

○ Deep geothermal energy and benchmark with other renewables



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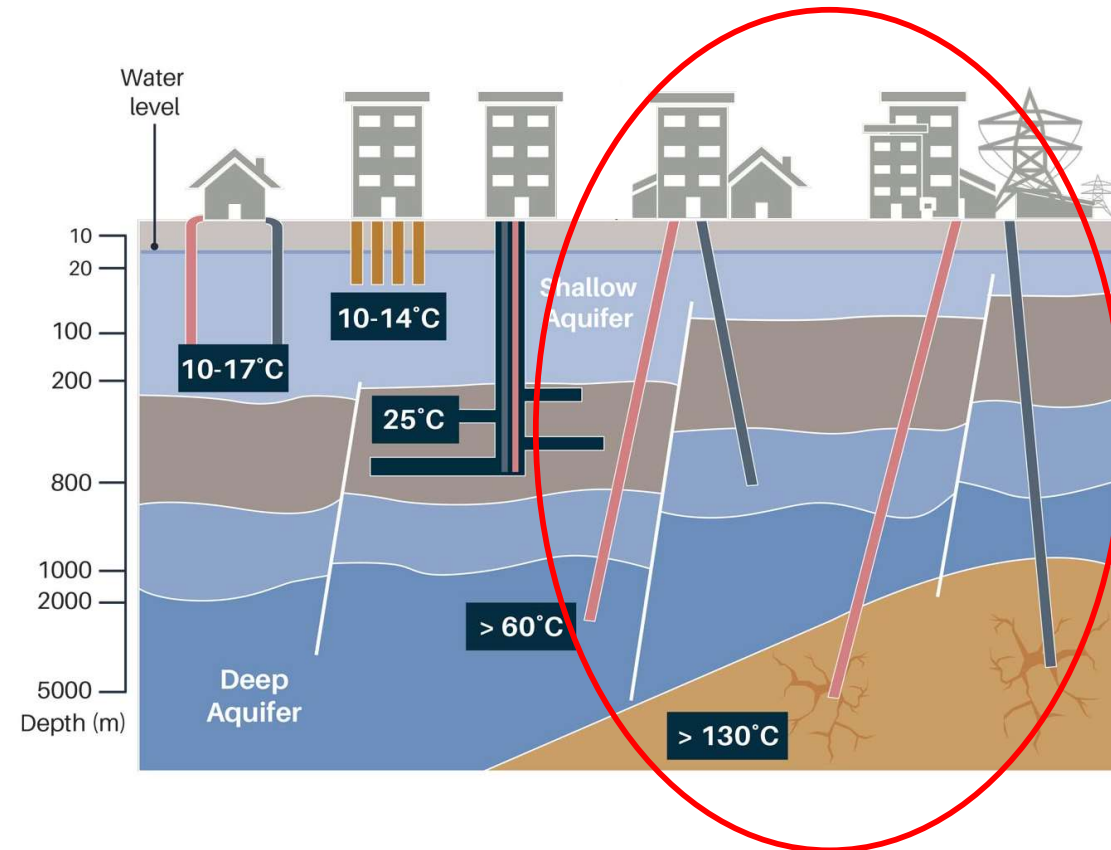


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○ What is deep geothermal energy?

- No consensual definition
- Exclusion of:
 - Geothermal probes
 - Heat pumps on shallow aquifers
- Deep geothermal energy can be used for:
 - Heat and cooling generation
 - Power generation
 - Raw material coproduction
- Main potential in Continental Europe: Heat generation
- Focus on France

