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

16th of February 2021
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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

- **Rittershoffen (FR)**
  - 24MWth

- **Bruchsal (DE)**
  - 0.55MWe+ district heating

- **Insheim (DE)**
  - 4.8MWe

(Glaas, 2021)
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
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

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

Source: Turboden
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
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
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
Why at Rittershoffen?

Isotherm at the top of Buntsandstein (sandstone)

West-East geological cross section
2D old seismic survey available
6 oil 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

Maximising the success of the project
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
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-July 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$_2$eq/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

This work was performed in the framework of the H2020 MEET EU project which has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 792037

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