GEOTHERMAL ENERGY

PRENZLAU (Germany)

Geothermal energy rather takes a subordinate position among renewable energy sources. There are two possible sources for it: the radioactive decay of natural radio nuclides which causes the spreading of heat onto the earth surface, and the storage of solar energy in the top earth layers. For this reason, geothermal energy is available in many places and independent from the different seasons of the year, even if some regions do have a higher potential than others. The installation in the town of Prenzlau – which was built when this was still the German Democratic Republic, and was re-activated in 1995 – was the first one in the world to extract heat from the Earth's interior by means of a 2.9 km deep drilling hole, without mass transfer.

GENERAL ASPECTS

Prenzlau lies in the State of Brandenburg, roughly 100 km north of Berlin and 40 km from the Polish border, in the Ueckermark lake region. It was founded early in the twelfth century, and therefore has many old buildings, which were seriously damaged in the Second World War. Today, about 23,000 people live there. Several technical colleges and various industries are located there.

Climatic Data:

Mean temperature, the heating period: 3.8 °C

CONTEXT

In north-eastern Germany, north of a line joining Cottbus, Berlin, and Magdeburg, geological stratum waters are to be found. At depths between 1,000 and 1,500 metres, they are 40°C to 55°C warm, and 55°C to 80°C between 1,500 and 2,000 m. In the GDR, there were three geothermal heating plants, one of them in Prenzlau, which came on line in 1987. At that time, it supplied heat to 501 flats by means of 42°C thermal water. That system functioned by mass transfer. In 1989, it had to be closed down because of severe damage to the sandstone reservoirs from which the thermal water was pumped. The fact that the plant was closed down does not discredit the use of geothermal energy, but was due to the defective engineering design of the system.

On the basis of the existing heat-supply systems and the pending renovation of some housing estates, the town had a heat-supply concept for its entire area prepared in 1991. On that basis, the town administration decided to extend the existing heat-supply contracts, expand the district-heating network, and develop concepts for economical and environmentally compatible exploitation of the deep underground water. On 10 Nov. 1994, the new Prenzlau Geothermal Heating Plant [Geothermische Heizzentrale Prenzlau = GHZ] went into operation.

EXPERIENCE OF PRENZLAU

The plant was constructed by carefully planned conversion of existing production facilities, and building new ones.

Completed, it comprises:
3 oil or gas-fired hot-water boilers (two 4.1-MW boilers, and one with 1 MW capacity)
A geothermal plant consisting of
- a plate heat exchanger (150 kW) for direct heat exchange
- a heat pump (350-500 kW) for extracting heat from the bore water
In a first stage, the three boilers with all their peripheral equipment were installed. All conversion and expansion work that was necessary during the installation of the geothermal plant had to be undertaken during operation, i.e. without interruption the supply.

The basic element of the new geothermal plant was deepening the injection drilling hole, which went down to about 1,050 m, to a depth of 3,000 m. About 950 m of the old piping ($9^6/_8$ inch) of the injection bore was used. After cutting open the side of the pipe string and deflecting it, the drilling hole was continued at $6^5/_8$ inches to the final depth. This was the prerequisite for installing the piping for utilization of geothermal energy.

Technical spec. of the drilling hole

- Utilization of an existing drilling hole by deeping it
- Final depht: 2.786 m
- Rock temperature at final depht: 108 ° C
- Inside diameter of the heat-exchanging pipe string: 950 m: $9^6/_8$ inches, from there to final depht: $6^5/_8$ Zoll

