THE NEUSTADT-GLEWE GEOTHERMAL PLANT: FROM EXPLORATION TO SUCCESSFUL OPERATION

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ABSTRACT

Germany has a considerable hydrogeothermal potential which is available for the envionmentally sustainable and resource-saving production of heat. The example of the Neustadt-Glewe Geothermal Heating Plant is one more proof of the principle feasibility of energy production using highly saliferous deep waters as heat source. Since the end of January 1995, operation of the GHP has been going on smoothly which confirms the correctness of the selected technical and technological solutions. In 2003, the plant is being extended by an additional cooling stage in the form of an upstream power generation unit. This paper presents the experience gathered in the exploration of the site, the planing, operation and extension of the Neustadt-Glewe Geothermal Plant.

1. GEOTHERMAL RESOURCES IN GERMANY

In Germany, the utilisation of deep geothermal resources is based on natural geothermal reservoirs with adequate geothermal deposits on one side, and on rocks allowing hydrogeothermal energy use only after creation of artificially fractured systems on the other side. Regarding the natural reservoirs, primarily porous rocks filled with formation water (pore reservoirs) and secondarily fractured or cavernous rocks are of particular interest as potentially productive horizons. In large regions of Germany, there exist such productive horizons bearing 40 to max. 120 °C hot formation waters in depths ranging from 1,000 to 3,000 m [1].
The economically efficient exploitation of these reservoirs requires large flowrates (50 – 100 m³/h per well with an economically justifiable drawdown). North Germany offers the most favourable geological conditions, as the North German Basin is characterised by very good pore reservoirs with high effective porosities (≥ 20 %) and a good cross-flow capacity (permeabilities ≥ 0,5 x 10^{-12} m^2 ≅ 500 mD) which extend in many regions. At present, three Geothermal Heating Plants are operated in North Germany. This paper presents the experience gathered in the exploration of the site, the planning and operation of the Neustadt-Glewe Geothermal Plant.

