GHEtool calculation report

Course 10.2



23/11/26

Licensed report by:

Enead BV

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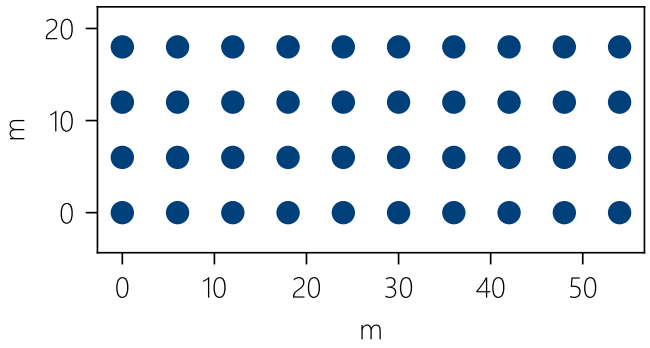
1.1 Structure of the report

First, in Chapter 2, a summary of all the simulations will be provided. Chapter 3 discusses the inputs that are consistent across all scenarios. In Chapter 4, the different simulation results are presented and discussed. Chapter 5 contains appendices with more detailed information.

2.1 Simulation

Input



Number of boreholes: 40

Average minimum borehole spacing: 6,0 m

Borehole depth (w.r.t. surface): 100,0 m

2 x U tube DN32 PN16

Water

SCOP heating: 5,00; SEER cooling: 20,00; SCOP DHW: 3,00

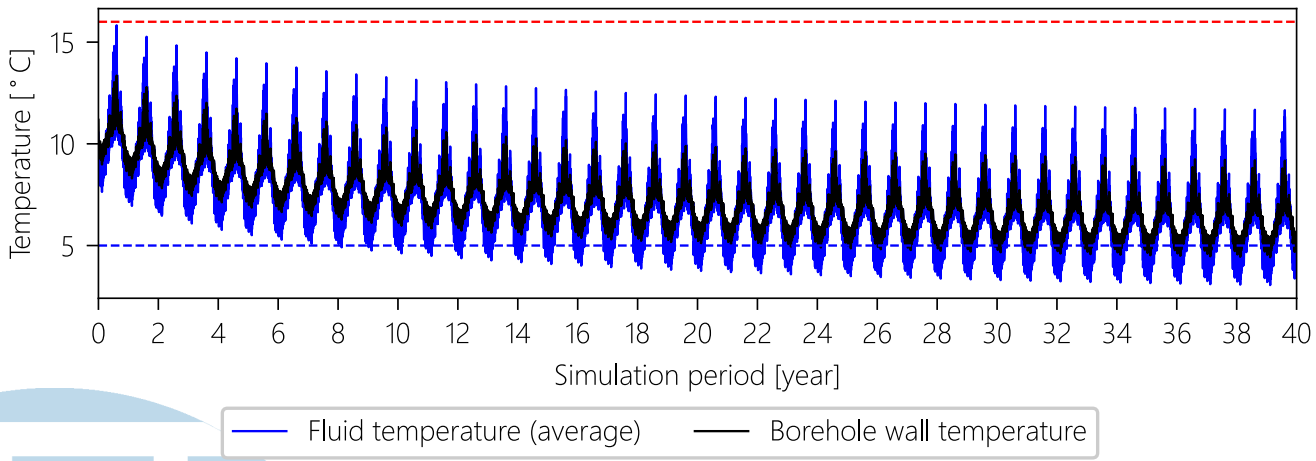
Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW

Results

Effective borehole thermal resistance (extraction): 0,1085 m·K/W, Reynolds number: 3 032 (transitional)

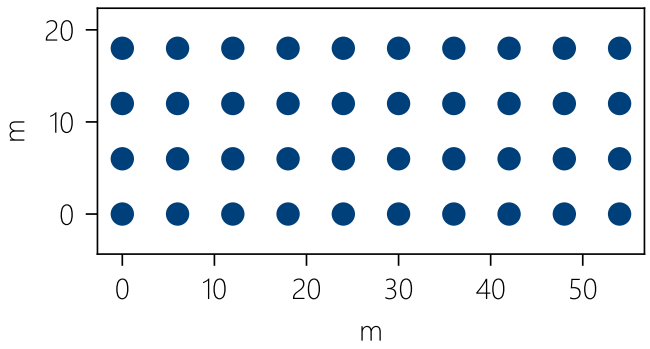
Effective borehole thermal resistance (injection): 0,1060 m·K/W, Reynolds number: 4 396 (turbulent)

Maximum average fluid temperature: 15,83 °C, Minimum average fluid temperature: 3,06 °C



2.2 DC - 5 kW - inlet

Input



Number of boreholes: 40

Average minimum borehole spacing: 6,0 m

Borehole depth (w.r.t. surface): 100,0 m

2 x U tube DN32 PN16

Water

SCOP heating: 5,00; SEER cooling: 20,00; SCOP DHW: 3,00

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW

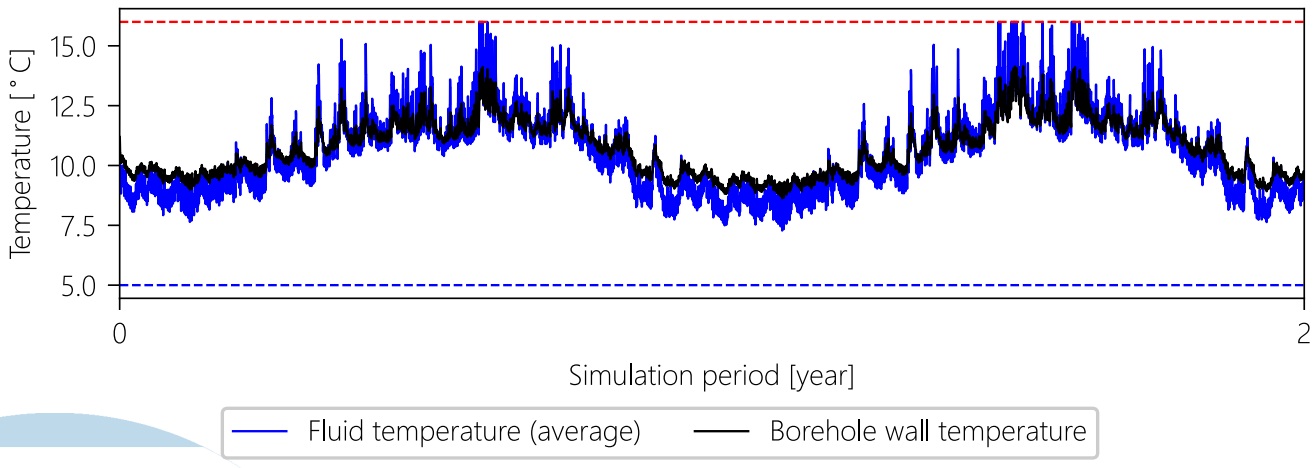
Results

Effective borehole thermal resistance (extraction): 0,1070 m·K/W, Reynolds number: 3 459 (transitional)

Effective borehole thermal resistance (injection): 0,1060 m·K/W, Reynolds number: 4 416 (turbulent)

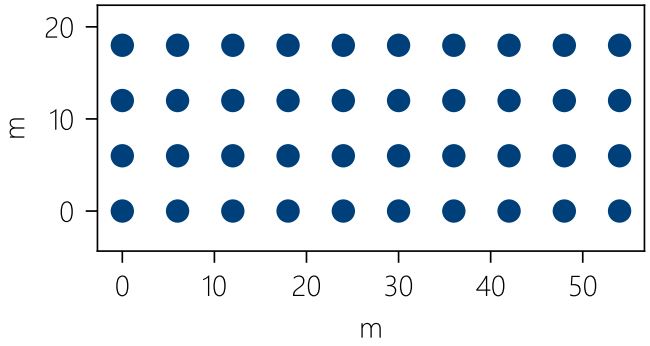
Yearly average regeneration: 51 571 kWh/y (injection)

Maximum average fluid temperature: 16,00 °C, Minimum average fluid temperature: 7,28 °C



2.3 DC - 5 kW - outlet

Input



Number of boreholes: 40

Average minimum borehole spacing: 6,0 m

Borehole depth (w.r.t. surface): 100,0 m

2 x U tube DN32 PN16

Water

SCOP heating: 5,00; SEER cooling: 20,00; SCOP DHW: 3,00

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW

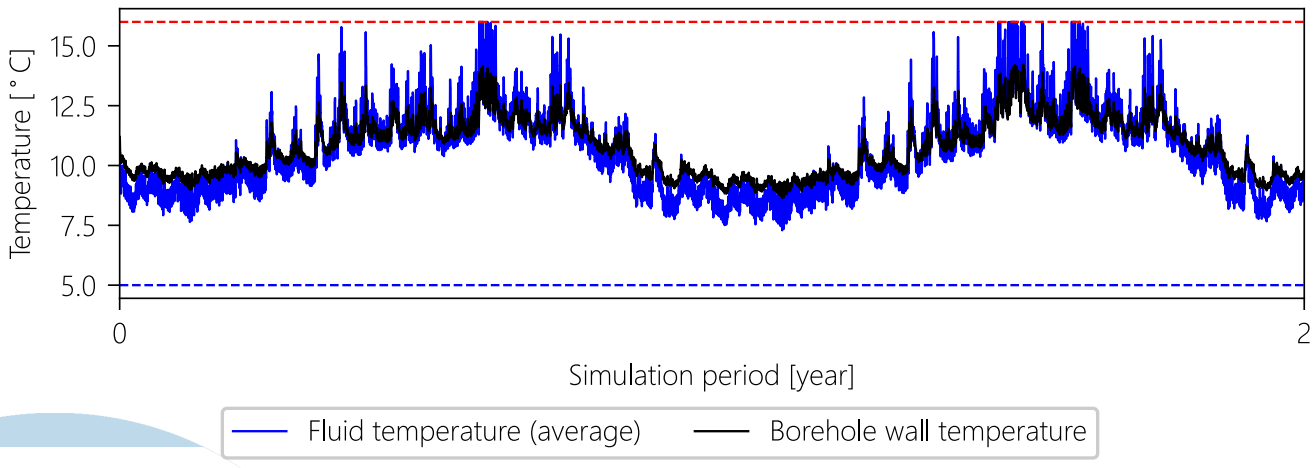
Results

Effective borehole thermal resistance (extraction): 0,1070 m·K/W, Reynolds number: 3 460 (transitional)

Effective borehole thermal resistance (injection): 0,1060 m·K/W, Reynolds number: 4 416 (turbulent)

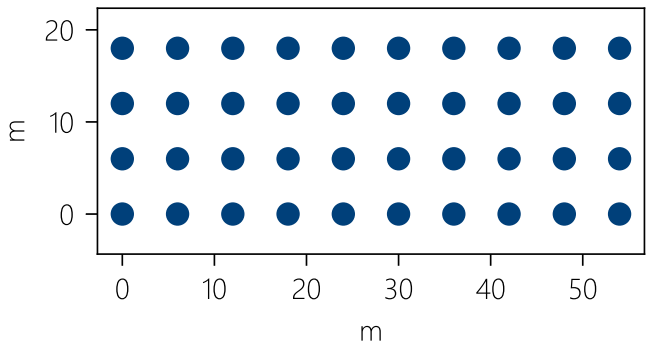
Yearly average regeneration: 53 797 kWh/y (injection)

Maximum average fluid temperature: 16,00 °C, Minimum average fluid temperature: 7,29 °C



2.4 DC - 5 kW - inlet - 2°C

Input



Number of boreholes: 40

Average minimum borehole spacing: 6,0 m

Borehole depth (w.r.t. surface): 100,0 m

2 x U tube DN32 PN16

Water

SCOP heating: 5,00; SEER cooling: 20,00; SCOP DHW: 3,00

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW

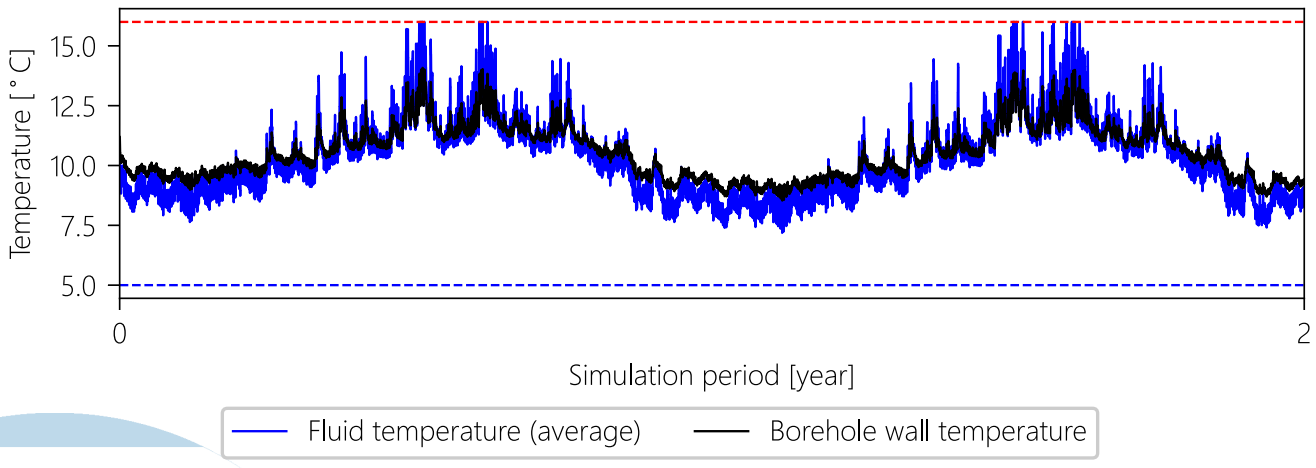
Results

Effective borehole thermal resistance (extraction): 0,1071 m·K/W, Reynolds number: 3 449 (transitional)

Effective borehole thermal resistance (injection): 0,1060 m·K/W, Reynolds number: 4 416 (turbulent)

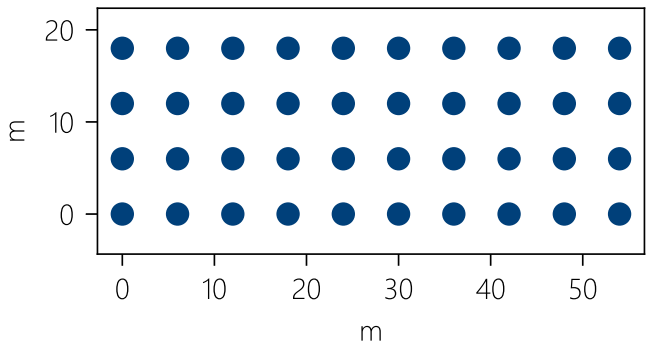
Yearly average regeneration: 36 842 kWh/y (injection)

Maximum average fluid temperature: 16,00 °C, Minimum average fluid temperature: 7,18 °C



2.5 DC - 10 kW - inlet

Input



Number of boreholes: 40

Average minimum borehole spacing: 6,0 m

Borehole depth (w.r.t. surface): 100,0 m

2 x U tube DN32 PN16

Water

SCOP heating: 5,00; SEER cooling: 20,00; SCOP DHW: 3,00

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW

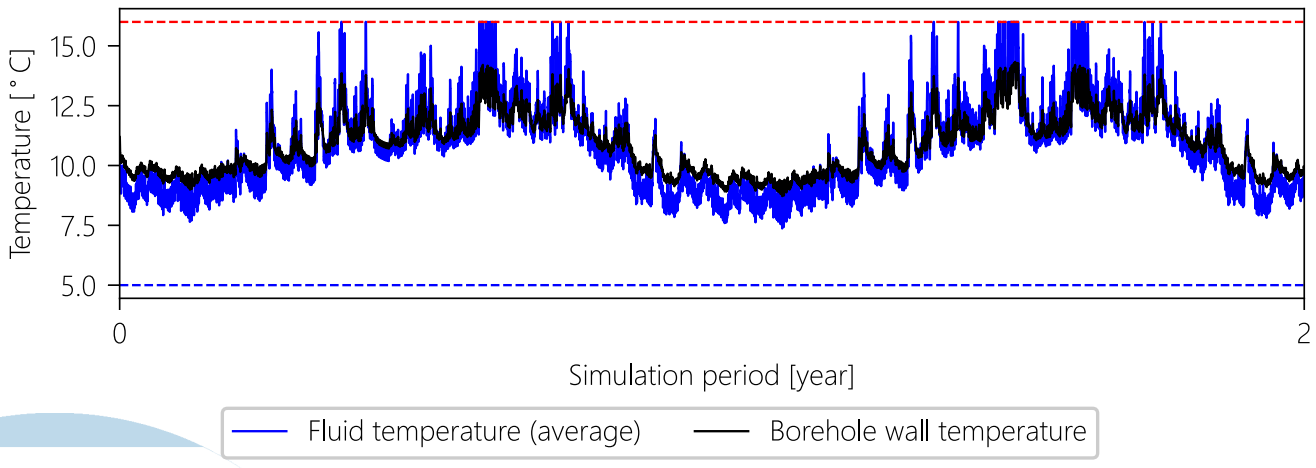
Results

Effective borehole thermal resistance (extraction): 0,1070 m·K/W, Reynolds number: 3 468 (transitional)

Effective borehole thermal resistance (injection): 0,1060 m·K/W, Reynolds number: 4 416 (turbulent)

