clean energy ahead
TURBODEN

MOVE THE WORLD FORWARD
MITSUBISHI HEAVY INDUSTRIES GROUP

HEAT ELECTRIFICATION SOLUTIONS

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Turboden S.p.A.

A Group Company of MITSUBISHI HEAVY INDUSTRIES

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MOVE THE WORLD FORWARD MITSUBISHI HEAVY INDUSTRIES GROUP

OVER 40 YEARS OF A VIABLE SUSTAINABILITY

Since 1980, Turboden S.p.A. is a pioneer in the **energy transition**, offering technological solutions to industries and utilities for heat and power generation.

The strength of being part of **Mitsubishi Heavy Industries group**, together with the vast technical expertise in the carbon mitigation, the capability to be flexible throughout the project lifecycle, make Turboden a dependable partner for **optimised solutions to decarbonize processes.**

Having established itself as a **world-leading company in sustainable power production**, with 450 Organic Rankine Cycle (ORC) plants in more than 50 countries, Turboden is one of the major technology partners for energy efficiency and sustainability.

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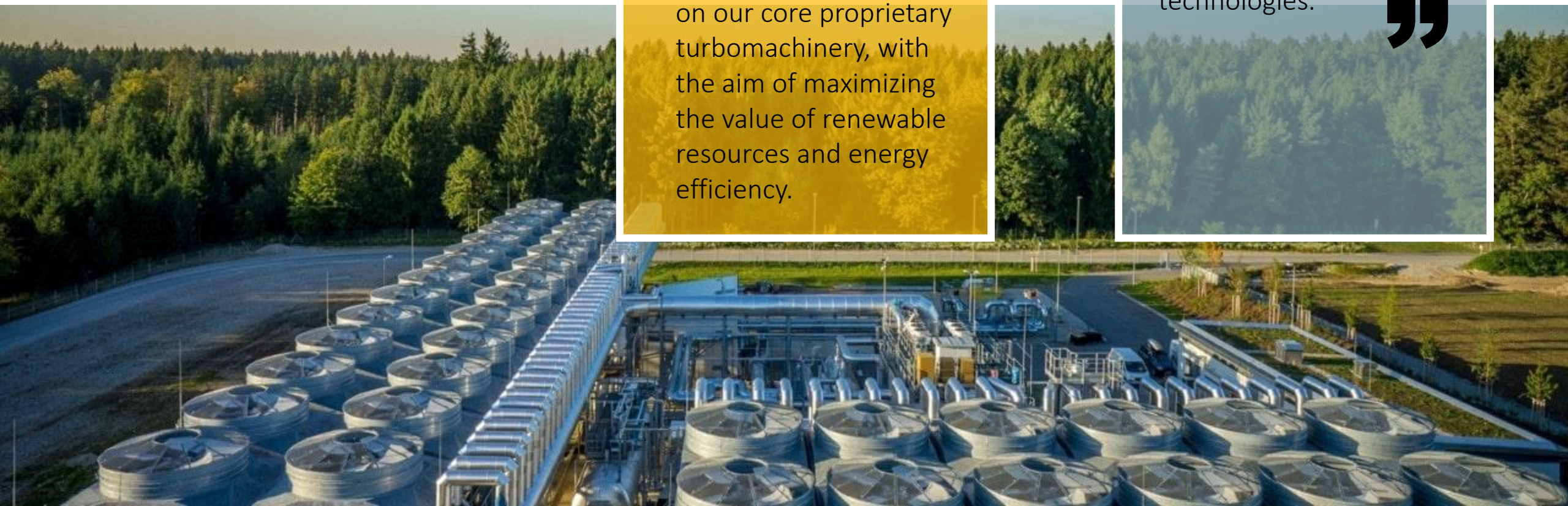
OUR MISSION

We provide unique, reliable and advanced technologies founded on our core proprietary turbomachinery, with the aim of maximizing the value of renewable resources and energy efficiency.

OUR VISION

To accelerate the transition to a world powered by low-carbon technologies.



