



TURBODEN
GEO THERMAL

Cod. 11-COM.P-5-rev.74

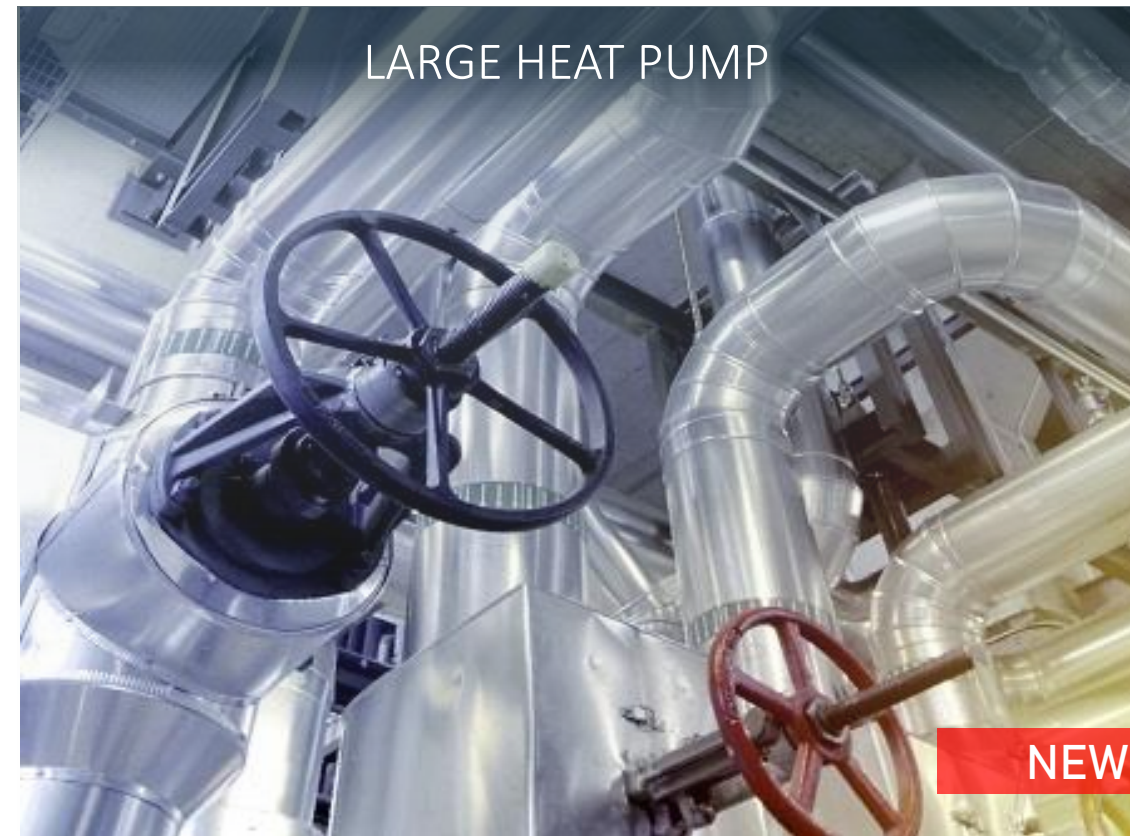
SMARTER BINARY SYSTEMS DELIVERED.



TURBODEN AND GEOTHERMAL ENERGY

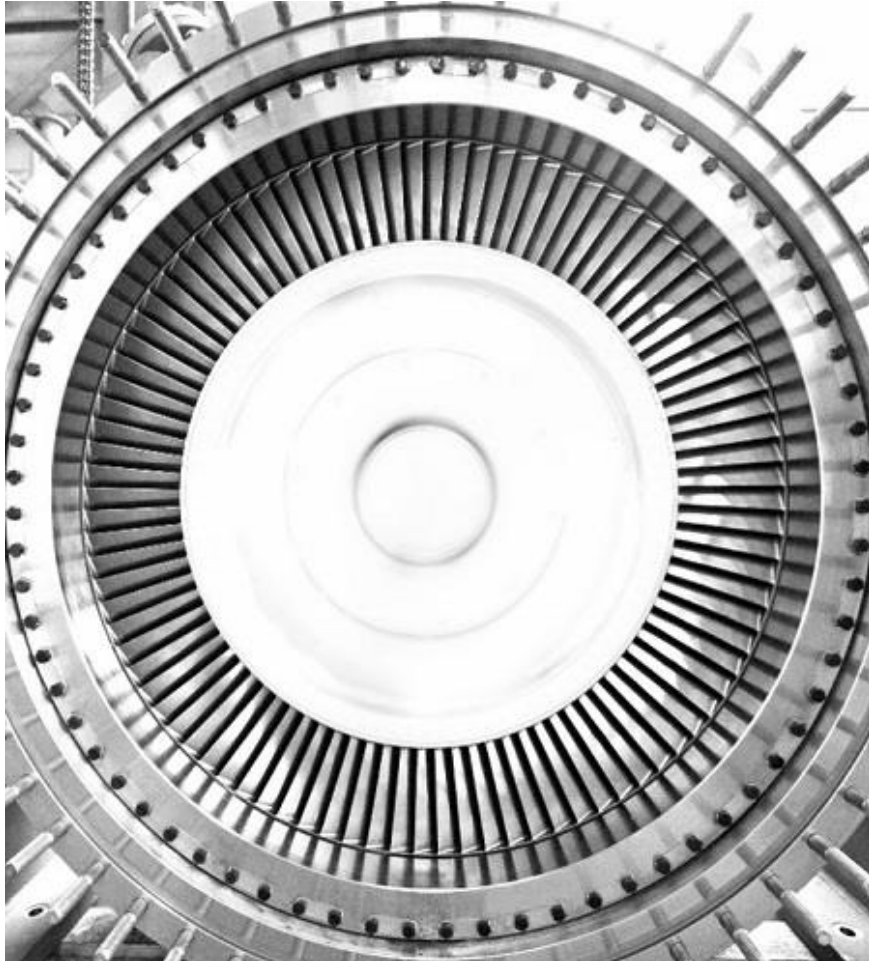
We provide efficient and reliable binary ORC power plants, suitable for the production of electricity from low-to-high enthalpy sources.