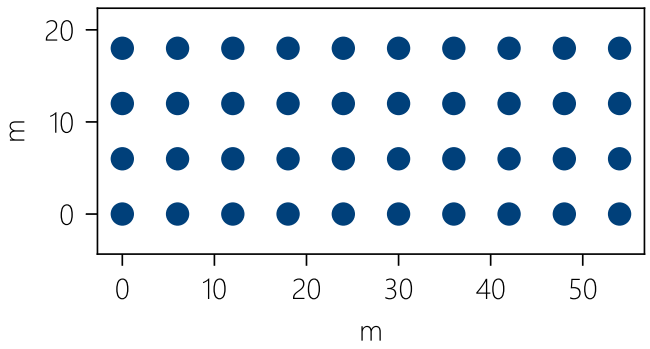
Yearly average regeneration: 63 046 kWh/y (injection)

Maximum average fluid temperature: 16,00 °C, Minimum average fluid temperature: 7,37 °C



2.6 DC - 20 kW - inlet

Input



Number of boreholes: 40

Average minimum borehole spacing: 6,0 m

Borehole depth (w.r.t. surface): 100,0 m

2 x U tube DN32 PN16

Water

SCOP heating: 5,00; SEER cooling: 20,00; SCOP DHW: 3,00

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW

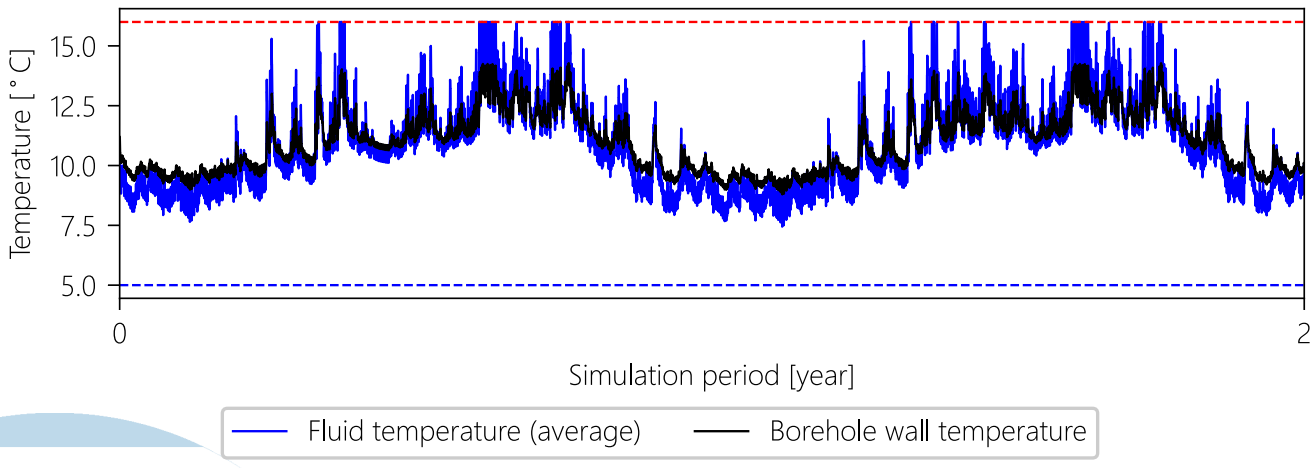
Results

Effective borehole thermal resistance (extraction): 0,1070 m·K/W, Reynolds number: 3 476 (transitional)

Effective borehole thermal resistance (injection): 0,1060 m·K/W, Reynolds number: 4 417 (turbulent)

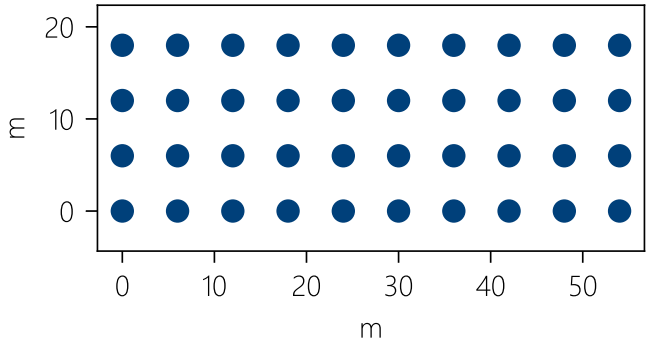
Yearly average regeneration: 70 063 kWh/y (injection)

Maximum average fluid temperature: 16,01 °C, Minimum average fluid temperature: 7,44 °C



2.7 DC - 20 kW - inlet - 500h

Input



Number of boreholes: 40

Average minimum borehole spacing: 6,0 m

Borehole depth (w.r.t. surface): 100,0 m

2 x U tube DN32 PN16

Water

SCOP heating: 5,00; SEER cooling: 20,00; SCOP DHW: 3,00

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW

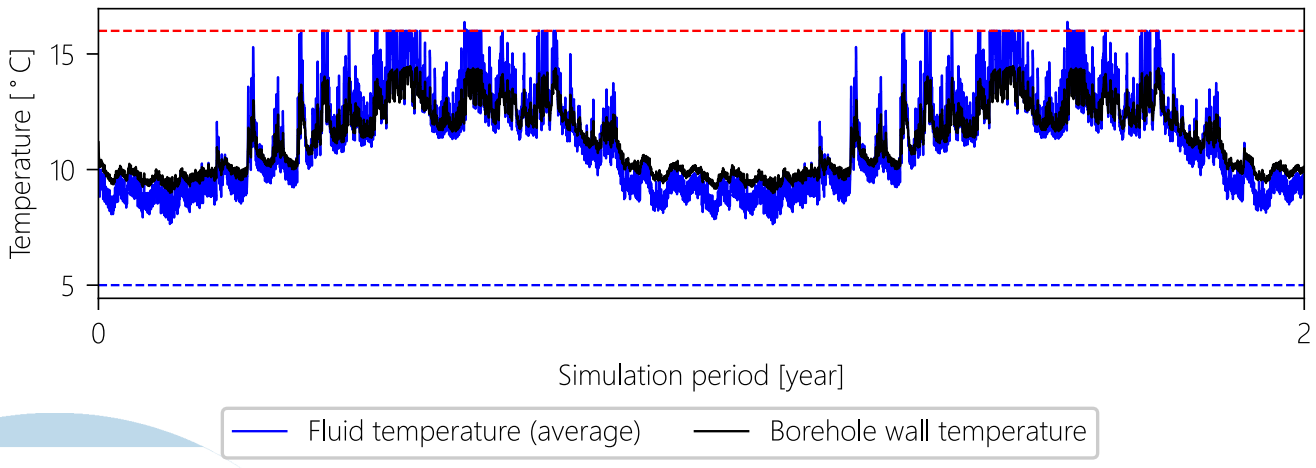
Results

Effective borehole thermal resistance (extraction): 0,1069 m·K/W, Reynolds number: 3 495 (transitional)

Effective borehole thermal resistance (injection): 0,1060 m·K/W, Reynolds number: 4 461 (turbulent)

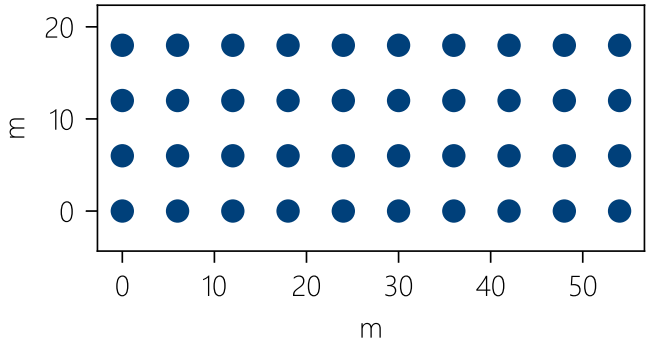
Yearly average regeneration: 88 761 kWh/y (injection)

Maximum average fluid temperature: 16,39 °C, Minimum average fluid temperature: 7,63 °C



2.8 DC - 20 kW - inlet - 18°C - yearly

Input



Number of boreholes: 40

Average minimum borehole spacing: 6,0 m

Borehole depth (w.r.t. surface): 100,0 m

2 x U tube DN32 PN16

Water

SCOP heating: 5,00; SEER cooling: 20,00; SCOP DHW: 3,00

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW

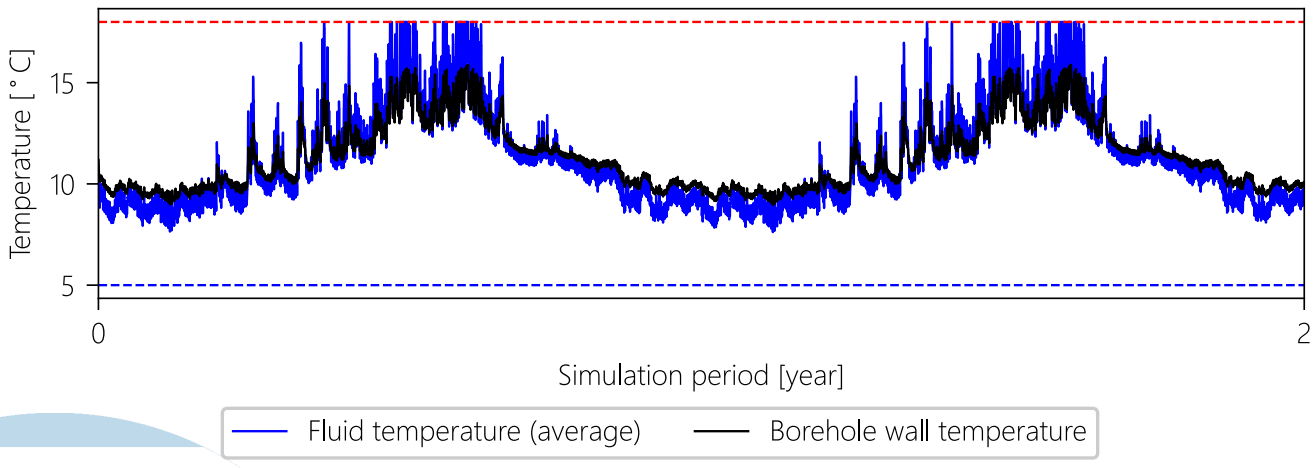
Results

Effective borehole thermal resistance (extraction): 0,1069 m·K/W, Reynolds number: 3 494 (transitional)

Effective borehole thermal resistance (injection): 0,1059 m·K/W, Reynolds number: 4 650 (turbulent)

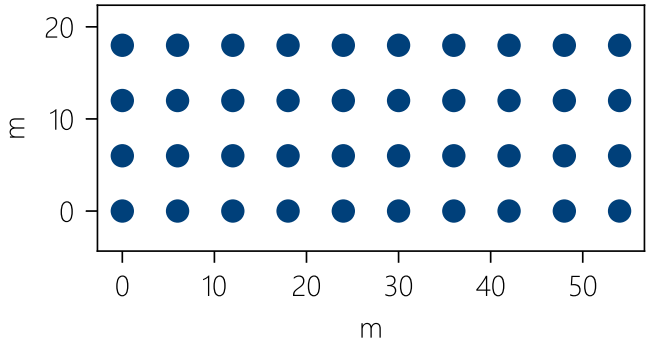
Yearly average regeneration: 88 761 kWh/y (injection)

Maximum average fluid temperature: 18,00 °C, Minimum average fluid temperature: 7,62 °C



2.9 DC - 20 kW - inlet - 18°C - SP

Input



Number of boreholes: 40

Average minimum borehole spacing: 6,0 m

Borehole depth (w.r.t. surface): 100,0 m

2 x U tube DN32 PN16

Water

SCOP heating: 5,00; SEER cooling: 20,00; SCOP DHW: 3,00

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW

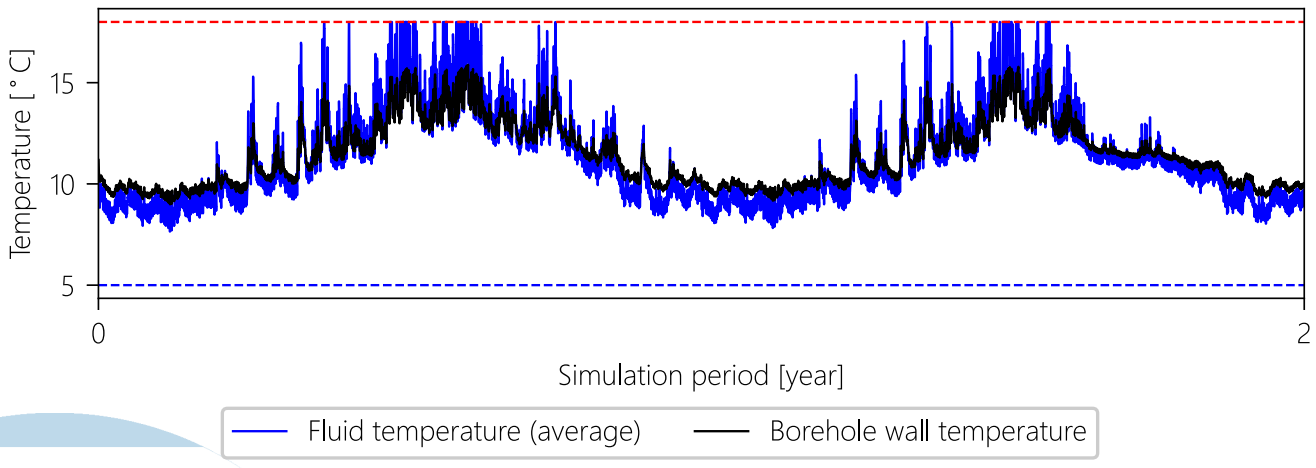
Results

Effective borehole thermal resistance (extraction): 0,1069 m·K/W, Reynolds number: 3 496 (transitional)

Effective borehole thermal resistance (injection): 0,1059 m·K/W, Reynolds number: 4 650 (turbulent)

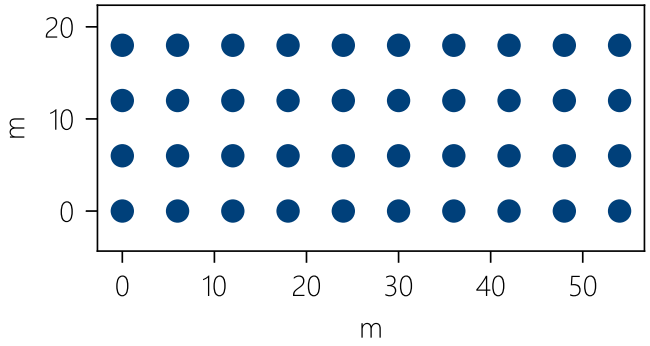
Yearly average regeneration: 88 761 kWh/y (injection)

Maximum average fluid temperature: 18,01 °C, Minimum average fluid temperature: 7,64 °C



2.10 DC - 20 kW - inlet - 18°C - PH

Input



Number of boreholes: 40

Average minimum borehole spacing: 6,0 m

Borehole depth (w.r.t. surface): 100,0 m

2 x U tube DN32 PN16

Water

SCOP heating: 5,00; SEER cooling: 20,00; SCOP DHW: 3,00

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW

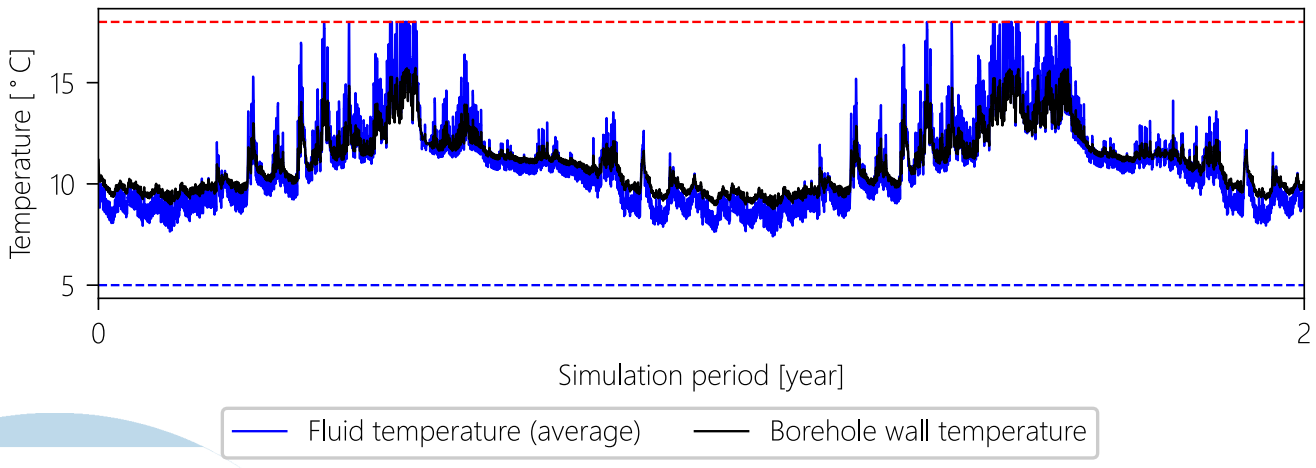
Results

Effective borehole thermal resistance (extraction): 0,1070 m·K/W, Reynolds number: 3 472 (transitional)

Effective borehole thermal resistance (injection): 0,1059 m·K/W, Reynolds number: 4 650 (turbulent)

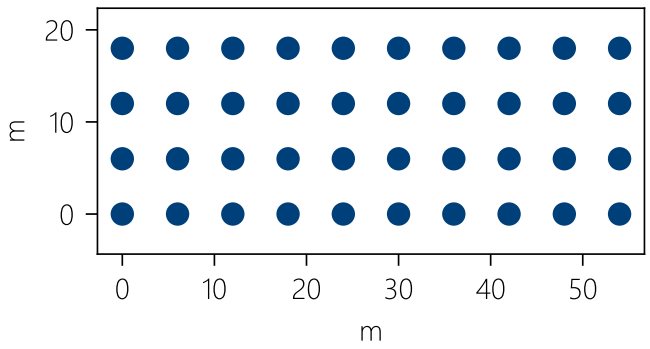
Yearly average regeneration: 73 336 kWh/y (injection)

