

# Biomass PowerON 2023

Stockholm, 11-12 October 2023



Sustainable Technologies for Combined Heat & Power  
in District Heating and Wood Industry:  
ORC & Large Heat Pumps

*Alessandro Guercio*

*Business Developer and Sales - Biomass applications*

*[alessandro.guercio@turboden.it](mailto:alessandro.guercio@turboden.it)*

# TURBODEN IS A GROUP COMPANY OF MHI

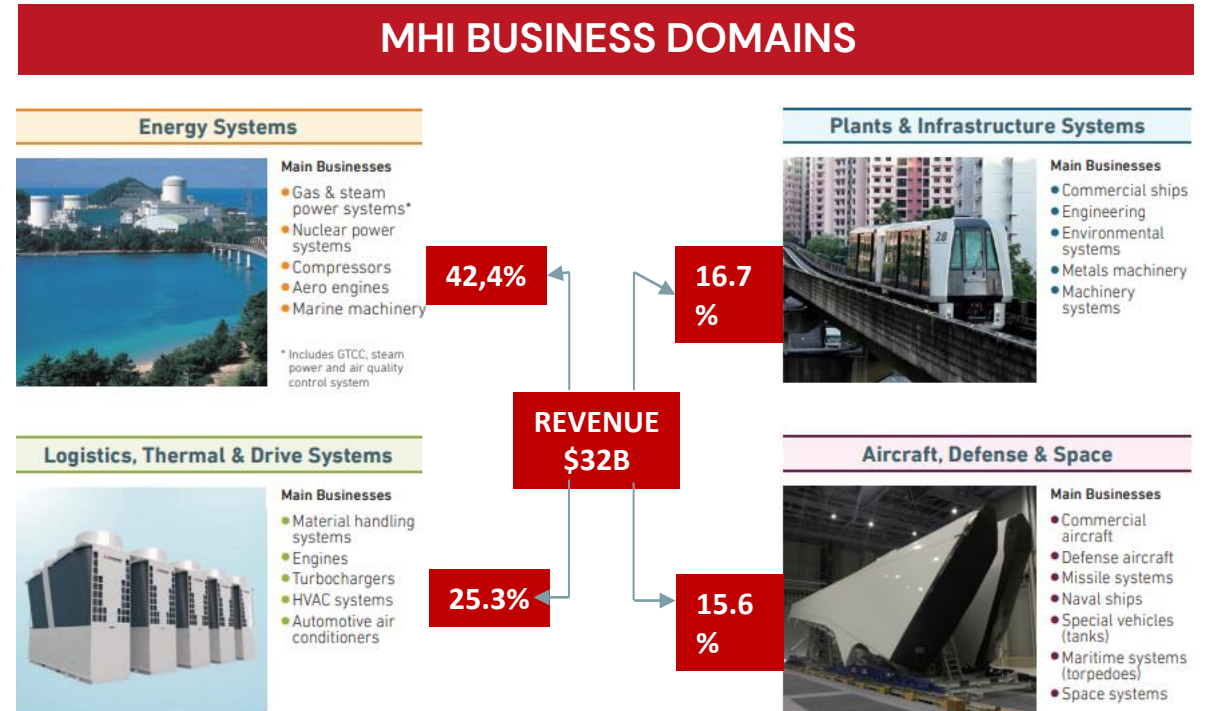


One of the world's leading heavy machinery manufacturers, with consolidated sales of around \$38 billion (in fiscal 2021).

