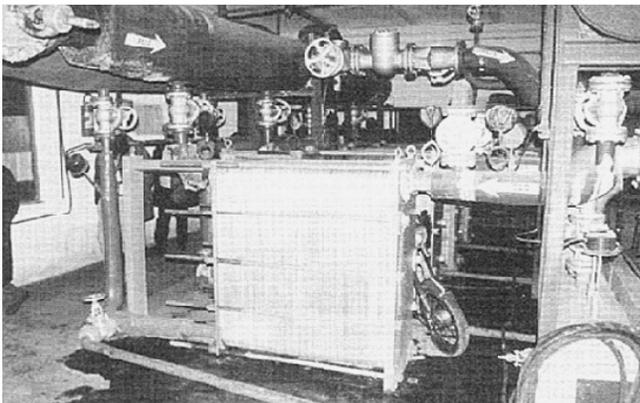


Figure 3. Plate heat exchangers, Oradea district heating system.

The fluid from the production well is pumped to three storage tanks and then to four large plate heat exchangers (Figure 3). The geothermal fluid then goes to a 300 m³ storage tank at 20°C before being pumped into the injection well at 3.5 bar pressure. Cold city water at 15°C is first stored in a 1000 m³ tank before being pumped to the plate heat exchangers. The geothermal fluid heats the city water which is then stored in six vertical tanks totaling 300 m³ at 55°C (Figure 4). From these storage tanks the heated water is circulated to the apartments.



Figure 4. Central heat exchanger building and storage tanks, Oradea district heating system.

THE UNIVERSITY OF ORADEA HEATING SYSTEM

The geothermal heating system at the University of Oradea was placed on line in 1981. It provides domestic hot water and space heating for the university campus, and for three apartment blocks located in the vicinity. The campus has 10 main buildings to accommodate about 13,000 students, along with a small greenhouse and several ancillary buildings totaling about 145,000 m² of floor space. The National Geothermal Research Institute is housed in one of the buildings. Starting in the fall of 1997, the Institute will provide a one-year specialization program in non-conventional energy sources and in low-enthalpy geothermal energy, along with a post-graduate course in geothermal energy for Romanian and international students (mainly aimed at Central and Eastern European countries) as part of an International Geothermal Training Center. The Institute has also designed and developed a pilot binary cycle power plant using carbon dioxide as a working fluid. The first plant used a piston engine for the working fluid expansion and produced 1 MW of power. A second power plant uses a turbine (Figure 5). Both are experimental installations and therefore, used for testing usually during the warm period of the year when more geothermal water is available for the evaporator (Rosca and Maghiar, 1995; University of Oradea Guide Book, 1997).

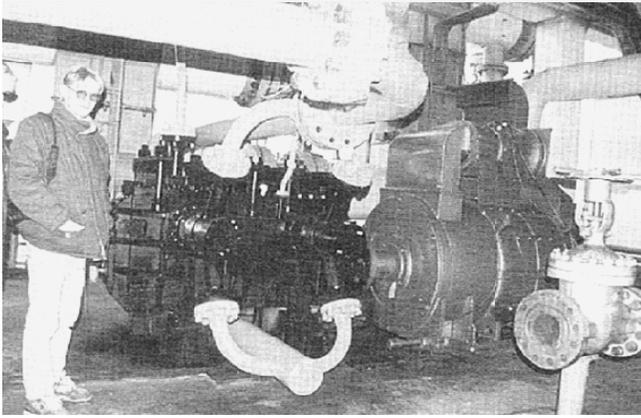


Figure 5. CO₂ binary plant, University of Oradea.

The campus geothermal well is 2991 m deep and produces 85°C water at an artesian flow of 25 L/s. The water flows into a storage tank and is then piped to the heating station located about 400 m from the well. The thermal energy was originally transferred to the space heating water and to the fresh water in shell-and-tube heat exchangers. In 1994, these were replaced by new stainless steel plate heat exchangers (Figure 6). The heated water then flows through standard cast iron radiators in each room based on a design temperature of 18°C. The maximum thermal power demand of the heating system is about 3.4 MWt.



Figure 6. Plate heat exchangers, University of Oradea.

