



clean energy ahead[®]
TURBODEN

WASTE HEAT RECOVERY

INCREASE YOUR ENERGY EFFICIENCY WITH ORC TECHNOLOGY.

They believe in us



HEIDELBERGCEMENT



AGC



Turn waste heat into useful power

Turboden Organic Rankine Cycle (ORC) units enable power production by converting residual, low-grade heat into useful power in industrial processes and in combined cycles when coupled with reciprocating engines and gas turbines. Turboden turbogenerators in this field can generate up to 20 MW electric per single shaft.

▼ PRODUCTION PROCESS

Unexploited heat streams produced by industrial processes like cement, glass, steel, ferroalloy, non-ferrous metals (copper, aluminum, etc.), silicon metal, carbon black, etc.



▼ COMBINED CYCLES

When coupled with gas turbines, reciprocating engines, and fuel cells.



Electric power / Mechanical power



Why choose ORC for energy efficiency?

GENERATE PROFIT FROM LEVERAGING A WASTE HEAT SOURCE

REDUCE SPECIFIC PRODUCTION COST BY DECREASING ENERGY DEMAND

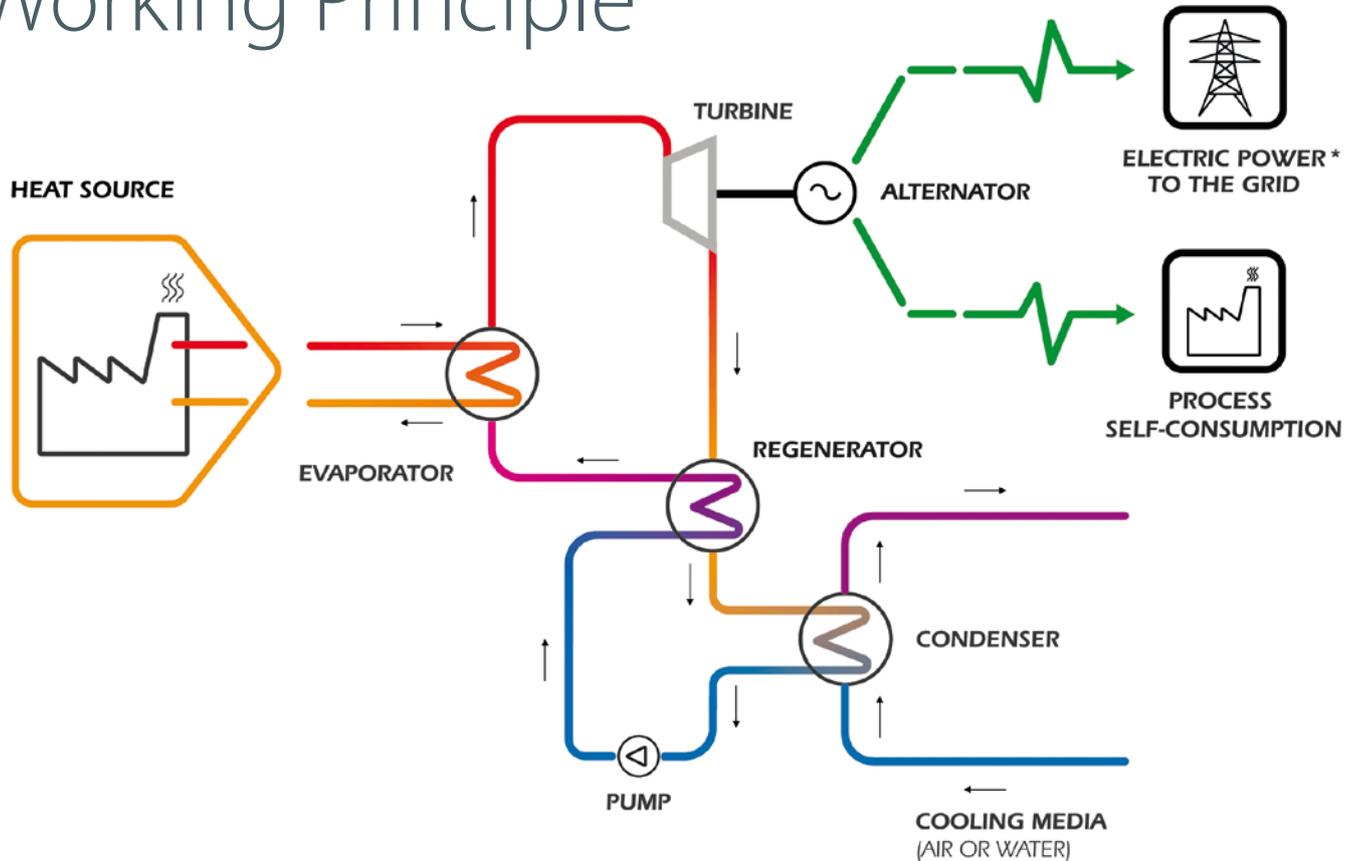
IMPROVE ENERGY-INTENSIVE INDUSTRY SUSTAINABILITY

REDUCE CO₂ EMISSIONS

- ▼ ease of integration with no impact on production process or prime equipment (engine, gas turbine) operation
- ▼ no water consumption
- ▼ negligible fluid refilling required
- ▼ automatic operation with no operator attendance required
- ▼ high cycle efficiency up to 30%
- ▼ heat input from gaseous, liquid and condensing streams (from 100°C)
- ▼ high-efficiency and full flexibility operation from 10% to 110% of the nominal load



Working Principle



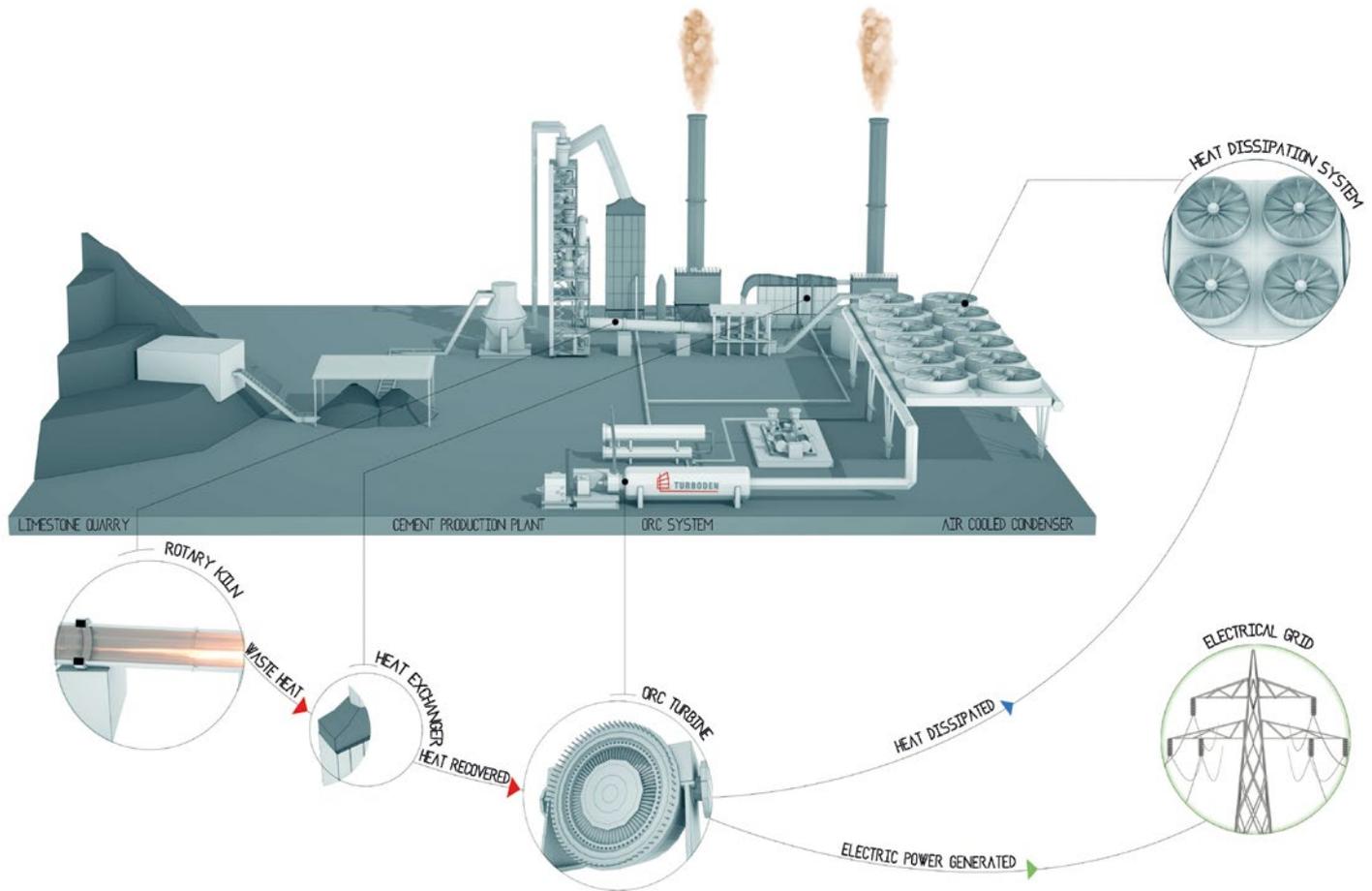
* ORC units can produce electric and/or mechanical power