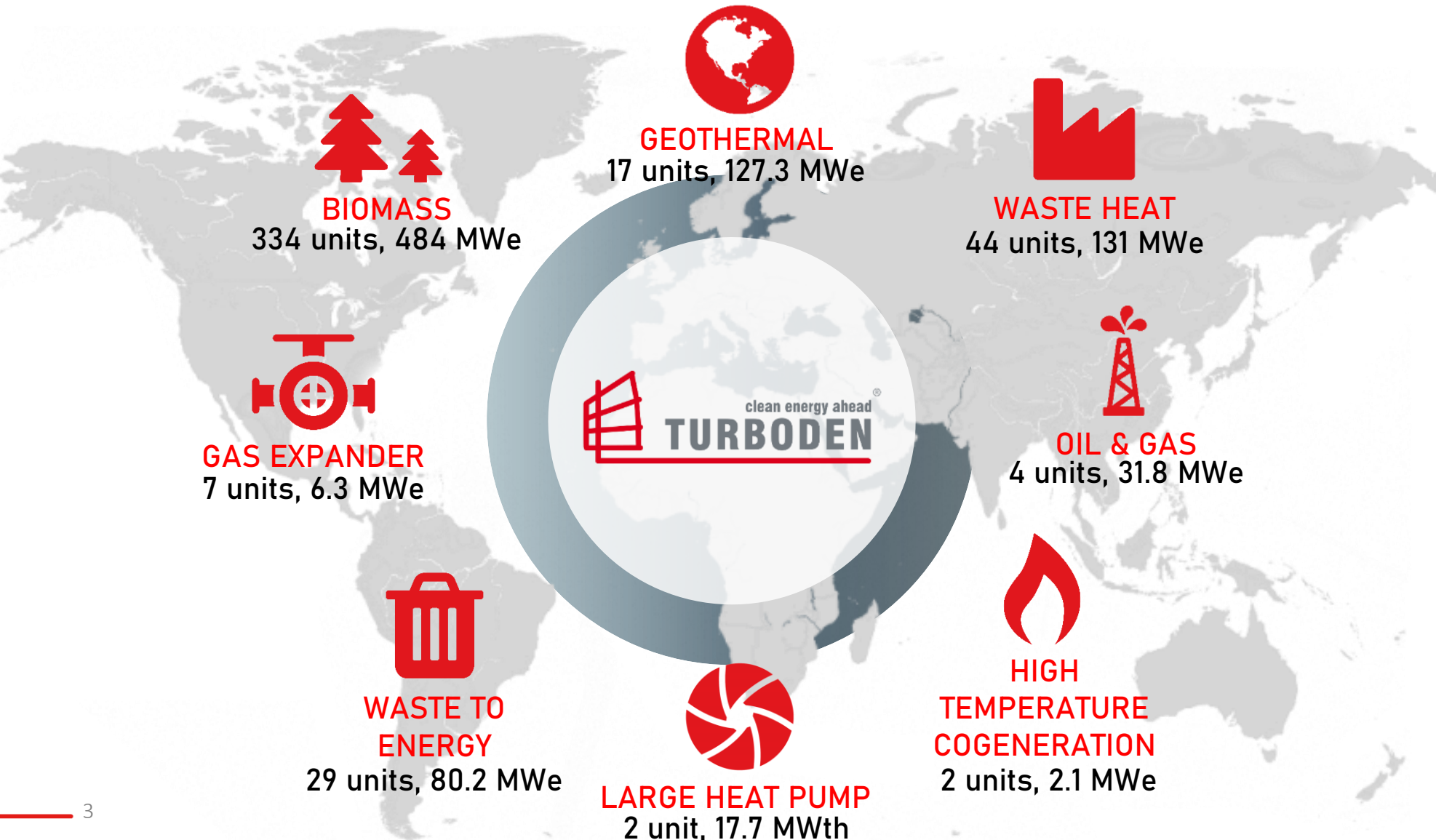
Foundation July 7, 1884



Under the energy domain, Turboden represents one of MHI green technology asset, a **front runner** in the **energy transition business**.



# GLOBAL AND PROVEN EXPERIENCE



Experience in over  
**50**  
countries

With  
**430+**  
installations

Power generated  
**25 thousand**  
GWh

Cumulative operation time  
**20 million**  
hours

Last update: September 2023

\* including two hybrid power plants

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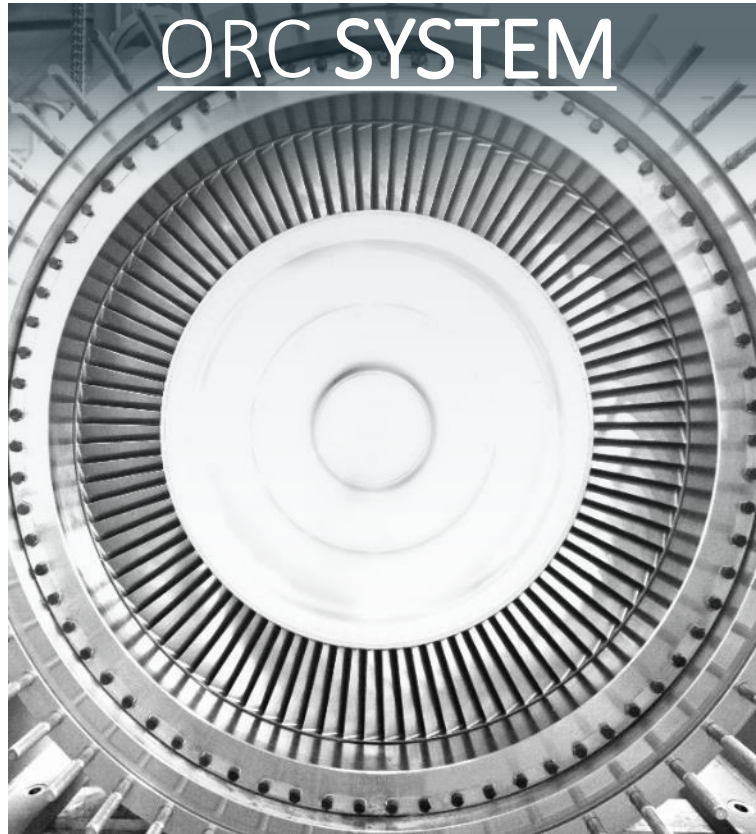


# LEADER IN BIOMASS SINCE 1980

Since its foundation Turboden has been committed to delivering efficient and reliable cogeneration solutions from renewable sources.

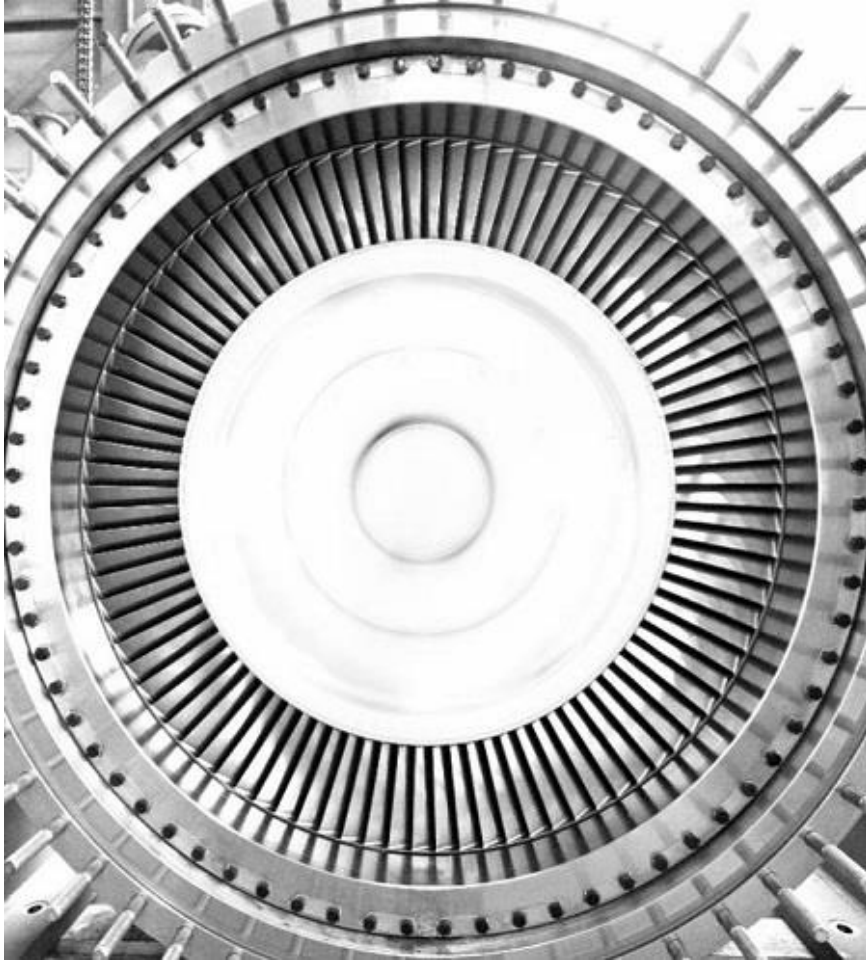


# TURBODEN PRODUCTS TO BIOMASS APPLICATIONS



Designed for decarbonisation

# ORC SYSTEM



Turboden Organic Rankine Cycle (ORC) plants produce electric power and heat with high efficiency and automatic operation by using any kind of biomass, from virgin wood to organic residues from various production processes.

