Rittershoffen heat plant for industry and Soultz-sous-Forêts power plant (Rhine Graben, France)

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The Upper Rhine Graben

Graben formation started at the Eocene (about 55 million years)

Part of the East European Cenozoic Rift System

Normal faults and fractures along N-S axis

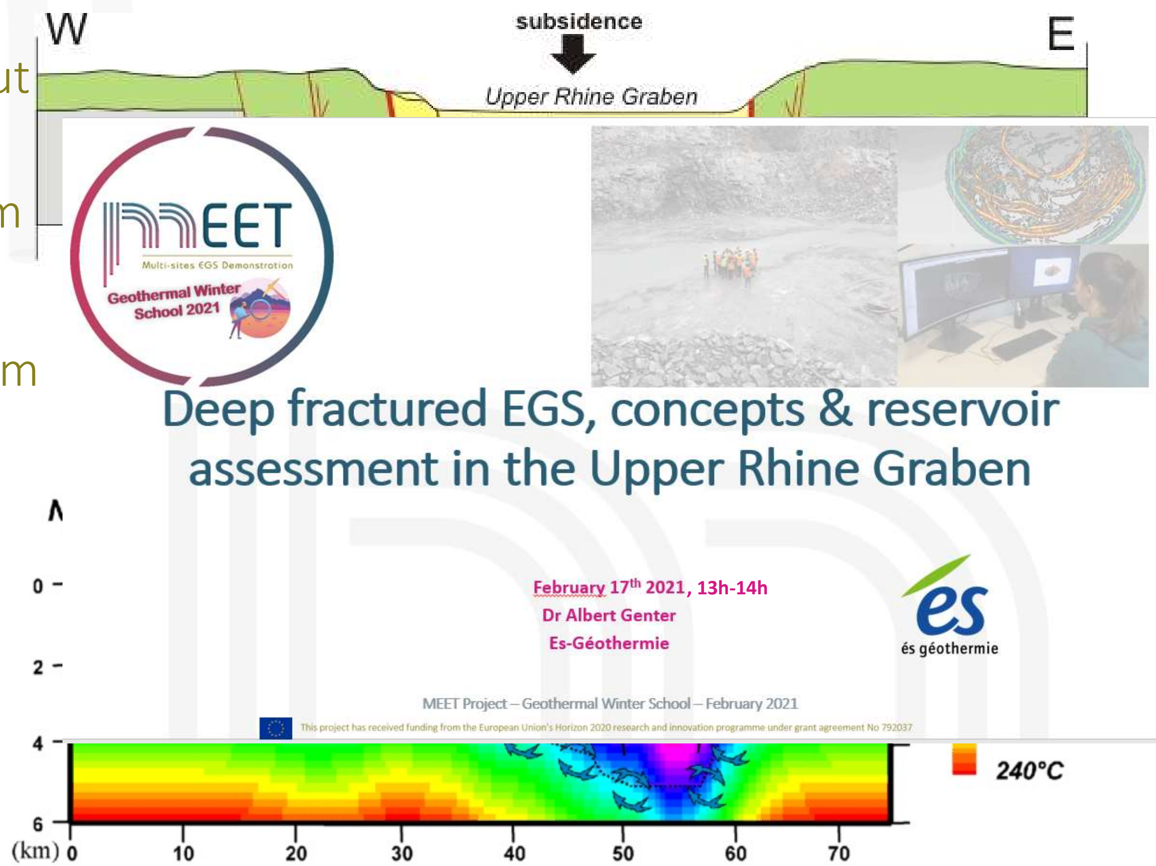
Fluid circulation in this complex fracture system evidenced by temperature anomalies

Deep geothermal brines, with temperature over 150°C suitable for:

→ Heat generation

→ Power generation

→ Mineral extraction?



(Le Carlier et al., 1994)

Geothermal fluid in the Rhine Graben

High salinity in all deep geothermal project: 100 g/l

Na-Ca-K-Cl type brine with many minor and trace elements

Gas Liquid ratio: 1 to 1.3

Main dissolved gas: CO_2 (90%)

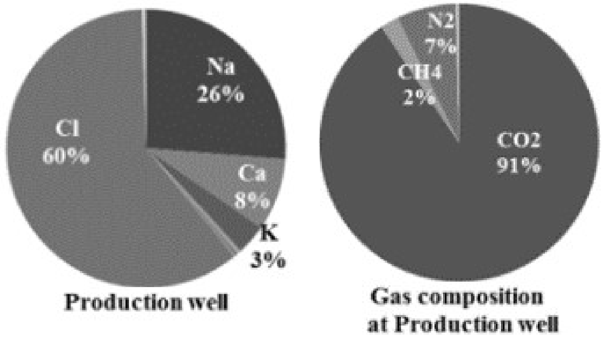
Carbonate scaling if pressure below Gas Break-out Pressure

→ Need of pressurized geothermal loop

→ Downhole production pump necessary to keep the pressure and increase production flowrate

Scale formation with temperature decrease (barite, galena…)

→ Anti-scaling treatment

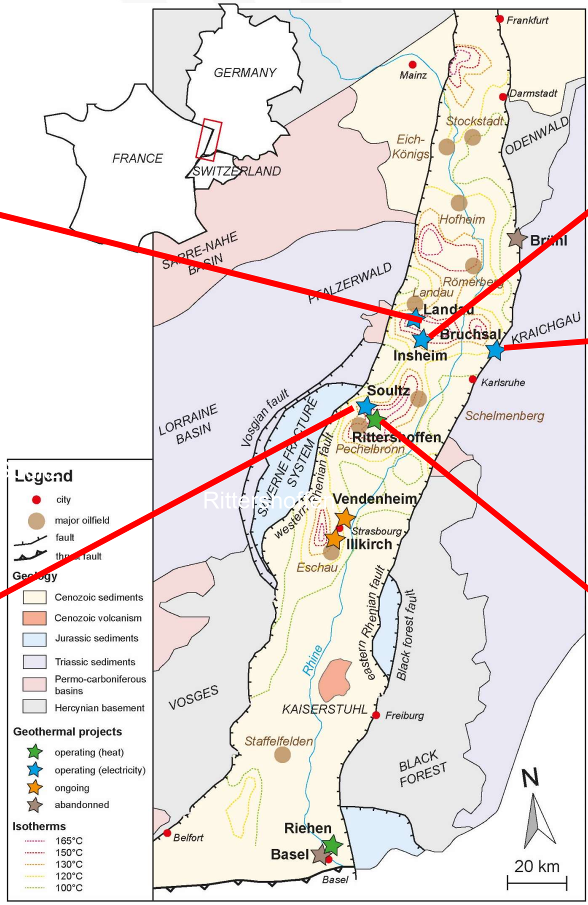


(Mouchot et al., 2018)