The detailed layout of the cascaded system is shown in Figure 7 (Rosca and Maghiar, 1995). The geothermal water is pumped by the deep well pump (DWP) to the storage and degassing tank (SDT) through a surface steel pipe insulated with rock wool and covered by aluminum sheets. The pump is only required when the electric power units are in operation; otherwise, the artesian flow is adequate for the space heating requirements. The tank are kept under pressure to prevent carbonate scaling. The geothermal water is then delivered by pumps (CP1) to the binary electric power unit evaporator (E), the plate heat exchangers (PHX1) for space

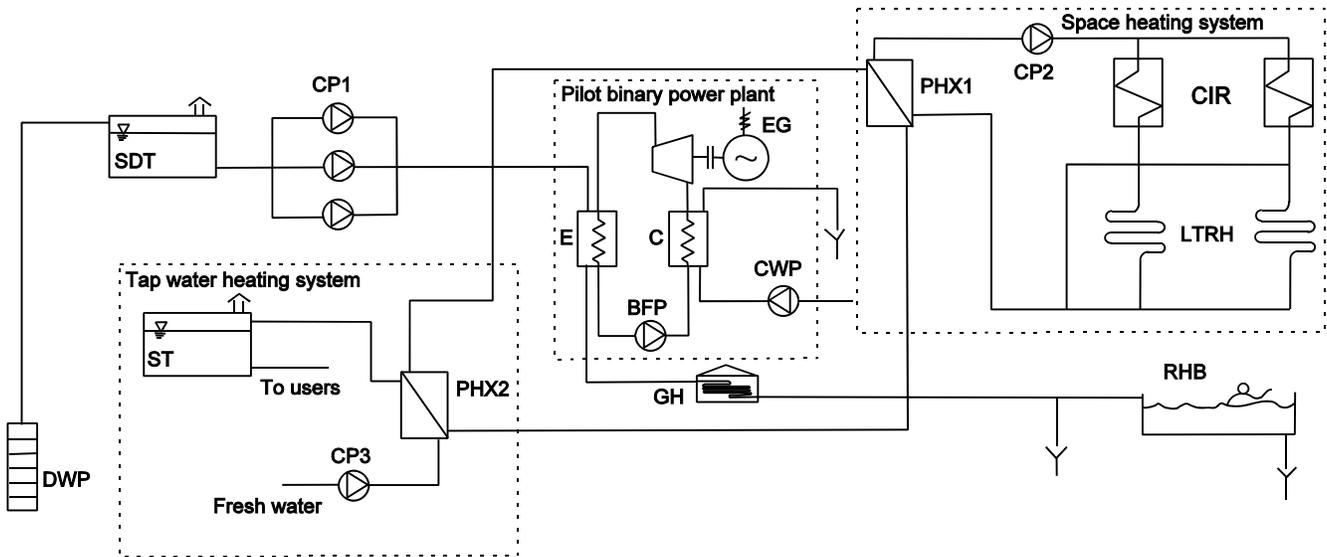


Figure 7. University of Oradea heating system.

heating, and PHX2 for domestic tap water heating. The geothermal water outflow from the evaporator is about 45-50°C, suitable for heating the greenhouse at partial load. The space heating water is circulated by pumps (CP2) first to building cast iron radiators (CIR) and then to low-temperature room heaters (LTRM), or returned directly to the heat exchangers. The domestic tap water is pumped by circulation pump (CP3) to a storage tank (ST) located on top of the highest building. From the ST, the hot tap water is distributed to users by gravity flow. The waste geothermal water is finally used for recreational and health bathing (RHB) in outdoor swimming pools, and an indoor physio-kinetic therapy facility. It is then discharged into a small river running just outside the campus. Since the geothermal water does not contain toxic or polluting chemicals and the river is fed by natural geothermal springs, the surface disposal, thus, has no adverse environmental effects.

The annual savings of this system for tap water heating and space heating is about 65,000 GJ corresponding to an annual fuel saving of about 7,720 tonnes of coal equivalent. This also prevents 24,000 tonnes of CO₂, 34 tonnes of SO₂, 39 tonnes of NO_x, 2,190 tonnes of ash and 6 tons of particles from being released into the atmosphere as compared to a coal fired heating plant.

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