The ORC turbogenerator makes use of a closed thermodynamic cycle to convert heat into electricity. The thermal power recovered from the waste heat 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, an internal heat recovery takes place improving the cycle efficiency. Downstream the regenerator, the organic vapor is condensed and pumped back to start the cycle again. The heat of condensation can either be used by the heat users or dissipated.

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

Make your process more sustainable

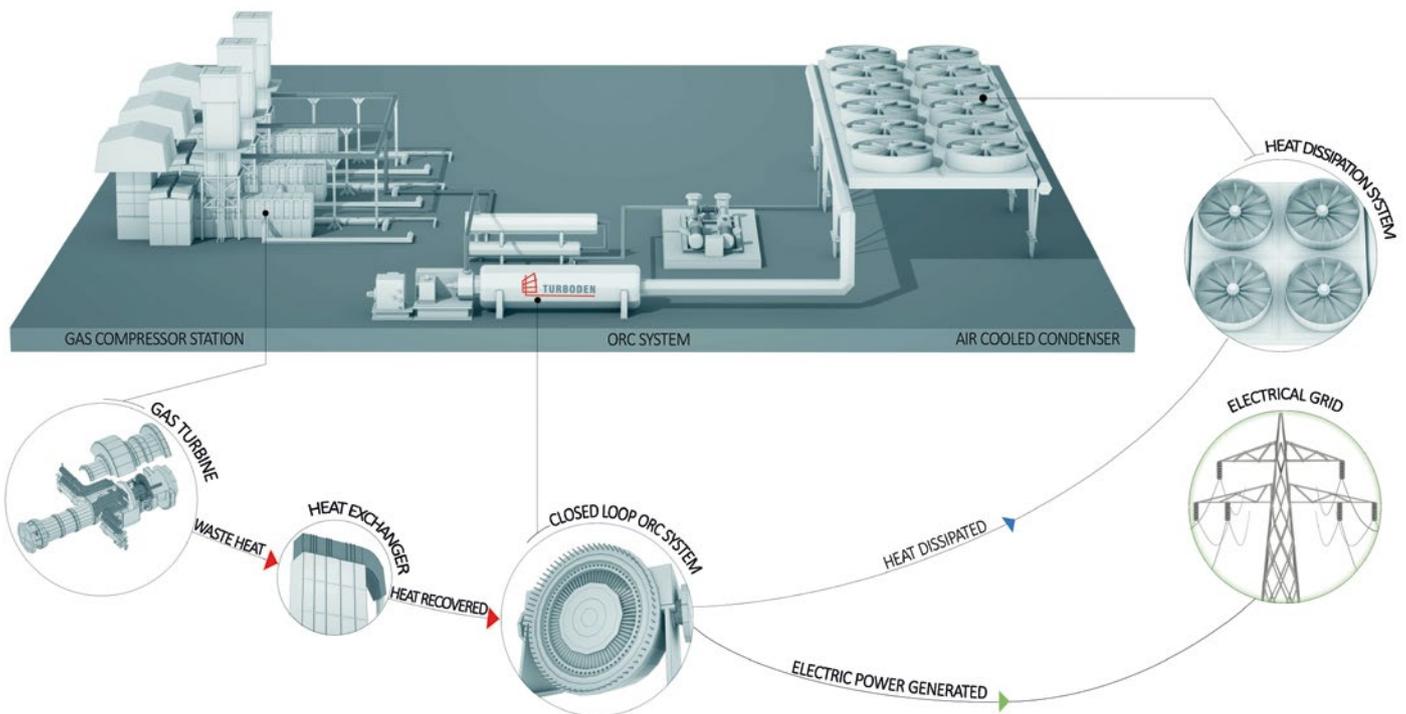
Energy-intensive industries have unexploited waste heat streams. For example, in cement production process, Turboden ORC systems can produce electric power by recovering waste heat from two hot gas streams: kiln pre-heater gas and clinker cooler air.