Geothermal project in the Rhine graben

Landau (DE)
Combined Heat & Power plant
3MWe+ district heating

Soultz (FR) 1.7MWe



(Glaas, 2021)

Insheim (DE) 4.8MWe

Bruchsal (DE) 0.55MWe+
district heating

Rittershoffen (FR) 24MWth

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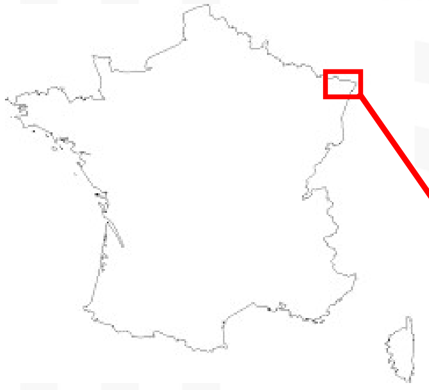
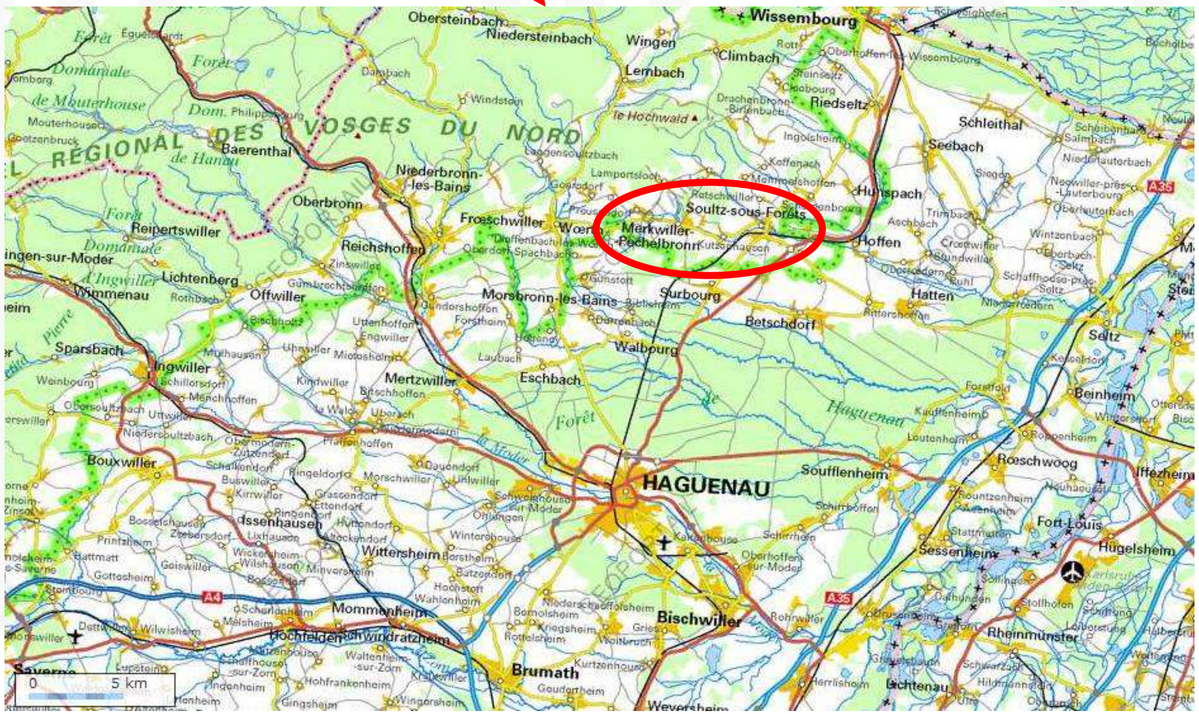
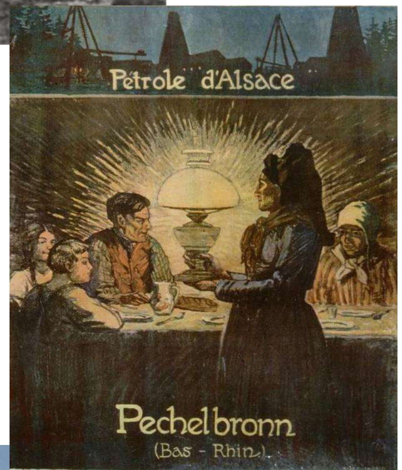
The Soultz geothermal power plant



Pechelbronn oil field





- About 5000 of oil wells
- First worldwide logging (1927, Schlumberger)
- Lot of geophysical data
- Thermal anomaly known since 1929

Soultz: HDR concept to EGS

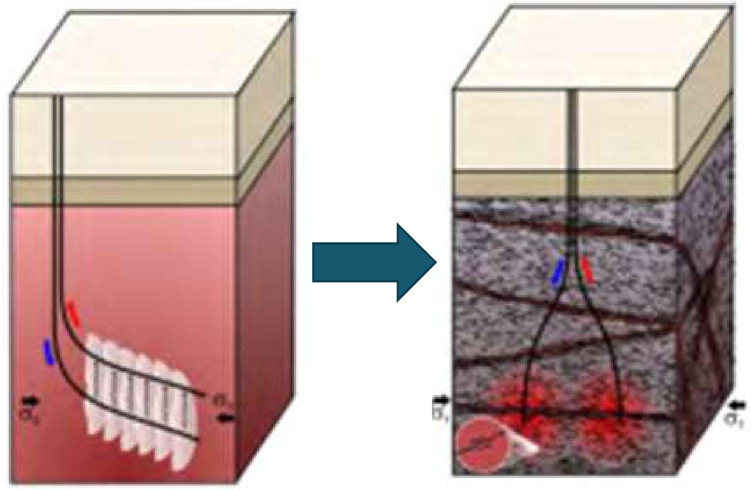
Initially a test of Hot Dry Rock concept

Several issues in the concept:

- Existing geothermal brine and natural faults
- High pressure injection
- Anomalous induced seismicity

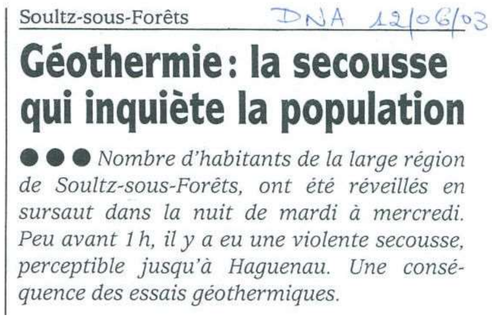
Change to Enhanced Geothermal System:

- Looking for existing permeable faults
- Enhanced well’s connection with natural reservoir



Hot dry rock (HDR)

Enhanced geothermal system (EGS)



