EXERGY’S MAJOR INNOVATIONS AND THEIR PROVEN PERFORMANCES

INDUSTRY PITCH – ORC SEMINAR

Luca Xodo – Head of Business Development
Radial Outflow Turbine

Tosunlar plant: 2 pressure level - single turbine

Umurlu I plant: 12 MW plant

NCG expander

The NOSE CONE
EXERGY

› Supplier of the full ORC cycle, utilising the Radial Outflow Turbine

› 2 factories, Italy and Turkey, manufacturing the Turbine

› Offering added value, resource assessments, financing possibilities, EPC services
THE RADIAL OUTFLOW TURBINE

1. The fluid enters the turbine disk axially in its center.
2. Deviates by 90° in the Nose Cone.
3. Expands radially through a series of stages mounted on the single disk.
4. At the discharge of the last rotor, the fluid flows through a radial diffuser.
5. Is conveyed to the recuperator and/or condensation section of the system, through the discharge volute.

3D cross section of the radial outflow turbine.
THE RADIAL OUTFLOW TURBINE

Why choose a centrifugal (outflow) turbine to expand a fluid?

Efficiency and simplicity!

› **Excellent match** between volumetric flow and the cross section across the radius.
› **No 3D effects** thanks to pressure differential
› **Simpler construction** technology:
  - straight blades
  - multiple stages and pressure on single disk
› **Easy maintenance**
  - removable mechanical group

Only the Radial Outflow Turbine allows multiple pressure admissions on a single disk.
## REFERENCES

<table>
<thead>
<tr>
<th></th>
<th>MW</th>
<th># Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Geothermal</strong></td>
<td>335.5</td>
<td>21</td>
</tr>
<tr>
<td><strong>Heat Recovery</strong></td>
<td>22.8</td>
<td>14</td>
</tr>
<tr>
<td><strong>Biomass</strong></td>
<td>2.9</td>
<td>5</td>
</tr>
<tr>
<td><strong>CSP</strong></td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>362.2</td>
<td>41</td>
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</tbody>
</table>

- **Geothermal**: 335.5 MW, 92%
- **Heat Recovery**: 22.8 MW, 7%
- **Biomass**: 2.9 MW, 1%
- **CSP**: 1.0 MW, 0%
PROVEN PERFORMANCE
TOSUNLAR I PLANT
TOSUNLAR I PLANT

4MW 2 PRESSURE LEVELS - 1 TURBINE

FLOW DIAGRAM
TOSUNLAR I PLANT

4MW 2 PRESSURE LEVELS - 1 TURBINE

INLET OF 2 PRESSURE LEVEL STREAMS
# TOSUNLAR 1 PLANT

## 4MW 2 PRESSURE LEVELS - 1 TURBINE

<table>
<thead>
<tr>
<th><strong>RESOURCE TEMPERATURE</strong></th>
<th>105 °C</th>
</tr>
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<tbody>
<tr>
<td><strong>REINJECTION TEMPERATURE</strong></td>
<td>65 °C</td>
</tr>
<tr>
<td><strong>GUARANTEED MWel</strong></td>
<td>3,478</td>
</tr>
<tr>
<td><strong>CORRECTED MWel</strong></td>
<td>↑ 3,850</td>
</tr>
<tr>
<td><strong>PLANT OVER-PERFORMANCE</strong></td>
<td>+ 10,7%</td>
</tr>
<tr>
<td><strong>TURBINE EFFICIENCY</strong></td>
<td>91,69%</td>
</tr>
<tr>
<td></td>
<td>93,65%</td>
</tr>
</tbody>
</table>

*Third Party Test by POLITECNICO MILANO 1863*
UMURLU I PLANT
UMURLU I PLANT
2 PRESSURE LEVELS - 2 TURBINES 12MW

FLOW DIAGRAM
UMURLU I PLANT
2 PRESSURE LEVELS - 2 TURBINES 12MW
UMURLU I PLANT
2 PRESSURE LEVELS - 2 TURBINES 12MW

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resource Temperature</td>
<td>145°C</td>
</tr>
<tr>
<td>Reinjection Temperature</td>
<td>70°C</td>
</tr>
<tr>
<td>Guaranteed MWeL</td>
<td>12</td>
</tr>
<tr>
<td>Corrected MWeL</td>
<td>&gt;13,670</td>
</tr>
<tr>
<td>Overproduction</td>
<td>↑13,9%</td>
</tr>
</tbody>
</table>

