Geothermal Energy Conversion with ORC Power Plants

An Overview and Ideas for Improvements

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TU Delft Propulsion & Power

Content

- ✓Mature technology: a short overview
- ✓…but innovation may still improve products: some examples
- ✓KCORC: what is it? …and a proposal

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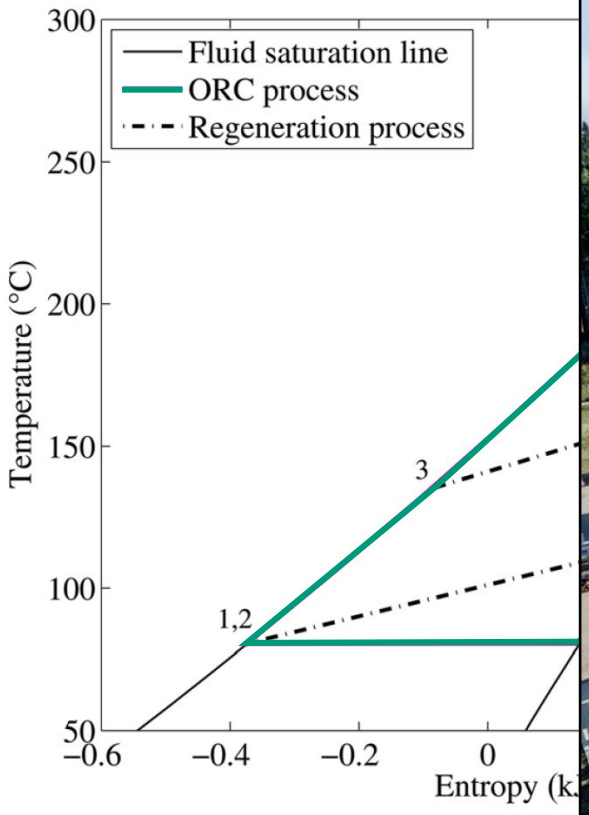
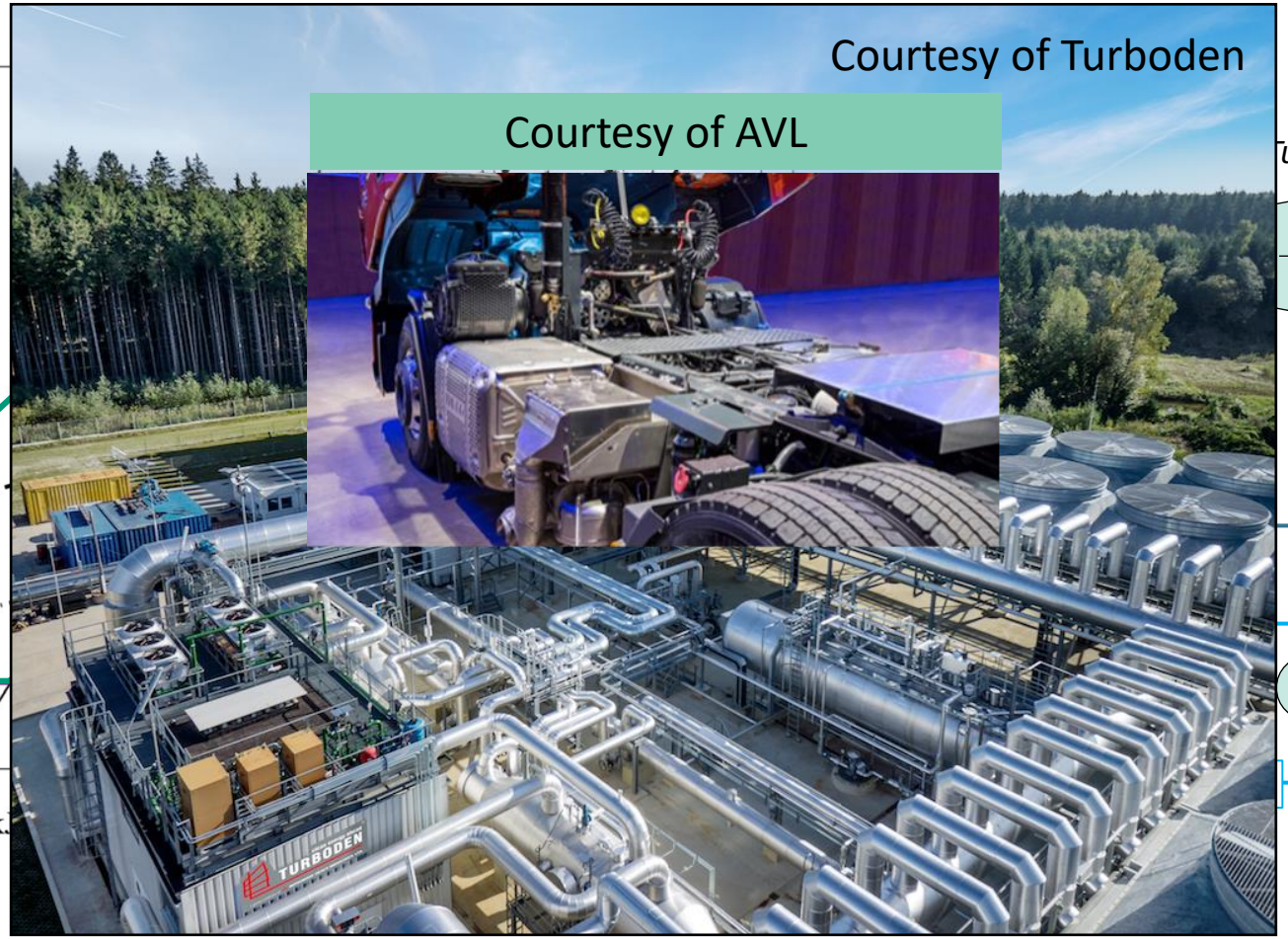
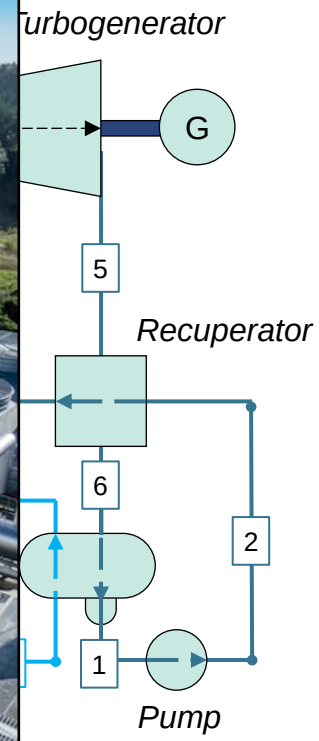
Organic Rankine Cycle technology







