

clean energy ahead[®]
TURBODEN

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



GEO THERMAL ORC

SMARTER BINARY SYSTEMS DELIVERED.



Geo

GEO THERMAL

Dependable, Flexible, Efficient, Durable.



GEO THERMAL ENERGY

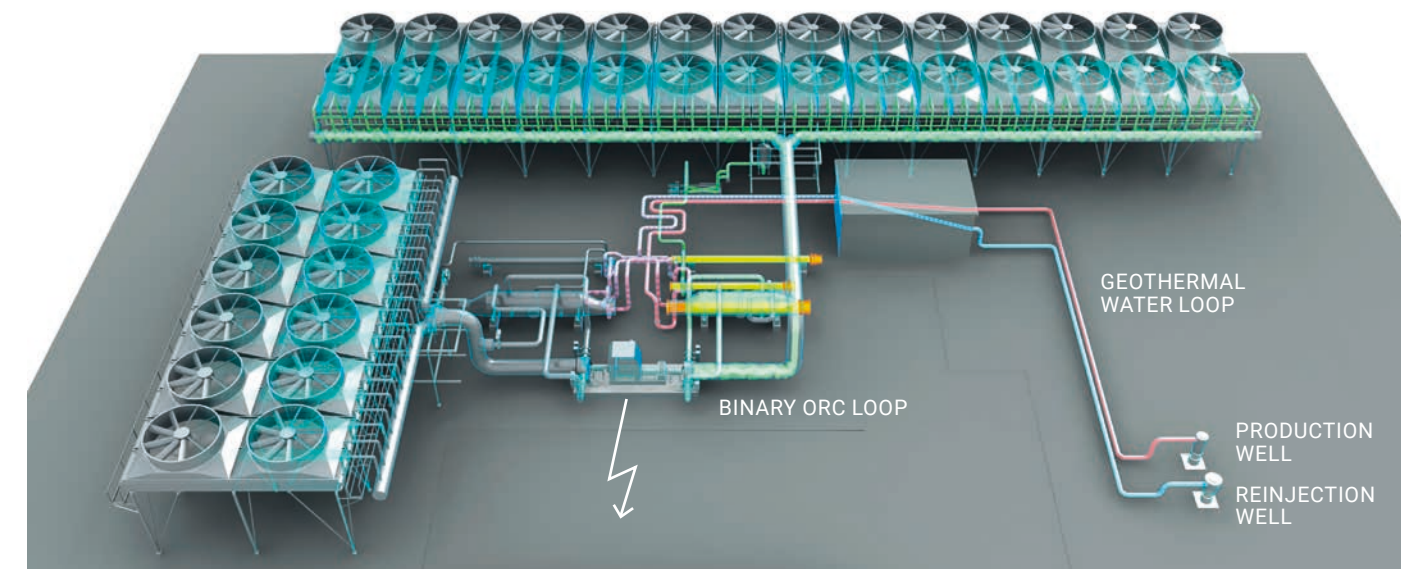
Heat from the earth can be used as an energy source and can be found in many regions of the world, especially at tectonic plate boundaries or at places where the crust is thin enough to let the heat through. The most common way of capturing the energy from geothermal resources is to tap into naturally occurring hydrothermal convection systems, where cooler water seeps into earth's crust and is heated up within a reservoir.

BINARY ORC TECHNOLOGY

Binary plants do not directly use geothermal fluid for electric power generation, but a secondary fluid is heated up and vaporized by means of heat exchange with the geothermal fluid, in order to drive a turbine and produce electricity. The heat that is not converted can be delivered to a thermal user or dissipated by means of a suitable cooling system. In such way geothermal fluid remains within a closed loop of piping (from the reservoir to the reinjection) without passing through the turbine.

TURBODEN SOLUTION

Turboden ORC solutions make the majority of geothermal sources exploitable, due to applicability at low temperatures and flexibility of the technology. Furthermore, the synergy with Mitsubishi Heavy Industries – world-class geothermal plants provider – allows to develop innovative solutions, such as combined flash & binary geothermal plants.



WHY SELECTING A FLUID DIFFERENT FROM WATER

By selecting a “lower boiling fluid” rather than water it is possible to efficiently exploit also heat sources within the range of 100 °C to 200 °C. Thermodynamic cycle configurations, which are inaccessible in the state diagram of water, can be obtained with organic fluids having different parameters, and with high efficiency.

ADVANTAGES

- > Geothermal fluid remains isolated from the environment and the turbine
- > Dry expansion: no fluid condensation in the turbine (unlike in the geothermal flash steam turbines), with no erosion
- > High molecular mass fluid: low peripheral speed are required for the turbine, with low mechanical stress
- > Low enthalpy drop across the turbine: low number of turbine stages, thus turbine size and cost is smaller
- > Small expansion ratio across the turbine: small blades size increase during expansion compared to water steam



TURBODEN TECHNOLOGY

A PROVEN SOLUTION

- › The design of the turbine is carried out by Turboden representing the core know-how since 1980
- › More than 300 Turboden ORC successfully implemented with capacity sizes from 200 kWe to 20 MWe per single shaft
- › Proven experience with 9 different organic fluids, also non-flammable and with low GWP
- › Off grid capability (island mode) and active grid balancing
- › Combined Heat and Power solutions

A RELIABLE CHOICE

- › Average plant availability: 99% on all the fleet in operation
- › Complete in-house design (above ground process and technology)
- › On site activities: specialized staff for supervision to erection, start-up and commissioning
- › Strong after sale services: remote monitoring, localized maintenance, LTSA with spare parts

AN EXTRAORDINARY TURBINE

- › More than 60 different turbines developed on 4 standard frames
- › More than 90% turbine isentropic efficiency achieved
- › Patented seals and bearing replacing system ensures short maintenance procedures
- › Axial geometry is the most widely adopted in turbomachinery design, proven with billions of working hours worldwide
- › Multi stage axial turbines are less sensitive than radial ones to ambient temperature variations, showing nearly constant efficiency over wide range of operating conditions
- › Direct drive: rotation speed from 1500 rpm to 3000 rpm
- › Robust design, low vibration, and strict quality tests in collaboration with Mitsubishi team

AFTER MARKET


Turboden after sale services are provided by an experienced staff of more than 40 specialists. Turboden can provide fully extended operation guarantees and customized maintenance packages through its localized staff, combined with a unique 24/7 remote monitoring tool.

