GeoTHERM expo & congress

Freitag, 27. Februar 2026, 9.50 Uhr Ortenauhalle Kongress 2 Oberflächennahe Geothermie	Friday, 27 February 2026, 9.50 am Ortenauhalle Congress 2 Near-surface geothermal energy

Towards a more accurate design of borefields: using variable fluid properties, flow rate and heat pump efficiency

Für eine genauere Auslegung von Bohrfeldanlagen: unter Berücksichtigung variabler Flüssigkeitseigenschaften, Durchflussraten und Wärmepumpeneffizienz

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Using variable fluid properties, flow rate and heat pump efficiency The design of shallow geothermal borefields is not trivial and comes with quite a lot of assumptions related to the ground properties, the thermal demand of the building and many others. Three of the parameters that are typically assumed to be constant are: the fluid properties (viscosity, density etc.), the flow rate and the heat pump efficiency.

From a historical perspective, these assumptions made sense. In Europe, ground source heat pumps became popular as a very efficient way to heat buildings, and borefields were designed to cope with this (high) heating demand. At the same time, heat pumps were almost exclusively on/off machines, meaning they operated only at maximum power. Within this context, assuming constant efficiency, constant flow rate and constant fluid properties was not unreasonable.

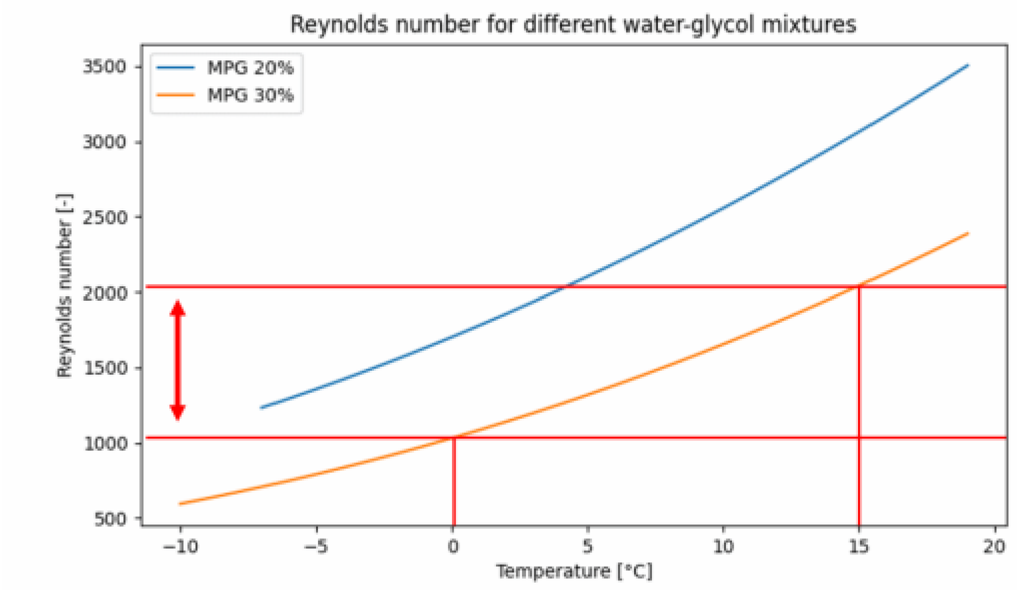
However, times have changed, and the assumptions that were valid 20 years ago are now more and more leading to oversized or underperforming systems. Below, these three assumptions are discussed together with why it would be better to move away from the constant approach.

Fluid properties

The properties such as viscosity and density of the heat transfer fluid depend heavily on the fluid temperature. In turn, these fluid properties have a big effect on the Reynolds number, the flow regime (laminar or turbulent) and hence the heat transfer capabilities of the borehole as expressed by the effective borehole thermal resistance.

Nowadays, with borefields being used for both heating and cooling, the fluid temperature can easily range from 0 to 15 °C, leading to a factor 2 difference in Reynolds number. For systems with a high cooling demand (like offices and auditoria), assuming that the Reynolds number (and therefore the effective borehole thermal resistance) is constant can easily lead to oversizings of 20 %.

Modern design software, such as GHEtool, allows these temperature-dependent fluid properties to be included directly in the borefield sizing, reducing the reliance on constant assumptions.



Flow rate

When heat pumps were still on/off, a constant flow rate assumption was valid. Nowadays, most heat pumps modulate between 100 % and 30 % of their rated heating power. This also means that the flow rate through the borefield can easily scale with a factor of 2 to 3, leading again to a significant difference in the Reynolds number and the borehole thermal resistance, which can vary heavily over time.

For systems (like single U-tubes) that require turbulent flow to achieve good heat transfer with the ground, halving the flow rate can have a big effect on the heat transfer rate (especially if the flow falls from a turbulent to laminar regime) and hence on the heat pump efficiency.

Software that incorporates variable flow conditions, rather than assuming a constant value, provides a more realistic picture of system performance over the full operating range.

Heat pump efficiency

Typically, when you design a geothermal borefield, you use an SCOP to convert the building heating demand to an actual geothermal extraction demand. This SCOP, however, is tabulated for very specific conditions (like B0/W35) which you will only occasionally see in practice. In reality, especially due to part-load operation, the fluid temperatures will often be higher, improving the efficiency. On the other hand, the highest peak powers will have a COP lower than the SCOP, resulting in slightly higher minimum temperatures.

Assuming a constant efficiency can therefore lead to significant underestimations of the real performance of the heat pump. Instead of being 4.86 for B0/W35, the average efficiency over 20 years might turn out to be closer to 6.24 (based on data provided by Alpha Innotec).

By dynamically accounting for variable operating conditions, like the fluid properties, flow rate and heat pump efficiency, GHEtool allows designers to more closely match the simulated system behaviour with reality and end up with more accurate designs.