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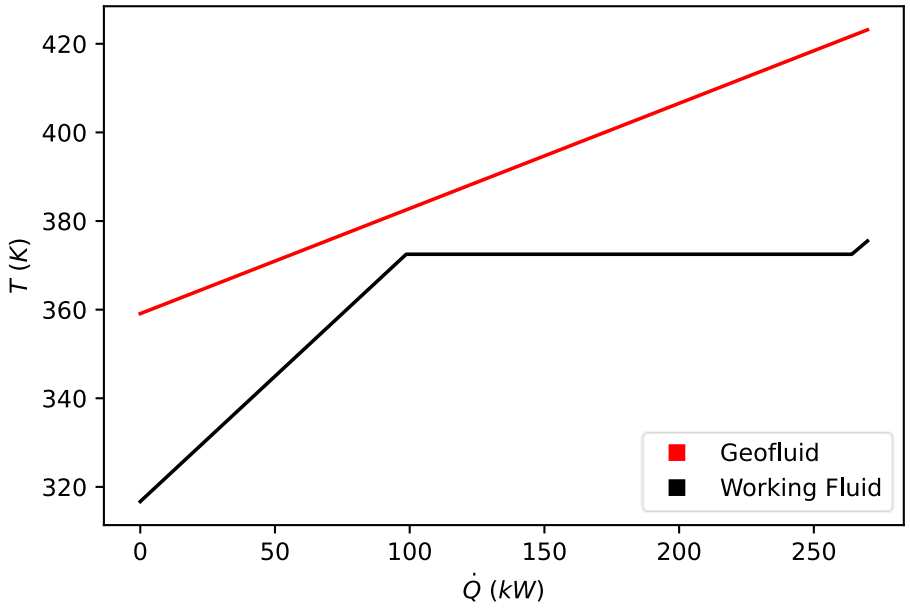
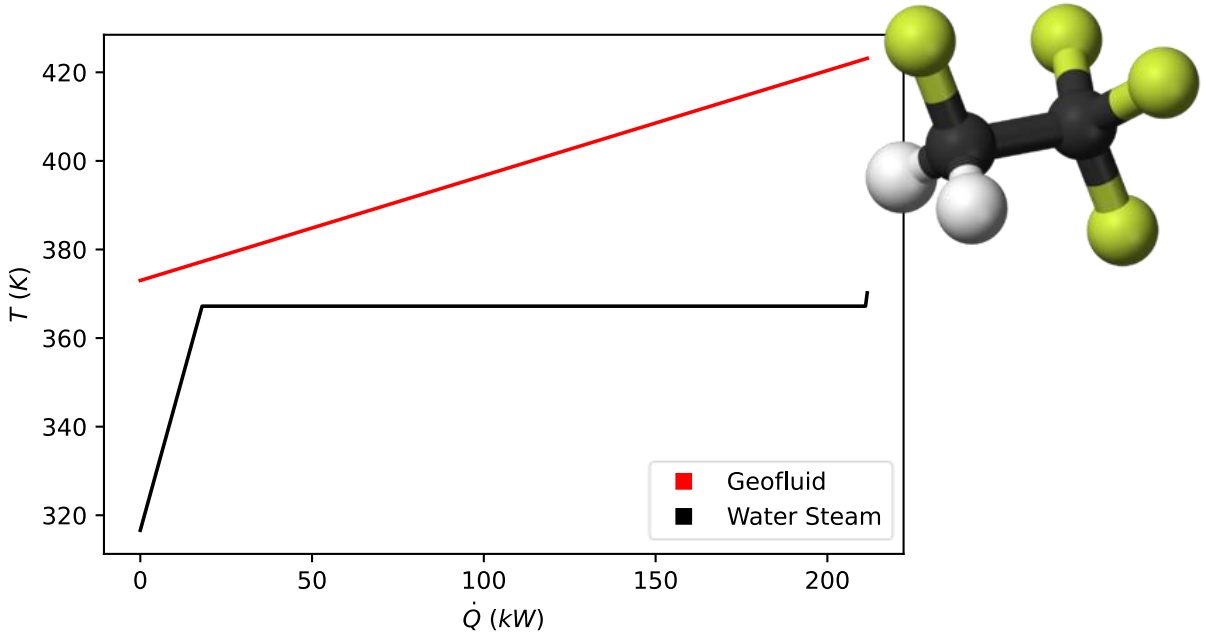
Geothermal: If direct flash is not possible or CO_2 emissions must be avoided…

