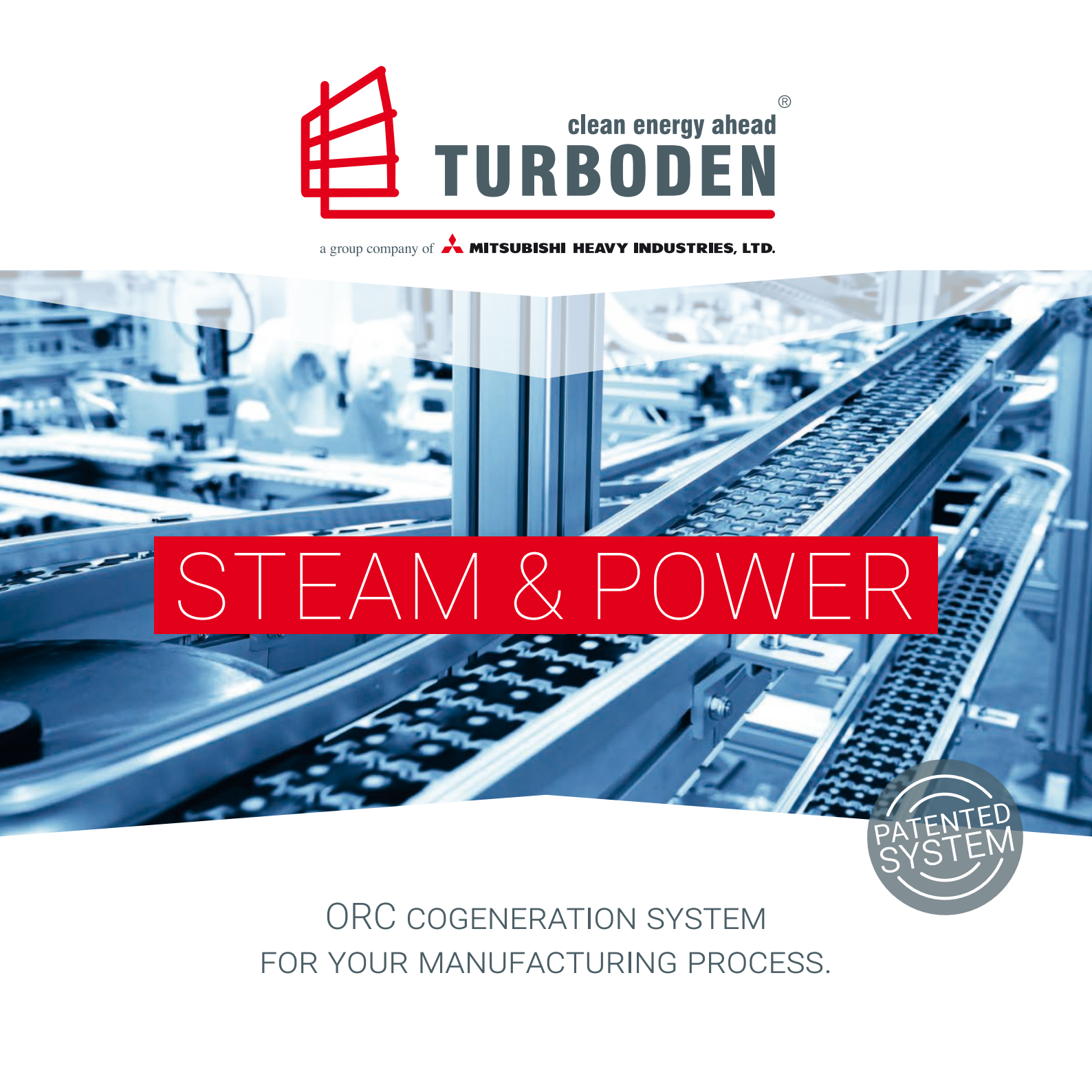


clean energy ahead[®]
TURBODEN

a group company of  **MITSUBISHI HEAVY INDUSTRIES, LTD.**



STEAM & POWER

PATENTED
SYSTEM

ORC COGENERATION SYSTEM
FOR YOUR MANUFACTURING PROCESS.



STEAM & POWER

Your Steam requirement with an electricity boost.



WHAT IT IS

Steam & Power (ST&P) ORC is a new technological solution for Combined Heat & Power (CHP) generation. It allows the production of electricity and a valuable high temperature heat carrier, such as steam, directly exploitable in manufacturing processes.

