Rittershoffen Geothermal Heat Plant

Enhanced Geothermal System (EGS) for heat generation

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EXPLORATION

$E_{exploration}$
2.82e5 – 9.65e5 MJ

CONSTRUCTION

POWER PLANT

Heat exchanger

$L_{fw\ pipe}$
100 – 300 m

$L_{gw\ pipe}$
100 – 300 m

$M_{HE,Rit}$
23.07 – 92.28 t

Pumps

P_{LSP}
200 – 1200 kW

P_{Pump}
0 – 500 kW

Building

$A_{Powerplant}$
692 – 2100 m^2

WELL DRILLING

Drilling

L_w
1300 – 5500 m

$Ratio_{MD,well}$
1 – 1.3

N_{in} and N_{prod}
1 – 2

$km_{cuttings}$
50 – 500 km

Drilling Platform

$A_{Platform}$
6500 – 20000 m^2

Stimulation

$V_{chemsti}$
40 – 250 m^3

$V_{hydrsti}$
1000 – 5000 m^3

Testing

CO_2 testing
0 – 3.12e5 kg

OPERATION AND MAINTENANCE

P_{direct}
0.1 – 5%

P_{CO_2}
0 – 1%

P_{CH_4}
0 – 0.001%

Q
140 – 350 t/h

LT
20 – 40 years

OH
5000 – 8500 h

MW
10 – 40MW

km_{OM}
0 – 20000 km

END OF LIFE

E_{abd}
7.72e5 – 1.5e6 MJ

$M_{Cement,Abd}$
2500 – 50000 kg

Scope of the study:
Not volcanic
General
Heat
Stimulation

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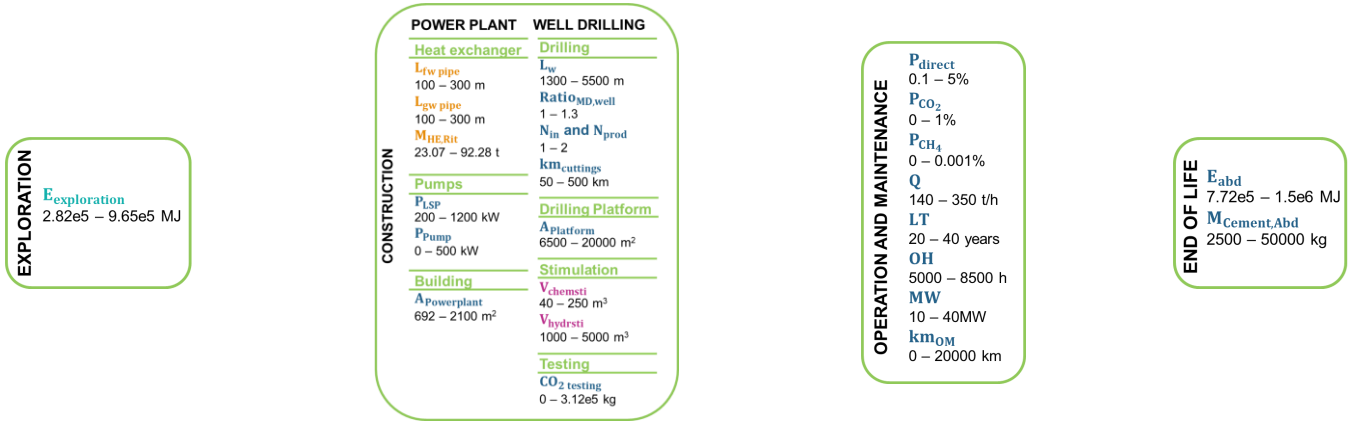
Step 2 : Reference parameterized LCA model

Reference model to estimate Climate Change, total impact category (ILCD 2018) based on 26 parameters



$$GHG_{Rittershoffen} = \frac{GHG_{exploration} + GHG_{PowerPlant} + GHG_{Drilling} + GHG_{OperationMaintenance} + GHG_{EndofLife}}{\mathrm{MW} \cdot OH \cdot 1000 \cdot LT \cdot \left(1 - \frac{Loss}{year} \cdot LT\right)}$$

kWh produced over the plant's lifetime

PRELIMINARY RESULTS

Step 3 : Identification of the key variables

With Sobol indexes thanks to a global sensitivity study

- First order index (S1)
- Parameters contributing the most to the **variability** of the Climate change, total impact category (ILCD 2018)

