



clean energy ahead[®]
TURBODEN

BIOMASS

OUR EXPERIENCE FOR YOUR COGENERATION PLANT.

They believe in us



HEIDELBERGCEMENT

AGC

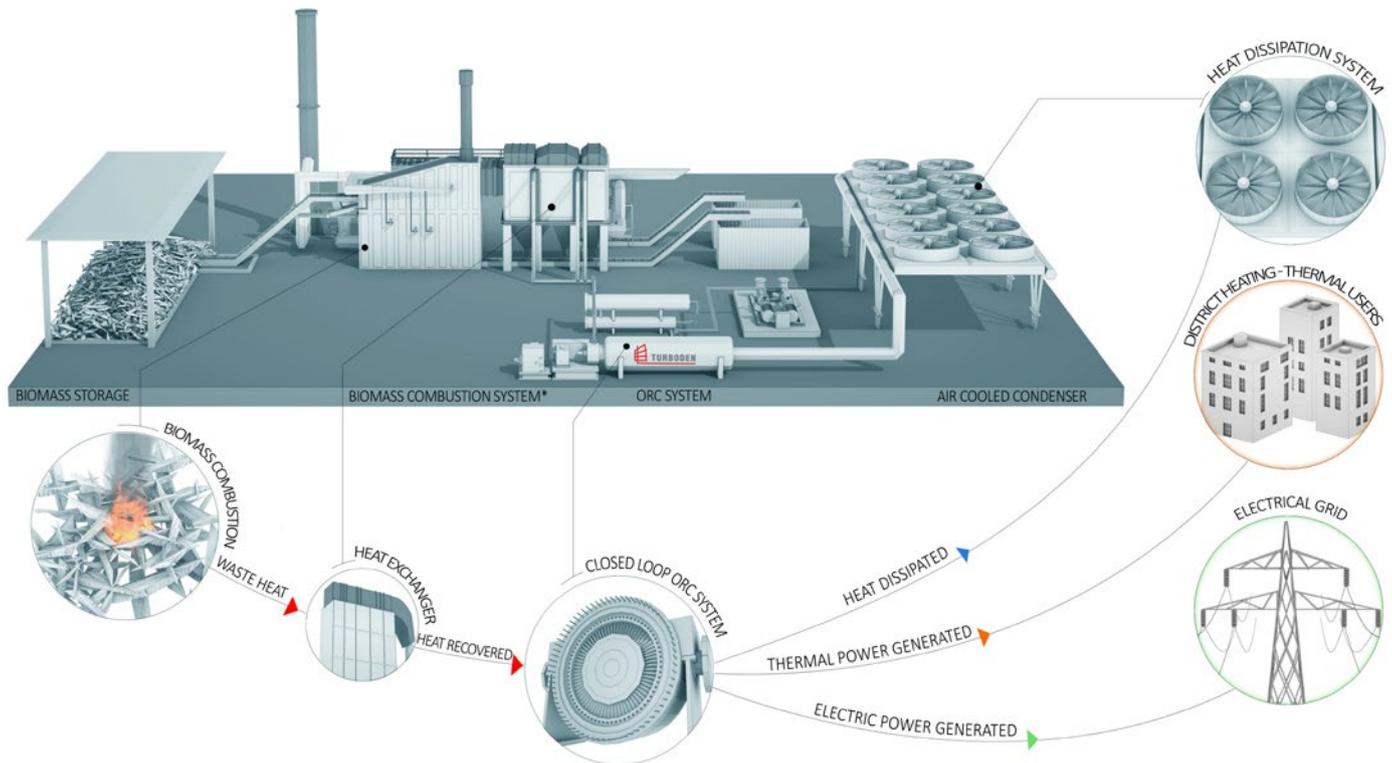


Turn green fuel into useful power

Turboden Organic Rankine Cycle (ORC) units are employed for generation of electric power only and Combined Heat and Power (CHP) with high efficiencies by using any kind of biomass, from virgin wood to organic residues from various production processes. Turboden turbogenerators in this field can generate up to 20 MW of electricity per single shaft.

POWER ONLY: generation of electric power only with no condensing heat valorization.

CHP: generation of heat and electric power.



Example of a biomass plant integrated with a Turboden ORC system.

* In alternative to more traditional combustion systems, gasification and pyrolysis solutions may be applied.



Why choose Turboden for your biomass plant?

