

POWER PRODUCTION IN SOULTZ

Daniel Fritsch – EEIG
Philippe Lutz – EDF R&D

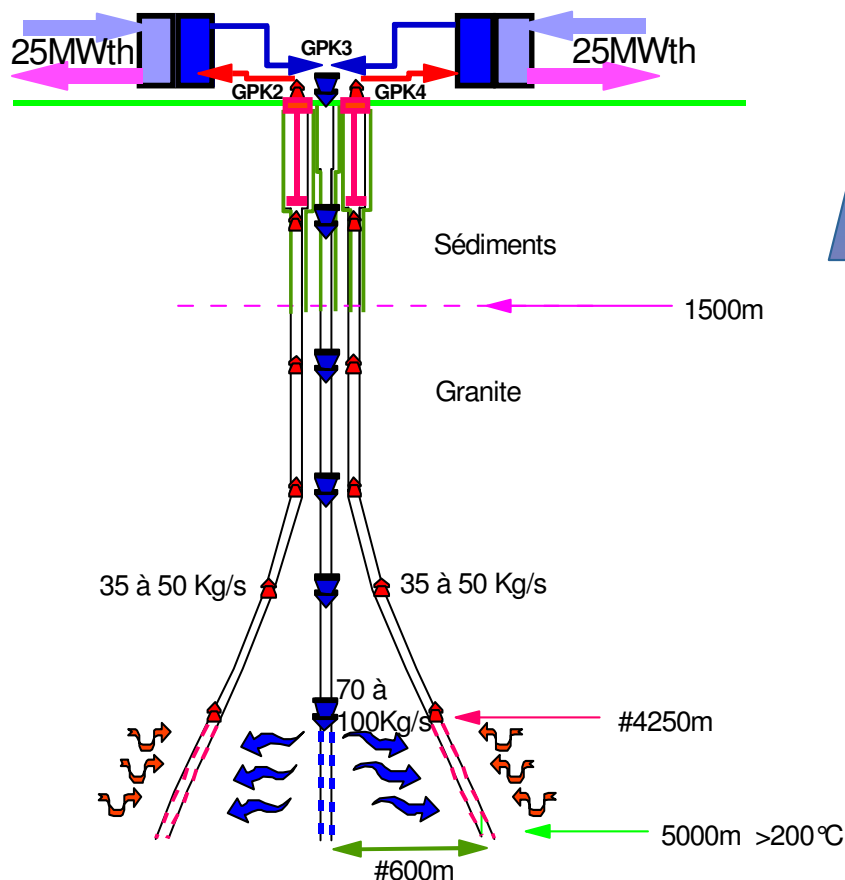
SOULTZ project history

Soultz “Enhanced Geothermal System” (EGS) Pilot Plant is an European Project (EC) with the support of France (ADEME) and Germany (BMU), co-financed by Industrial Partners (ES, PW, EDF)

- Investigation on the Soultz-sous-Forêts site start : 1987
- First circulation test between GPK2 and GPK1 : 1997
145 °C at 3500 m depth, 25 l/s between the wells
- Deepening of GPK2 well at 5000 m depth : 2000
200 °C at 5000 m
- Current EGS Pilot Plant in 2 phases :
 - *Phase I (2001-2005) : Drilling of 2 new deviated deep wells (GPK3 and GPK4) and stimulation of the underground reservoir*
 - *Phase II (2004-2008) : Continuation of the reservoir stimulation, circulation tests between the wells with the help of submersible pumps, and conversion of geothermal energy in electrical energy at surface (ORC power plant)*



Schematic presentation of the EGS plant



Secondary Loop (Surface) :
Expected surface temperature : 185 °C
Heat exchanging system
Available thermal energy : 50 MWth
Surface power plant facilities
Produced electrical energy : 5 MWe
Objective : Convert geothermal heat
in useful energy (electricity)

Primary Loop (Underground) :
2 production wells, 1 re-injection well
“Closed” brine circulation
Expected Flowrate : 70-100 l/s
Depth : 4500-5000 m
Bottom temperature : 200 °C
Pumping system (EGS)
Objective : Extract geothermal heat
from hot rocks

