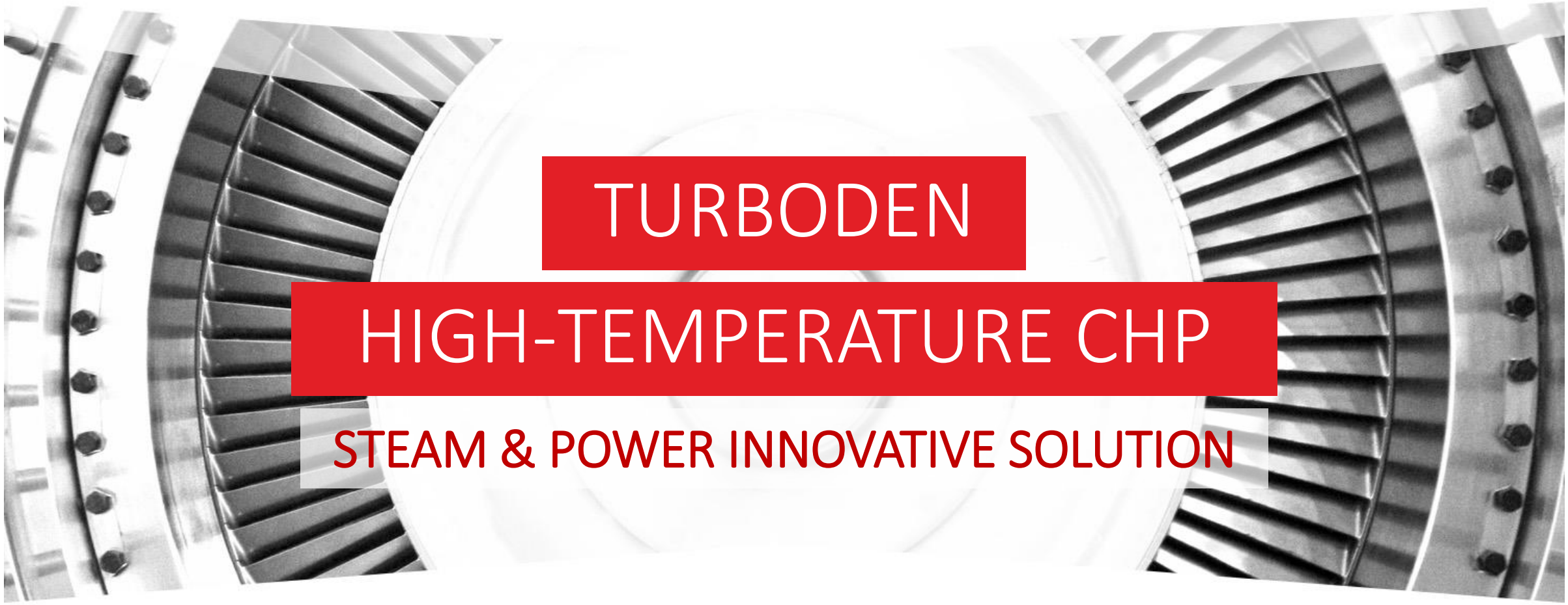
clean energy ahead®
TURBODEN

MOVE THE WORLD FORWARD MITSUBISHI HEAVY INDUSTRIES GROUP



TURBODEN

HIGH-TEMPERATURE CHP

STEAM & POWER INNOVATIVE SOLUTION

HIGH-TEMPERATURE COGENERATION SYSTEM FOR YOUR INDUSTRIAL PROCESS.

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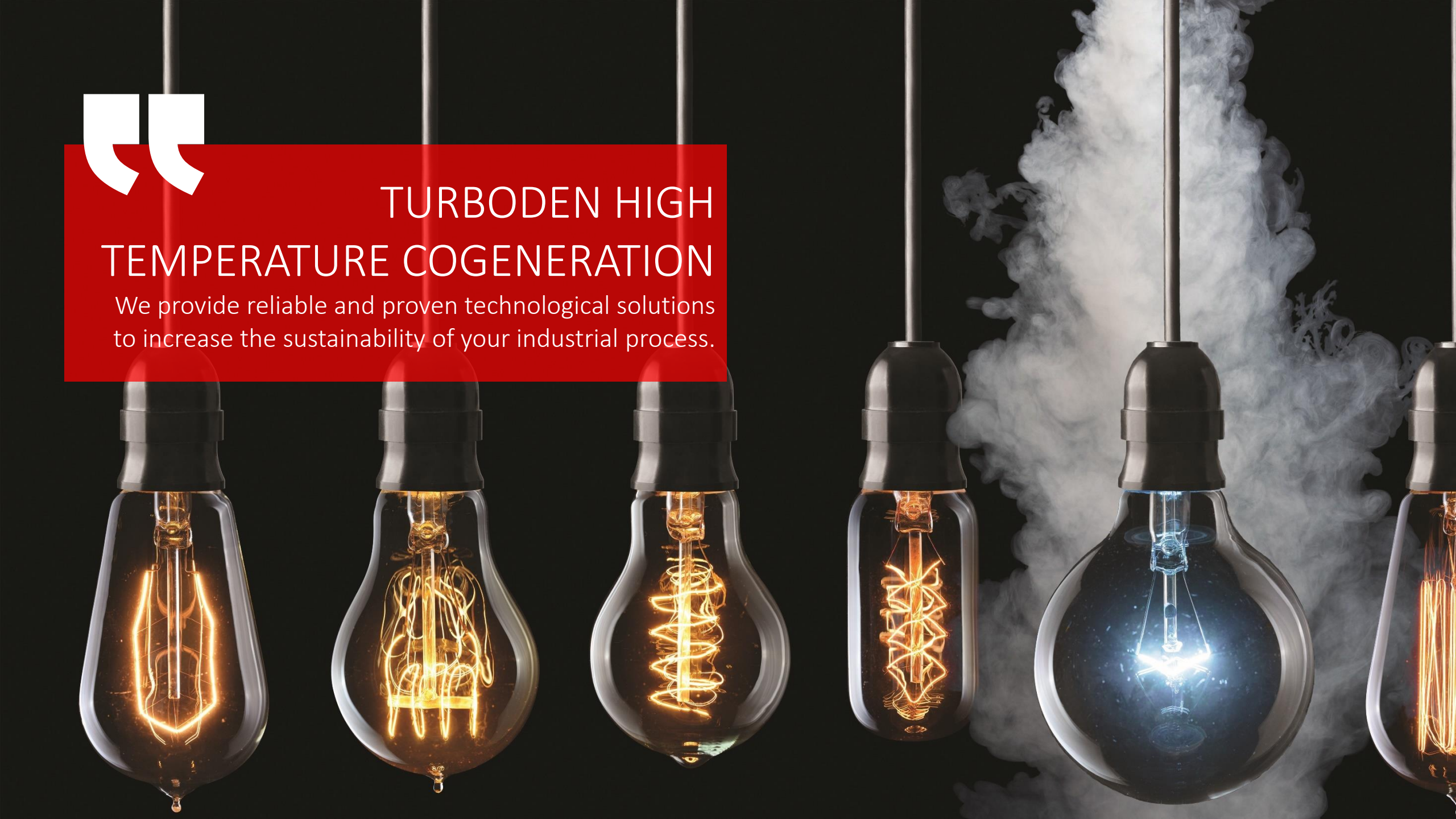