Working fluid selection: match the T-profile of the thermal source





…or bottoming of a flash steam power plant

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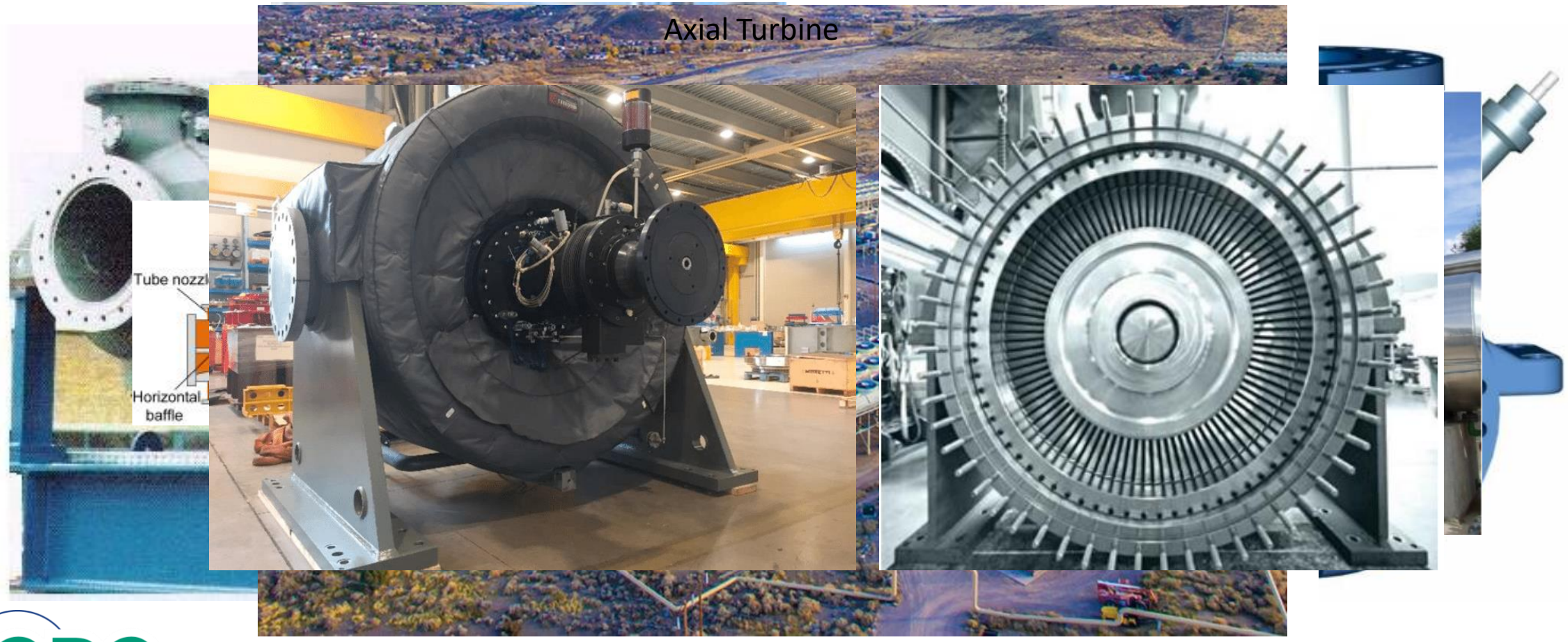
Other advantages

- Cycle configurations: saturated (superheated), supercritical (at low *P*), two-pressure levels, cogenerative…
- From few hundreds kW to hundreds of MW → from propane to cyclopentane
- Simplicity: low P, low $\Delta h_{\text{turbine}}$, dry and clean expansion, non-extractive regeneration, direct drive
- Higher condensing P than steam
  (@ $T_{\text{cond}} = 313\ \text{K}$, $P_{\text{steam}} = 0.07\ \text{atm}$ vs. $P_{\text{organic fluids}} > 1\ \text{atm}$)
- …