GENERATE PROFIT FROM BIOMASS, VALORIZING HEAT AND POWER

PROVIDE A RELIABLE SOURCE OF POWER, ALSO FOR ISLAND MODE OPERATION

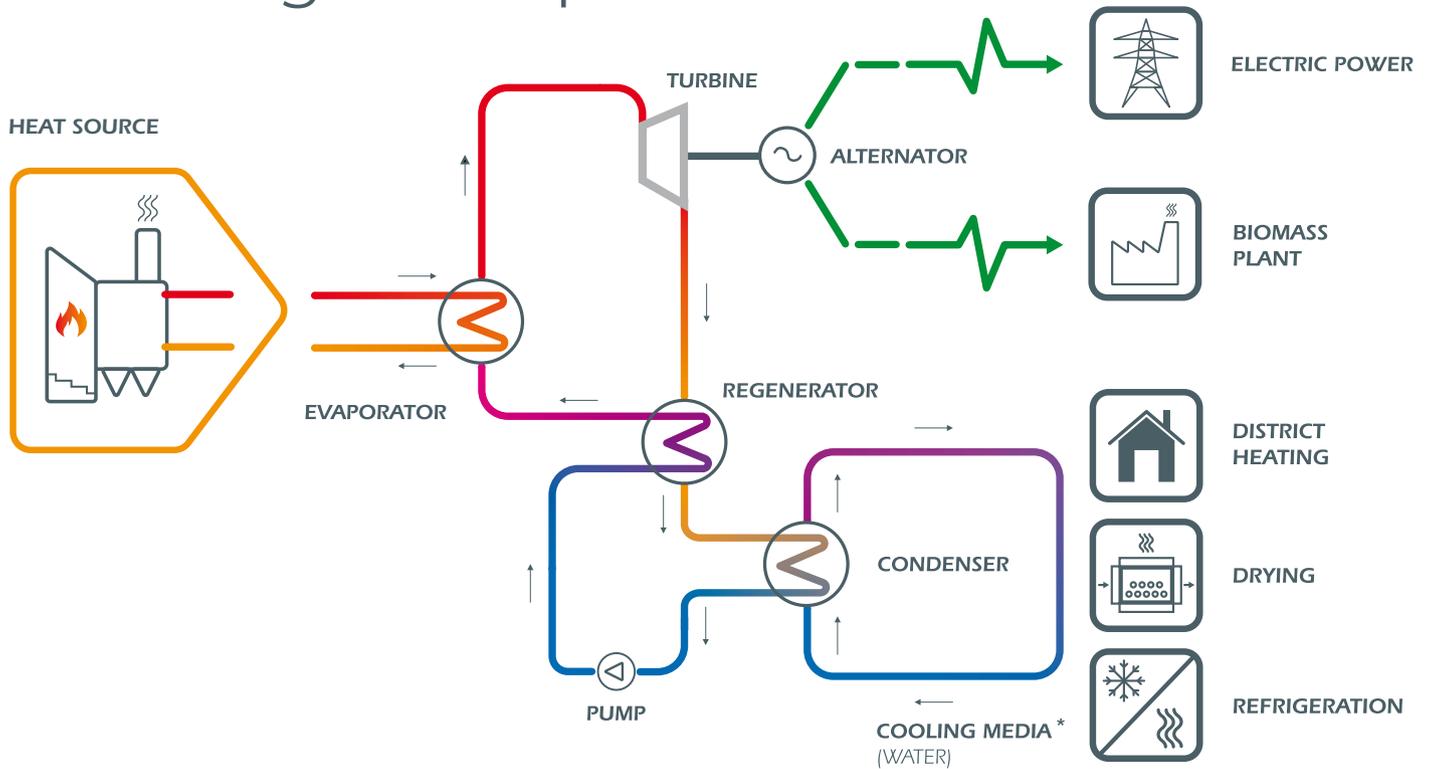
IMPROVE COMPANY SUSTAINABILITY

REDUCE CO₂ EMISSIONS

- ▼ automatic operation with no operator attendance required
- ▼ minimum maintenance requirements
- ▼ electrical efficiency for CHP / CCHP models up to 22%
- ▼ electrical efficiency for power-only models up to 30%
- ▼ high-efficiency and full flexibility operation from 10% to 110% of the nominal load