THE INNOVATION PRINCIPLE

The innovation principle of Steam & Power ORC is the temperature level of the cycle. It allows the cogeneration of electricity and medium pressure steam with a very high overall energy efficiency.

THE TECHNOLOGY

Steam & Power ORC comes from the technological coupling of the Turboden pioneering ORC solution and Bono Sistemi experience in high temperature boiler manufacturing.

100% fuel

steam



electricity



losses



THE FEATURES

- > Electrical Power rating from 500 kWe up to 3 MWe.
- > CHP steam output pressure range from 6 bar up to 30 bar
- > CHP steam output flow rate range from 4 ton/h up to 30 ton/h

**Expected values for 12 bar (a) steam production*

WHY

COGENERATION

Steam & Power ORC system represents a great economic and sustainable opportunity for manufacturing processes.

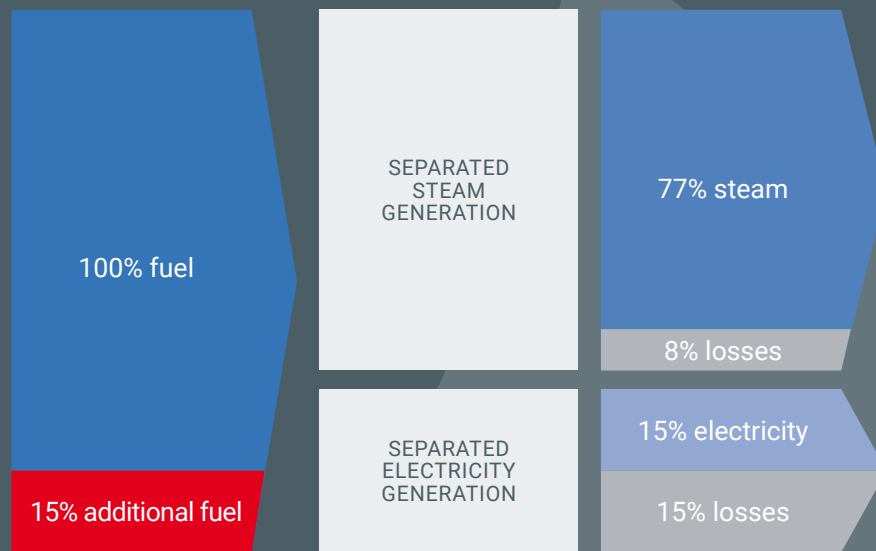
THE ADVANTAGES

- > Excellent economic return of investment (PBT < 3 years, IRR > 30%)
- > Hedge against rising electricity costs
- > Efficient & sustainable solution for increasing steam demands
- > Improving System Resiliency in Energy Infrastructure
- > CHP during grid outages - "Island Mode"
 - Continued operations
 - Avoided shutdown costs
- > Avoided costs of new regulations (coal, oil fired boilers)

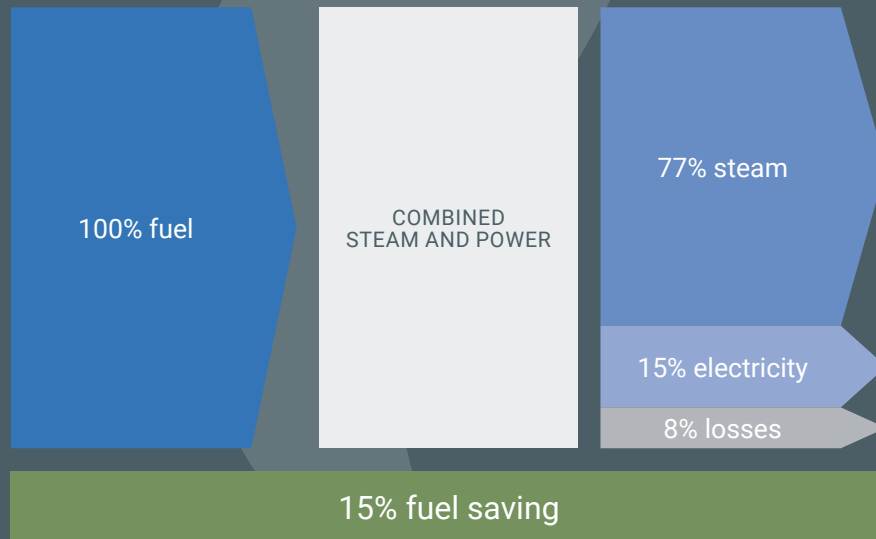
ENVIRONMENTAL BENEFITS

- > Becoming "greener"
- > Reduced GHGs emissions
- > Increased energy output per unit of fuel consumption with improved energy conversion efficiency
- > Suited for sustainability plans