Power plants: examples…



Courtesy of Ormat, Turboden, Exergy, Orcan Energy

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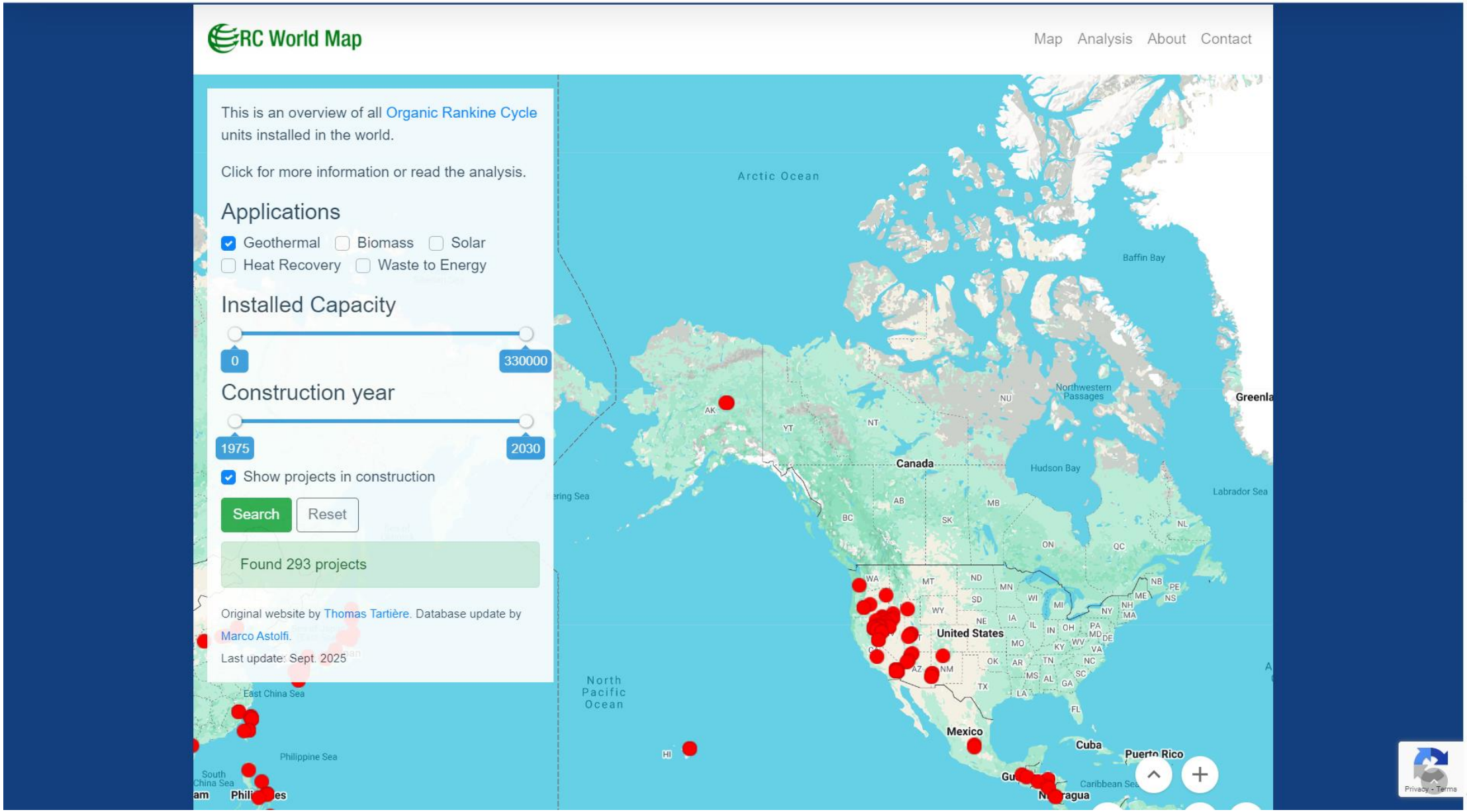
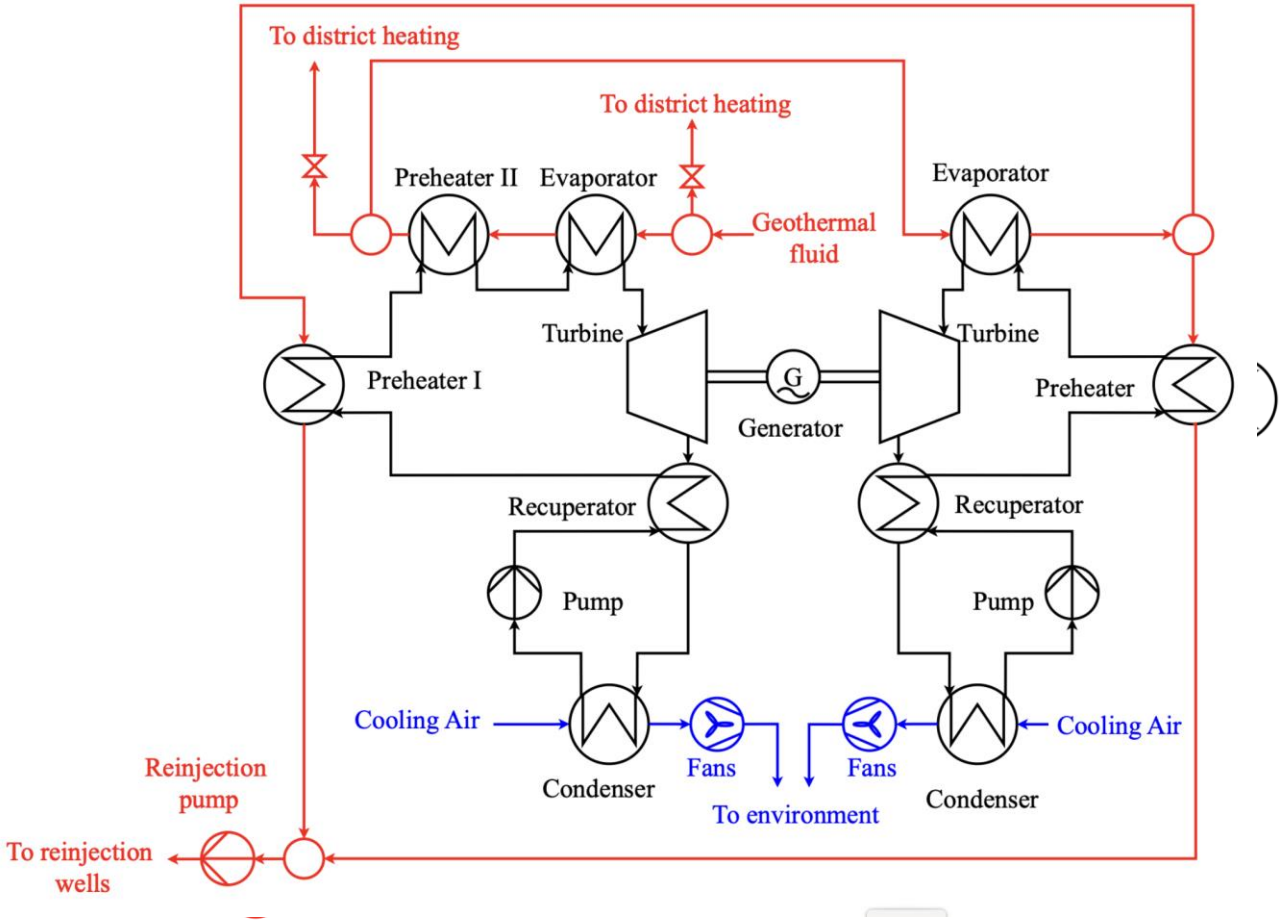