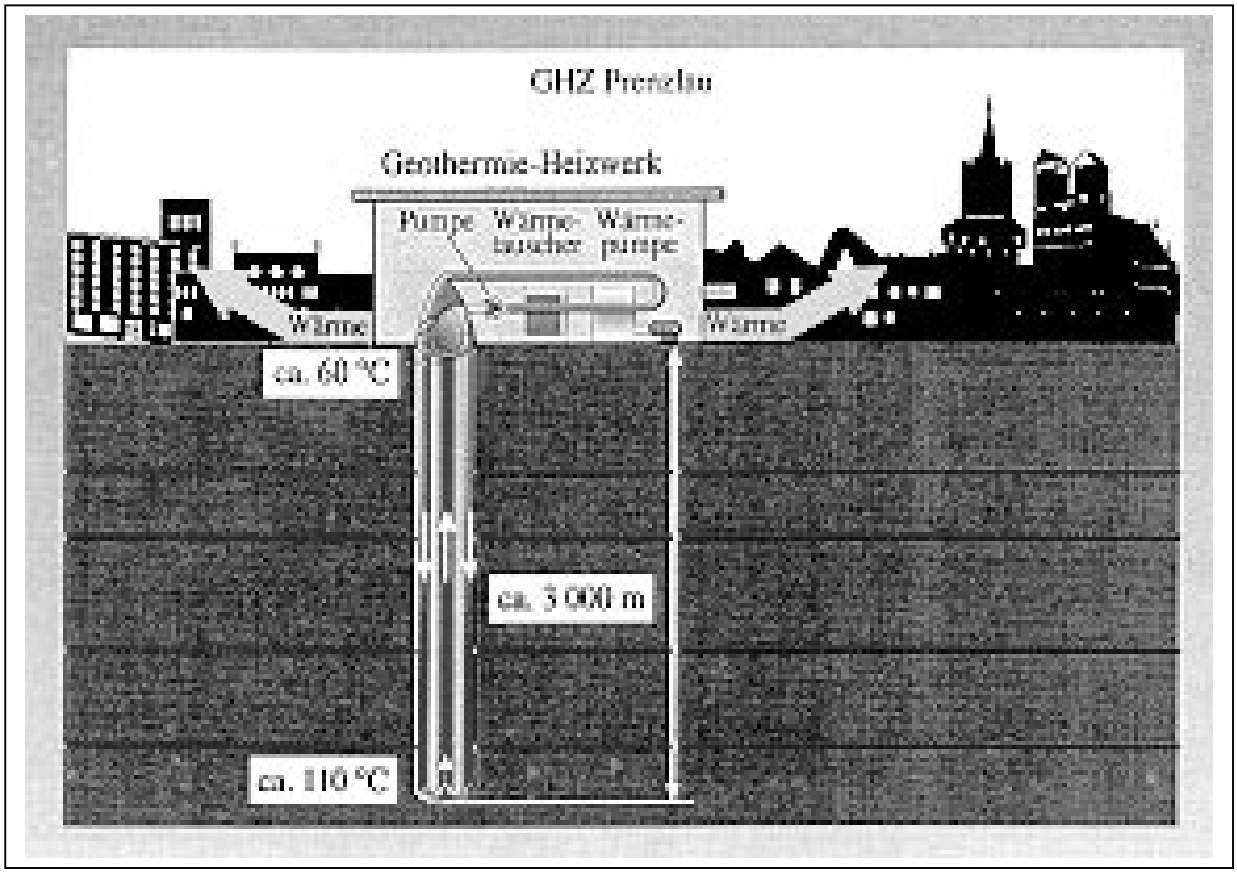
Principle of the drilling hole

- Underground heat exchanger in the form of a coaxial pipe.
- Active surface for heat exchanger: 1 463 m^2
- Insulated inner pipe for leading the operating medium to the surface.
- Heat source: geothermal energy, utilization of the geothermal stratum.
- Dwell time of operating medium in the hole: 4-10 hours
- Speed of flow: 5 to 65 m/min

Drilling hole technology

The process technology applied in the Prenzlau geothermal plant contains only elements that are familiar to operators of heat-generating facilities. The deep drilling hole is fitted with a coaxial pipe, by means of which the surrounding rock is exploited as a heat source. Cold water is passed downwards in the annular gap of the coaxial pipe. During its slow passage through the rock, it heats up by convection, and then rises to the surface in the insulated central pipe. There, the warm water passes into the above-ground heat utilization plant, where it is cooled, and then returned to the annular gap by a drilling hole circulating pump. Thus a closed, simple, and easily managed circuit is created, which has high reliability and a long service life.

The geothermal plant was linked to the return leg of the low-temperature district-heating network, since the greatest effectiveness was to be expected from this version. The thermal energy of the drilling hole circuit is transferred to the heating return leg all year round, by means of the heat exchanger. The complete plant is operated automatically – including the sequential control of all the heat generators. Summer and winter operation differ. In winter, the boilers are in operation, while the heat pump is only switched on during summer, and thus only serves to provide hot water. The small boiler is switched on during peak load periods, if necessary, but in general, the energy demand in summer is met from the geothermal source. In the first year of operation, the heat pump was also in operation in winter; but this proved to be uneconomical, since the heat pump's figure of merit is too small, and the boilers are running anyway.



