Proceedings World Geothermal Congress 2000
Kyushu - Tohoku, Japan, May 28 - June 10, 2000

INCREASE OF THE EFFICIENCY OF THE NEUBRANDENBURG GEOTHERMAL HEATING PLANT THROUGH SURPLUS HEAT STORAGE IN SUMMER

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Key Words: cogeneration, aquifer, waste heat storage

ABSTRACT

The Neubrandenburg Public Utilities run two energy generation plants representing the state-of-the-art, thus improving considerably the ecological balance through economically profitable operation.
The Neubrandenburg Geothermal Heating Plant (GHP) supplies heat to a residential area with 15 MW connected load.
Since 1997, power and heat are moreover supplied to the high-temperature district supply system from a combined gas and steam turbine process.
In both generation plants, there exist problems in summer regarding the exploitation of the potential.

- The power plant would require a very big heat store to shift surplus heat into the winter season. Therefor, the surplus heat will be stored in the aquifer of the GHP.
- Due to low thermal water temperatures, additional heating with gas driven units (absorption heat pump, boiler) is required in the GHP. The surplus heat of the gas and steam turbine plant increases the geothermal deposit temperature up to 80 °C.

Under the conditions in the thermal water system

- thermal water flow max. 100 m³/h
- heat storage temperature 80 °C

12,000 MWh/a are stored in the 4.2 MW ATES. 8,500 MWh/a can be reproduced in winter.

1. INTRODUCTION

Within the framework of their district heat supply, the Neubrandenburg Public Utilities run two energy generation plants which represent in specific ways, respectively, the state-of-the-art and contribute significantly through economic operation to the improvement of the ecological balance.

Since 1987, the Neubrandenburg GHP supplies heat to the residential area "Rostock Street" and the school for handicapped children, which is directly recovered from geothermal water (Figure 1). In addition, this heat supply system is supported by an absorption-type heat pump and conventionally fired boiler units.
The thermal water is produced from aquifers via 1,200 to 1,300 m deep wells. Aquifers are sandstone layers with water-filled pores and limited by impermeable formations on top and underneath.
The waters found under Neubrandenburg have a salt content ranging from 120 to 130 g/l and are produced with relatively low temperatures - 53 - 55 °C - and a volume flow exceeding 100 m³/h.
Since 1997, both power and heat for the central high-temperature district heat supply system are supplied by a gas and steam cogeneration plant (Figure 2). The system allows a primary energy exploitation of almost 90 % which becomes fully effective only when both kinds of energy can be exploited at the time of production. In winter, when both power and heat demand are equally high, this does not represent any problem. However, in summer the heat demand is much too low with the power demand being almost unchanged.
That is why considerable amounts of the waste heat coming from the gas and steam cogeneration plant have to be discharged via a recooling unit.

2. METHODS

In summer, there exist problems in both generation plants regarding the utilisation of the existing potential in order to achieve high energetic efficiency and economic profitability.
The aquifer thermal energy storage project is to solve these problems through the synergies resulting from the combination of the systems:

- The steam and power cogeneration plant requires a very large thermal energy store for shifting the surplus heat fed hitherto to the recooling unit from the summer into the winter season. This is done by storing the surplus heat in the aquifer of the GHP which is not utilised in summer (Figure 3).
- Due to the low thermal water temperature, permanent reheating by gas-driven units (absorption-type heat pump, boiler) is necessary in the GHP. With the waste heat of the gas and steam cogeneration plant it is possible to increase the temperature level of the geothermal deposit up to 80 °C. Required additional heating will be implemented via the district heating system of the Neubrandenburg Public Utilities.

Each of the generation plants gains in a specific way from their combination which finally leads to the increase of the energy efficiency and economic profitability of the energy production of the Neubrandenburg Public Utilities as a whole.