RC World Map
Map Analysis About Contact
This is an overview of all Organic Rankine Cycle units installed in the world.
Click for more information or read the analysis.
Applications
Geothermal Biomass Solar
Heat Recovery Waste to Energy
Installed Capacity
0
330000
Construction year
1975
2030
Show projects in construction
Search
Reset
Found 293 projects
Original website by Thomas Tartière. Database update by Marco Astolfi.
Last update: Sept. 2025
Arctic Ocean
Baffin Bay
Northwestern Passages
Canada
Hudson Bay
Labrador Sea
United States
Mexico
Cuba
Puerto Rico
North Pacific Ocean
East China Sea
Philippine Sea
South China Sea

Cycle configurations: examples

Split cycle → Cogeneration



L. Galieti, *Integrated design of ORC power plants operating with low temperature heat sources*, PhD thesis, TU Delft, 2026

Industrial innovation: large turbines…

Larger capacity, more stages → innovative axial turbine designs

- Unconventional cantilever
- Radial outflow
- Planar bearings

Courtesy of Turboden, Exergy and Ormat

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Small-capacity power plants

- Some EU cogeneration scenarios
- Most value in thermal energy
- Economy is not driven by electric efficiency
- Flexible operation
- Low cost (modularity)

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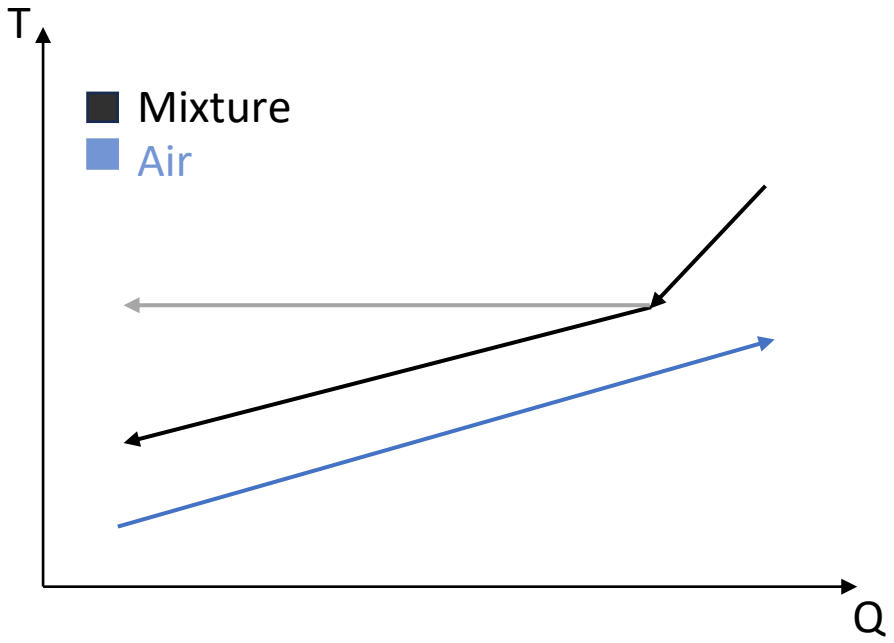
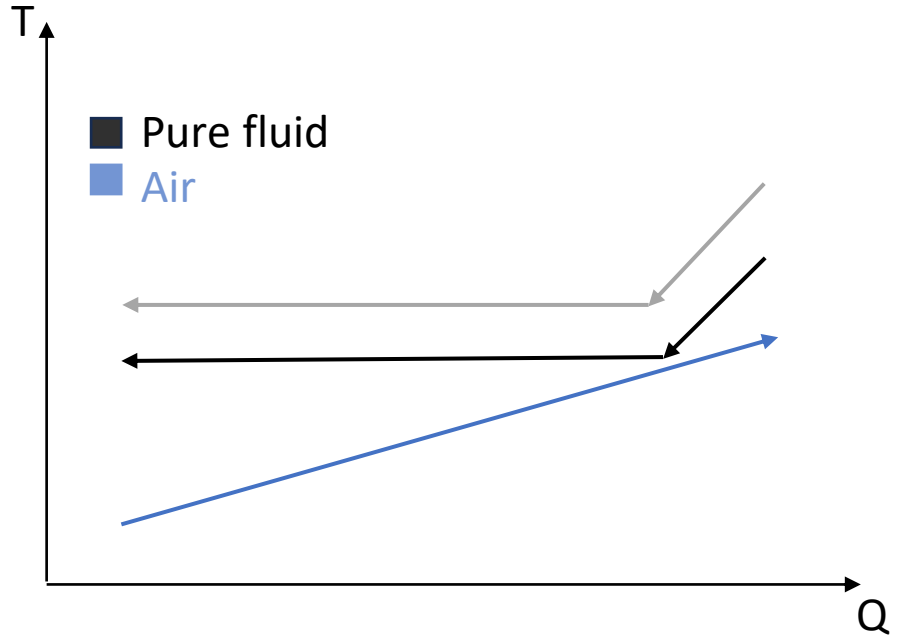
Research: optimal working fluid (also mixture)