OUR PRODUCTS



Designed for decarbonization.

ORC SYSTEM FEATURES



Simplicity

- ✓ Remote monitoring and automatic operation
- ✓ No water use and treatment required
- ✓ Minimal maintenance activities



Flexibility

- ✓ Ease of integration
- ✓ Excellent part load capability down to 10% load
- ✓ Different primary energy sources



Dependability

- ✓ High availability
- ✓ Long life (> 25 years)
- ✓ 40+ years in the design and production of turbomachinery

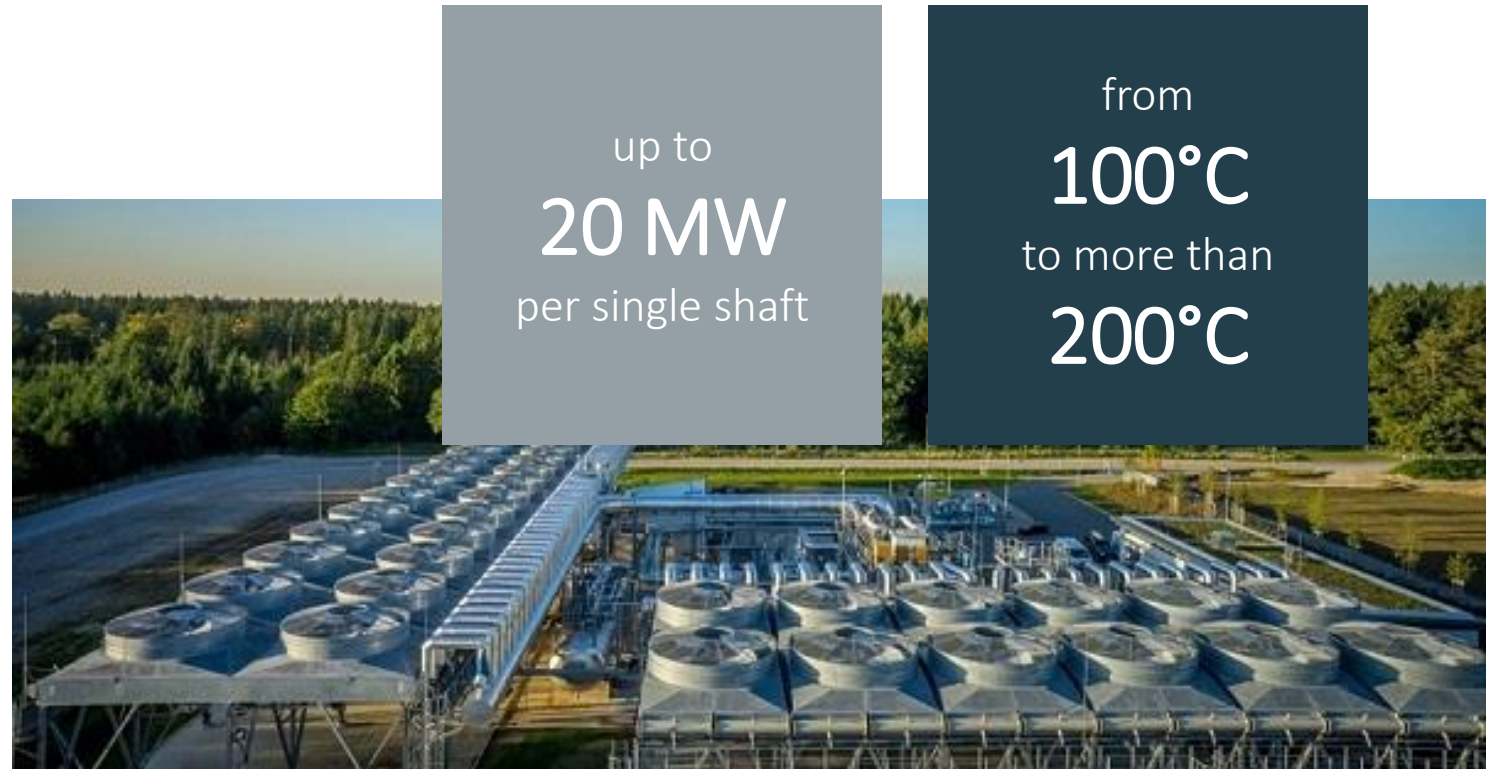


Sustainability

- ✓ Core system for renewable energy and energy efficiency
- ✓ Clean generation of power and heat
- ✓ Reduction of CO₂ emissions

TURBODEN GEOTHERMAL FEATURES

- Working fluids: hydrocarbons, HFCs, HFOs
- Thermodynamic process and control philosophy designed by Turboden
- Turbine type: axial multi stage, Turboden proprietary design
- Key equipment designed in house (e.g. air cooled condenser, heat exchangers)
- Operation in remote areas: off grid capability (island mode) and active grid balancing
- Combined heat and power solutions
- Low O&M requirements
- Remote monitoring and long term service
- Combined solutions with existing single flash plants or new back-pressure turbines

