RENEWABLE HEATING AND COOLING IN CROATIA: ANSWER TO THE CURRENT CHALLENGES OF HIGH PRICES AND SECURITY OF SUPPLY

CHP BIOMASS PROJECTS IN CROATIA

Marco Baresi
Institutional Affairs and Marketing Director

May, 24th 2022
OUR MISSION

We provide unique, reliable and advanced technologies founded on our core proprietary turbomachinery, with the aim of maximizing the value of renewable resources and energy efficiency.
OVER 40 YEARS OF A Viable Sustainability

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, which produce electric and thermal power exploiting multiple sources.

Thanks to its long experience in the energy efficiency sector, today Turboden expands its solutions offering with gas expanders and large heat pumps.
OUR PRODUCTS

- ORC SYSTEM
- LARGE HEAT PUMP
- GAS EXPANDER

Designed for decarbonisation.

CHP biomass projects in Croatia
GLOBAL AND PROVEN EXPERIENCE

- **BIOMASS**
  327 units, 476.6 MWe

- **WASTE TO ENERGY**
  25 units, 66.2 MWe

- **HIGHLAND HEAT PUMP**
  1 unit, 5.7 MWth

- **OIL & GAS**
  5 units, 37.3 MWe

- **WASTE HEAT**
  37 units, 89.7 MWe

- **GAS EXPANDER**
  2 units, 1.3 MWe

- **HIGH TEMPERATURE COGENERATION**
  2 units, 2.1 MWe

- **GEOTHERMAL**
  16 units, 119.1 MWe

Experience in over 50 countries

With 400+ installations

Power generated 25 thousand GWh

Cumulative operation time 19 million hours

Last update: April 2022

* including two hybrid power plants

Copyright © – Turboden S.p.A. All rights reserved
TURBODEN BIOMASS UNIT DESIGN

CHP SOLUTIONS (low and high temperature cogeneration)

Turboden units generate Combined Heat and Power (CHP) solution - providing either hot water or higher temperature heat medium (e.g. saturated steam or thermal oil). Alternatively Turboden can provide also electric power only solutions.

<table>
<thead>
<tr>
<th></th>
<th>POWER-ONLY</th>
<th>CHP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical efficiency</td>
<td>up to 30%</td>
<td>up to 22%</td>
</tr>
</tbody>
</table>
THE ORC CYCLE – HOW IT WORKS

The ORC turbogenerator uses medium-to-high temperature thermal oil to preheat and vaporize a suitable organic working fluid in the evaporator (4>5).

The organic fluid vapor rotates the turbine (5>6), which is directly coupled to the electric generator, resulting in clean, reliable electric power.

The exhaust vapor flows through the regenerator (6>7), where it heats the organic liquid (2>3) and is then condensed in the condenser and cooled by the cooling circuit (7>8>1).

The organic working fluid is then pumped (1>2) into the regenerator and evaporator, thus completing the closed-cycle operation.
EXAMPLE OF A BIOMASS PLANT WITH ORC SYSTEM

HEAT TRANSFER FLUID

The heat from biomass combustion is transferred to the ORC working fluid by means of an intermediate circuit or directly via the combustion gases in direct exchange systems. The media used in the intermediate circuits are thermal oil, saturated steam or superheated water.

*In alternative to more traditional combustion systems, gasification and pyrolysis solutions may be applied.
APPLICATIONS

- sawmill residues or by-products
- bark
- wood dust and chips
- pellet
- furniture waste
- particle board screen dust
- recycled wood waste
- olive pomace and pits
- bruning & trimmings
- barley dust
- malt dust
- rice husks
- almond shells
- sunflower husks
- coffee husks and spent ground
- corn cobs
- coconut shells and husks
- empty fruit bunches
- palm kernel shells
- cotton gin waste, stalks
- paper

HEAT USERS

- 130°C
- 50°C (low temperature)
- 200°C (high temperature)
- TRIGENERATION
- FOOD
- RICE
- PELLET
- SAWMILL
- DRYING
- DISTRICT HEATING
- FISH FARMING
- GREENHOUSE
- LAUNDRY AND IRONING WORKSHOPS
- MALT PRODUCTION
- MDF/PLYWOOD
- SYNTHETIC FIBERS
- BEER
- CHEMICAL PROCESSES
- PULP & PAPER
- DAIRY
- VEGETABLES OILS REFINING

TYPICAL FUELS

- with absorption chiller.