TRADITIONAL SYSTEM



CHP - ST&P ORC COGENERATION SYSTEM



PES (Primary Energy Saving) suitable for CAR Qualification

MORE ENERGY

NO LOSSES

Effective CHP systems satisfy directly the thermal requirement of the manufacturing process. ST&P ORC does producing thermal energy in the form of steam and minimizing losses. In fact, ST&P ORC produces electricity & steam without hot water to be exploited.

AT YOUR SERVICE

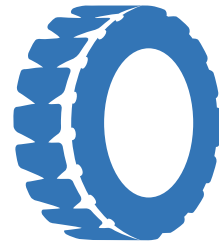
Steam & Power ORC was conceived to satisfy many manufacturing processes requiring electricity and relevant amount of medium pressure steam.



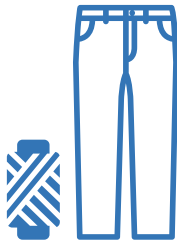
food & beverage



chemical & pharmaceutical



plastic & rubber



textile



paper & wood industry



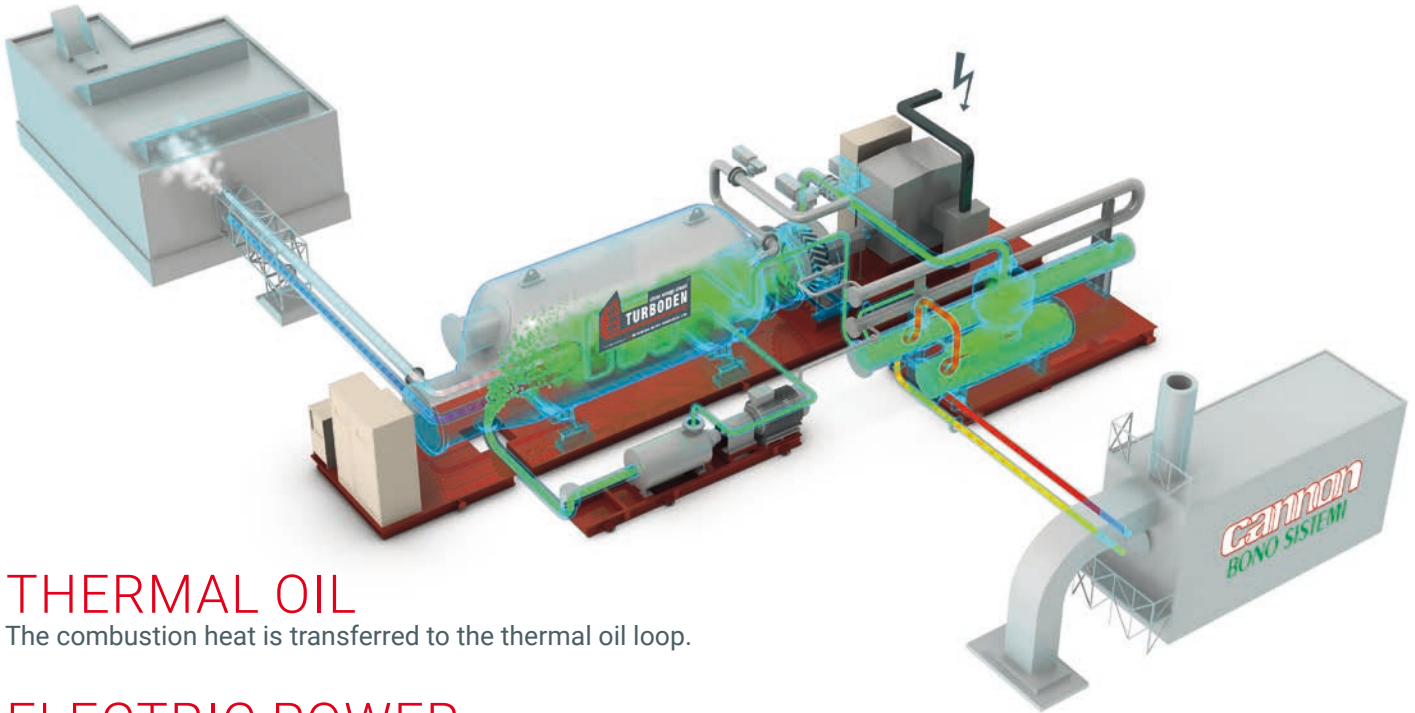
oil & gas



WORKING PRINCIPLE

HEAT SOURCE

The fuel (natural gas, syngas, diesel, fuel oil, wood pellet and others) is fed to the combustion chamber of Bono Sistemi boiler. There it is mixed with preheated air and burned.



THERMAL OIL

The combustion heat is transferred to the thermal oil loop.

ELECTRIC POWER

