Modeling Enhanced Geothermal Systems (EGS) for Energy and Metal Recovery

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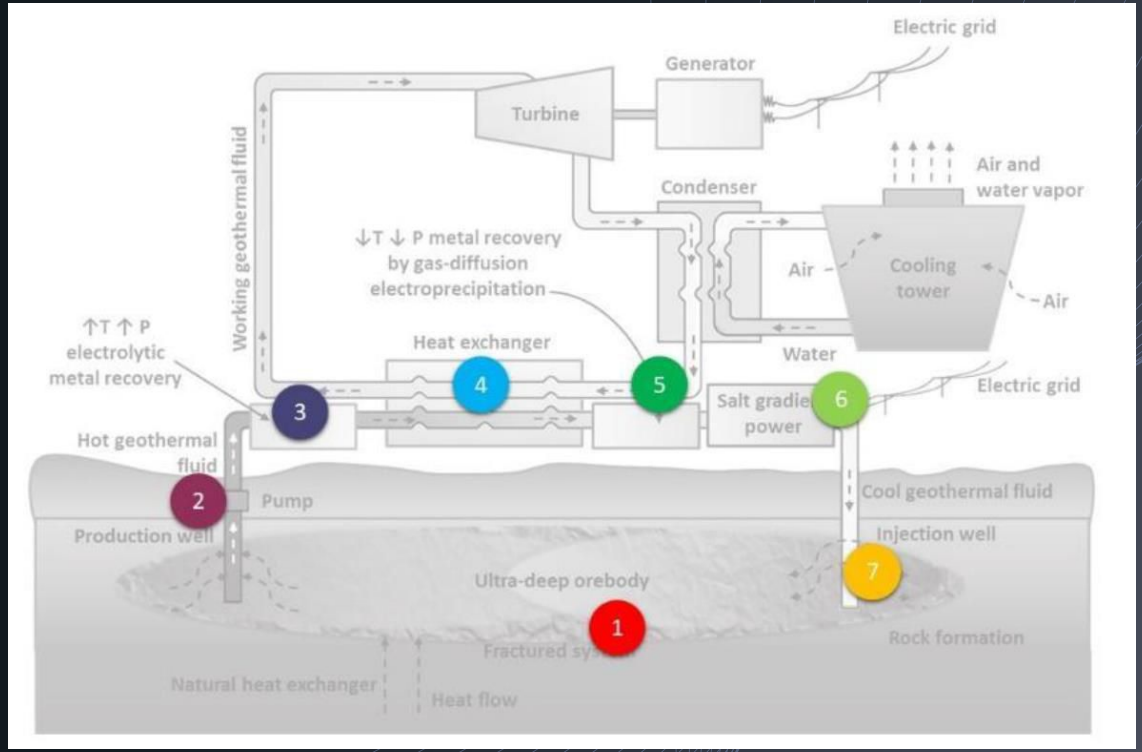
July 2019

Objective

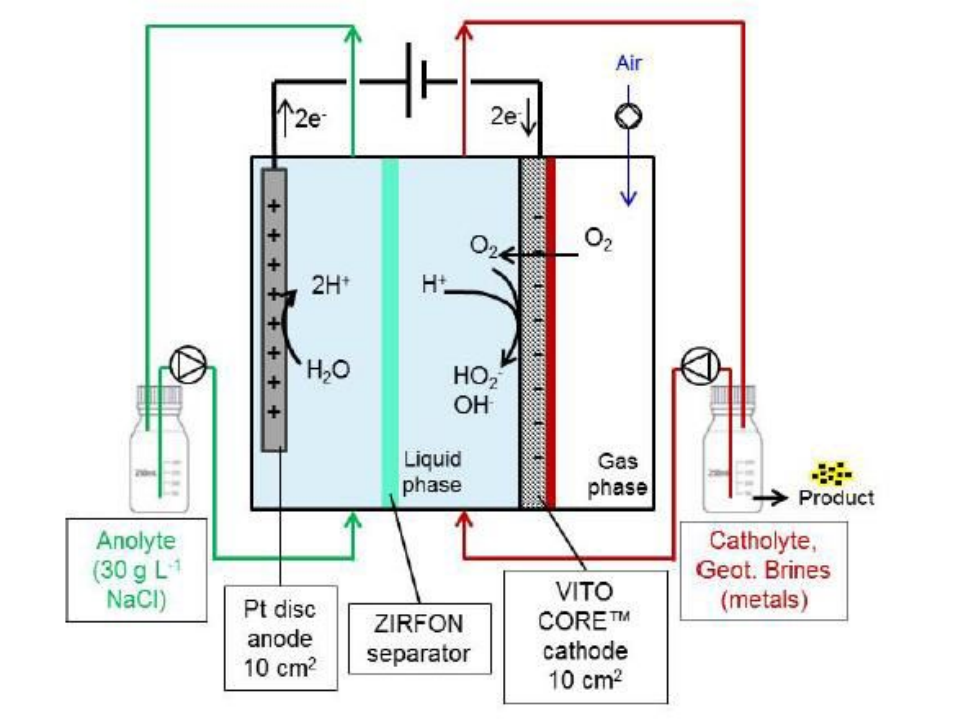
- Creating a model pipeline to analyze data for valorizing metals and energy

System Modeling



Focussed on processes 3 to 6

Electro-precipitation



Model Approach

Individual System -Model Training

Logistic regression was used to model the system components, using experimental data.