Copyright © – Turboden S.p.A. All rights reserved
### ORC SYSTEM – KEY POINTS

**Simplicity**
- ✓ Remote monitoring and automatic operation
- ✓ No water use and treatment required
- ✓ Minimal maintenance activities

**Flexibility**
- ✓ Ease of integration
- ✓ Excellent part load capability down to 10% load
- ✓ Different primary energy sources

**Dependability**
- ✓ High availability
- ✓ Long life (> 25 years)
- ✓ 40+ years in the design and production of turbomachinery

**Sustainability**
- ✓ Core system for renewable energy and energy efficiency
- ✓ Clean generation of power and heat
- ✓ Reduction of CO$_2$ emissions
## TURBODEN PLANTS IN CROATIA

<table>
<thead>
<tr>
<th>Customer/End user</th>
<th>City</th>
<th>Description</th>
<th>Electric power (MW)</th>
<th>Thermal power (MW)</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lika Energo Eko</td>
<td>Udbina</td>
<td>CHP - Pellet</td>
<td>1,0</td>
<td>4,0</td>
<td>Biomass</td>
</tr>
<tr>
<td>Pelet Grupa doo</td>
<td>Novska</td>
<td>CHP - Pellet</td>
<td>1,0</td>
<td>4,0</td>
<td>Biomass</td>
</tr>
<tr>
<td>Vrbovsko Eko Energija d.o.o.</td>
<td>Vrbovsko</td>
<td>CHP - Sawmill/Timber drying kilns</td>
<td>1,8</td>
<td>7,2</td>
<td>Biomass</td>
</tr>
<tr>
<td>Spin Valis International doo</td>
<td>Pozega</td>
<td>CHP - Sawmill/Wood drying</td>
<td>1,3</td>
<td>5,2</td>
<td>Biomass</td>
</tr>
<tr>
<td>Uniconfort Srl / Pana</td>
<td>Turopolje</td>
<td>CHP – Sawmill</td>
<td>1,0</td>
<td>4,0</td>
<td>Biomass</td>
</tr>
<tr>
<td>Undisclosed</td>
<td>Undisclosed</td>
<td>CHP - Sawmill/Wood drying</td>
<td>1,0</td>
<td>4,0</td>
<td>Biomass</td>
</tr>
<tr>
<td>Uniconfort Srl</td>
<td>Bjelovar</td>
<td>CHP – Sawmill</td>
<td>1,2</td>
<td>4,8</td>
<td>Biomass</td>
</tr>
<tr>
<td>Kircek Energy d.o.o.</td>
<td>Ljubescica</td>
<td>CHP - Wood drying</td>
<td>0,7</td>
<td>2,8</td>
<td>Biomass</td>
</tr>
<tr>
<td>Uniconfort Srl</td>
<td>Zakanje</td>
<td>CHP - Wood industry</td>
<td>1,1</td>
<td>4,4</td>
<td>Biomass</td>
</tr>
<tr>
<td>Inel-montaza d.o.o. / Spin Valis d.d.</td>
<td>Pozega</td>
<td>CHP - Furniture factory</td>
<td>0,6</td>
<td>2,4</td>
<td>Biomass</td>
</tr>
<tr>
<td>Amarc Din Energo</td>
<td>Novoselec</td>
<td>CHP - Sawmill</td>
<td>1,3</td>
<td>5,4</td>
<td>Biomass</td>
</tr>
<tr>
<td>Gal Energy d.o.o.</td>
<td>Mraclin</td>
<td>CHP - Woodchip and sawdust</td>
<td>1</td>
<td>4</td>
<td>Biomass</td>
</tr>
<tr>
<td>Geo Power Energy Development d.o.o.</td>
<td>Velika Ciglena, Bjelovar</td>
<td>Electric power production</td>
<td>17,5</td>
<td></td>
<td>Geothermal</td>
</tr>
</tbody>
</table>

CHP biomass projects in Croatia
In 2021 the 1.3 MWe biomass plant for Din Energo doo was started-up. The Croatian pellet company has chosen the ORC technology to produce heat to be used for the drying process and electricity to the grid, enough to cover the needs for the production process.