Soultz Project status

What has been done in 2004-2006 (1)

- **3 wells completion and stimulation :**

Completion of the last deviated deep well GPK4 : April 2004

Hydraulic and chemical stimulation of GPK4 : September 2004 and March 2005

New chemical stimulation of GPK4 (RMA) : May 2006

- **First circulation test between the 3 wells :** July to December 2005

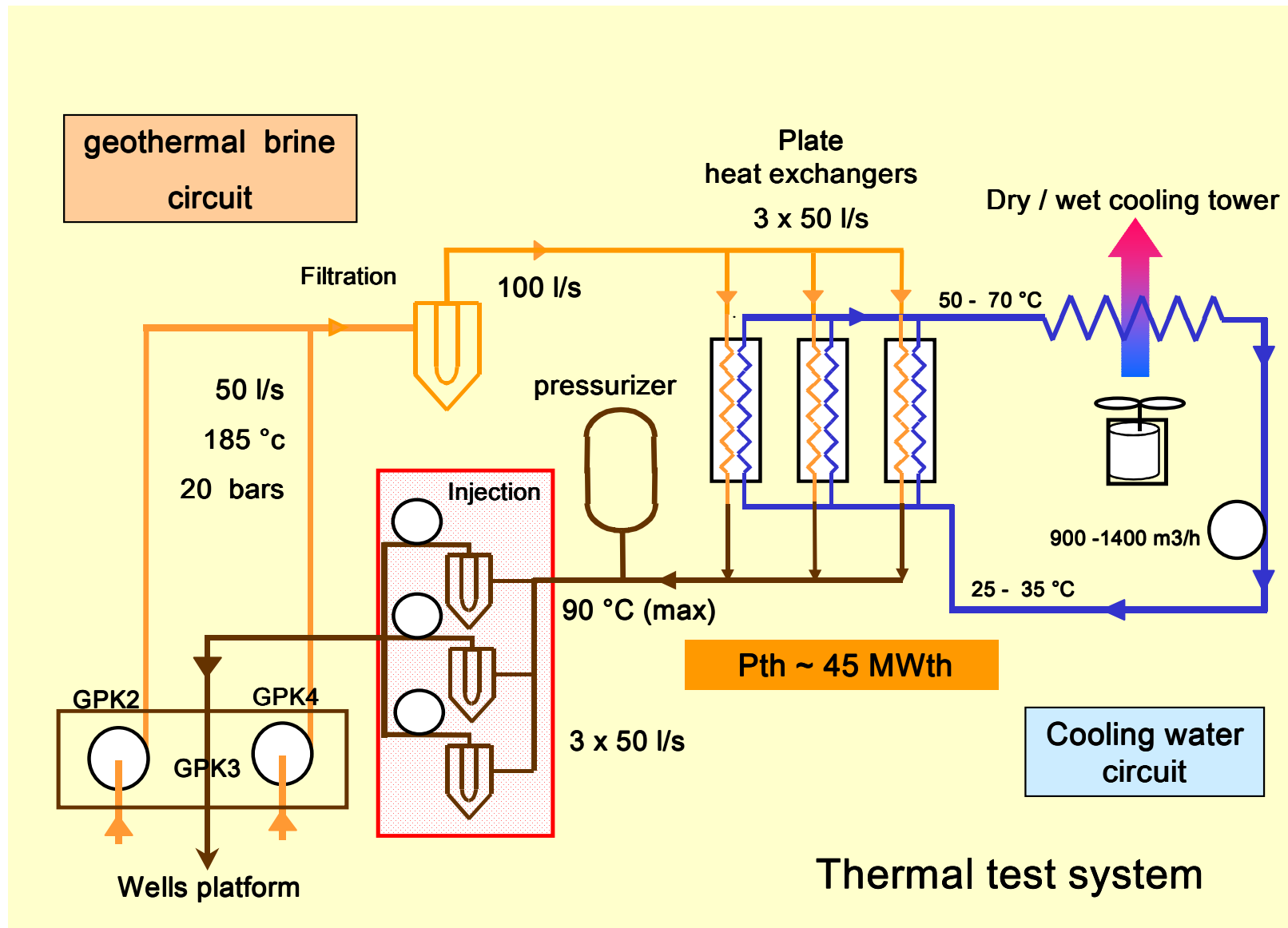
Test performed without submersible pumps (buoyancy thermal effect)
15 l/s in total, 152 °C in average at surface, 5.5 MWth dissipated
through a lagoon