## KEY POINTS

- Large range size starting from 500kW electric + 2MW heat
- High temperature thermal output up for district heating and industry process up to 150°C
- Provide a reliable source of power also for island mode operation
- Reduce specific production cost by decreasing energy demand
- Improve company sustainability
- Reduce CO<sub>2</sub> emissions

# 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. hot water or pressurized water up to 150°C).

Electric efficiency of CHP solutions up to 21%.

Alternatively, Turboden can provide also electric power only solutions with gross electrical efficiency up to 30%.

### POWER-ONLY

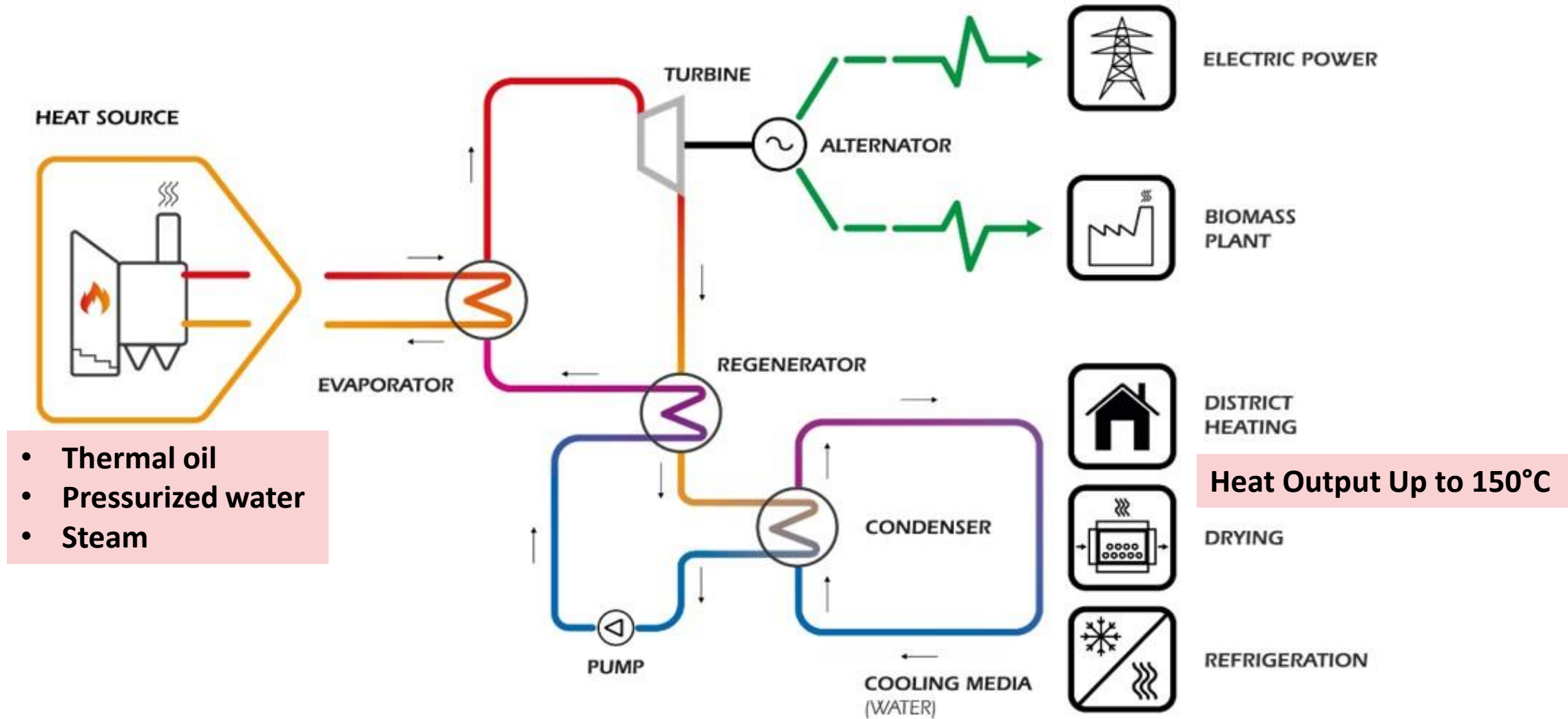
Electrical efficiency  
up to  
**30%**

### CHP

Electrical efficiency  
up to  
**22%**



# THE ORC CYCLE IN BIOMASS-FIRED APPLICATION





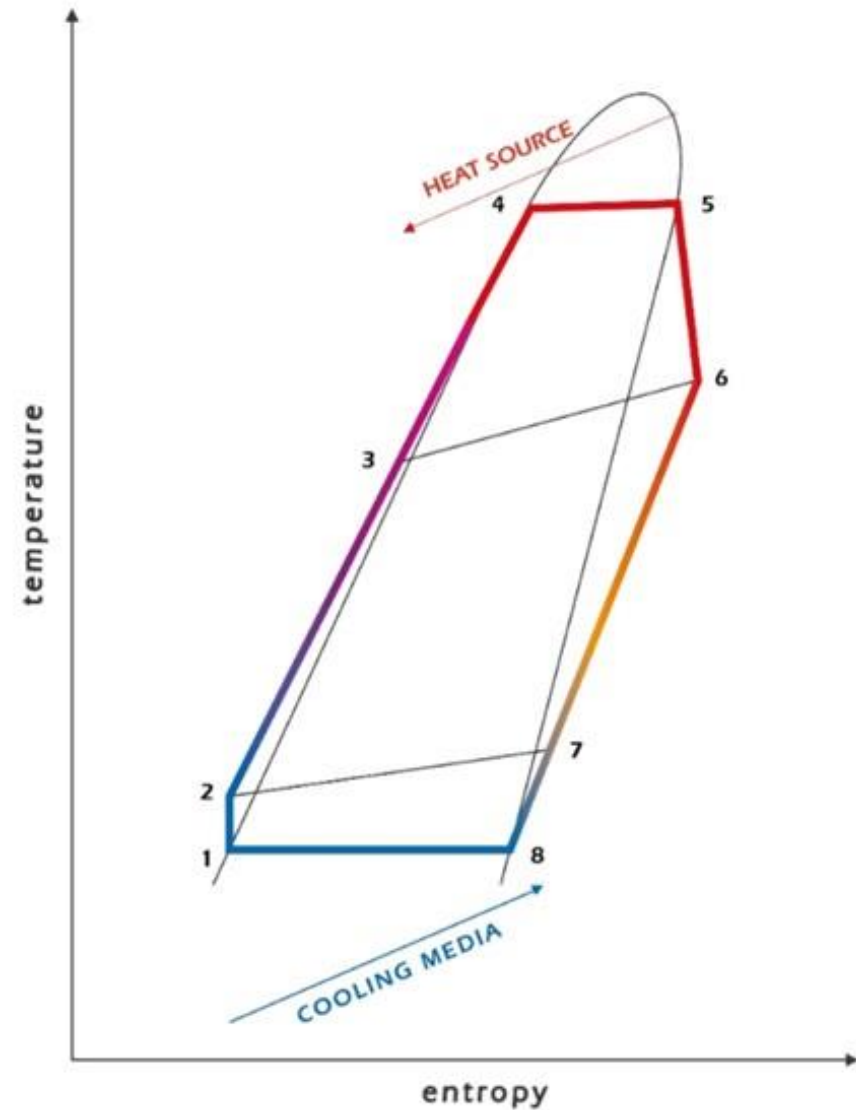
# THE ORC CYCLE – HOW IT WORKS

The ORC turbogenerator uses medium-to-high temperature heat sources to preheat and vaporize an 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 electric power.

