

How to design with tilted boreholes?

Author: Wouter Peere – Date: 28/01/2025

When there is limited space to drill a borefield, it can be beneficial to design your borefields with certain tilted boreholes. This has the advantage that you require less surface area and that you decrease the thermal interference between the different boreholes due to the tilt. GHEtool Cloud is one of the few borefield software solutions that allow you to design your borefields with tilted boreholes, and in this article, we go into detail about the definitions used when entering your borefield design into the tool.

!Note

Tilted boreholes are included in the design and optimisation licence of GHEtool Cloud. If you think this might also be interesting for your projects, you can check out our licence page [here](#).

Design definitions for borefield

Before we can begin designing our first tilted borehole, there are a few important definitions we need to understand.

Borehole length vs borehole depth

There is an important distinction between borehole length and borehole depth.

- The **borehole depth** is defined as the distance between the ground surface and the lowest point in your borefield, measured along the borehole. When you drill starting from the ground surface, this represents the lowest point you drill to.
- The **borehole length** is the actual length of the vertical heat exchanger. Since the boreholes are connected to the horizontal piping at a certain buried depth, the borehole length is equal to the borehole depth – the buried depth.

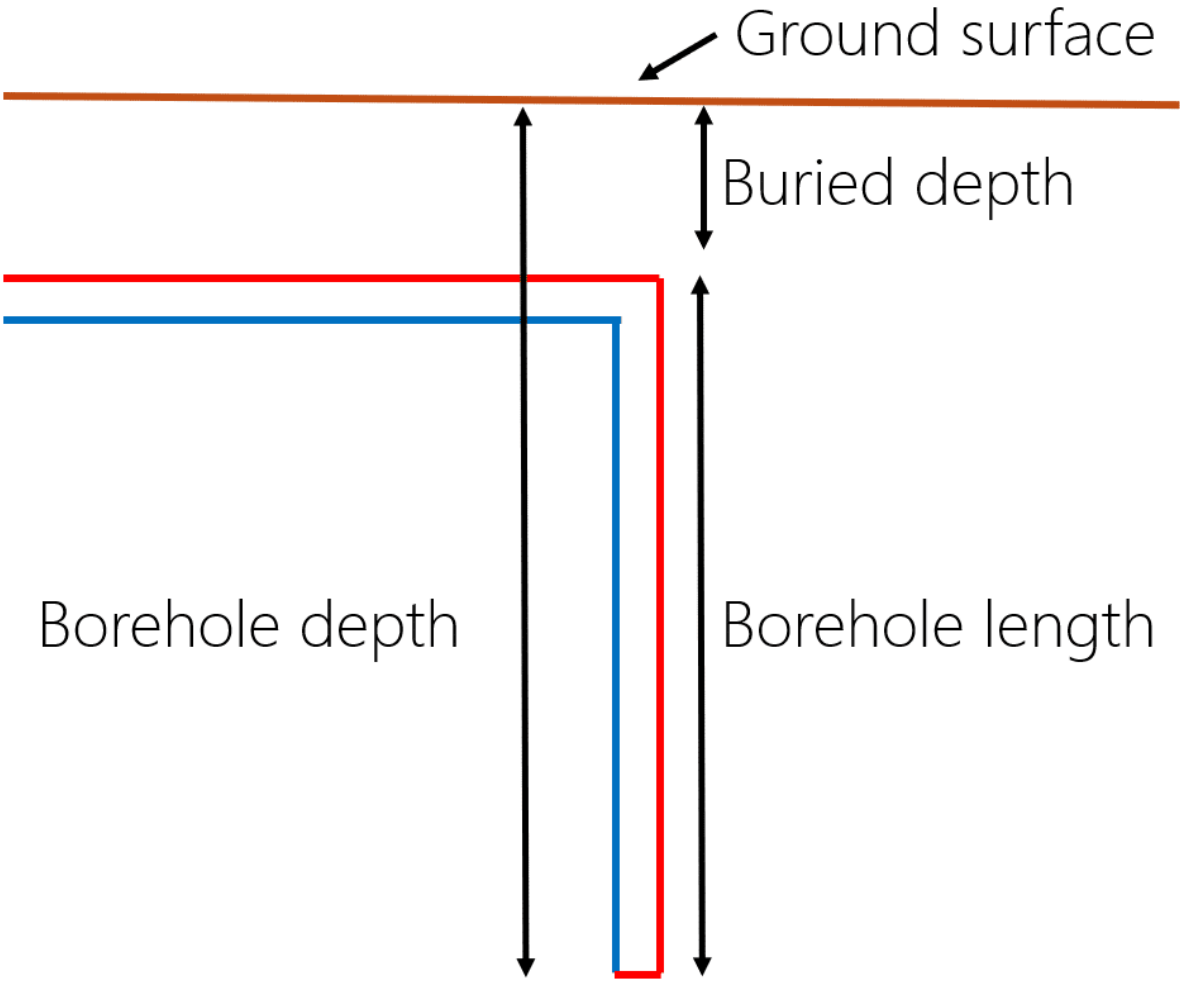
In GHEtool Cloud, you can enter your borefield design using either the ground surface (i.e. borehole depth) or the buried depth (i.e. borehole length) as a reference.