Soultz-sous-Forêts DNA 12/06/03

Géothermie : la secousse qui inquiète la population

●●● *Nombre d’habitants de la large région de Soultz-sous-Forêts, ont été réveillés en sursaut dans la nuit de mardi à mercredi. Peu avant 1 h, il y a eu une violente secousse, perceptible jusqu’à Haguenau. Une conséquence des essais géothermiques.*

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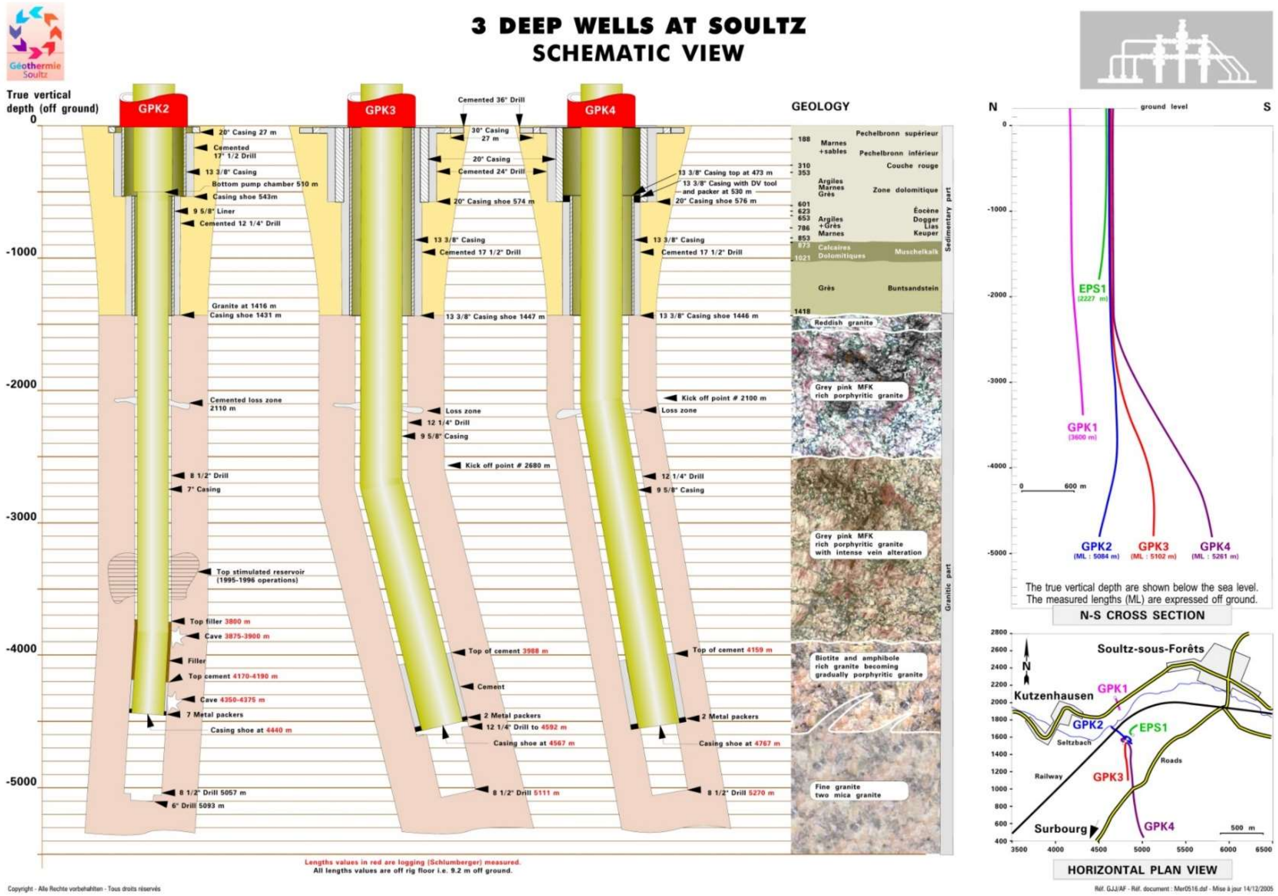
Soultz brief history



History

1987-1992: GPK-1 drilling

1995: Drilling of GPK-2 (3.9 km)

1997: First circulation test

2000: GPK-2 Deepening to 5 km

2001-2002: GPK-3 and 4 drilling (5 km)

2005: Deep circulation test

2008-2012: First power plant

2014-2016: Industrial power plant

Thermodynamical ORC cycle

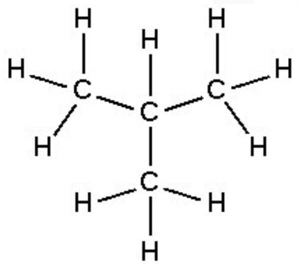
Need to pressurize the geothermal brine

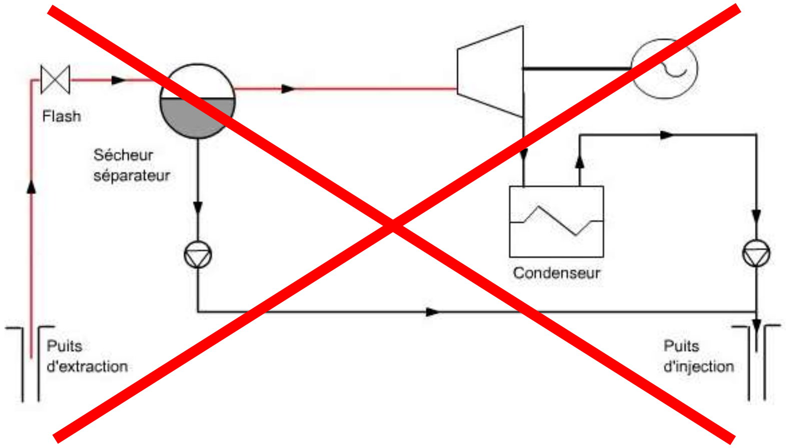
→ Use of Organic Rankine Cycle plant instead of flash plant