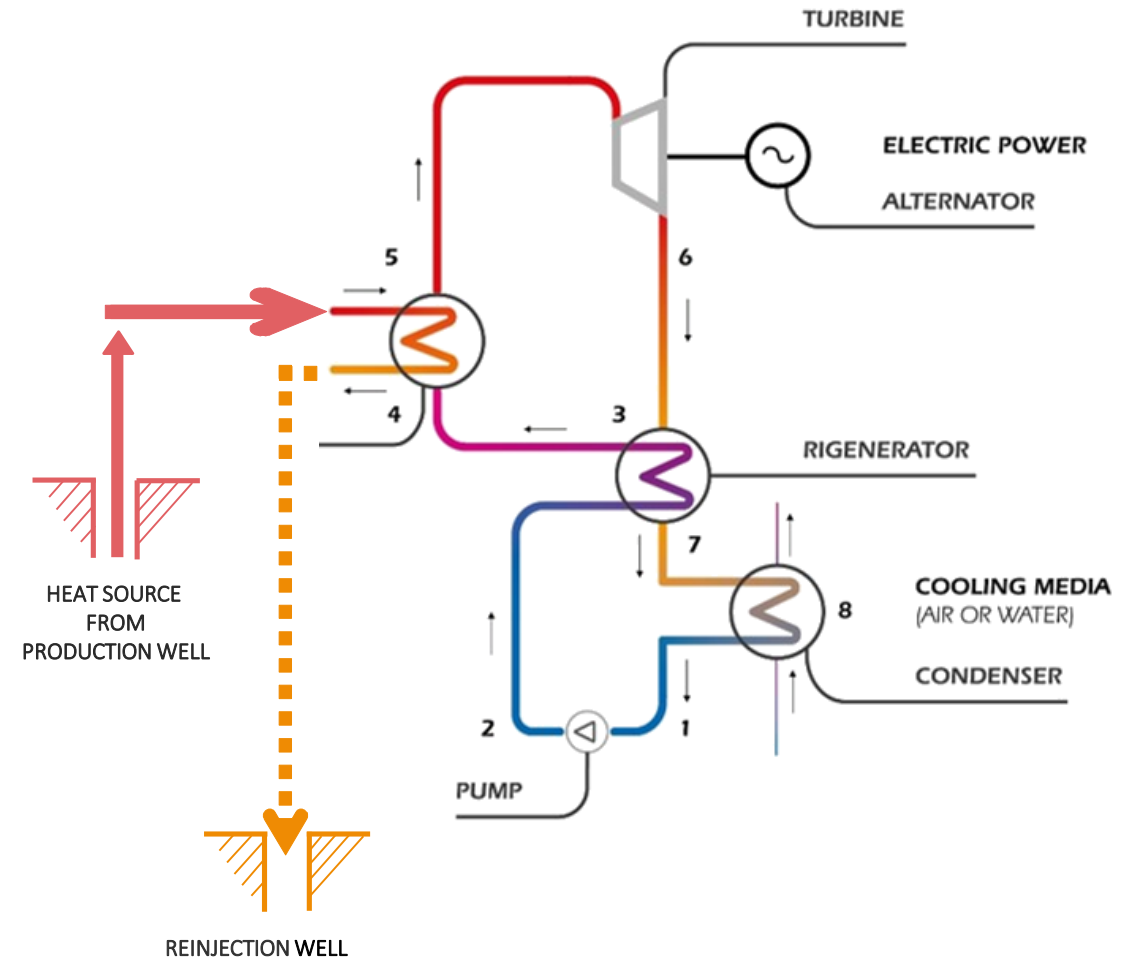


THE ORC CYCLE – HOW IT WORKS

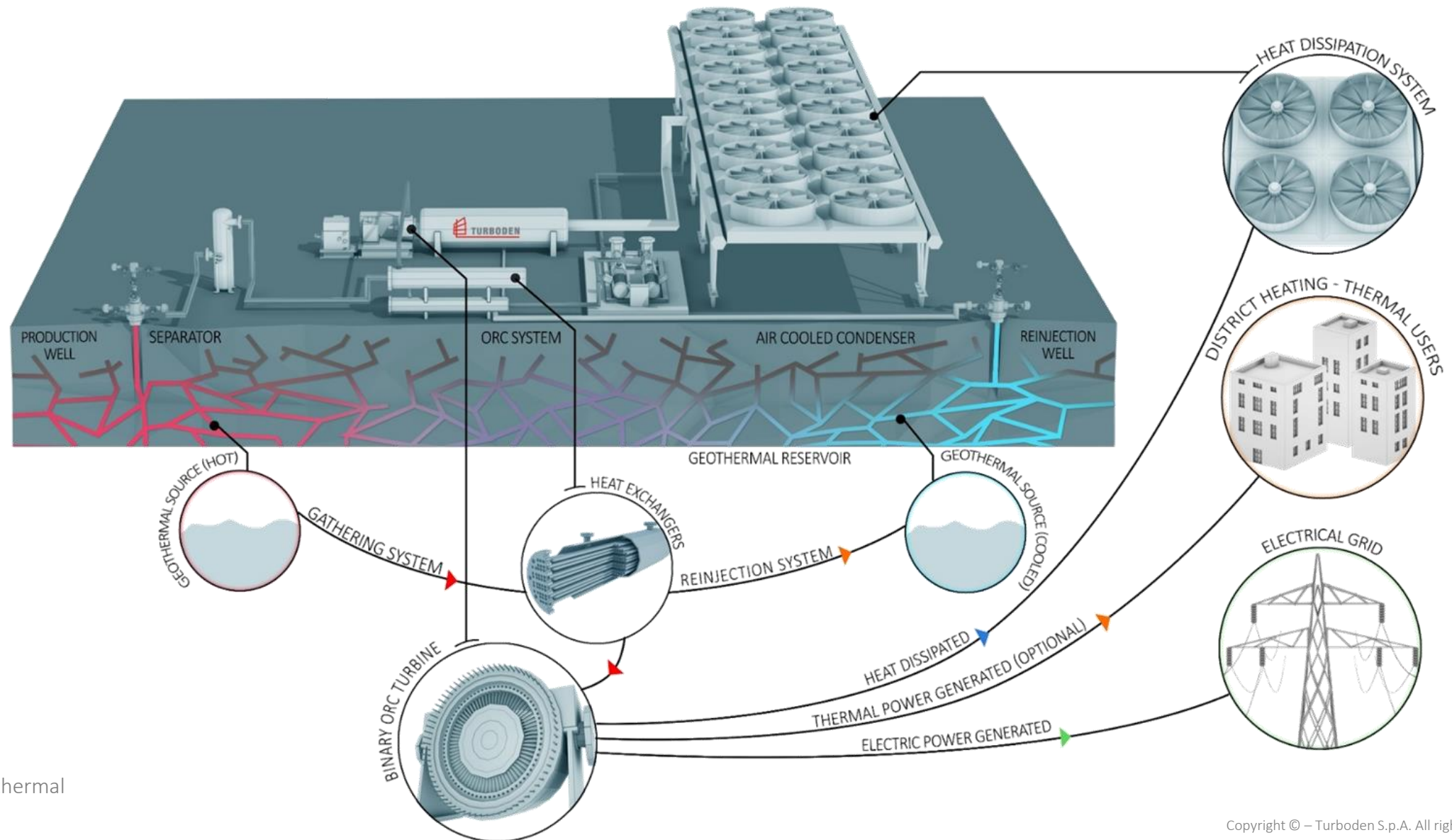
Differently from the conventional geothermal steam turbines, the ORC process uses low-to-high enthalpy geothermal fluid to preheat and vaporize a suitable organic working fluid within a closed loop:

- The organic fluid vapor rotates the turbine, which is coupled to the electric generator.