Example of a cement production plant integrated with a Turboden ORC system.

Make your plant more sustainable

Designed upon specific site features, the ORC-based heat recovery system exploits the gas turbines' exhausts to produce up to 30% ÷ 40% of additional useful power. The ORC system follows the gas turbines' operation mode producing additional power (for the station itself or for external users) without any impact on the gas compressor station operation.



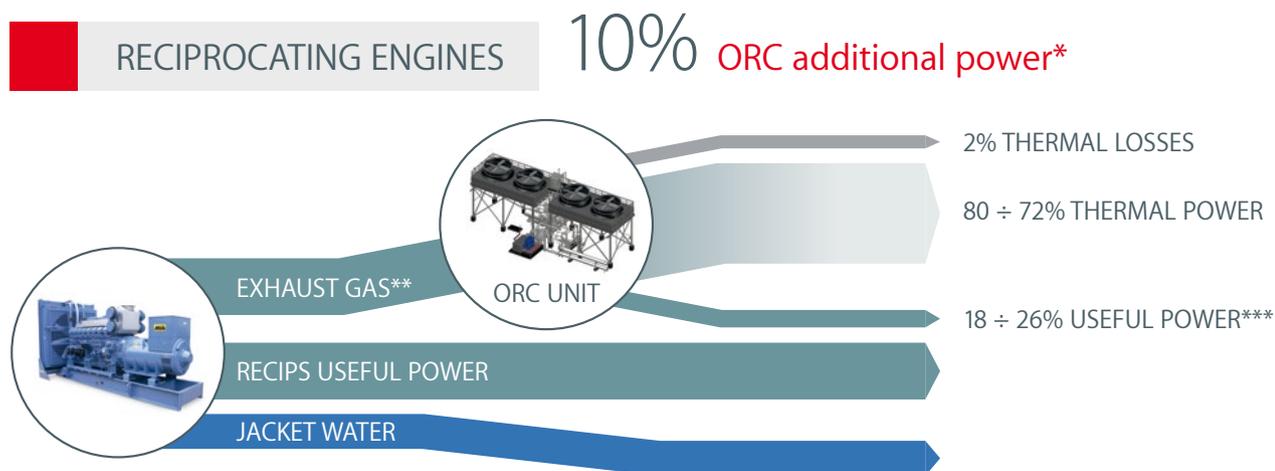
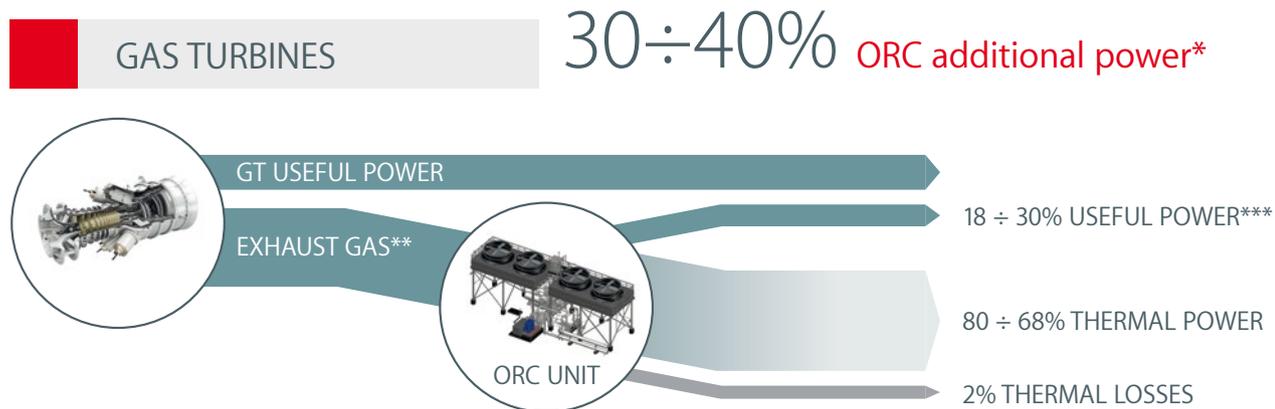
Example of gas turbines bottoming with ORC technology.