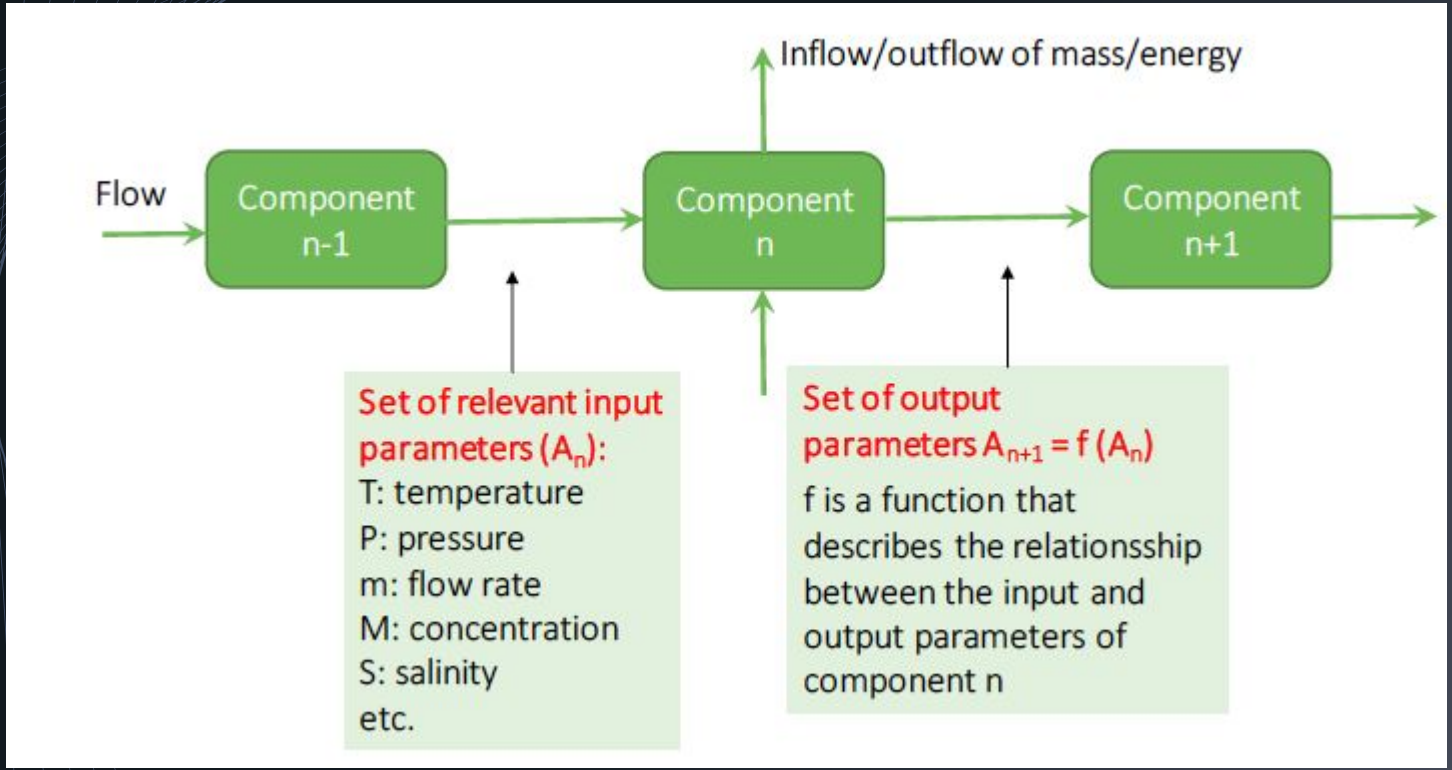
Testing Data Generation- Stochastic Model

Monte Carlo method was used to generate input data from a given distribution.