Maximum average fluid temperature: 18,00 °C, Minimum average fluid temperature: 7,41 °C



2.11 DC - 20 kW - inlet - 18°C - PH+

Input



Number of boreholes: 40

Average minimum borehole spacing: 6,0 m

Borehole depth (w.r.t. surface): 100,0 m

2 x U tube DN32 PN16

Water

SCOP heating: 5,00; SEER cooling: 20,00; SCOP DHW: 3,00

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW

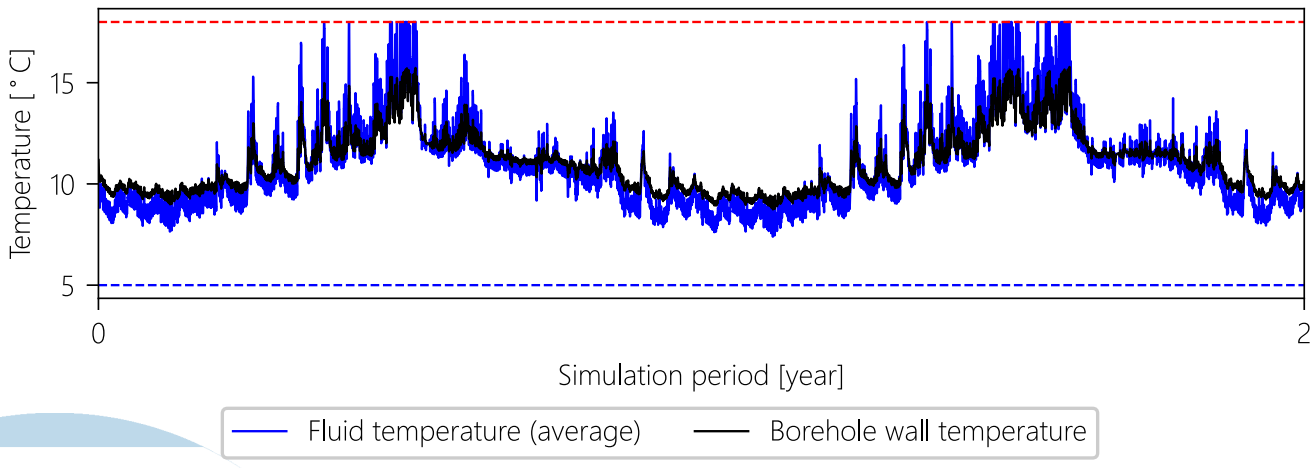
Results

Effective borehole thermal resistance (extraction): 0,1070 m·K/W, Reynolds number: 3 470 (transitional)

Effective borehole thermal resistance (injection): 0,1059 m·K/W, Reynolds number: 4 650 (turbulent)

Yearly average regeneration: 73 327 kWh/y (injection)

Maximum average fluid temperature: 18,01 °C, Minimum average fluid temperature: 7,39 °C



This section contains all the input data that is identical across all simulations. Input data that varies between scenarios is provided and discussed within the relevant scenario sections. The following subsections cover the following topics: ground data, borefield configuration, pipe data, fluid data, flow data, and efficiency data.

3.1 Ground data

The ground is modelled as a single homogeneous layer with an average thermal conductivity of 2,00 W/(m·K) and a volumetric heat capacity of 2,40 MJ/(m^3·K). This means that the ground properties are assumed to remain constant at all depths.

A ground temperature gradient is taken into account. Using a geothermal heat flux of 0,07 W/m^2, a ground surface temperature of 9,60 °C and the ground thermal conductivity, the average ground temperature can be calculated for each borehole depth. For example, the average ground temperature is 10,47 °C at 50 m and 11,33 °C at 99 m.

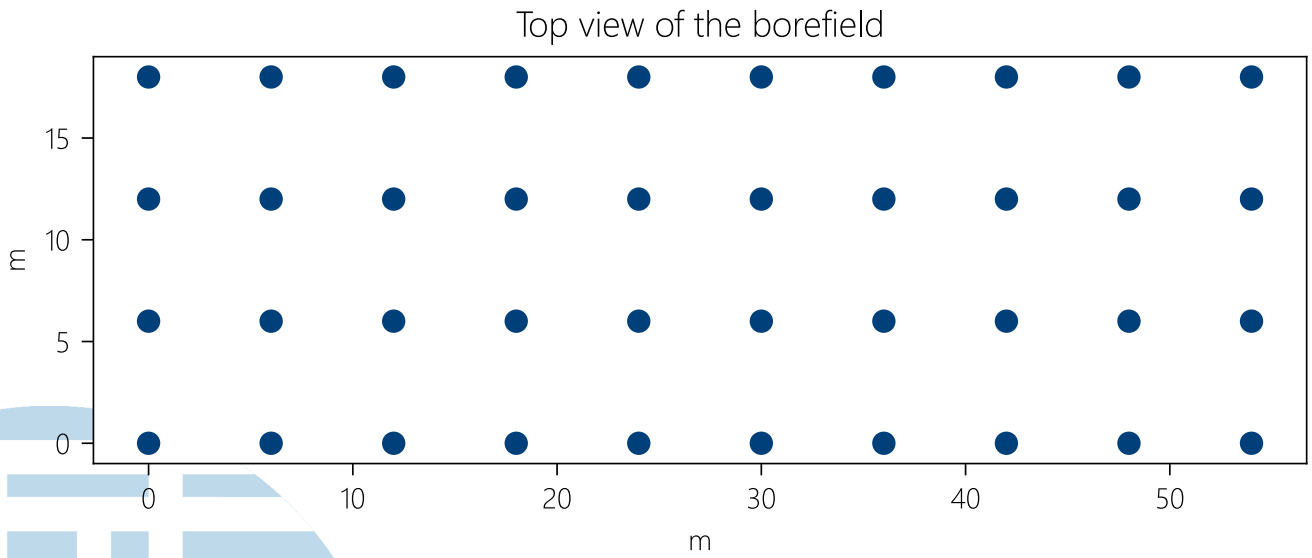
Please note that for all ground property calculations, both the borehole depth and the buried depth are taken into account. This means that the average ground properties, as seen by the borehole, are calculated from the buried depth down to the full borehole depth. The region above the buried depth is not considered.

3.2 Borefield configuration

The simulations were carried out with a borefield consisting of 40 boreholes, with an average buried depth of 1,00 m, an average borehole depth of 100,00 m and an average borehole length of 99,00 m. This results in a total borehole length of 3 960,00 m.

The minimum average borehole spacing is 6,00 m. This is defined as the average of the smallest distances between the centres of all pairs of boreholes in the borefield.

(The borehole depth is defined as the vertical distance between the ground surface and the deepest point of the borehole. The buried depth is the distance between the ground surface and the start of the borehole. The borehole length, sometimes called the 'active length' is the actual length of the heat exchanger measured along the borehole.)



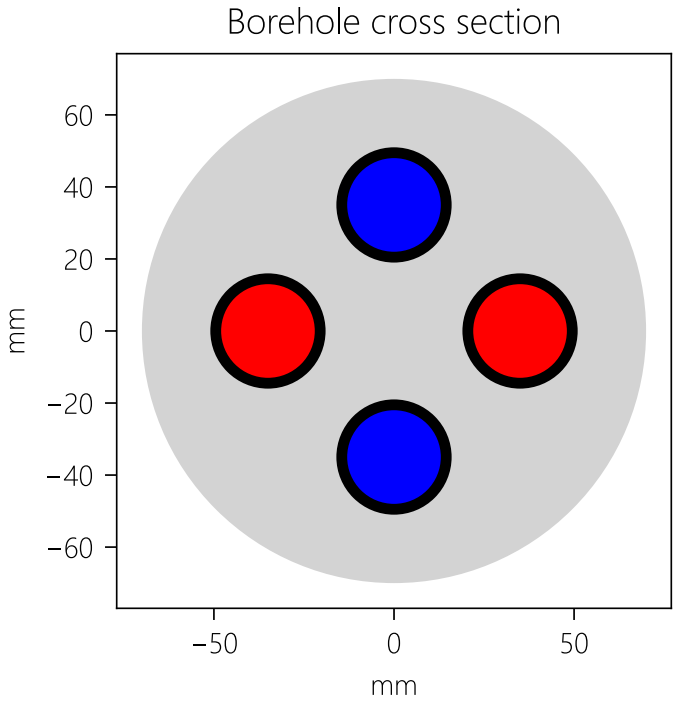
The coordinates of the different boreholes are given in the table below.

x [m]	y [m]	Length [m]	Depth [m]	Buried depth [m]	Tilt [°]	Orientation [°]
0,00	0,00	99,00	100,00	1,00	0,00	0,00
0,00	6,00	99,00	100,00	1,00	0,00	0,00
0,00	12,00	99,00	100,00	1,00	0,00	0,00
0,00	18,00	99,00	100,00	1,00	0,00	0,00
6,00	0,00	99,00	100,00	1,00	0,00	0,00
6,00	6,00	99,00	100,00	1,00	0,00	0,00
6,00	12,00	99,00	100,00	1,00	0,00	0,00
6,00	18,00	99,00	100,00	1,00	0,00	0,00
12,00	0,00	99,00	100,00	1,00	0,00	0,00
12,00	6,00	99,00	100,00	1,00	0,00	0,00
12,00	12,00	99,00	100,00	1,00	0,00	0,00
12,00	18,00	99,00	100,00	1,00	0,00	0,00
18,00	0,00	99,00	100,00	1,00	0,00	0,00
18,00	6,00	99,00	100,00	1,00	0,00	0,00
18,00	12,00	99,00	100,00	1,00	0,00	0,00
18,00	18,00	99,00	100,00	1,00	0,00	0,00
24,00	0,00	99,00	100,00	1,00	0,00	0,00
24,00	6,00	99,00	100,00	1,00	0,00	0,00
24,00	12,00	99,00	100,00	1,00	0,00	0,00
24,00	18,00	99,00	100,00	1,00	0,00	0,00
30,00	0,00	99,00	100,00	1,00	0,00	0,00
30,00	6,00	99,00	100,00	1,00	0,00	0,00
30,00	12,00	99,00	100,00	1,00	0,00	0,00
30,00	18,00	99,00	100,00	1,00	0,00	0,00
36,00	0,00	99,00	100,00	1,00	0,00	0,00
36,00	6,00	99,00	100,00	1,00	0,00	0,00
36,00	12,00	99,00	100,00	1,00	0,00	0,00
36,00	18,00	99,00	100,00	1,00	0,00	0,00
42,00	0,00	99,00	100,00	1,00	0,00	0,00
42,00	6,00	99,00	100,00	1,00	0,00	0,00
42,00	12,00	99,00	100,00	1,00	0,00	0,00
42,00	18,00	99,00	100,00	1,00	0,00	0,00

48,00	0,00	99,00	100,00	1,00	0,00	0,00
48,00	6,00	99,00	100,00	1,00	0,00	0,00
48,00	12,00	99,00	100,00	1,00	0,00	0,00
48,00	18,00	99,00	100,00	1,00	0,00	0,00
54,00	0,00	99,00	100,00	1,00	0,00	0,00
54,00	6,00	99,00	100,00	1,00	0,00	0,00
54,00	12,00	99,00	100,00	1,00	0,00	0,00
54,00	18,00	99,00	100,00	1,00	0,00	0,00

3.3 Pipe data

Inside the borehole with a diameter of 140 mm, 2 DN32 PN16 U-tubes will be installed and the pipe legs are positioned at a distance of 35 mm from the borehole center. The borehole will be grouted with a material that has a thermal conductivity of 1,50 W/(m·K).



3.4 Fluid data

As a heat transfer fluid, water with 100,0 v/v% was selected, which provides frost protection down to approximately 0 °C. For a more accurate simulation, the fluid properties (such as viscosity and density) are assumed to be temperature-dependent and therefore vary throughout the simulation period. This is particularly important for buildings with a high cooling demand, since heat transfer during heat injection (i.e., cooling) is more efficient than during extraction (i.e., heating). To account for this, no single fixed value should be used for the fluid properties.

3.5 Flow data

The total flow rate through the borefield is 8,00 kg/s, corresponding to a flow of 0,20 kg/s per borehole in the system.

3.6 Efficiency data

To calculate the resulting geothermal load, the heat pump is modelled to have a SCOP of 5,00 in heating and 3,00 for the production of domestic hot water. The cooling is modelled with an SEER of 20,00.

4.1 Simulation

In the first subsection, the scenario-specific input parameters will be discussed. Afterwards, the simulation results are presented.

4.1.1 Input

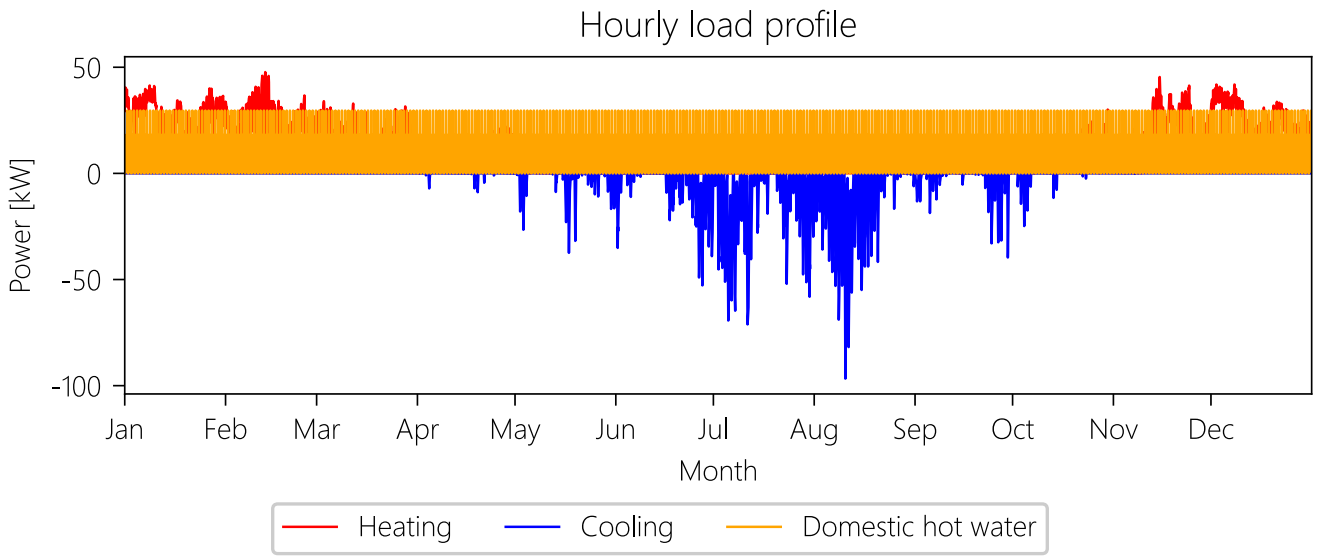
General simulation settings

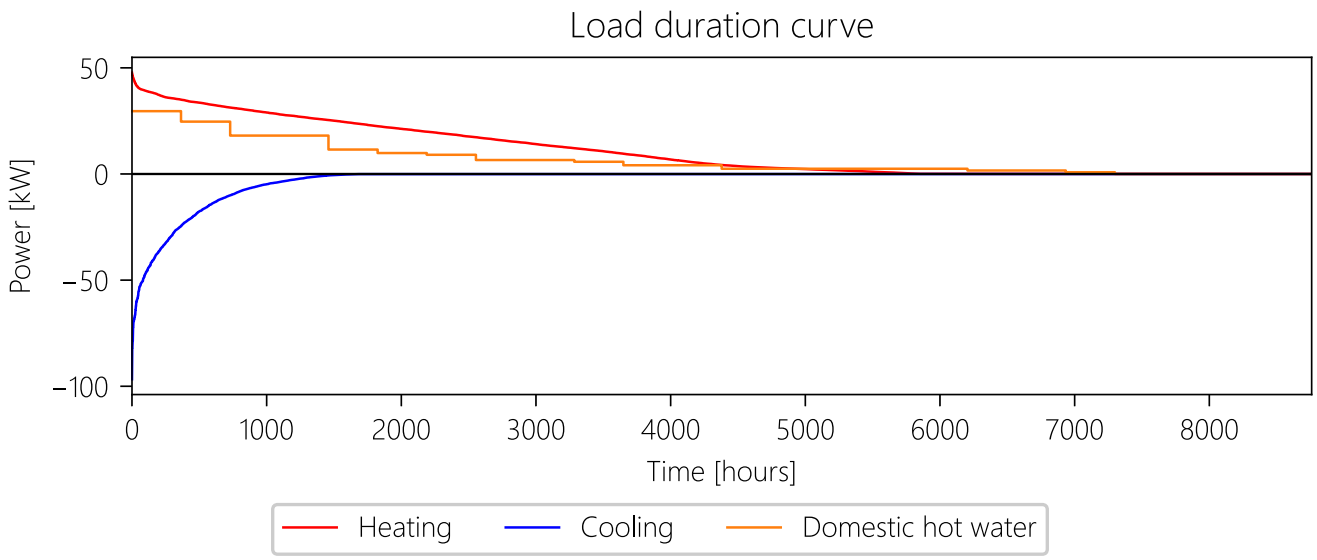
The scenarios in this report have been simulated with a simulation period of 40 years, starting in January. The minimum and maximum average fluid temperatures were 5,00 °C and 16,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Load data

For the simulation, a building load was used. This means that, in order to calculate the resulting extraction and injection loads for the ground, the efficiency of the heat pump will be taken into account. Below you can find a summary of the load.

