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Unterhaching Power Plant and Overall System

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ABSTRACT

After two successful drillings at Unterhaching a power – heat coupling station is in construction. The aim is to convert the energy of the thermal water into electrical energy with a Kalina cycle power station and to use parallel the geothermal energy for district heating. The temperatures and flow rates in the two wells for production and injection are tested. The tests show temperatures of more than 122° C and a productivity as well as injectivity index of more than 200 [m³/h/MPa] respectively 300 [m³/h/MPa]. These results enable to operate an electrical power station of 3.35 [MW_{el}] and to use about 40 [MW_{th}] for district heating. With an optimal controlled operation of the power – heat coupling system a reduction of 40,000 metric tons of the CO_2 emission per year can be reached.

1. INTRODUCTION

Six years ago the council of the community of Unterhaching decided to use the geothermal energy stored in a depth of more than 3000 m in an aquifer in the southern Bavarian Molasse basin, the so called Malm. The principal motivation of the municipality was to install a reliable future energy supply on the basis of very low CO_2 – emissions for their citizens. To reach this aim, one planned a power – heat coupling power-station in order to use the energy of the thermal water in two steps. The prediction (J. Ruhland 2001) of a temperature of more than 115° C and a flow rate of 150 [l/s] at a drawdown of 500 [m] allowed to plan a power station for the conversion of the energy of the thermal water into electrical energy and to use in a second step the geothermal energy for district heating in Unterhaching. The economic profitability of the project was given by the economic safeguard provided by the Renewable Energy Law of the Federal Republic of Germany which over a period of 20 years guarantees a fixed payment by the regional supplier for the delivery of electricity generated by geothermal energy with a 3.4 [MW_{el}] power station and by selling of approximately 20 [MW_{th}] heat power.

In order to cover any risks involved, the local council requested insurance for the project to cover the success of the exploration of the first well. This first private insurance for a deep geothermal well has been achieved. For the insurance company, firm temperature forecasts and a seismic data based evaluation (R. Thomas and R. Schulz) of the risk concerning the southern Bavarian Molasse were the determining factors.

2. THE UNTERHACHING PROJECT

For an effective realization of the project the local council founded a company, the Geothermie Unterhaching GmbH & Co. KG. Until today the community is the only associate and this should continue due to the intention of the citizens. The intention of the council was to steer the project with respect to the economic success. Therefore the business consulting company Rödl & Partner was charged with the management of the total project.

The main tasks for the project management were the allocation of an area for the exploration of the thermal water by the Bavarian state ministry of Economics, the conclusion of an insurance for the exploration risk, the drilling of two wells for the production and injection of the thermal water, the construction of a power station with a Kalina cycle, the construction of the closed thermal water cycle, the construction of a district heating system and of a conventional heat station for redundancy and peak heating. Finally the allocation of a claim for exploitation which must also be allocated by the Bavarian state ministry for Economics should guarantee the reliable and economic operation of the power- heat coupling system over at first 50 years.

2.1 The Unterhaching wells UHA GT 1, GT 1A, GT 2

The exploration area which had a size of approximately 16 [km²] has been allocated by the ministry in late spring 2002, but with the comment of the responsible public administration, that one can only expect in this area a temperature of maximum 95° C and it would be extremely impossible to have such a huge yield in production as it has been predicted in the feasibility study. Therewith the project has become a challenge for all responsible persons involved.

Before the planning of the drilling of the first well UHA GT 1, an investigation of the area was been performed by the interpretation of reflection seismic profiles (R. Thomas and R. Schulz) performed by the Leibniz Institute for Applied Geosciences. This investigation is as important as a reliable feasibility study in order to make the right plan for drilling and to have the best chance to get high production rates in a well.

From the seismic data adequate fault zones could be identified nearby the area of the GT 1 drilling place. The top Malm was estimated with just more than 3,000 [m] vertical depth. A slight deviation of 300 [m] to a fault in direction to NW from the vertical has been suggested. The location of the borehole, which was decided to be the production well, was determined by available land for the drilling place and the later on constructed power plant.

The planning and controlling of the drilling was put in hand of the Geothermie Neubrandenburg (GTN). The drilling itself was performed by the working pool Wärmestrom Bavaria, i.e. Drilltec, Anger's Söhne, Streicher AG. The company used a former horizontal drilling technique brought in vertical position (fig.1). The drilling started on January 25, 2004. After several technical pitfalls and

Figure 1: Derrick of the wells UHA GT 1 and GT 1A, the height of the derrick is only 19 [m].

accidents, for example leaky tubes at the first tour of the well or stuck drilling tools which were blasted and cemented in the first branch of the GT 1, the final branch of the well GT 1A was drilled down to a true vertical depth of 3350 [m], i.e. 3,446 [m] mMD on September 19, 2004. At least after one hydrochloric acid treatment the borehole was successful. The measured production rate was 65 [l/s] with a drawdown of 70 [m]. The water temperature was 122.8° C. It was proven that the predictions of the feasibility studies were less than the reality. A side effect of this result was a big run for geothermal claims in southern Bavaria in order to realize geothermal power stations for the production of electrical current.