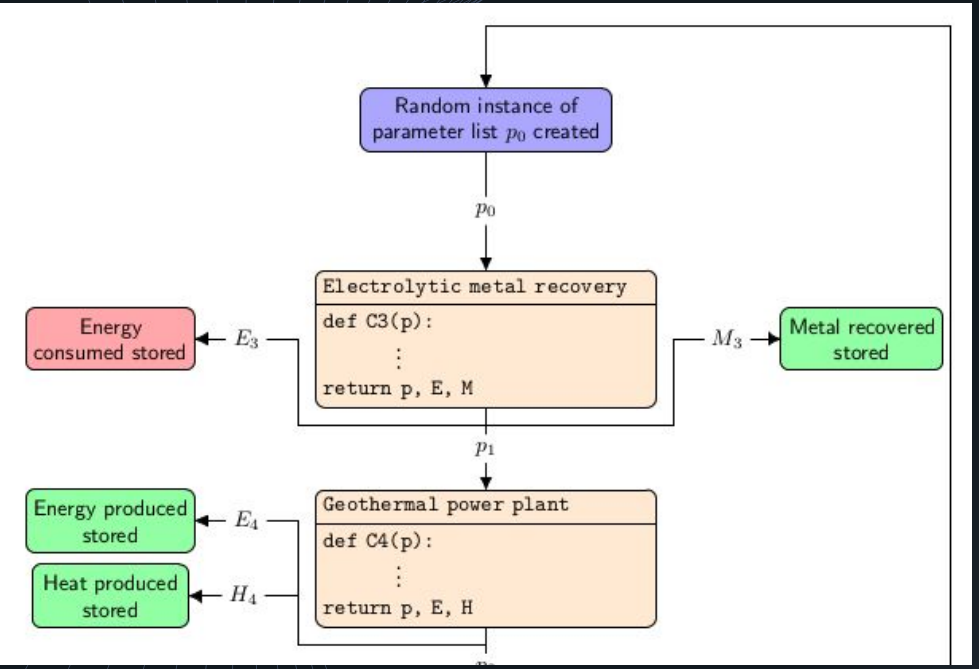
Test Data

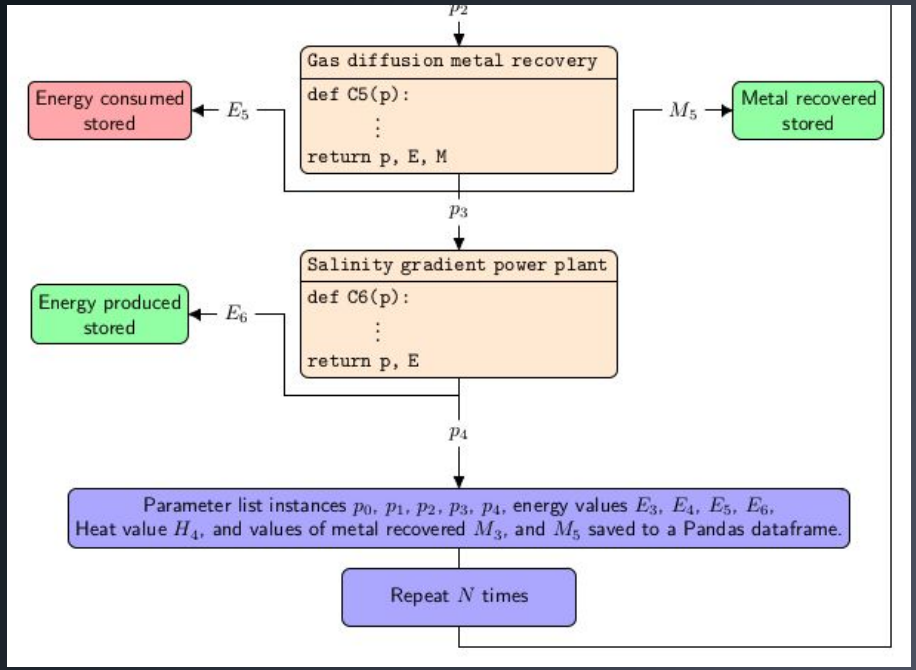
The model was tested with real brine data from 1. **Mol**, Belgium, **Reykjavik**, Iceland, **Landau**, Germany, **Cornwall**, UK, and **Pannoni,** Romania.