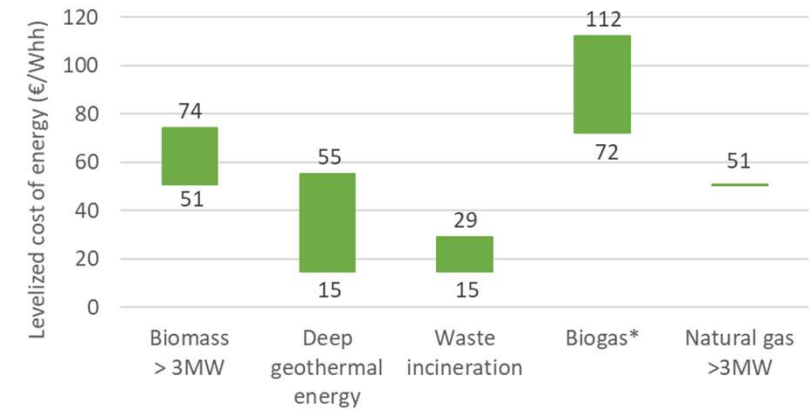
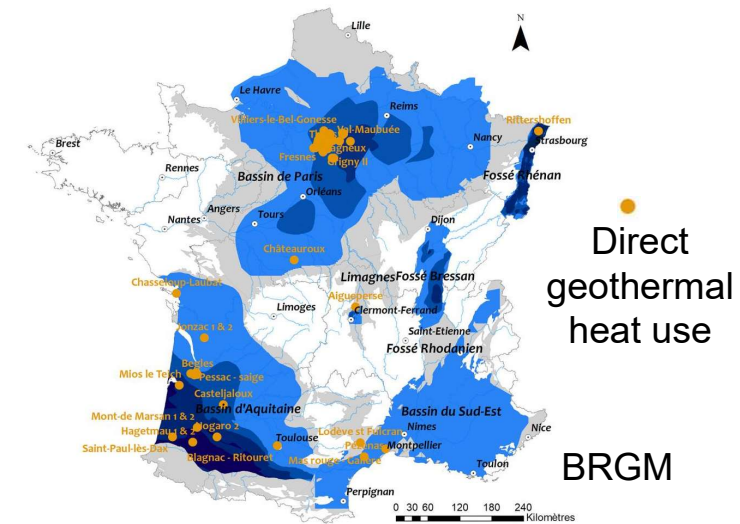


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• Cost comparison for heat generation

- Cost of geothermal district heating and cooling is between 15 to 55 €/MWh in France
- Cheaper than: Gas, Biomass, Biogas, Fuel
- 71 deep geothermal installations in France (49 in Paris, 21 in the Aquitaine basin)
- In 2018, the heat production from these installations reached 1,8 TWh with an installed capacity of 627 MW.
- But how far the geothermal sector can provide a path to achieving the European Commission's 55% emissions reduction target by 2030?
- Environmental impact assessment using LCA methodology



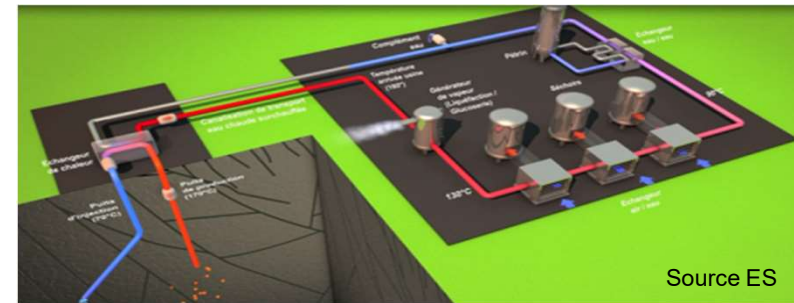
Cost of renewable energies and waste heat in France, ADEME, 2019

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○ Focus on the Rittershoffen geothermal plant

- Located in the French Upper Rhine Graben
- Roquette Frères starch plant at Beinheim, France, on the Rhine river
- 2 000 t of corn and wheat daily transformed
- Total heat demand of the starch plant: 80 MWth
- Use biomass (50%), geothermal energy (25%), natural gas (20%) and biogas (5%)
- Rittershoffen geothermal plant: 3 shareholders (Electricité de Strasbourg, Roquette Frères and Caisse des dépôts)

