Maximizing energy utilization from biomass residues with ORC Technology

This state-of-the-art equipment, particularly suitable for distributed generation, allows the production of heat and power from renewable sources (biomass, geothermal, CSP) and heat recovery in industrial processes.

The company which was founded in 1980 in Milan by Mario Gaia, Associate Professor at Politecnico di Milano, has now more than 35 years of experience.

In 2013 Turboden became part of Mitsubishi Heavy Industries group (MHI), one of the world’s leading heavy machinery manufacturers with consolidated sales of over $33 billion (in fiscal 2014).

Today Turboden has more than 320 plants in 34 countries accounting for more than 400 MW installed.

More than 300 plants worldwide
The majority fed by solid biomass

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</thead>
<tbody>
<tr>
<td>0.2 - 6.5</td>
<td>234</td>
<td>274.1</td>
<td>45</td>
<td>86.6</td>
<td>279</td>
<td>360.7</td>
</tr>
</tbody>
</table>
Turboden experience from Central to Eastern Europe

Austrian business model

- Small villages (mountain area) → distributed generation
- Thermal energy needed (district heating)
- Biomass of good quality available on site (sawmill waste wood, forest thinning, etc.)
- No needs of certified steam engineer
- Emphasis on renewables

Ideal conditions for small/middle size (200 kW÷1 MW) ORC CHP biomass power plants

Austria is the best European example of biomass utilization, with 13% of the energy needs covered by this source. Around 20% of households have heat and sanitary water from biomass.

Biomass ORC units in Europe

<table>
<thead>
<tr>
<th>Country</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>74</td>
</tr>
<tr>
<td>Italy</td>
<td>75</td>
</tr>
<tr>
<td>Austria</td>
<td>30</td>
</tr>
<tr>
<td>Latvia</td>
<td>15</td>
</tr>
<tr>
<td>Poland</td>
<td>11</td>
</tr>
<tr>
<td>etc.</td>
<td></td>
</tr>
</tbody>
</table>

First Germany and later Italy and other EU countries followed the successful Austrian model, thanks also to:
- High price of electricity
- Incentive for renewable energy (feed-in tariffs)

Strong growth of this market between 2005 and 2010
Turboden Biomass Plants in Eastern Europe and CSI

POLAND

- **N° plants**: 11
- **MW installed**: 8.6
- **Description**: District heating

CROATIA

- **N° plants**: 8
- **MW installed**: 8.8
- **Description**: District heating

CZECH REPUBLIC

- **N° plants**: 2
- **MW installed**: 3.1
- **Description**: District heating

ESTONIA

- **N° plants**: 2
- **MW installed**: 3.2
- **Description**: District Heating

RUSSIA

- **N° plants**: 4 under construction
- **MW installed**: 16.7
- **Description**: District Heating

LATVIA

- **N° plants**: 15
- **MW installed**: 16.9
- **Description**: District Heating

BELARUS

- **N° plants**: 4
- **MW installed**: 8.9
- **Description**: District Heating

ROMANIA

- **N° plants**: 2
- **MW installed**: 2.7
- **Description**: District heating

**ESOLO d.o.o. – Cnomaž (SLO)**

- **Startup**: 2012
- **ORC**: 10 CHP Split
- **Power**: 999 kW
- **Water temp.**: 60 – 80 °C
- **Description**: Wood Drying

**Knca (SLOVAKIA)**

- **Startup**: 2013
- **ORC**: 10 CHP Split
- **Power**: 1 MWe
- **Water temp.**: 60 – 80 °C
- **Description**: Pellet Industry

**Building Energy – Krusevac (SRB)**

- **Startup**: 2017
- **ORC**: 50 CHP
- **Power**: 4500 kW
- **Water temp.**: 60 – 80 °C
- **Description**: District heating

**Eco Energy – Sarnitsa (BG)**

- **Startup**: 2013
- **ORC**: 12 HRS split
- **Power**: 1200 kW
- **Water temp.**: 25 – 35 °C
- **Description**: Power only
Roundtable discussion
Opportunities and challenges

**Best conditions**
- Huge biomass potential
- Low biomass cost
- Food and forest industry
- Thermal energy needed (district heating)
- Strong government commitment in renewables

**Barriers**
- Lack of policy framework
- Lack of finance
- Lack of knowledge

**ORC Key driver**
All power plants remotely controlled
High availability (>98%)
Low O&M required
Proposals

Turboden ORC technology proved its suitability for distributed energy production power plants

Given the high availability of biomass in Eastern Europe and Central Asia, ORC-biomass power plants represent concrete solutions to produce green electricity with a reliable alternative and renewable source

The European experience shows that targeted national policies can entail a huge development of distributed ORC power plants

HOW?

1. Definition of national targets for solid biomass in the energy mix
2. Steady regulatory framework with Feed in Tariff (FiT) for power and heat production
3. Dissemination of best practices

The European experience can be replicated in other countries of Eastern Europe and Central Asia, for a greater and greener sustainability of these regions
Back up slides
European current legislation

European directive 651/2014 valid from 1/07/2014 to 31/12/2020.

- Art.42:
  Power > 1000 kW → FEED IN PREMIUM established with auction.
  Power < 1000kW → FEED IN PREMIUM without auction
  The premium must be added to the price of the electricity sold by the producer.