Working Principle



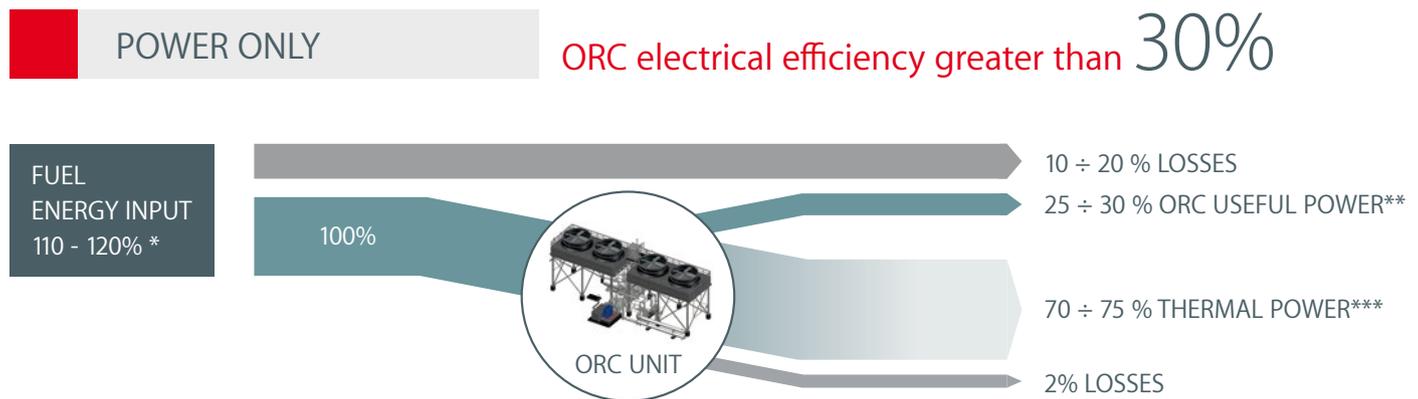
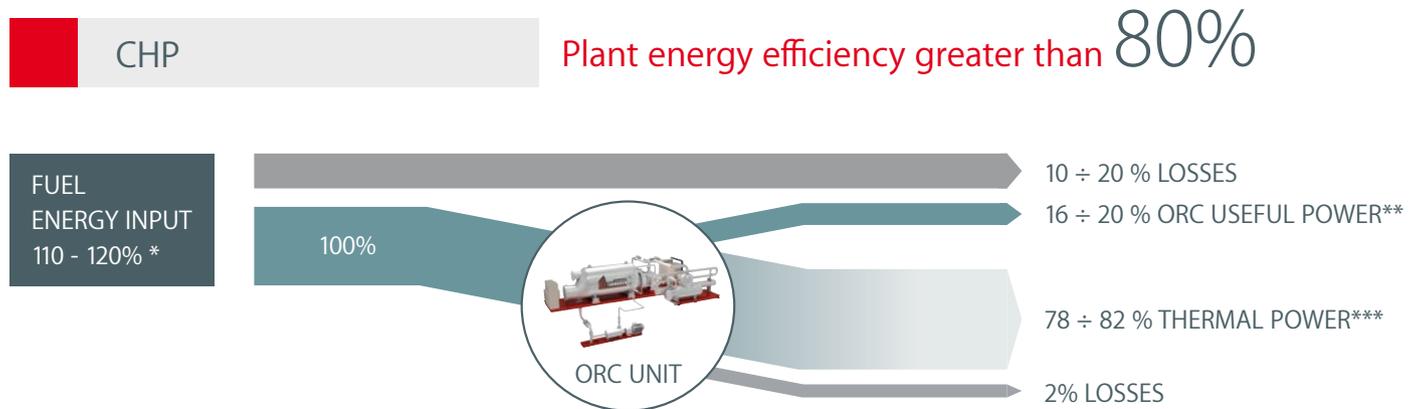
The ORC turbogenerator makes use of a closed thermodynamic cycle to convert heat into electricity. The thermal power recovered from biomass combustion vaporizes a suitable organic working fluid, which then expands through the turbine and produces clean and reliable electric power through the alternator. Thanks to the regenerator, internal heat recovery takes place improving the cycle efficiency. Downstream from the regenerator, the organic vapor is condensed and pumped back to start the cycle again. The heat from condensation can either be used by the heat users or dissipated.

The heat from biomass combustion is transferred to the ORC working fluid by means of an intermediate circuit or directly via the combustion gases in direct exchange systems. The media used in the intermediate circuits are thermal oil, saturated steam or superheated water.

* In Turboden power-only units, in which thermal users are not present, the cooling media can be either water or air with air cooled condensers.

Add free power to your biomass plant

Turboden ORC units can be used in Combined Heat & Power (CHP) plants or for electric power production only.