Add free power to your cycle

In combined cycles, Turboden ORC units can be installed downstream of:

- ▼ Gas turbines (GT), with up to 40% of additional power
- ▼ Reciprocating engines (RECIPS), with up to 10% of additional power

In both cases the combined cycle achieves an efficiency greater than 50%.



* ORC power output compared to GT or RECIPS shaft capacity (e.g. 10 MW GT -> 3÷4 MWe ORC).

** Min. flow to ORC: 10-15 kg/s.

*** Mechanical and/or electric power, calculated on thermal power input to ORC.



From words to deeds



HOLCIM ROMANIA (LAFARGEHOLCIM GROUP) - ROMANIA

- ▼ SIZE: 4 MWe
- ▼ STATUS: in operation since 2012
- ▼ PRODUCTION PROCESS: cement
- ▼ COOLING SYSTEM: water cooled condenser + cooling towers
- ▼ HEAT CARRIER: thermal oil + superheated water



CRH (FORMER HOLCIM) - SLOVAKIA

- ▼ SIZE: 5 MWe
- ▼ STATUS: in operation since 2014
- ▼ PRODUCTION PROCESS: cement
- ▼ COOLING SYSTEM: water cooled condenser + cooling towers
- ▼ HEAT CARRIER: thermal oil



SÖNMEZ ÇIMENTO - TURKEY

- ▼ SIZE: 7.3 MWe
- ▼ STATUS: in operation since 2020
- ▼ PRODUCTION PROCESS: cement
- ▼ COOLING SYSTEM: air cooled condenser (no water consumption)
- ▼ HEAT CARRIER: thermal oil



CARPATCEMENT (HEIDELBERG CEMENT GROUP) - ROMANIA

- ▼ SIZE: 3.8 MWe
- ▼ STATUS: in operation since 2015
- ▼ PRODUCTION PROCESS: cement
- ▼ COOLING SYSTEM: air cooled condenser (no water consumption)
- ▼ HEAT CARRIER: thermal oil



AGC - ITALY

- ▼ SIZE: 1.3 MWe
- ▼ STATUS: in operation since 2012
- ▼ PRODUCTION PROCESS: float glass
- ▼ COOLING SYSTEM: water cooled condenser + cooling towers
- ▼ HEAT CARRIER: thermal oil



DÜZCECAM - TURKEY

- ▼ SIZE: 6.2 MWe
- ▼ STATUS: in operation since 2018
- ▼ PRODUCTION PROCESS: float glass
- ▼ COOLING SYSTEM: air cooled condenser (no water consumption)
- ▼ HEAT CARRIER: thermal oil



CONTAINER GLASS COMPANY - ITALY

- ▼ SIZE: 0.5 MWe
- ▼ STATUS: in operation since 2015
- ▼ PRODUCTION PROCESS: container glass
- ▼ COOLING SYSTEM: water cooled condenser + cooling towers
- ▼ HEAT CARRIER: thermal oil



FERALPI - GERMANY

- ▼ SIZE: 2.7 MWe
- ▼ STATUS: in operation since 2013
- ▼ PRODUCTION PROCESS: steel (electric arc furnace)
- ▼ COOLING SYSTEM: water cooled condenser + cooling towers
- ▼ HEAT CARRIER: saturated steam