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW





4.1.2 Results

Ground load

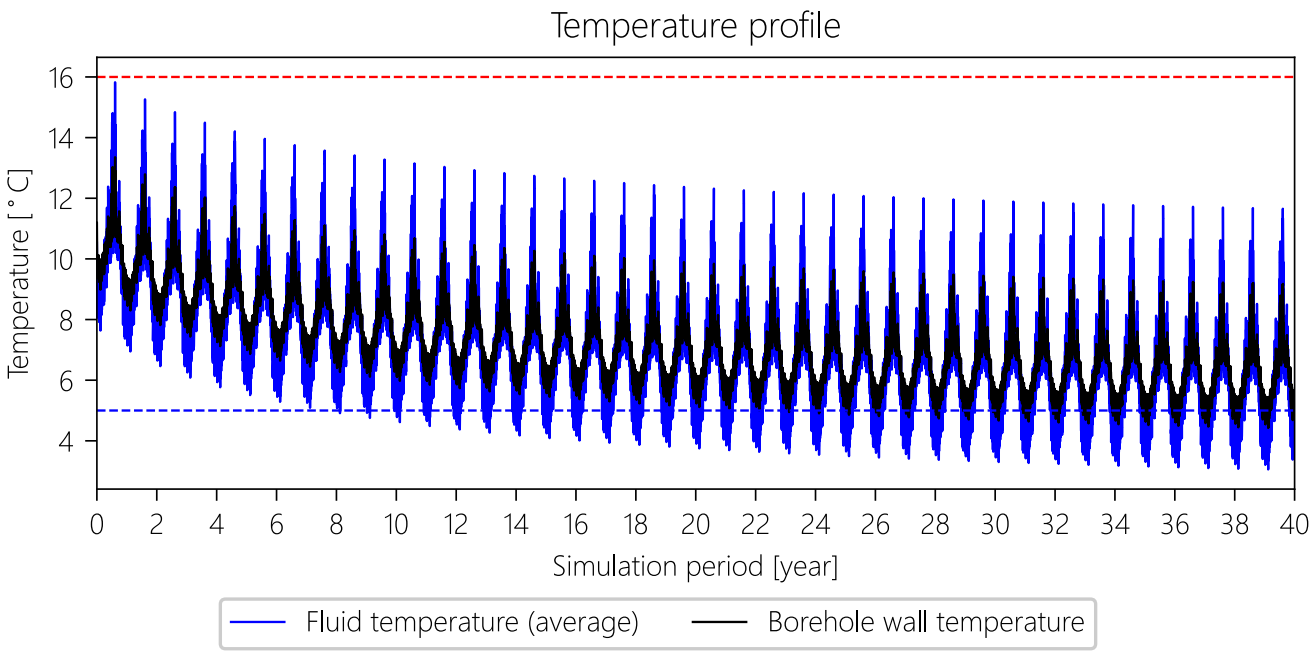
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	114 049 kWh/y	50,1 kW
Injection demand	25 288 kWh/y	101,5 kW

Temperature evolution of the borefield

Using the pipe, fluid, and flow properties, the Reynolds number was calculated. Since this number depends on the fluid temperature and therefore varies over the simulation period, it was updated at every timestep to achieve the most accurate result possible.
Doing so, the Reynolds number during heat extraction was 3 032, whilst it was 4 396 during injection. This corresponds respectively to a transitional and turbulent flow regime, with an effective borehole thermal resistance of 0,1085 m·K/W and 0,1060 m·K/W during heat extraction and injection.

Below, the hourly simulation for the borefield is shown. The blue line represents the average fluid temperature between the inlet and outlet of the borehole at each hour of the simulation. The black line shows the borehole wall temperature, which is the interface between the borehole and the ground. The difference between both lines is determined by the effective borehole thermal resistance.



The maximum average fluid temperature over the whole simulation period is 15,83 °C, and the minimum average fluid temperature is 3,06 °C.

Pressure drop

The pressure drop over a single borehole is 5,87 kPa during extraction and 5,78 kPa during injection.

4.2 DC - 5 kW - inlet

In the first subsection, the scenario-specific input parameters will be discussed. Afterwards, the simulation results are presented.

4.2.1 Input

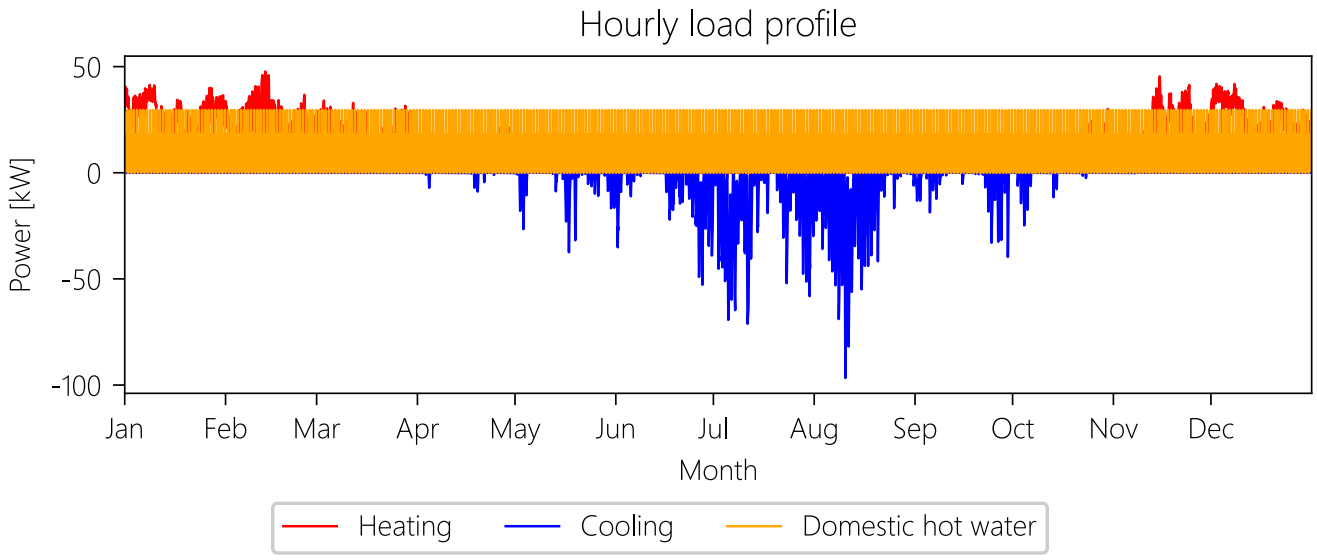
General simulation settings

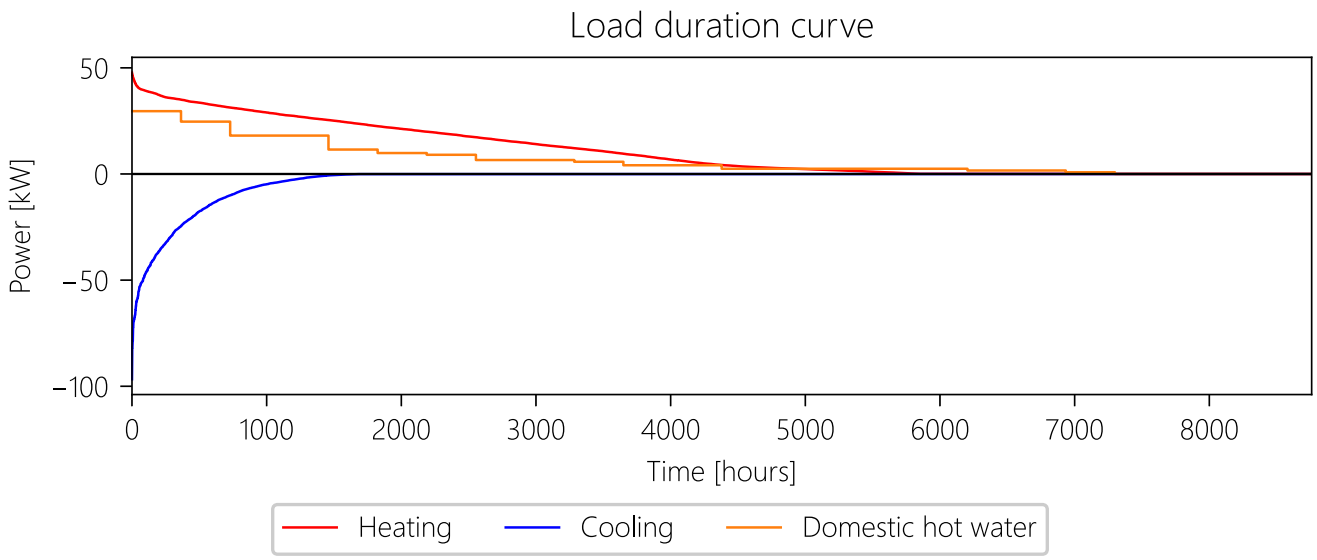
The scenarios in this report have been simulated with a simulation period of 2 years, starting in January. The minimum and maximum average fluid temperatures were 5,00 °C and 16,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Load data

For the simulation, a building load was used. This means that, in order to calculate the resulting extraction and injection loads for the ground, the efficiency of the heat pump will be taken into account. Below you can find a summary of the load.

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW





Regeneration data

For the regeneration, a heat exchanger with the outside air was used (such as e.g. a dry cooler). The available power of this exchanger is 5,00 kW/K with a minimum temperature difference (pinch temperature) across the heat exchanger of 0,00 0,00unit.

The weather file that was used is: BEL_Brussels.064510_IWEC.epw.

The algorithm used is 'yearly', which counteracts the imbalance in every year individually. When the selected regeneration technology is too small, a smaller imbalance can still remain.

The used horizon for the regeneration algorithm was 4380 hours and the regeneration was placed right before the borefield inlet.

4.2.2 Results

Regeneration

Over the whole simulation period, an average of 51 571 kWh/year in injection was regenerated. The maximum regeneration power was 50,24 kW. Due to the regeneration, the imbalance reduced from -88 760 kWh/year to -37 189 kWh/year.

Ground load

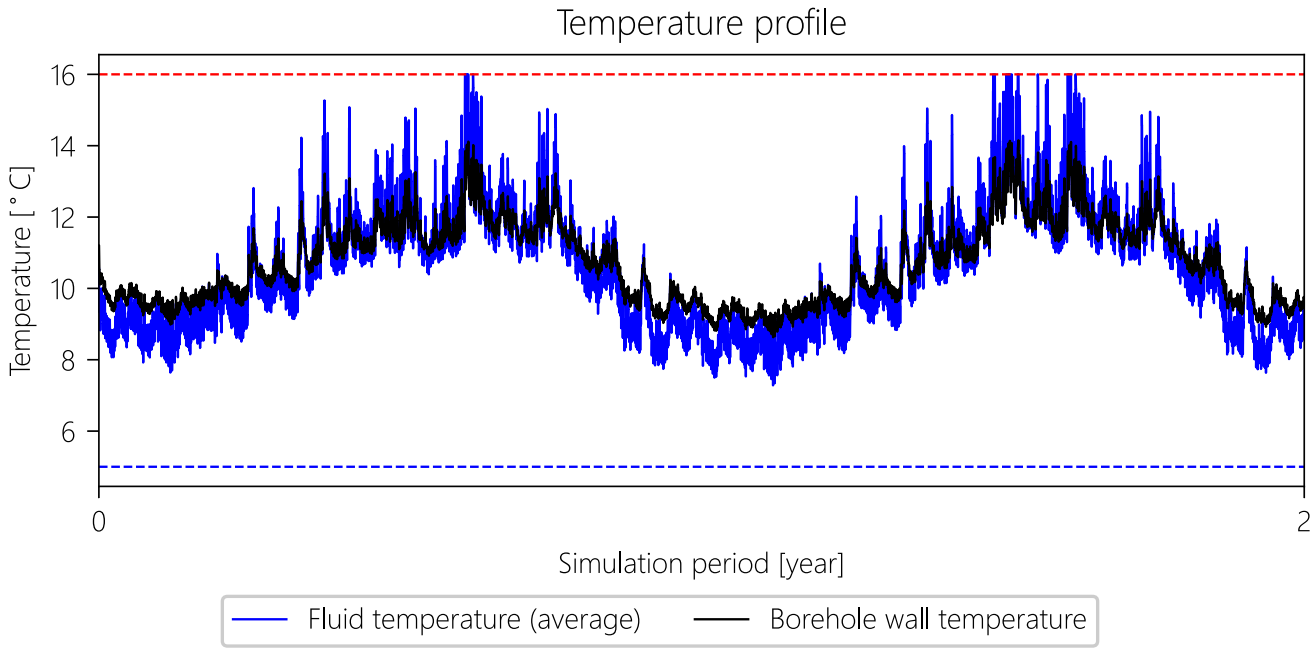
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	114 049 kWh/y	50,1 kW
Injection demand	25 288 kWh/y	101,5 kW
Regeneration (injection)	51 571 kWh/y	50,2 kW

Temperature evolution of the borefield

Using the pipe, fluid, and flow properties, the Reynolds number was calculated. Since this number depends on the fluid temperature and therefore varies over the simulation period, it was updated at every timestep to achieve the most accurate result possible.
Doing so, the Reynolds number during heat extraction was 3 459, whilst it was 4 416 during injection. This corresponds respectively to a transitional and turbulent flow regime, with an effective borehole thermal resistance of 0,1070 m·K/W and 0,1060 m·K/W during heat extraction and injection.

Below, the hourly simulation for the borefield is shown. The blue line represents the average fluid temperature between the inlet and outlet of the borehole at each hour of the simulation. The black line shows the borehole wall temperature, which is the interface between the borehole and the ground. The difference between both lines is determined by the effective borehole thermal resistance.



The maximum average fluid temperature over the whole simulation period is 16,00 °C, and the minimum average fluid temperature is 7,28 °C.

Pressure drop

The pressure drop over a single borehole is 5,64 kPa during extraction and 5,56 kPa during injection.

4.3 DC - 5 kW - outlet

In the first subsection, the scenario-specific input parameters will be discussed. Afterwards, the simulation results are presented.

4.3.1 Input

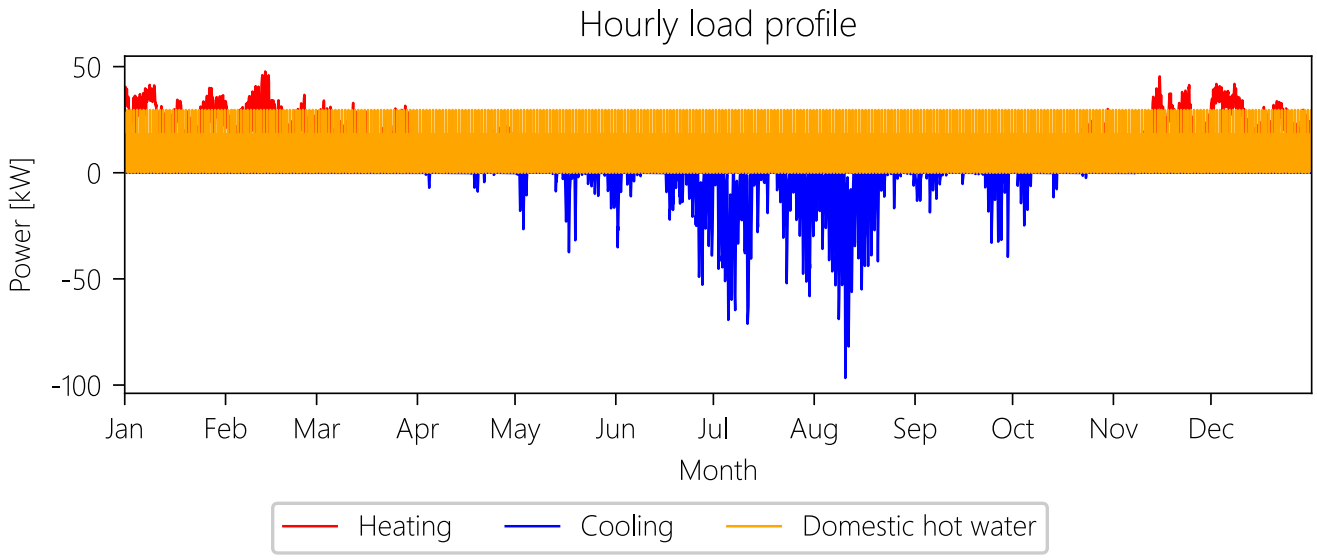
General simulation settings

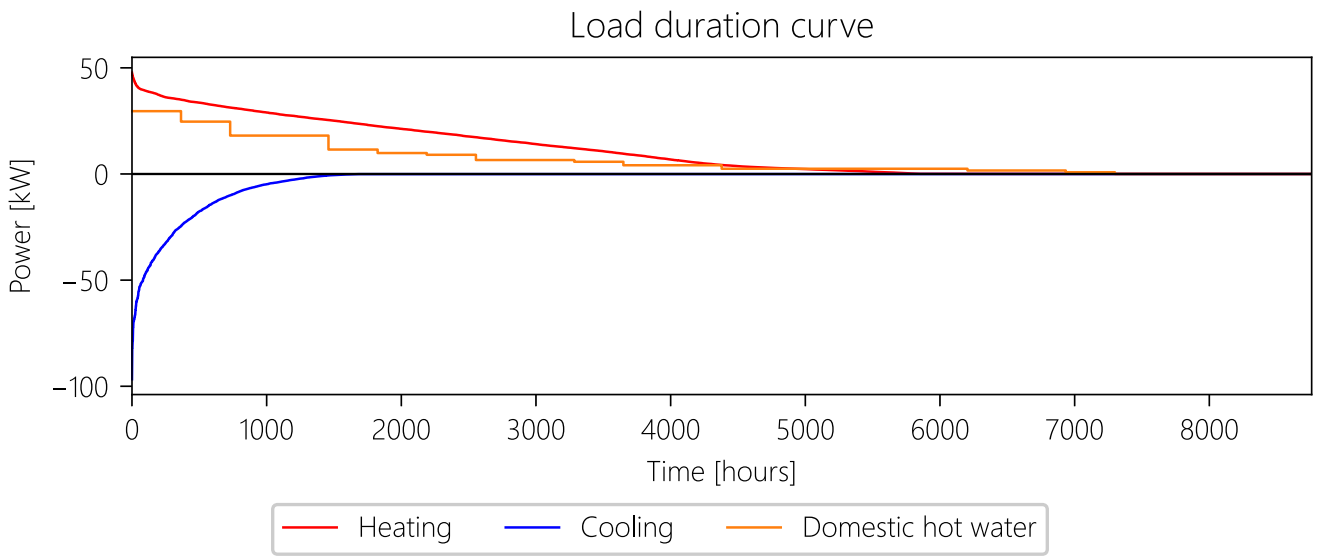
The scenarios in this report have been simulated with a simulation period of 2 years, starting in January. The minimum and maximum average fluid temperatures were 5,00 °C and 16,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Load data

For the simulation, a building load was used. This means that, in order to calculate the resulting extraction and injection loads for the ground, the efficiency of the heat pump will be taken into account. Below you can find a summary of the load.

