How to interpret temperature plots?

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Temperature plots are at the centre of good borefield design. This plot tells you everything you need to know about your design, but it also has some limitations. In this article, the interpretation behind those temperature plots will be explained (interpretation plots) and also some of the effects that are not included are discussed (not included).

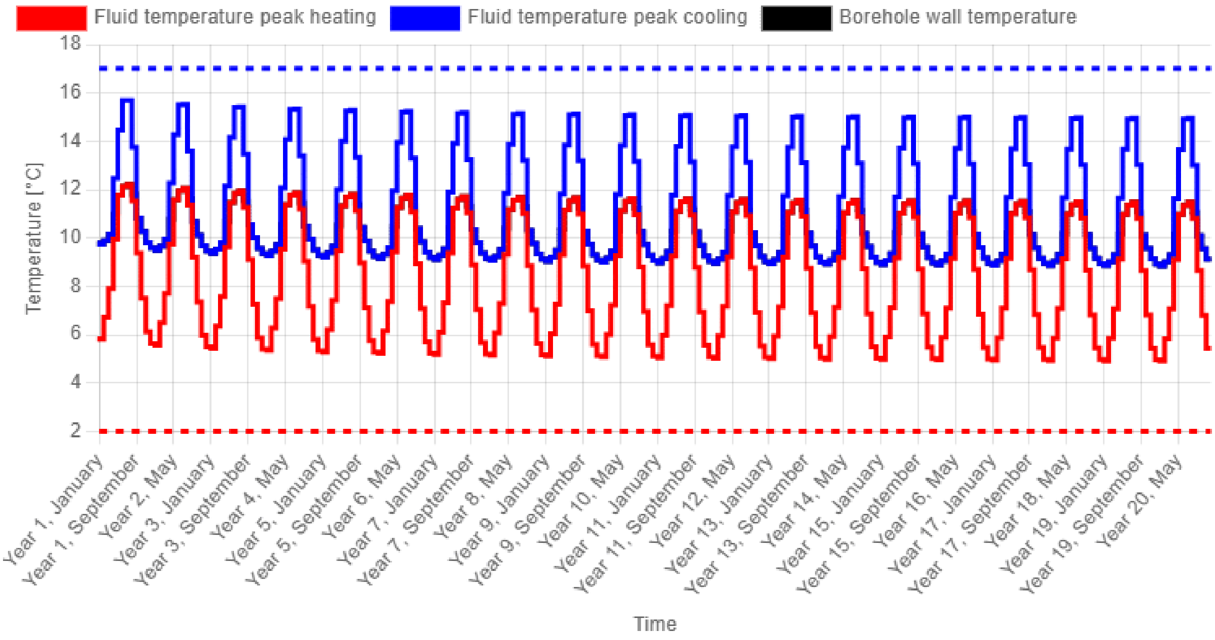
Interpretation of temperature plots

Within GHEtool Cloud, you can have two types of temperature profile resolution: monthly profiles and hourly profiles.

> ***!Caution***
> *In this article the 'building load' terminology is used, i.e. 'heating' and 'cooling'. If you work with a geothermal load directly in the Thermal Demand tab, the terminology becomes 'extraction' and 'injection'.*

Monthly temperature profile

In this section, we will discuss some of the insights you can get from looking and studying a monthly based temperature profile.



When looking at the figure above, you can see that we have 3 different lines on the temperature plot. The two dotted lines are respectively the maximum and minimum allowed average fluid temperature in the geothermal system. This parameter you can set in the 'Earth' tab. The other curves are:

- **Borehole wall temperature** This is the temperature of the borehole wall, i.e. the ground close to the borefield. Note that this line is often invisible since it lies under the other lines in the graph.

