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First Experiences with the Geothermal Power Plant in Neustadt-Glewe (Germany)

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ABSTRACT

The first geothermal plant of Germany in Neustadt-Glewe with 200 kW gross electrical power started up on 12. November 2003.

Two specific features of the plant require high technology solutions for engineering and operation:

- the lowest brine temperature (95 - 97° C) for electrical power station
- combined heat and power station.

The plant is water cooled, using cooling towers. A new deep well for cooling water was drilled for reduction of salt- and iron capacity in the cooling water.

The gross electrical capacity of the station was 165 kW . A part of geothermal heat is always used in the local district heating system. The geothermal power plant with two water cooling towers ensures full power in the important summer time for electrical part of combined heat and power station.

We are going to report on the technical operation of the plant, evaluate the usefulness of changes in the set up and show further optimisation potentials.

1. INTRODUCTION THE NEUSTADT-GLEWE GEOTHERMAL HEAT PLANT

The North German Basin is one of the best-explored areas in Germany. In 1968, for example, the exploration borehole "E-Parchim 1" was drilled 17 km away from today's location of the Neustadt-Glewe heat plant. Drilled to a depth of 7030 m, this borehole served the exploration of natural gas. This and other findings of the oil and gas industry were systematically used by the East German government to use geothermal energy for heating purposes. The Neustadt-Glewe geothermal project developed in 1984 provided for six boreholes and triple usage - industrial heat for a nearly leather plant, district heating for a residential area, and use of the brine (230g salt per litre) for tanning. One injection and production one borehole were drilled to 2400 m depth in 1988 and 1989.

The two existing boreholes have been managed by the local electricity utility company Wemag located in Schwerin since the leather plant, one of the largest heat consumers, was closed down in the wake of the political turnaround of 1989,. The Neustadt-Glewe geothermal heat plant with a thermal capacity of 3500 kilowatts was commissioned in 1994 and has since contributed a stable 95 – 98% to heat requirements. Two gas boilers are on stand-by to cover peak loads and for back-up purposes.

2. DEVELOPMENT OF THE NEUSTADT-GLEWE GEOTHERMAL POWER PLANT

Bewag project: The 200 kilowatt Neustadt-Glewe geothermal power plant

In Germany, electricity generation from geothermal heat has only since March 2000 been government-funded under the so-called Renewable Energies Act. Electricity from wind, the sun, biomass and hydros have already enjoyed this privilege since 1990. The change in legislation aroused the interest in the use of geothermal energy for power production.

Bewag developed a ORC geothermal power plant with the following key features:

1. Wet cooling towers reducing own consumption to 18 – 20%,

2. Cogeneration because the sale of heat would increase revenues.

Bewag then looked for a project to put the know-how to good account. The geothermal power plant in Neustadt-Glewe, a little town with 8000 inhabitants located 200 km northwest of Berlin, lent itself well for this purpose.

The high share of geothermal heat in the overall heat volume supplied to the town of Neustadt-Glewe implied that spare capacity was available for other uses (electricity generation) in the summer months and interseasonal periods. In addition, the smoothly operating Neustadt-Glewe geothermal plant was not subject to any geological risks, and also the operational risk inherent in the small innovative ORC plant was limited.

Another crucial factor for the project was that this 200 kilowatt project could be implemented within the financial framework of the originally planned 125 kilowatt project with air cooling towers, i.e. of € 800,000 capital costs, out of which € 400,000 were grant-funded. The final costs of the project then amounted to € 950,000.

3. TECHNICAL CONCEPT /OPERATION

The following two technical characteristics posed major technological challenges with a view to financial resources being limited by:

1. the worldwide coldest geothermal power plant (95 – 97° C brine temperature);
2. heat-led cogeneration plant with regular outages in the heating period.

3.1. Geothermal water cycle

As the production well and the boiler house are located approx. 500 metres apart, the most favourable solution for geothermal water supply to the power plant was a short brine bypass to and from the filter house. The brine flow

rate to the power plant is controlled in the boiler house via the temperature of the geothermal water. The max. brine flow rate is 100 m³/h with a whole thermal power (97 /60° C) of 3950 kW. The max. brine thermal power for power station is 2550 kW (97/73° C).

The technical concept pays special attention to the situation of outages of the ORC power plant and the related increases in the injection temperature. Problems resulting from contact of the brine with materials (230 g salt per litre) have been largely excluded by the use of fibre glass.

3.2 ORC turbine cycle and operation

With respect to the prevailing primary energy temperatures of 95 – 97° C, low-boiling (31° C), heavy perfluoropentane (C_5F_{12}) was chosen since its thermodynamic properties allowed usage of a simple single-stage turbine without gearing. On the other hand, this requires large volume flows and correspondingly large-size pipe sections and volumes (condenser).

The technically intricate Kalina technology that uses a water-ammonia mix was discarded due to the potential problem of freezing during regular outage periods in the heating season.