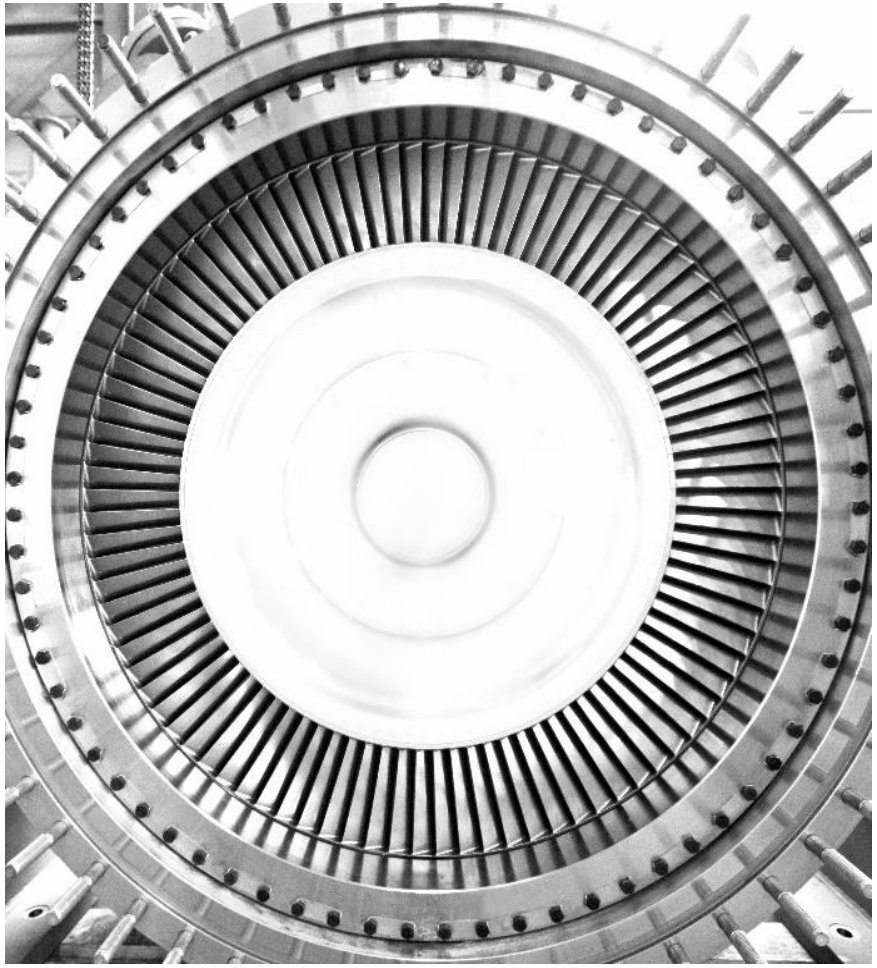
TURBODEN HIGH TEMPERATURE COGENERATION

We provide reliable and proven technological solutions to increase the sustainability of your industrial process.

OUR PRODUCTS

Designed for decarbonisation.

ORC SYSTEM



Turboden Steam & Power Organic Rankine Cycle (ORC) system is a new technical solution for Combined Heat & Power (CHP) generation, with a **very high overall energy efficiency (>90%)**, directly employed in manufacturing and industrial processes.

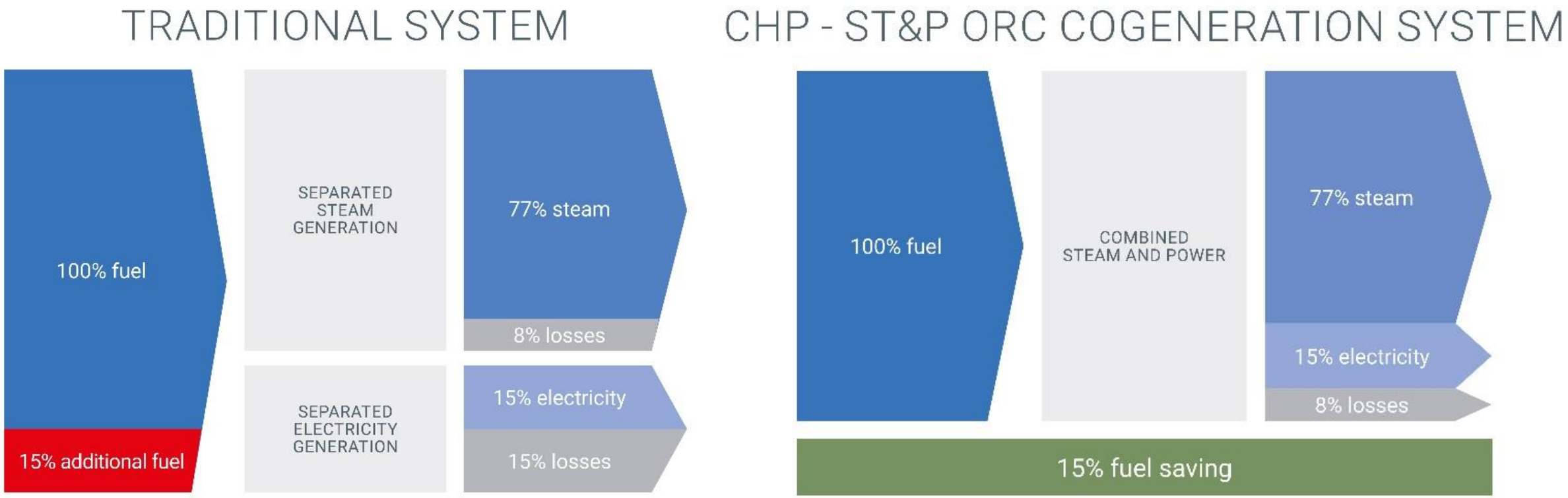
It allows the production of **electricity** and a **valuable high-temperature heat carrier**, such as steam (3-30 bar).

