Industrial Services

Electricity and heat from the depth – economic use of geothermal energy

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SIEMENS

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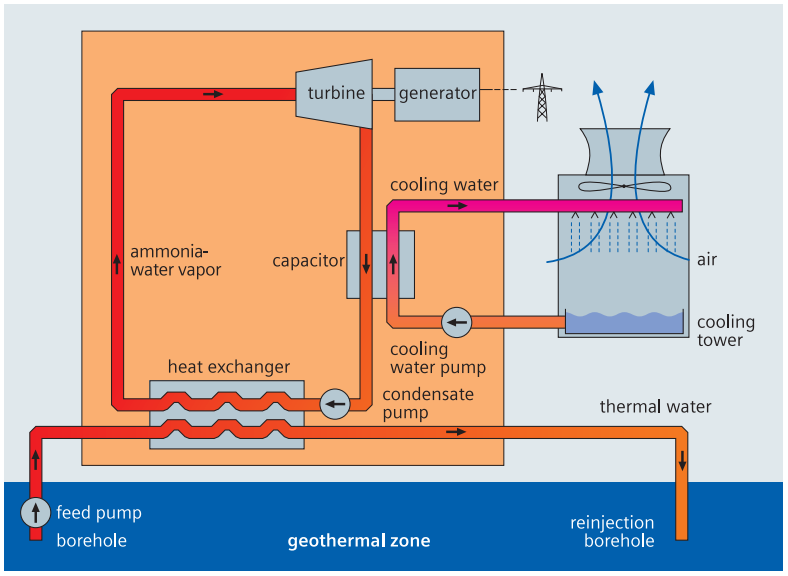
There is increasingly great emphasis on renewable sources of energy in the debate on reducing greenhouse gases. According to the Status Report by the German federal government on energy supplies, the long-term potential for utilizing heat from renewable forms of energy such as biomass, solar energy and geothermal energy in Germany amounts to as much as 820 TWh or more than 50 % of today's heat requirement. The amendment of the German Renewable Energy Sources Act (EEG) has also made geothermal energy interesting as a source of electricity. With an innovative utilization concept and a new technical process, the municipality of Unterhaching near Munich is demonstrating that this energy source can also be used economically. The most modern and productive geothermal power plant in the world operating in the low temperature range is being constructed here with Siemens technology.

The natural heat of the earth provides a means of generating power in base load mode without emissions and independent of the weather or time of day. Experts estimate that the electricity generating potential alone of the hot water-bearing aquifers in Germany amounts to more than half of the annual electricity requirement in Germany. It will doubtless take a long time to get anywhere near attaining this figure. For all that, the potential of this form of energy has been recognized by the political decision makers. In particular, increasing the guaranteed payment for electricity from originally 9 to 14 to 15 euro cents per kilowatt hour of electric power for systems with a capacity of less than 10 megawatts has provided an incentive to invest in this technology. In accordance with the Renewable Energy Sources Act (EEG), the minimum payment which has been fixed for system operation over twenty years at the same time provides long-term investment security.

The investment costs for geothermal energy depend essentially on the drilling depth, the volume of thermal water that can be pumped and its temperature. It can normally be assumed that the temperature in the earth's upper crust increases by an average of three to four degrees Celsius per hundred meters. For commercial exploitation of this free form of energy water at a temperature of about 100 °C is needed and this is found at an average depth of 3,500 meters. Practical experience shows that geothermal power plants in Germany are not only possible in the geological hotspots of the Upper Rhine rift valley and the Eifel but also in geologically older regions such as the South German Molasse Basin and the North German basin. The groundwater-bearing Upper Jurassic karst of the South German/Upper Austrian Molasse Basin is the most important reservoir of geothermal energy for heat utilization in central Europe. Water at a temperature of over 100 °C is already found at a depth of

Outside view of the Unterhaching geothermal power plant (computer animation)

View of the machine house at Unterhaching geothermal power plant (computer animation)



Operation of a binary geothermal power plant

about 3,000 m. There are particularly high resources in the region around Munich and in the area southwest of the Landshut-Neuöttinger Hoch. Large amounts of energy can be extracted here essentially thanks to the relatively high temperatures and the good porosity of the underground rock.

In the summer of 2004, water at a temperature of 122 °C and with a yield of 150 liters per second was encountered at a depth of 3,446 m in the largest geothermal deep borehole in Germany in Unterhaching near Munich. About 38 MW of thermal energy are available all year round in a temperature range between 60 °C and 122 °C. Depending on the weather conditions this can be used either for the production of district heating or electricity up to 3.4 MW. The thermal water is then returned to the so-called reinjection borehole about 3.5 km away as the crow flies where it is fed back underground again.

A portion of the thermal water is cooled via a heat exchanger. This heat is made available to households, businesses and municipal facilities via a district heating network. Since comparatively low additional fuel costs are incurred, the heat can be offered at a constant and competitive price in the long-term. Fossil fuels are only used either if demand for heat exceeds the delivery capability of the borehole (e.g. at peak times) or if the thermal water circuit stops for technical reasons.

In summer when only little district heat is needed the energy freed up in this way can be transferred into a second circuit and used for generating electricity. A heat engine based on innovative technology is used to obtain a high energy yield. This technology uses a mixture of gas and ammonia to drive the steam turbine for generating electricity. The great advantage of this technology is that the mixture does not have a fixed boiling point such as water at 100 °C but has a variable boiling point. This range lies well below that of water depending on the mixing ratio of water/ammonia. The closer the evaporation curve of the mixture can be brought to the temperature curve of the cooling thermal water the better the heat transmission. The heat utilization efficiency of power plants with a water-ammonia circuit is considerably higher compared with that of conventional geothermal power plants.

Siemens I&S planned and is delivering the geothermal plant as a turnkey project individualized to the needs of Unterhaching. The expected power output is calculated after an economic feasibility study has been made of a potential geothermal heat source. As soon as this "water data" is available the experts devise suitable power plant concepts as the basis for decision making and deliver the entire technology with all control and electrotechnical components, thermal equipment and turboset consisting of turbine, transmission and generator. In Unterhaching the aim is to generate 3.34 MW, sufficient to supply 2,000 households with electricity and another 4,000 homes with hot water. This will reduce CO_2 emissions by around 40,000 t. Siemens is also responsible for the construction of the administrative building and machine house including noise abatement measures and will carry out maintenance at the power plant for the first ten years of operation. The start of commercial operation is planned for the fall of 2007.

Over the past few years Siemens I&S has further developed the technology of the water – ammonia circuit for this application through specific innovation. It is now possible to achieve the same or even higher heat utilization efficiency while reducing the complexity of the system. Meanwhile further planning is in progress at Siemens I&S to use techniques for the efficient recovery of heat in other areas as well. This technology can actually be used wherever residual heat is still wasted, for example in the steel and paper industry, or in glass or cement works. At all events, there is a need to reduce greenhouse gases.

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