GLOBAL AND PROVEN EXPERIENCE

Largest plant in operation **29 MWe**

Largest plant under construction **120 MWe**

Overall capacity installed **1,050 MWe**

Worldwide presence in **50+ countries**

Around **460 plants**

HEAT GENERATION
2 units, 18 MWth

HIGH TEMPERATURE POWER GENERATION* + COGEN
442 units, 810 MWe

GEOTHERMAL POWER GENERATION
20 units, 247 MWe

Last update: August 2024
* ORC and gas expanders included.

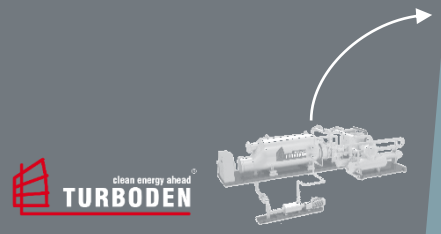
MHI AT A GLANCE

MITSUBISHI HEAVY INDUSTRIES

FOUNDATION	EMPLOYEES	GROUP COMPANIES	SALES
1884	77,430	260	¥4.2TN ($31BN*)
over 130 years of history	(Consolidated)	(Consolidated)	(FY2022, consolidated)

*On the FY2022 average JPY/USD exchange rate.

DIVERSE PRODUCTS

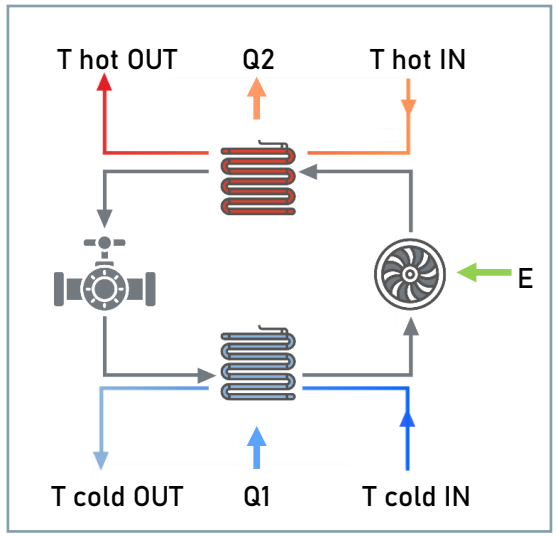


- ENERGY SYSTEMS
- PLANTS & INFRASTRUCTURE SYSTEMS
- LOGISTICS, THERMAL & DRIVE SYSTEMS
- NUCLEAR ENERGY SYSTEMS
- MACHINERY SYSTEMS
- INTEGRATED DEFENSE & SPACE SYSTEMS
- COMMERCIAL AVIATION SYSTEMS
- ENGINEERING SOLUTIONS

DELIVERING ON THE ENERGY TRANSITION

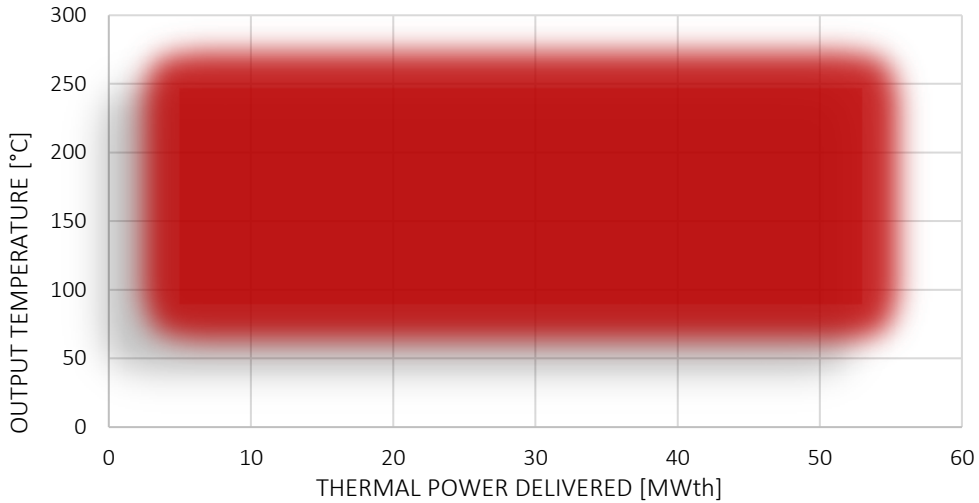
In 2013, Turboden became part of MHI Group. Today, Turboden and MHI are committed to achieving carbon neutrality by 2040 – *Mission Net Zero* – both in its operations as well as in its value chain.