The hot thermal oil makes the ORC working fluid evaporating. The organic vapour generated expands to the turbine that drives an electric generator, producing electric power.

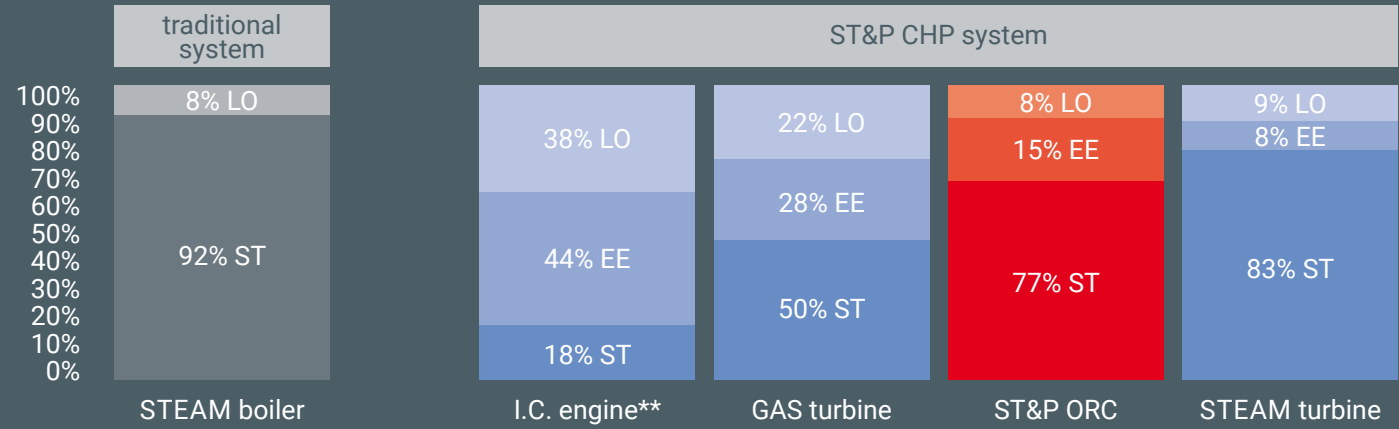
THE STEAM PRODUCTION

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.

From the condenser the organic fluid, in liquid phase, is collected to the pump, which increases the pressure and moves the organic fluid to the regenerator, preheater and evaporator, closing Organic Rankine Cycle loop.

TECHNOLOGY OVERVIEW

Key performance parameter*



* Turboden elaboration of major OEM datasheets
** Jacket water heat is accounted as losses
Legend: LO = losses EE = electricity ST = steam

	IC engine	GAS turbine	ST&P ORC	STEAM turbine
1/FCP*	0,54	0,72	0,9	0,9
Electrical Output	high ☺	high ☺	medium	low
Steam Output	low	medium	high ☺	high ☺
Total Efficiency	low	medium	high ☺	high ☺
Market Availability & Modularity	high ☺	low	high ☺	low
Flexible Operation At Partial Loads	medium	low	high ☺	low
Avaliability	low	medium	high ☺	medium

*1/FCP- Fuel Chargable to Power – Additional amount of fuel needed for the CHP system operation, considering constant thermal output. 1/FCP is an index of electrical efficiency of a system working in cogeneration.