Model Approach

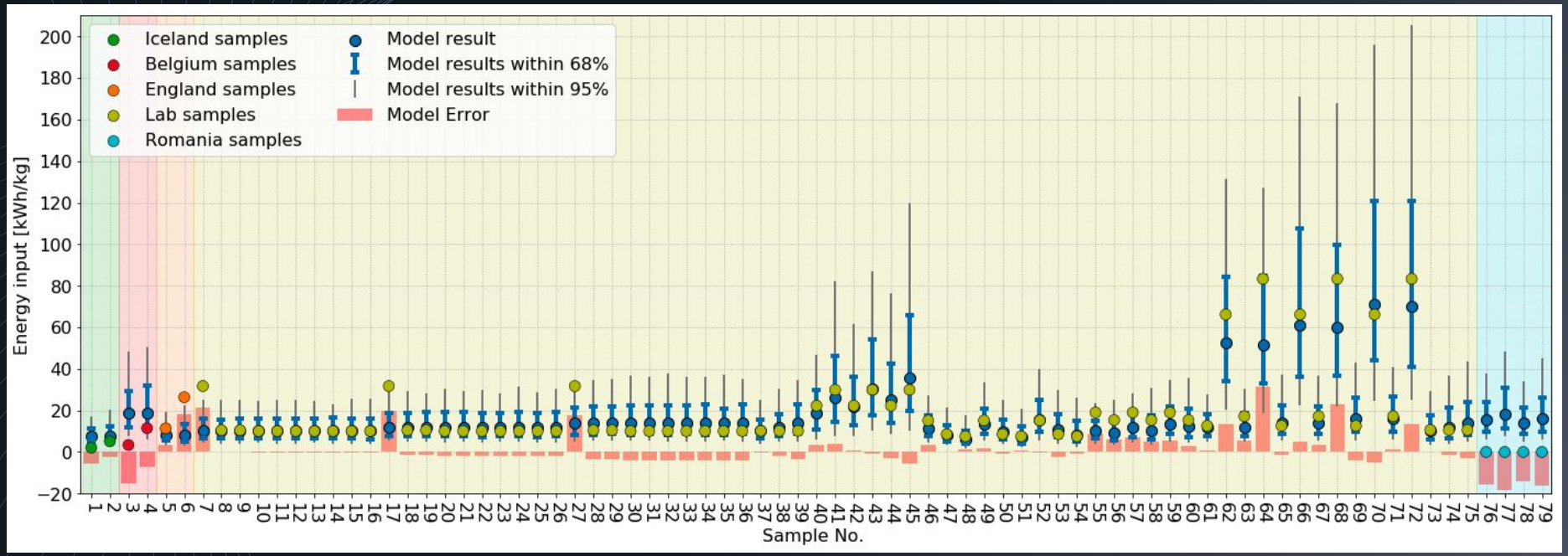


Model Algorithm

