Heat Pump and Paper Industry
Thank you EHPA for the kind invitation to speak here!
This is the Atlas Copco Group

Customers in more than 180 countries

43,000 employees in 70 countries

Established in 1873 Stockholm, Sweden

Turnover of 111 BSEK/11 BEUR
A decentralized Group

BOARD OF DIRECTORS

PRESIDENT AND CEO

GROUP MANAGEMENT

COMPRESSOR
TECHNIQUE

- Compressor Technique Service
- Industrial Air
- Oil-free Air
- Professional Air
- **Gas and Process**
- Medical Gas Solutions
- Airtec

VACUUM
TECHNIQUE

- Vacuum Technique Service
- Semiconductor Service
- Semiconductor
- Semiconductor Chamber Solutions
- Scientific Vacuum
- Industrial Vacuum

INDUSTRIAL
TECHNIQUE

- Industrial Technique Service
- MVI Tools and Assembly Systems
- General Industry Tools and Assembly Systems
- Chicago Pneumatic Tools
- Industrial Assembly Solutions
- Machine Vision Solutions

POWER
TECHNIQUE

- Power Technique Service
- Specialty Rental
- Portable Air
- Power and Flow

Brussels, February 1st, 2023
EHPA-Repower EU: Heat pump and paper industries
**Atlas Copco Energas – An overview**

<table>
<thead>
<tr>
<th>Establishment</th>
<th>July 16, 1984 (date of registration)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shareholders</td>
<td>Atlas Copco Holding GmbH, Essen, Germany (100 %)</td>
</tr>
<tr>
<td>Certification</td>
<td>DIN EN ISO 9001, DIN EN ISO 14001, DIN ISO 45001, DIN EN ISO 50001, SCC</td>
</tr>
<tr>
<td>Facility size</td>
<td>Total area: 66 000 m² Factory area: 28 500 m²</td>
</tr>
<tr>
<td>Construction code</td>
<td>All common international codes and standards</td>
</tr>
</tbody>
</table>

**Products manufactured**
- Custom-made integrally-geared centrifugal compressors in single and multi-stage (1 – 8 stages) configurations
- Turbo-expanders for process gas applications and energy recovery (incl. solutions for power plants)
- Corresponding aftermarket products and services for our products
## Product overview

<table>
<thead>
<tr>
<th>Type</th>
<th>Technology</th>
<th>No. of stages</th>
<th>Max. power kW</th>
<th>Max. pressure bar a</th>
<th>Types of gases</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Compressors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Integrally-geared for process gas</td>
<td>1 – 8</td>
<td>37 000</td>
<td>205</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>Non-geared for air</td>
<td>1 – 3</td>
<td>37 000</td>
<td>7</td>
<td>Air</td>
</tr>
<tr>
<td></td>
<td>Non-geared for polyolefins</td>
<td>1</td>
<td>6 000</td>
<td>40</td>
<td>PE / PP</td>
</tr>
<tr>
<td></td>
<td>Oil-free gas screw</td>
<td>1 – 3</td>
<td>1 100</td>
<td>30</td>
<td>(Bio)-methane, NG, BOG, CO2, mixed refrigerant</td>
</tr>
<tr>
<td></td>
<td>Oil-injected gas screw</td>
<td>1</td>
<td>250</td>
<td>16</td>
<td>(Bio)-methane, NG, BOG, CO2, mixed refrigerant</td>
</tr>
<tr>
<td><strong>Expanders</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Geared</td>
<td>1 – 4</td>
<td>23 000</td>
<td>250</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>Non-geared</td>
<td>1 – 4</td>
<td>23 000</td>
<td>200</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>Oil-free gas screw</td>
<td>1 – 3</td>
<td>500</td>
<td>25</td>
<td>Natural Gas (pipe-line)</td>
</tr>
<tr>
<td><strong>Compander</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Geared</td>
<td>1 – 8</td>
<td>37 000</td>
<td>205</td>
<td>All</td>
</tr>
</tbody>
</table>
Steam Generation
Case Overview

- **Upgrade of the steam production** in a German Paper Mill
- The plant has already a shortage of steam for the actual paper production
- Future Increase of Cardboard production requires additional steam
- **Turn Key Supply of a Heat Pump System**
- Heat Pumps System for Base Load Steam Demand
  - Approx. 42 t/h Steam
  - 5 bar
  - 175 °C
  - Total COP =2,3
  - 11 MW heat recovery from Drying Hood
Case: Base Load Heat Pumps Steam Generator for a German Paper Mill