- The exhaust vapor flows through the regenerator and condenser, which is cooled by air or water.
- The organic working fluid is then pumped again, thus completing the closed-cycle operation.

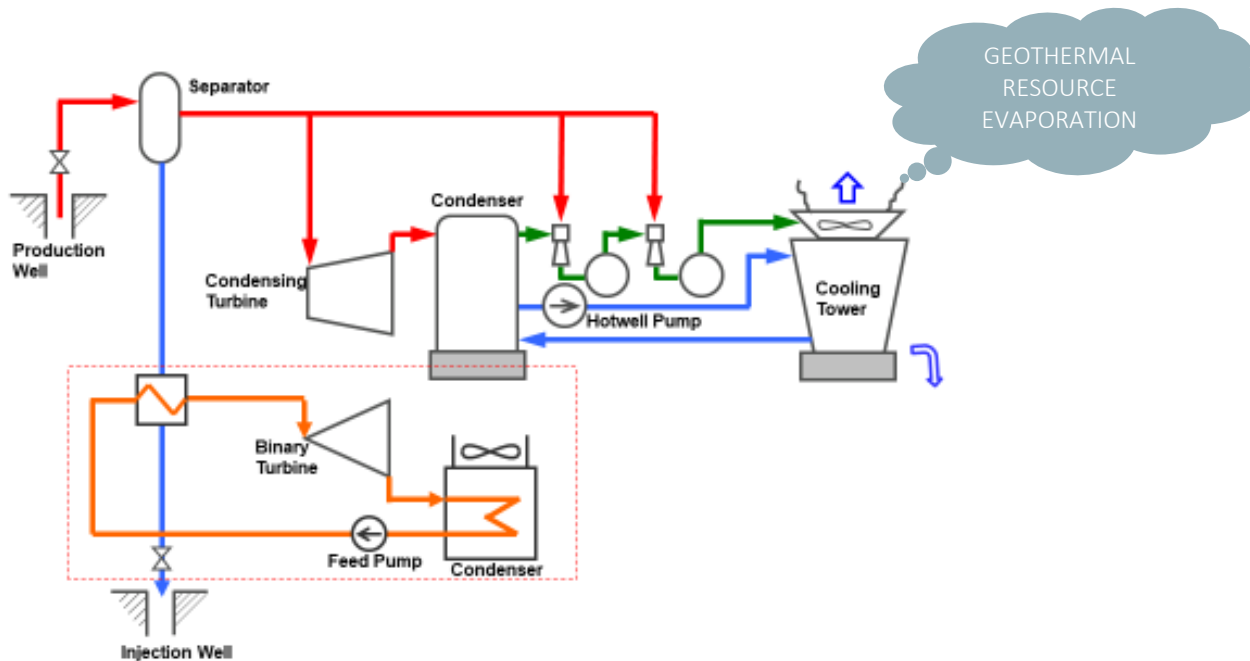
In such way the ORC turbine is not in contact with the geothermal fluid, which remains enclosed in the heat exchangers, allowing a full reinjection of all the brine and steam condensate with zero emissions to the ambient.