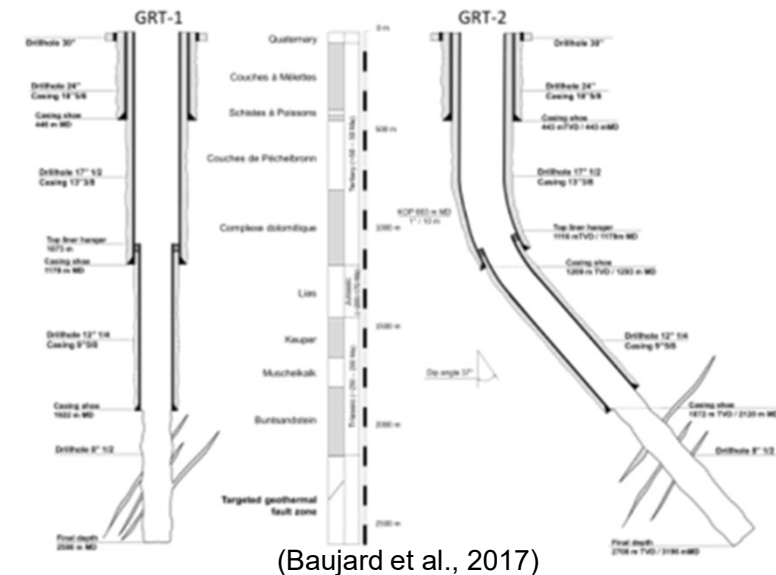


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○ Description of the Rittershoffen heat plant

- Reservoir characteristics
 - Reservoir depth: 2500 m
 - Fractured sandstone and Carboniferous granite
 - Na-Ca-K-Cl dominated brine
 - TDS:100 g/l, NCG: 0.24%mass
 - Bottom hole temperature: 177°C
- Drilling
 - 2 wells in operation
 - 1 production well: GRT-2 (drilled in 2014)
 - 1 injection well: GRT-1 (drilled in 2012)
 - Classified as EGS project



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○ Description of the Rittershoffen heat plant

- Plant design
 - In operation since May 2016
 - 1 primary loop (brine) and 1 transport loop (fresh water)
 - Pressurized geothermal loop (25 bar)
 - No NCG emission in operation
 - 1 down-hole production Line Shaft Pump
 - Max heat capacity: 27.5 MWth
 - Total electrical consumption: 550 kW
 - 15 km long transport loop, 1 m deep
- Operational data
 - Over 95% of availability
 - 180 GWh of heat supplied