Soultz Project Status

What has been done in 2004-2006 (2)

- **Preparation of the next circulation loop with submersible pumps :**
scheduled beginning of 2007
Order of one Line-shaft Submersible Pump (LSP)
Negotiation for renting of an Electrical Submersible Pump (ESP)
Ordering of a second injection pump, tubular heat exchangers and air cooling system
Expectation of 30-40 l/s in total and approx. 175 °C (beginning of the test : early 2007)
- **ORC Power Plant :**
Call for tender for a first demonstrative power unit of 1.5 MWe (gross output power)
ORC technology has been preferred to Kalina technology as the aim of the Soultz EGS Pilot Plant is not to develop new and not sufficiently referenced technology for energy conversion (risks focused on EGS itself and pumps technology at 200 °C)

SOULTZ thermal test loop



SOULTZ conversion plant stakes

Characteristics of geothermal brine

- Hot brine : max 185°C,
- High dissolved solids content > 100 g/l
- Corrosive (high Cl) => material selection
- High flow (~100 kg/s),
- Partially cooled only (> 70°C) to avoid scaling,
- Temperature evolution unknown

Issues :

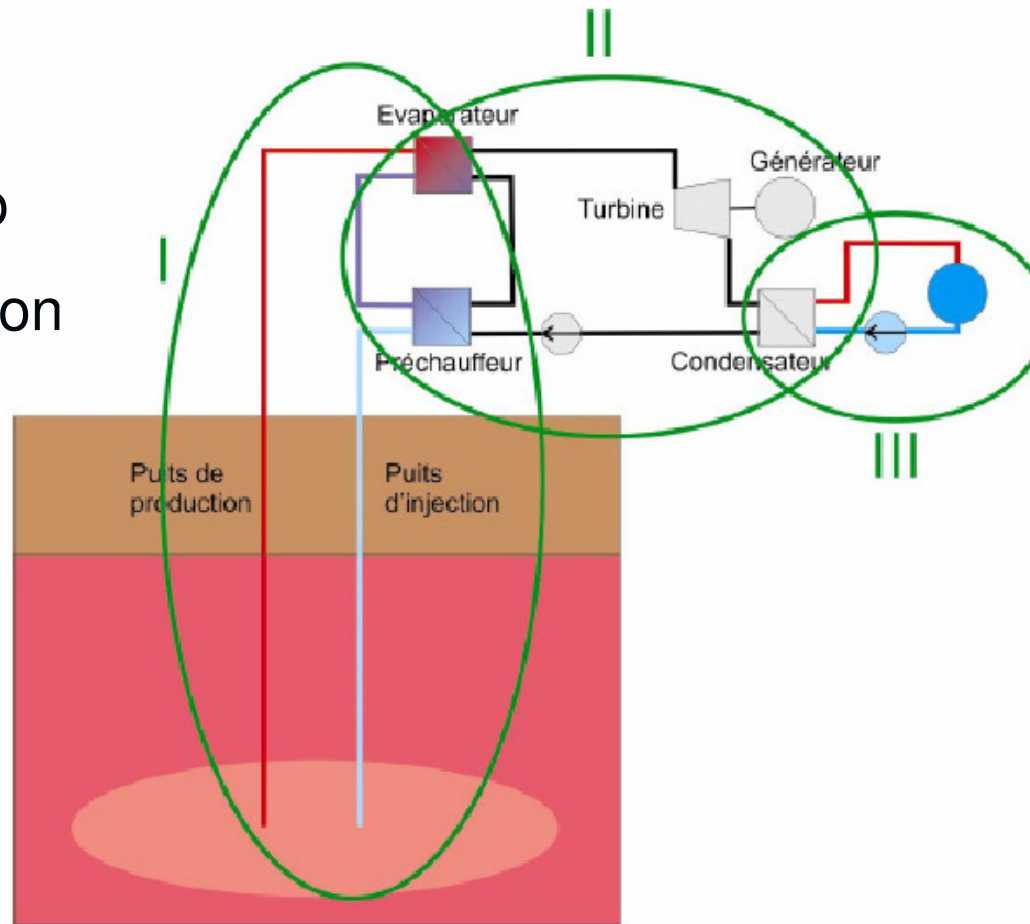
- temperature and density evolution with flow in wells
- buoyancy effect to be computed to assess pump power requirements
- working fluid choice

