Design Project - SIE 2019

Claudine Karlen, Mischa Weber

Supervisor EPFL : Prof. Lyesse Laloui, Benoît Cousin

Supervisor Romande Energie : Giulio Caimi, Juliette Bouclon

Technical and financial Analysis of Deep Geothermal Heat Production in Epalinges, VD

1 Introduction

Context

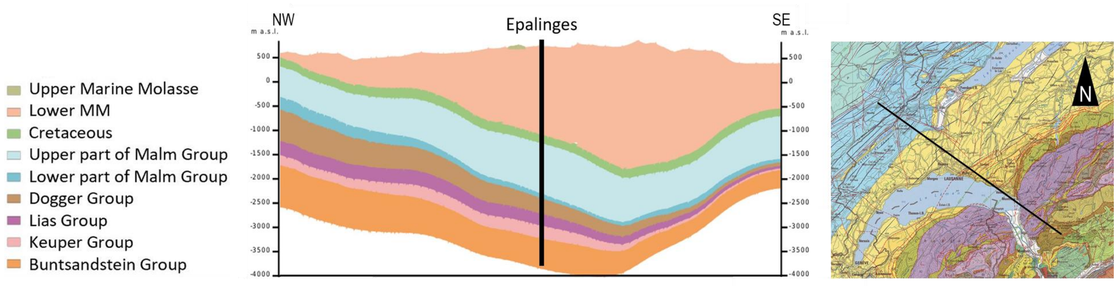
The use of deep geothermal heat (below 500m) by means of open systems is to date a rather uncommon practice in Switzerland. Its implementation is site-dependent as it relies on the presence and exploitability of a deep thermal aquifer. In case no thermal water can be extracted, a closed system presents an alternative means of exploiting geothermal heat, however, financially much less promising. Knowledge of the deep underground in Switzerland is very limited and feasibility of an open system can only be ascertained upon a first drilling. Therefore, investing in deep geothermal energy exploitation comes with a high risk. Romande Energie Services (RES) is currently planning a district heating (DH) system for the community of Epalinges (VD), potentially based on deep geothermal energy. This design project investigates the technical and economical feasibility of exploiting deep geothermal energy in Epalinges.

Goals

- Study of experiences from other geothermal projects
- Determination of the geothermal potential in Epalinges for both, open and closed systems
- Financial analysis using a probabilistic approach
- Study of the regulatory frame

2 Geothermal Potential

Epalinges lies in the Molasse Basin, where three geological layers of interest for geothermal energy exploitation have been identified: Cretaceous, Malm and Dogger.



Geology of the Molasse Basin, GeoMol15[1]

Method

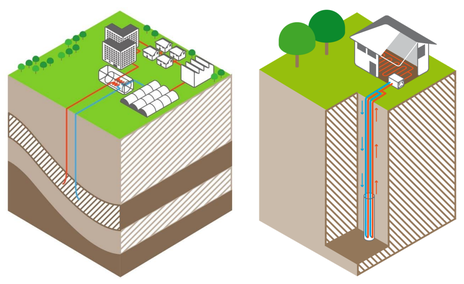
Open System:

- A deep aquifer is accessed through a production well. The thermal water is pumped to the surface, cooled with additional use of a heat pump and returned to the deep underground through a reinjection well.
- Calculation of exploitable power via energy conservation:

$$P = m * c_p * \Delta T$$

Closed System:

- A heating fluid circulates in a closed circuit, requiring only one borehole.
- Approximation of exploitable power with the Line Source Model.



Open System[2] *Closed System[2]*

Results

- The exploitable power by means of an open system is by far higher than with a closed system.
- Because of higher flow rates, the exploitable power of the Malm is higher than that of the Dogger.
- The line source model overestimates the exploitable power for the Malm and the Dogger, a maximum of 300 kW is thus assumed.