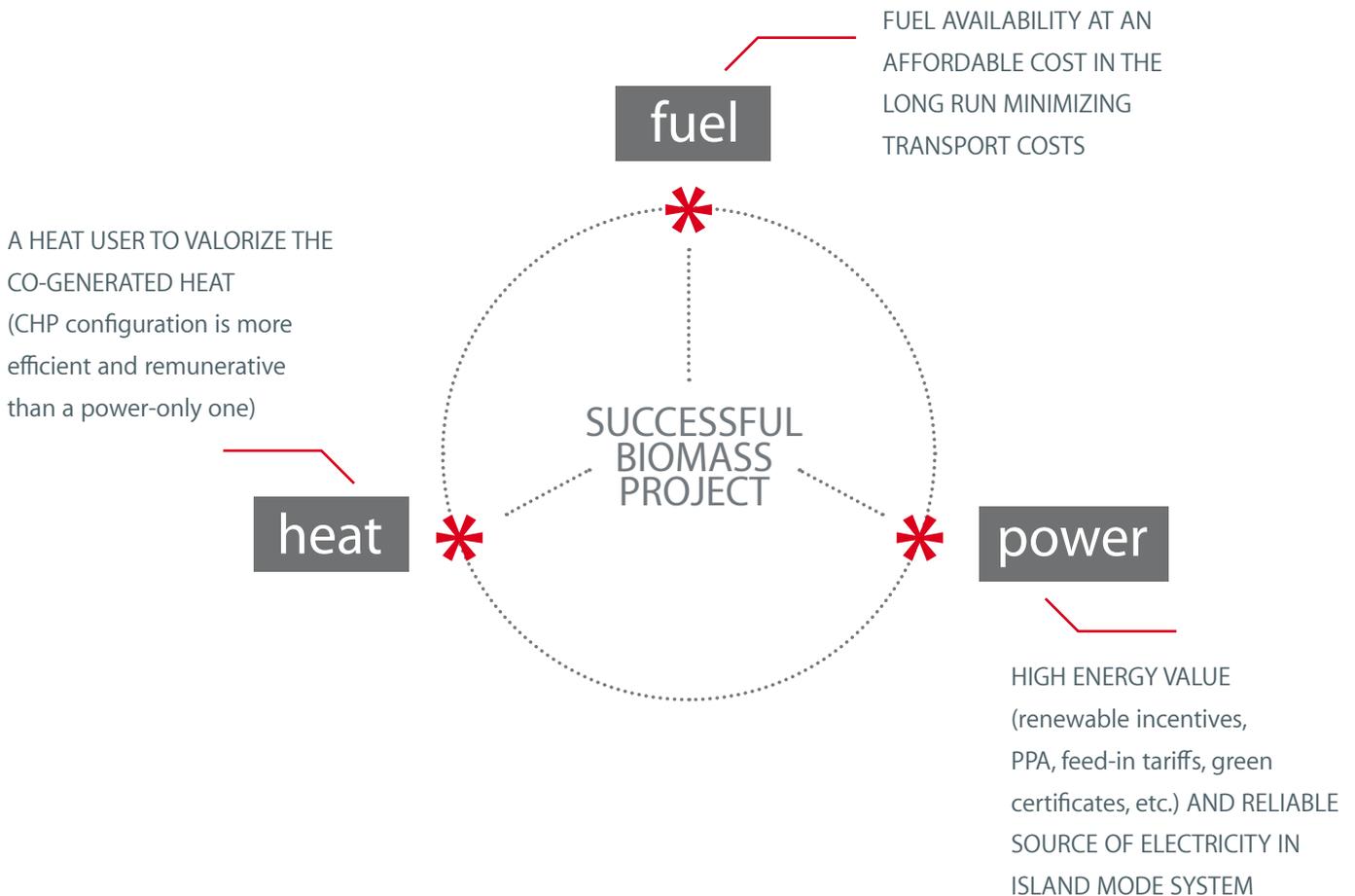


* Depending on specific fuel, CHP configuration, and boiler supplier.