A FULL-FLEDGED PORTFOLIO TO COVER LARGE SIZES AND HIGH TEMPERATURES



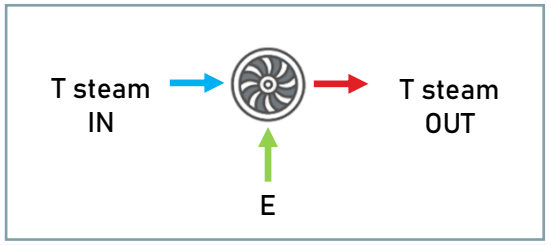
LHP

Large Heat Pumps (LHP) are utility-scale heating plant, designed to transfer large quantities of heat from a lower temperature source to a higher temperature heat user, such as district heating grid or industrial process.



Turboden heat generation solutions.

NOTE: capability to operate at high lift and at high output temperature, thanks to optimised solutions.



MVR

Mechanical vapor recompression (MVR) system, acting as an open cycle water heat pump, increases both the temperature and the pressure of a water stream, to generate steam at specific conditions needed.

Large-scale (thermal power output from 5 MWth)

High temperature (output temperature beyond 200°C, including steam generation)

DEPENDABLE PARTNER TO REDUCE CARBON FOOTPRINTS

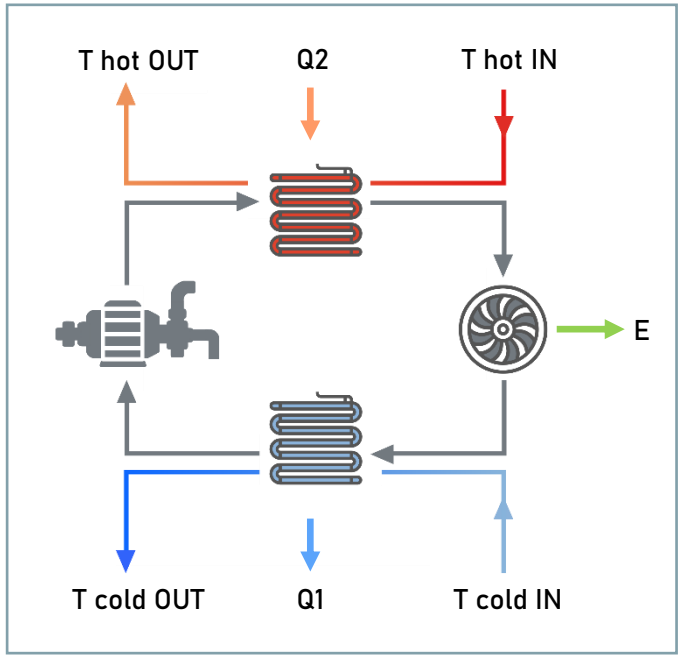
Turboden delivers reliable heat-upgrade systems designed to decarbonize the following sectors:

- district heating networks, exploiting multiple heat sources including cooling water from industries;
- industrial applications, such as refinery & petrochemical, chemical & pharmaceutical, food & beverage, pulp & paper;
- Carbon Capture Sequestration (CCS).