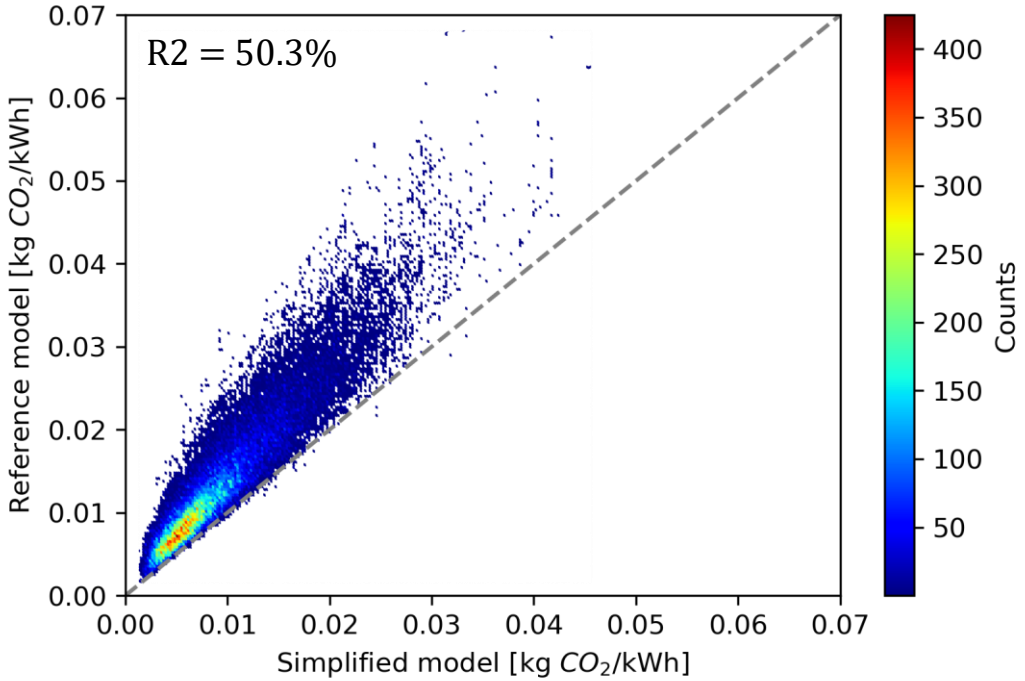
		S1
Heat output	$\mathbf{MW}$	57%
Well length	$\mathbf{L_w}$	14%
Power production pump	$\mathbf{P_{LSP}}$	7%
Number of production wells	$\mathbf{N_{prod}}$	3%
Direct emissions	$\mathbf{P_{direct}}$	2%
Lifetime	$\mathbf{LT}$	2%
CO_2 in direct emissions	$\mathbf{P_{CO_2}}$	1%
Operating hours	$\mathbf{OH}$	1%
Explained variance		87%

PRELIMINARY RESULTS

Step 4 : Simplified model for Climate Change total [kg CO_2-eq/kWh]

Based on 6 parameters explaining 83% of the climate change variability from the reference model

Six parameters: Heat output (**MW**), well length ($\mathbf{L_w}$), power production pump ($\mathbf{P_{LSP}}$), number of production wells ($\mathbf{N_{prod}}$), lifetime (**LT**) and operating hours (**OH**)



$$GHG_{Rittershoffen} =$$

$$-\left(\frac{(N_{prod}+1)\cdot[86622.13229\cdot 10^{3.51E-04*L_w}+39.51008\cdot L_w^{1.046}+58.45841\cdot L_w^{1.22}+22.26399\cdot L_w^{1.23}+243.97870\cdot L_w]}{LT\cdot MW\cdot OH\cdot(0.83333\cdot LT-1000)}\right.$$

$$+\frac{N_{prod}\cdot P_{LSP}\cdot(45.69987\cdot LT+650.79088)}{LT\cdot MW\cdot OH\cdot(0.83333\cdot LT-1000)}$$

$$+\frac{49982.64343\cdot LT}{LT\cdot MW\cdot OH\cdot(0.83333\cdot LT-1000)}$$

$$\left.+\frac{7.86E-02\cdot N_{prod}\cdot P_{LSP}+6.74846}{MW\cdot(0.8333\cdot LT-1000)}\right)$$

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PRELIMINARY RESULTS

Step 4 : Simplified model for Climate Change total [kg CO_2-eq/kWh]

Applicability Domain : For which installation can the simplified model be used?

1) Heat generating power plant (not necessarily with stimulation)
2) FR electricity mix
3) Low direct emissions (0.1-5%)
4) Variables within the following ranges

		Unit	Min	Max
Heat output	$\mathbf{MW}$	MW	10	40
Well length	$\mathbf{L_w}$	m	1300	5500
Power production pump	$\mathbf{P_{LSP}}$	kW	200	1200
Number of production wells	$\mathbf{N_{prod}}$	-	1	2
Lifetime	$\mathbf{LT}$	years	20	40
Operating hours	$\mathbf{OH}$	h/y	5000	8500

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Step 5 : Comparison with literature - Climate Change total [kg CO_2-eq/kWh]

- So far no comparison with published results was possible
- Difficulties:
  - Few available LCA on heat production from deep geothermal power plants only
  - Fewer available LCA studies within the simplified model's boundaries
- Words of caution
  - Impact category
  - Level of details

Thank you for your attention !

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