** Depending on size, heat sink temperature (for CHP unit), and heat dissipation system type (for power-only unit).

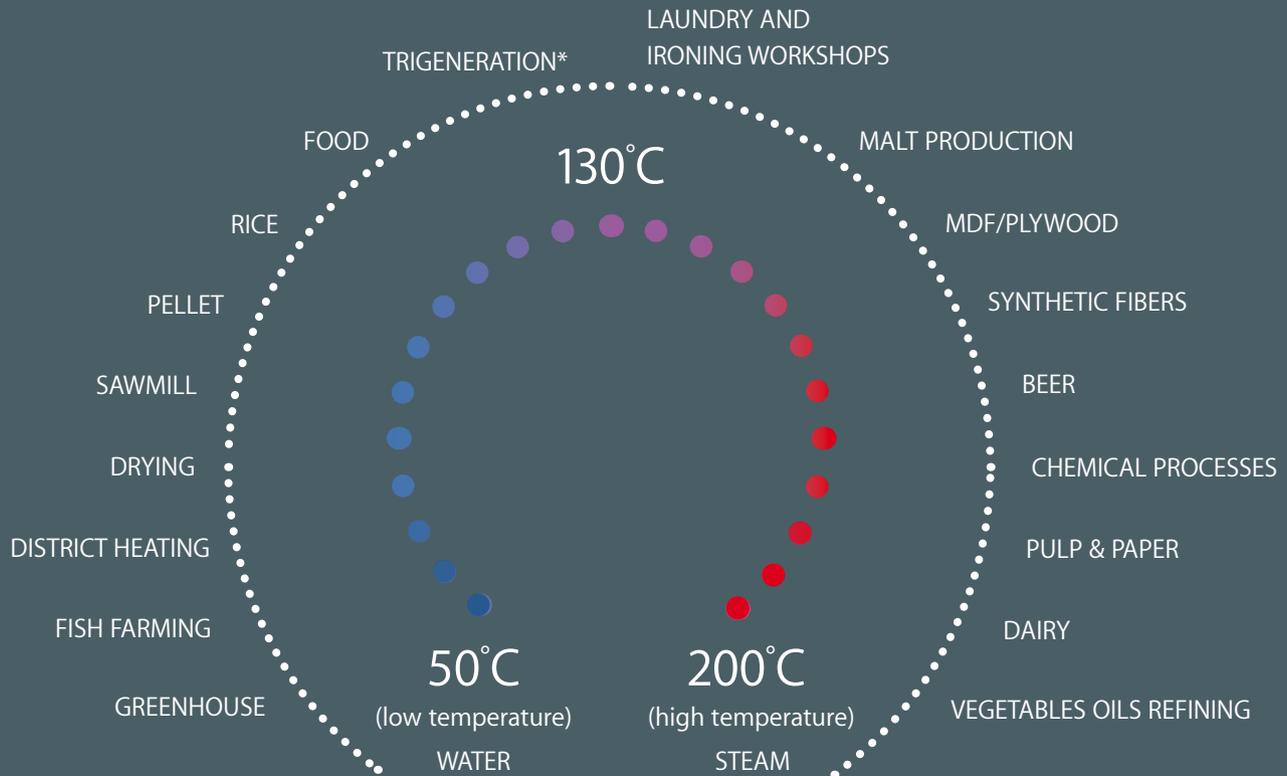
*** In the form of hot water at 80°C up to saturated steam at 12 bar.

Key factors for success



INCENTIVES: any instrument, scheme or mechanism applied by a State, that promotes the use of energy from renewable sources by reducing the cost of that energy, increasing the price at which it can be sold, or increasing the volume of such energy purchased.

Applications



FUELS

- ▼ sawmill residues or by-products
- ▼ bark
- ▼ wood dust and chips
- ▼ pellet
- ▼ furniture waste
- ▼ particle board screen dust
- ▼ recycled wood waste
- ▼ olive pomace and pits
- ▼ pruning & trimmings
- ▼ barley dust
- ▼ malt dust
- ▼ rice husks
- ▼ almond shells
- ▼ coffee husks and spent ground
- ▼ corn cobs
- ▼ coconut shells and husks
- ▼ empty fruit bunches
- ▼ palm kernel shells
- ▼ cotton gin waste, stalks
- ▼ paper
- ▼ sunflower husks

* with absorption chiller

Examples of successful projects

	SAWMILL, MDF, PANEL BOARD	RICE, CEREALS, FOOD PROCESSING	DISTRICT HEATING	PELLET & CHARCOAL	POWER ONLY
Reference projects	87 plants	8 plants	166 plants	41 plants	20 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 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 pellet production 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.



Bio



From words to deeds



STARWOOD - TURKEY

- ▼ SIZE: 5.5 MWe
- ▼ STATUS: in operation since 2016
- ▼ DESCRIPTION: CHP in an MDF panels factory
- ▼ WATER TEMPERATURE (IN/OUT): 90 - 110°C
- ▼ FUEL: MDF panels residues and wood waste



WEST FRASER MILLS - CANADA

- ▼ SIZE: 4 X 6.5 MWe
- ▼ STATUS: in operation since 2014 - 2015
- ▼ DESCRIPTION: power only in two large sawmills
- ▼ WATER TEMPERATURE (IN/OUT): 24 - 34°C
- ▼ FUEL: residues from sawmill process (mainly bark)



ATHENS ENERGY - UNITED STATES OF AMERICA

- ▼ SIZE: 8 MWe
- ▼ STATUS: in operation since 2016
- ▼ DESCRIPTION: power only in a wood pellet factory
- ▼ WATER TEMPERATURE (IN/OUT): 25 - 33°C
- ▼ FUEL: virgin wood