- > Long Term Service Agreement (LTSA)
- > Spare parts packages
- > Extended warranty
- > Availability guarantee


REMOTE ASSISTANCE

TOS - Turboden Online Service is a website dedicated to the ORC maintenance and service. Via the TOS Turboden offers the customer a fast, personalized transparent tool that allows to report any system anomalies over the Internet:

- > ORC performance control & optimization
- > Troubleshooting (24/7)
- > Fast problem solving responses
- > Maintenance plan



Customer Support
request or Turboden
planned checks



Trend analysis,
local operator
informations



Discussion
and decisions



REACTION PLAN:
on site or from
remote



SELECTED REFERENCES



SAUERLACH (GERMANY)

- > Customer: SWM - StadtWerke München
- > Scope of supply: EPC supply of power plant and steam above ground system
- > Start-up and availability: March 2013, 98%
- > Heat source: geothermal water at 140°C
- > Design capacity: 5 MWe



DÜRRNHAAR (GERMANY)

- > Customer: Hochtief EM
- > Scope of supply: EPC supply of power plant and steam above ground system
- > Start-up and availability: December 2012, 98,6%
- > Heat source: geothermal water at 138°C
- > Design capacity: 5,6 MWe



KIRCHSTOCKACH (GERMANY)

- > Customer: Hochtief EM
- > Scope of supply: EPC supply of power plant and steam above ground system
- > Start-up and availability: March 2013, 98,9%
- > Heat source: geothermal water at 138°C
- > Design capacity: 5,6 MWe



TRAUNREUT (GERMANY)

- > Customer: Geothermische Kraftwerksgesellschaft Traunreut mbH
- > Scope of supply: EPC supply of power plant and steam above ground system
- > Start-up: January 2016
- > Heat source: geothermal water at 118°C
- > Design capacity: 4,1 MWe



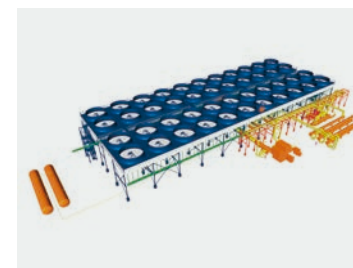
SUGAWARA (JAPAN)

- > Customer: Mitsubishi Heavy Industries
- > Scope of supply: ORC engineering, turbine and generator supply
- > Start-up and availability: June 2015, 98,4%
- > Heat source: geothermal water and steam at 140°C
- > Design capacity: 5 MWe



SOULTZ-SOUS-FORÊTS (FRANCE)

- > Customer: GEIE
- > Scope of supply: : EPC supply of power plant
- > Start-up: July 2016
- > Heat source: geothermal water at 180°C
- > Design capacity: 1,7 MWe



VELIKA CIGLENA (CROATIA)

- > Customer: Geoen
- > Scope of supply: EPC supply of power plant and steam above ground system
- > Start-up: 2017
- > Heat source: geothermal water and steam at 170°C
- > Design capacity: 15 MWe



NEVIS (ST. KITTS AND NEVIS)

- > Customer: Nevis Renewable Energy International
- > Scope of supply: EPC supply of power plant and steam above ground system
- > Start-up: 2017
- > Heat source: geothermal water and steam at 179°C
- > Design capacity: 10 MWe

STRENGTHS

- › Experience: global leader of ORC technology since 1980
- › References: about 275 ORC units in operation and more than 50 under construction all over the world
- › Performance: high performance at top level, due to in-house designed turbines and specifically selected fluids
- › Plant availability: 99% average operation time
- › Cutting-edge technology: internal R&D centre focusing on fluid dynamics research and turbine design
- › High-quality: due to careful production and testing at production facility in Brescia, Italy
- › Flexibility: tailored solutions to satisfy customer needs
- › Scope: Engineering and Procurement extendable to full EPC supply
- › After-sale services: strong expertise and prompt solutions
- › Cooperation with Mitsubishi Heavy Industries for global geothermal projects

ABOUT US

Turboden is an Italian company founded in 1980 and a global leader in the design, manufacturing, and after-sale services of Organic Rankine Cycle (ORC) turbogenerators, which exploit heat to generate electric and thermal power.

Turboden has more than 330 plants in 35 countries and offers geothermal solutions from 1 MWe to 40 MWe per single generator.

Since 2013 Turboden is part of Mitsubishi Heavy Industries Ltd (MHI), one of the core companies of the Mitsubishi Group, founded in 1884 as a shipbuilding company, and now known as the largest Japanese conglomerate company, supplying more than 700 products.

MHI's products cover from commodity equipment, such as machinery and equipment, to transportation systems, integrated defence and space system. Beyond 130 years of history and technologies on land, sea, air and space, MHI's products contribute to make the society better.

As of today Mitsubishi Heavy Industries has delivered more than 3 GW of geothermal power in 13 different countries.

Turboden and Mitsubishi Heavy Industries can offer together fully integrated geothermal solutions, combining the advantages of the two technologies.