WHY CHOOSE ORC FOR HIGH-TEMPERATURE COGENERATION?

- Generate profit thanks to the efficiency achieved by a combined production of electricity and thermal energy
- Reduce specific production cost by decreasing energy demand
- Improve company sustainability
- Contribute to lower carbonisation and combat climate change

THE ADVANTAGES

The combined heat and power production systems are universally recognized as a remunerative, efficient and sustainable way to produce energy for manufacturing industries.



THE PROCESSES

Steam & Power (ST&P) ORC System can satisfy many manufacturing processes requiring electricity as well as relevant amount of medium-pressure steam.

AGROFOOD & BEVERAGE

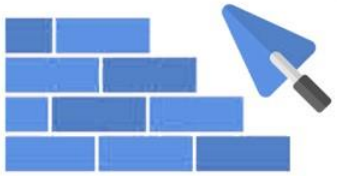
CHEMICAL & PHARMACEUTICAL

PAPER & WOOD INDUSTRY

TEXTILE

PLASTIC & RUBBER

OIL & GAS

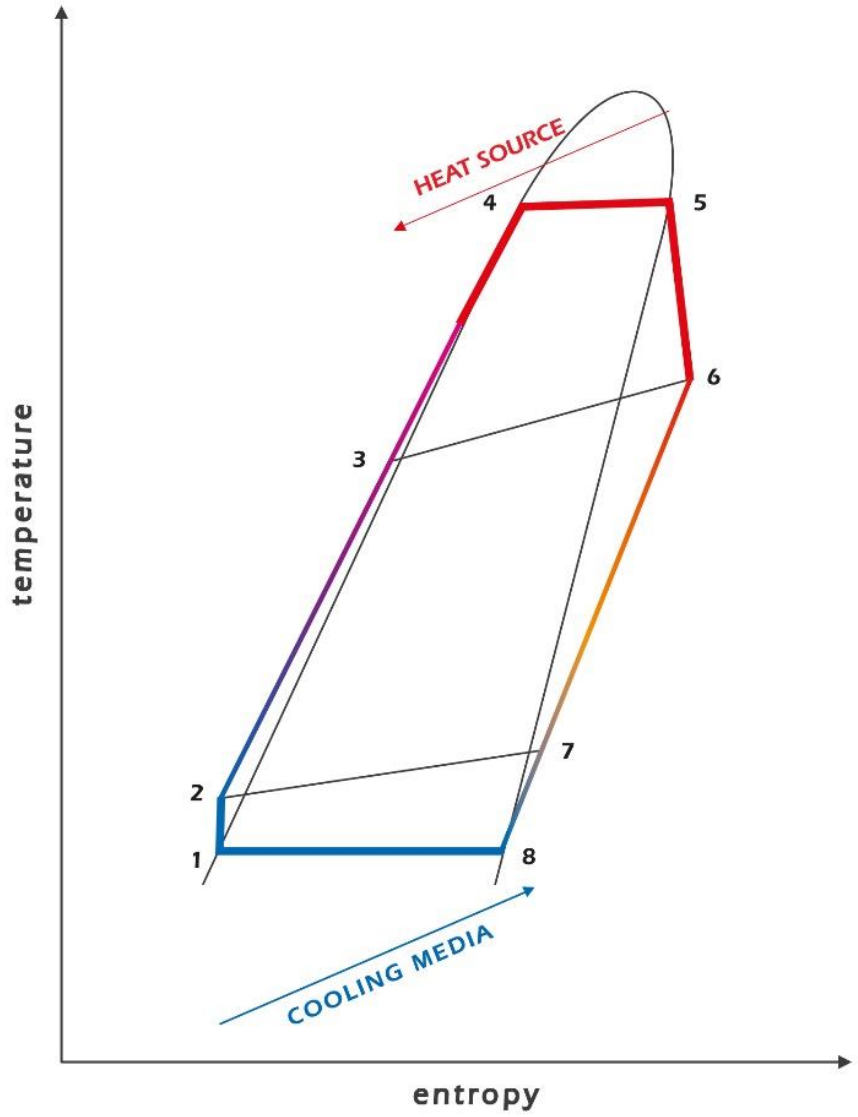


BRICK

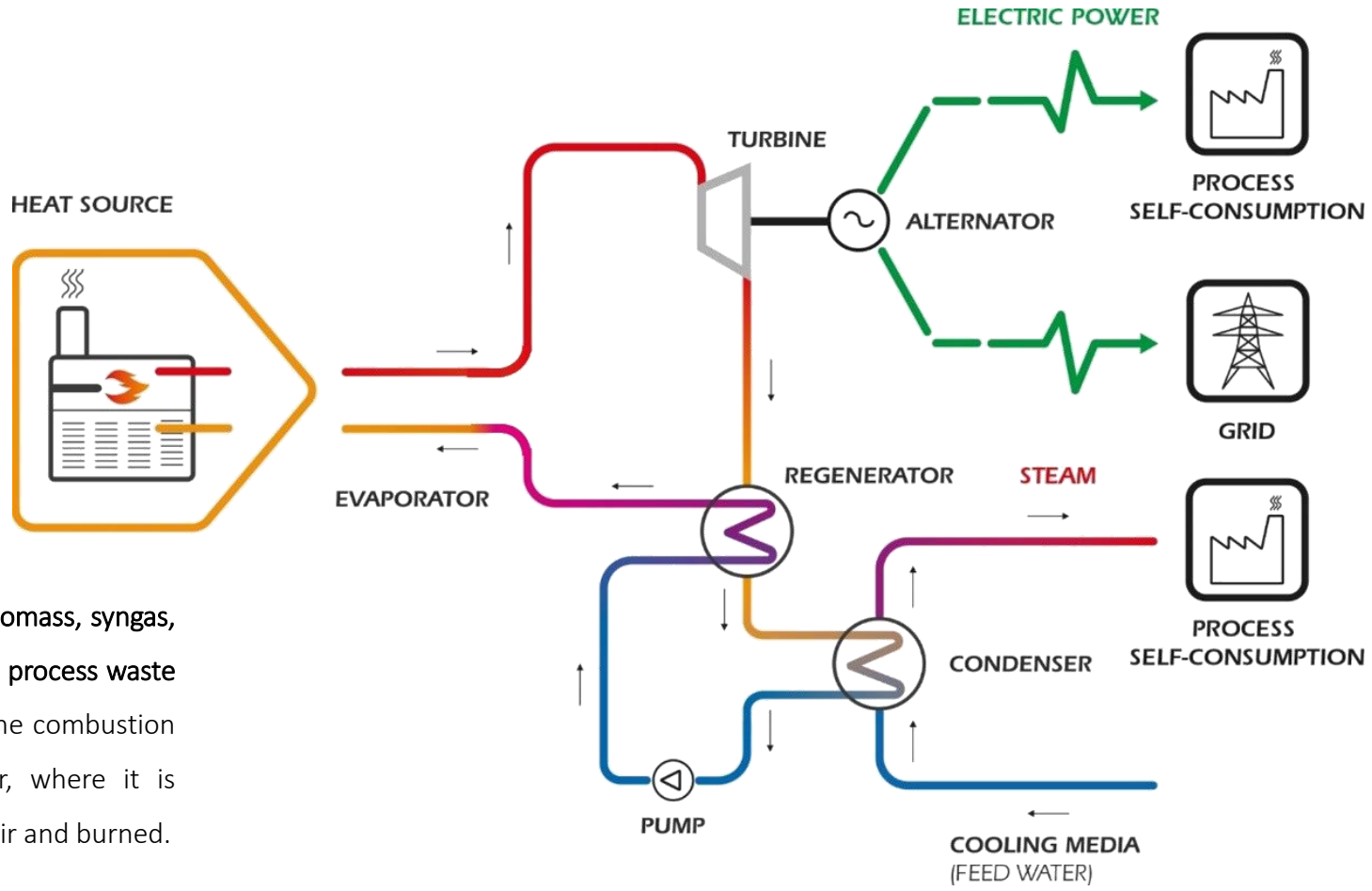
THE CYCLE

The Organic Rankine Cycle's principle is based on a turbogenerator that works with an organic fluid, characterized by high-molecular mass which leads to a slower rotation of the turbine, lower pressures and no erosion of the metal parts and blades.

The turbine transforms thermal energy into mechanical energy and finally into electric energy through an electrical generator.



STEAM & POWER ORC SYSTEM®



HEAT SOURCE