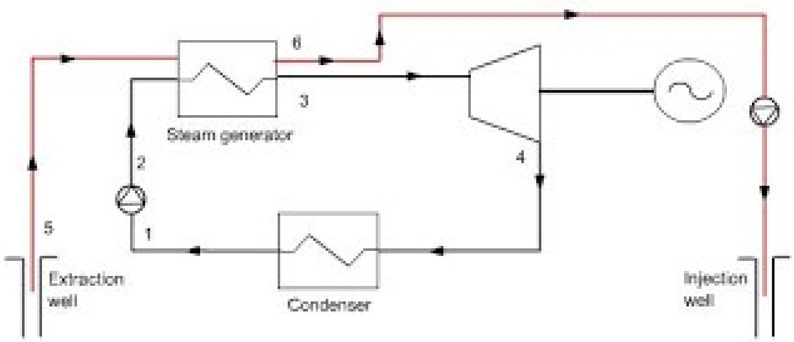
Working fluid: isobutane

Condenser: Air-condenser

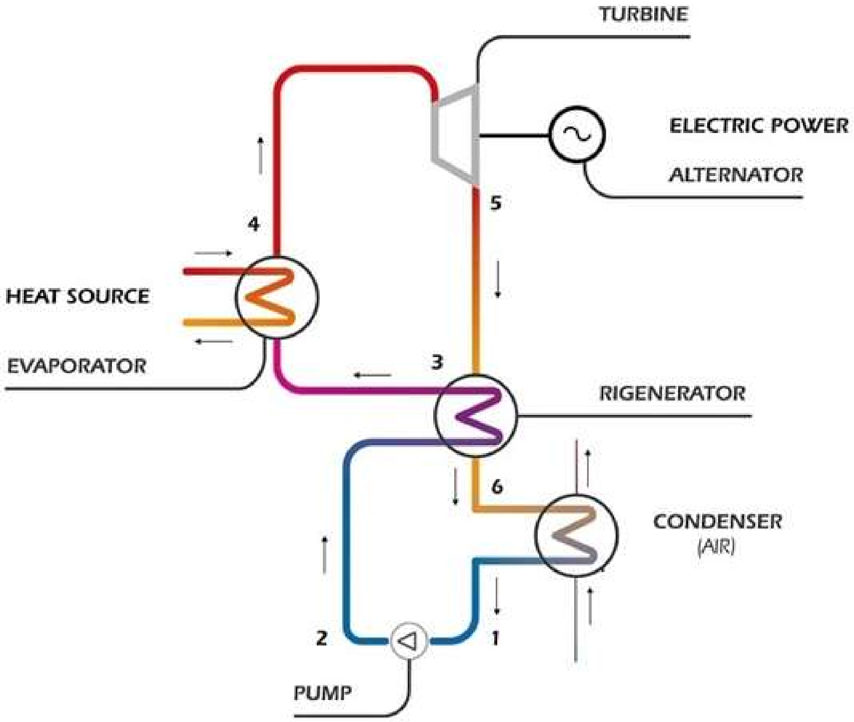
Turbine: axial 3000 rpm







Thermodynamical ORC cycle

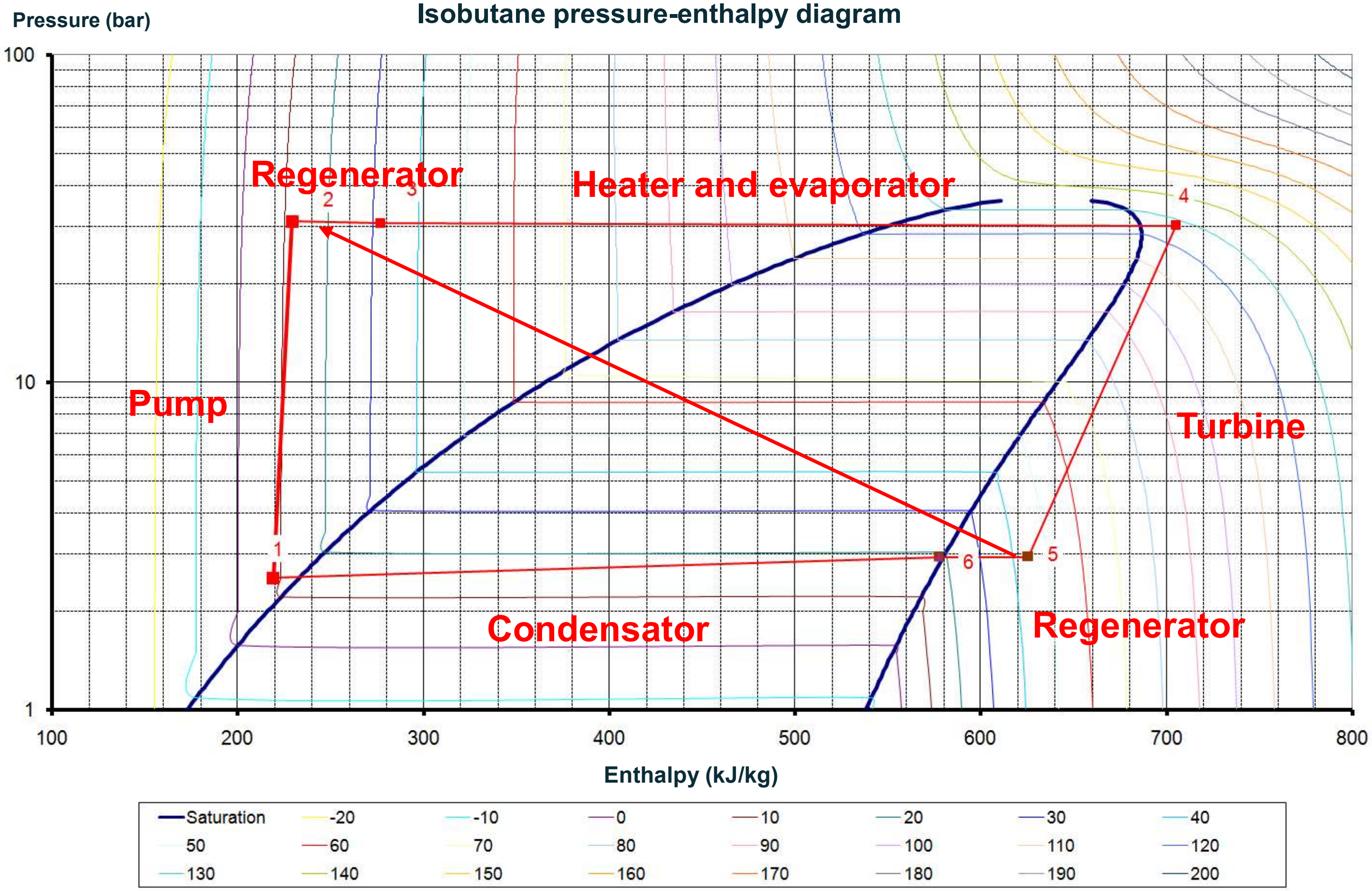


Source: Turboden

Principles of the « Organic Rankine Cycle »

- 1 → 2: Low pressure liquid isobutane is pumped to 30 bar
- 2 → 3: Then high pressure liquid isobutane is pre-heated in the regenerator
- 3 → 4: Heating and vaporization of isobutane in the evaporator using geothermal heat
- 4 → 5: High pressure vapor isobutane vapor rotates the turbine, generating power
- 5 → 6: Exhaust low pressure vapor isobutane flows through the regenerator, where it heats the high pressure liquid isobutane (2 → 3)
- 6 → 1: Low pressure vapor isobutane is condensed in the air-condenser