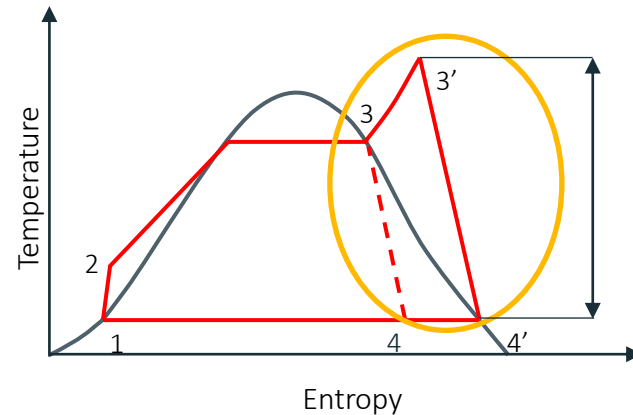
The exhaust vapor flows through the regenerator (6>7), where it heats the organic liquid (2>3) and is then condensed and cooled by the cooling circuit (7>8>1).

The organic working fluid is then pumped (1>2) into the regenerator and evaporator, thus completing the closed-cycle operation.

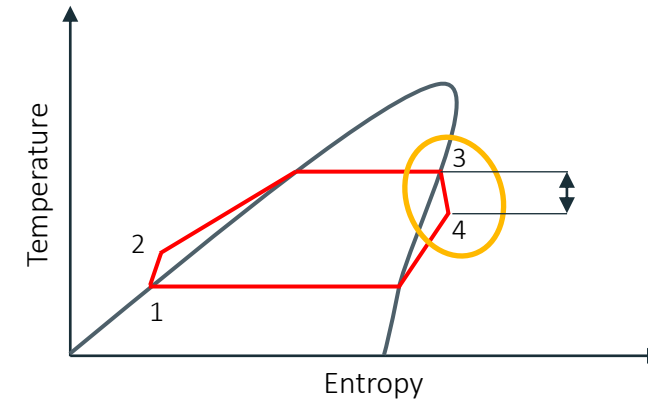


# THERMODYNAMIC CYCLE: ORC VS STEAM

STEAM RANKINE CYCLE



ORGANIC RANKINE CYCLE



Thermodynamic features and consequences

- Superheating needed
- Risk of blade erosion due to possible liquid formation during the expansion
- High enthalpy drop – turbine with high stages number

- No need to superheat
- No risk of blade erosion thanks to dry expansion in the turbine
- Small enthalpy drop -turbine with low stage number

Operation and maintenance costs

- Water treatment required
- Highly skilled / patented personnel needed
- Periodic major overhaul

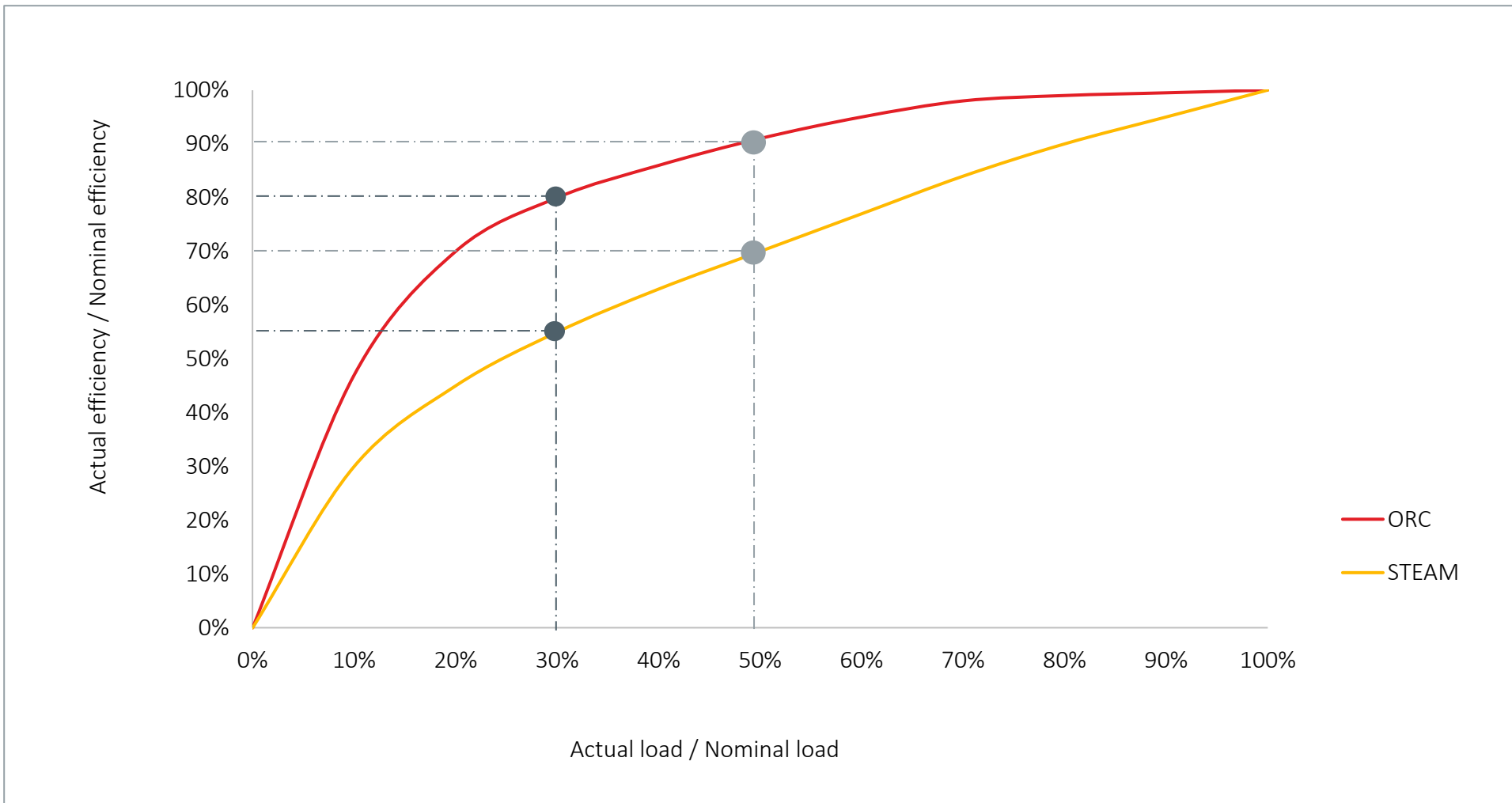
- Water-free system
- Minimum Operation & Maintenance cost
- No major overhaul
- Completely automatic