The fuel (**natural gas, biomass, syngas, diesel, naphtha, pellets, process waste and other**) is fed into the combustion chamber of the boiler, where it is mixed with preheated air and burned.

ELECTRIC POWER PRODUCTION

The combustion heat is transferred to the working fluid of the ORC module in the evaporating diathermic oil boiler, it expands into the turbine, which drives the **electric generator producing electricity**.

STEAM PRODUCTION

Downstream the turbine, the organic vapour pre-heats the organic liquid in the regenerator and is then condensed at high temperature releasing its latent heat for **steam generation** to feed the manufacturing process.

MULTI-FUEL TECHOLOGY

01 HEAT SOURCE

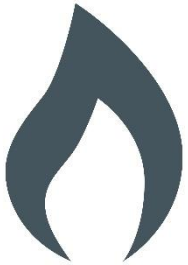
FUELS

- Natural gas
- Poor gases (from landfill, coke oven gas, APG, syngas, etc.)
- **Wood biomass**
- Pellets
- **Waste (sludge, residues, etc.)**
- HFO, LFO, Diesel
- Coal
- …

HEAT RECOVERY

- Heat recovery from gas turbines
- Heat recovery from industrial processes
- …

02 ORC UNIT



HIGH-TEMPERATURE COGENERATION

03 HEAT MEDIA

- Steam
- Pressurized water
- Thermal oil
- Air
- …

04 PROCESS

- Pulp & Paper
- Food & Beverage
- Chemicals
- Rubbers
- Plastics
- Textiles
- …

FEATURES

100% FUEL

> Electric power rating from 500 kWe to 6 MWe

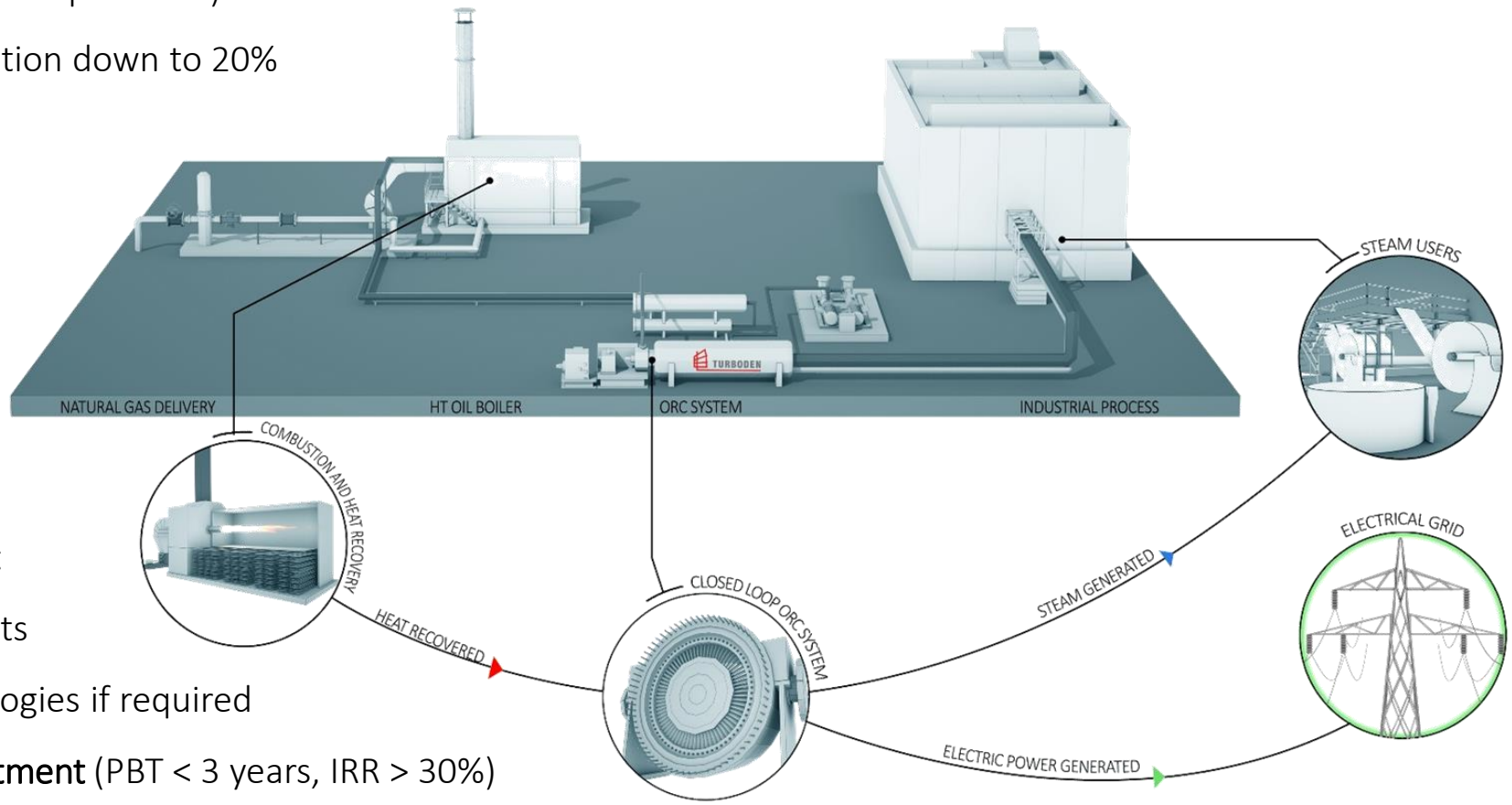
> CHP steam output pressure range from 5 to 30 bar