Site: Novoselec, Croatia
Customer: Amarc Din Energo
Configuration: CHP
ORC power: 1.3 MWe
THE POTENTIAL ... BEFORE REPOWER EU

Contribution of bioelectricity within the renewable electricity in 2030 (in ktoe)

Notes: *Final NECP still missing for DE, IE & LU. When no data is presented it means that this data was not available in the NECP.
Sources: draft and final NECPs
THE POTENTIAL ... BEFORE REPOWER EU

Bioelectricity in 2018 and in 2030 (in ktoe) (Germany in the right secondary axis)

- Total bioelectricity in 2018
- Total bioelectricity in 2030

Notes:
- *2030 data from the draft NECP*  
- Final NECP still missing for DE, IE & LU. When no data is presented it means that this data was not available in the NECP*  
- Sources: draft and final NECPs
In December 2018, the first geothermal plant for electricity production in Croatia was started up. The peculiarity is represented by the size of this turbine, which has been defined as "one of the largest ORC turbines in the world" and certainly the largest of its kind in operation in EU27 with its 17.5 MW.
OUR EXPERIENCE. YOUR POWER.
## Examples of Successful Projects

<table>
<thead>
<tr>
<th>Sawnmill, Wood-Based Panel</th>
<th>Rice, Cereals, Food Processing</th>
<th>District Heating</th>
<th>Pellet and Charcoal Prod.</th>
<th>Power Only</th>
</tr>
</thead>
<tbody>
<tr>
<td>91 plants</td>
<td>8 plants</td>
<td>167 plants</td>
<td>41 plants</td>
<td>20 plants</td>
</tr>
</tbody>
</table>

### Fuel
- Wood residues (e.g. bark, sawdust, etc.) from sawmill production process.
- Rice husks, corn cobs, recovered locally from the rice/cereals processing industry.
- Various depending on geographical area (typically wood chips).
- Wood residues (e.g. bark, sawdust, etc.) from pellet and charcoal production process.
- Various depending on geographical area.

### Power
- Used to feed internal auxiliaries; it can also be used to sustain island operation.
- Used to feed internal auxiliaries; it can also be used to sustain island operation.
- Incentives as a renewable source. Also used partly to power internal users.
- Used to feed internal auxiliaries.
- Incentives as a renewable source.

### Heat
- Fully used in drying chambers as hot water or low-pressure steam.
- Used for rice processing as hot water or steam, cereal drying.
- Used to feed the heating network.
- Used as hot water for wood drying in the process.
- No use.

### Note
- Fuel generated as by-product by the industry, heat and electricity valorized internally by the same industry.
- Fuel produced as by-product by the facility, heat and electricity valorized internally by the same industry.
- Fuel collected from various sources, heat sold to the local district heating network, electricity partly used internally, and the rest sold to the grid.
- Fuel generated as by-product by the facility, heat and electricity valorized internally by the same industry.
- Fuel collected from various sources, electricity sold to the grid. Business model viability subject to biomass price fluctuation.
Turboden holds the know-how of the ORC technology thanks to its 40-years experience and over 60 turbine models for combined heat and power ORC plants, that are flexible to exploit different sources like geothermal, many kind of biomass, waste heat from industrial process or gas turbines, urban waste and natural gas.

**KEY POINTS**

- Large range size up to 20 MWe per single shaft
- Different applications: geothermal, biomass, waste heat recovery, waste to energy, Oil & Gas, combined cycles, high-temperature cogeneration
- Generate profit by valorizing a renewable source or waste heat
- Reduce specific production cost by decreasing energy demand
- Improve company sustainability
- Reduce CO₂ emissions

CHP biomass projects in Croatia