Other features

- Low flexibility with significantly lower performances at partial load
- Convenience for large plants and high temperatures

- High flexibility - Wide operational range from 10% to 110%
- High availability (average >98%)

# COMPARISON WITH STEAM TECHNOLOGY



50% PARTIAL LOAD  
ORC 90%  
STEAM 70%

30% PARTIAL LOAD  
ORC 80%  
STEAM 55%

NOTE: steam turbine suffers partial load operation due to high risk of blade erosion.

# EXAMPLES OF SUCCESSFUL PROJECTS

	SAWMILL, WOOD-BASED PANEL	RICE, CEREALS, FOOD PROCESSING	DISTRICT HEATING	PELLET AND CHARCOAL PROD.	POWER ONLY
	91 plants	10 plants	166 plants	46 plants	31 plants
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.

# CHP FOR DISTRICT HEATING IN SWEDEN

**CUSTOMER:**  
Solör Bioenergy Group

**COUNTRY:**  
Sweden

**STATUS:**  
in operation since 2012

**ORC SIZE:**  
2.3 MWe + 9,6 MWth @ 90°C

Revamped in 2023

2.6 MWe + 11 MWth @ 90°C

**DESCRIPTION:**  
CHP in district heating

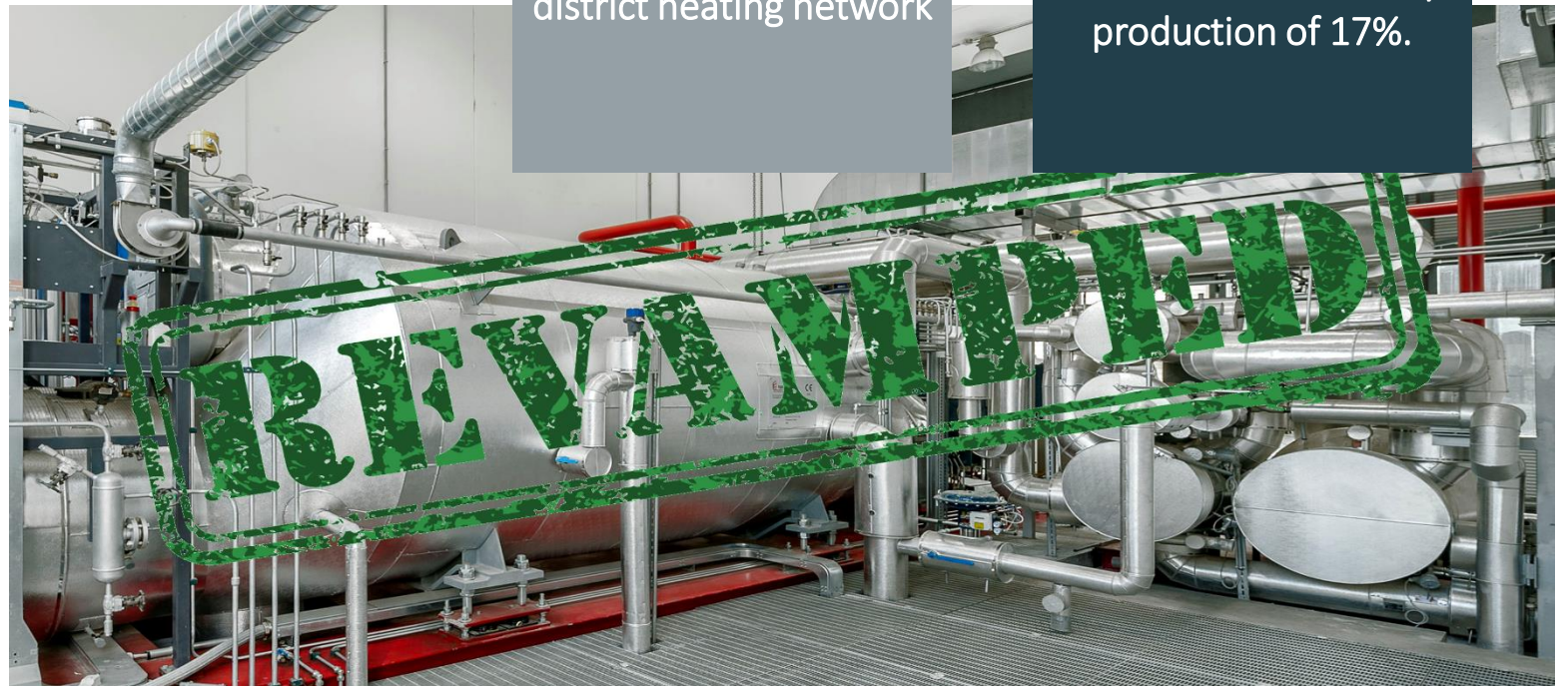
**FUEL:**  
waste wood

**HEAT CARRIER:**  
Thermal oil

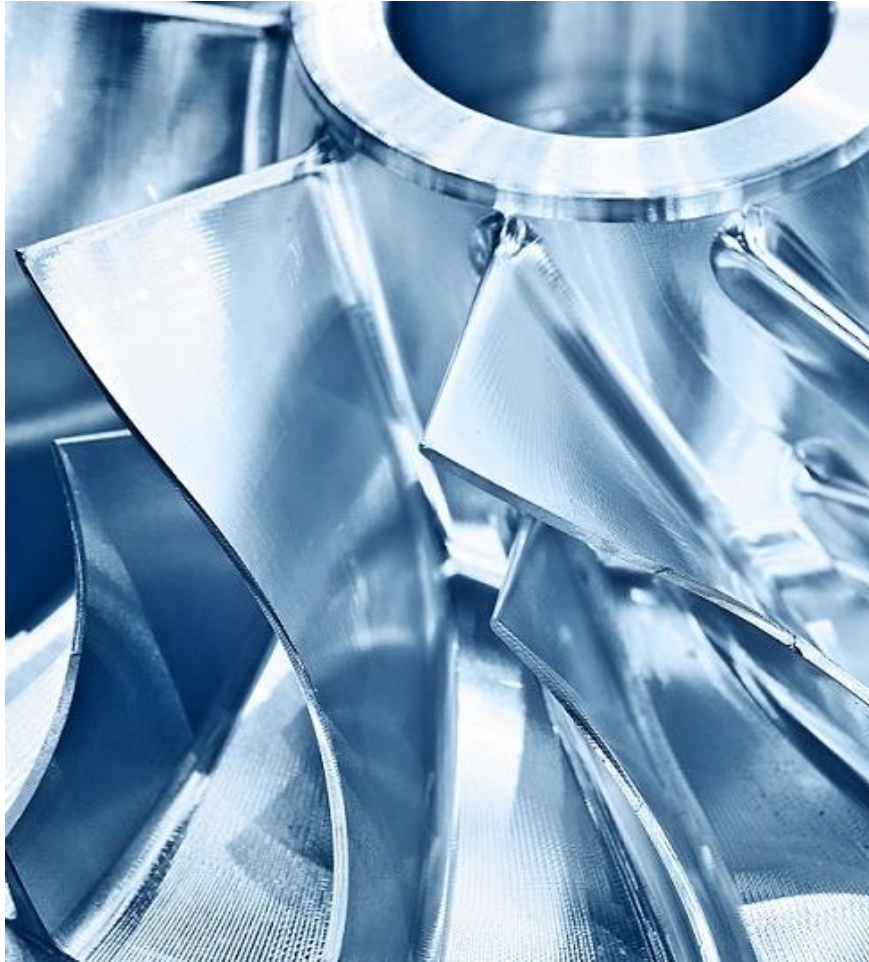
**WATER TEMPERATURE (IN/OUT):**  
60 - 90°C

Electric & thermal  
power production to a  
district heating network

ORC plant revamped in  
2023 to increase the  
the nominal electricity  
production of 17%.



# TURBODEN LARGE HEAT PUMPS

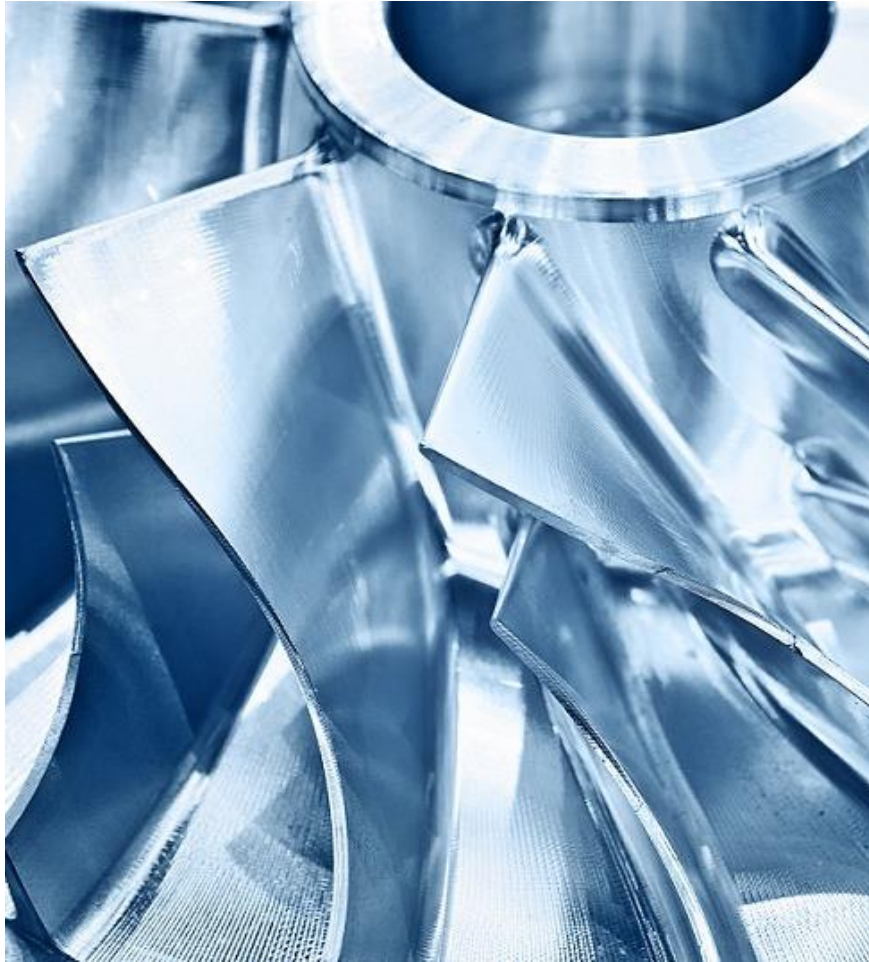


Large Heat Pumps are utility-scale heating plants that allow to transfer large quantities of heat from a colder source, like groundwater or waste heat, to a higher temperature heat user, like a district heating network or an industrial process. Turboden specializes in large scale, electrical heat pumps, based on turbocompressor technology.

