Proceedings European Geothermal Congress 2007
Unterhaching, Germany, 30 May-1 June 2007

The Concept of Hybrid Power Plants in Geothermal Applications

Bernd Kapp and Horst Kreuter

Baischstraße 7, D-76133 Karlsruhe

bernd.kapp@aufwind.com and kreuter@geo-t.de

Keywords: hybrid concept, geothermal, biogas, power plant

ABSTRACT

In many regions of Germany, the temperature of geothermal brine that can be tapped in natural reservoirs generally is below 120°C. The production of electricity is economically not feasible in most of these areas, because with low temperatures the degree of efficiency and thus the amount of produced power is too small. With the new hybrid concept, it is now possible to feed in energy from a second renewable energy source into the geothermal power cycle while raising the temperature at the same time.

1. INTRODUCTION

Electricity generation out of a geothermal energy source depends on the local geological situation. Reservoir temperatures lower than 120°C are usually found if reservoir rocks are not deep enough or if the temperature gradient is too low.

The hybrid biogas-geothermal power concept (figure 5) which was developed by GeoThermal Engineering GmbH in 2004 helps a community in the Upper Rhine Valley to realize a geothermal power project in spite of these unfavourable circumstances.

2. TECHNICAL REALIZATION OF THE HYBRID CONCEPT

In Neuried, the geothermal power plant will be coupled with a biogas power plant. This project is now being implemented in this village for the first time worldwide.

Figure 1: Biogas power plant (Schmack Biogas)

In a fermentation process, methane is produced and then combusted in gas engines (CHP). These engines drive a generator which feeds in electricity into the grid. With the help of heat exchangers, the waste heat of both the exhaust and the cooling system of the engines are fed into the low temperature power-cycle of the geothermal power plant.

The exemplary calculation shows different effects on the capacity factor: Based on geothermal power with an inlet temperature of e.g. 110°C and a amount of waste heat up to 3 MW from biogas engines, the cycle can be heated up to about 115°C or more depending on the arrangement of the heat exchanger in the cycle and the value of the geothermal energy. In addition to the higher heat input in the rankine cycle the temperature increase of the fluid leads to a higher efficiency in the cycle. Both, ORC and Kalina Cycle, show a strong transient of the efficiency in the temperature range between 100°C and 120°C.

Different thermodynamic calculations with the software Thermoflow were performed to investigate the influence of the hybrid concept compared to the common stand-alone solution of a geothermal power plant (figure 2). A comparison between the different cycles (Kalina and ORC using isobutane) is shown in figure 3.

Figure 2: Geothermal Kalina power plant Husavik, Iceland (Exorka)

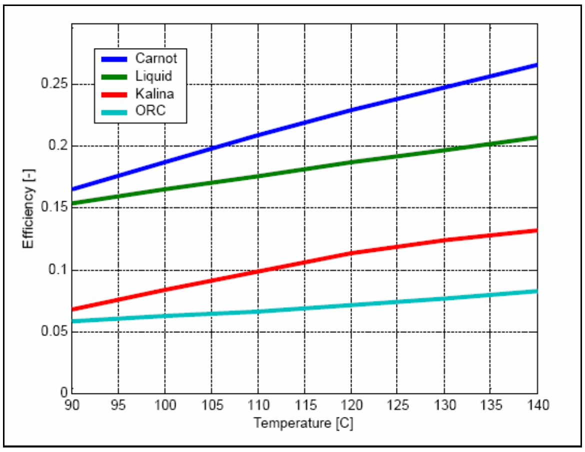

Figure 3: Efficiency of ORC - and Kalina cycle

Based on a Kalina cycle configuration in figure 6a the increase of gross power in the hybrid cycle in figure 6d reached a value of about 360 kWel. The power increase in the hybrid ORC isobutane cycle in figure 6c achieved even a value of 400 kWel.

In addition to this improvement of efficiency and power, more synergy effects arise: The waste heat of both, the thermal power and the biogas power, can be sold to neighbouring customers. The heat can be used in many different ways: for example for private or office heating, swimming pools or even for vegetable production in greenhouses. Heat is mainly needed during winter time. In contrast to this seasonal usage, the waste heat of the biogas plant can be fed into the geothermal power plant cycle during the whole year.

To guarantee a constant heat supply, back-up systems need to be installed, usually based on conventional heat sources like oil or gas. By combining these two renewable energy sources, there will always be a renewable back-up system available in case one of the two sources shouldn't be, e.g. in case of servicing. Hence, there is no more need for a conventional back-up system if the waste heat is sufficient. If the geothermal power plant is down, the biogas waste heat, which is normally being fed into the geothermal cycle, can then be used for direct heating. The waste heat of the geothermal power plant itself suffices for the direct heat use system.