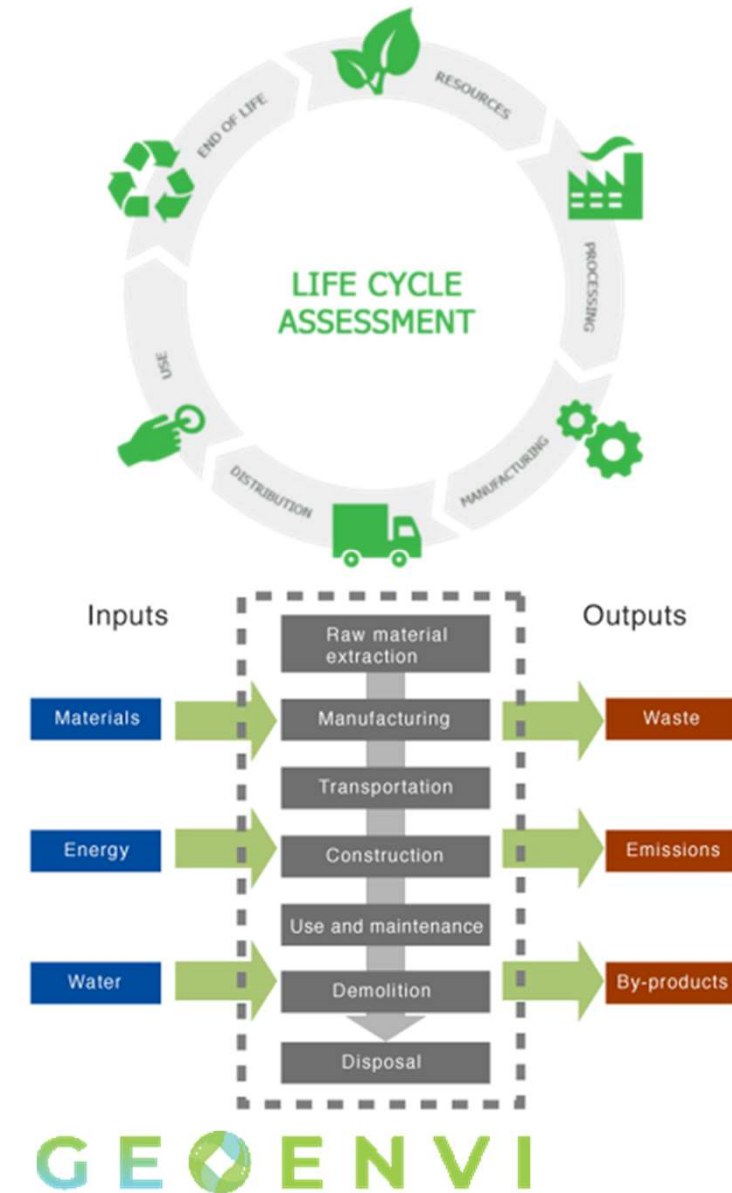


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○ Assessing the environmental impacts

- Case study for the GEOENVI H2020 project
 - Application of guidelines proposed within the GEOENVI H2020 project (Blanc et al., 2020)
 - Functional unit: production of 1 kWh of heat delivered to district heating
 - System boundaries: the upstream module and the core module
 - Ecoinvent database v3.6 used for the activities of the upstream module
- Comparison
 - Natural gas
 - Biomass
 - Based on ecoinvent database v3.6



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○ Life Cycle Inventory

Life cycle inventory including:

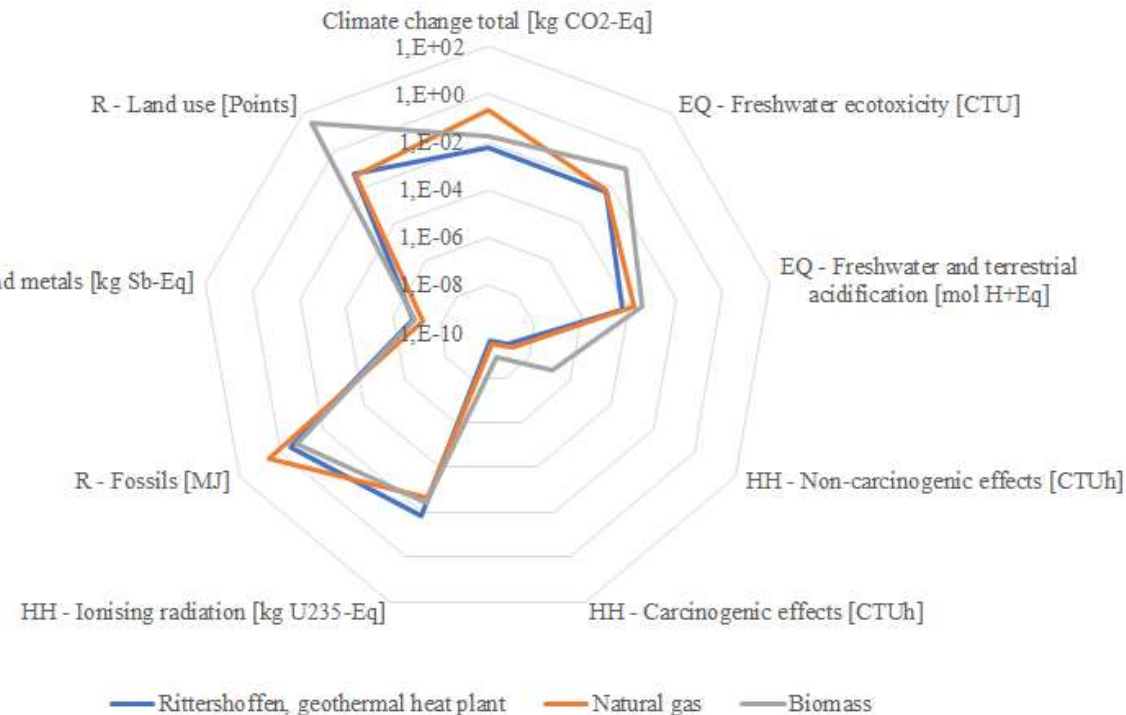
- Exploration
- Drilling preparation
- Drilling
- Well stimulation
- Well testing
- Plant construction
- Plant operation and maintenance
- End of life