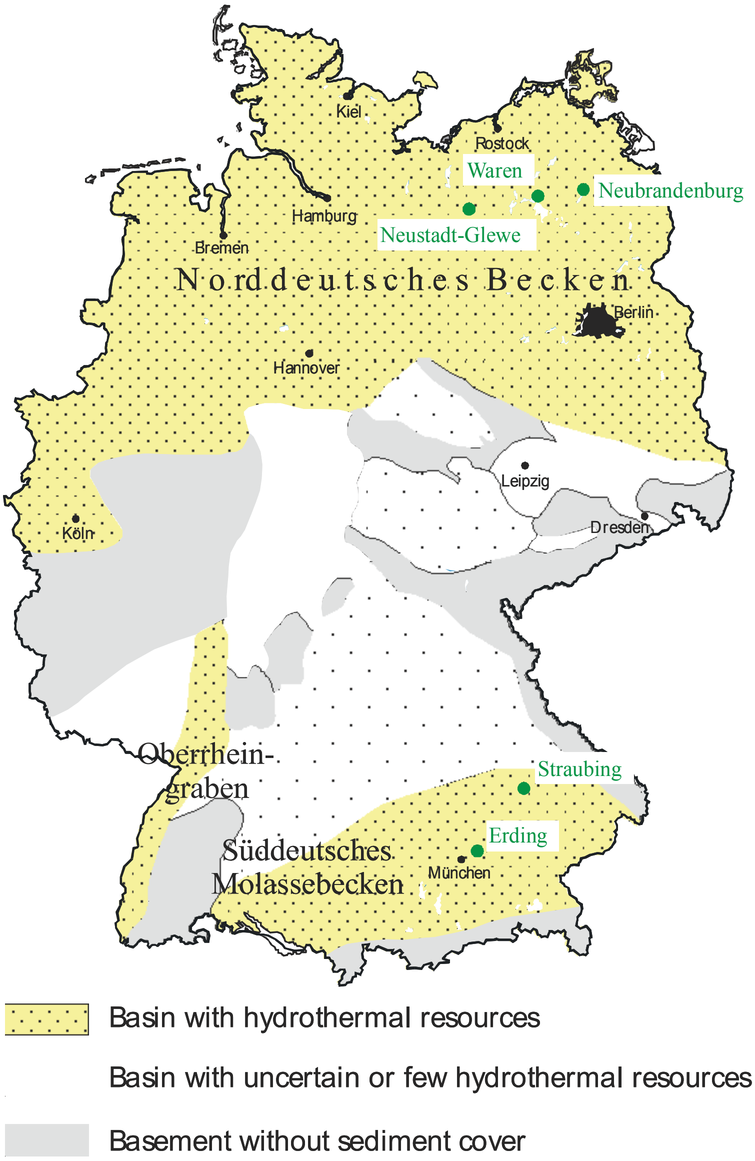

Figure 1: Extension of natural geothermal pore reservoirs in Germany and location of the Neustadt-Glewe Geothermal Plant

2. THE NEUSTADT-GLEWE GEOTHERMAL PLANT

The Neustadt-Glewe Geothermal Plant (cf. Fig. 1) was commissioned in January 1995 supplying exclusively in direct heat transition the base load of a district heating system amounting to a thermal output of about 11 MW, thus covering the demand of a major part of the town of Neustadt-Glewe. The installed geothermal capacity is 6 MW; a gas-fired boiler unit is operated to cover the peak-load. Compared to all the other geothermal plants installed in Germany by now, the site of Neustadt-Glewe is characterised by the hitherto deepest wells, the highest thermal water temperature and water mineralisation [2].

2.1 Exploration and Development

Thanks to intensive oil and gas exploration carried out in the North German Basin, the general existence of reservoir rocks is known. That is why the first step when selecting and exploring the adequate site implied the complex inquiry of the stock of data on the wells and seismic logs for the near environment focusing on: the regional geological conditions, extension and formation of reservoirs, temperature conditions, composition of the thermal waters. On this basis, a first estimate of the reservoir extension, the technically exploitable geothermal energy potential and potential methods of development was done. This first step was followed by special vibro-seismic logging, then the drill site and the target horizons of the first well were planned. Through this well, several sandstone horizons were developed and analysed according to complex special investigation programmes (well logging, formation tests, laboratory investigations) for their suitability. These investigations form the essential prerequisite for a successful technical reservoir development or implementation of stimulation measures, thus influencing directly the technical implementation and dimensioning of the future plant [3]. Having drilled the 2nd well and completed testing, an Upper Triassic sandstone horizon was selected as the productive horizon which is characterised by the following parameters:

- depth: abt. 2,200 – 2,300 m; thickness: 40 - 60 m
- temperature: abt. 100 °C, formation water mineralisation: abt. 220 g/l
- porosity: 20 – 22 %; permeability: 0.5 – $1*10^{-12}$ m^2