Glide over condensation: lower $T_{\min}$ or air cooler fan power

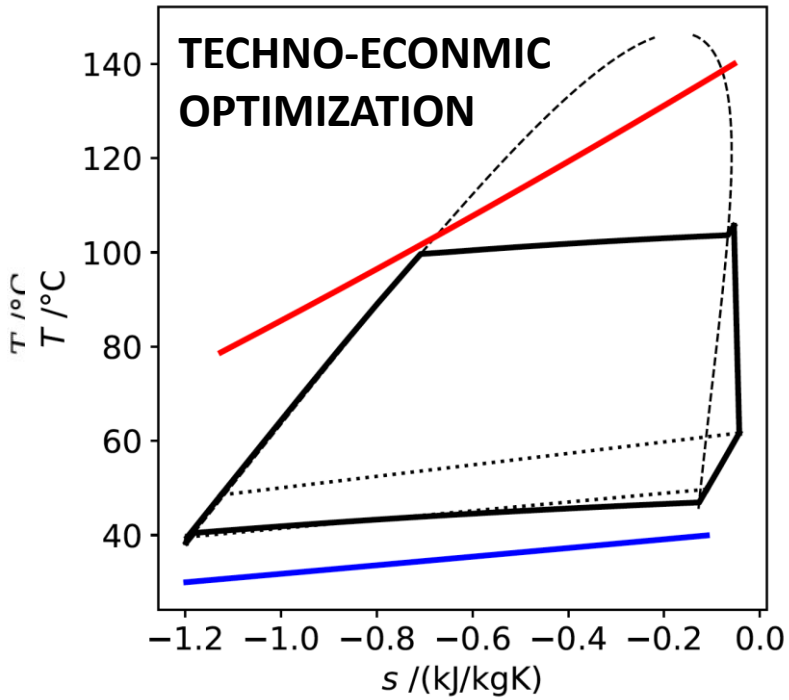




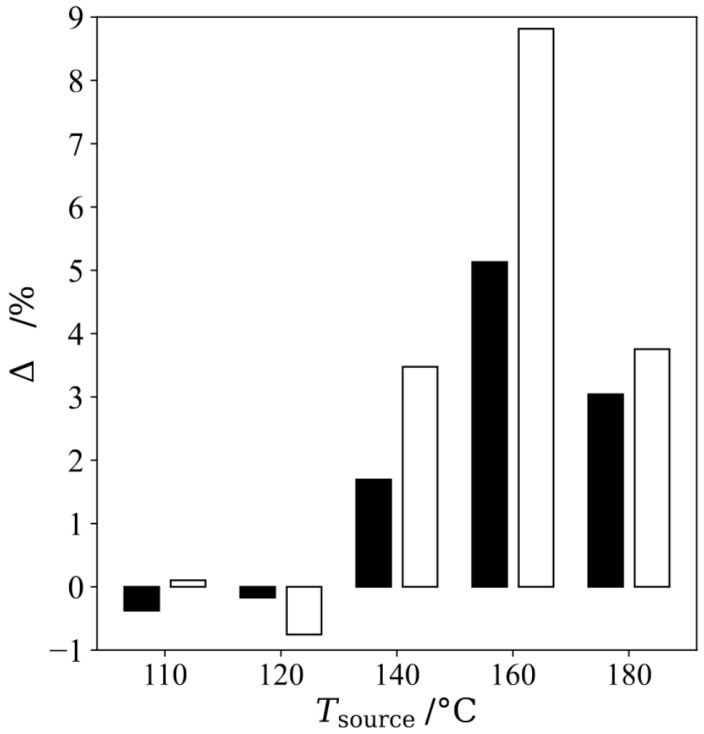
Glide over evaporation: better *coupling* with thermal source

Mixture working fluid: possible advantages

L. Galieti, *Integrated design of ORC power plants operating with low temperature heat sources*, PhD thesis, TU Delft, 2026



Propane (75%) / isobutane (25%)



Optimal mixture vs optimal pure fluid:
Δ% difference in power output (□) and CAPEX (■).
$\Omega_{turb} = 3000$ rpm, $\dot{m}_{source} = 200$ kg/s

KCORC Knowledge Center on Organic Rankine Cycle technology

- Established in 2013, legally incorporated in 2017, global
- ~ 400 members (many are young professionals): OEM's, Suppliers, Users, Academia, R&D institutes
- Biennial conference, workshops, working groups (e.g., TEHAG, S&R)
- Scholarships, outreach (lobbying), technical guidelines
- www.kcorc.org (recently revamped!)

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A North-American geothermal power committee?

- Inspired by the Thermal Energy Harvesting Advocacy Group (TEHAG)
- Driven by the envisaged growth of the geothermal power (North America)
- Activities: technical and policy advice (lobbying)
- Supported also by EU Colleagues (Academics)
- Anyone interested?

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