Thermodynamic ORC cycle



Net ORC cycle efficiency function of:

- geothermal inlet temperature
- air temperature

About 12.5% with 150°C (brine inlet) and 11°C (air)

Carnot theoretical efficiency: 32.8%

Turbine isentropic efficiency: 85%

Installed capacity: 1.8 MWe

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MEET H2020 Project

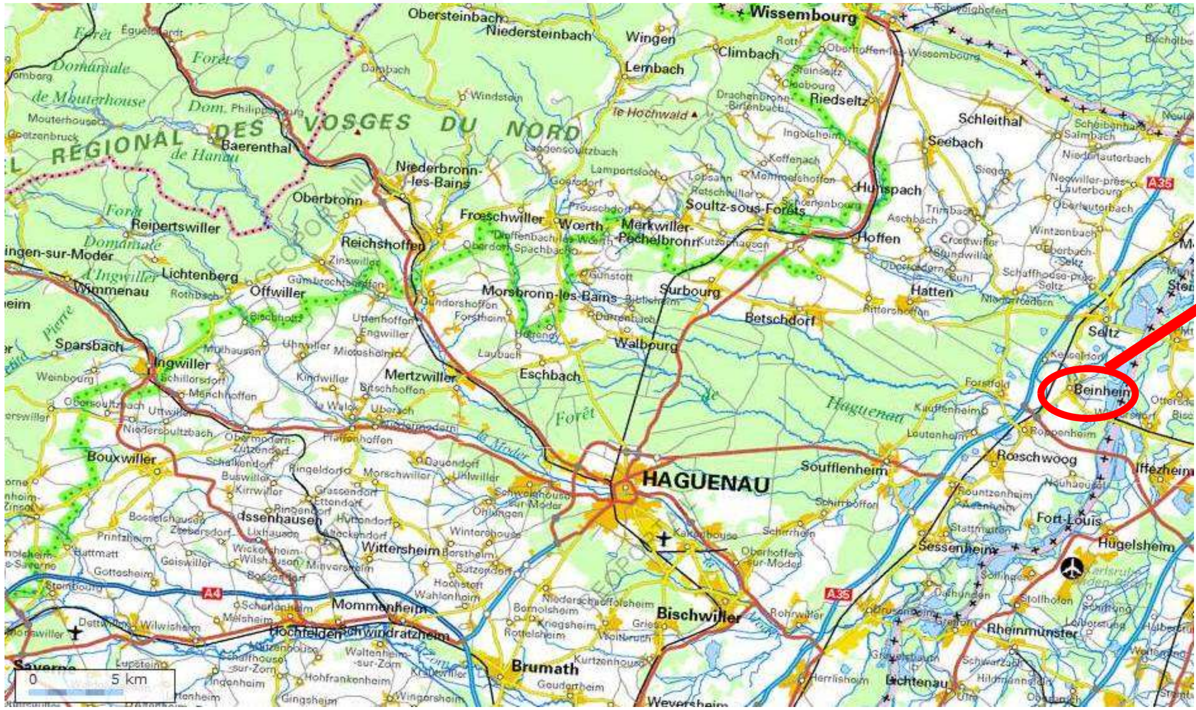
- Aims at boosting the development of Enhanced Geothermal Systems (EGS) across Europe in various geological contexts
- Soultz: increasing the thermal heat extraction by lowering the injection temperature (40°C instead of 70°C)
- Test of pilot heat exchanger for scaling and corrosion studies
- Test of a mini-ORC in a couple of weeks

Virtual visit of the Soultz geothermal power plant

The Rittershoffen geothermal heat plant

RG1

Roquette starch plant at Beinheim



Family group

Revenue: 3.7 Bn€ in 2019

1 starch plant on the Rhine river

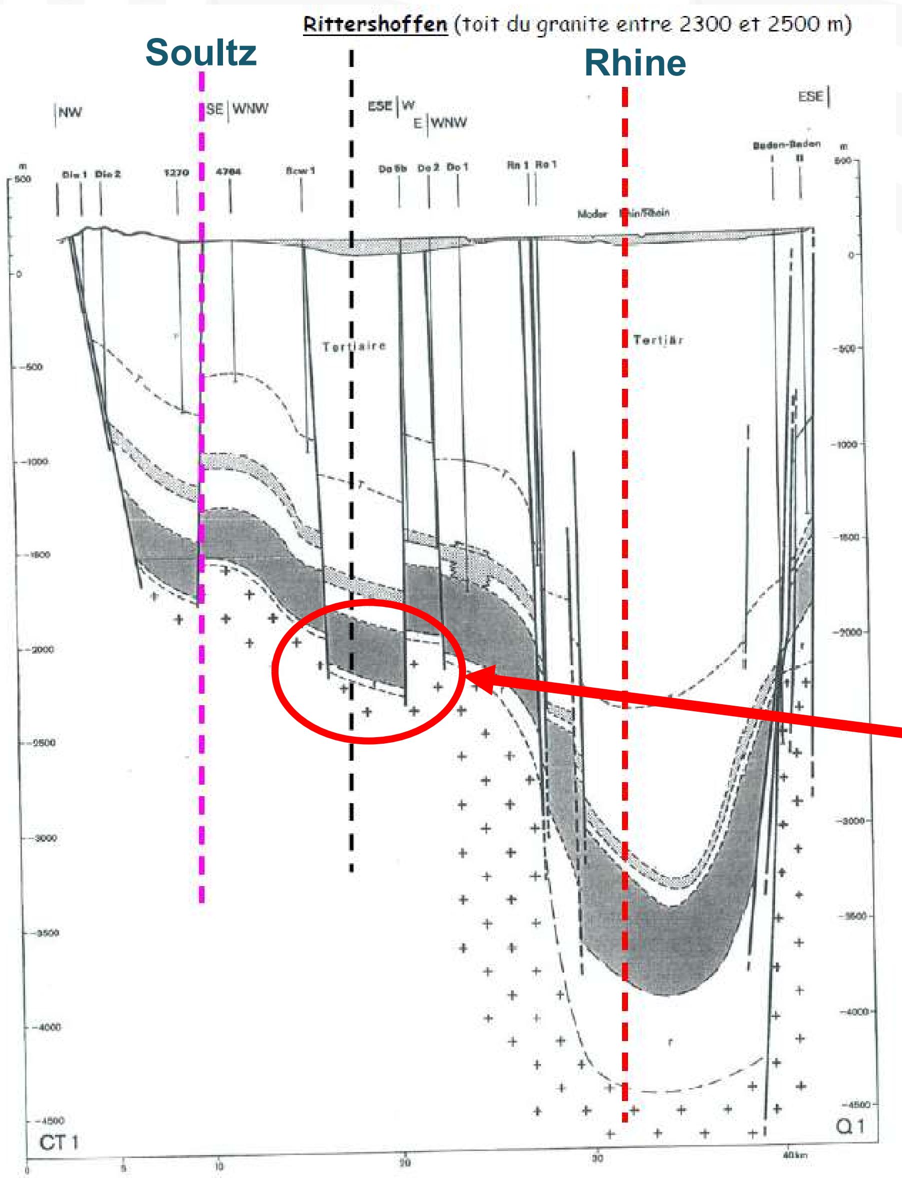
Daily transformation of 2 000 tons of wheat and corn