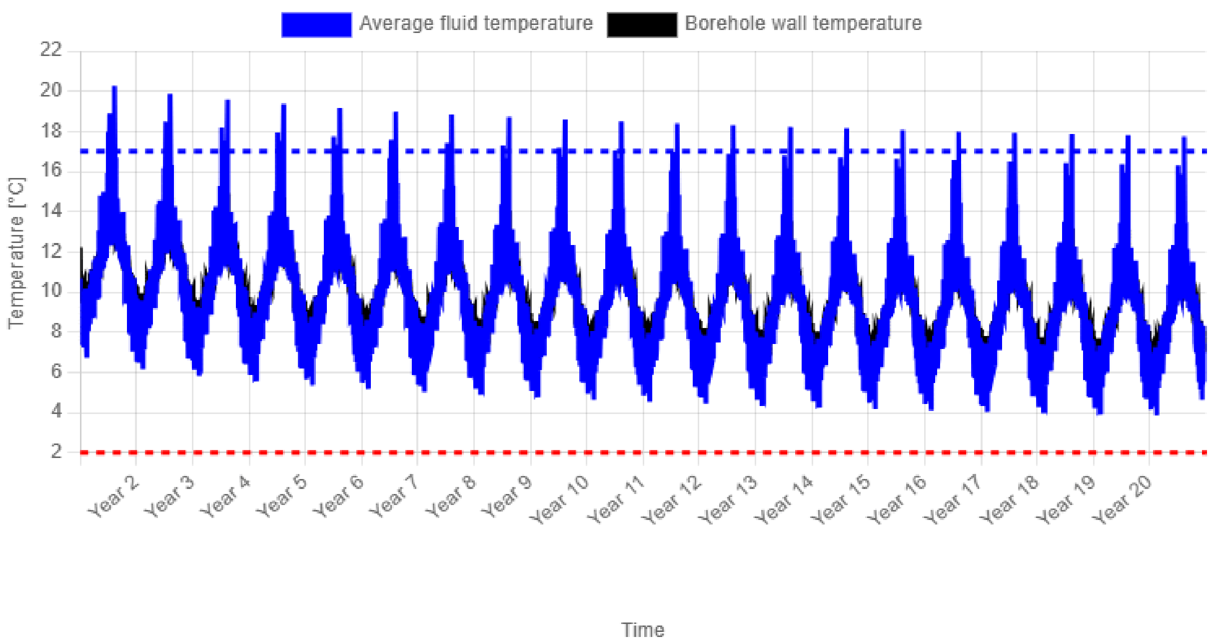
Next, there are two temperatures related to the peak loads: i.e. the maximum amount of power in both heating and cooling. These high peaks lead to the most extreme fluid temperatures and are hence the most crucial in borefield design.

- **Fluid temperature peak cooling** This is the average fluid temperature between in and outlet you get during the peak in cooling.
- **Fluid temperature peak heating** This is the average fluid temperature between in and outlet you get during the peak in heating.

Hourly temperature profile

When you have an hourly temperature profile, you see lesser lines on the temperature plot. Where the monthly profile had to take into account that each month has potentially both heating and cooling, an hourly profile has only one of the two. Therefore, an hourly profile only shows you one line for the fluid temperature.

> ***! Note***
> *Strictly speaking, even on an hourly basis, there could be a switch between heat injection and extraction within one hour. This would however require temperature simulations with a smaller-than-hourly load resolution, which is overkill for a geothermal design process.*



The two dotted lines are respectively the maximum and minimum allowed average fluid temperature in the geothermal system. This parameter you can set in the 'Earth' tab. The other curves are:

- **Borehole wall temperature** This is the temperature of the borehole wall, i.e. the ground close to the borefield. Note that this line is often invisible since it lies under the other lines in the graph.
- **Average fluid temperature** This is the average fluid temperature between inlet and outlet for every hour in the simulation period.

Which effects are not included in the graphs?

While GHEtool Cloud demands numerous parameters across its various tabs to generate a single result, it is essential to note that certain factors are not considered and merit special attention. The design of a geothermal system, particularly for large projects, poses an intriguing challenge that necessitates extensive knowledge, complemented by valuable tools such as GHEtool Cloud.