> CHP steam capacity range from 5 to 40 t/h

* Steam production at 10 bar(g).

THE ADVANTAGES

- Fuel flexibility (for both gaseous and liquid fuels)
- **High flexibility at partial load** operation down to 20%
- High total efficiency: **92%**
- Prevailing steam output
- High availability: **98%**
- Modularity
- Island operation
- Outdoor installation
- **Low operation & maintenance cost**
- Hedge against rising electricity costs
- Combined with other CHP technologies if required
- **Excellent economic return of investment** (PBT < 3 years, IRR > 30%)
- In case of ORC turbine maintenance the boiler doesn't stop the steam production



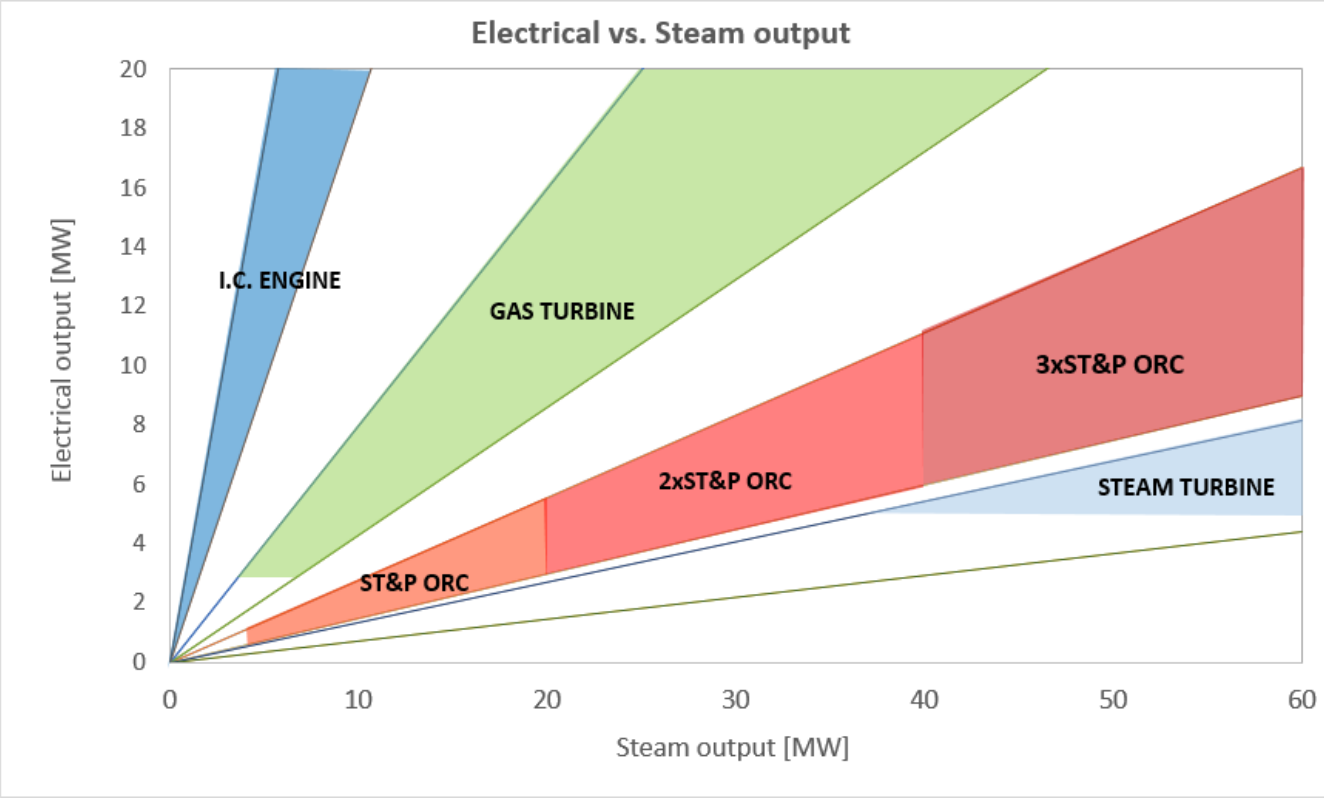
TURBODEN MAIN SIZES

Turboden Steam & Power system® could be used to substitute old steam generators or to be placed in parallel to existing steam generating system in a sustainable and cogenerative way.

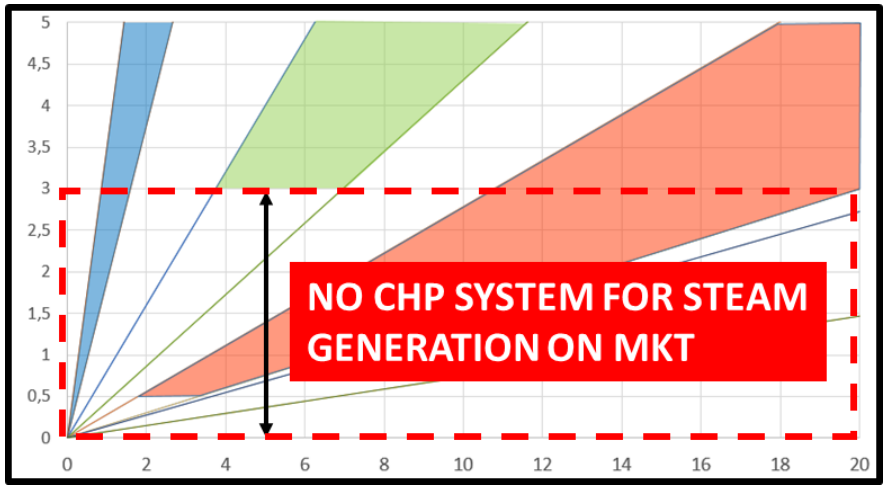
	TD 4 CHP	TD 6 CHP	TD 10 CHP	TD 15 CHP	TD 25 CHP
Steam capacity [ton/h]	4	6	10	15	25
Electrical gross output [kW]	550	835	1,410	2,110	3,570
Electrical gross efficiency [%] **	15	15	15	15	15
Captive consumption [%]***	9	9	9	9	9
Natural gas consumption [Sm3/h]	370	555	930	1,390	2,325

* Intermediate sizes available upon request. Expected performances with 12 bar steam output.
** Respect to fuel input.
*** On electrical output gross.