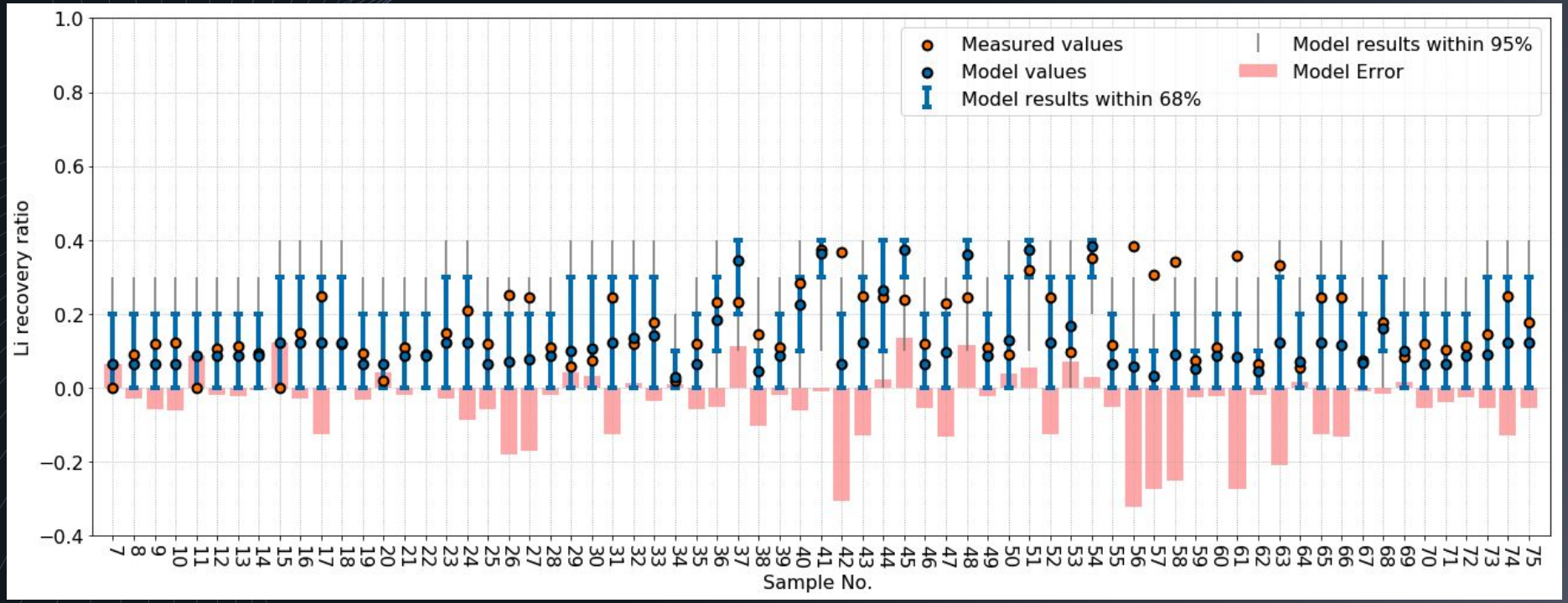




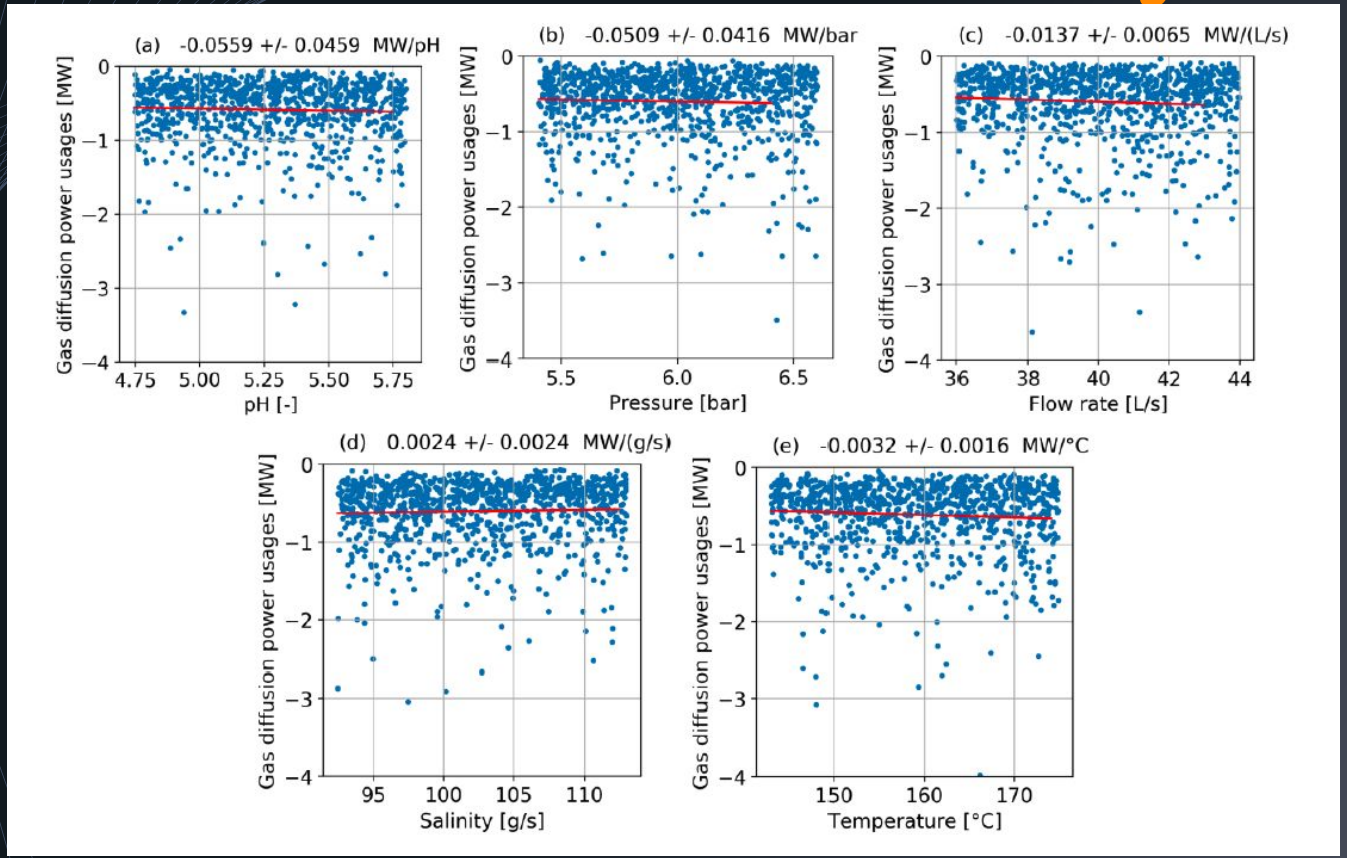
Model Results - Energy (EP)