SOBONO - THE PHILIPPINES

- ▼ SIZE: 5.5 MWe
- ▼ STATUS: in operation since 2017
- ▼ DESCRIPTION: CHP in a farm for cereals dryers (6 months) / power only (6 months) - island mode
- ▼ WATER TEMPERATURE (IN/OUT): 34 - 42°C / 37 - 78°C
- ▼ FUEL: rice husk and corn cobs



SÄGEWERK SCHWAIGER - GERMANY

- ▼ SIZE: 2.6 MWe
- ▼ STATUS: in operation since 2014
- ▼ DESCRIPTION: CHP in sawmill
- ▼ WATER TEMPERATURE (IN/OUT): 60 - 80°C
- ▼ FUEL: residues from sawmill process (mainly bark)



SO.SV.A.V. - ITALY

- ▼ SIZE: 0.7 MWe
- ▼ STATUS: in operation since 2017
- ▼ DESCRIPTION: CHP for the district heating network - direct exchange system
- ▼ WATER TEMPERATURE (IN/OUT): 95 - 105°C
- ▼ FUEL: virgin wood



KANTOR ENERGY - UNITED KINGDOM

- ▼ SIZE: 6.7 MWe
- ▼ STATUS: in operation since 2017
- ▼ DESCRIPTION: power only
- ▼ WATER TEMPERATURE (IN/OUT): n/a (ACC)
- ▼ FUEL: recycled wood



STIA HOLZINDUSTRIE - AUSTRIA

- ▼ SIZE: 0.4 MWe
- ▼ STATUS: in operation since 1999
- ▼ DESCRIPTION: CHP in wooden flooring production factory
- ▼ WATER TEMPERATURE (IN/OUT): 60 - 90°C
- ▼ FUEL: virgin wood



PARBORIZ - ITALY

- ▼ SIZE: 0.6 MWe
- ▼ STATUS: in operation since 2008
- ▼ DESCRIPTION: CHP in an agrifood factory
- ▼ WATER TEMPERATURE (IN/OUT): 60 - 80°C
- ▼ FUEL: rice husk



MODERN LUMBER TECHNOLOGY - RUSSIA

- ▼ SIZE: 2 x 2.8 MWe
- ▼ STATUS: in operation since 2017
- ▼ DESCRIPTION: CHP in a lumber factory
- ▼ WATER TEMPERATURE (IN/OUT): 61 - 88°C
- ▼ FUEL: virgin wood