ORI MARTIN - ITALY

- ▼ SIZE: 2.2 MWe
- ▼ STATUS: in operation since 2016
- ▼ PRODUCTION PROCESS: steel (electric arc furnace)
- ▼ COOLING SYSTEM: water cooled condenser + cooling towers
- ▼ HEAT CARRIER: saturated steam



ARVEDI - ITALY

- ▼ SIZE: 10 MWe
- ▼ STATUS: in operation since 2018
- ▼ PRODUCTION PROCESS: steel (electric arc furnace)
- ▼ COOLING SYSTEM: water cooled condenser + cooling towers
- ▼ HEAT CARRIER: saturated steam



ORTADOGU ENERJI - TURKEY

- ▼ SIZE: 3 X 2.3 MWe
- ▼ STATUS: under construction
- ▼ HEAT SOURCE: exhaust gas of 12x1.4 MW GE Jenbacher (site 1) and 28x1.4 MW GE Jenbacher + 4x1.2 MW MWM (site 2) gas engines – Landfill gas
- ▼ COOLING SYSTEM: air cooled condenser (no water consumption)
- ▼ HEAT CARRIER: thermal oil



GASCO - EGYPT

- ▼ SIZE: 28 MWe
- ▼ STATUS: under construction
- ▼ HEAT SOURCE: exhaust gas of 5X30 MW GT (4 in operation, 1 in stand-by) in the gas compressor station of Dahshour
- ▼ COOLING SYSTEM: air cooled condenser (no water consumption)
- ▼ HEAT CARRIER: thermal oil



UZTRANSGAZ - UZBEKISTAN

- ▼ SIZE: 1 MWe
- ▼ STATUS: in operation since 2021
- ▼ HEAT SOURCE: exhaust gas of 3x15 MW GE gas turbines in the gas compressor station serving the Hodzhaabad Underground Storage System
- ▼ COOLING SYSTEM: air cooled condenser (no water consumption)
- ▼ HEAT CARRIER: thermal oil



CEREAL DOCKS - ITALY

- ▼ SIZE: 0.5 MWe
- ▼ STATUS: in operation since 2012
- ▼ HEAT SOURCE: exhaust gas of 1x7 MWe Wärtsilä diesel engine
- ▼ COOLING SYSTEM: water cooled condenser + closed water loop with air-coolers
- ▼ HEAT CARRIER: not present, direct exchange



TRANS GAS - CANADA

- ▼ SIZE: 1 MWe
- ▼ START UP: in operation since 2011
- ▼ HEAT SOURCE: exhaust gas of 3.5 MWe Solar gas turbine in a gas compressor station along TransGas pipeline
- ▼ COOLING SYSTEM: water cooled condenser + closed water loop
- ▼ HEAT CARRIER: thermal oil



HSY - FINLAND

- ▼ SIZE: 1.3 MWe
- ▼ START UP: in operation since 2011
- ▼ HEAT SOURCE: exhaust gas of 4x4 MWe MWM gas engines - Landfill gas
- ▼ COOLING SYSTEM: water cooled condenser + closed water loop
- ▼ HEAT CARRIER: thermal oil

A top-down view of a washing machine drum. The drum is white and has a central hub. It is surrounded by a metal frame with a grid of vertical bars. The text "ABOUT US" is written in white on a red rectangular background in the center of the drum.

ABOUT US



Turboden, a Mitsubishi Heavy Industries company, 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 2016). 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 has the constant support of its parent company regarding financial solidity, sharing of business practices (including customer warranties) and technological development.