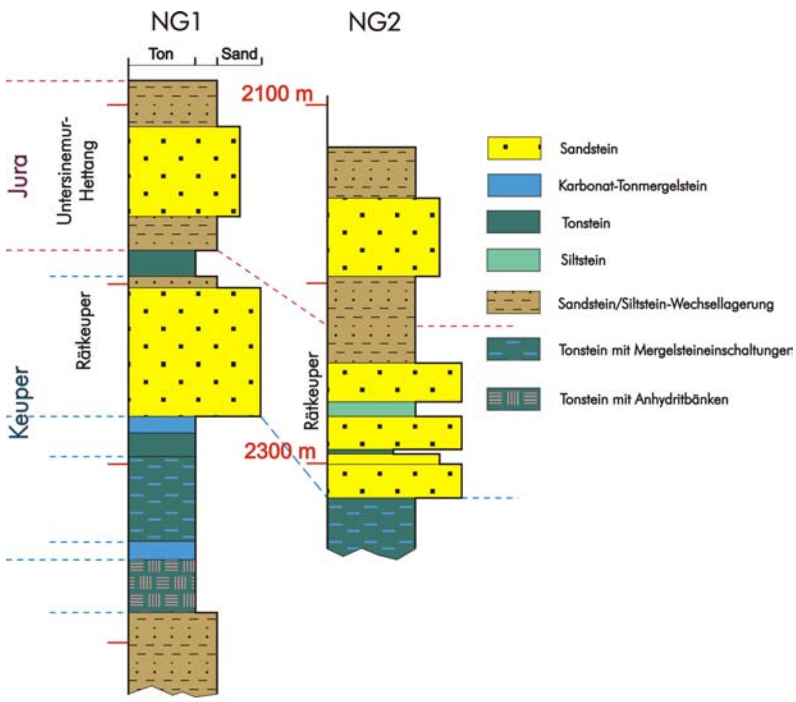

Figure 2: Lithological cross-sections through the near-well reservoir sections of the two wells on the site of Neustadt-Glewe (separate file)

The measured productivities of the selected sandstone reservoir range from 110 and 180 $m^3/(h*MPa)$. The exploration of the site was completed by chemical and microbiological analyses of the waters as well as hydrodynamical and geochemical modelling of the longevity of the thermal water loop.

2.2 Construction and Operation

Following the exploration and development, the wells were installed finally and the pIanning of the surface thermal water loop was modified. Figure 3 shows a photo of the Geothermal Plant (built in 1994) and its principle scheme.

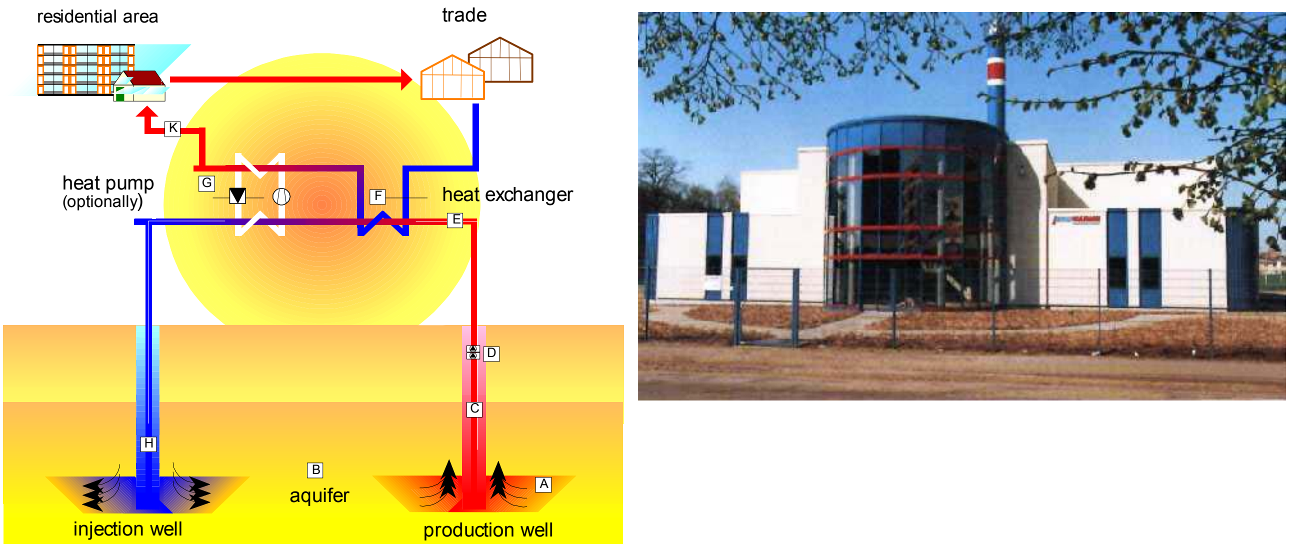

Figure 3: Principle scheme and view of the central part of the Neustadt-Glewe Geothermal Heating Plant

The operation going on for 7 years now basically confirmed the plant concept; material and equipment resisted the high temperatures and the extremely high salt contents of the waters. Problems which occurred over a short period of time when reinjecting the thermal waters could be solved by soft acidizing. The experience gathered during the long-term operation showed that in particular in case of this plant the entry of oxygen and ex-solvong of gas from the thermal water must be avoided. This is made possible with a pressure maintenance and nitrogen filling system. From this experience, the general requirement of special monitoring of the operation of such geothermal plants can be deviated [4].