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW





Regeneration data

For the regeneration, a heat exchanger with the outside air was used (such as e.g. a dry cooler). The available power of this exchanger is 5,00 kW/K with a minimum temperature difference (pinch temperature) across the heat exchanger of 0,00 0,00unit.

The weather file that was used is: BEL_Brussels.064510_IWEC.epw.

The algorithm used is 'yearly', which counteracts the imbalance in every year individually. When the selected regeneration technology is too small, a smaller imbalance can still remain.

The used horizon for the regeneration algorithm was 4380 hours and the regeneration was placed right after the borefield outlet.

4.3.2 Results

Regeneration

Over the whole simulation period, an average of 53 797 kWh/year in injection was regenerated. The maximum regeneration power was 58,90 kW. Due to the regeneration, the imbalance reduced from -88 761 kWh/year to -34 964 kWh/year.

Ground load

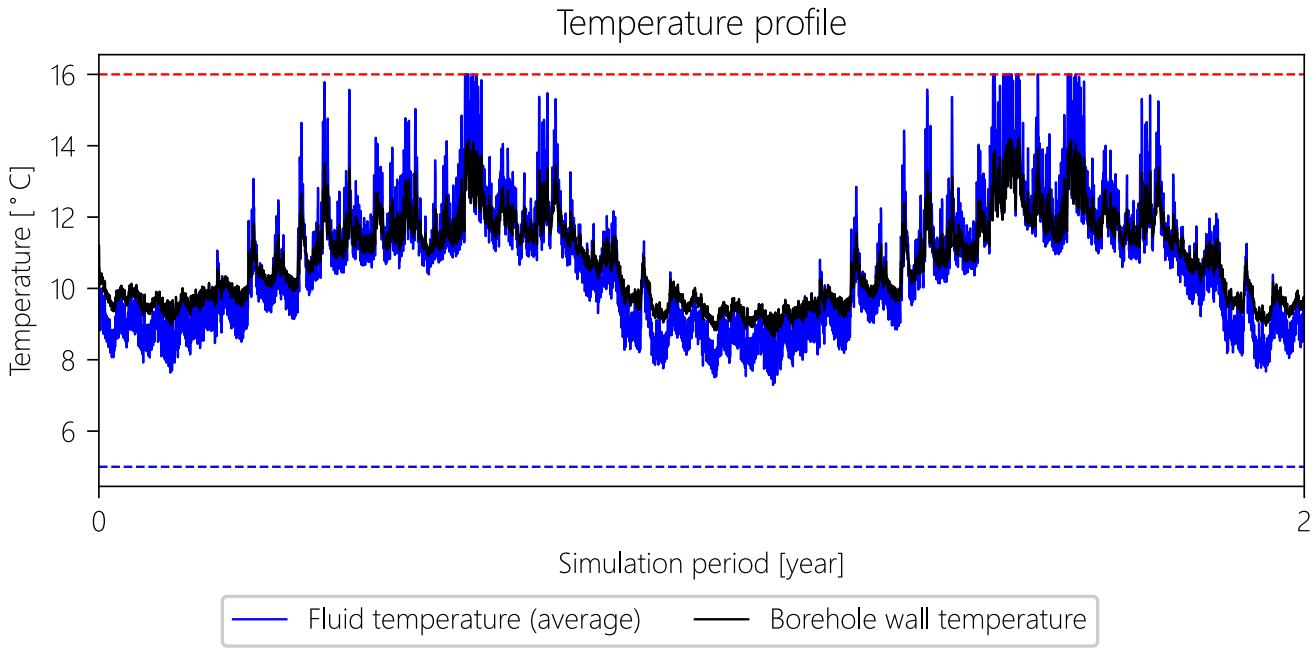
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	114 049 kWh/y	50,1 kW
Injection demand	25 288 kWh/y	101,5 kW
Regeneration (injection)	53 797 kWh/y	58,9 kW

Temperature evolution of the borefield

Using the pipe, fluid, and flow properties, the Reynolds number was calculated. Since this number depends on the fluid temperature and therefore varies over the simulation period, it was updated at every timestep to achieve the most accurate result possible.
Doing so, the Reynolds number during heat extraction was 3 460, whilst it was 4 416 during injection. This corresponds respectively to a transitional and turbulent flow regime, with an effective borehole thermal resistance of 0,1070 m·K/W and 0,1060 m·K/W during heat extraction and injection.

Below, the hourly simulation for the borefield is shown. The blue line represents the average fluid temperature between the inlet and outlet of the borehole at each hour of the simulation. The black line shows the borehole wall temperature, which is the interface between the borehole and the ground. The difference between both lines is determined by the effective borehole thermal resistance.



The maximum average fluid temperature over the whole simulation period is 16,00 °C, and the minimum average fluid temperature is 7,29 °C.

Pressure drop

The pressure drop over a single borehole is 5,64 kPa during extraction and 5,56 kPa during injection.

4.4 DC - 5 kW - inlet - 2°C

In the first subsection, the scenario-specific input parameters will be discussed. Afterwards, the simulation results are presented.

4.4.1 Input

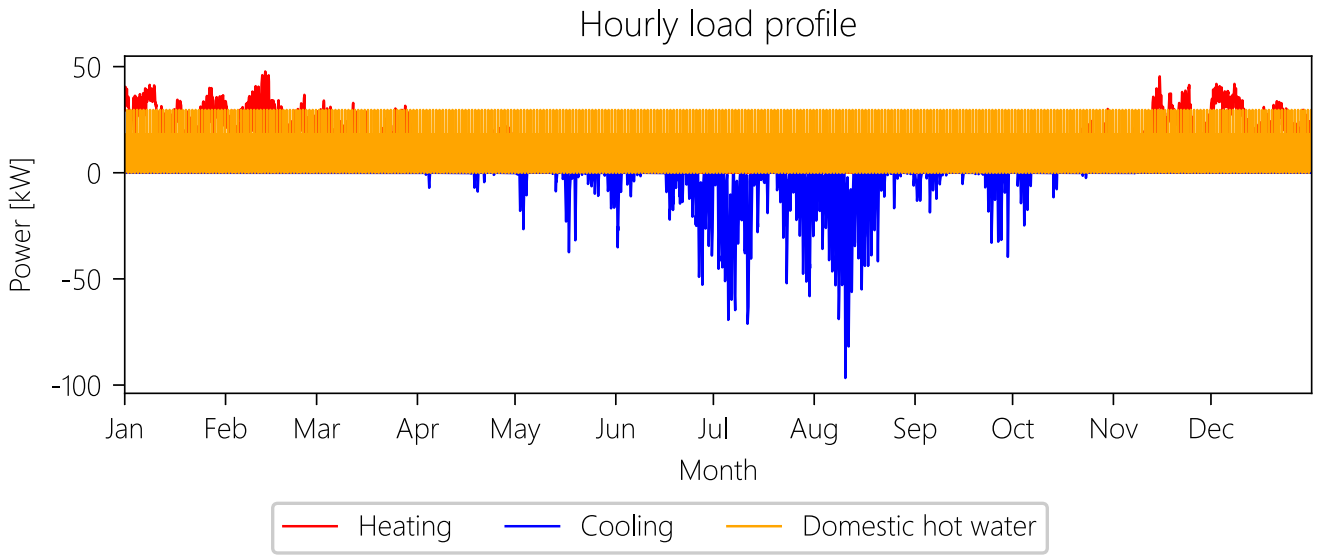
General simulation settings

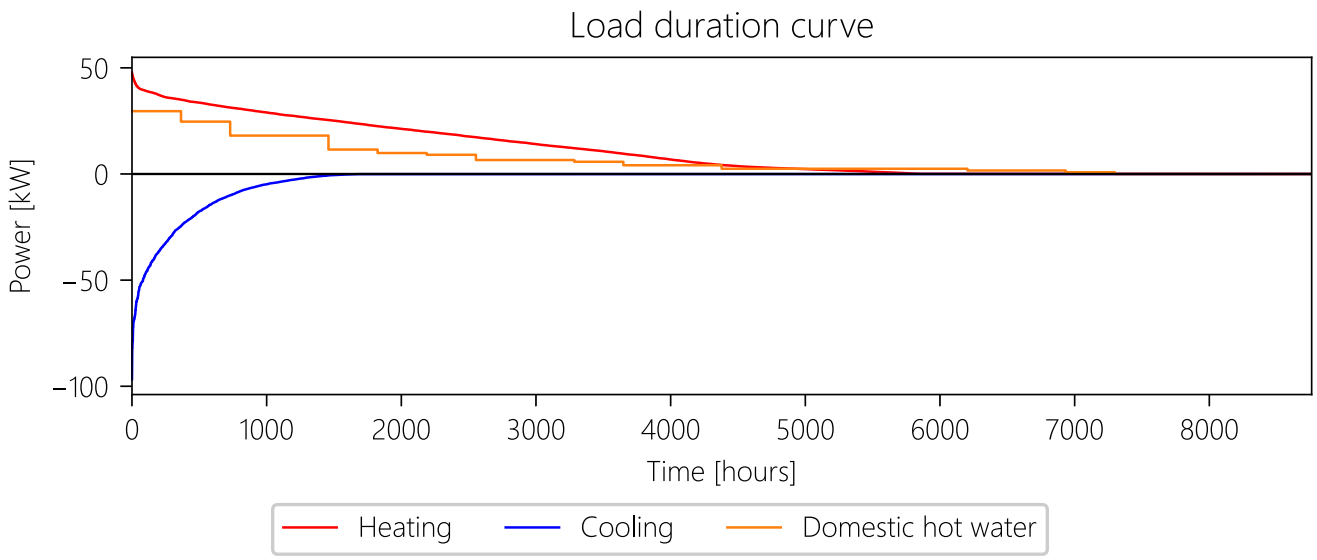
The scenarios in this report have been simulated with a simulation period of 2 years, starting in January. The minimum and maximum average fluid temperatures were 5,00 °C and 16,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Load data

For the simulation, a building load was used. This means that, in order to calculate the resulting extraction and injection loads for the ground, the efficiency of the heat pump will be taken into account. Below you can find a summary of the load.

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW





Regeneration data

For the regeneration, a heat exchanger with the outside air was used (such as e.g. a dry cooler). The available power of this exchanger is 5,00 kW/K with a minimum temperature difference (pinch temperature) across the heat exchanger of 2,00 2,00unit.

The weather file that was used is: BEL_Brussels.064510_IWEC.epw.

The algorithm used is 'yearly', which counteracts the imbalance in every year individually. When the selected regeneration technology is too small, a smaller imbalance can still remain.

The used horizon for the regeneration algorithm was 4380 hours and the regeneration was placed right before the borefield inlet.

4.4.2 Results

Regeneration

Over the whole simulation period, an average of 36 842 kWh/year in injection was regenerated. The maximum regeneration power was 48,56 kW. Due to the regeneration, the imbalance reduced from -88 761 kWh/year to -51 919 kWh/year.

Ground load

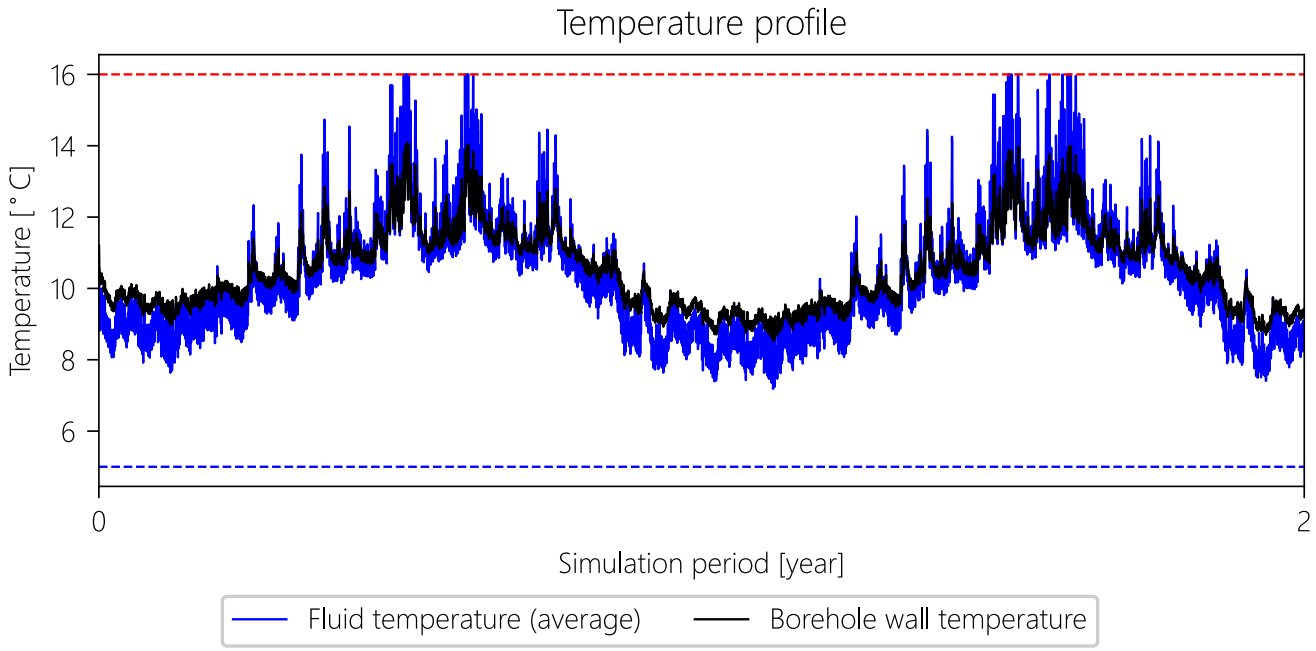
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	114 049 kWh/y	50,1 kW
Injection demand	25 288 kWh/y	101,5 kW
Regeneration (injection)	36 842 kWh/y	48,6 kW

Temperature evolution of the borefield

Using the pipe, fluid, and flow properties, the Reynolds number was calculated. Since this number depends on the fluid temperature and therefore varies over the simulation period, it was updated at every timestep to achieve the most accurate result possible.
Doing so, the Reynolds number during heat extraction was 3 449, whilst it was 4 416 during injection. This corresponds respectively to a transitional and turbulent flow regime, with an effective borehole thermal resistance of 0,1071 m·K/W and 0,1060 m·K/W during heat extraction and injection.

Below, the hourly simulation for the borefield is shown. The blue line represents the average fluid temperature between the inlet and outlet of the borehole at each hour of the simulation. The black line shows the borehole wall temperature, which is the interface between the borehole and the ground. The difference between both lines is determined by the effective borehole thermal resistance.



The maximum average fluid temperature over the whole simulation period is 16,00 °C, and the minimum average fluid temperature is 7,18 °C.

Pressure drop

The pressure drop over a single borehole is 5,64 kPa during extraction and 5,56 kPa during injection.

4.5 DC - 10 kW - inlet

In the first subsection, the scenario-specific input parameters will be discussed. Afterwards, the simulation results are presented.