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Life Cycle Assessment results

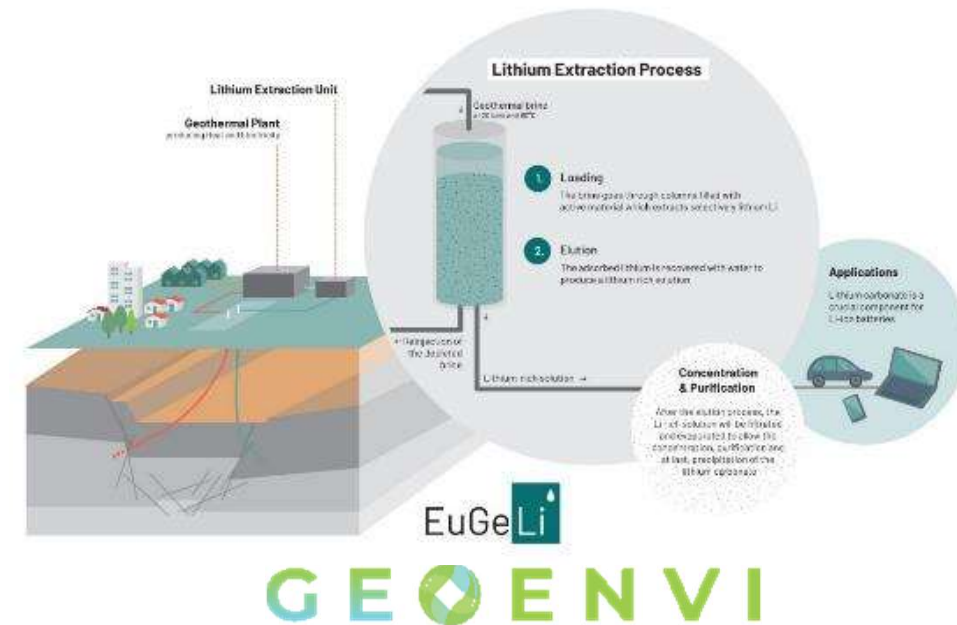
- GHG emission:
 - 5.9 gCO_{2eq}/kWh_{th}
 - About 3 and 40 times lower than biomass or natural gas
 - 44 000 tCO_{2eq} saved every year compare to natural gas
- Most of potential impacts similar or lower than those of heat produced from biomass and natural gas
- Land use: about 640 less than biomass
- Yes, Geothermal sector can provide a path to achieving the European Commission's 55% emissions reduction target by 2030 and need financial and public support



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○ Raw materials recovery

- About 200 mg/L of Li
- Strategic mineral for electric mobility and energy storage
- First onsite test in Europe at Rittersshoffen for Li extraction under the EuGeLi project
- Potential up to 3,000 t/year of Li carbonate
- Up to 1,100 tCO_{2eq}/year saved from shipping
- Ongoing studies estimate that 50% of geothermal heat could cover all the heat and power required for Li recovery and processing
- Targeting nearly zero carbon emission Lithium production in Europe



○ Thank you for your attention

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