Summary of technology

Large Heat Pumps (LHP) are heating plant solutions that allow to transfer large quantities of heat from a colder source to a higher temperature heat user. Turboden LHP technology – based on closed cycle - leverages 40+ years' experience in power plant design with custom made products operated by means of high temperature thermodynamic cycles. Among the heat generation technologies, Turboden is also developing a mechanical vapors recompression systems (aka "MVR"). MVR solution is a multi-stage integrally geared compressor, which compresses superheated steam up to the required process pressure and temperature. It can be installed downstream a closed loop heat pump or in a stand-alone process configuration. The MVR enhance the efficiency of heat generation with a cost-effective solution in the thermal power to supply range between 1 to 5 MW. Hereafter are reported the main features of Turboden heat generation solutions.

LHP technology summary:
- Highly efficient: Electrically driven system based on turbo compressor technology.
- Large scale: Thermal power output from 5 MWth to 40 MWth per single unit.
- High lift: More than 100 °C, possible thanks to custom design.
- High temperature: Output up to 250 °C (superheated steam generation in combination with MVR).
- Environment-friendly: Experience with 10+ different working fluids with low GWP from synthetic to natural refrigerants.

Main application:
- Large scale heat user with required temperature up to 250 °C with possibility to generate steam – mainly district heating network (DHN) and industrial user with possibility to generate steam.

Additional informations:
- Heat source side: Possibility to evaluate different streams such as water process mixture, steam, chemical compounds, etc.
- Heat user side: Heat carriers could be either liquid (water, thermal oil, etc.) or vapor (saturated steam, superheated steam, etc.)
High-Temperature Heat Pumps

- Application specific design according to existing process.
- Possible combination with storage system to cope with heat demand fluctuations (not part of Turboden scope of supply).
- Heat exchangers are typically heavy-duty shell & tube type with the possibility to select proper materials depending on the working medium.
- Flexible operation with fast start-up and shut down.

Table 1: Performance of Turboden reference cases

<table>
<thead>
<tr>
<th>$T_{\text{source,in}}$ (°C)</th>
<th>$T_{\text{source,out}}$ (°C)</th>
<th>$T_{\text{sink,in}}$ (°C)</th>
<th>$T_{\text{sink,out}}$ (°C)</th>
<th>COP$_{\text{heating}}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>8</td>
<td>104</td>
<td>170</td>
<td>2</td>
</tr>
<tr>
<td>75</td>
<td>70</td>
<td>65</td>
<td>95</td>
<td>8.2</td>
</tr>
</tbody>
</table>

Project example – First 12MWth heat pump at 170°C steam output for a paper mill

Large Heat Pump under construction in a paper mill in northern Europe. The LHP will replace Natural Gas boilers for thermal power production. EPC scope of supply.

- Low temperature waste heat produced by the paper mill can be upgraded through a LHP in combination with MVR to generate process steam within the paper mill itself.
- Double Heat recovery of wastewater and Exhaust air from paper mill through intermediate water loop.
- Heat supply capacity of 12 MW at 170°C 3.5 bar(a).
- Full integration with paper mill process. Control system designed to be highly flexible.
- High flexibility with 3 compression stages and variable frequency driver.
- Working fluid: iso-butane (R600a).
- Expected start-up: Q4 2024.

FACTS ABOUT THE TECHNOLOGY

**Heat supply capacity:** 5 MW to 40 MW LHP, 1 MW to 20 MW MVR.

**Temperature range:** Up to 250°C (superheated steam), with maximum lift exceeding 100°C.

**Working fluid:** Turboden has more than 40 years of experience in using Hydrocarbons such as butane, pentane and cyclopentane thanks to ORC technology. R1233zd is used in a heat pump in operation and water is used in MVR systems.

**Compressor technology:** Integrally geared centrifugal compressor (IGCC)

**Specific investment cost for installed system without integration:** 1000 – 300 €/kW (thermal supply capacity) depending on the heat pump and MVR unit size and temperature Lift.

**TRL level:** Large heat pump with hydrocarbons and HFOs is a proven technology (TRL 9), the MVR is under development (TRL 5).

**Expected lifetime:** 20+ years.

**Size:** Custom made – depending on specific size and application.

Contact information

Emanuele Pingaro, Turboden S.p.A.
emasie.pingaro@turboden.it
+39 3427626670

All information were provided by the supplier without third-party validation. The information was provided as an indicative basis and may be different in final installations depending on application specific parameters.