GEOHERMAL ORC PLANT LAYOUT



HYBRID CYCLE CONFIGURATIONS

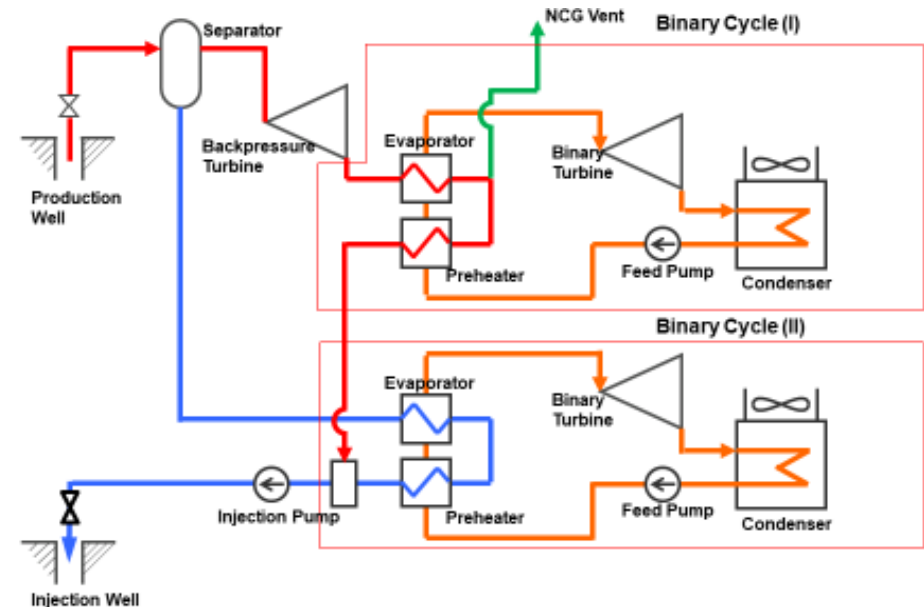


PROS

- Turboden and Mitsubishi can offer the integrated solution
- Typically applied as «retrofit» project (ORC added to existing single flash)
- No additional drilling cost / risk required
- Capacity can be increased using the existing infrastructure

CHALLENGES

- Scaling risk has to be mitigated by acid dosing of brine
- Cooling interaction with reservoir shall be studied carefully
- Geothermal resource evaporation through the cooling towers



PROS

- Turboden and Mitsubishi can offer the integrated solution
- More efficient than flash cycle if NCG are high in the resource
- 100% reinjection of geothermal fluid achievable

CHALLENGES

- Typically applied as «greenfield» project
- More complicated process to be engineered