4.5.1 Input

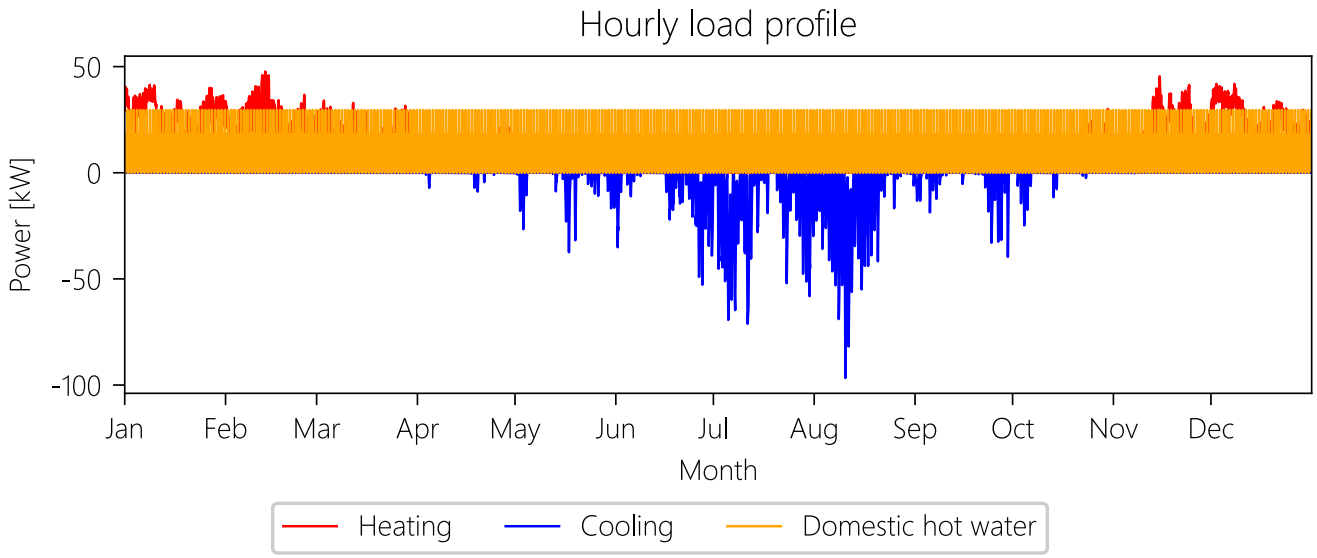
General simulation settings

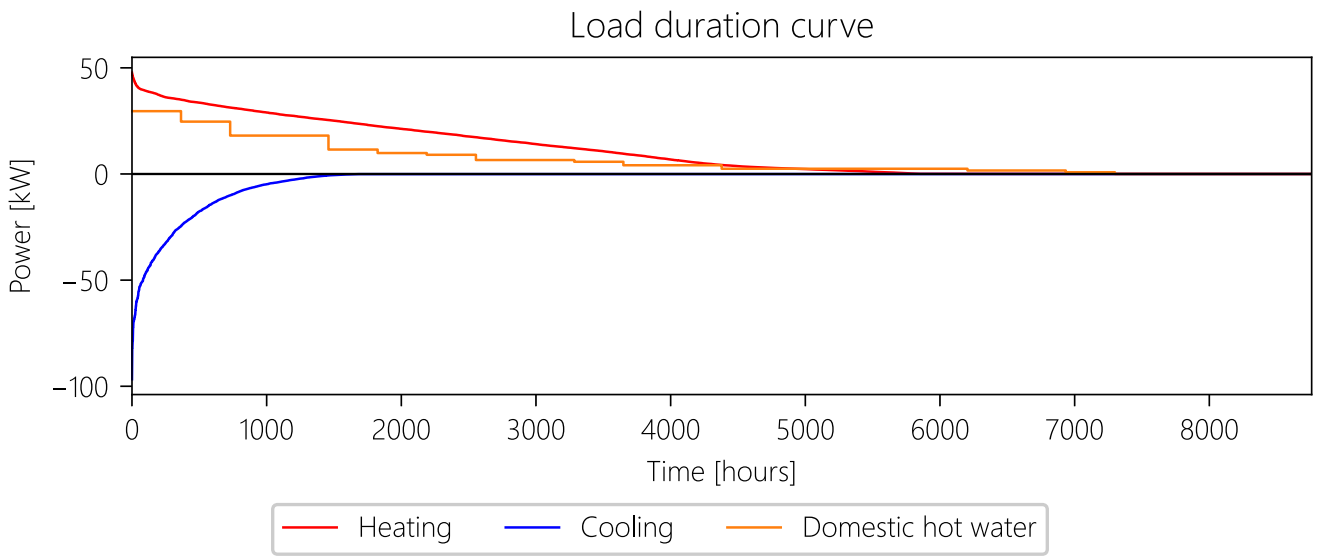
The scenarios in this report have been simulated with a simulation period of 2 years, starting in January. The minimum and maximum average fluid temperatures were 5,00 °C and 16,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Load data

For the simulation, a building load was used. This means that, in order to calculate the resulting extraction and injection loads for the ground, the efficiency of the heat pump will be taken into account. Below you can find a summary of the load.

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW





Regeneration data

For the regeneration, a heat exchanger with the outside air was used (such as e.g. a dry cooler). The available power of this exchanger is 10,00 kW/K with a minimum temperature difference (pinch temperature) across the heat exchanger of 0,00 0,00unit.

The weather file that was used is: BEL_Brussels.064510_IWEC.epw.

The algorithm used is 'yearly', which counteracts the imbalance in every year individually. When the selected regeneration technology is too small, a smaller imbalance can still remain.

The used horizon for the regeneration algorithm was 4380 hours and the regeneration was placed right before the borefield inlet.

4.5.2 Results

Regeneration

Over the whole simulation period, an average of 63 046 kWh/year in injection was regenerated. The maximum regeneration power was 77,13 kW. Due to the regeneration, the imbalance reduced from -88 761 kWh/year to -25 715 kWh/year.

Ground load

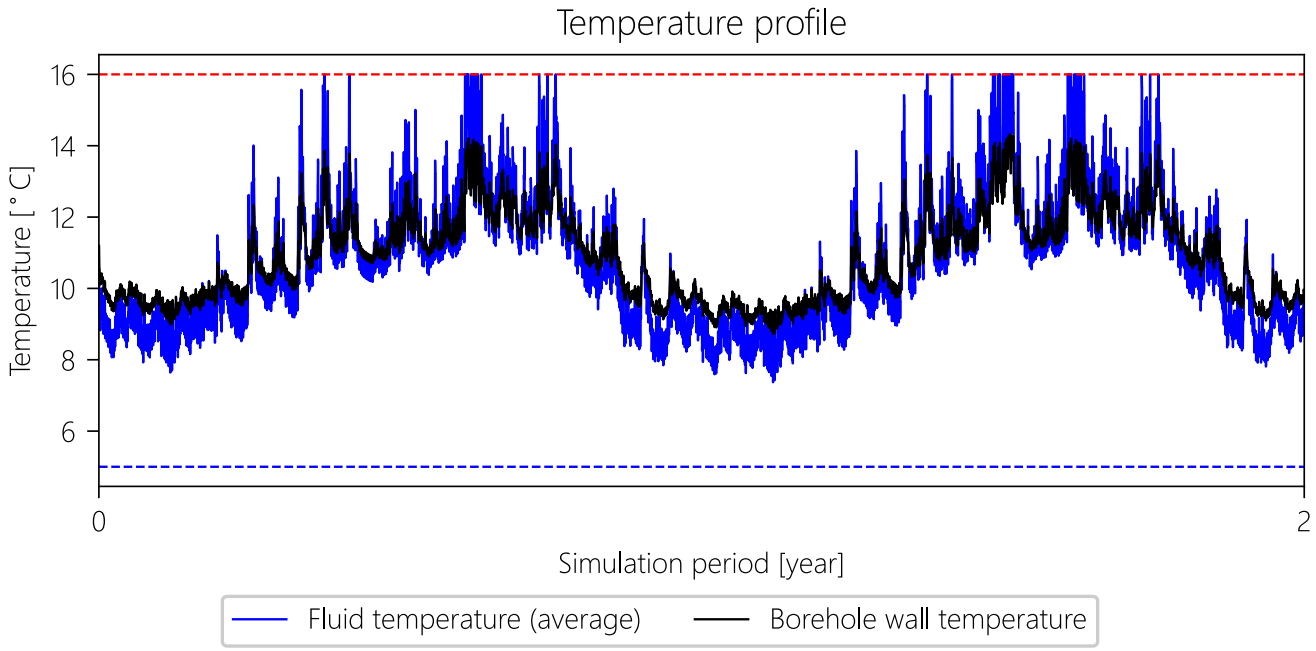
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	114 049 kWh/y	50,1 kW
Injection demand	25 288 kWh/y	101,5 kW
Regeneration (injection)	63 046 kWh/y	77,1 kW

Temperature evolution of the borefield

Using the pipe, fluid, and flow properties, the Reynolds number was calculated. Since this number depends on the fluid temperature and therefore varies over the simulation period, it was updated at every timestep to achieve the most accurate result possible.
Doing so, the Reynolds number during heat extraction was 3 468, whilst it was 4 416 during injection. This corresponds respectively to a transitional and turbulent flow regime, with an effective borehole thermal resistance of 0,1070 m·K/W and 0,1060 m·K/W during heat extraction and injection.

Below, the hourly simulation for the borefield is shown. The blue line represents the average fluid temperature between the inlet and outlet of the borehole at each hour of the simulation. The black line shows the borehole wall temperature, which is the interface between the borehole and the ground. The difference between both lines is determined by the effective borehole thermal resistance.



The maximum average fluid temperature over the whole simulation period is 16,00 °C, and the minimum average fluid temperature is 7,37 °C.

Pressure drop

The pressure drop over a single borehole is 5,63 kPa during extraction and 5,56 kPa during injection.

4.6 DC - 20 kW - inlet

In the first subsection, the scenario-specific input parameters will be discussed. Afterwards, the simulation results are presented.

4.6.1 Input

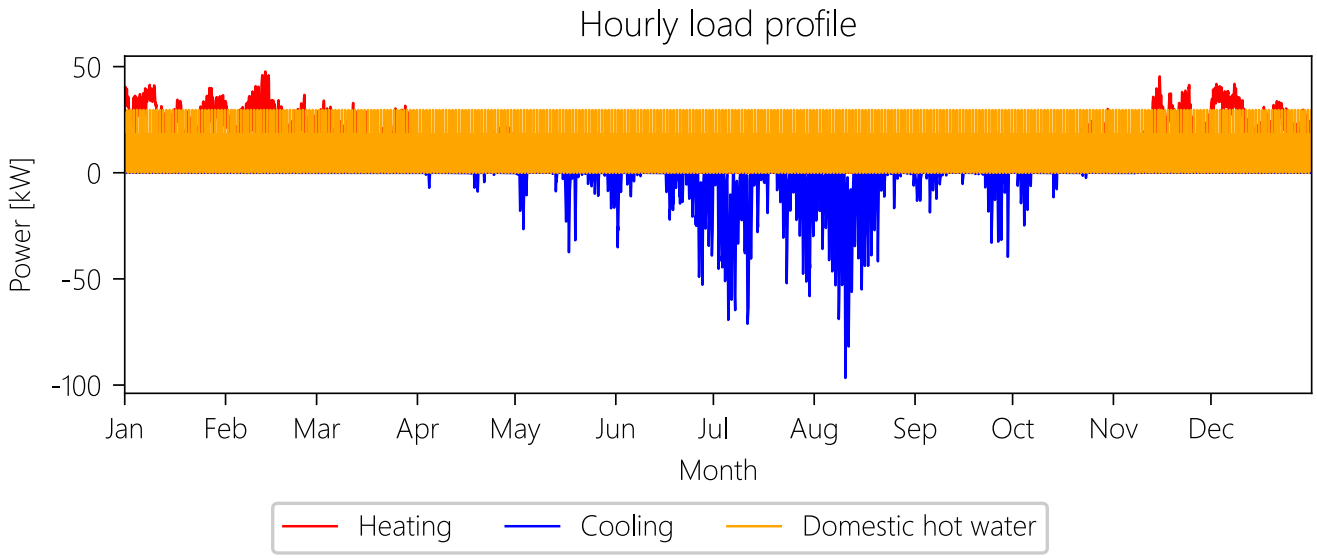
General simulation settings

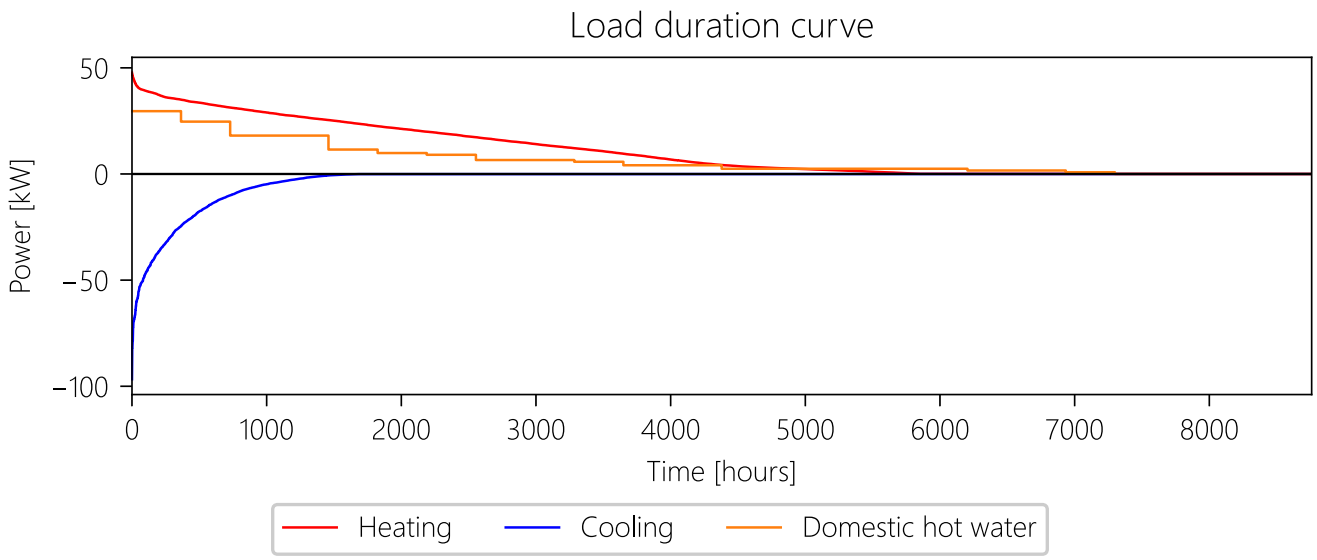
The scenarios in this report have been simulated with a simulation period of 2 years, starting in January. The minimum and maximum average fluid temperatures were 5,00 °C and 16,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Load data

For the simulation, a building load was used. This means that, in order to calculate the resulting extraction and injection loads for the ground, the efficiency of the heat pump will be taken into account. Below you can find a summary of the load.

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW





Regeneration data

For the regeneration, a heat exchanger with the outside air was used (such as e.g. a dry cooler). The available power of this exchanger is 20,00 kW/K with a minimum temperature difference (pinch temperature) across the heat exchanger of 0,00 0,00unit.

The weather file that was used is: BEL_Brussels.064510_IWEC.epw.

The algorithm used is 'yearly', which counteracts the imbalance in every year individually. When the selected regeneration technology is too small, a smaller imbalance can still remain.

The used horizon for the regeneration algorithm was 4380 hours and the regeneration was placed right before the borefield inlet.

4.6.2 Results

Regeneration

Over the whole simulation period, an average of 70 063 kWh/year in injection was regenerated. The maximum regeneration power was 97,10 kW. Due to the regeneration, the imbalance reduced from -88 761 kWh/year to -18 698 kWh/year.

Ground load

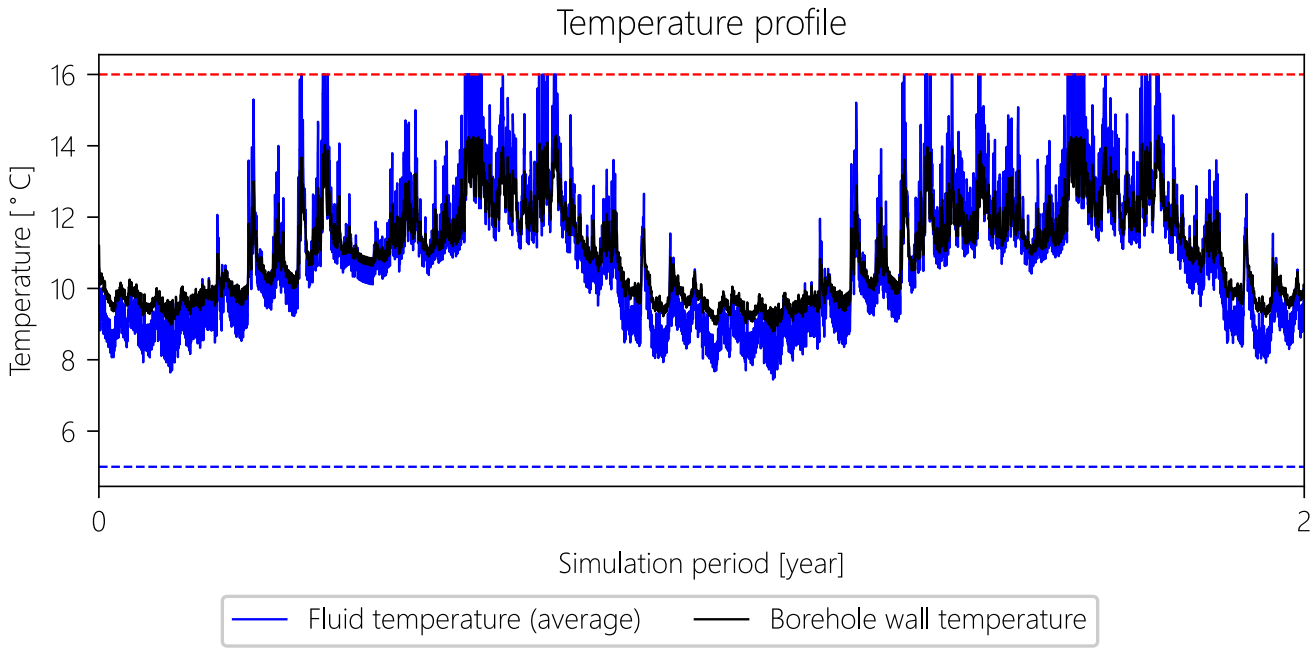
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	114 049 kWh/y	50,1 kW
Injection demand	25 288 kWh/y	101,5 kW
Regeneration (injection)	70 063 kWh/y	97,1 kW

Temperature evolution of the borefield

Using the pipe, fluid, and flow properties, the Reynolds number was calculated. Since this number depends on the fluid temperature and therefore varies over the simulation period, it was updated at every timestep to achieve the most accurate result possible.
Doing so, the Reynolds number during heat extraction was 3 476, whilst it was 4 417 during injection. This corresponds respectively to a transitional and turbulent flow regime, with an effective borehole thermal resistance of 0,1070 m·K/W and 0,1060 m·K/W during heat extraction and injection.