## KEY POINTS

- Large-scale: output from 6 MWth to 30 MWth per unit
- High-temperature lift ( $\Delta T$  up to 80°C and more)
- High-temperature output (including steam generation)
- Various fields of application: geothermal, biomass, waste heat in energy-intensive industries, waste to energy, power plants

# FEATURES



## Simplicity

- ✓ Remote monitoring and automatic operation
- ✓ Simple technical features
- ✓ Fast start-stop procedures



## Flexibility

- ✓ Fully tailored solutions with optimised performance
- ✓ Experience with a number of different refrigerants
- ✓ Ease of integration



## Dependability

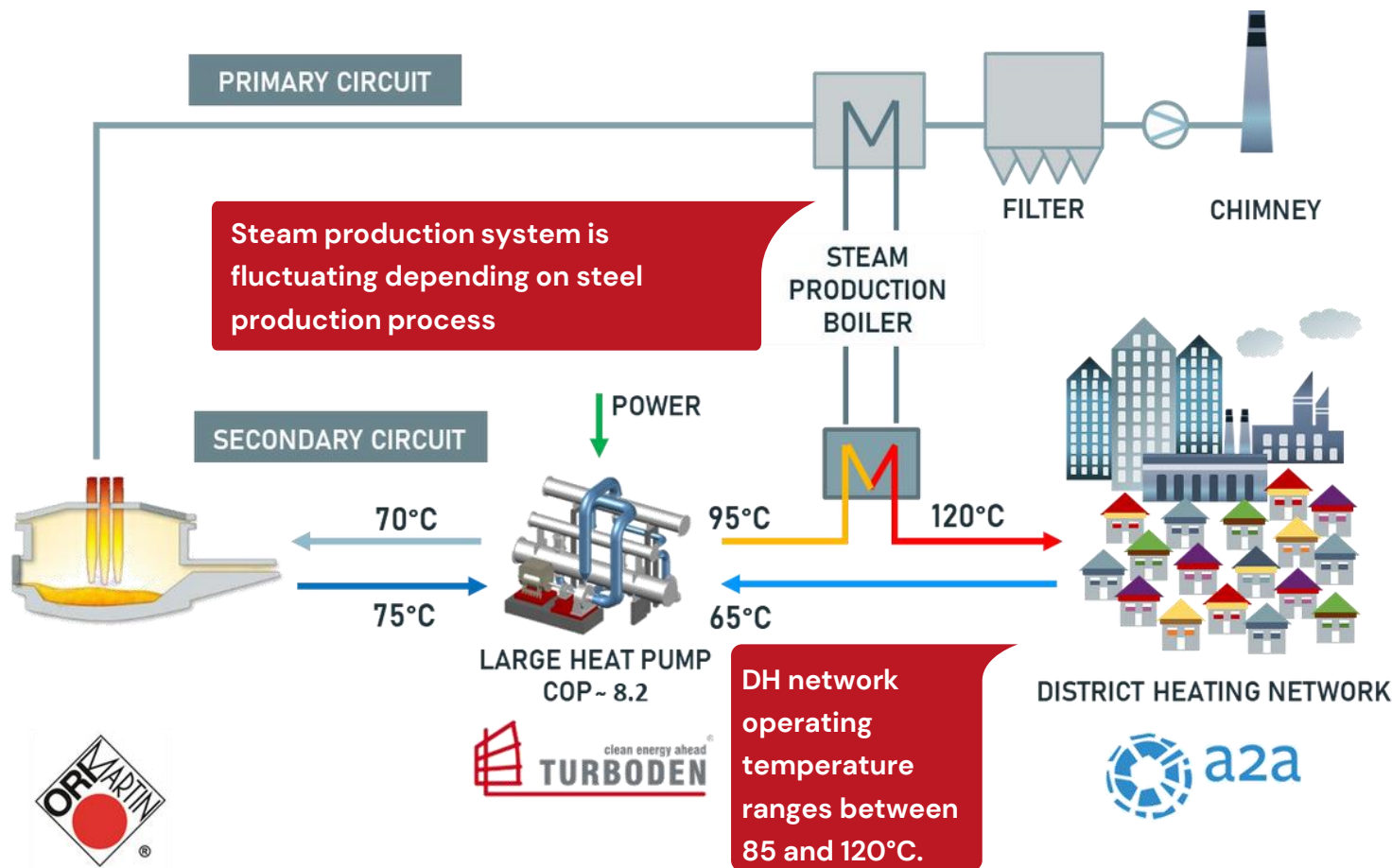
- ✓ Several proven technical solutions shared with sister ORC technology
- ✓ Global after sales service with 24/7 assistance
- ✓ Long design life



## Sustainability

- ✓ Core system for renewable energy and energy efficiency
- ✓ Clean generation of higher-grade heat
- ✓ Non-toxic, low Global Warming Potential (GWP) refrigerants

# REFERENCE CASE: ORI MARTIN STEELWORK



## Main technical features of LHP

- 6 MWth design heat delivered with output temperature up to 120°C
- Full integration with DH network. Control system designed to be highly flexible depending on:
  - DH network operating temperature
  - Steam production boiler heat production
- High flexibility with 2 compression stages and variable frequency driver
- Working fluid: Low GWP
- Start-up in May 2023







THANK YOU FOR YOUR ATTENTION

[alessandro.guercio@turboden.it](mailto:alessandro.guercio@turboden.it)

[www.turboden.it](http://www.turboden.it)



# CHP IN WOOD INDUSTRY

**CUSTOMER:**

Stia Holzindustrie

**COUNTRY:**

Austria

**STATUS:**

in operation since 1999

**ORC SIZE:**

0.5 MWe

**DESCRIPTION:**

CHP in a wood factory (wooden flooring and panels)

**FUEL:**

wood residues

**HEAT CARRIER:**

thermal oil

**WATER TEMPERATURE (IN/OUT):**

60 - 90 °C

Longest Turboden  
ORC in operation

More than 80 plants  
integrated with  
wood industries



# POWER GENERATION IN SAWMILL

**CUSTOMER:**

West Fraser Mills

**COUNTRY:**

Canada

**STATUS:**

in operation since 2014 – 2015

**ORC SIZE:**

26 MWe (4 x 6.5 MWe)

**DESCRIPTION:**

power only in two large sawmills

**FUEL:**

residues from sawmill process (mainly bark)