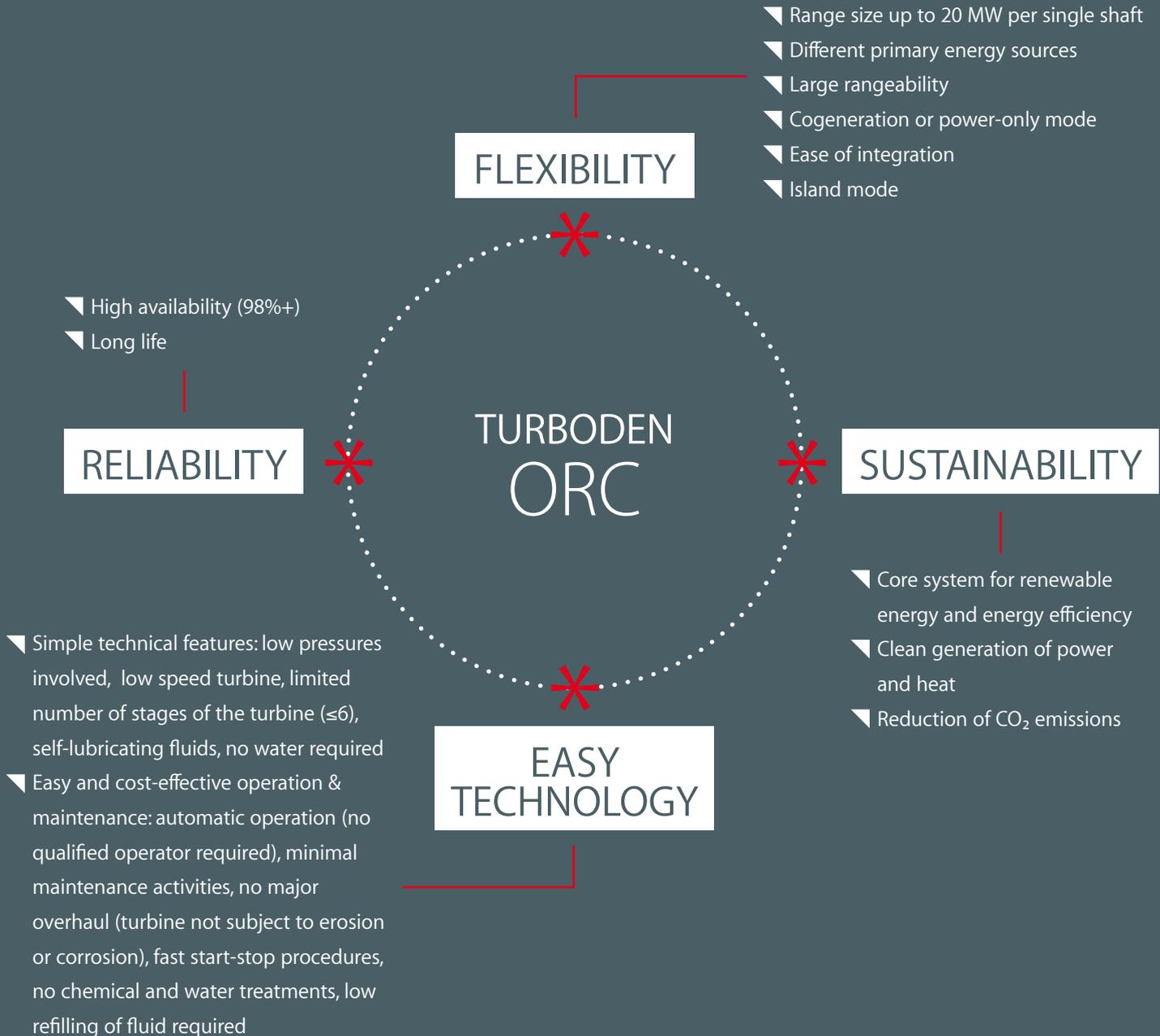
CAPABILITIES & EXPERIENCE

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

- ▼ 3 service subsidiaries and 5 international service partner companies

CUSTOMIZED SERVICES

- ▼ single contact for requests for support
- ▼ dedicated staff 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

Meet our global and proven experience



WHR

PLANTS: 35
TOTAL CAPACITY: 86 MWe

PLANTS: 409
COUNTRIES: 50
TOTAL CAPACITY: 750 MWe
CUMULATIVE OPERATION TIME: 19 million hours
AVERAGE AVAILABILITY: 98+%

Update November 2021



WASTE HEAT RECOVERY



Turboden S.p.A. | Via Cernaia, 10 | 25124 Brescia | Italy

This brochure does not constitute a legal binding offer and it is subject to change without notice. All rights reserved.