Third Party Test by POWER ENGINEERS
THE NCG EXPANDER
THE NCG EXPANDER

MORE EXTRA POWER WITH THE NCG EXPANDER

› Designed to recover additional MW of power from non-condensable gases of the geothermal fluid
› In house design
› Single shippable standard module

ADVANTAGES
Improved performances and profitability of the plant
Resource conditions can change over time, or fail to meet expectations. A quick and inexpensive change to the first stage of the turbine, allows Exergy to better optimize the turbine for the new conditions, recovering some of the lost power.
# NOSE CONE

**Assumptions:**

- Heat exchangers and ACC (NO CHANGE)
- Brine flow rate (824 t / h)

<table>
<thead>
<tr>
<th>Nose Change</th>
<th>Brine Temperature [°C]</th>
<th>Net Power [kWe]</th>
<th>Net power increase [%]</th>
<th>Absolute difference [kWe]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td>145</td>
<td>6240</td>
<td></td>
<td></td>
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<tr>
<td>Same turbine</td>
<td>130</td>
<td>4188</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>Nose Changed</td>
<td>130</td>
<td>4489</td>
<td>7.2%</td>
<td>301</td>
</tr>
<tr>
<td>Optimized turbine</td>
<td>130</td>
<td>4620</td>
<td>10.3%</td>
<td>432</td>
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</tbody>
</table>
GREENECO ENERJI, SARAYKÖY 1, TURKEY

YEAR: 2015
APPLICATION: GEO POWER: 12 MW
KARADENIZ HOLDING, UMURLU 1, TURKEY

YEAR: 2015
APPLICATION: GEO
POWER: 12 MW
EDA RENOVAVEIS, PICO ALTO, TERCEIRA (AZORES, PT)

YEAR: 2017
APPLICATION: GEO
POWER: 4 MW
AKÇA ENERJİ
DENIZLI, TURKEY

YEAR: 2014
APPLICATION: GEO
POWER: 4MW
ENEL GREEN POWER
BAGNORE, ITALY

APPLICATION: GEO
YEAR: 2012
POWER: 1MW
Click for video
WASTE HEAT RECOVERY FROM INDUSTRIAL PROCESSES AND POWER STATIONS
GLASS MILL
APPLICATION:
SISECAM
TARGOVISHTE
WASTE HEAT RECOVERY

HEAT RECOVERY SYSTEM FOR TARGOVISHTE GLASS MILL
## Waste Heat Recovery

### Heat Recovery System for Targovishte Glass Mill

#### Performance of the Unit

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Gross El Power</td>
<td>5 MW</td>
</tr>
<tr>
<td>Net El Power</td>
<td>4.7 MW</td>
</tr>
<tr>
<td>Efficiency</td>
<td>22.6%</td>
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<tr>
<td>Total Thermal Input</td>
<td>21.3 MW</td>
</tr>
<tr>
<td>Exhaust Vol. Flow</td>
<td>270,000 Nm^3/H</td>
</tr>
<tr>
<td>Inlet Temperature</td>
<td>420°C</td>
</tr>
<tr>
<td>Outlet Temperature</td>
<td>200°C</td>
</tr>
<tr>
<td>CAPEX (total)</td>
<td>10,500,000,00 €</td>
</tr>
<tr>
<td>OPEX</td>
<td>100,000,00 €/year</td>
</tr>
<tr>
<td>Operating Hours</td>
<td>8,000h</td>
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</table>
WASTE HEAT RECOVERY

3D EXAMPLE OF AN ORC HEAT RECOVERY SYSTEM

1 Preheater 2 Evaporator 3 ACC 4 Recuperator 5 Radial outflow Turbine (ROT)
Come to meet us at our booth and turbine exhibition