CROATIA’S FIRST GEOTHERMAL POWER PLANT

Rocco Altieri – Sales Engineer - Geothermal
SINCE 1980

Turboden is an Italian firm and a global leader in the design, manufacture, and maintenance of Organic Rankine Cycle (ORC) systems, highly suitable for distributed generation.

ORC systems can generate electric and thermal power exploiting multiple sources, such as renewables (biomass, geothermal energy, solar energy), traditional fuels, and waste heat from industrial processes, waste incinerators, engines or gas turbines.

Prof. Mario Gaia makes experience in the field of ORC within his research group at Politecnico di Milano.

’60 - ’70

First prototype of a solar thermodynamic ORC.

1976

1980

Prof. Mario Gaia founds Turboden to design and manufacture ORC turbogenerators.

1998

First ORC geothermal plant in Austria (1 MW).

2001

MHI acquires the majority of Turboden. Italian quota-holders stay in charge of management.

2009

United Technologies Corp. (UTC) acquires the majority of Turboden’s quota.

2013

Start up of two large geothermal power plants in Croatia, 17.5 MW, and USA, 14 MW.

2018

More than 370 ORC plants in the world, 310 in operation.

2019

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## SELECTED GEOTHERMAL REFERENCES

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Capacity (MWe)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>Dürrnhaar, Germany</td>
<td>5.6</td>
<td></td>
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<tr>
<td>2013</td>
<td>Kirchstockach, Germany</td>
<td>5.6</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Sauerlach, Germany</td>
<td>5 MWe + 4 MWth</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>Sugawara, Japan</td>
<td>5 MWe</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td>Traunreut, Germany</td>
<td>4.1 MWe + 12 MWth</td>
<td>Start-up expected in 2016</td>
</tr>
<tr>
<td>2015</td>
<td>Soultz-sous-Foretz, France</td>
<td>1.7 MWe</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Afyon, Turkey</td>
<td>3 MWe</td>
<td></td>
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<tr>
<td>2018</td>
<td>Velika Ciglena, Croatia</td>
<td>17.5</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>Lightning Dock, New Mexico (USA)</td>
<td>14 MWe</td>
<td></td>
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<tr>
<td>2018</td>
<td>Holzkirchen, Germany</td>
<td>3.3 MWe + 10 MWth</td>
<td></td>
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<tr>
<td>2016</td>
<td>Berlin, El Salvador</td>
<td>8 MWe</td>
<td></td>
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</tbody>
</table>
VELIKA CIGLENA - PROJECT LOCATION

The Velika Ciglena project area is located in the SW part of Pannonian basin, in the Bjelovar depression (NE part of Croatia). The reservoir was discovered in 1990 by the VC-1 well within the scope of exploration for oil, conducted by INA-Naftaplin. Oil was not found, but a promising geothermal potential was established. A casing was lowered into the well at the depth of 2574 m. An unusual high temperature (172 °C) was registered.
VELIKA CIGLENA – THE LARGEST ORC IN EU

The Velika Ciglena geothermal power plant is the largest ORC system in Europe. Turboden provided engineering and procurement of equipment for the customer GEOEN.

For this particular project, Turboden designed and manufactured a unique single turbine with 5-stages with optimized performance at rotation speed of 1500 rpm, receiving by Mitsubishi Heavy Industries the prize for the best innovation 2016 in the group.
VELIKA CIGLENA – THE POWER PLANT

The ORC binary power plant exploits steam and hot water at 170°C to produce electricity to feed the local power grid. The plant has been successfully started up in 2018 and it grants a highly efficient behavior in all the operation conditions thanks to the flexibility of the ORC system.

Technical on design data:
- Two production wells (brine and steam)
- Two reinjection wells
- 17,5 MW Nominal Capacity
VELIKA CIGLENA - CURRENT STATUS

Current status:

- Hot commissioning started on November 2018, and *first synchronization* was achieved on 03/12/2018.
- Currently, electric grid *feed-in is limited to 10 MW by the operator*
- First months of operation have been performed with one production well, producing *10 MW net* electric (partial load).
- On mid of May the *second production well* was partially opened. Total production still as above.
- After November 2019, the feed-in limit is expected to be removed, allowing to increase *flow and power to nominal values*.
CONCLUSION

• The Velika Ciglena geothermal power plant is the largest ORC system in Europe, and the first Turboden’s geothermal ORC in the Pannonian basin.

• The Pannonian basin ranges among several countries (mainly Serbia, Croatia, Hungary, Slovakia, and Romania), providing good geothermal resource both for heat and power production.

• Turboden proven technology and experience can provide optimized solutions for the success of the geothermal projects in the area, also for combined heat-and-power configurations.
THANK YOU FOR YOUR ATTENTION

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