SOULTZ conversion plant modelling

ORC conversion loop : heat conversion

Primary loop
heat extraction

Cooling loop
heat rejection

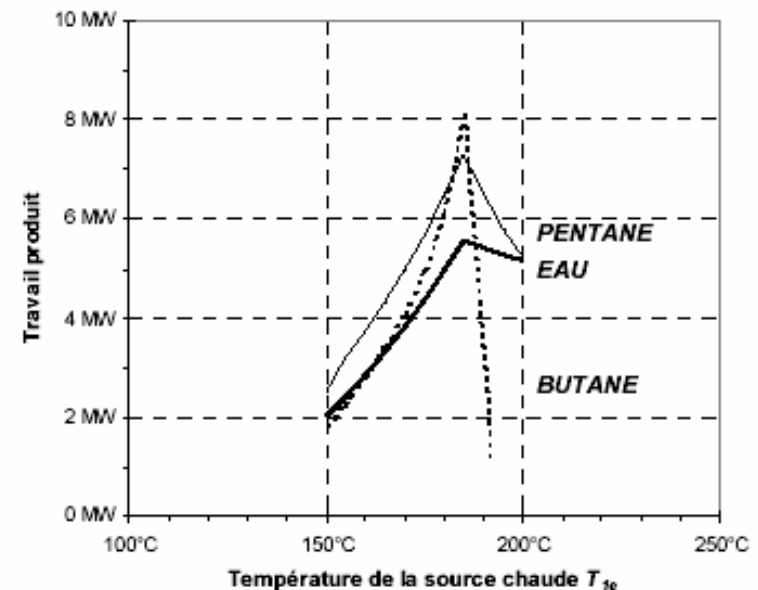
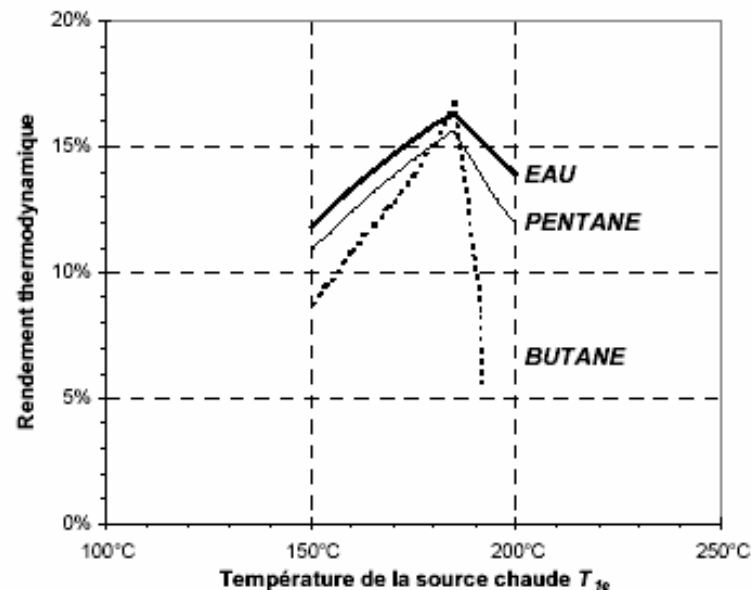
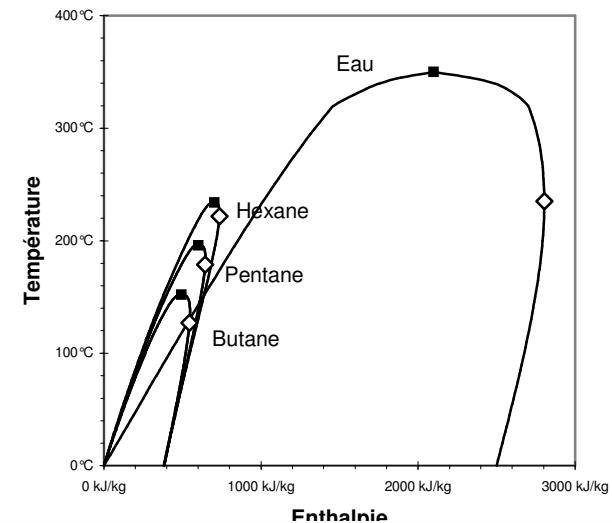