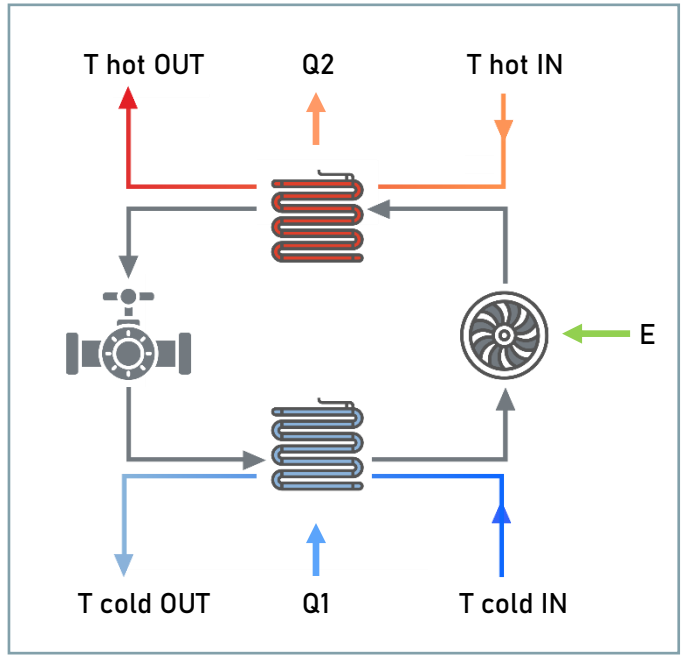
INNOVATION ROOTED IN STRONG ENGINEERING CAPABILITIES

WHY TURBODEN?

- Wide and in-depth knowledge in thermodynamic cycle design.
- Deep experience with a wide range of working fluids, including natural refrigerants.
- In-house tailor-made turbomachines (Turboden and MHI Compressor Corporation).
- Full-spectrum projects, from engineering to management and service.
- Key components selection and design (e.g., heat exchangers).
- Capability to manage large complex projects and processes integration.