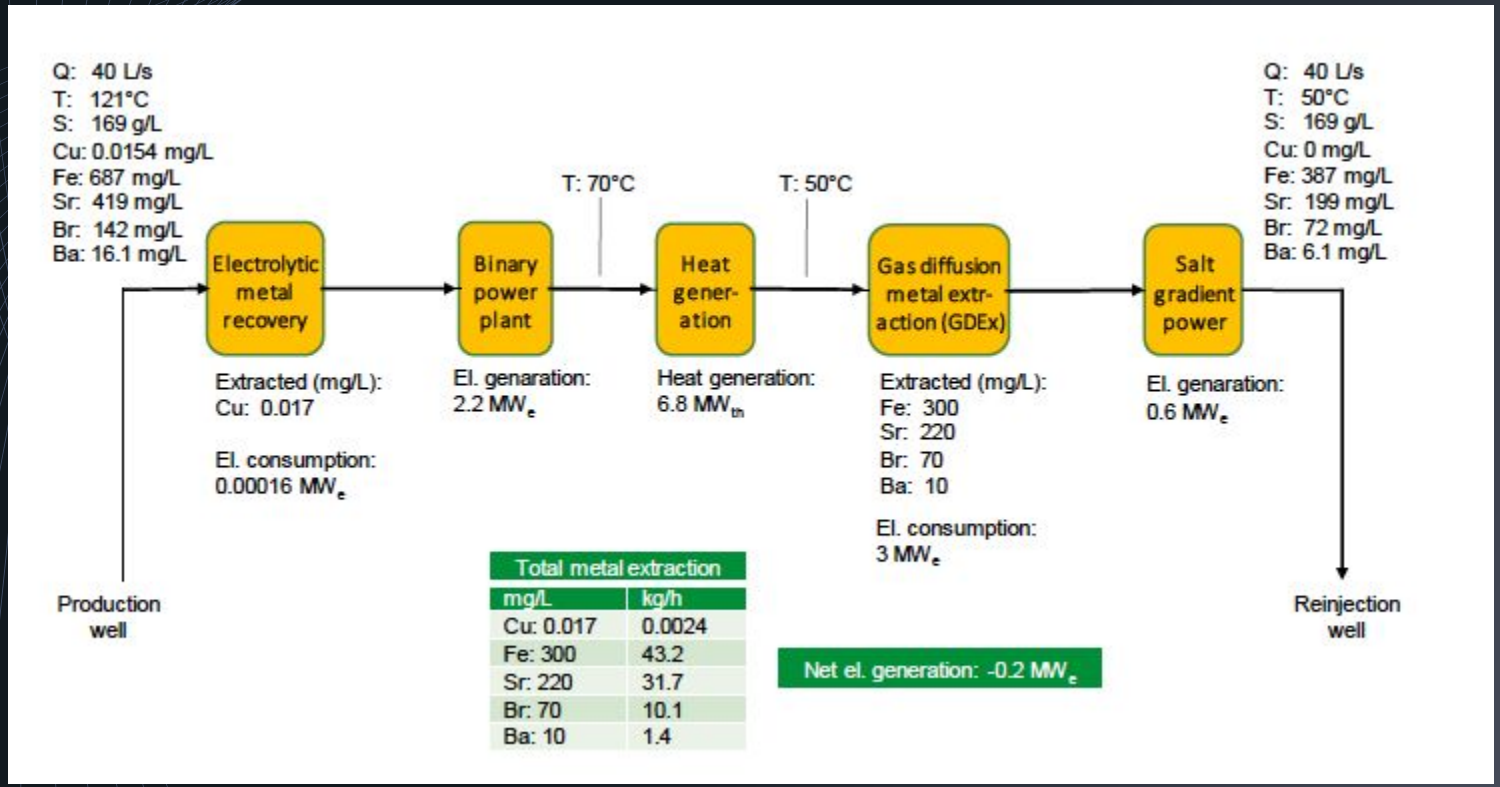
Model Results - Li Recovery



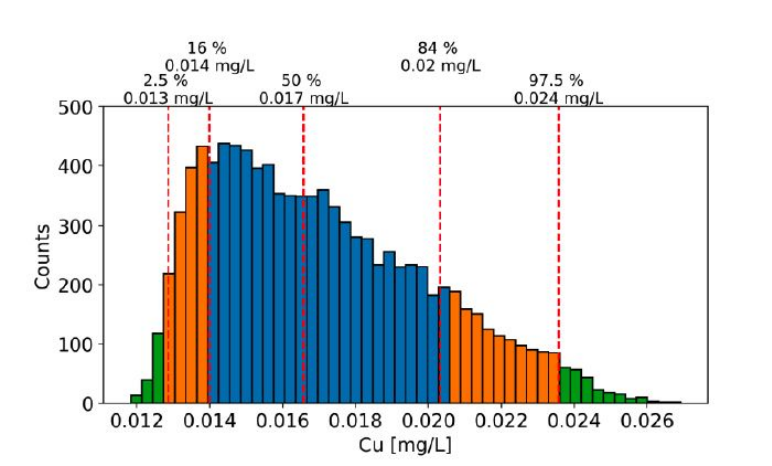
Model Results - Sensitivity study

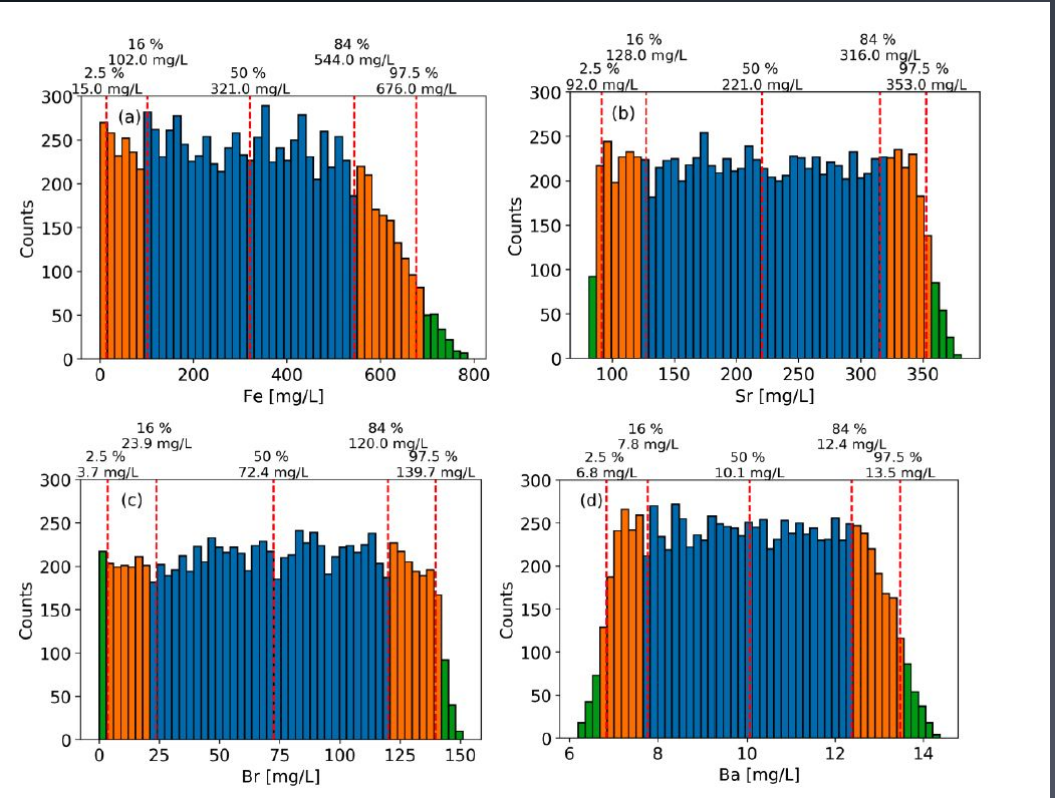


Results - Mol, Belgium

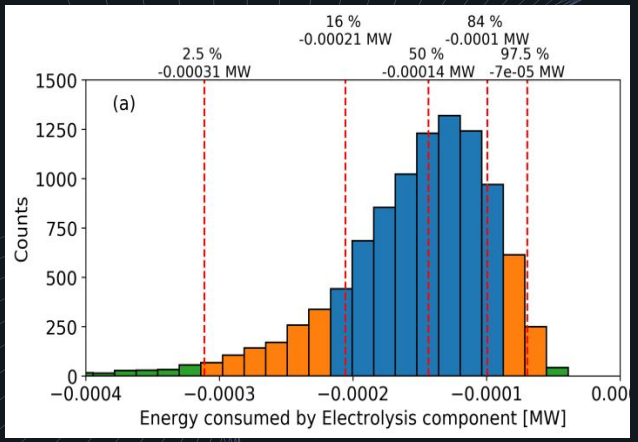


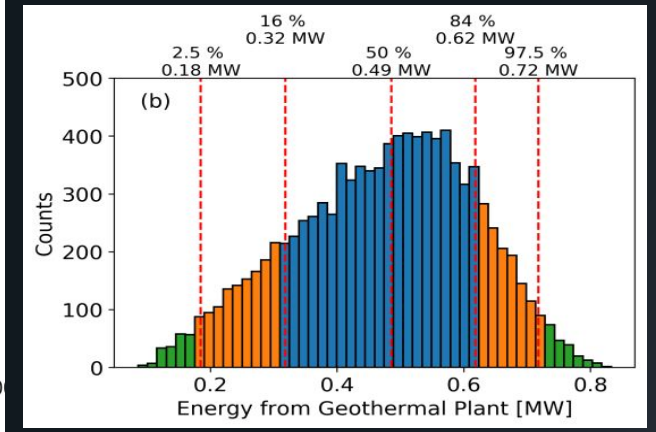
Results - Metals - Mol, Belgium

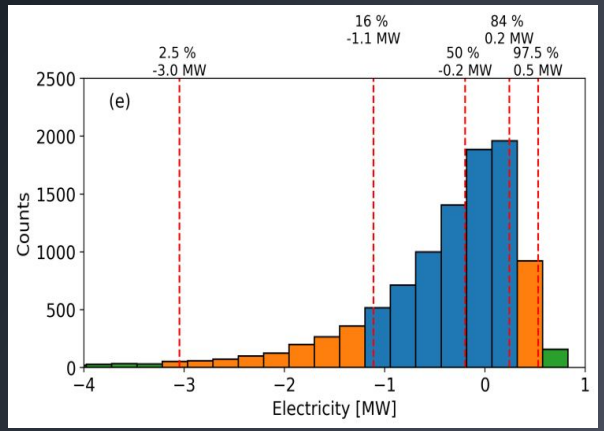


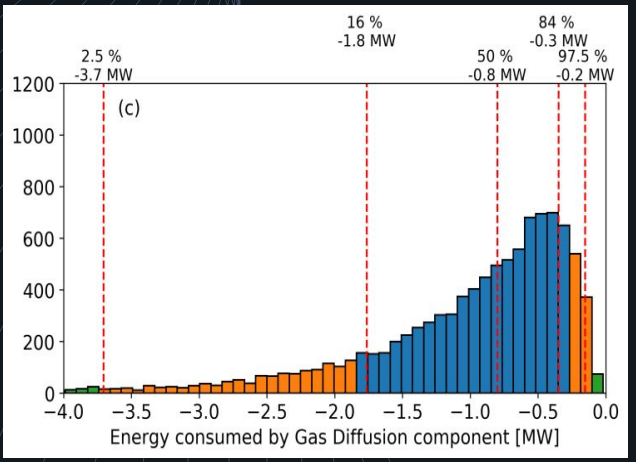


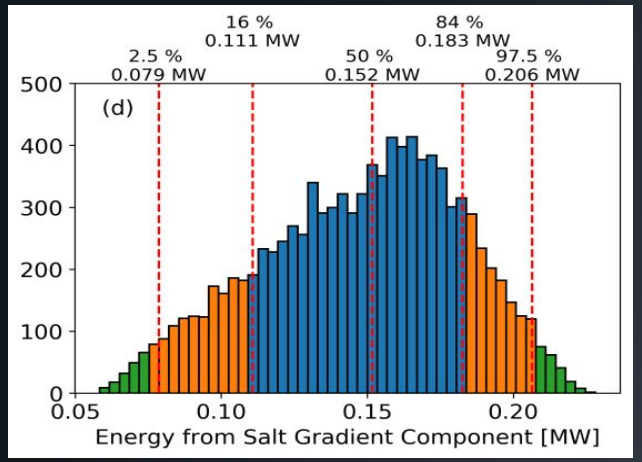
Results - Energy - Mol, Belgium











Results - Summary

	Reykjanes	Landau	Balmatt	Cornwall	Romania
Q (L/s)	100	40	40	40	55
T /°C)	150	123	121	175	140
S (g/L)	35	103	169	10.8	10.8

El. generation MW_e					
Binary plant	3.6	1.3	2.2	2.3	1.6
Salt gradient plant	0.083	0.084	0.6	0.008	0.01