SOULTZ power plant modelling

ORC working fluid selection :

Organic rather than water

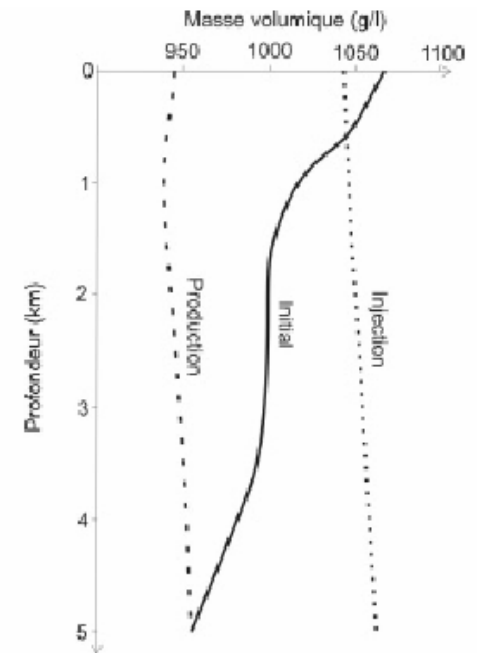
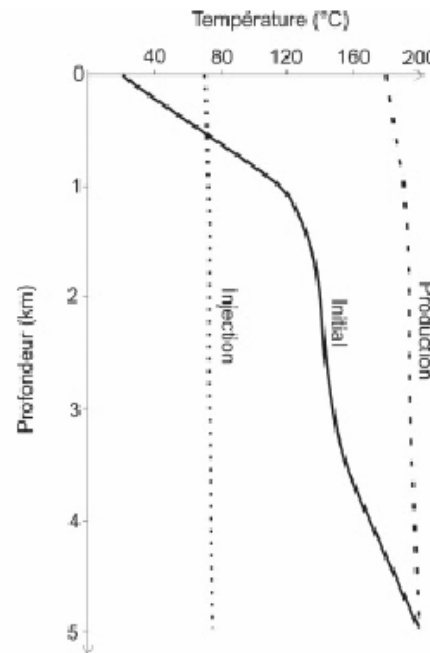
- › Lower latent heat
- › Higher density.
- › Higher molecular weight.



SOULTZ power plant energy balance modelling

Entry parameters

Parameter	Expected value (prod.)	Expected value (inj.)
Flowrate	50 l/s (x2)	100 l/s
Productivity / Injectivity	1 l/s/bar	1 l/s/bar
Fluid salt content	100 g/l	100 g/l
Fluid viscosity	$143 \cdot 10^{-5} \text{ kg/m}^3/\text{s}$	$404 \cdot 10^{-5} \text{ kg/m}^3/\text{s}$
Casing stiffness	$5 \cdot 10^{-5} \text{ m}$	$5 \cdot 10^{-5} \text{ m}$
Bottomwell temperature	200°C	
Wellhead temperature	188°C*	70°C



SOULTZ power plant energy balance modelling

Total Dynamic Head pressures calculation results :

	GPK2	GPK4	GPK3
F_t	13.4 bar	3.0 bar	13.5 bar
H_d <i>Buoyancy Drawdown</i>	21.1 bar (-28.9 bar) (50 bar)	20.8 bar (-29.2 bar) (50 bar)	75.2 bar (-24.8 bar) (100 bar)
P_d	20 bar	20 bar	-20 bar
TDH	54.6 bar	43.8 bar	68.7 bar

Electrical power balance results :