LARGE HEAT PUMP

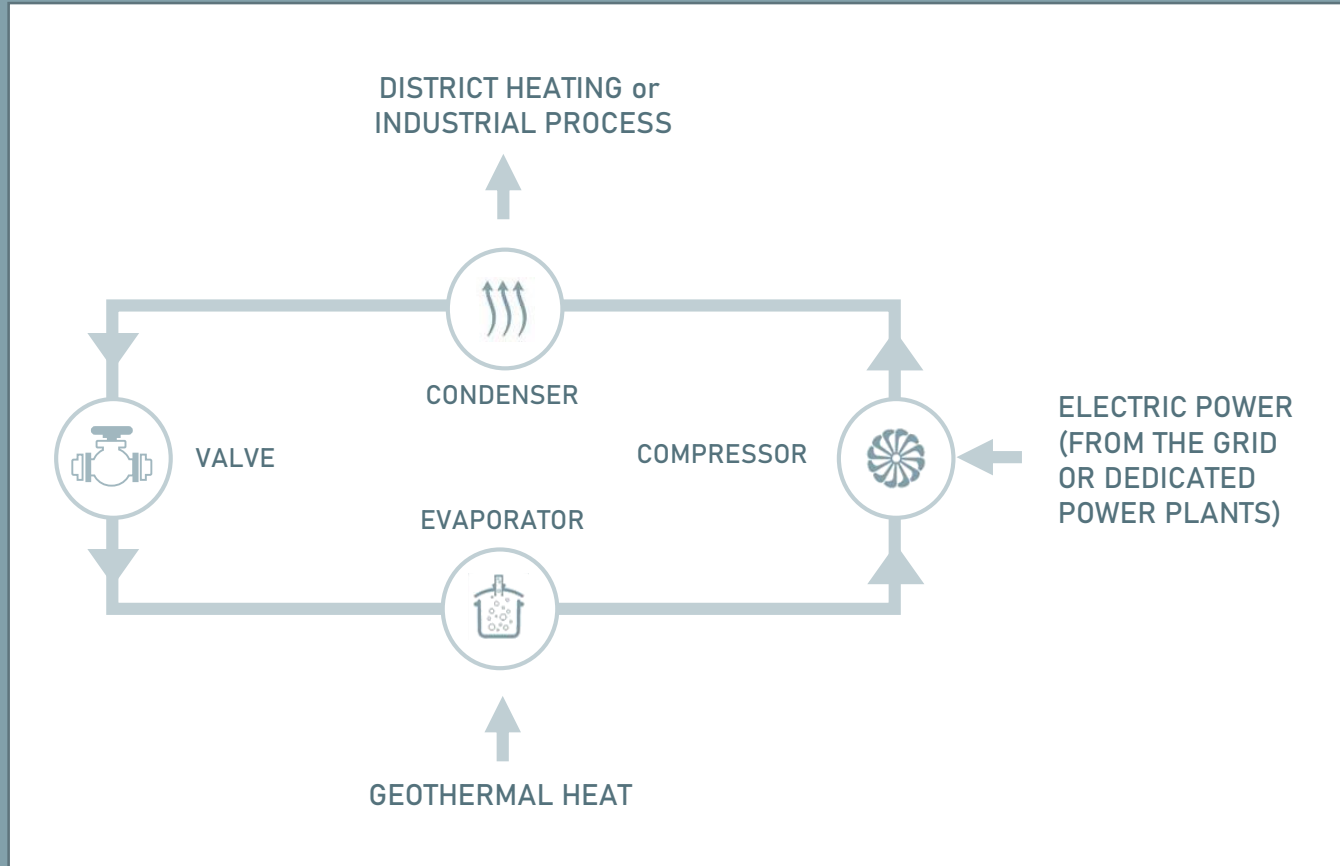


Large Heat Pumps are utility-scale heating plants that supply large quantities of higher temperature heat exploiting a colder energy source like mid-low enthalpy geothermal water. Large heat users, such as district heating networks, can benefit from this clean energy source, otherwise hardly exploitable.

KEY POINTS

- Large-scale: output from 3 MWth to 30 MWth per unit
- High-temperature lift (ΔT up to 80°C and more)
- High-temperature output: above 100°C, including steam generation
- Benefits from years of experience with geothermal ORC projects

LARGE HEAT PUMP SCHEMATIC

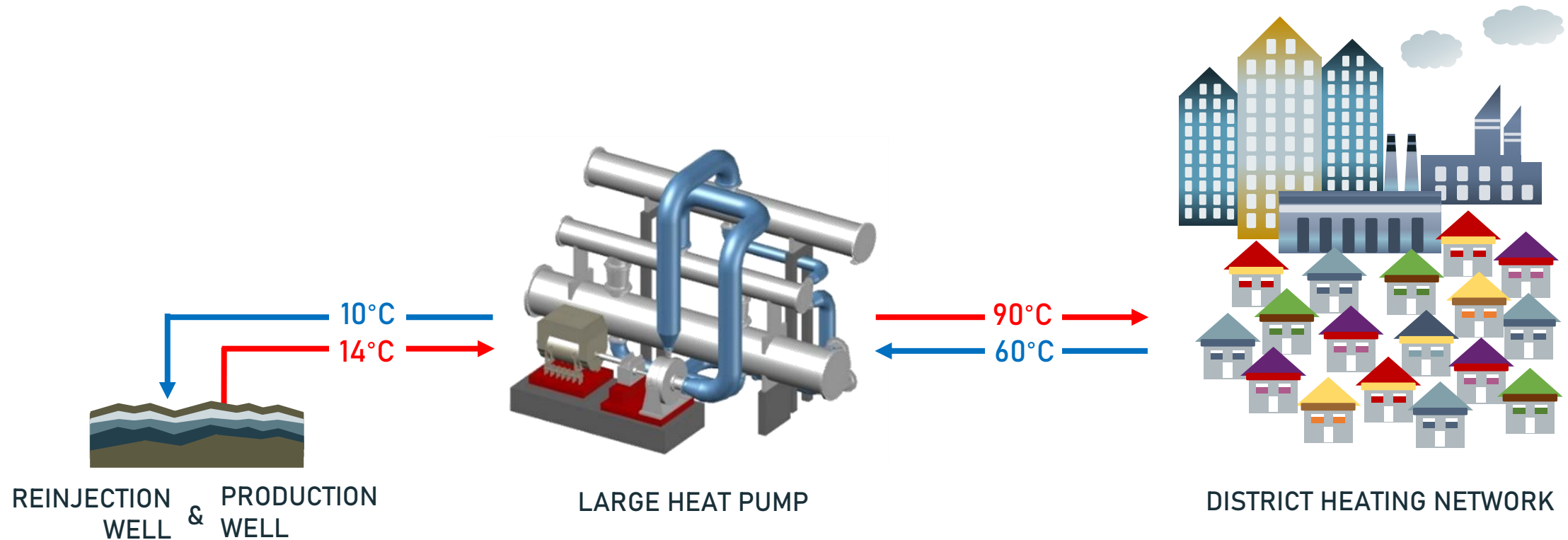


GEOHERMAL HEAT SOURCES

- Low-temperature ground-source water
- Mid-low enthalpy geofluids
- Further cooling of brine before reinjection