The location of the injection well, UHA GT 2 was planned after a reprocessing of seismic profiles of 1976 and 1986 recorded from the oil exploration industry. It is situated approximately 3.5 [km] east from GT 1A because of a big fault zone located at 1.4 [km] SE from an available place just inside of the local border of the municipality. For this location less temperature but a better productivity as in well GT 1A has been forecasted.

Since fall 2004 until spring 2006 we had no success to find a further company for drilling who had access to an adequate derrick for drilling a depth of more than 3,000 [m] due to the lack of capacity of derricks of that category. In addition, there was in Bavaria a very time consuming proof of the static of mostly standard derricks belonging to a foreign drilling company (fig. 2), also for companies inside the European Union. On June 22, 2006 we started the UHA GT 2 with help of the British company EDECO and Anger's Söhne.

Figure 2: Standard derrick for UHA GT 2

After some bad experiences with the use of bicenter drag bits during declined drilling, one changed to normal roller bits and a subsequently following treatment of the borehole with a bicenter scraper. This technique extended the estimated drilling time more than double but showed that the use of bicenter drag bits is not useful in declined drilling.

After reaching the estimated depth down to 3,350 [m] true vertical depth (3.595 [m] mMD) on November 12, 2006 the first tests of the well showed that the required hydraulic parameters could not be achieved, even not after several treatments with acid. The analysis of the mud samples and the evaluation of the well-log made it evident that one was still drilling in a zone of the top Malm due to a similar parallel declination of the Malm and the deviated drilling. Therefore it was decided to deepen the well. On January 12, 2007 the final true vertical depth of 3,590 [m] (3,864 [m] mMD) was reached.

After a further treatment with acid, the hydraulic test (fig. 3) proved an average water temperature of 135° C (141° C on the ground level of the borehole). The production was much better than 350 [m³/h/MPa], even higher as in the GT 1A (M. Wolfgramm et al., 2007).

Figure 3: Hydraulic test at the UHA GT 2.

2.2 The Kalina Power Station

In principal, two systems are available for the low enthalpy power generation. Since the thirties of the last century the Organic Rankine Cycle (ORC) is used in different geothermal power stations (e.g. G. Pernecker and St. Uhlig, 2007 or U. Kaplan, 2007). In the seventies, Alexander Kalina developed a new heat exchange technique to produce vapor at a low temperature level. In the so called Kalina cycle a mixture of ammonia and water is used to generate a vapor cycle at low level temperatures around 100° C as a power source for the turbines. It is expected to gain with this binary system an increase of efficiency in comparison to the ORC cycle may be up to 25 % (A. Kalina, 1984 and 1986) and (Y.M. El-Sayed and M.Tribus, 1985). The reason of this supposition is the boiling of the binary ammonia – water mixture at a variable temperature unlike pure water or other fluids which boil at a constant temperature. Variable temperature boiling permits the working fluid to maintain a temperature closer to that of the hot combustion gases in the boiler, thus, improving the exergy efficiency, a fact which has been well known among engineers.

The first European geothermal power plant with Kalina technology with 2 [MW_{el}] has been installed at 2002 in Husavik, Iceland.

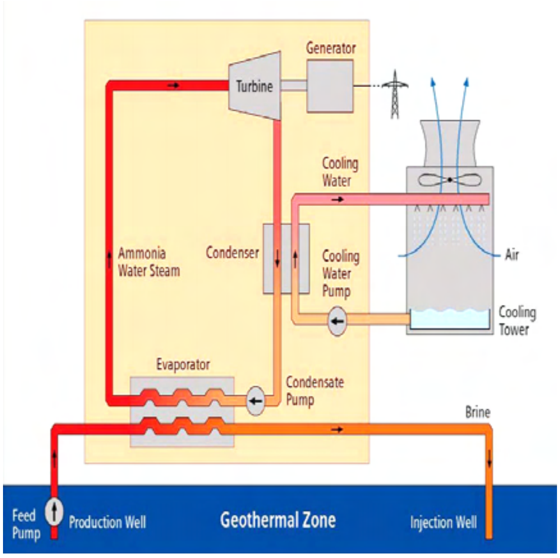

Figure 4: Principle of a Kalina cycle

The Unterhaching project had the goal from the beginning of the project, to install Kalina technology (fig.4). On November 18, 2005 the Geothermie Unterhaching GmbH & Co. KG signed a contract with Siemens AG for the construction of the first geothermal Kalina power plant in Germany (fig. 5).

Figure 5: Model of the Kalina power station at Unterhaching (design by Siemens AG)

The facility was designed with a rated electric power output of 3.36 [MW]. The generated power will be fed into the public grid of a fee. The building housing the Kalina facility is largely completed. It is planned to start with the production of electricity in August 2007.