2.3 Geothermal Power Generation

The geothermal potential of the site of Neustadt-Glewe which is at disposal throughout the year in the same order of magnitude is not exploited yet sufficiently due to the limited consumer potential and the specific characteristics of the demand on heat supply. Figure 4 shows that for an examplary year. On few days only, the maximum thermal water flowrate is needed. In summer and in the transitional period, the deep pump works basically at minimum speed producing about 40 m^3/h.

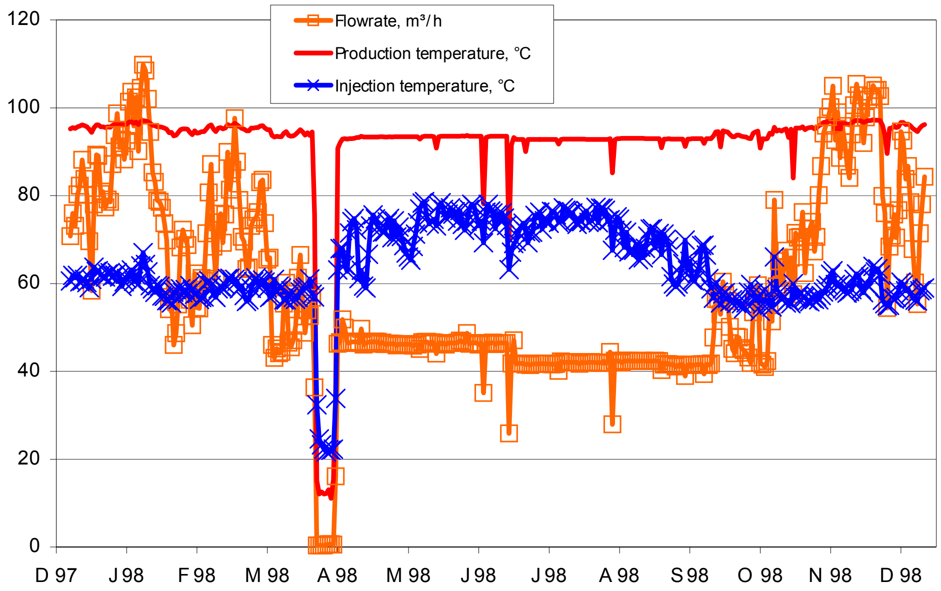

Figure 4: Operating parameters of the thermal water loop as of 1998

For that reason, the plant is extended by another cooling stage in the form of an upstream power generation unit. This planned demonstration plant is based on the well proven ORC (Organic Rankine Cycle) technology. Figure 5 shows the principle scheme.

Now, the mode of operation of the thermal water loop changes fundamentally. In the future, the maximum possible flowrate of 110 m^3/h will be produced generally. The part of the thermal water which is not required for the supply of heat is fed into the ORC unit via a surface pump where it is cooled down to 70 °C. The regulating variable for the splitting of the two thermal water flows and, thus, of the thermal water temperature after the mixing point is the given outdoor temperature-dependent temperature in the heating network after the direct heat exchanger.

Under full load and the conditions of dimensioning, the machine provides a guaranteed rated power of 210 kW on the cooling water side. It works on perfluoropentane (C_5F_{12}) which is expanded in a single-stage turbine.

An open evaporative cooling tower was selected for re-cooling, thus avoiding

- reductions of the output of the power plant as they occur with dry air coolers and at high outdoor temperatures in summer
- high power demand of the ventilators

and reducing the noise pollution of the environment.