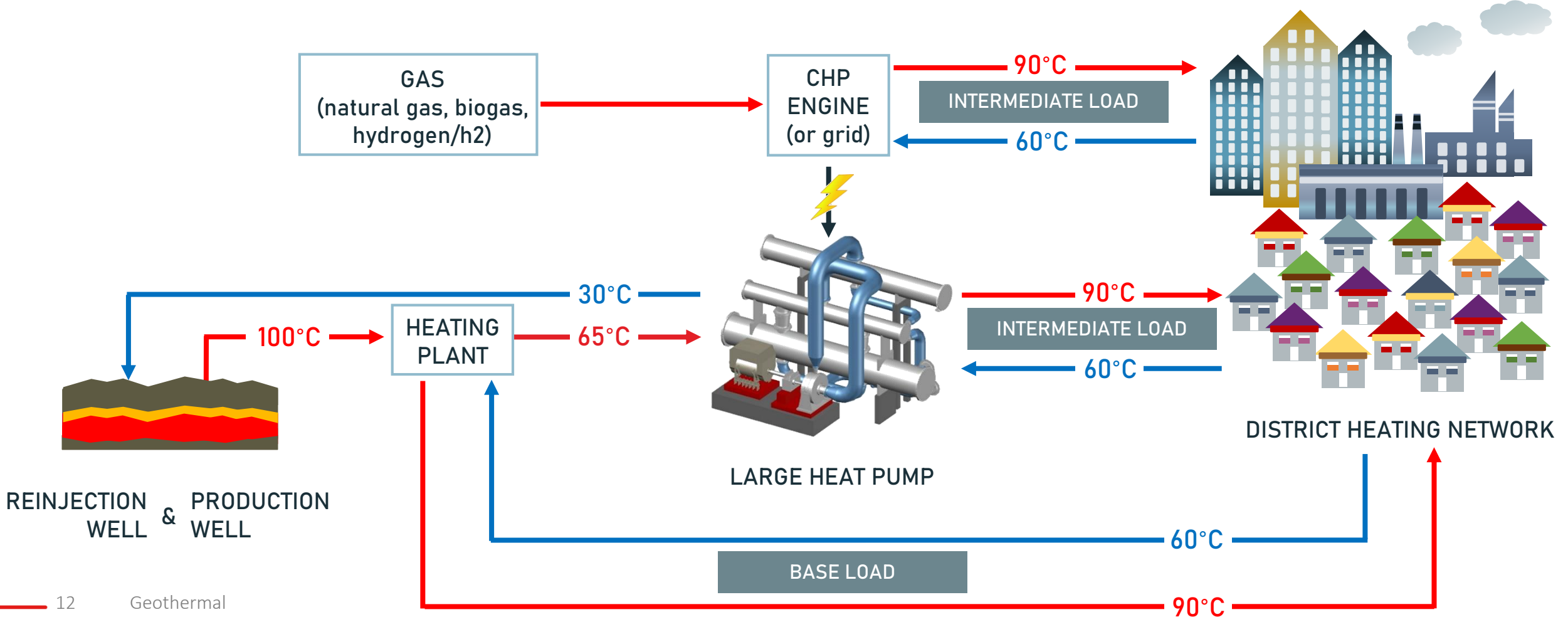
EXAMPLE: GROUND SOURCE PROJECTS

Even the energy contained in a shallow aquifer at low temperature can be used to feed a LHP and supply heat to a district energy network at higher temperature.



EXAMPLE: GEOTHERMAL DISTRICT HEATING

Deep geothermal can be used for direct heat supply to district heating grids or industrial users through a heating plant, while a LHP can extract further energy at lower temperature before reinjection and supply the users with additional heat at suitable temperature.



REFERENCES



SELECTED GEOTHERMAL PROJECTS



Site: Dürrnhaar, Germany

Customer: SWM - StadtWerke München

Configuration: power only

ORC power: 5.6 MWe

Liquid brine: 138 °C



Watch the video



Site: Kirchstockach, Germany

Customer: SWM - StadtWerke München

Configuration: power only

ORC power: 5.6 MWe

Liquid brine: 138 °C



Watch the video



Site: Sauerlach, Germany

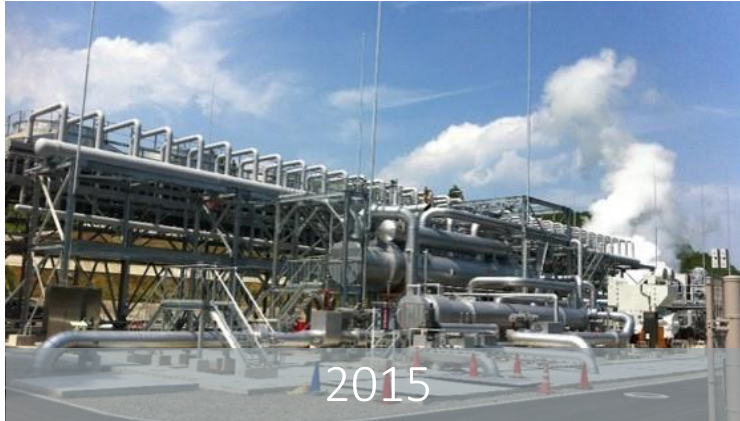
Customer: SWM - StadtWerke München

Configuration: power & heat

ORC power: 5 MWe + 4MWth

Liquid brine: 140 °C

SELECTED GEOTHERMAL PROJECTS



Site: Sugawara, Japan
Customer: Kyushu Electric
Configuration: power only
ORC power: 5 MWe
Liquid brine + steam: 140 °C



Site: Traunreut, Germany
Customer: GKT Traunreut
Configuration: power & heat
ORC power: 4.1 MWe + 12 MWth
Liquid brine: 118 °C



Site: Soultz-sous-Forêts, France
Customer: GEIE
Configuration: power only
ORC power: 1.7 MWe
Liquid brine: 170 °C

SELECTED GEOTHERMAL PROJECTS



Site: Afyonkarahisar, Turkey

Customer: Afjet A.S.

Configuration: power only

ORC power: 3 MWe

Liquid brine: 110 °C



Site: Velika Ciglena, Croatia

Customer: MB Holding

Configuration: power only

ORC power: 17.5 MWe

Liquid brine + steam: 171 °C



Watch the video



Site: Lightning Dock, USA

Customer: Cyrq

Configuration: power only

ORC power: 14 MWe

Liquid brine: 155 °C



Watch the video

SELECTED GEOTHERMAL PROJECTS



Site: Holzkirchen, Germany
Customer: Holzkirchen GmbH
Configuration: power & heat
ORC power: 3.4 MWe + 10 MWth
Liquid brine: 152 °C