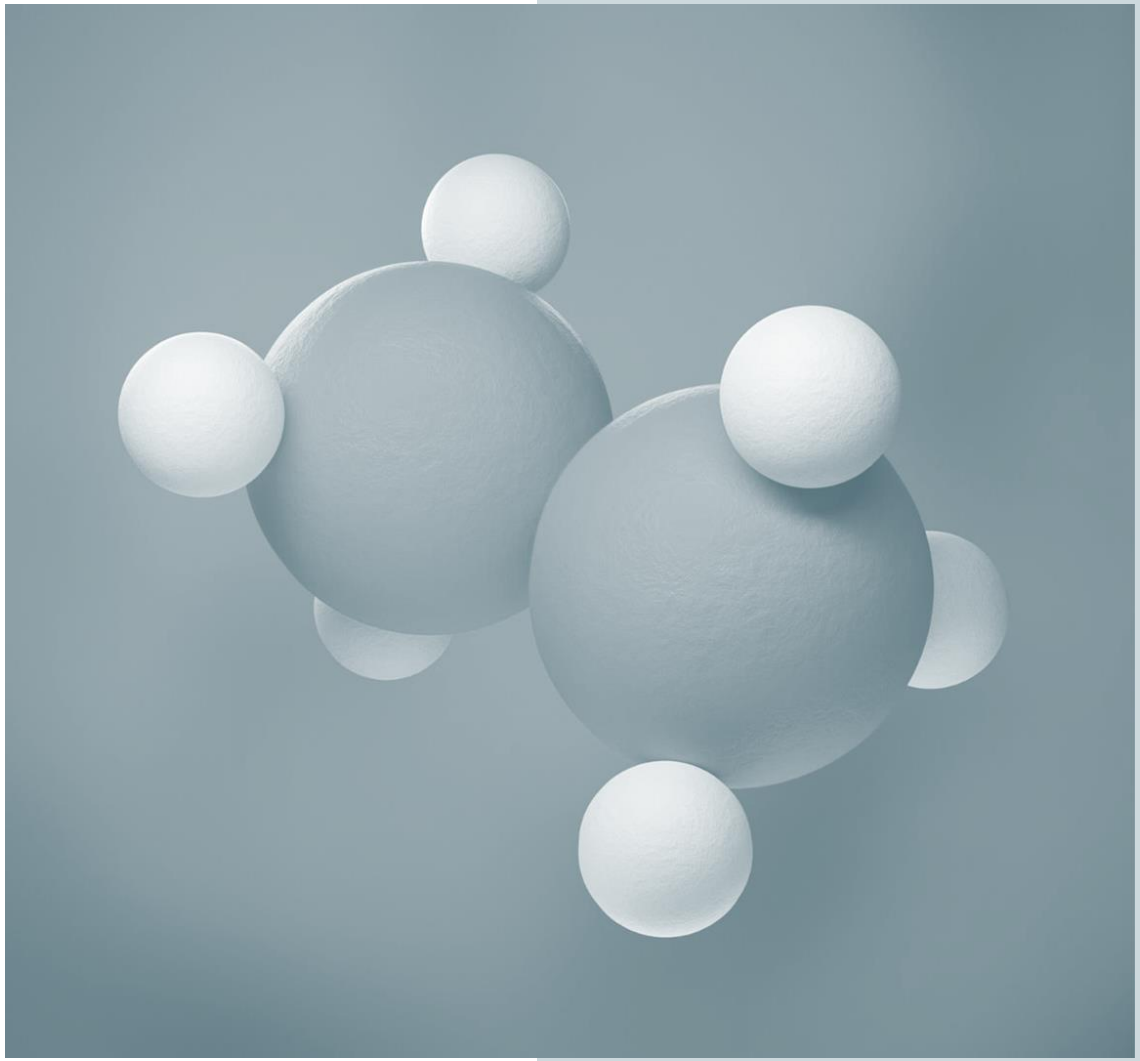
ORC



LHP

FLEXIBILITY TO MANAGE DIFFERENT FLUIDS

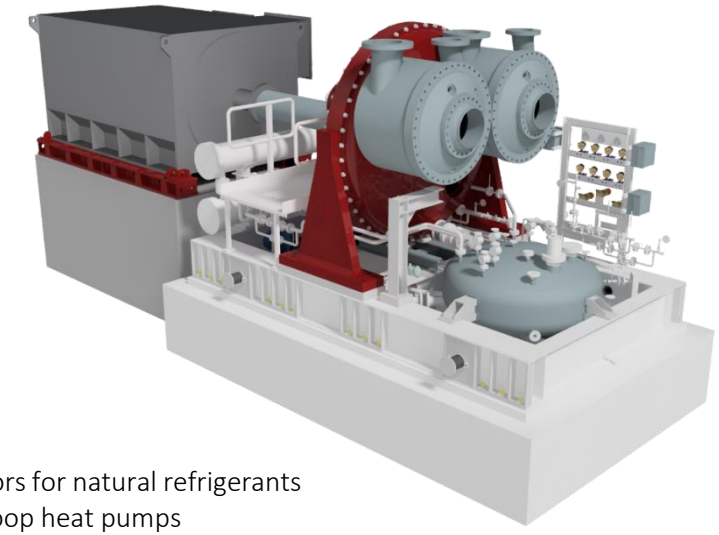
- Natural refrigerants with low ODP and GWP[1].
- Cost effectiveness (hydrocarbons up to 10 - 15 times lower than equal performances HFOs).
- HFOs within possible PFAS ban[2].
- High temperature suitable.
- Flammability handled as usual best practice in industrial plants[3].



[1] GWP: Global Warming Potential. ODP: Ozone Depletion Potential.
[2] Council of the EU and the European Council, https://www.consilium.europa.eu/en/press/press-releases/2023/10/05/fluorinated-gases-and-ozone-depleting-substances-council-and-parliament-reach-agreement/.
[3] HEX construction according to ASME and international standard. ATEX requirements: IEAC 600079-10 as ZONE 2. Ventilation according to EN378. Turboden experience with 40+ reference plants in operations adopting hydrocarbons.