Both renewable energy systems produce base load electricity. An uptime of more than 8,000 hours a year is possible. Therefore, a complex control system is necessary which has to adjust the geothermal power circuit to the variation in load of the biogas system, of the direct heat use system and to the variation of the ambient temperature.

Figure 4: Geothermal power plant detail (exorka)

A hybrid power plant like the project in the Upper Rhine Valley can generate up to 44,000 MWh of power per year supplying up to 28,000 people with electric power. In comparison to a conventional natural gas power station, the emission of CO_2 can be reduced by up to 18,000 tons per year.

3. CONCLUSION

By combining a geothermal power plant with another renewable energy source, the generation of geothermal energy can be extended regionally. Geothermal reservoirs with temperatures below 120°C can thus be made profitable. This doesn't only apply to parts of the favoured geothermal reservoir of the Upper Rhine Valley but even more so to other regions in Germany and Europe. Especially in the Molasse basin in Bavaria, where the temperatures of the brines in the Malm karst reservoir average between 100°C and 120°C, the hybrid concept provides a high potential. Hence, projects, that wouldn't be profitable being based on geothermal energy only, can now be realized by using the hybrid concept.

REFERENCES

THERMOFLOW: Comprehensive Thermal Engineering Software. Thermoflow Inc., Sudbury. Ma, USA.

Kapp. B., Kreuter, H., Borchert, G. & Treyer, H.: Das Geothermie-Biogas Hybridkraftwerk in Neuried. Geothermische Vereinigung e. V., Tagungsband, Geothermische Jahrestagung, Unterschleißheim, (2005).