!Hint

Most of the time, you will work with the borehole depth. Only when drilling a few levels below a building does it make sense to enter your information relative to the buried depth.

!Note

For most projects, the buried depth is small in comparison to the borehole depth. As a result, the borehole length almost equals the borehole depth, meaning no significant difference is seen in the results, regardless of how you enter the data.

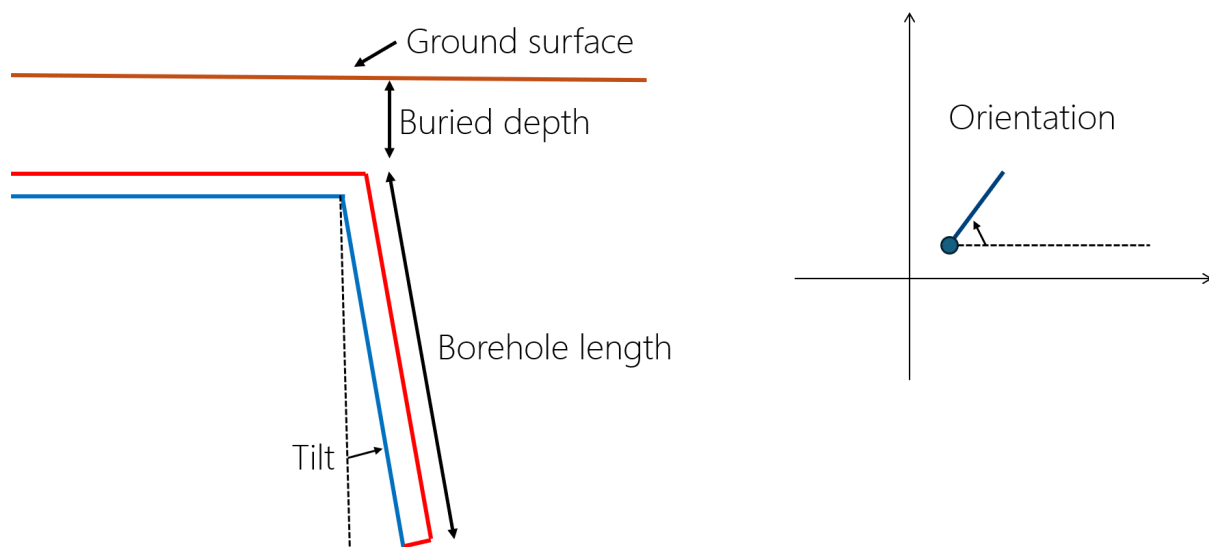


Tilt and orientation

When dealing with tilted boreholes, two additional parameters come into play: tilt and orientation.

- **Tilt** is defined as the angle between the vertical line and the tilted borehole, measured counterclockwise, and can range from 0° to 90° .
- **Orientation** is viewed from the top and is defined as the angle between the borehole and the horizontal line, also measured counterclockwise.

Both the tilt and the orientation can be adjusted for each borehole individually, offering complete design flexibility.



Tilted boreholes in GHEtool Cloud

You can enter your tilted boreholes in GHEtool Cloud under the 'Borefield' tab using the 'customised' borefield configuration. Here, you can view all the coordinates of the boreholes in your field. If you deselect the option that all boreholes have an identical (buried) depth, the option to add the borehole tilt becomes available. Once enabled, you can adjust the tilt and orientation for each borehole by either clicking on the borehole in the 2D graph or selecting it from the list of coordinates.

!Hint

To save time when duplicating all the boreholes in your field, you can start with a preconfigured borefield and click on a borehole in the 2D graph below. A prompt will appear allowing you to convert your borefield into a custom borefield, which can then be adapted to include tilted boreholes.

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x-coor (m)	y-coor (m)	Borehole length	Buried depth	Tilt (°)	Orientation (°)	
0.00	0.00	120.00	10.00	15.00	0.00	+ - ↗
0.00	6.00	120.00	10.00	15.00	180.00	+ - ↗
0.00	12.00	120.00	10.00	0.00	0.00	+ - ↗
0.00	18.00	120.00	10.00	20.00	90.00	+ - ↗

The boreholes have identical (buried) depth

Are there inclined boreholes?