Dynamic behaviour

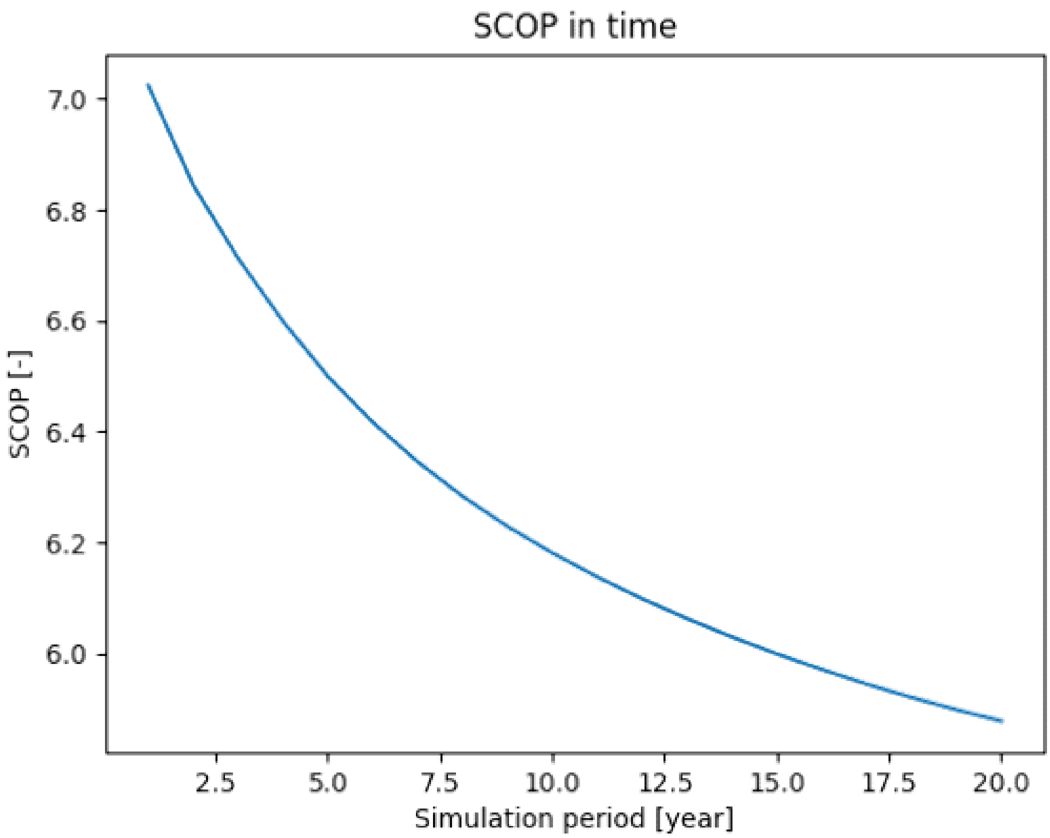
All the ground models within GHEtool are what is called 'static' or 'steady-state'. This means that it neglects the thermal inertia inside the fluid and the borehole grout. Every kilowatt (kW) of power you obtain outside the borefield is drawn instantaneously from the ground, which is of course not what happens, since first the fluid cools down, afterwards the grout and after a certain amount of time the ground. This assumption can be seen as an intrinsic safety feature when designing geothermal systems, as the average fluid temperatures you obtain are most likely better than they will be in reality when there is thermal inertia.

> ***! Note***
> *GHEtool is currently working together with the KU Leuven (The SySi Team) on how we can effectively model this short-term behaviour of the borefield. Once the model is fully validated, we will implement it in GHEtool Cloud for you. You can find some links to the research below in the references.*

Varying SCOP/SEER

GHEtool Cloud operates under the assumption that the geothermal load remains constant every year. This also implies that the Seasonal Coefficient of Performance (SCOP) and Seasonal Energy Efficiency Ratio (SEER) are identical for both the first and last years. However, in the case of a system with a significant imbalance, this assumption is highly conservative.

For instance, consider a scenario where there is a persistent imbalance that progressively cools down the ground each year. In practice, as the ground temperature decreases, the SCOP will also decrease, resulting in less heat being extracted from the soil. This counteracts the initial imbalance, compensating for its effects. This is shown in the figure below. Where the SCOP decreases over the simulation period, but it in a decreasing manner.



> ***! Note***
> *GHEtool is currently working with heat pump manufacturers to get a more detailed picture of the heat pump efficiency implemented in GHEtool Cloud. Stay tuned for more updates!*

Conclusion

This article showed you what you can do with the temperature plots within GHEtool Cloud, but also what you cannot do. Geothermal design is a complex practise that requires training and experience. However, with our ongoing development and collaboration with research and industry partners, we want to give you the best and most reliable tool for the design of geothermal systems.

Do you want to stay up-to-date with our latest developments? Subscribe to our newsletter!

References

- Watch our video explanation over on our YouTube page by clicking here.
- Meertens, L. (2024). Reducing Capital Cost for Geothermal Heat Pump Systems Through Dynamic Borefield Sizing. *IEA HPT Magazine 42*(2), https://doi.org/10.23697/9r3w-jm57.
- Meertens, L., Peere, W., Helsen, L. (2024). Influence of short-term dynamic effects on geothermal borefield size. In *Proceedings of International Ground Source Heat Pump Association*. Montréal (Canada), 28-30 May 2024.