

Operations update of European geothermal binary units delivered by Turboden

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ABSTRACT

Turboden stands among the pioneers of Organic Rankine Cycle Technology (ORC), being at the same time the European Leader for Geothermal application. Currently there are more than 370 Turboden ORC plants in operation in 42 countries worldwide, featuring in-house designed turbines.

Turboden is present in Europe with five geothermal binary plants in operation, and three under construction. The plants are located in Germany, France and Croatia, supplying base-load power and heat for the local communities.

In the last years, Turboden has successfully implemented 4 geothermal plants in the Molasse basin (Bavaria, south of Munich). One 5 MW geothermal power plant (in Sauerlach), two other 5,6 MW plants in the same region (in Dürrenhaar and Kirchstockach), and a 4,1 MW cogenerative geothermal plant in the city of Traunreut, designed to deliver also up to 12 MW thermal power to the local heating grid [1].

In August 2017, Turboden has won a European tender for a 3,4 MWel plant to be realized in Holzkirchen. This order confirms Turboden's leadership in the German market.

Turboden successful experience continues in France, for the Soultz-sous-Forêts plant in operation. Currently Turboden is in the construction phase for another geothermal plant in the Upper Rhyne Valley.

In Croatia, Turboden has constructed one of the largest single ORC turbines for the 17.5 MW Velika Ciglena project.

The technical features and the operational data of these plants will be described in detail, focusing on both the performance figures and availability of the ORC unit and on the overall availability of the projects (including downhole geothermal pumps and balance of plant).

1. OVERVIEW OF TURBODEN'S PRESENCE IN EUROPE

Turboden has a strong presence in the European geothermal market, which grows every year because of solid performances of its existing plants in operation.

Germany, more specifically the Molasse basin, has been an area of focus for Turboden and its efforts have been rewarded with four geothermal plants operating with high availability figures. Another one, in Holzkirchen, is currently under construction and will add to the reference list of Turboden.

Moving away from Germany, other developments include a 17.5 MW plant built in Croatia for the production of electricity. The Velika Ciglena plant hosts one of the biggest turbines ever built for a binary plant. Another plant worth of mentioning is the Soultz-sous-Forêts plant, located in France, in operation since 2016 with continuous operation and good performance figures.

2. SAUERLACH

Sauerlach geothermal plant has been in operation since the beginning of 2013. It is one of the three geothermal plants operated by the local utility provider StadtWerke München, built by Turboden. Sauerlach plant has a gross power of 5 MW with a water temperature of 140°C. A custom turbo-generator has been employed to maximize efficiency, minimize noise emissions and provide a smart usage of space available. The plant is a unique example of architectural integration of a power plant with a building, with a turbogenerator indoor (two turbines coupled to the same double-shaft generator), and a dissipation system (air cooled condensers) placed on the roof. Along with the production of electricity, the plant is capable of island mode operation to feed the local municipality with highly available heat.

Sauerlach has recently won the Geothermal Energy Prize of Bavaria mainly due to the outstanding operational data in 2017. During this period the plant has reached an overall availability (including balance of plant and ESP pump) of 98%. The ORC availability was 99.5% [2].



Figure 1: Sauerlach geothermal plant

3. KIRCHSTOCKACH AND DÜRNHAAR

Kirchstockach and Dürnhaar plants have followed Sauerlach in Turboden’s expansion to the Molasse Basin. They are power-only plants with an identical gross power of 5.6 MW. Both plants are in operation since 2012 and run by StadtWerke München since the takeover in 2016. Due to the proximity of the plants to the city of Munich, highly stringent noise limits are respected. Moreover, the HFC-245fa, a non-flammable liquid, has been used in order to minimize the environmental risk in the area, which hosts a forest. Both plants have double-pressure level cycles with a geothermal water temperature of 138°C.

A detailed analysis of availability and performance of the ORC conducted in collaboration with the owner has shown the following average performance figures in the period 2015-2017.

Dürnhaar: Average ORC availability 98,2%; total availability of plant (including ESP pump and balance of plant): 83%.

Kirchstockach: Average ORC availability 98,1%; total availability of plant (including ESP pump and balance of plant): 90,1%.

Both plants have exceeded by far the guaranteed performance for operation during the above mentioned 3 year period, despite real world operating conditions (scaling at evaporator inlet, and fouling on air condensers that has been removed during periodic maintenance activities) [2].