TURBODEN COMPRESSOR PORTFOLIO

TURBODEN LHP HERMETIC COMPRESSOR LINE*



Compressors for natural refrigerants
in closed loop heat pumps

*Patent pending

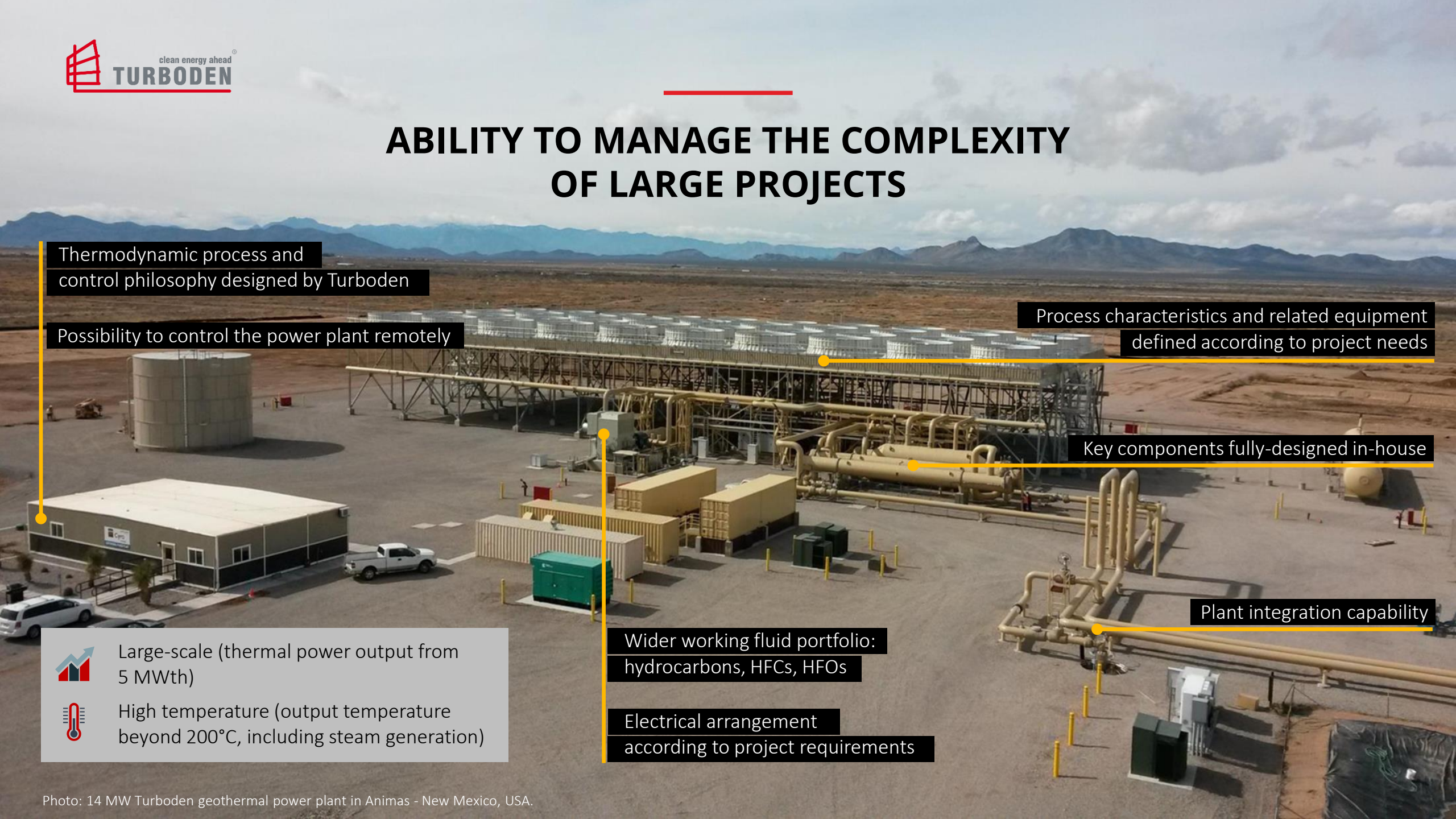
- Heavy duty machine designed for continuous operation with reduced maintenance
- Power range: 300 – 18,000 kW
- Impeller diameter up to 1,500 mm
- Enhanced flexibility for optimal part load operation and quick process adaptation
- Maximum safety with no harmful fugitive emissions
- Availability of MVR for steam generation

MITSUBISHI HEAVY INDUSTRIES COMPRESSOR

API617 beam type compressors

- Special Purpose API centrifugal compressor designed for critical process operation
- Power up to 50+ MW
- Impellers diameter up to 1,700 mm
- High reliability and availability
- DGS sealing system with leakage recovery system

ABILITY TO MANAGE THE COMPLEXITY OF LARGE PROJECTS



Thermodynamic process and control philosophy designed by Turboden

Possibility to control the power plant remotely

Process characteristics and related equipment defined according to project needs

Key components fully-designed in-house

Plant integration capability

Wider working fluid portfolio: hydrocarbons, HFCs, HFOs

Electrical arrangement according to project requirements

Large-scale (thermal power output from 5 MWth)

High temperature (output temperature beyond 200°C, including steam generation)

Photo: 14 MW Turboden geothermal power plant in Animas - New Mexico, USA.