In order to achieve the described objective, there have to be established two conditions:

- Construction of the hydraulic connection between the central primary district heat supply system which is fed by the gas and steam cogeneration plant, and the secondary district heat supply system in the western part of the town which is supplied by the GHP.
- Creation of the possibility to reverse the direction of the thermal water flow in the wells and the surface piping systems of the GHP.

Then, the plant will be operated as follows:

- The summer surplus heat coming from the gas and steam cogeneration plant fed hitherto to the recooling unit is supplied to the central primary district heating network and led into the GHP.
- In the GHP, this heat serves two purposes: On one hand, the sanitary hot water supply of the networks in the western part of the town is secured, and on the other hand, the heat is fed at a temperature of 80 °C via one of the wells of the thermal water loop, thus increasing the heat potential existing there by about 30 K. Therefor, the thermal water is led from the Broda drilling field to the "Rostock Street" drilling field.
- In winter, a part of the heat supply is implemented by the GHP through discharge of the heat stored in the aquifer. Now, the connection to the central district heat supply system serves only the coverage of the peak load and stand-by in case of failure. Thermal water is led then also via the usual way from the "Rostock Street" drilling field to the Broda drilling field. However, the temperature in the system will not be restricted - as presently - to the natural store temperature (52 °C at the well head). The heat demand can be covered from the section where the temperature was increased up to 80 °C in summer.

3. TECHNIQUES

The following work will be implemented within the framework of the project in the second half of the year 1999:

- The wells of a GHP are installed in a way that they serve either production (Gt N 1/86 in the "Rostock Street" drilling field) or injection (Gt N 3/86, Gt N 4/96 in the Broda drilling field). With the transition to an aquifer thermal energy storage system it must be possible that the wells fulfil both functions alternatively. Basically, this is done by exchanging the well heads in the wells Gt N 1/86 and Gt N 3/86 and installing additional filters and pumps. At the same time, the corrosion proofing system is completed in all wells. Special demands are made on the stability of the chemical balance of fluid/fluid and fluid/matrix. The Mesozoic pore-type aquifers with their highly-mineralised formation water represent a reservoir type which is very common in North Germany and used for thermal energy storage in such a depth for the very first time (Figure 4).
- In the surface thermal water system, the O_2 protection system will be completed, and components will be replaced or re-connected which do not allow at present to reverse the direction of flow or do not comply with the new demands on their temperature stability.
- The GHP will be connected via a district heat pipeline to the central district supply network of the Neubrandenburg Public Utilities. Heat exchangers will be installed for separation of the systems.
- The automation unit of the GHP will be adapted to the new requirements.

4. RESULTS

4.1 Energy balance

Under the conditions in the thermal water system

- thermal water flow max. 100 m³/h
- heat storage temperature 80 °C

a thermal capacity of maximum 4.2 MW can be led into the „warm side“ of the aquifer thermal energy store.
This offers the possibility to store heat amounting to 12,000 MWh/a just from the summer surplus heat coming from the gas and steam cogeneration plant. Thereof, 8,500 MWh/a will be recovered in winter (Figure 5).
Thus, the storage efficiency will be about 70 %.
In addition, also the sanitary hot water demand and - to a less extent - even the heating demand in the "Rostock Street" network will be covered by the use of the surplus heat from the gas and steam cogeneration plant via storage in the underground in summer. This will increase the extent of the surplus heat utilisation by another 3,200 MWh/a.
The essential improvement of the energy balance through the extended use of the waste heat of the gas and steam cogeneration plant has a side effect in terms of quality. Without any additional energy expenditure it will be possible to make available a higher network temperature to the district heat consumers in the "Rostock Street" area. This fact plus increased supply guarantee will elevate the heating comfort considerably.

4.2 Ecological balance

By retrofitting the GHP as an aquifer thermal energy storage system, the environment will be saved from the emission of 1,550 t of CO_2 per year.