Electrolysis comp.	-0.3	-0.12	-0.00016	-0.005	-0.003
Gas diffusion comp.	-0.3	-0.6	-3	-0.08	-6
Net el. generation	3.1	0.7	-0.2	2.2	-4.4
Heat generation	3	3	6.8	3.4	2.7

Metal extracted	mg/L	kg/h	mg/L	kg/h	mg/L	kg/h	mg/L	kg/h	mg/L	kg/h
Cu – Copper	17	6.12	0.038	0.005	0.017	0.002	0.4	0.058	0.2	0.04
As – Arsenic	0.11	0.039	9.7	1.4						
Ag –Silver	0.06	0.022								
Sb – Antimony	0.013	0.005								
Fe- Iron	40	14.4	40	5.8	300	43.2			0.7	0.14
Br – Bromine	30	10.8	100	14.4	70	10.1				
Zn – Zink	5	1.8							1.3	0.26
Sr – Strontium			230	33.1	220	31.7	13	1.9	200	40
Li – Lithium			50	7.2			6	0.86		
Ba – Barium					10	1.4			5	1
B – Boron							4	0.58		
Mn - Manganese							3.4	0.49		
Total metal extr.	92	33	430	62	600	86	27	3.9	207	41

Conclusion

1. A model pipeline was constructed, which will output the metals recovered, and the net energy for power plant, upon putting in details about a geothermal fluid can be input
2. HTHP electrodeposition is feasible if brine is rich in noble metal content - It consumes very little power for 1 kg of metal removed.
3. Electro-precipitation process consumes a lot of energy. However, this can be improved by better cell design.
4. Salinity gradient / Reverse electrodialysis produces enough energy to sustain Electrochemical process.
5. Among the brines studied, Reykjavik Iceland site is most suitable for pilot plant construction (metal value & net energy)

Future Direction

1. Improve cell design for EP.
2. Collect more data for SGP-RED and ED.
3. Try bootstrapped / ensemble models