**HEAT CARRIER:**

thermal oil

**WATER TEMPERATURE (IN/OUT):**

24 - 34°C

The largest lumber  
producer in North  
America

More than 80 plants  
for sawmills  
worldwide



# CHP IN PELLET FACTORY

**CUSTOMER:**

Athens Energy

**COUNTRY:**

United States of America

**STATUS:**

in operation since October 2016

**ORC SIZE:**

8 MWe

**DESCRIPTION:**

power only in a wood pellet factory

**FUEL:**

virgin wood

**HEAT CARRIER:**

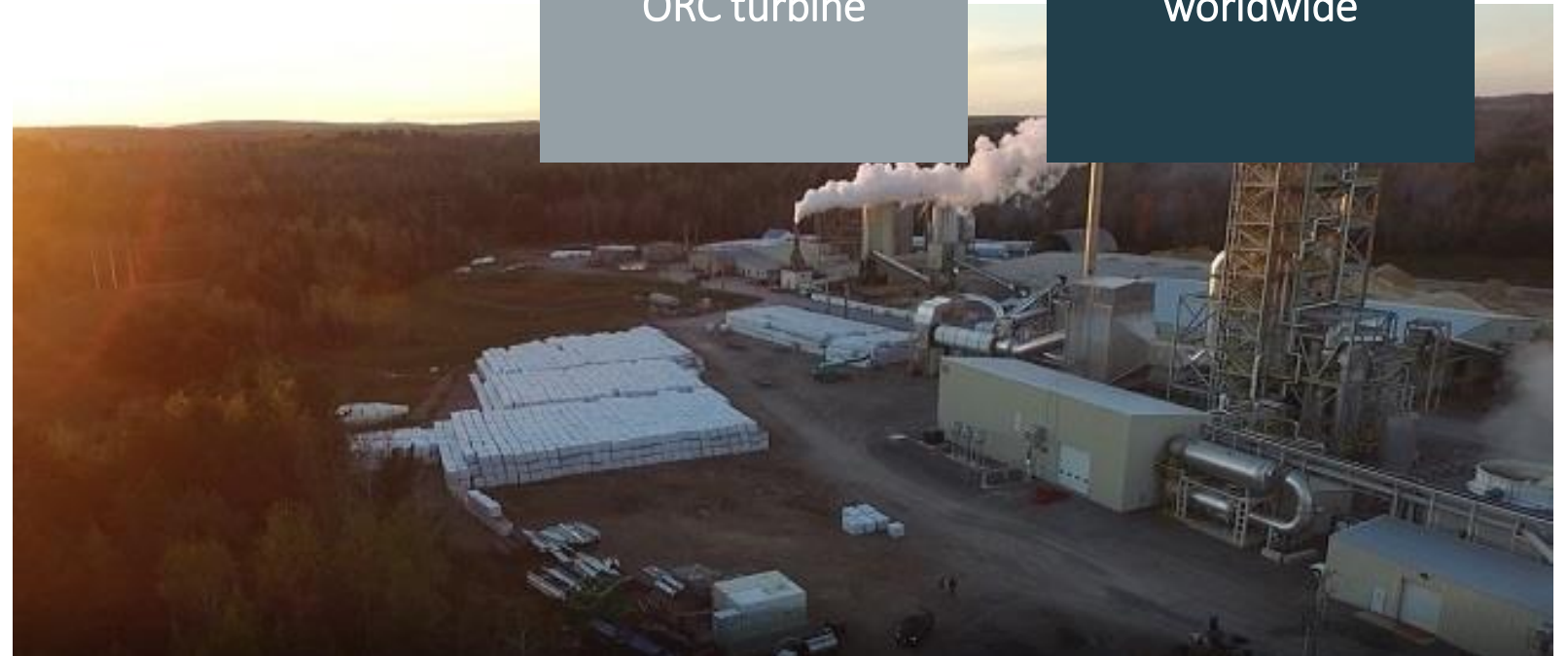
thermal oil

**WATER TEMPERATURE (IN/OUT):**

25 - 33 °C

The largest  
Turboden biomass  
ORC turbine

More than 40 plants  
for pellet industry  
worldwide



# CHP IN WOOD-BASED PANEL INDUSTRY

**CUSTOMER:**

Starwood

**COUNTRY:**

Turkey

**STATUS:**

in operation since October 2016

**ORC SIZE:**

5.5 MWe

**DESCRIPTION:**

CHP in an MDF panels factory

**FUEL:**

panels residues and wood waste

**HEAT CARRIER:**


thermal oil

**WATER TEMPERATURE (IN/OUT):**

90 - 110 °C

**ADDITIONAL FEATURES:**

ORC turbine locally produced by Turboden Turkey



About 10 plants  
(CHP and power only  
solutions) in Turkey

Tailored solutions  
for MDF, particle  
board, plywood  
factories, etc.

# CHP FOR DISTRICT HEATING NETWORK

**CUSTOMER:**

Fernheizwerk Toblach-Innichen

**COUNTRY:**

Italy

**STATUS:**

in operation since December 2003

**ORC SIZE:**

1.5 MWe

**DESCRIPTION:**

CHP for the district heating network

**FUEL:**

wood chips

**HEAT CARRIER:**

thermal oil

**WATER TEMPERATURE (IN/OUT):**

60 - 80 °C



Renewable energy  
for houses heating

166 total plants  
for district heating



# POWER GENERATION IN AGRO FOOD INDUSTRY

**CUSTOMER:**

Rice Hull

**COUNTRY:**

California, USA

**STATUS:**

Under construction, expected start-up 2021

**ORC SIZE:**

3.6 MWe

**DESCRIPTION:**


Electric power only with air cooled condenser (no water consumption)

**FUEL:**

rice husk

**HEAT CARRIER:**

thermal oil



Different kind of fuels: rice, cereal, production waste, etc.

Profitable management of agro residues

# POWER GENERATION IN AGRO FOOD INDUSTRY

**CUSTOMER:**

Sobono

**COUNTRY:**

The Philippines

**STATUS:**

in operation since December 2017

**ORC SIZE:**

5.5 MWe

**DESCRIPTION:**

CHP in a farm for cereals dryers

**FUEL:**

rice husk

**HEAT CARRIER:**

thermal oil

**WATER TEMPERATURE (IN/OUT):**

40 - 80 °C

Efficient exploiting  
of different kind  
of waste

Island mode  
operation