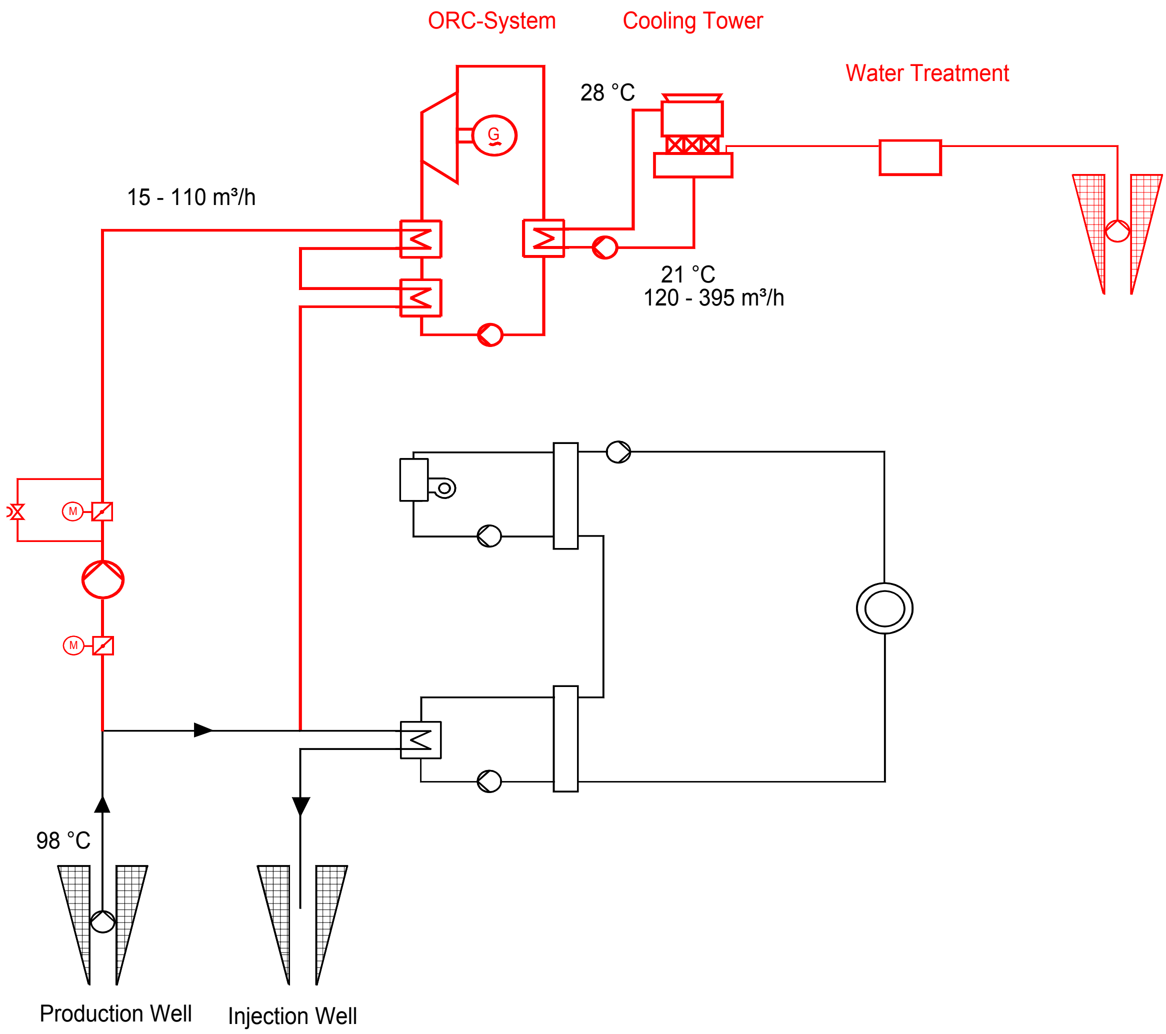

Figure 5: Principle scheme of the Neustadt-Glewe GHP upon extension

The know-how gathered in the exploration, planning and long-term operation of the plant makes possible a broad application in other regions.

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