Figure 1. The Neubrandenburg Geothermal Heating Plant


Figure 2. The Neubrandenburg Gas and Steam Cogeneration Plant

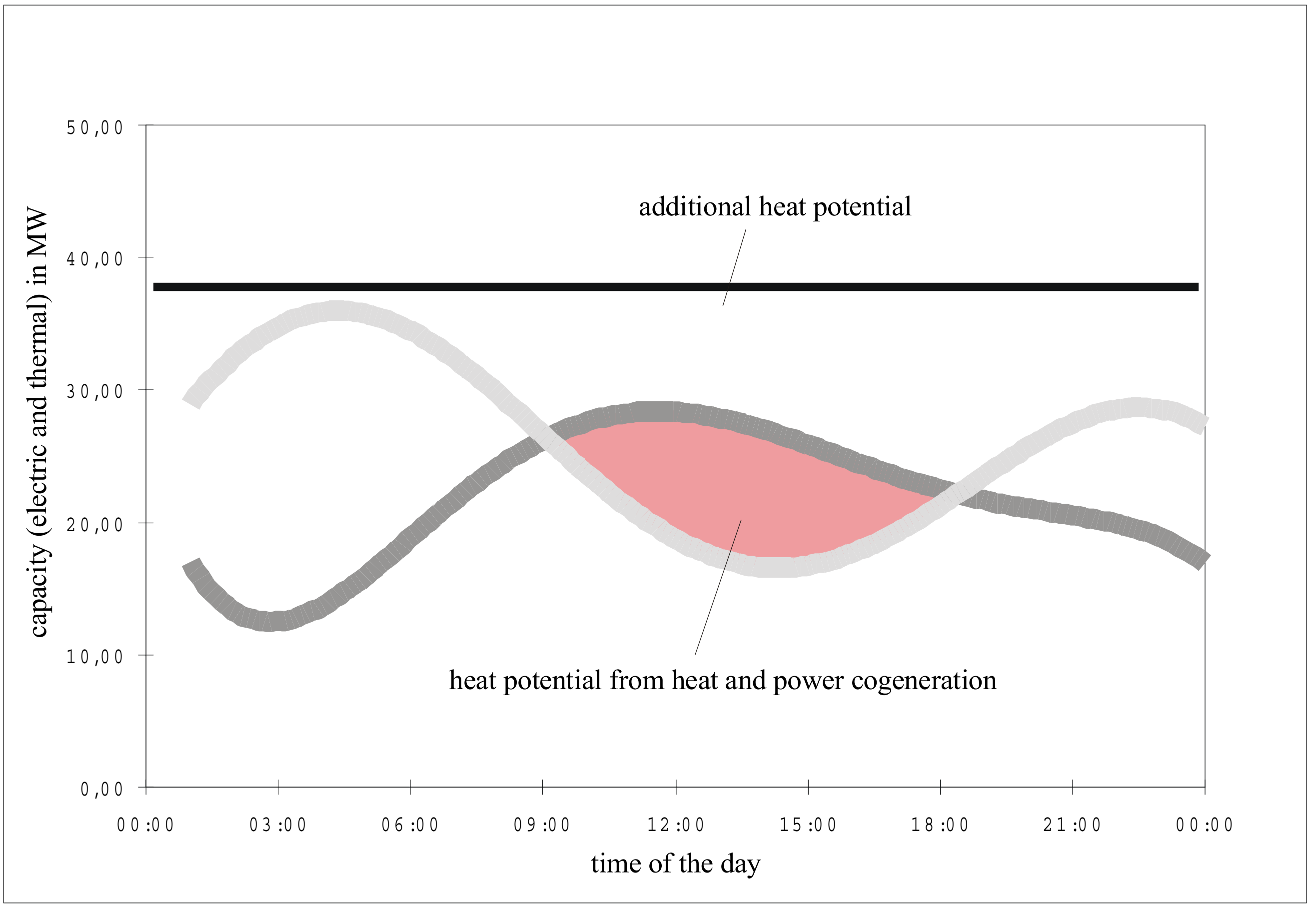

Figure 3. Heat potential for storage