EXPERIENCE IN PROCESS INTEGRATION

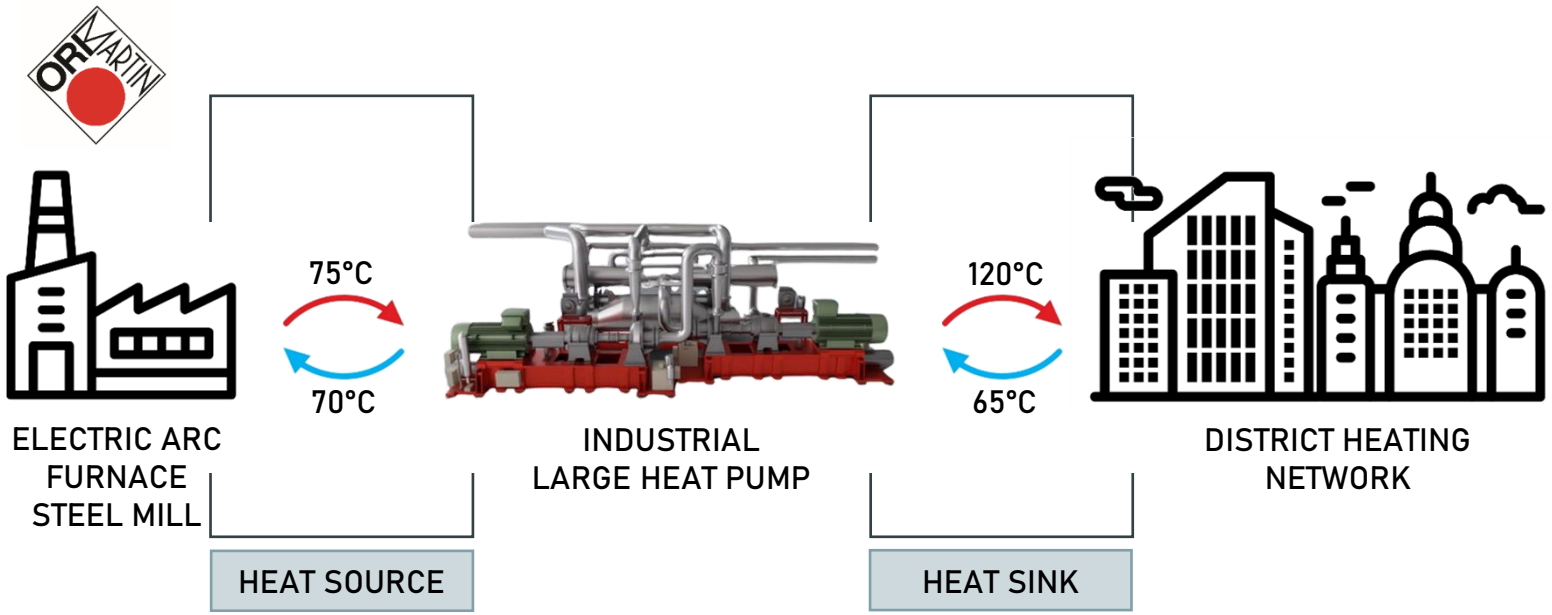
Turboden is skilled at integrating its systems within existing industrial processes, such as cement, steel, glass but also pellet and MDF panels.

190+ plants

in production processes

Last update: May 2024

CASE HISTORY: ORI MARTIN STEELWORKS



WATCH THE VIDEO

Instead of wasting the heat generated during the steelmaking process and dissipated through cooling towers, the customer enhanced its value by installing a LHP to upgrade the heat for district heating, taking advantage of a more efficient and sustainable solution.