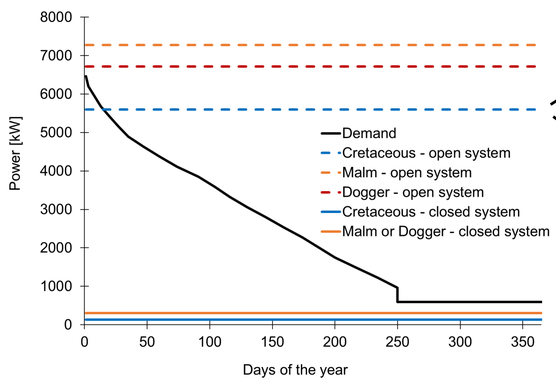
Depth, temperature, expected flow rate and exploitable power of three geological layers[1]

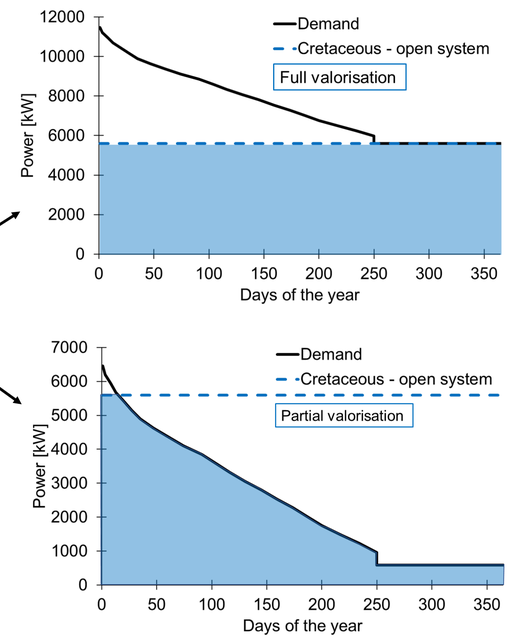
	Cretaceous	Malm	Dogger
Depth [m]	1950	2500	3300
Temperature [°C]	65	85	105
Flow rate [l/s]	20	20	15
P_{open} [MW]	**5.6**	**7.3**	**6.7**
P_{closed} [kW]	**132**	**300**	**300**

3 Financial Analysis

Energy Demand in Epalinges

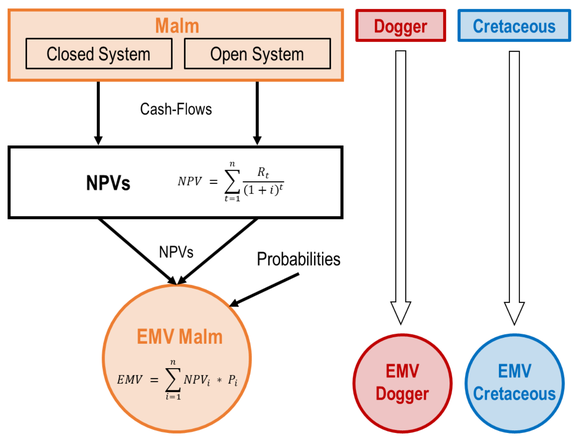
The consumer profile, thus the potential to valorise geothermal energy, has an impact on the financial viability of the project. Two valorisation scenarios are analysed: Partial valorisation and full valorisation.