Annual needs of heat: 600 GWh

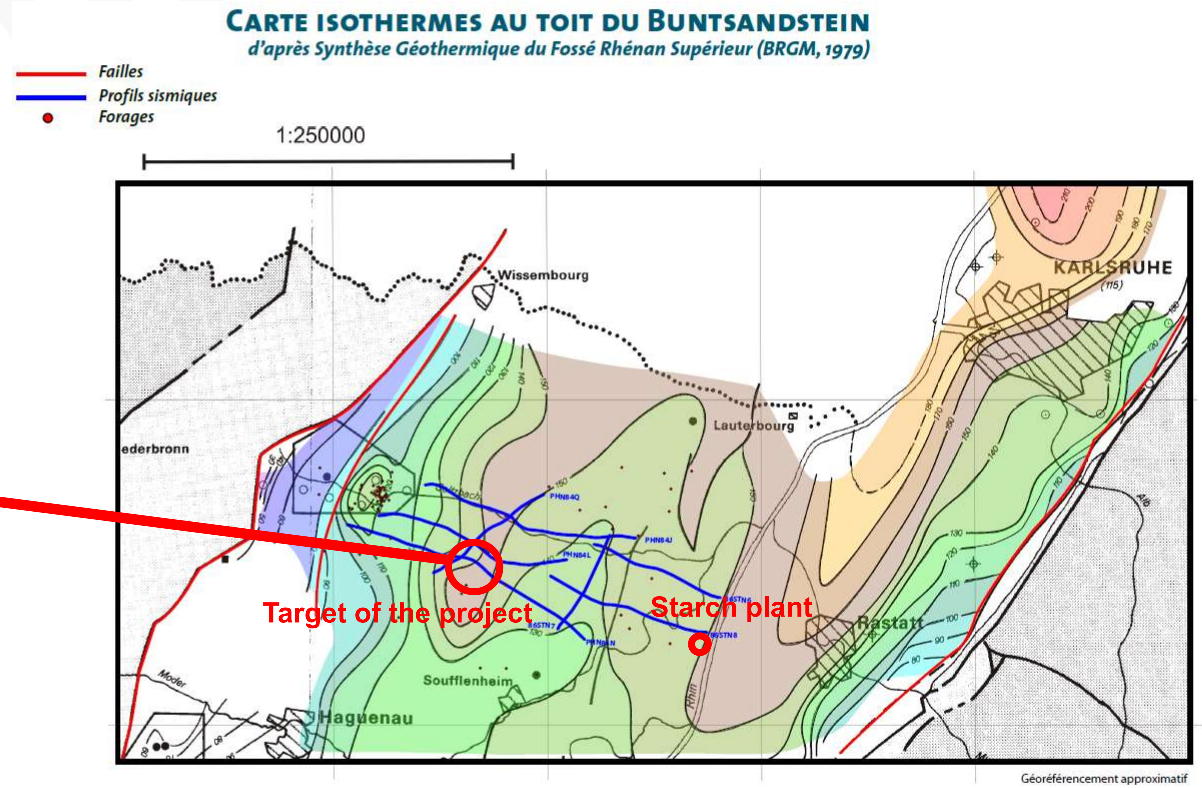
Diapositive 15

RG1 RAVIER Guillaume; 02/02/2021

Why at Rittershoffen?

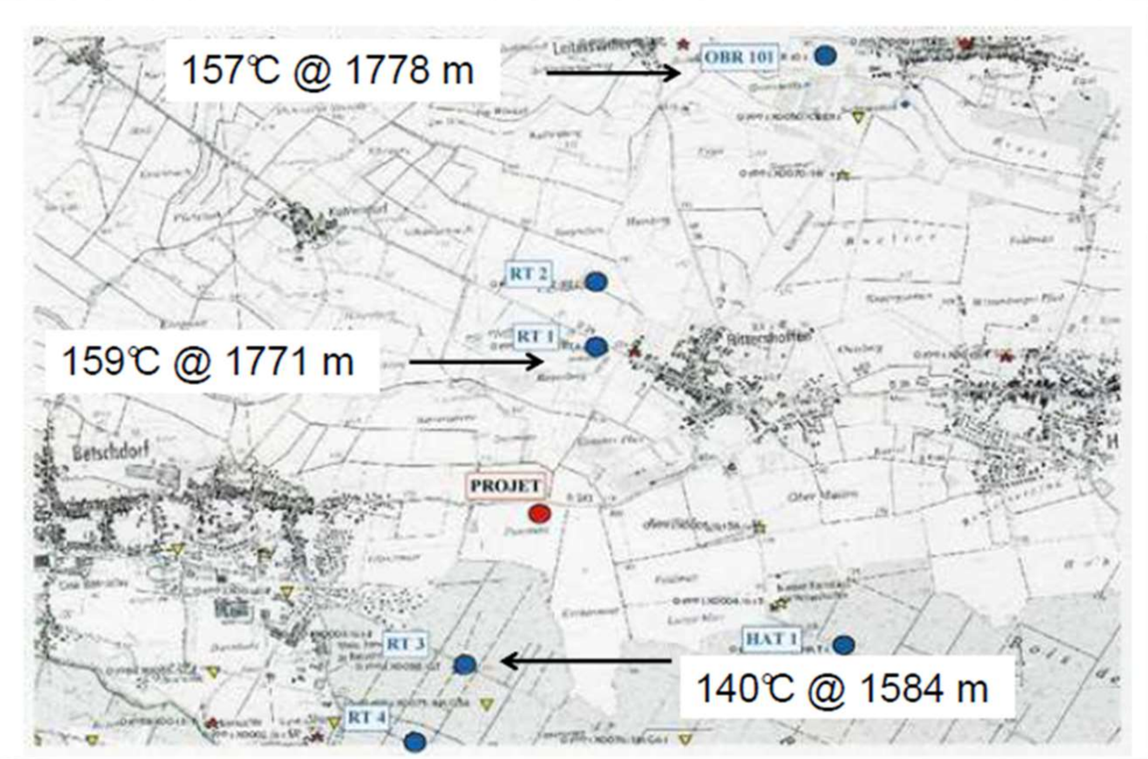


West-East geological cross section



Isotherm at the top of Buntsandstein (sandstone)

