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The Hybrid Power Plant Neuried, Germany

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ABSTRACT

Biogas and geothermal are both renewable energy sources with a large potential to contribute to the EU target of increasing the share of renewable energy to 20 % until 2020. Currently, the worldwide first hybrid power concept coupling a biogas and a geothermal power plant is implemented in Neuried in the Upper Rhine Graben. The biogas plant is operational since 2007; the geothermal project is at a far developed state. From a technical point of view, the hybrid approach considerably increases the power generation efficiency. In combination with the integrated heat use concept, it reduces CO_2-emissions by up to 46,000 tons per year, supports the local energy supply and disposes of a diversified revenue structure. The pioneer hybrid plant Neuried can serve as the general proof of concept for this environmentally sound way of energy production.

1. INTRODUCTION

Both the German Government and the European Union want renewable energies to play a more important role in the future energy mix. Until 2020, the share of renewable energies in the total energy consumption of the EU is supposed to be increased to 20 %.

Geothermal energy and biomass are two major players in the renewable energy market, both being able to supply base load energy. The estimated technical production and demand potential of geothermal power production in Germany amounts to 50 % of the yearly electricity demand in Germany (Kaltschmitt et al. 2006). The theoretical potential of geothermal power from combined heat and power plants is about 25 % of the yearly German electricity demand (TAB 2003). The potential of biomass for electricity production depends amongst others on the future use of biofuel in the traffic sector.

The hybrid concept at the power plant in Neuried in the Upper Rhine Graben aims at coupling biogas and geothermal power production. This is achieved by using the excess heat of the fermentation gas engines in the low temperature electricity and heat generation of the geothermal power plant. The hybridization increases the efficiency and economy of the plant and is the first combination of these two renewable energies worldwide. In addition, a sophisticated heat use concept is implemented.

The biogas plant was constructed and started operation in 2007. The geothermal project is at a far developed stage and well prepared with 2D- and 3D-seismic surveys thus using an extensive geological data basis plus interpretations. The two wells for the geothermal loop are planned to be drilled in 2010. The production well is supposed to supply 75 l/s brine water with a temperature of 120 °C from limestone and sandstone aquifers at depths between 2500 and 3000 m.

For the execution of the geothermal part of the project Neuried, a project company is in the process of being founded. Shareholders of this company are going to be the municipality of Neuried in collaboration with an investor. Several funding opportunities and risk mitigation solutions are available for this project and are in place or currently negotiated. The presentation will report on the hybrid plant concept with special focus on the geothermal project development, its challenges and its opportunities.

2. HYBRID POWER PLANT CONCEPT

The hybrid power plant concept is based on the coupling of a biogas and a geothermal power plant. In the biogas power plant, methane gas gained from renewable resources (biomass) is burned. The demand for biomass secures the economic basis of the local agricultural for a period of over 20 years, a business which is at the moment very dependent on the European subsidies for tobacco production.

The excess heat from the cooling cycle and the exhaust fumes of the gas engines is fed into the power cycle of the geothermal plant. The additional heat input leads to a higher efficiency of the geothermal power plant: more electricity can be produced.

The geothermal part of the hybrid plant will consist of a doublet (one production and one injection well) connected to the surface power plant. The production well is supposed to supply 75 l/s of brine water with a temperature of 120 °C. The brine water is reinjected into the aquifer through the injection well.

For the electricity generation from the low temperature geothermal reservoir, the Kalina technology was chosen, as it offers a higher efficiency than the also available ORC technology for the expected conditions.

The planned total electrical capacity of the plant is about 4.2 MW_{el}, where 2.8 MW_{el} are attributed to the geothermal part and 1.4 MW_{el} to the biogas plant. This hybrid power generation contributes to up to 30,000 tons of CO_2-emissions saving every year (compared to a brown coal plant).

2.1 Heat Use Concept

The waste heat from the geothermal power plant is available for further heat use. Against the background of the highest possible energy efficiency of the entire hybrid plant, it is provided to establish heat customers in the immediate surroundings of the site.

It was possible to reach an agreement with a sawmill as such an ideal heat customer. The sawmill requires a large and constant heat quantity of 6 MW throughout the year for the wood drying process. This is a significant advantage

compared to the supply of residential housing from an economical and ecological point of view. Figure 1 shows the planned location of the sawmill adjacent to the biogas and the geothermal plants.