Below, the hourly simulation for the borefield is shown. The blue line represents the average fluid temperature between the inlet and outlet of the borehole at each hour of the simulation. The black line shows the borehole wall temperature, which is the interface between the borehole and the ground. The difference between both lines is determined by the effective borehole thermal resistance.



The maximum average fluid temperature over the whole simulation period is 16,01 °C, and the minimum average fluid temperature is 7,44 °C.

Pressure drop

The pressure drop over a single borehole is 5,63 kPa during extraction and 5,55 kPa during injection.

4.7 DC - 20 kW - inlet - 500h

In the first subsection, the scenario-specific input parameters will be discussed. Afterwards, the simulation results are presented.

4.7.1 Input

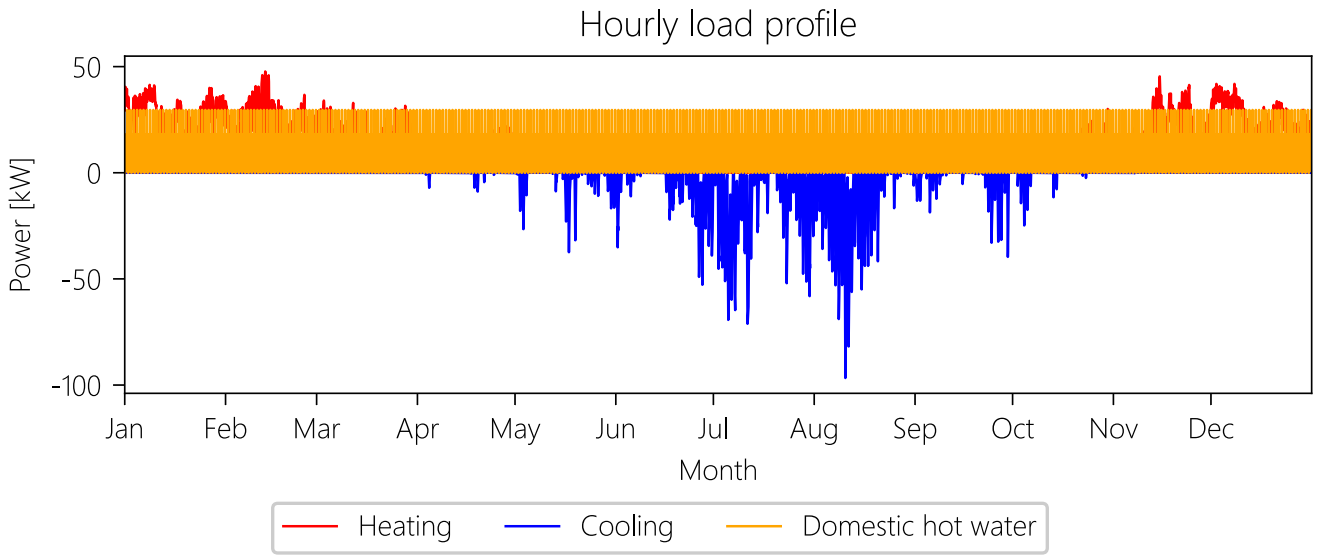
General simulation settings

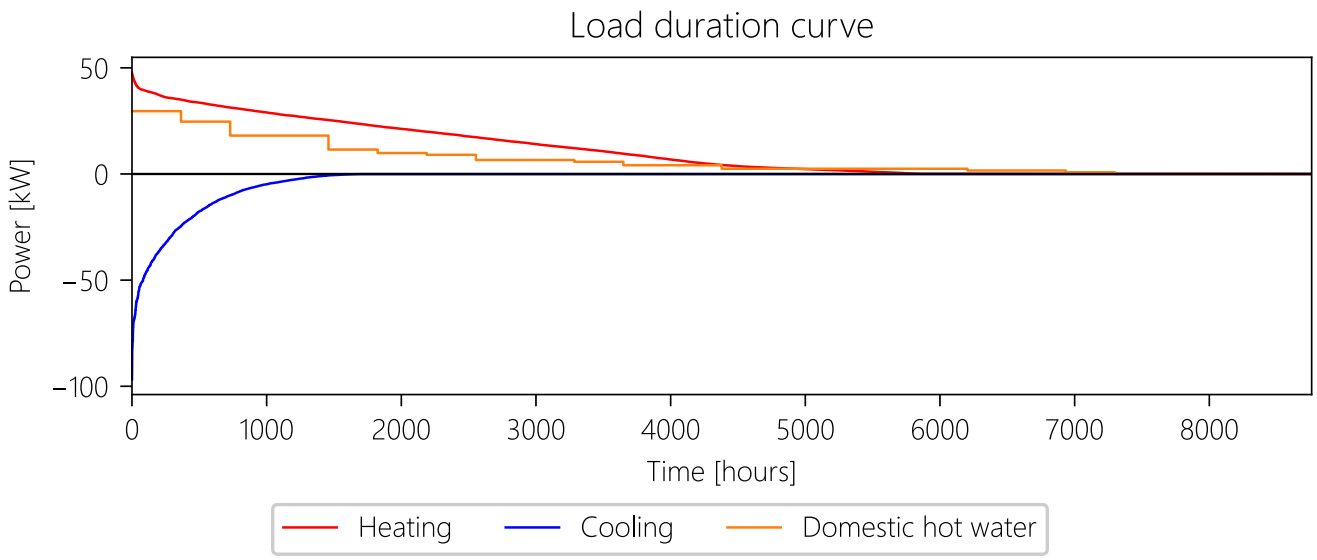
The scenarios in this report have been simulated with a simulation period of 2 years, starting in January. The minimum and maximum average fluid temperatures were 5,00 °C and 16,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Load data

For the simulation, a building load was used. This means that, in order to calculate the resulting extraction and injection loads for the ground, the efficiency of the heat pump will be taken into account. Below you can find a summary of the load.

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW





Regeneration data

For the regeneration, a heat exchanger with the outside air was used (such as e.g. a dry cooler). The available power of this exchanger is 20,00 kW/K with a minimum temperature difference (pinch temperature) across the heat exchanger of 0,00 0,00unit.

The weather file that was used is: BEL_Brussels.064510_IWEC.epw.

The algorithm used is 'yearly', which counteracts the imbalance in every year individually. When the selected regeneration technology is too small, a smaller imbalance can still remain.

The used horizon for the regeneration algorithm was 500 hours and the regeneration was placed right before the borefield inlet.

4.7.2 Results

Regeneration

Over the whole simulation period, an average of 88 761 kWh/year in injection was regenerated. The maximum regeneration power was 93,48 kW. Due to the regeneration, the imbalance reduced from -88 761 kWh/year to 0 kWh/year.

Ground load

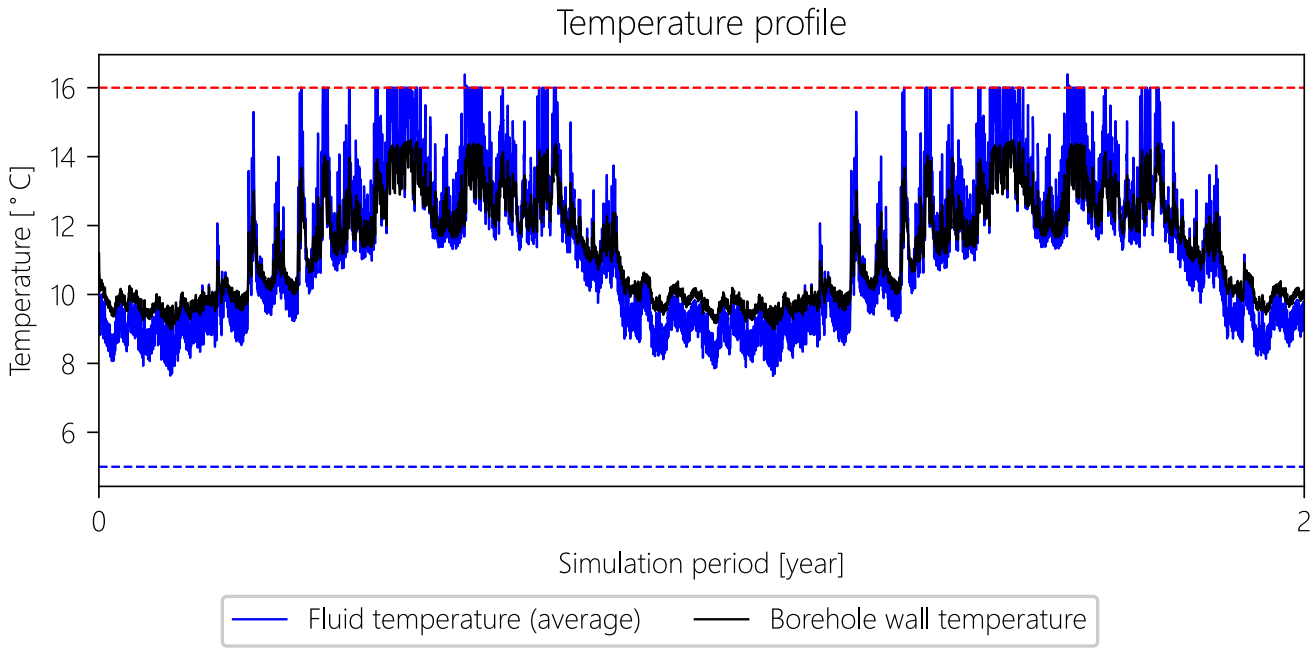
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	114 049 kWh/y	50,1 kW
Injection demand	25 288 kWh/y	101,5 kW
Regeneration (injection)	88 761 kWh/y	93,5 kW

Temperature evolution of the borefield

Using the pipe, fluid, and flow properties, the Reynolds number was calculated. Since this number depends on the fluid temperature and therefore varies over the simulation period, it was updated at every timestep to achieve the most accurate result possible.
Doing so, the Reynolds number during heat extraction was 3 495, whilst it was 4 461 during injection. This corresponds respectively to a transitional and turbulent flow regime, with an effective borehole thermal resistance of 0,1069 m·K/W and 0,1060 m·K/W during heat extraction and injection.

Below, the hourly simulation for the borefield is shown. The blue line represents the average fluid temperature between the inlet and outlet of the borehole at each hour of the simulation. The black line shows the borehole wall temperature, which is the interface between the borehole and the ground. The difference between both lines is determined by the effective borehole thermal resistance.



The maximum average fluid temperature over the whole simulation period is 16,39 °C, and the minimum average fluid temperature is 7,63 °C.

Pressure drop

The pressure drop over a single borehole is 5,62 kPa during extraction and 5,54 kPa during injection.

4.8 DC - 20 kW - inlet - 18°C - yearly

In the first subsection, the scenario-specific input parameters will be discussed. Afterwards, the simulation results are presented.

4.8.1 Input

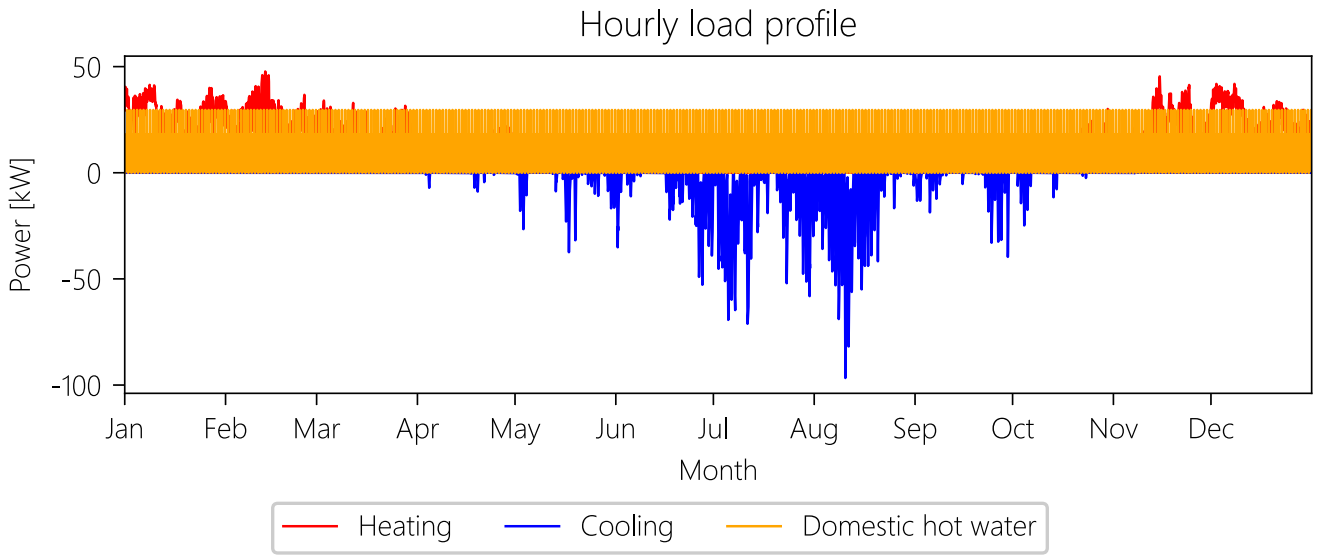
General simulation settings

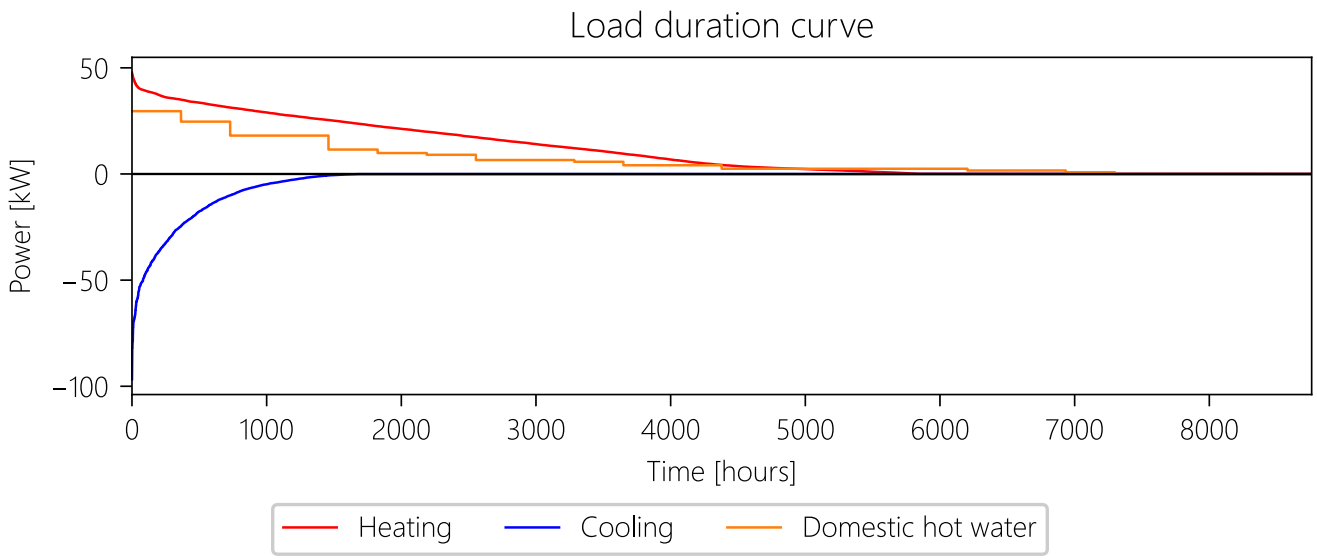
The scenarios in this report have been simulated with a simulation period of 2 years, starting in January. The minimum and maximum average fluid temperatures were 5,00 °C and 18,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Load data

For the simulation, a building load was used. This means that, in order to calculate the resulting extraction and injection loads for the ground, the efficiency of the heat pump will be taken into account. Below you can find a summary of the load.

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW





Regeneration data

For the regeneration, a heat exchanger with the outside air was used (such as e.g. a dry cooler). The available power of this exchanger is 20,00 kW/K with a minimum temperature difference (pinch temperature) across the heat exchanger of 0,00 0,00unit.

The weather file that was used is: BEL_Brussels.064510_IWEC.epw.

The algorithm used is 'yearly', which counteracts the imbalance in every year individually. When the selected regeneration technology is too small, a smaller imbalance can still remain.

The used horizon for the regeneration algorithm was 4380 hours and the regeneration was placed right before the borefield inlet.

4.8.2 Results

Regeneration

Over the whole simulation period, an average of 88 761 kWh/year in injection was regenerated. The maximum regeneration power was 104,71 kW. Due to the regeneration, the imbalance reduced from -88 761 kWh/year to 0 kWh/year.