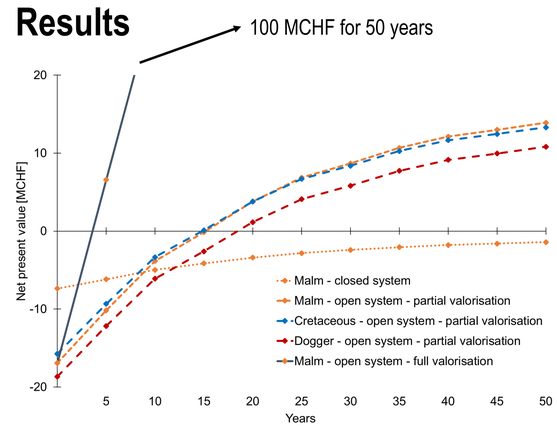


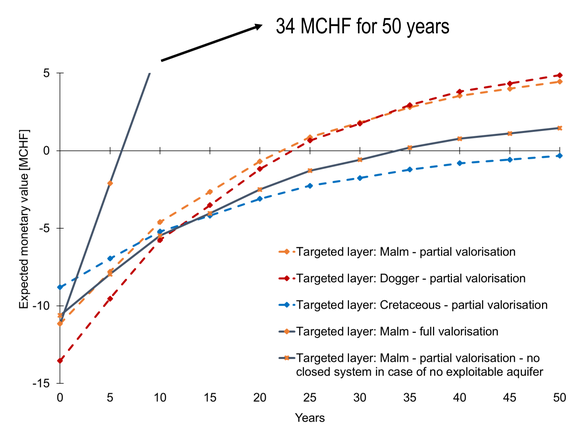
Method

- **Net Present Value (NPV):** There are several possible outcomes of a drilling: Finding an aquifer in the targeted layer, in another penetrated layer or finding no aquifer in any layer. Every outcome results in different cash-flows due to different investment-, operational- and maintenance costs, subsidies and revenues. Net present values were calculated for each outcome to compare the economic potential of targeting the layers of Cretaceous, Malm and Dogger, each. Costs were estimated from literature and comparable projects.
- **Expected Monetary Value (EMV):** Expected monetary value analysis is used to account for the uncertainty of finding an exploitable deep aquifer. The expected net present value of every target layer is calculated, combining the probability and NPV of each possible outcome. Here, an independent probability of exploitability for each layer of 0.23 is assumed[4].



Results





- A full valorisation scenario results in significantly higher profitability than partial valorisation of the energy.
- An open system with partial valorisation is profitable considering a lifetime of 15-20 years, while a closed system is not profitable considering 50 years.
- With $P_{exploitability}$ = 0.23, a geothermal system with partial valorisation in the layers of Malm and Dogger is expected to be profitable considering a lifetime of less than 25 years. A system in the Cretaceous is not expected to be profitable considering 50 years.
- The envisaging of a closed system as an alternative to an open system improves the EMV.
- The probability of exploitability determines the expected profit of a system.

Expected monetary values with different $P_{exploitability}$ for targeting the layer of Malm in a partial valorisation scenario

4 Regulatory Framework

Planning

- The legal right of use of the public underground lies with the canton. The utilisation of its resources is ruled by cantonal law[3].
- The general duty of spatial planning (art. 2 al. 1 LAT) also applies to the underground[3].
- The promotion of local energies and DH systems is anchored in the spatial development goals of the canton of Vaud (PDCn).

Three levels of spatial planning in Switzerland:

Federation *Plan sectoriel*
Canton *Plan directeur cantonal*
Community *Plan d'affectation*

} Construction: Conformity with spatial planning (art. 22 LAT)

Permission

- Procedure and requirements defined in the cantonal *loi sur les ressources naturelles du sous-sol* (LRNSS).

Permis de recherche en surface (appel d'offres, enquête publique) → Permis de recherche en sous-sol (enquête publique) → Concession (enquête publique)

Financial Incentives

- Federal support for direct utilisation of geothermal heat to reduce CO_2 emissions from buildings (art. 34 al. 2 loi sur le CO_2).

Contributions for direct utilisation of geothermal **heat**: Prospection → Development of resource

Max. 60% of attributable costs covered until 2025 (art. 112 ordonnance sur le CO_2)

5 Conclusion

- Geothermal energy is optimally used to provide the base load of a consumer structure.
- The financially most interesting layer to target for a deep geothermal system is the Malm.
- Implementing a closed system in case of no exploitability is preferable over abandoning the project.
- In the current situation, it makes sense to pursue the geothermal project in Epalinges from an economical point of view. It is suggested to undertake indirect characterisation of the local underground. This enables determination of a more accurate probability of exploitability and assessment of the risk of investment.
- The legal situation in the canton of Vaud is favourable for deep geothermal energy production. However, financial contributions are essential for the project and are only granted until year 2025.

References

[1]Federal office of topography, swisstopo, https://viewer.geomol.ch, March 2019
[2]EnergieSuisse, OFEN, Géothermie en Suisse, 2017.
[3]Abegg and Dörig, Wie der Untergrund vom Recht erfasst wird, Zürcher Hochschule für angewandte Wissenschaften, Bau-, Planungs-, und Umweltdirektorenkonferenz und Energiedirektorenkonferenz, 2019.
[4]Le Conseil Fédéral, Conception et mise en oeuvre des mesures d'encouragement pour l'utilisation de la géothermie profonde en Suisse, March 2017.