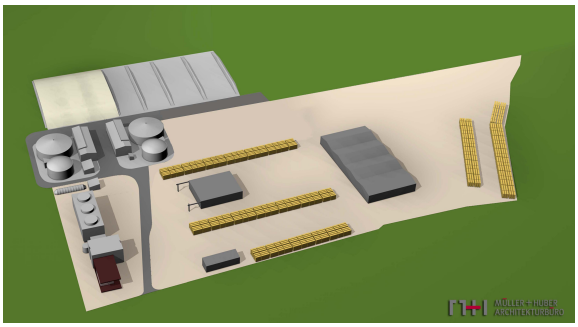

Figure 1: Bird's eye view of the hybrid power plant in its planned final stage with the biogas plant (top left), the geothermal plant (bottom left) and the heat customer (bottom right)

In addition, it is intended to supply the remaining heat after usage by the sawmill to a commercial area north of the plant, the so-called business park BASIC. The district heating system further contributes to the ecologically excellent energy balance of the hybrid plant.

This sophisticated heat concept accounts for approximately 16,000 tons of emission saving per year.

3. GEOLOGICAL AND GEOTHERMAL SITUATION

3.1 Geology

The township of Neuried is located in the geothermal province of the Upper Rhine Graben in south-east Germany in the state of Baden-Württemberg. The site is located between Offenburg and Strassburg in France.

Figure 2 shows a cross-section of the Upper Rhine Graben north of the site where the general stratigraphy and the characteristic mosaic of faults and tectonic blocks can be observed.

The project uses a multi-layer approach in order to sum up water from several deep aquifers. The target aquifers are the carbonates of the Lower Keuper and the Upper Muschelkalk in the top part, a mighty sandstone layer of the Buntsandstein and the underlying and partly weathered basement granites. Top and bottom edge of the reservoir lie at around 2500 m and 3000 m depth. The total reservoir thickness is about 500 m. The hydraulic active (permeable) layer pile is expected to be about 300 m to 400 m.

3.2 Drilling Concept

In general, the subsurface of the Upper Rhine Graben is characterized by a complex mosaic of tectonic blocks and many hydraulically active fault zones. Therefore, the drilling concept in Neuried provides for diagonal drilling through a hydraulic active fault zone. The drill path is optimized concerning the orientation of the fault area in order to increase the chances of accessing open cracks and permeable zones.

3.3 Temperature

The brine water and rock temperature in the Muschelkalk and Buntsandstein aquifers cannot be exactly determined before drilling completion and tests. The expected temperature estimate is based on drilling results and temperature measurements of reference drillings in the region like the drillings Offenburg 5, Offenburg 6 and Offenburg 9 or Cronenbourg in France, which for example showed 152 °C at 3220 m depth. Some values needed to be extrapolated to greater depths.

The reference data show an average geothermal gradient of 4.45 °C/100 m. In areas of deep reaching hydraulic active fault zones, geothermal anomalies with an increased gradient of over 5 °C/100 m could be determined. The temperature in the Muschelkalk reservoir is estimated between 117 °C and 128 °C. For the Buntsandstein aquifer, a temperature of 118 °C to 130 °C can be expected. The assumed average reservoir temperature at the site of the project Neuried is 120 °C to 132 °C. The project planning is based on the conservative reservoir temperature scenario of 120 °C.

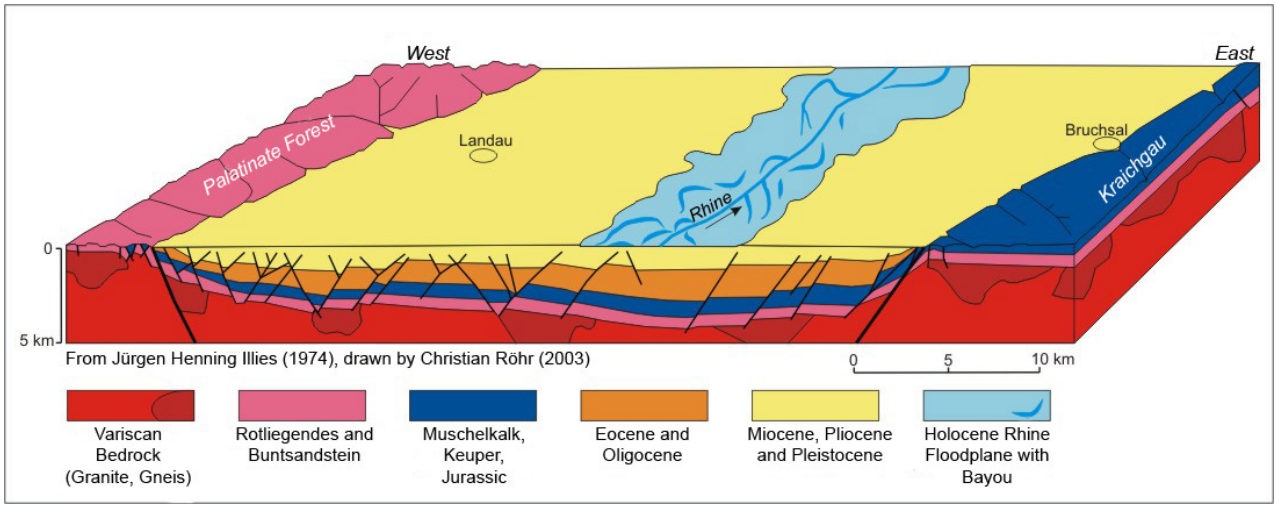

Figure 2: Cross-section of the Upper Rhine Graben (modified from Oberrheingraben 2009)

3.4 Flow Rate and Stimulation

With the multi-layer approach and the development of a hydraulic active fault zone, a flow rate between 75 and 100 l/s is expected and aimed for. The actual volume flow which can be extracted from the reservoir will be determined by hydraulic tests.