Heat Pump
n-Butan Cycle
COP = 3.6
P = 6.6 MW

Evaporator
Water
T = 40°C

Heat Pump Compressor
T = 129°C

Condenser
Steam Generator
T = 129°C

Steam 41.8 t/h
5.0 bara and 175°C
Q = 25 MWth

Drying Hood
Drying – Sizing – Post Drying

Steam and Condensate System
Condensate Injection
4.2 t/h

Steam 37.6 t/h
1,025 bara and 100.4°C
Q = 17.4 MWth

Q = 10.8 MWth

Waste Air
T = 45°C

T = 60°C

T = 40°C

Pre-Heater

Air

from Drying Hood T_dew = 60-70°C

T = 35°C

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Heat Pump Products

Sample References

Heat Pump, 40MW\textsubscript{thermal}

Steam Compressor, Product Steam 12 bara @ 275°C

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Heat Pumps Steam Generator for German Paper Mill

COP of Steam Generating Heat Pump

Total Heat Pump System COP= 2,3

Q = 25 MW Steam at 175°C @ 5 bar abs

10,8 MW \text{thermal}
Waste Heat from Drying Hood

6,6 MW HP Power

4,4 MW Steam Compressor

Q = 17,4 MW Steam at 100,4°C @ 1,025 bar abs

Closed Loop Butane Heat Pump COP= 3,6

Steam compressor used to increase pressure and temperature of the steam
What if 150°C is sufficient?
=> Higher efficiency if you go to lower Temperature
Large scale engineered Heat Pumps Steam Generator Systems

Average CAPEX per MW$_{\text{thermal}}$ of a Engineered Heat Pump System

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# Case: Base Load Heat Pumps Steam Generator for a German Paper Mill

## OPEX, CAPEX & TCO comparison – Base Load Steam Production

<table>
<thead>
<tr>
<th></th>
<th>Gas Fired Boiler</th>
<th>Electric Boiler</th>
<th>Heat Pump Steam Generator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam Demand</td>
<td>175 °C @ 5 bar abs; ~42 t/h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Required Heat</td>
<td>kW</td>
<td>25.000</td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td>%</td>
<td>96,00</td>
<td>99,00</td>
</tr>
<tr>
<td>Primary Energy Demand*3</td>
<td>kWh</td>
<td>26.042</td>
<td>25.253</td>
</tr>
<tr>
<td>Yearly Primary Energy Consumption</td>
<td>MWh</td>
<td>216.719</td>
<td>210.152</td>
</tr>
<tr>
<td>Total price per kWh</td>
<td>EUR/kWh</td>
<td>0,07</td>
<td>0,22</td>
</tr>
<tr>
<td>Price per kWh</td>
<td>EUR/kWh</td>
<td>0,04</td>
<td>0,13</td>
</tr>
<tr>
<td>Tax and Duties*1</td>
<td>EUR/kWh</td>
<td>0,01</td>
<td>0,04</td>
</tr>
<tr>
<td>Grid usage fee</td>
<td>EUR/kWh</td>
<td>0,05</td>
<td>0,04</td>
</tr>
<tr>
<td>Carbon tax</td>
<td>EUR/kWh</td>
<td>0,01</td>
<td></td>
</tr>
<tr>
<td>Energy Cost yearly</td>
<td>TEUR</td>
<td>15.170</td>
<td>46.233</td>
</tr>
<tr>
<td>CO2 Emission *2</td>
<td>tons/year</td>
<td>43.517</td>
<td>*4</td>
</tr>
<tr>
<td>OPEX - 10 years</td>
<td>TEUR</td>
<td>151.703</td>
<td>462.333</td>
</tr>
<tr>
<td>CAPEX (approx.)</td>
<td>TEUR</td>
<td>1.300</td>
<td>1.500</td>
</tr>
<tr>
<td>TCO - 10 years</td>
<td>MEUR</td>
<td>153.003</td>
<td>463.833</td>
</tr>
</tbody>
</table>

*1 Excluding VAT and other recoverable taxes and levies; *2 200,8 g CO₂/kWh; *3 95% utilization assumed; *4 100% renewable energy assumed
Case: Base Load Heat Pumps Steam Generator for a German Paper Mill

TCO – Total Cost of Ownership for 10 years

**Summary**

- Heat Pumps Systems are the most efficient solution for CO2 neutral base load steam generation in Paper Mills
- Significant Reduction of CO2 Emissions
- TCO compare to electric boilers, the high CAPEX is off set by the high OPEX
- TCO compared to fossile fuel steam generation systems the Electric Energy Cost is the dominating factor

**Electric Energy Price Development**
- Decoupling of the price from Fossile Fuel Price
- High Electric Energy cost can be offset by CCfD’s (Carbon Contract for Differences)
- With the increase of Renewables Energy Production the Electric Energy price is expected to fall

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Industrial Applications
Turbocompressor Heat Pumps

- Many industries use LP/MP Steam as universal heat carrier
- Especially in distillation, drying and boiling processes all heat is rejected after usage
- Heat pumps allow a true energetic Circular Economy

Chemical Industry
Production
Food

Paper

District Heating

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Thank you!