2.3 The Power – Heat Coupling System

Up to 40 [MW_{th}] of heat-power can be provided geothermally. This would be sufficient to provide 2/3 of the households in Unterhaching with geothermal heat. Therefore we prefer a priority of heat delivery in winter times, i.e. the electricity production is controlled by the demand of heat during the heating-period (fig. 6)

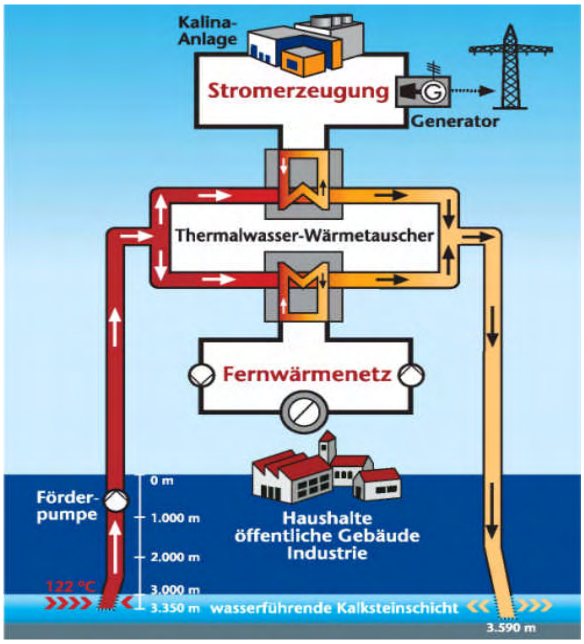

Figure 6: Model of power – heat coupling of a geothermal power station

Since the temperature of the thermal water after the heat exchange for the Kalina cycle has approximately 60° C the system is designed with two parallel thermal water branches for the heat exchange. In the normal operation mode, one branch provides with 125 [l/s] of thermal water the Kalina cycle and a second branch provides with 25 [l/s] of thermal water the heat exchange for district heating. Therewith the necessary basic input temperature for district heating is guaranteed during the heating period. At very cold period with duration over several days, the production of electricity can be decreased or even switched off in this mode of operation.

For a reliable supplying of the delivery of heat, a fossil fuel heat plant with two hot water boilers rated at 23.5 [MW_{th}] has been built as a backup and to cover peak load demand. (fig.7)

2.4 Provision of district heating

The installation of the district heating pipeline in the first section in Unterhaching was carried out from May to December 2006. In all, around 12 [km] of pipeline was installed. The connected capacity of the users hooked up in construction phase one is currently around 22 [MW_{th}]. this represents today 130 customers, including municipal objects, managed properties and private households. Therewith around 40 % of the heat demand in Unterhaching is covered by geothermal energy. The expansion of the network is going on. At the end of 2007 the ring closure of the district heating system will be finished with which one can provide 40 [MW_{th}].

3. CONCLUSION

The Unterhaching geothermic project is setting new standards in the exploitation of this environmentally friendly source of energy. By using this energy in a power – heat coupling mode, the decrease of CO_2 emissions is up to 40,000 metric tons per year. In comparison to an estimation of static energy consumption in Unterhaching at 1998 the production of CO_2 emissions was 60,000 metric tons at that time.

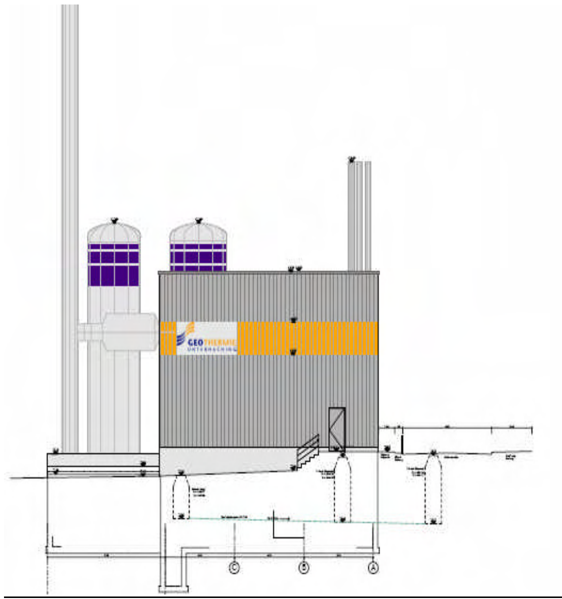

Figure 7: Heat plant for back up and peak-load demand

Up to 150 litres of more than 120° C hot thermal water are extracted from a depth of over 3,300 [m] every second. The borehole dimensions and output volume of high temperature thermal water are unmatched in Germany.

Geothermal energy is used in an ideal operation simultaneously for district heating and the production of electricity. A temperature range between 60° C and 122° C provides some 40 [MW_{th}] of thermal heat-power and 3.36 [MW] electrical power.

4. ACKNOLEDGMENTS

The innovative facility has a pilot character and is funded by the German Federal ministry for the Environment Protection and Reactor Safety, and by the Bavarian Ministry for Economics, Infrastructure, Traffic and Technology.

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