- Art.43:
  Power < 500kW → FEED IN TARIFF

Considering the price of biomass (> 50+60,- €/ton in Europe) each country defined its incentive

**ITALY**
- Decreto incentivi – premium:
  300<Pel<1000 kWe → 185 €/MWh
  1000<Pel<5000 kWe → 115 €/MWh
- 75 ORC biomass power plants realized by Turboden

**GERMANY**
- Decreasing incentive – feed in tariff (comprehensive of electricity price) from 230 €/MWh (in 2009) to the current level of ~ 100 €/MWh
- 74 ORC biomass power plants realized by Turboden

**UK**
- Renewables Obligation Certificates – premium:
  96 €/MWh for power only
  128 €/MWh for cogeneration (heat and electricity)
- 8 ORC biomass power plants realized by Turboden

Other worldwide experiences:
In **Turkey**, since 2012, an incentive for biomass power plants is in place: 130 $/MWh of feed in tariff for renewables + 20 $/MWh for local content greater than 50%. Turboden installed five ORC biomass plants for a total power of 17,5 MWe
Turboden Biomass Plants in the Balkans

Esol d.o.o. – Crnomalj (SLO)
- Startup: 2012
- ORC: 10 CHP Split
- Power: 999 kWe
- Water temp.: 60 – 80 °C
- Description: Pellet plant

PANa – Turopolje (HR)
- Startup: 2015
- ORC: 10 CHP Split
- Power: 1045 kWe
- Water temp.: 60 – 80 °C
- Description: Pellet plant

Vrbosko Eko Energija – Vrboska (HR)
- Startup: 2016
- ORC: 18 CHP Split
- Power: 1862 kW
- Water temp.: 60 – 90 °C
- Description: Pellet plant

LikA Energo – UbDina (HR)
- Startup: 2012
- ORC: 10 CHP Split
- Power: 999 kW
- Water temp.: 60 – 80 °C
- Description: Pellet plant

Moderator – UbDina (HR)
- Startup: 2017
- ORC: 3 CHP
- Power: 340 kW
- Water temp.: 60 – 80 °C
- Description: Pellet plant

AAT Geotermæ– Prelog (HR)
- Startup: 2017
- ORC: 4 MW Geothermal
- Power: 4200kWe
- Water temp.: 110–70 °C (in/out ORC)
- Description: Geothermal

Bioenergana Bjelovar – Bjelovar (HR)
- Startup: 2017
- ORC: 10 CHP Split
- Power: 1045 kWe
- Water temp.: 60 – 80 °C
- Description: Pellet plant

MB Holding – Velika Ciglena (HR)
- Startup: 2017
- ORC: 16 MW geotermal
- Power: 16000 kW
- Water temp.: 170–70 °C (in/out ORC)
- Description: Pellet plant

Pelet Groupa – Novska (HR)
- Startup: 2014
- ORC: 10 CHP Split
- Power: 999 kW
- Water temp.: 60 – 80 °C
- Description: Pellet plant

Quercus – Novska (HR)
- Startup: 2017
- ORC: 10 CHP Split
- Power: 1045 kWe
- Water temp.: 60 – 80 °C
- Description: Pellet plant

Spin Vals – Pozega (HR)
- Startup: 2015
- ORC: 14 CHP Split
- Power: 1450 kW
- Water temp.: 60 – 80 °C
- Description: Sand mill

Building Energy – Krusevac (SRB)
- Startup: 2017
- ORC: 50 CHP
- Power: 4500 kW
- Water temp.: 60 – 80 °C
- Description: Pellet plant

Eco Energy – Sarnitsa (BG)
- Startup: 2013
- ORC: 12 HRS split
- Power: 1200 kW
- Water temp.: 25 – 35 °C
- Description: Pellet plant

District Heating

Power only
<table>
<thead>
<tr>
<th>#</th>
<th>Location</th>
<th>ORC Module (size)</th>
<th>Client</th>
<th>Heat Source</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Russia - Toržok, Tverskaya oblast</td>
<td>2x TURBODEN 28 CHP (5.7 MWe)</td>
<td>Modern Lumber Technology</td>
<td>Wood biomass</td>
<td>Under construction</td>
</tr>
<tr>
<td>2</td>
<td>Russia- Arkhangelsk Region</td>
<td>2x TURBODEN 22 CHP (4.6 MWe)</td>
<td>Ustianskiy Timber Industry Complex</td>
<td>Wood biomass</td>
<td>Under construction</td>
</tr>
<tr>
<td>3</td>
<td>Russia - Khabarovsk Region</td>
<td>TURBODEN 50 CHP (5 MWe)</td>
<td>Prodesa Medioambiente</td>
<td>Wood biomass</td>
<td>Under construction</td>
</tr>
<tr>
<td>4</td>
<td>Russia - Yamal Nenets Region</td>
<td>2x TURBODEN 10 CHP (2 MWe)</td>
<td>Zvezda-Energetika</td>
<td>Wood biomass</td>
<td>Under construction</td>
</tr>
<tr>
<td>5</td>
<td>Belarus, Rechitsa, Речица</td>
<td>TURBODEN 22 CHP Split (2.2 MWe)</td>
<td>Polytechnik Luft- und Feuerungstechnik GmbH</td>
<td>Wood biomass</td>
<td>In operation since June 2011</td>
</tr>
<tr>
<td>6</td>
<td>Belarus, Rechitsa, Речица</td>
<td>TURBODEN 22 CHP Split (2.2 MWe)</td>
<td>Polytechnik Luft- und Feuerungstechnik GmbH</td>
<td>Wood biomass</td>
<td>In operation since June 2011</td>
</tr>
<tr>
<td>7</td>
<td>Belarus, Baran</td>
<td>TURBODEN 30 CHPRS (3.2 MWe)</td>
<td>Polytechnik Luft- und Feuerungstechnik GmbH</td>
<td>Wood biomass</td>
<td>In operation since December 2013</td>
</tr>
<tr>
<td>8</td>
<td>Belarus, Minsk</td>
<td>TURBODEN 14 CHP (1.3 MWe)</td>
<td>Altenergy SIA</td>
<td>Wood biomass</td>
<td>In operation since March 2015</td>
</tr>
</tbody>
</table>