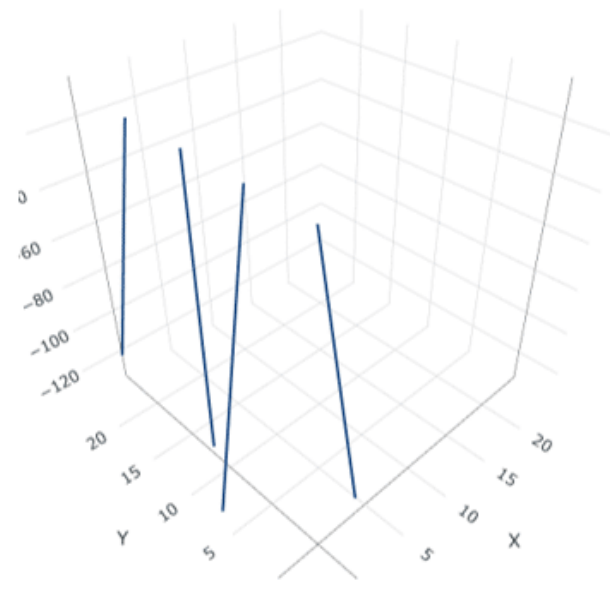
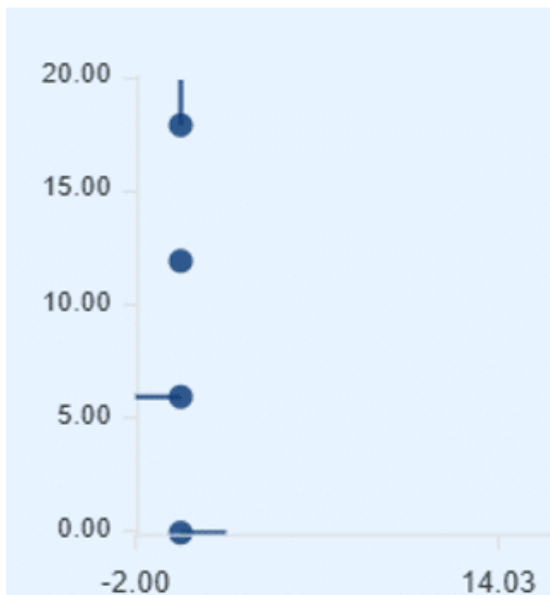
Borehole diameter
140

Unit
mm

!Note

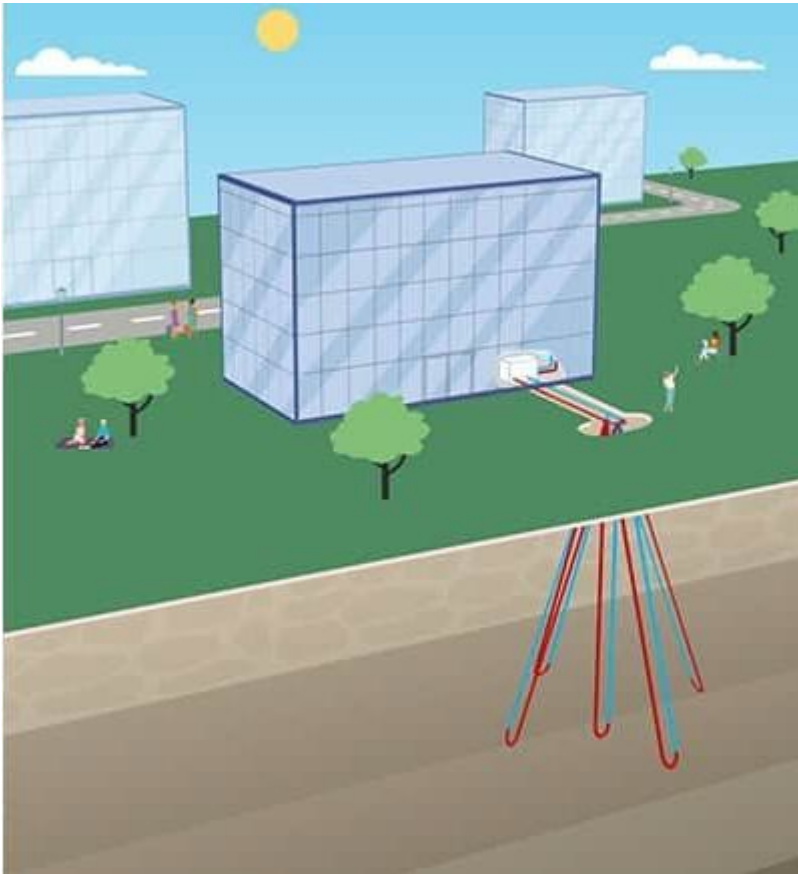
When working with tilted boreholes, it is only possible to use the borehole length option to define your borefield size, as the borehole length is measured along the axis of the borehole itself.

At the bottom of your page, you can view both 2D and 3D representations of your geothermal borefield, making it easy to access and refine your design.



Energy Pyramid – Celsius Energy

Tilted boreholes have been used in numerous projects worldwide where space constraints made traditional vertical geothermal solutions unfeasible. One well-known example is the 'Energy Pyramid' design from Celsius Energy, which reduces surface impact by up to 90% compared to conventional designs. This compact footprint makes geothermal energy installations viable in highly populated areas, preserving valuable real estate and allowing greater construction flexibility. This design has been successfully implemented in a project in New England (read the article [here](#)).



Celsius Energy pyramid borefield design. (Source: Celsius Energy)

Conclusion

This article has shown how GHEtool Cloud allows you to design even the most complex borefields with just a few clicks, making it easier than ever to create borefields with confidence.

References

- Watch our video explanation over on our YouTube page by clicking [here](#).
- Read more about the solution from Celsius Energy [here](#).



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<https://ghetool.eu>