Before the hydraulic tests, an acidification is planned in order to reduce the skin effect from the drilling works. If needed and promising, a second and stronger acidification can be conducted. Additional stimulation methods like hydraulic pressure or a side-track depend on the situation found after the drillings (geology, tectonics, access to the reservoir).

3.5 Water Level

The undisturbed water level in the reservoir is expected to be around ground surface level. The operation water level depends on the following circumstances:

- Permeability of the reservoir
- Connection to the reservoir via the production well
- Flow rate

The drawdown at a given flow rate can be determined from the results of hydraulic tests.

For the planning phase, the following assumptions were made:

- 75 l/s: 200 m drawdown
- 100 l/s: 300 m drawdown

3.6 Power Plant Technology

With regard to the geothermal power cycle for the project Neuried, it is intended to use the Kalina technology. Kalina power plants are binary systems which can be employed to produce power from low enthalpy resources.

Within binary power plants, heat is transferred from the geothermal brine to a secondary working fluid, which has a lower flash point than water. The steam to power the plant turbine is therefore produced at a much lower temperature than by direct steam use.

For the expected brine temperature of 120 °C in Neuried, Kalina plants promise higher energy conversion efficiency than ORC-power plants, the latter being the second alternative for low temperature binary systems.

4. PROJECT STATUS

Until 2005, several 2D-seismic surveys were performed in the area (see Figure 3). They were completed by a 3D-seismic campaign in 2006 in order to define the target area of the drillings. The 3D-seismic was followed by a detailed analysis and interpretation allowing for an underground geological model and precise statements on fault systems and stratigraphy. The project documentation also includes a feasibility study with extensive project description.

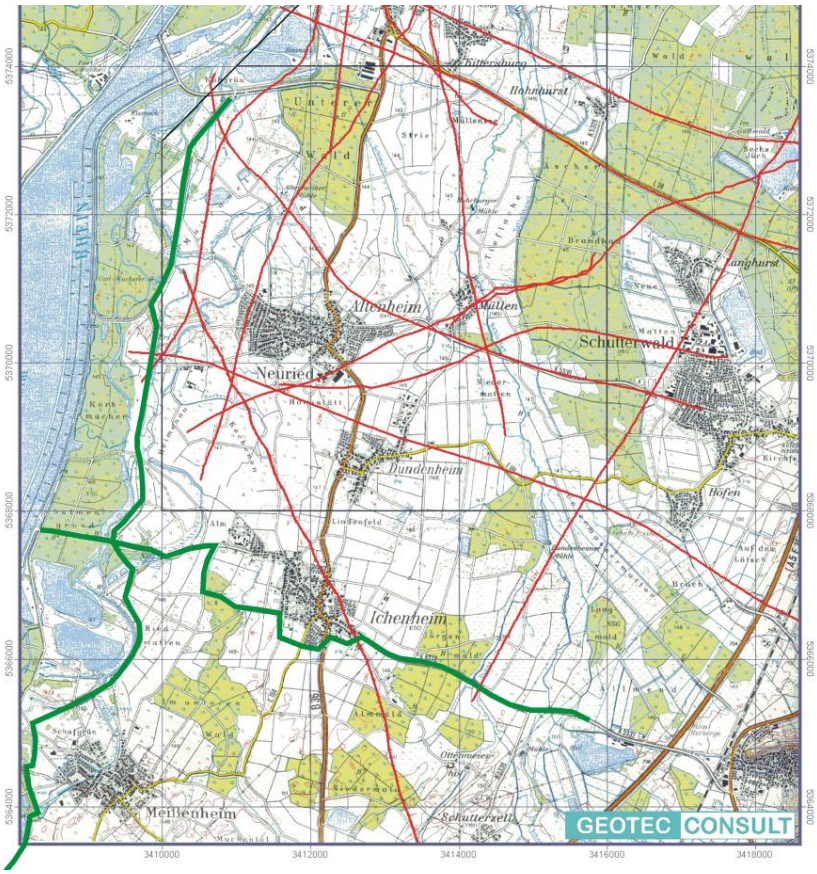

Figure 3: 2D-seismic profiles (red and green lines)

In addition, the state department for geology, resources and mining of Baden-Württemberg (LGRB) prepared a project report for Neuried in 2005 based on several 2D-seismic surveys. The expertise gives detailed insights on the geological and geothermal conditions at Neuried. The information is completed by recent statements by geothermal consultants and the LGRB on the scheduled stimulation methods, the project success parameter and reference drillings. In addition, a drilling plan is accomplished specifying e.g. the casing diameter, the landing depth of the respective pipe tours and the steel quality.