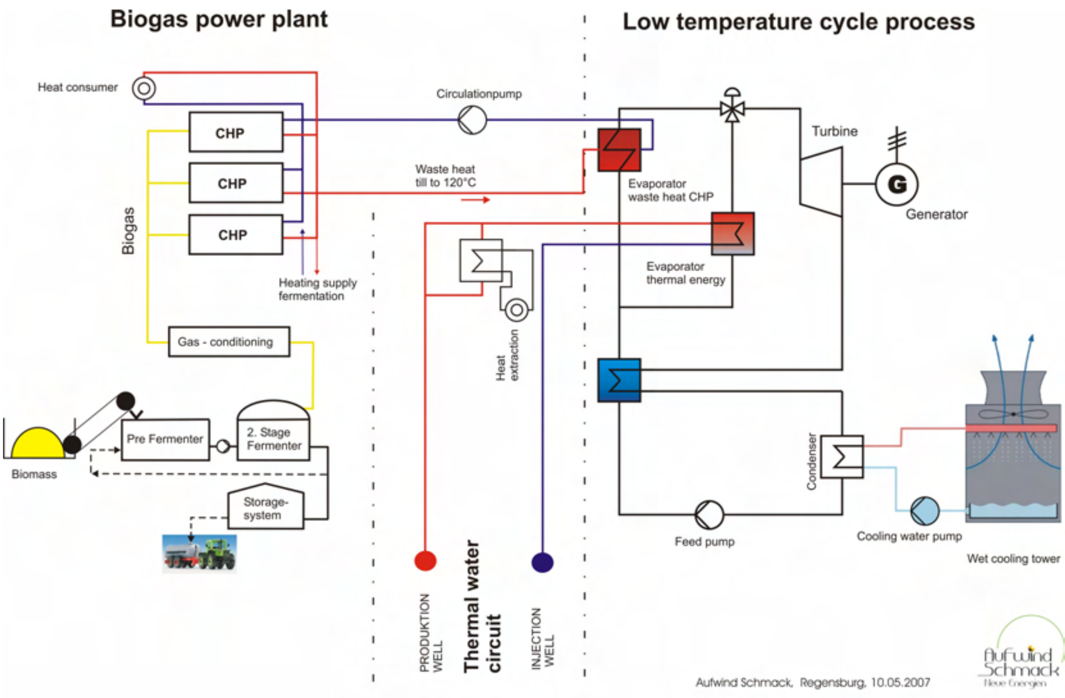

Figure 5: Flow diagram of a hybrid geothermal-biogas power plant

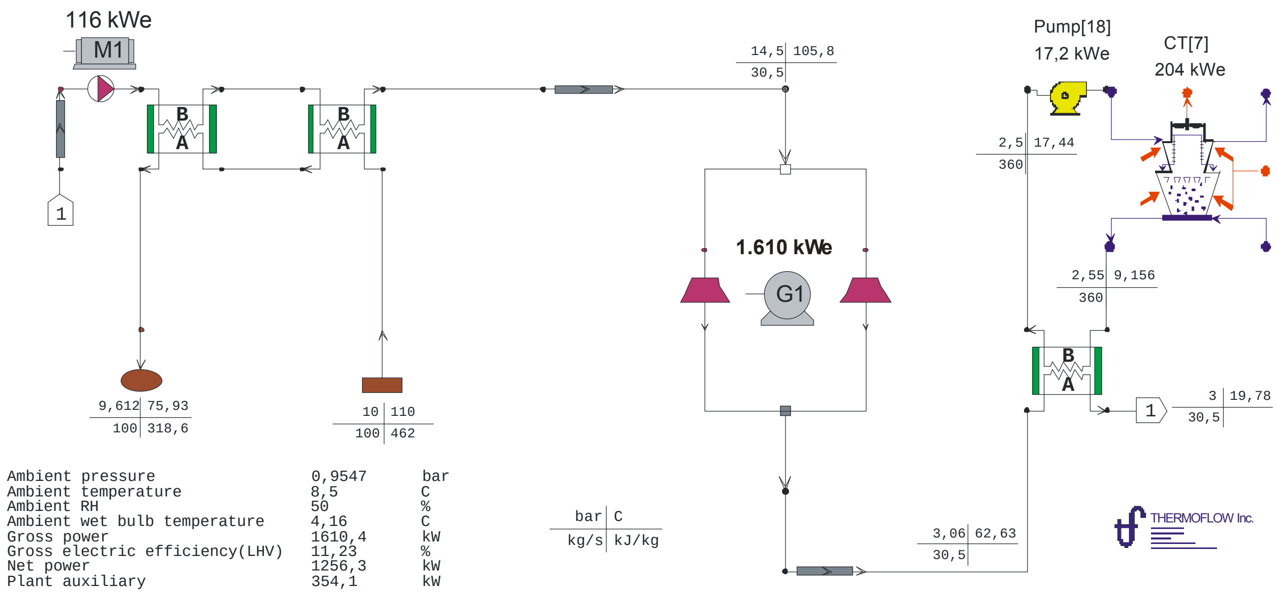

Figure 6a: Geothermal ORC – cycle with isobutane