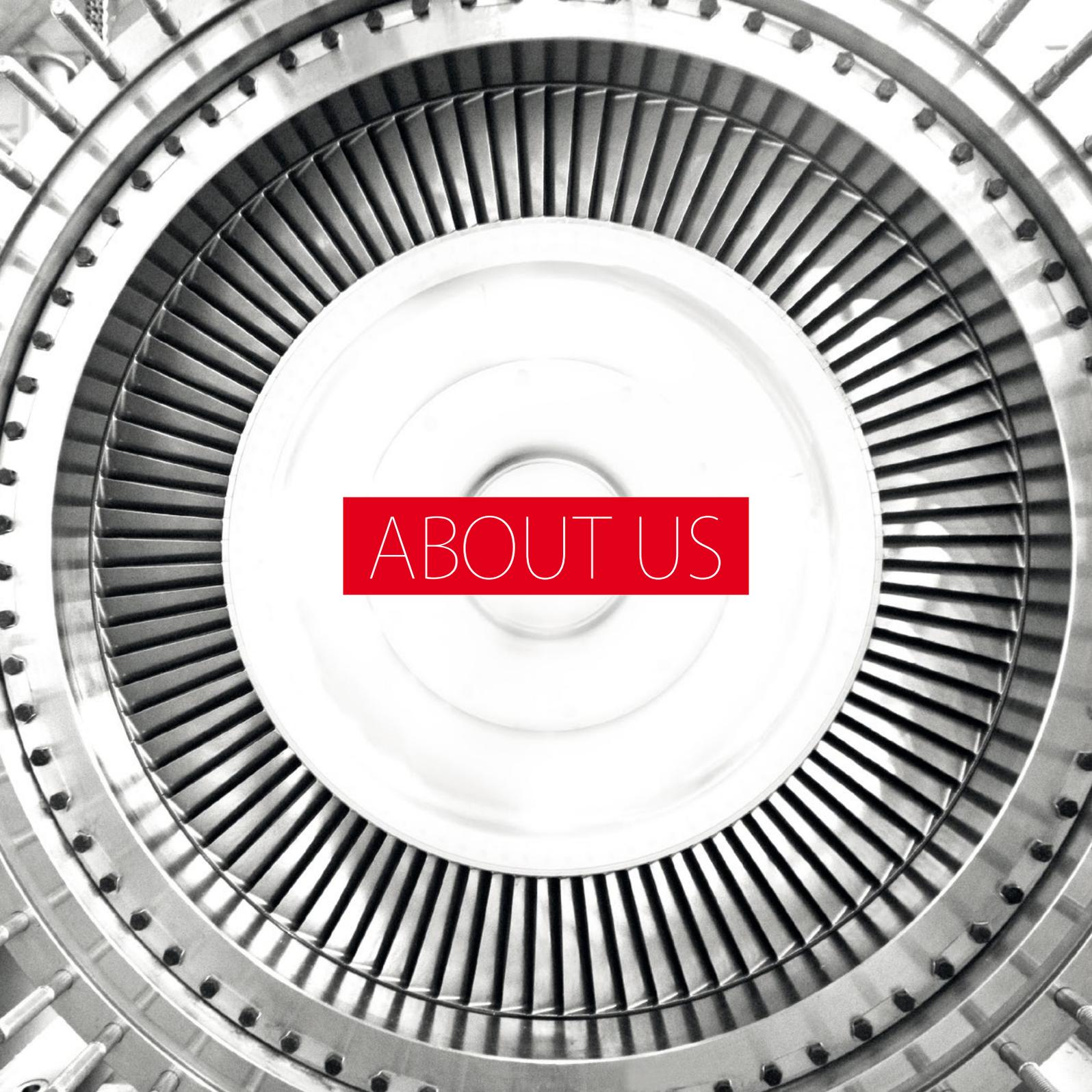
MAYR-MELNHOF HOLZ LOBEN - AUSTRIA

- ▼ SIZE: 3 X 1.5 MWe
- ▼ STATUS: in operation since 2005
- ▼ DESCRIPTION: CHP in a sawmill
- ▼ WATER TEMPERATURE (IN/OUT): 75 - 95°C
- ▼ FUEL: residues from sawmill process (mainly bark)



AGT - TURKEY

- ▼ SIZE: 5.5 MWe
- ▼ STATUS: under construction
- ▼ DESCRIPTION: power only in a wooden furniture factory
- ▼ WATER TEMPERATURE (IN/OUT): n/a (ACC)
- ▼ FUEL: virgin wood

A top-down view of a circular industrial machine, possibly a centrifuge or a specialized washing machine. The central part is a white, shallow bowl. Surrounding it is a metal grate with many vertical slats. The outermost ring is a thick metal flange with numerous bolts or screws around its perimeter.

ABOUT US



Turboden, a group company of Mitsubishi Heavy Industries, is an Italian firm and a global leader in the design, manufacture and maintenance of Organic Rankine Cycle (ORC) systems, highly suitable for distributed power generation. ORC systems can generate electric and thermal power exploiting multiple sources, such as renewables (biomass, geothermal energy, solar energy), traditional fuels and waste heat from industrial processes, waste incinerators, engines or gas turbines.



Mitsubishi Heavy Industries, Ltd. (MHI), headquartered in Tokyo, is one of the world's leading industrial firms with 80,000 group employees and annual consolidated revenues of around 38 billion U.S. dollars (year 2018). For more than 130 years, the company has channeled big thinking into innovative and integrated solutions that move the world forward. MHI owns a unique business portfolio covering land, sea, sky and even space. MHI delivers innovative and integrated solutions across a wide range of industries from commercial aviation and transportation to power plants and gas turbines, and from machinery and infrastructure to integrated defense and space systems.

Why Turboden?

PART OF MITSUBISHI HEAVY INDUSTRIES GROUP

Turboden benefits from the Mitsubishi Heavy Industries global network in a number of ways, including: financial stability, sharing of business practices (including customer warranties) and technology development.