(in kW)	Production			Injection	TOTAL
	GPK2	GPK4	Total		
ORC loop					6081
Primary loop	606	487	1093	1154	2239
Cooling loop					1216
Net power output					2626

Conclusion

Underground reservoir stimulation :

Today the underground reservoir stimulation is still to be achieved ; further stimulations (chemical and hydraulic) of GPK4 and GPK3 are planned for the last quarter of 2006

Challenge of the circulation test with submersible pumps : first semester 2007

This test shall be crucial in terms of feasibility of the EGS concept, performance of the underground reservoir and effective power consumption of the pumping system (evaluation of the global power efficiency of the pilot)

1.5 MWe ORC Power Plant - Call for Tender calendar :

Launching of the tender end of August 2006 to 6 potential suppliers

Deadline for receiving the offers : mid-October

Expected date for signing a contract : November 2006

Expected commissioning of the 1.5 MWe ORC power plant : September 2007



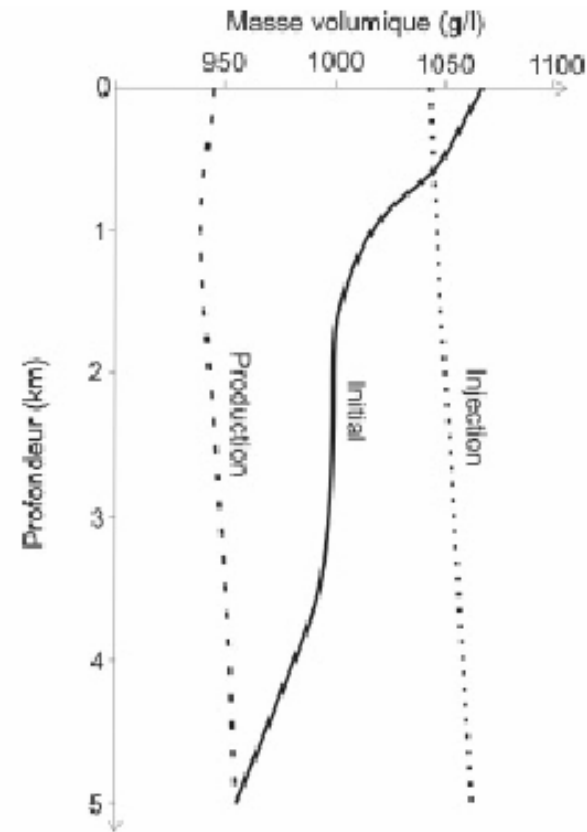
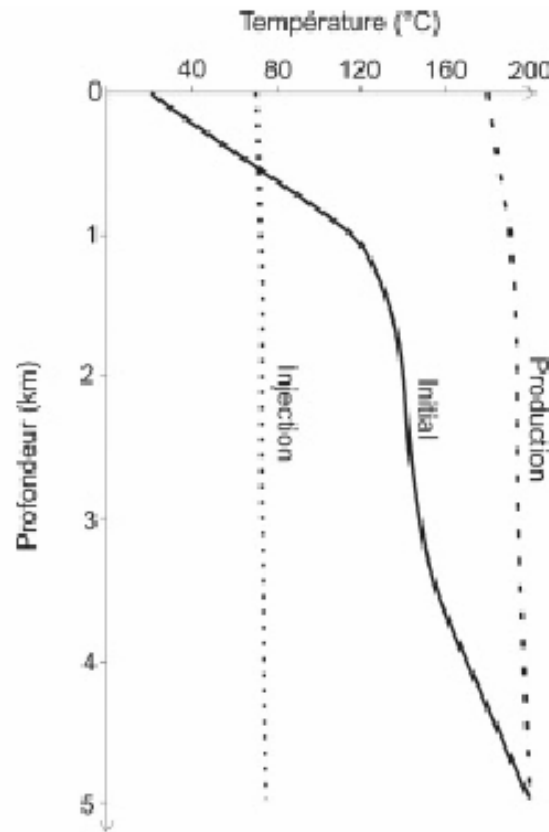
Thank you for your attention



and see you in Soultz

SOULTZ power plant modelling

Temperature evolution in wells :



(GEOWATT calculation for 50 l/s)