The entire energy facility in Prenzlau supplies 2,000 residences, 1200 of them with heat for heating and with hot water, as well as two schools with gymnasiums and three office buildings, and has a total installed load of 10.5 MW. The construction costs were shared by the European Commission, the Federal and State governments, and the town of Prenzlau. The customers served were not charged anything. When the new heat-supply contracts were signed, the shut-off valve after the customer's main station was specified as the supply point by mutual agreement.

Profitability analysis

Heat demand	
annual heat demand	11,500 MWh/a
average hot water demand	1,500MWh/a
Heat generation	
heat generation – geothermal	3,900 MWh
heat generation – boilers	7,600 MWh
Capital costs	
investments under ground	3,000,000 DM
investments above ground	1,000,000 DM
annual repayment	9 %

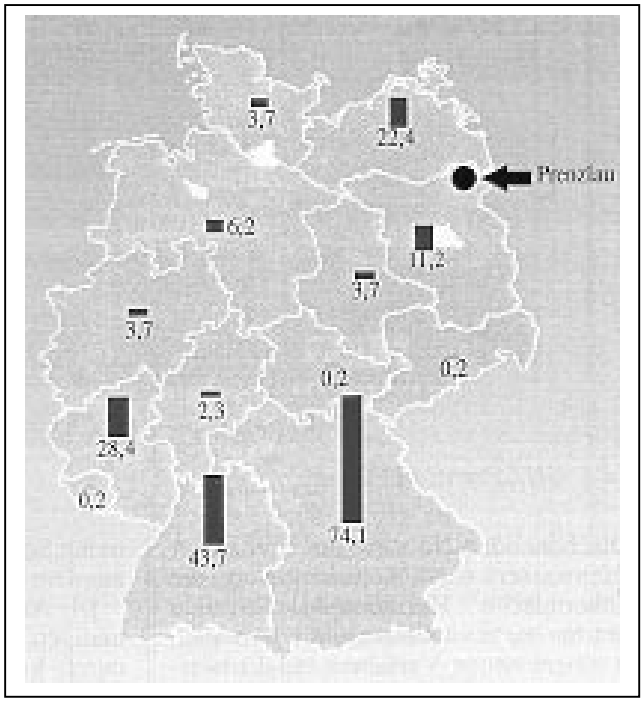
Annual costs	
maintenance	10,000 DM/ a
energy	215,000 DM/ a
labour	7,500 DM/ a
capital servicing	360,000 DM/ a
Total	**592.500 DM/ a**
Unit costs	
heat for heating	11,500 MWh/ a
unit energy costs	74,06 DM/ MWh
ditto without interest payment	29,06 DM/ MWh

At the Prenzlau site, the emissions of carbon dioxide and monoxide sank by 20% after the heating plant came on line. Before it was built, the steam was supplied by a sugar mill. The heating plant of the mill was fired with lignite (brown coal).

The present heating plant uses natural gas and fuel oil as fuels, thus reducing emissions of the substances mentioned. A good 30% of the energy demand in the district-heating service area is covered by the geothermal plant.

EVALUATION AND PERSPECTIVES

The deep bore technology offers several advantages:
– no drilling risk and no exploration risk (e.g. prospecting for thermal water)



– no mass transfer and no disturbance of materials equilibria, since the bore forms a closed vessel, and is therefore not an environmental hazard
– long service life, since there is practically no wear in the bore
– negligible maintenance and repair costs
– simple and safe operation
– high reliability
– available as a heat source all year round

The studies in Prenzlau show that more widespread use of geothermal energy can only be achieved if the legal and economic framework permits it to be competitive with other sources of energy. One aspect is a reduction in drilling costs by widespread application and simplified drilling techniques, since the cost structure of a geothermal plant is mainly determined by the capital costs. The operating costs of the purely geothermal installation are close to zero; only expenditures on maintenance of the circulating pumps and of the control equipment need be allowed for. There are potentials for savings in the Prenzlau system in optimizing the consumer system, and the resultant possibility of eliminating the heat pump.

In an industrial section that is not yet fully developed, the Prenzlau municipal utility has further facilities with which it could produced geothermal heat or thermal water. These could be put into operation if suitable customers are interested.

FOR FURTHER INFORMATION

Horst Wetzel
VEAG
Chausseestr. 23
D - 10115 BERLIN
Tel: +49 30 51 50 3773
Fax: +49 30 51 50 2874
E-mail: HoWetzel@VEAG.de

R. Stutzke
Stadtwerke Prenzlau GmbH
Frieclichstraße 20
D – 70221 PRENZLAU
Tel: +49 3984 8530
Fax: +49 3984 8531
E-mail: r.stutzke@t-online.de

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