Figure 2: Kirchstockach geothermal plant



Figure 3: Dürnhaar geothermal plant

4. TRAUNREUT

Located in Traunreut, a town in southeastern Bavaria which raises on a deep geothermal reservoir, the Traunreut power plant has been constructed and in operation since 2016. GKT (Geothermische Kraftwerkgesellschaft Traunreut GmbH) is operating the plant which produces about 4 MW electric power by exploiting the geothermal water at 118 °C and it is coupled with the district heating system of Traunreut.

The plant is able to deliver a peak load of 12 MW thermal power. HFC-134a is the fluid of choice for the operation, while the plant is optimized for highly efficient electricity production at a very low sound level (< 92 dBa PWL).

5. SOULTZ-SOUS-FORÊTS

The well-known Soultz-sous-Forêts geothermal site, located in Northern Alsace (France) is home to a Turboden ORC unit of 1.7 MWe. The reservoir is a deep fractured granite, thus the type and quality of the brine has high saline content (about 100 g/l of TDS). An enhanced geothermal system has been developed by GEIE to produce geothermal water at 160 °C. Thus, Turboden provided an innovative air-cooled ORC plant to exploit the heat from the geothermal brine and reinject into the source with a temperature of 75 °C. The selected fluid for the single-pressure level process was chosen as isobutane, which has proven to provide excellent results.

A detailed analysis of availability conducted in collaboration with the Owner has shown the following availability figures in the period 2017-2018:

Average ORC availability: 99,9%

Overall plant availability (including line shaft pump and balance of plant): 91,2% [2].



Figure 4: Soutz-sous-Forêts geothermal plant

6. HOLZKIRCHEN

The town of Holzkirchen is located in the south of Munich, on the Molasse basin. Turboden is constructing a 3.4 MW to be delivered to its customer, Geothermie Holzkirchen GmbH, by the first quarter of 2019. The aim of the customer is to provide the local grid with electric energy and server the households connected to the district heating network with clean thermal energy.

A double-pressure level system is being adopted by Turboden, which utilizes isobutane as the working fluid. The combined heat and power plant will have a geothermal water temperature of 152°C at the inlet and 50 °C at the outlet. This is possible thanks to the low salinity of the geothermal water. The plant is currently under commissioning, with start-up expected within Q1 2019.



Figure 5: Holzkirchen geothermal plant

7. VELIKA CIGLENA

In Croatia, Turboden has constructed one of the largest single ORC turbines, for the 17.5 MW Velika Ciglena project.

The innovation concerns the adoption of the 5 stage large axial ORC turbine on a geothermal plant in the World. The Velika Ciglena project exploits steam and hot water at 170 degrees Celsius to produce electricity to feed the local power grid. The region of Velika Ciglena is situated in Bjelovar subdepression, the north east of Croatia. Turboden ORC plant converts the heat of two geothermal wells into base-load electricity. The ORC process is based on a single turbine, with isobutane as working fluid. The cooling is made by air

cooled condensers. As of today, the Velika Ciglena is the largest single turbine installed in a geothermal ORC power plant in Europe.

The plant has been started up in December 2018.



Figure 6: Velika Ciglena geothermal plant

8. AFYON

Afyon Jeotermal Turizm ve Ticaret A.Ş (AFJET); was established in 1994 with the purpose of installing district heating facilities exploiting geothermal water resources and providing greenhouses with the return water. The company is a municipal enterprise, which possesses 24 geothermal wells to date and provides heating for 23900 homes.

The customer has 24 geothermal wells, which are exploited in different ways. In addition to electricity production, AFJET also provides heating for homes in the area and water for the greenhouses. An ORC system was requested to exploit a low temperature geothermal water resource.

A tailor-made Turboden solution was designed to address the customer’s need and the plant was put into operation in 2017. The unit produces 3 MWe. The geothermal brine is exploited at a temperature of 110°C and a flow rate of 150 kg/s while cooling towers are employed to cool down the condenser of the ORC.



9. NEW PROJECT IN FRANCE

Turboden has been awarded a new project in the Upper Rhyne Valley in France. The projected power output will be 11 MWe exploiting the liquid brine at 200°C

from a single deep well. As of the date of publication of this paper, the project is still under construction with the projection of start-up by the end of 2019.

10. CONCLUSION

The operational experience of Turboden ORC plants in Europe has shown that the most critical component for the overall plant availability is the electrical submersible geothermal pump (where present). The operational experience in the Molasse basin has allowed a steady increase of the availability of this critical component. Turboden ORC units have demonstrated the capability to exceed 98% availability. In geothermal plants where the balance of plant availability exceeds 90%, ORC unit availability tends to be even higher and has been exceeding 99% in multiple plants. This leads to the conclusion that in presence of a stable and continuous energy source system, the ORC technology is even more stable and reliable.

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