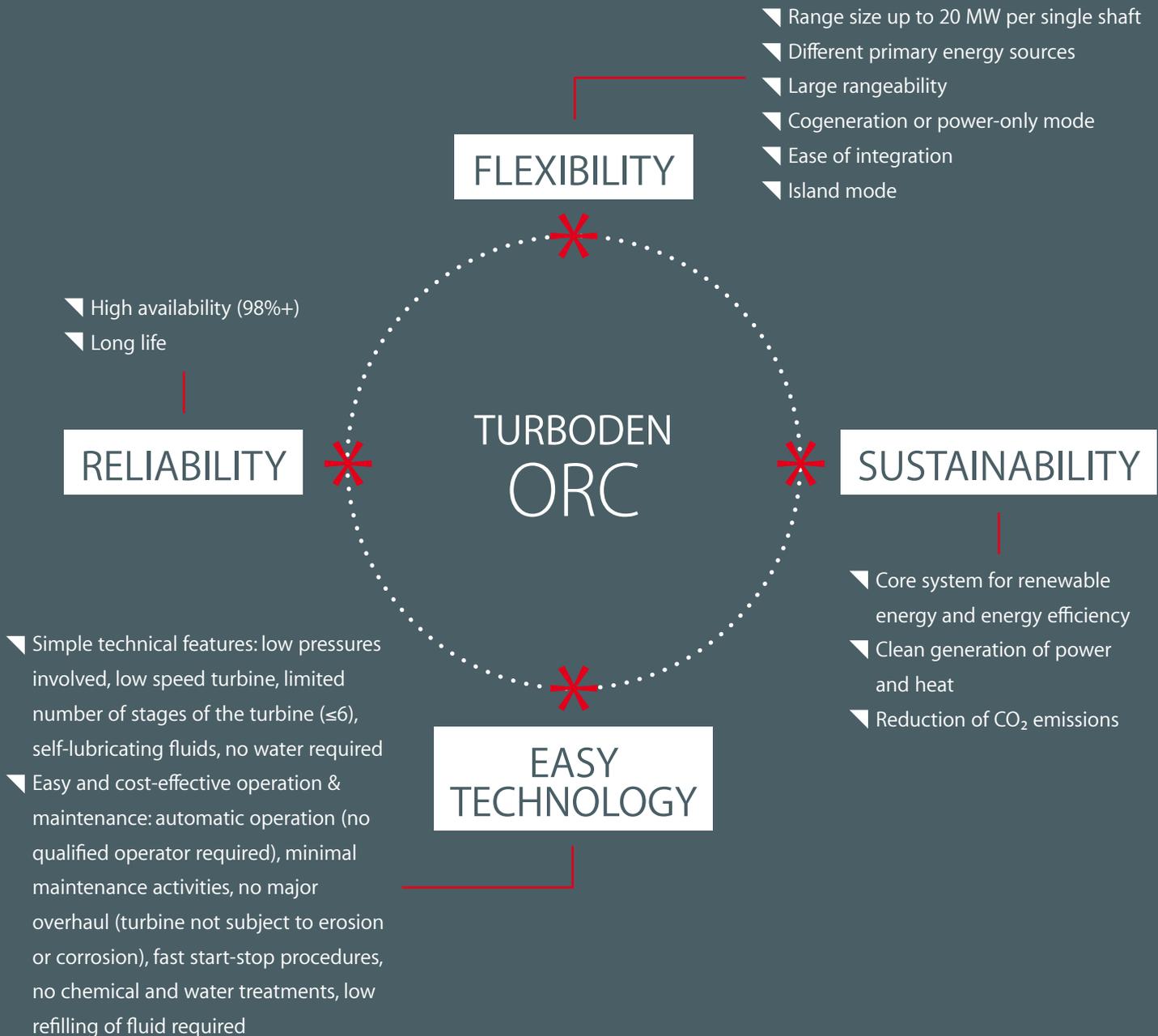
CAPABILITIES & EXPERIENCE

With 40+ years of experience, a global presence, 750+ MWe installations, and 400+ plants in 50 countries, Turboden is a market leader in the proprietary design and manufacturing of ORC optimized turbines.

CUSTOMER ORIENTATION

Optimized solutions for each customer and a qualified service department exclusively dedicated to customer assistance.

Feel our strengths



Always by your side

24/7

SUPPORT*

<2h

REACTION TIME

97%

PLANTS WITH AFTER-SALES
CONTRACTS

*up to

GLOBAL COVERAGE

- ▼ 2 service subsidiaries and 5 international service partner companies

CUSTOMIZED SERVICES

- ▼ single contact for requests for support
- ▼ staff dedicated to on-site and remote technical support
- ▼ assistance of an international network of companies able to provide technical support
- ▼ wide range of services provided
- ▼ prompt assistance and customized after-sales services
- ▼ remote technical support using innovative tools
- ▼ dedicated spare parts warehouse



CUSTOMER REQUEST
OR TURBODEN
PLANNED CHECKS



TREND ANALYSIS
WITH LOCAL
OPERATOR SUPPORT



FOCUSED TEAMWORK
AND TECHNICAL
DECISIONS



REACTION PLAN:
REMOTE OR ON-SITE



SATISFIED
CUSTOMER



BIOMASS



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