in the underground heat store

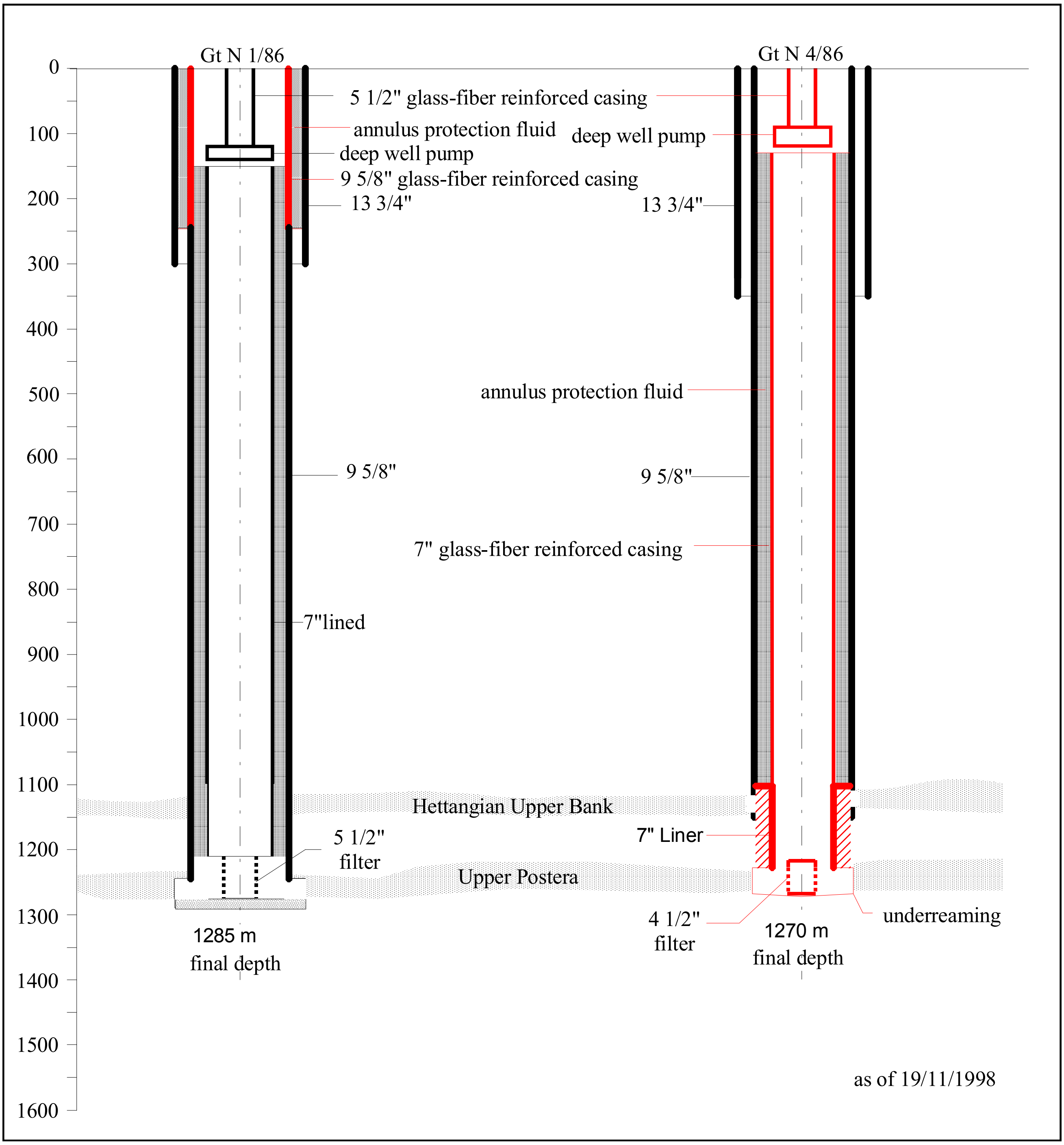

Figure 4. Reviewed concept for the ideal state of the Neubrandenburg geothermal wells according to the heat storage process