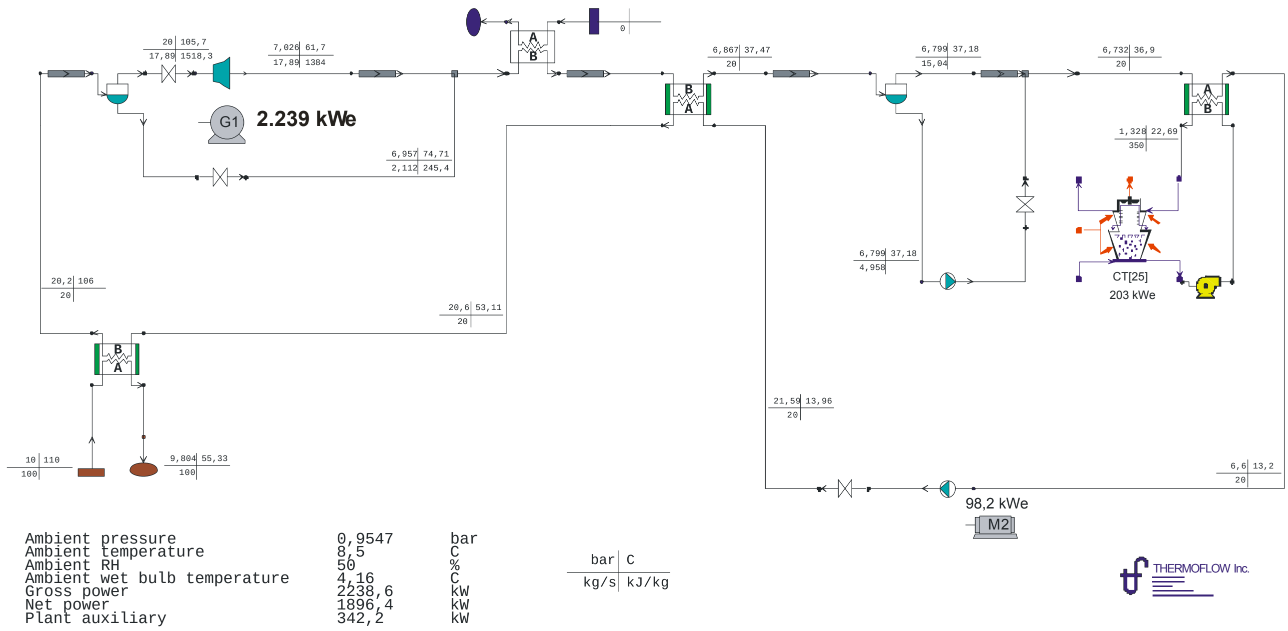

Figure 6b: Geothermal Kalina – cycle

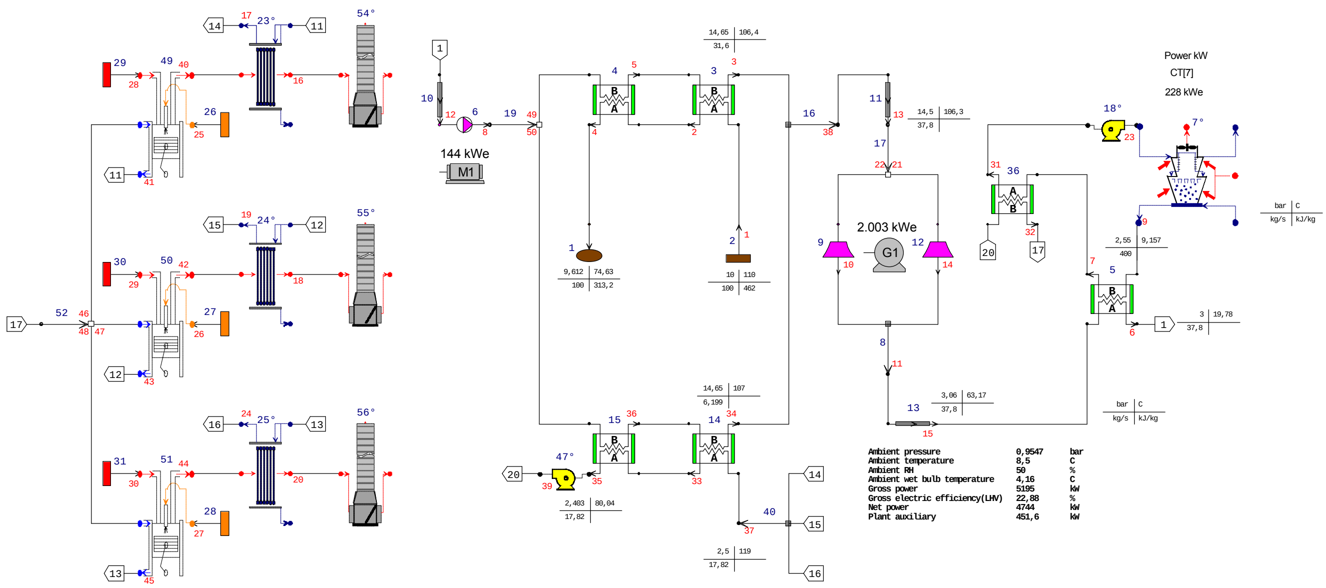

Figure 6c: Hybrid ORC – cycle with isobutane

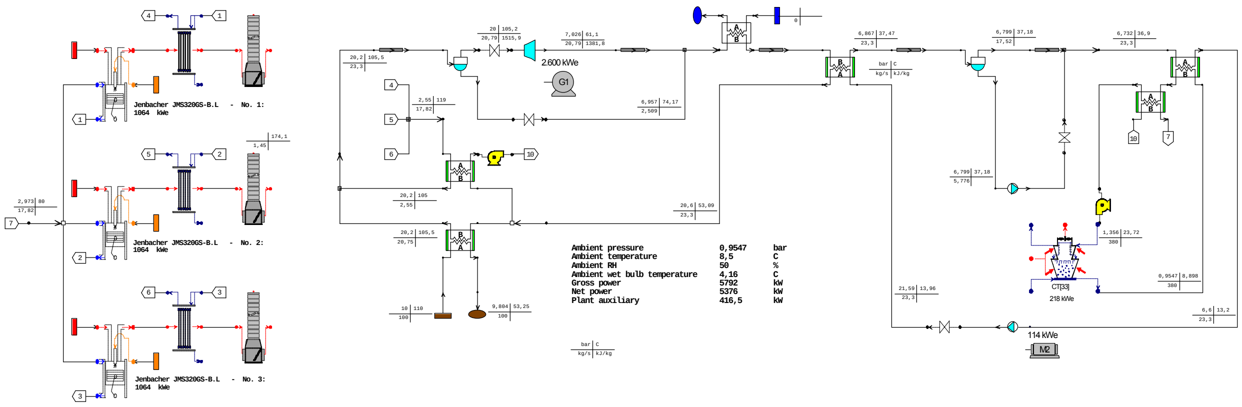

Figure 6d: Hybrid Kalina – cycle