TECHNOLOGIES BENCHMARK



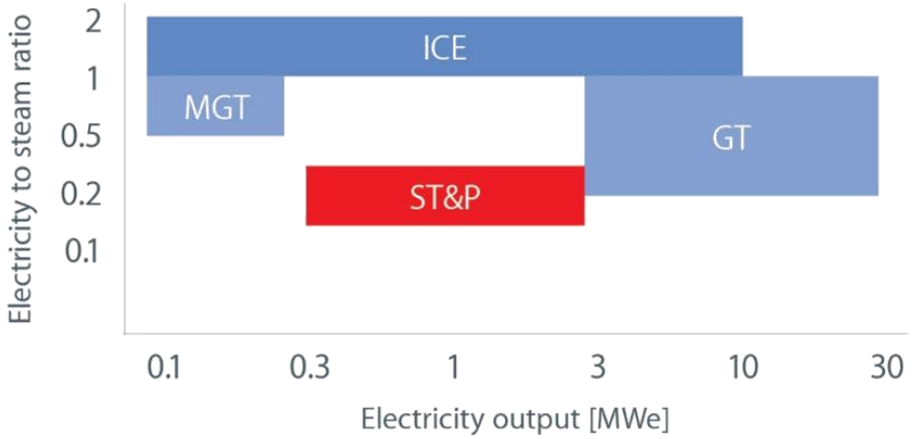
Each CHP technology (e.g. internal combustion engines, gas turbines, high-temperature CHP, etc.) has its own specific production characteristics in terms of steam and electricity productions.



Turboden ST&P system® covers a frame of electrical and steam output that is unmet by competing CHP technologies.

TECHNOLOGIES COMPARISON

TURBODEN POSITIONING IN THE CHP MARKET

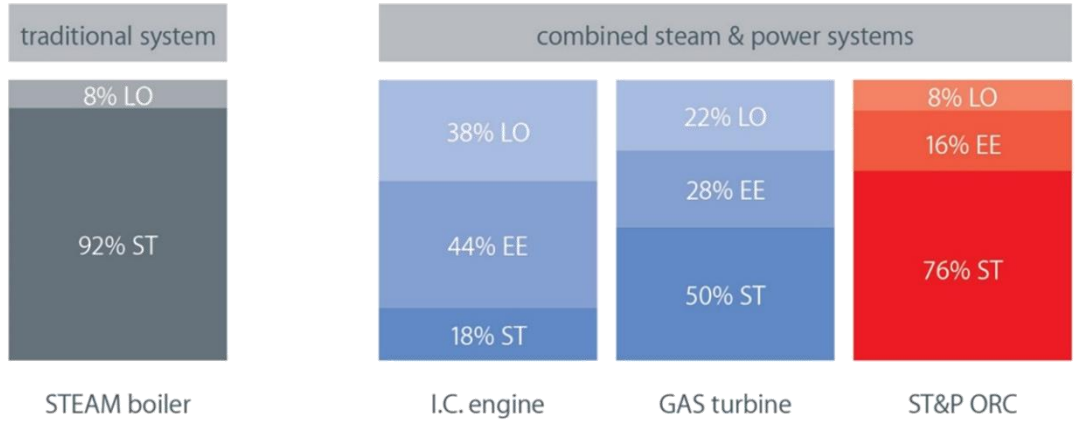


Legend:
ICE = Internal Combustion Engine
GT = Gas Turbine
MGT = Micro Gas Turbine
ST&P = Steam & Power ORC

1 : 4

electric/thermal power ratio

TURBODEN STEAM & POWER: A NEW COGENERATION TECHNOLOGY



NOTES
1. Turboden elaboration of major OEM datasheets.
2. Jacket water heat for I.C. engine is accounted as losses.