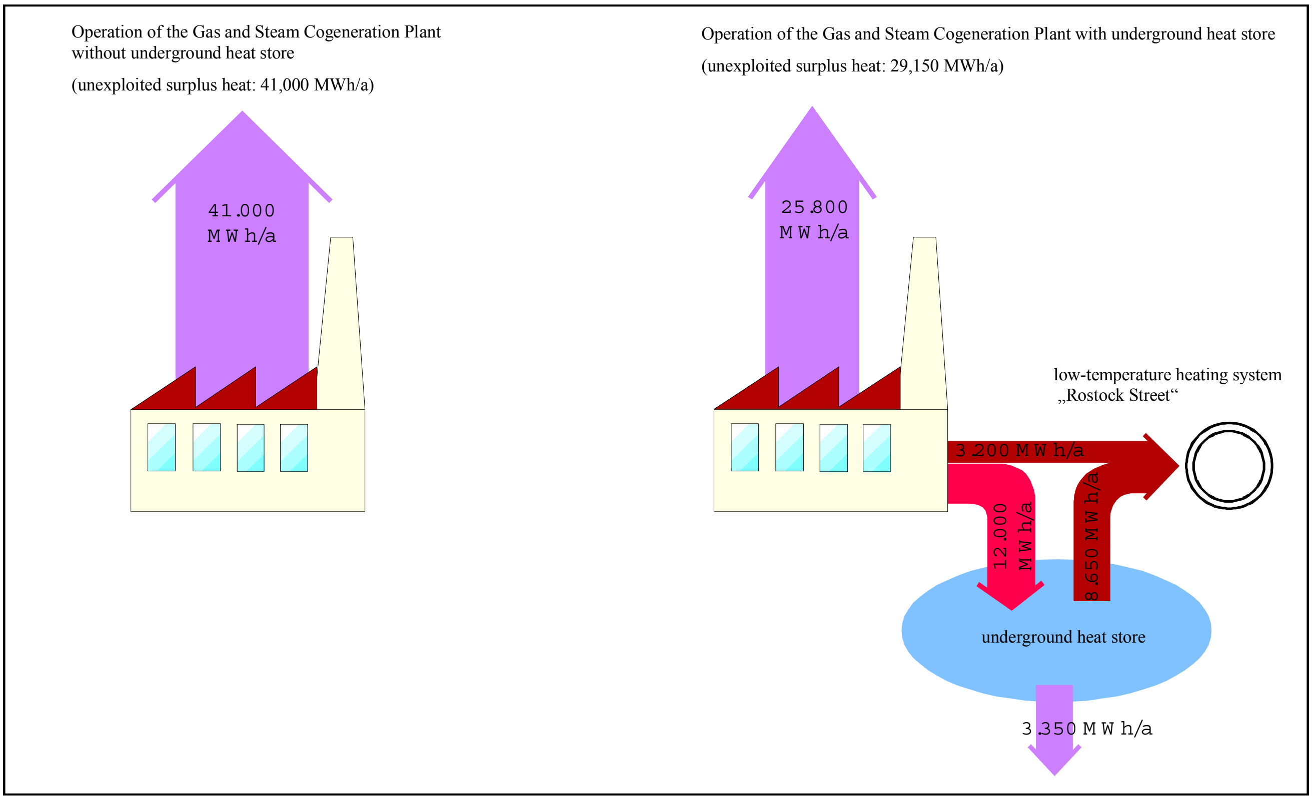

Figure 5. Influence of the underground heat store on primary energy use in the Neubrandenburg Gas and Steam Cogeneration Plant