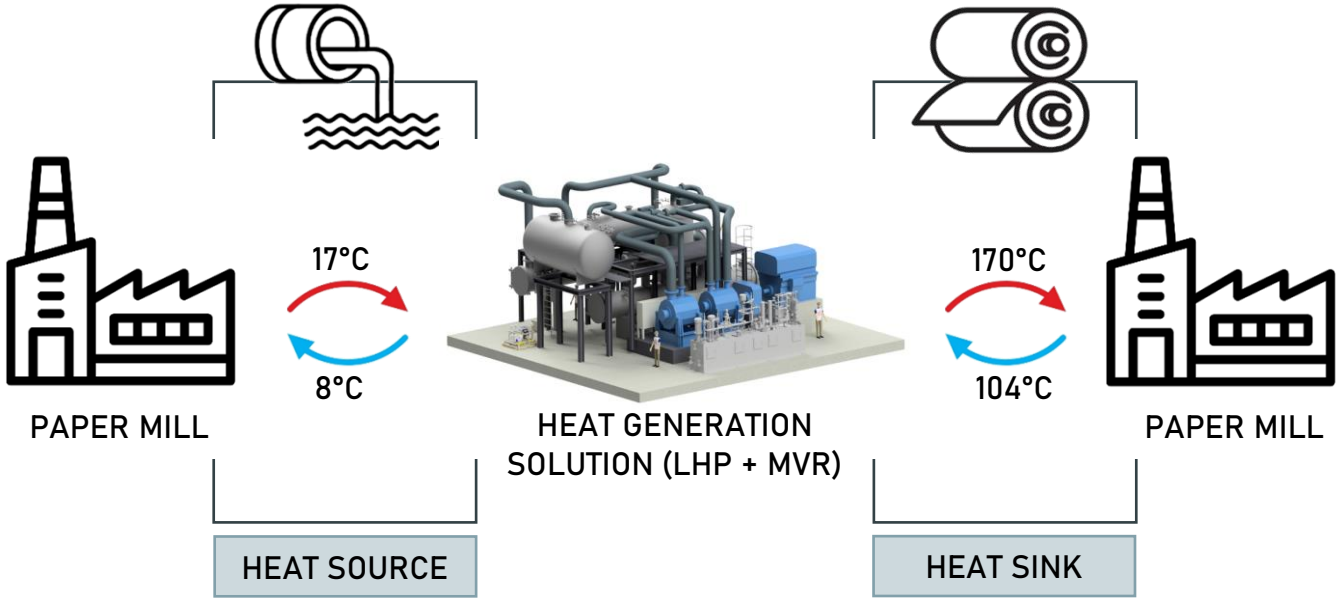
PROJECT FEATURES

- Country: Italy, in operation since 2023
- Size: 6 MWth (equivalent to 3,500 houses)
- Exploitation of steel mill waste heat to serve local district heating network
- Output: pressurized water at 120°C delivered to the district heating network

TECHNICAL FEATURES

- Centrifugal innovative compressor designed by Turboden
- LHP working fluid: synthetic refrigerant

CASE HISTORY: PULP & PAPER INDUSTRY



The customer valorized the low-temperature waste water from the paper mill by installing an innovative heat-upgrade solution, a LHP together with an MVR, to produce valuable steam for the paper mill itself.

PROJECT FEATURES

- Country: Northern Europe, under construction
- Size: 12 MWth
- Exploitation of paper mill waste heat to generate steam for the process
- Output: superheated steam at 170°C delivered to the paper mill

TECHNICAL FEATURES

- Integration of LHP with MVR to provide high-temperature steam at high efficiency (COP 2)
- Centrifugal MCO compressor
- LHP working fluid: natural refrigerant

DEDICATED AFTER-SALES SERVICE

Qualified staff is exclusively dedicated to the customer assistance, both from remote and on-site, with the aim of optimizing the management of the plants. The customer can choose the most suitable service package thanks to the wide range of services offered.

1. Customer request or Turboden planned checks
2. Trend analysis with local operator support
3. Focused teamwork and technical decisions
4. Reaction plan: remote or on-site
5. Satisfied customer

COVERAGE

1 main office in Brescia, 3 service subsidiaries and 3 international service partner companies.

ASSISTANCE

- Turboden 24/7 for troubleshooting and remote consultancy.
- Turboden software for automatic performance monitoring and operation parameters control.

CUSTOMISED SERVICES

- dedicated staff for remote technical support.
- dedicated staff of fields technicians for on-site planned maintenance, predictive maintenance, unplanned and extraordinary maintenance.
- dedicated spare parts warehouse.
- availability guarantee.

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