4.1 Project Schedule

The hybrid plant is built in two phases:

- 1. Phase: 1,4 MW_{el} Biogas power plant (completed in 2007 and in operation)
- 2. Phase Drilling of the wells, 2,3 MW_{el} Geothermal power plant and possible expansion of the biogas plant up to 3 MW_{el}.

Figure 4 shows a bird's eye view of the existent biogas plant. The beginning of the drilling works for the second project phase is planned for the beginning of 2010, depending on the availability of the drilling rig. After completion and successful testing of the production well, the injection well will be drilled. The results from the hydraulic test deliver the relevant design parameters (temperature, flow rate and chemistry of the thermal water) needed for the layout of the geothermal power plant.

The decision of constructing the geothermal power plant is going to be taken after successful first well testing. At this stage, the planning and construction of the expansion of the biogas plant can begin as well. The final project success is determined by a circulation test after completion of both wells. The operation start of the geothermal power plant is planned for 2012.

Figure 4: Biogas plant Neuried

5. REVENUE SITUATION AND ECONOMY

The profitability of any geothermal project mainly depends on the volume of water which can be extracted from the reservoir and to a lesser extent on the temperature. The cost-effectiveness also depends on the feed-in-tariff for electricity and the amount of heat that can be sold.

The German Government supports renewable energies with the Renewable Energy Law (EEG). This law specifies the revenues for electricity generated from renewable energies and guarantees a feed-in-tariff for 20 years. For the geothermal project Neuried, the guaranteed feed-in-tariff by the EEG amounts to 20 ct/kWh. Additionally, the law provides for an extra bonus of 3 ct/kWh, if 20 % of the available thermal capacity is used for heat supply.

The expected temperature (120 °C) and the flow rate (75 l/s) of the geothermal power plant and therefore the planned plant capacity were determined conservatively. With a higher flow rate of for example 100 l/s, there will be a higher revenue. Additional revenues can be expected from the heat sale.

Changes to the expected revenue situation are possible in the following areas:

- Investment costs: Increasing investment costs due to higher drilling and steel prices because of a high activity of oil companies driven by high oil prices.
- Increase in power production: Increase due to higher flow rate and higher plant efficiency.
- Bank loans: Adjustment of interest rates

For an innovative and current project like the hybrid power plant Neuried, governmental grants and promoting instruments for research and development are available. As one example, research optimizing the coupling of the waste heat of the biogas plant and the low temperature energy generation of the geothermal plant shall be funded.

6. RISK MITIGATION

With the existence and evaluation of extensive 2D- and 3D-seismics, the geothermal project Neuried is currently one of the most accurately and carefully prepared projects.

With this preparation, the negotiation of a complete risk mitigation package including exploration risk coverage at moderate costs could be achieved. This achievement is especially notable, because reference data on geothermal projects is much less existent in the Upper Rhine Graben than for example in the Southern German Molasse Basin. Several insurance providers however believe in the project success and have placed an offer for a comprehensive risk mitigation policy for Neuried.

In addition and as an extra benefit for the project, the State of Baden-Württemberg offered to contribute an amount of 1 Mio. € in order to facilitate the regional geothermal project development. The success parameters and also the threshold values for the insurance are a thermal capacity of 16.000 kW with a maximum drawdown of 200 m. These values have been approved by the ministry of the environment of Baden-Württemberg.

7. SUMMARY

The Hybrid project Neuried is the worldwide first power plant which combines energy use from biogas and geothermal in order to reach the maximum possible energy outcome. It combines benefits in technological, ecopolitical, regional and economical regards.

The extra heat from the biogas plant which will be fed into the Kalina cycle will increase the efficiency of the geothermal power generation.

Through the hybrid power generation in Neuried, up to 30,000 tons of CO_2-emissions saving can be realized every

year. The sophisticated heat concept accounts for another 16,000 tons of emissions saving per year.

The hybrid plant supplying the surrounding industrial and commercial area with local energy and renewable redundancy in power and heat generation supports the development of a regional power industry for Neuried.

The project has got access to insurance coverage of project and exploration risks. The renewable energy law guarantees generous feed-in-tariffs for a period of 20 years. The heat use concept provides for additional economic efficiency. Lastly, research and development grants can furthermore contribute to the project success.

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