STEAM & POWER ORC ADVANTAGES

- > Fuel flexibility (for both gaseous and liquid fuels)
 - > High total efficiency
 - > Prevailing steam output
 - > High availability
 - > High flexibility to partial load operation down to 20%
- > Low operation & maintenance cost
 - > Modularity
 - > Outdoor installation
 - > Island operation
 - > Combined with other CHP technologies if required



ABOUT TURBODEN

Turboden, a Mitsubishi Heavy Industries company, is an Italian company and a global leader in the design, manufacture, and after-sales services of Organic Rankine Cycle (ORC) turbogenerators, which exploit heat to generate electric and thermal power. Turboden has more than 320 plants in 33 countries and offers turbogenerators from 200 kWe to 20 MWe.

WHY TURBODEN

- > **Experience:** Turboden projects and manufactures ORC units since 1980
- > **References:** Turboden has in operation about 270 ORC units all over the world
- > **Performance:** high performance at top level, due to in-house designed turbines and specifically selected fluids
- > **Reliability:** 98% average functioning time
- > **Cutting-edge technology:** Turboden has an internal R&D centre focusing on fluid dynamics research
- > **High-quality:** due to careful production and testing at the internal production facility in Brescia, Italy
- > **Customer satisfaction:** we have clients buying different units over the years, the best proof of customer satisfaction.
Moreover, we offer a high degree of unit customization following client specific needs
- > **After-sale services:** extendable guarantees and maintenance packets

APPLICATIONS

Turboden ORC technology is used for cogeneration or power only generation from renewable sources, including biomass, geothermal, solar energy and waste heat from industrial processes, waste incinerators, engines or gas turbines. Steam & Power Cogeneration is the most innovative application of Turboden ORC System in combination with BONO HTH.

BIOMASS

GEO THERMAL

STEAM COGENERATION

OIL&GAS

WASTE TO ENERGY

HEAT RECOVERY

SOLAR THERMAL POWER

ADVANTAGES

Organic Rankine Cycle offers many advantages, such as:

- > High turbine / thermodynamic cycle efficiency
- > Turbine low mechanical stress
- > Absence of moisture during the vapour expansion, responsible for the erosion of the blades
- > Easy to use the unit is designed to be easily operated even by unskilled staff
 - Simple start up procedures
 - Simple maintenance procedure
 - Automatic and continuous operation
- > No operator attendance required
- > Long life of the plant (> 20 years)
- > No need to demineralize water

Due to these advantages, power plants based on ORC technology are quickly spreading around the world.



ABOUT BONO

Since 1958 Bono is dedicated to design, manufacture, install and service industrial boilers for standard and special applications. Headquartered in Italy, Bono is part of the Cannon Group, an international engineering company active worldwide with more than 18 locations and a wide service network supporting customers locally.

WHY CANNON BONO

The Bono focus is to develop the best technologies in energy saving, emissions reduction and smart solutions for customers. These green and efficient solutions were selected by several EPC contractors making BONO one of the recognized leaders in this field. Steam & Power Cogeneration is the most innovative application of BONO HTH in combination with Turboden ORC System.

APPLICATIONS

Traditionally BONO HTH, an innovative and proprietary design of Thermal Oil Heater, finds application in those industrial fields where high and precise process temperatures are required, such as production of syntetic fibers, chemical processes, wood industry, oil stocking and transportation and indirect steam generation. From the O&G to companies operating in food & beverage, pharmaceutical, paper and many other energy consuming industries.

ADVANTAGES

The main advantages of BONO HTH heater are:

- › Compact design with a reduced footprint and limited height
- › Complete and full accessibility for cleaning and repair, without the need for coil extraction during the whole heater lifetime
- › High efficiency thanks to the air preheater that can be in-built with advantages also in handling and space saving
- › The horizontal position of the burner allows an easier accessibility and extraction and it prevents problems deriving from unexpected fuel oil leakages
- › The wider combustion chamber gives naturally lower emissions. Together with other additional technologies BONO HTH can fulfil the most demanding emission levels required
- › BONO HTH is especially designed to reduce the thermal load preventing the chemical degradation of the oil
- › BONO HTH operates with all possible conventional fuels such as gas, diesel oil and crude oil. It can also be used with a wide range of waste fuels such as off gas, syngas and flare gas or biofuels and biogas

HTH THERMAL OIL BOILER

Thermal fluid horizontal type heaters with multi-tubular design, built for capacities ranging up to 40 MW. Thermal fluid syntetic type, can be used both in liquid and in vapour phase up to 400°C.