The single-stage turbine with 3 groups of nozzles has a boiling temperature of 75° C and pressure 4 – 4,5 bar. The condenser has a pressure of 1 bar. The synchronous generator with 3000 revolutions per minute has a power of 250 kVA.

The maximal electrical power was 165 kW with 97 m³/h brine flow and temperature 95,4/70,4° C. The deep pump was not be able to pump more brine, and a part of brine (3 – 7 %) are small gas bubbles by a pressure in the geothermal water cycle of 5 bar. The gross efficiency was in best point 7,4 % and the average efficiency in the hot summer time 6,5 %. The electrical own consumption of the power station - include the part of deep pump for power station - is 110 – 120 kW.

The electrical power production in the year is about 800 MWh – the power consumption of 300 households in Neustadt-Glewe. The power production from April to September 2004 was 400 MWh.

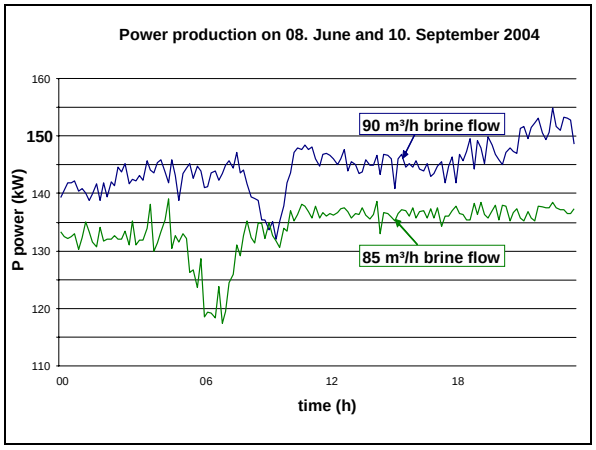


Figure 1: Power production on 08. June and 10. September 2004

The full costs of electricity of the geothermal power station be a depreciation only for the station about 20 years are roughly 18 Eurocent/kWh, considering the grant-fund 14 – 15 Eurocent/kWh.

3.3 Cooling water cycle

In order to produce the necessary amount of electricity in the main operating season of the geothermal power plant, in summertime, there was no alternative to the demanding solution of a wet cooling tower with chemical water treatment and an additional shallow well. Wet cooling towers feature higher efficiencies than air cooling towers, distinctly lower parasitic loads and no drop in performance during hot summers like the one in 2003. As salt and iron contents were high in the existing well, a new one was sunk to 117 m depth. The well water is treated in a chemical water treatment unit. The power station has two wet colling towers.

An additional potential problem was posed by the regular outages due to the use of cogeneration, and the resulting corrosion processes in the cooling water cycle.

4. IMPLEMENTATION STAGES

1. Project development:
   spring 2002 – autumn 2002
2. Heat purchasing contracts:
   negotiations began in June 2002
3. Incorporation of Erdwärme-Kraft GbR:
   03/12/2002
4. Grant funding notice received:
   05/12/2002
5. Order placed for ORC plant:
   January 2003
6. **"**Turning of the first sod":
   26/06/2003
7. ORC plant supplied:
   12/09/2003
8. Start-up:
   12/11/2003
9. New deep well and condenser:
   March 2004

5. OPERATIONAL EXPERIENCES AND CONCLUSIONS

1. As geothermal heat is **permanently available,** it plays a **unique role** among zero-emission renewable energies. At this depth, about 70% of the heat result from nuclear fission energy, the other come from the warm earth core. Similarly to hydro power plants, geothermal power plants will always be of an **individual nature,** although this does not mean that there is no potential for standardisation and cost cutting. A mushrooming of geothermal power plants similarly to the recent boom in wind turbines is therefore not to be expected in Germany.

2. Although underground aquifer reservoir projects like the one in Neustadt-Glewe are privileged in exploration as earlier exploration work had been done by the oil and gas industry, they are unlikely to deliver temperatures above 130° C in the North German Basin. The **drilling risk** will therefore increase in fissured reservoirs and in the event of artificial fissuring using the hot dry rock technology at greater depths**.**

3. Geothermal power plants should be operated at a brine flow rates as constant as possible **(base-load power plants).**

4. Fast load changes should be avoided to prevent destabilisation of the geological reservoirs (sand, limestone etc.). This technical advice does not apply to the hot dry rock technology used in bedrock. From a commercial point of view, however, a high load factor is required to achieve a reasonable a pay back time. Geothermal power plants are therefore not suitable as reserve power plants to back up sporadic wind or solar energy-based generation.

5. Our calculations with temperatures of up to 160° C had shown that parasitic loads can be reduced down 50% and lower by using **wet cooling towers**, with levels down to 20% being reached. This effect is even more pronounced in Neustadt-Glewe. In addition, operation in summertime can be ensured without any losses in performance.

APPENDIX



Figure 1: Whole Geothermal Power Station



Figure 2: ORC-turbine with new condenser (blue)