Maximising the success of the project



2D old seismic survey available

6 oils wells around the project

Known thermal anomaly (over 80°C/km)

Lower depth and less risky in term of drilling compare to Beinheim drilling location

Lower risk of seismicity

Higher probability of local permeability

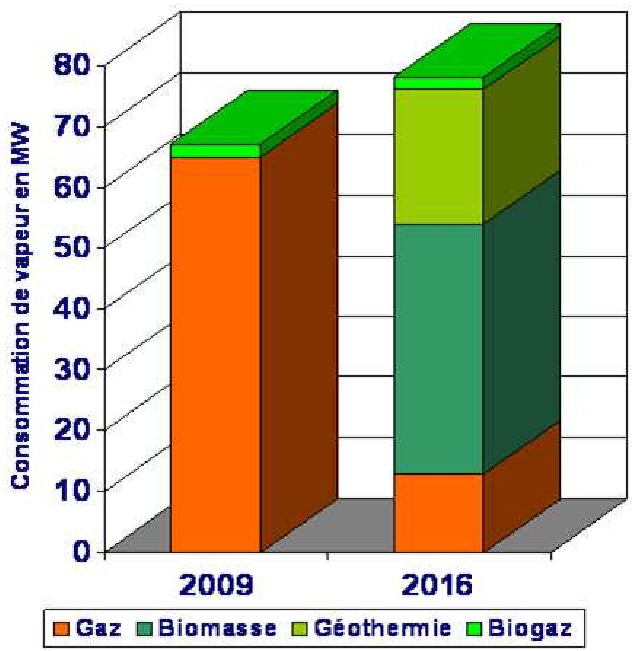
But need to transport the heat from the geothermal plant to the starch plant

Target of the project

ECOGI founded in 2011

3 shareholders (Electricité de Strasbourg, Roquette Frères and Caisse des dépôts)

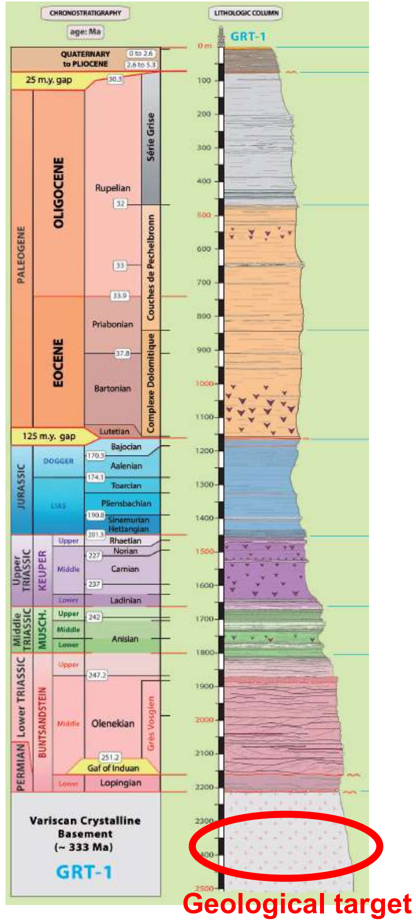
Target: supplying 25% of the total heat demand of the 1 Roquette starch plant at Beinheim



Evolution of the heat mix of the starch plant

2012: First drilling

- Drilling target: a fault zone at 2.2 km deep
- Nearly 3 month of drilling
- Low productivity index after drilling
- Thermal, chemical and hydraulic stimulation (Apr-Jully 2013)
- Max pressure during stimulation: 35 bar
- High injectivity index



(Duringer et al., 2019)

2014: Second drilling

2 new seismic lines

Same fault zone targeted at 1 km to north

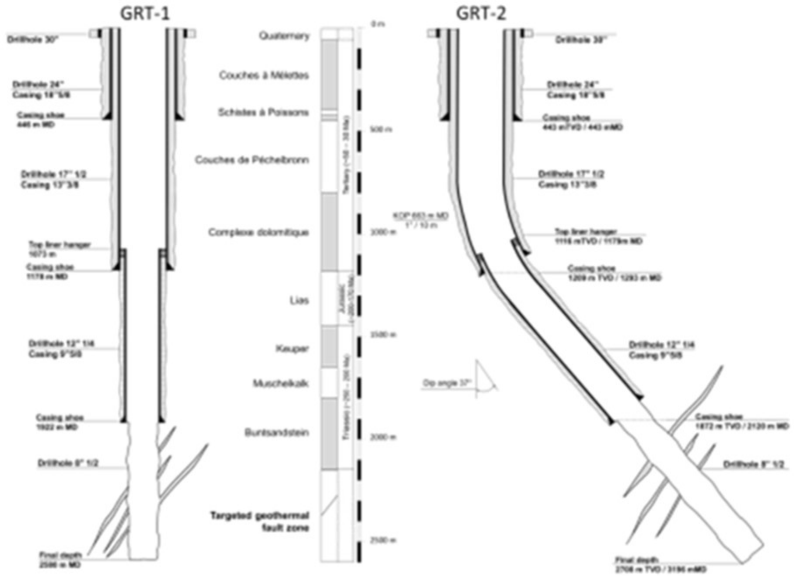
Nearly 4 month of drilling

Some issue during drilling due to high well inclination

Full mud loss in the targeted fault zone

High productivity index after drilling

No stimulation



2015-2016: Heat plant construction

Build from mid 2015 to mid 2016

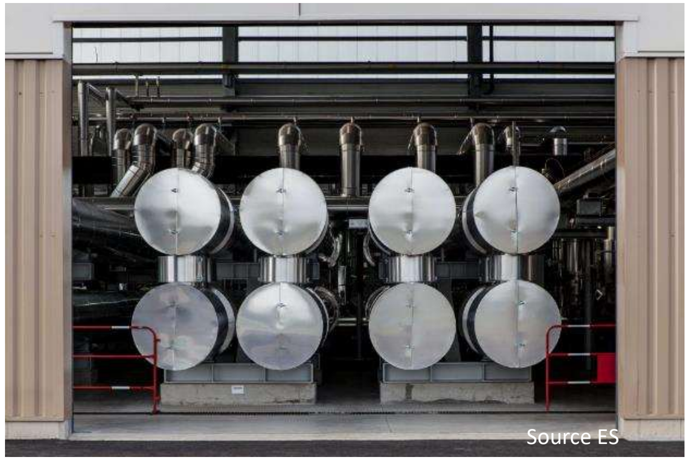
1 primary loop (brine) and 1 transport loop (fresh water)