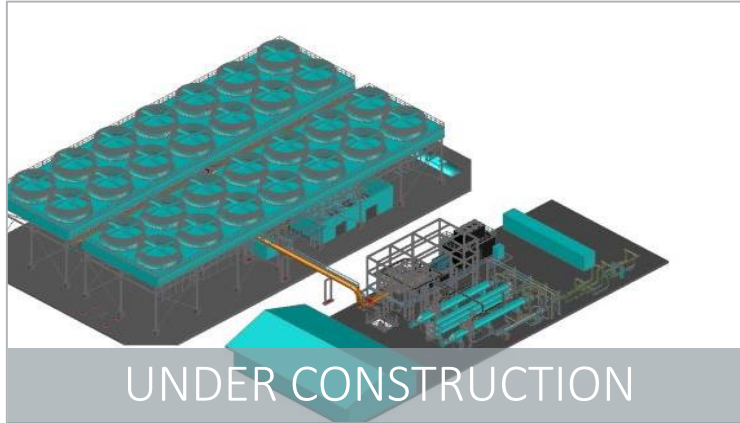


Site: Vendenheim, France
Customer: Fonroche Geothermie
Configuration: power only
ORC power: 11 MWe
Liquid brine: 200 °C



Site: Berlin, El Salvador
Customer: LaGeo
Configuration: bottoming plant
ORC power: 8 MWe
Liquid brine: 172 °C

SELECTED GEOTHERMAL PROJECTS



Site: Kirchweidach, Germany

Customer: EON

Configuration: power & heat

ORC power: 3.7 MWe

Liquid brine: 122 °C



Site: Olkaria, Kenya

Customer: KenGen

Configuration: power only

ORC power: 4 x 8 MWe

Liquid brine + steam: 160 - 190 °C



Site: Palayan, Bac-Man, the Philippines

Customer: Energy Development Corp.

Configuration: bottoming plant

ORC power: 29 MWe

Liquid brine: 171 °C

EDC PALAYAN BINARY PROJECT



THE NEED

expansion of the flash-technology based 140 MW current installed capacity in Bac-Man geothermal field operated by BGI (100% subsidiary of EDC).



THE SOLUTION

29 MW ORC binary plant inserted along the brine re-injection line currently present at site (bottoming application). Project completion is expected by the end of 2022. JCM grant awarded.



BAC-MAN GEOTHERMAL FIELD

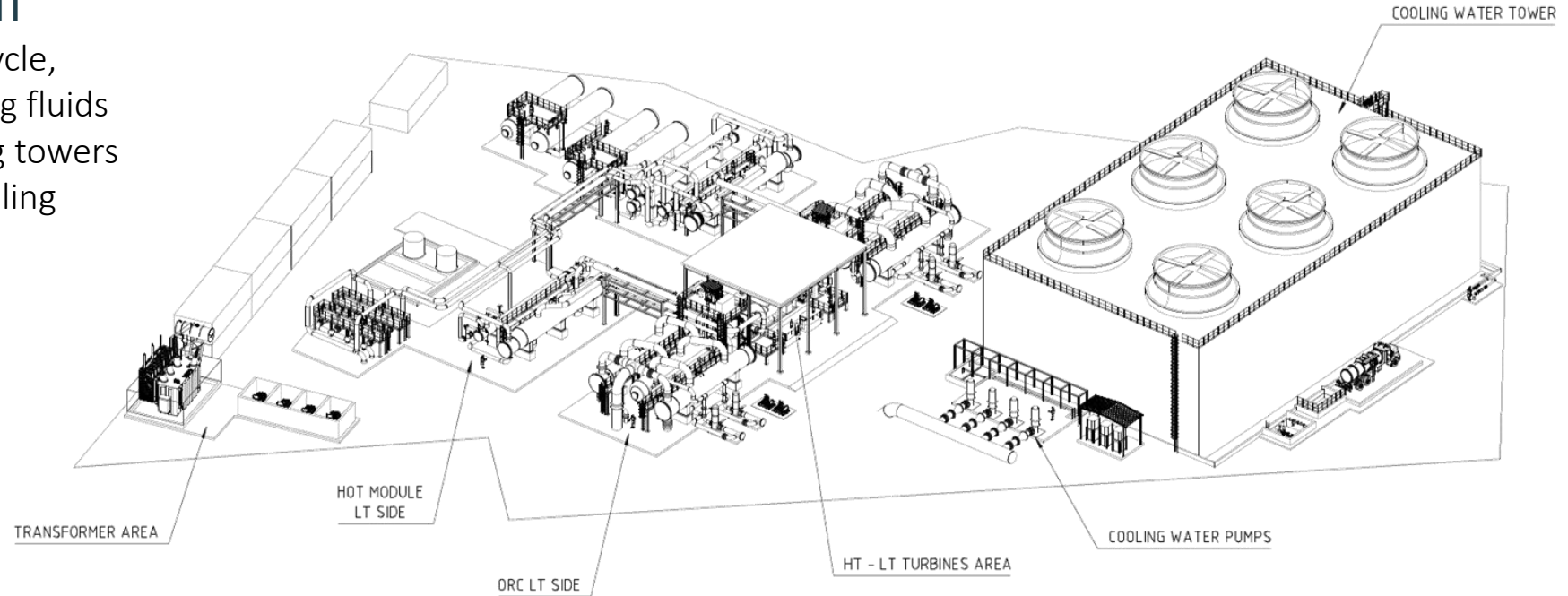
EDC PALAYAN BINARY PROJECT

THE ORC BINARY PLANT

- Two-pressure level ORC cycle, using hydrocarbon working fluids
- Water-cooled with cooling towers
- Acid dosing system for scaling inhibition

THE SCOPE

- engineering
- procurement
- technical advisory for erection
- commissioning
- start-up services / training





FIND OUT MORE



OUR EXPERIENCE. YOUR POWER.