Legend: LO = losses EE = electricity ST = steam

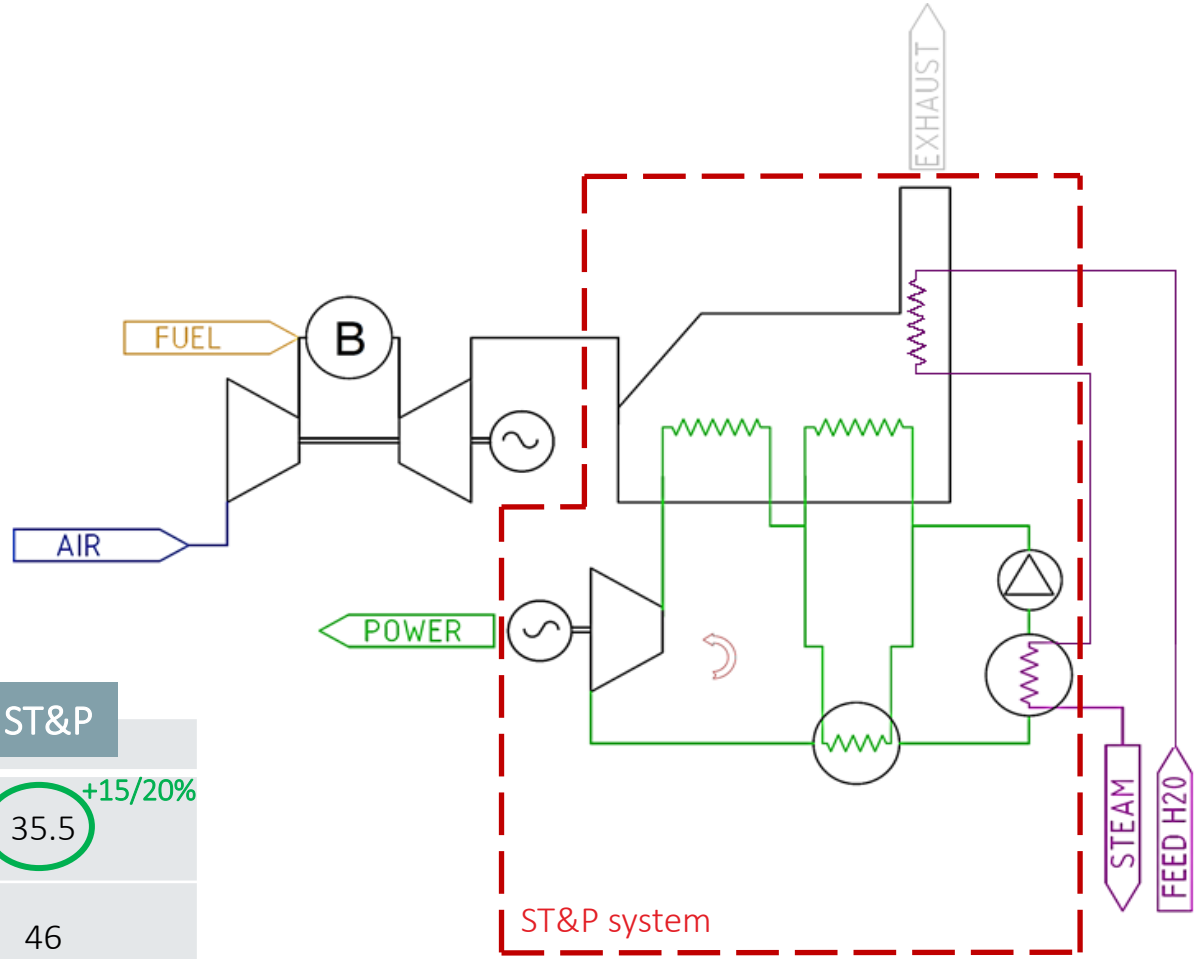
>90%

overall efficiency

COMBINED CYCLE: GAS TURBINE + STEAM & POWER

By adding Turboden Steam & Power system® at the bottom of gas turbine, you can enhance the electrical output of the CHP system maintaining a valuable steam output.

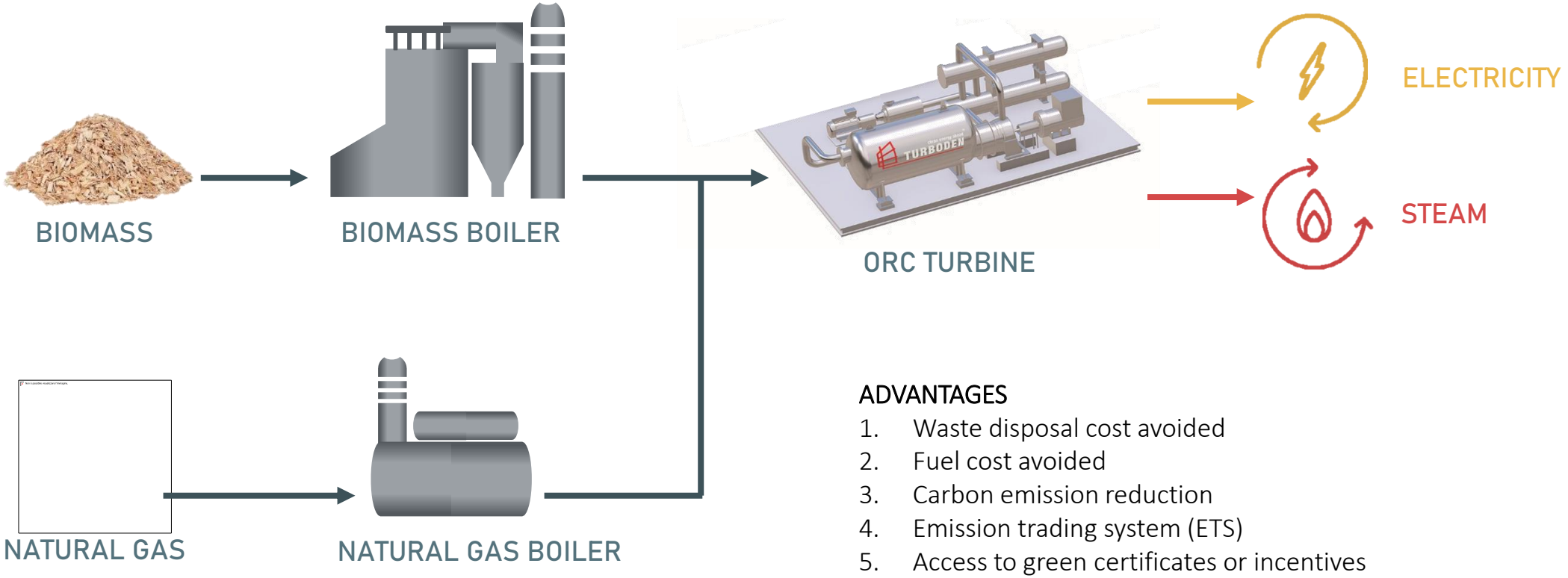
In direct exchange configuration, Turboden Steam & Power system® working fluid can directly evaporate by means of an exhaust gas heat exchanger.



	GT	GT + ST&P
Electrical efficiency [%]	30	35.5 +15/20%
Steam generation efficiency [%]	52	46

MULTI-FUEL TECHNOLOGY: BIOMASS AND WASTE

The Steam & Power solution can be totally or partially fueled by biomass or process waste.
The biomass-fed Steam & Power system can satisfy the energy demand of the manufacturing processes, as panel wood, who have internal availability of biomass from own production process or more in general companies who have the possibility to buy biomass. The same scheme can be applied exploiting process waste instead of biomass.



ADVANTAGES

1. Waste disposal cost avoided
2. Fuel cost avoided
3. Carbon emission reduction
4. Emission trading system (ETS)
5. Access to green certificates or incentives

CEREAL DOCKS

CUSTOMER:
Cereal Docks

COUNTRY:
Italy

STATUS:
under construction

ELECTRIC POWER PRODUCED:
1.35 MWe

STEAM PRODUCED:
10.6 ton/hour at 12bar(g)

DESCRIPTION:
electrical energy and steam production for a process of extraction and refining of oil from seeds

FUEL:
natural gas

CONTRACT:
rental

CEREAL DOCKS

THE CUSTOMER

Cereal Docks is an Italian industrial group, with 6 production facilities and 2 storage centers, operating in the feeds and foods primary processing sector, producing ingredients including meals, oils and lecithin, derived from oil seeds (soy, sunflower and rapeseed) and grains intended for applications in the foods, pharmaceutical, cosmetics, animal feeds, technical and energy.