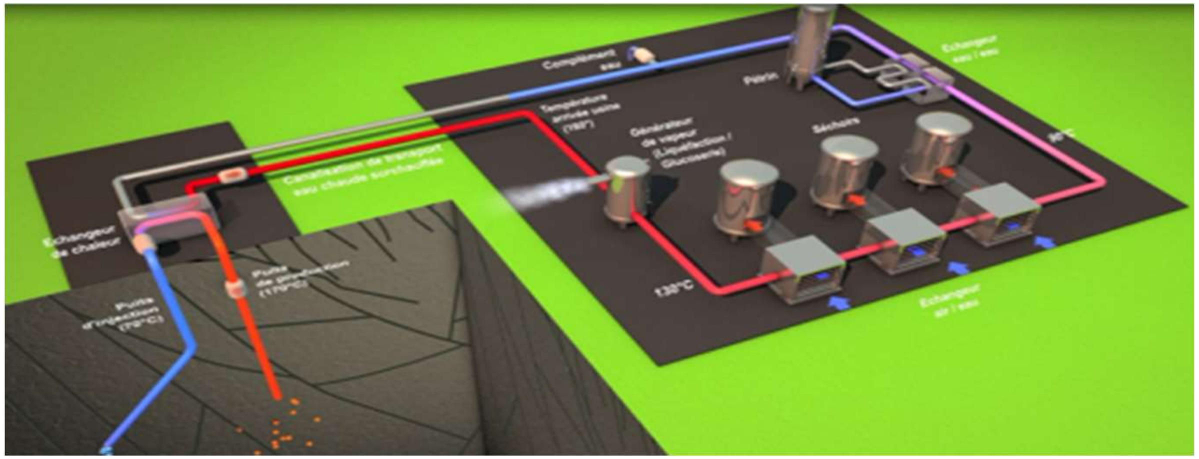
Pressurized geothermal loop (25 bar)

1 Downhole production Line Shaft Pump

12 heat exchangers in series

Max heat capacity: 27.5 MWth





2015-2016: Transport loop installation

15 km long transport loop, 1 m deep

Pipe in pipe system and pre-insulated pipes

<5°C of thermal loss over 2x15 km

2020 operational data

Operational data of 2020

Well head temperature: 168°C

Average production flowrate: 280 m^3/h

2 weeks of maintenance

Over 8400 h of operation (96% of availability)

180 GWh of heat supplied to the heat user

Average power of the heat user: 21.5 MWth

45 000 tCO_2 saved from natural gas burning

Project Life Cycle Assessment

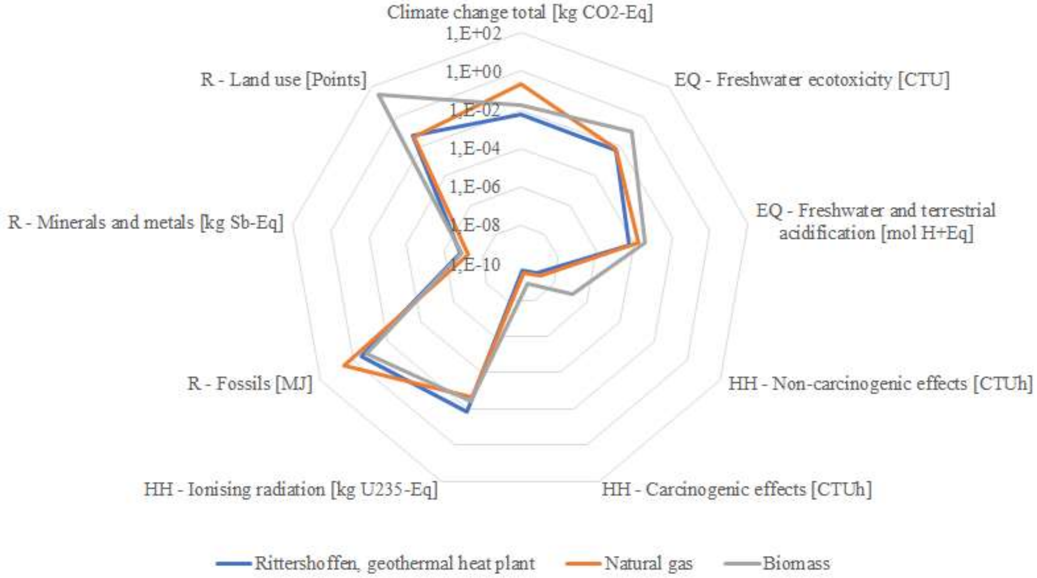
Life Cycle Assessment: From exploration to decommissioning

Most of environmental potential impact similar or lower than those of heat from biomass or natural gas

GHG content: 5.9 $gCO_2eq/KWth$, 40 time less than natural gas

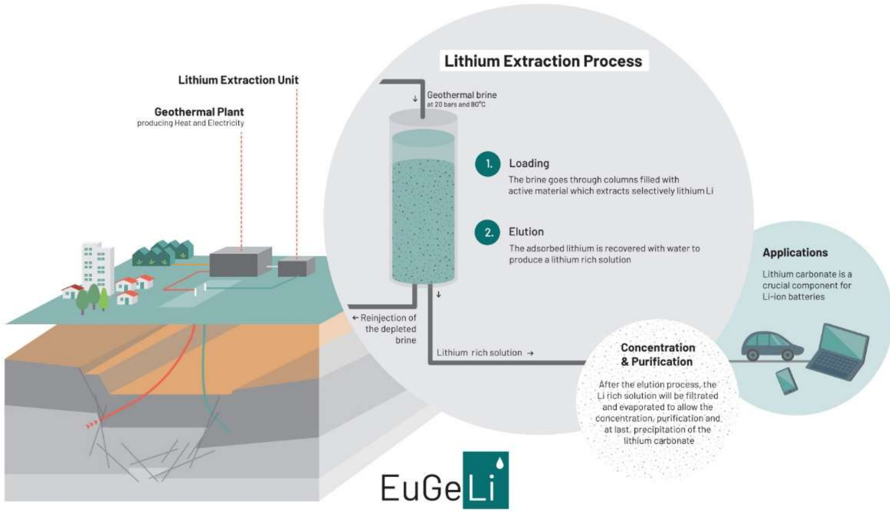
640 less need of land use compare to biomass

Only higher impact: ionizing radiation because of the electrical consumption during operation and the French mix with 75% of nuclear power plant



EuGeLi Project

- About 200 mg/L of Li
- Strategic mineral for electric mobility and energy storage
- Ongoing feasibility test at Rittershoffen for Li extraction under the EuGeLi project
- First onsite test in Europe



Virtual visit of the Rittershoffen geothermal heat plant

Thank you very much for your attention

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MEET Multi-sites EGS Demonstration

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és géothermie

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