The company's general headquarters is located in Camisano Vicentino (Vicenza), where Mauro and Paolo Fanin founded the company 36 years ago, a shining example of a successful family business.

THE NEED

Cereal Docks, a company with a big expertize in cogeneration solutions, decided to install Turboden technology in the factory of Camisano Vicentino in order to maximize the energy efficiency of the site.

The process of the production site of Camisano is in fact characterized by a strong consumption of steam.

OUR SOLUTION

Turboden provides a turnkey solution, supplying the complete system, from the natural gas-fired boiler to the high-temperature ORC turbogenerator.

The Turboden solution perfectly fits the energy needs of Cereal Docks, which uses a CHP ORC System to co-generate about 1,350 kW electric power and 10.5 ton/hour of steam at 12 bar(g) needed for the extraction and refining of oil from seeds.

CENTRALE DEL LATTE DI BRESCIA

CUSTOMER:
Centrale del Latte di Brescia

COUNTRY:
Italy

STATUS:
in operation since 2021

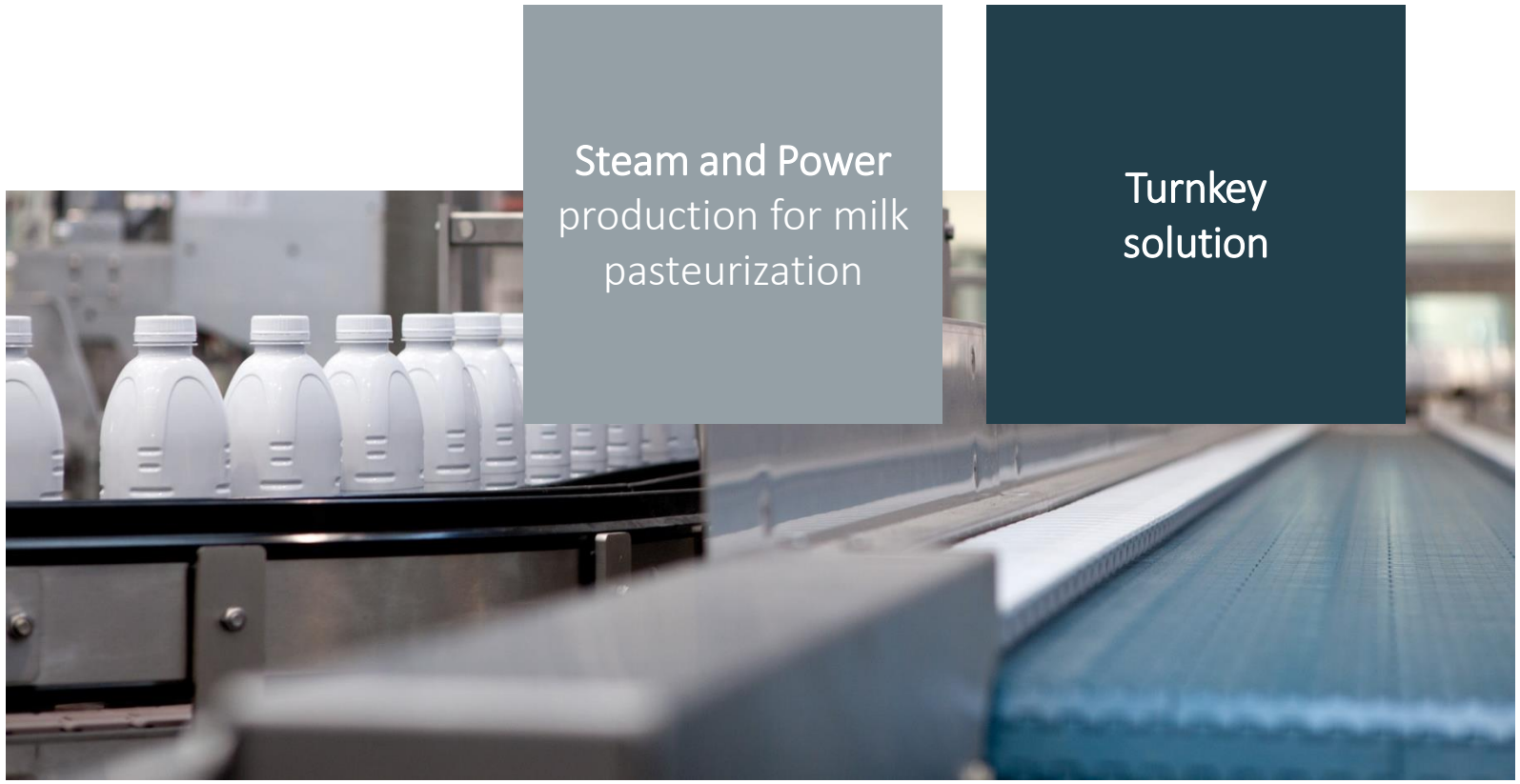
ELECTRIC POWER PRODUCED:
0.7 MWe

STEAM PRODUCED:
5 ton/hour at 15 bar(g)

DESCRIPTION:
electric power and steam production for milk pasteurization

FUEL:
natural gas

CONTRACT:
purchase



CENTRALE DEL LATTE DI BRESCIA

THE CUSTOMER

Centrale del Latte di Brescia established in 1930 with the objective of ensuring hygiene checks on milk and daily distribution to all citizens. Centrale del Latte di Brescia was the first municipal dairy in Italy to have a UHT plant for production of long-life milk. The company was the first in the world to pack UHT milk in fully recyclable PET bottles.

THE NEED

Centrale del Latte di Brescia used to produce steam by means of a traditional boiler buying electric power from the local grid. The customer decided to look at a cogeneration solution to increase the overall efficiency of the system and reduce related costs.

OUR SOLUTION

Turboden provides a turnkey solution, supplying the complete system, from the natural gas-fired boiler to the high-temperature ORC turbogenerator. The Turboden solution perfectly fits the energy needs of Centrale del Latte di Brescia, which uses an CHP ORC System to co-generate about 700 kW electric power and 5 ton/hour of steam at 15 bar(g) needed to pasteurize long-life milk.

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TURBODEN

MOVE THE WORLD FORWARD MITSUBISHI HEAVY INDUSTRIES GROUP

FIND OUT MORE

OUR EXPERIENCE. YOUR POWER.