Ground load

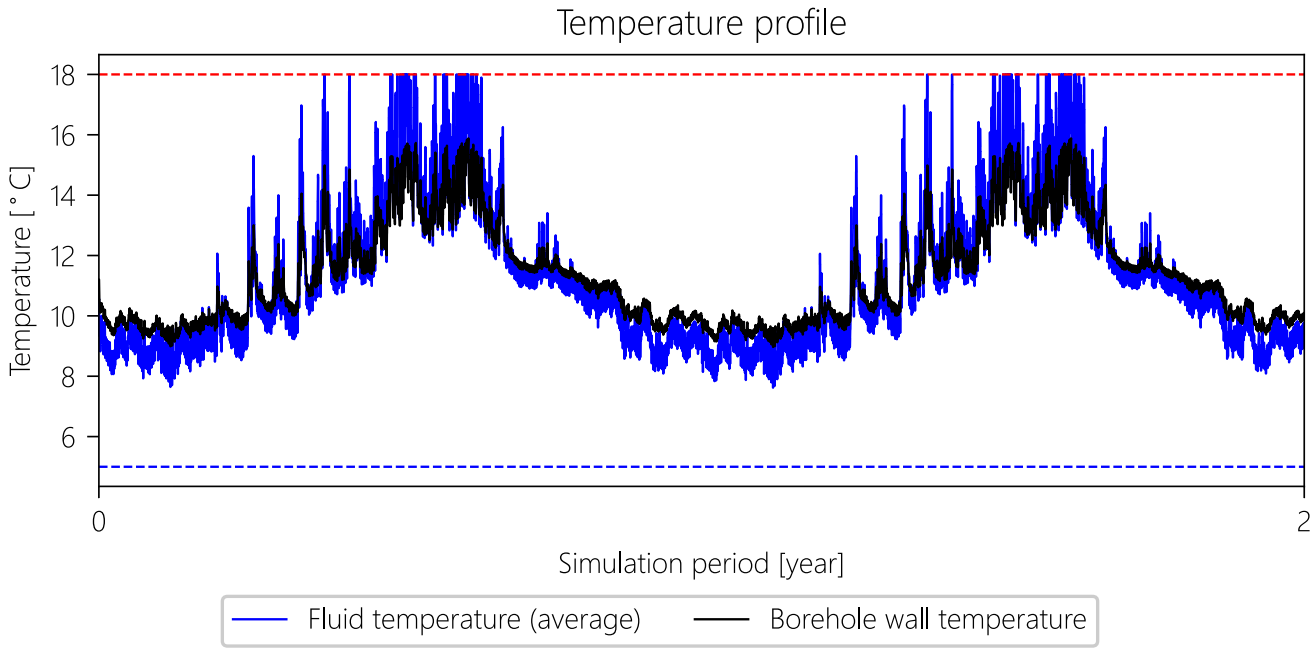
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	114 049 kWh/y	50,1 kW
Injection demand	25 288 kWh/y	101,5 kW
Regeneration (injection)	88 761 kWh/y	104,7 kW

Temperature evolution of the borefield

Using the pipe, fluid, and flow properties, the Reynolds number was calculated. Since this number depends on the fluid temperature and therefore varies over the simulation period, it was updated at every timestep to achieve the most accurate result possible.
Doing so, the Reynolds number during heat extraction was 3 494, whilst it was 4 650 during injection. This corresponds respectively to a transitional and turbulent flow regime, with an effective borehole thermal resistance of 0,1069 m·K/W and 0,1059 m·K/W during heat extraction and injection.

Below, the hourly simulation for the borefield is shown. The blue line represents the average fluid temperature between the inlet and outlet of the borehole at each hour of the simulation. The black line shows the borehole wall temperature, which is the interface between the borehole and the ground. The difference between both lines is determined by the effective borehole thermal resistance.



The maximum average fluid temperature over the whole simulation period is 18,00 °C, and the minimum average fluid temperature is 7,62 °C.

Pressure drop

The pressure drop over a single borehole is 5,62 kPa during extraction and 5,54 kPa during injection.

4.9 DC - 20 kW - inlet - 18°C - SP

In the first subsection, the scenario-specific input parameters will be discussed. Afterwards, the simulation results are presented.

4.9.1 Input

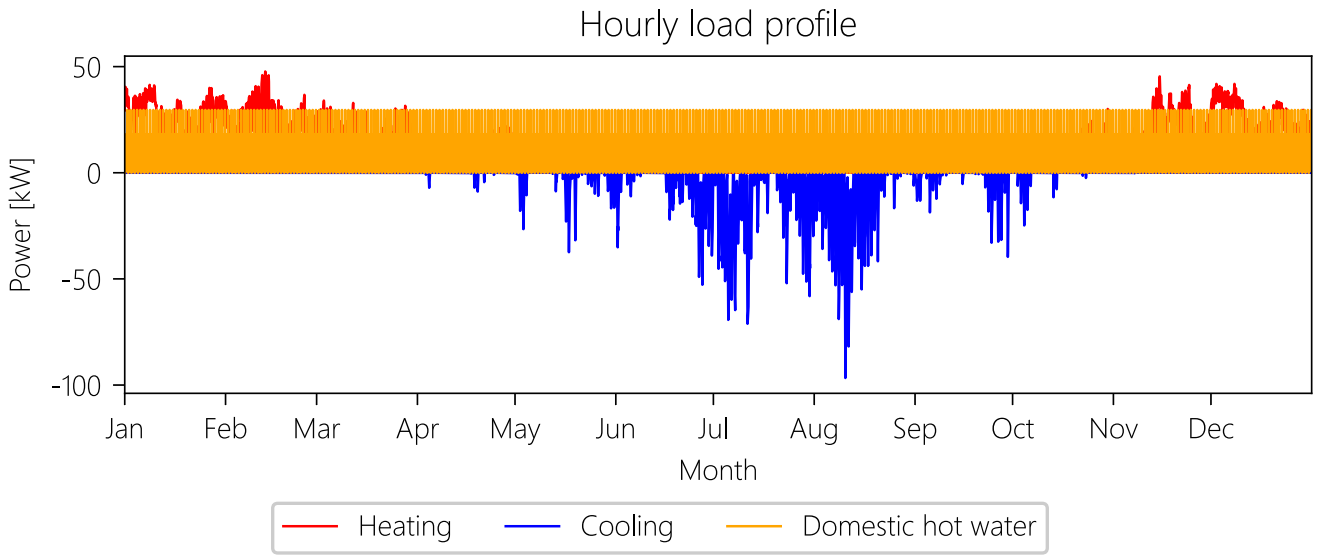
General simulation settings

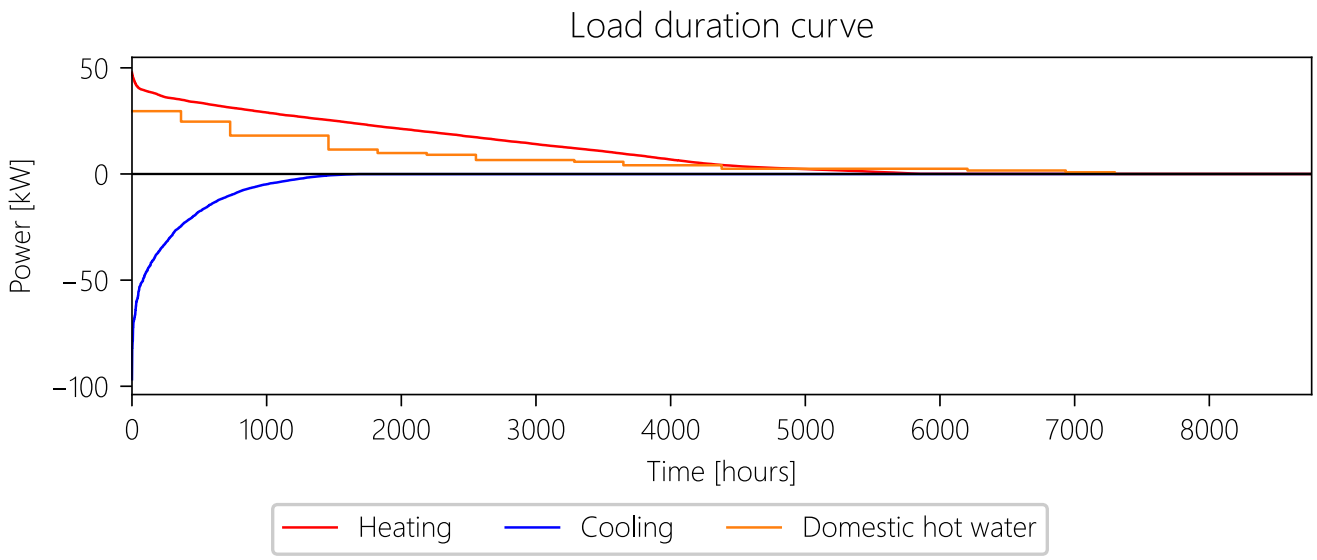
The scenarios in this report have been simulated with a simulation period of 2 years, starting in January. The minimum and maximum average fluid temperatures were 5,00 °C and 18,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Load data

For the simulation, a building load was used. This means that, in order to calculate the resulting extraction and injection loads for the ground, the efficiency of the heat pump will be taken into account. Below you can find a summary of the load.

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW





Regeneration data

For the regeneration, a heat exchanger with the outside air was used (such as e.g. a dry cooler). The available power of this exchanger is 20,00 kW/K with a minimum temperature difference (pinch temperature) across the heat exchanger of 0,00 0,00unit.

The weather file that was used is: BEL_Brussels.064510_IWEC.epw.

The algorithm used is 'simulation period', which counteracts the imbalance over the entire simulation period directly. This implies that it will try to regenerate as much as possible as soon as possible. This method can temporarily switch the regeneration from extraction to injection and vice versa, but over the entire simulation period, the system will be balanced, except when the selected regeneration technology is too small.

The used horizon for the regeneration algorithm was 4380 hours and the regeneration was placed right before the borefield inlet.

4.9.2 Results

Regeneration

Over the whole simulation period, an average of 88 761 kWh/year in injection was regenerated. The maximum regeneration power was 104,71 kW. Due to the regeneration, the imbalance reduced from -88 761 kWh/year to 0 kWh/year.

Ground load

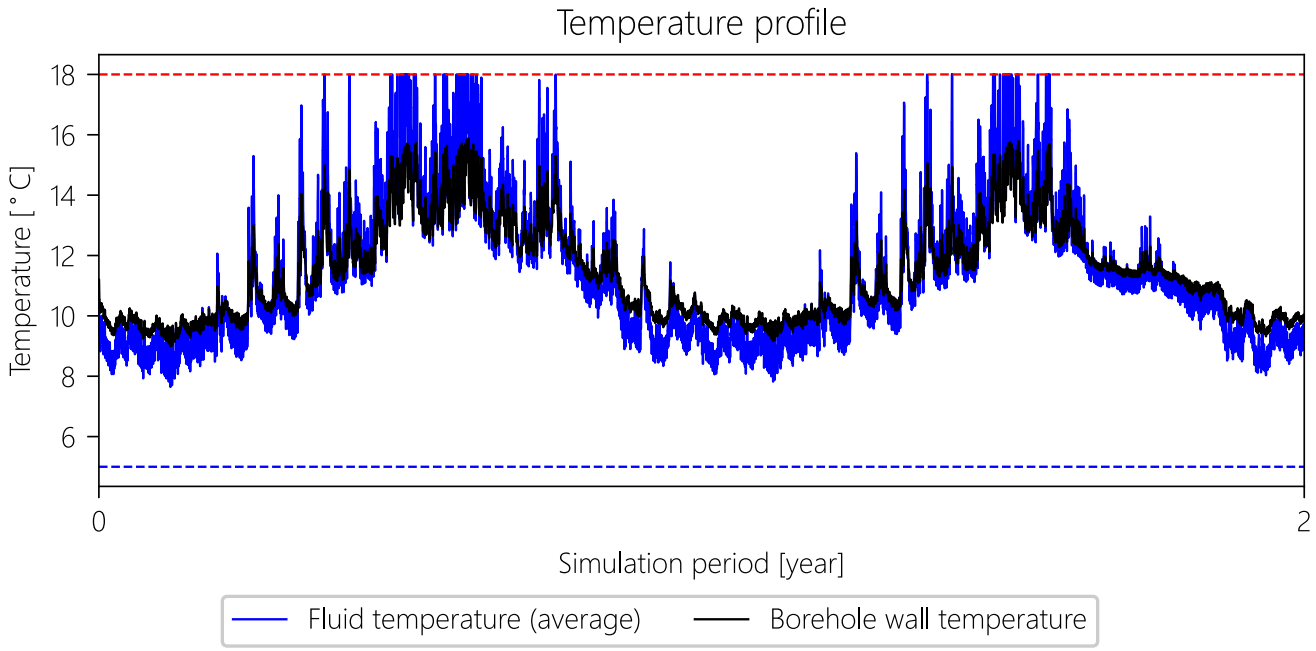
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	114 049 kWh/y	50,1 kW
Injection demand	25 288 kWh/y	101,5 kW
Regeneration (injection)	88 761 kWh/y	104,7 kW

Temperature evolution of the borefield

Using the pipe, fluid, and flow properties, the Reynolds number was calculated. Since this number depends on the fluid temperature and therefore varies over the simulation period, it was updated at every timestep to achieve the most accurate result possible.
Doing so, the Reynolds number during heat extraction was 3 496, whilst it was 4 650 during injection. This corresponds respectively to a transitional and turbulent flow regime, with an effective borehole thermal resistance of 0,1069 m·K/W and 0,1059 m·K/W during heat extraction and injection.

Below, the hourly simulation for the borefield is shown. The blue line represents the average fluid temperature between the inlet and outlet of the borehole at each hour of the simulation. The black line shows the borehole wall temperature, which is the interface between the borehole and the ground. The difference between both lines is determined by the effective borehole thermal resistance.



The maximum average fluid temperature over the whole simulation period is 18,01 °C, and the minimum average fluid temperature is 7,64 °C.

Pressure drop

The pressure drop over a single borehole is 5,62 kPa during extraction and 5,54 kPa during injection.

4.10 DC - 20 kW - inlet - 18°C - PH

In the first subsection, the scenario-specific input parameters will be discussed. Afterwards, the simulation results are presented.

4.10.1 Input

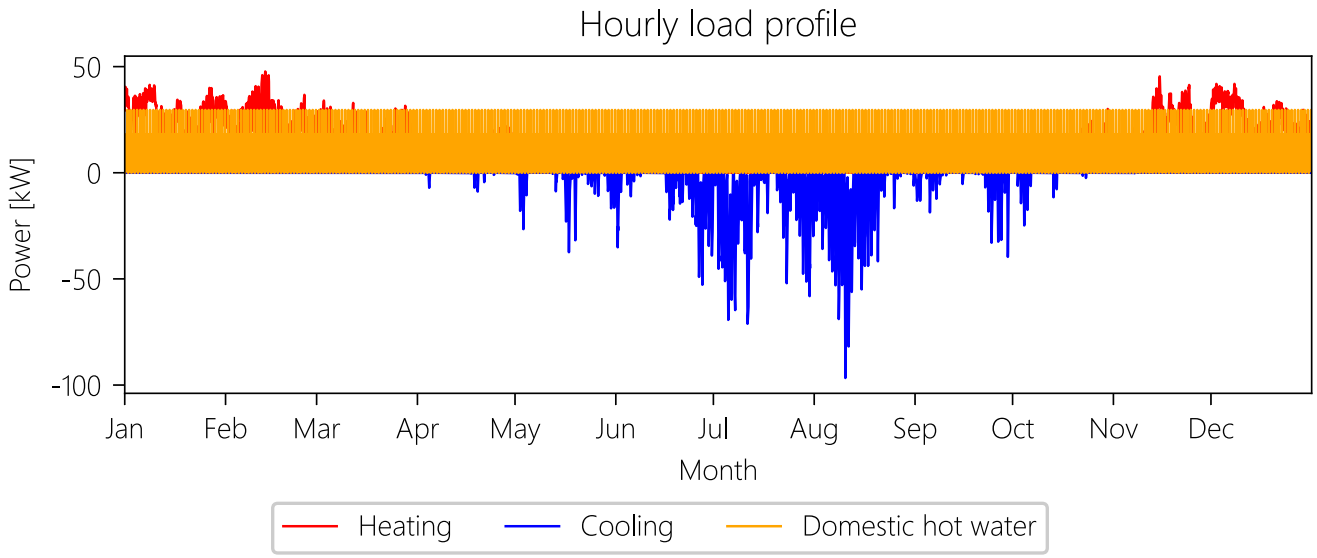
General simulation settings

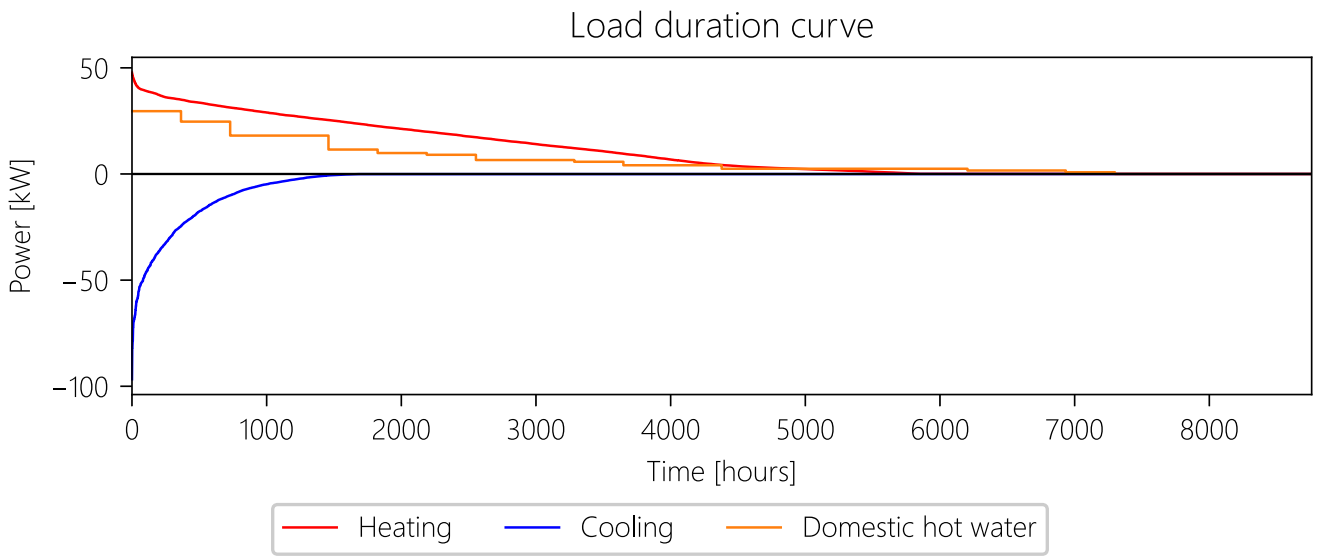
The scenarios in this report have been simulated with a simulation period of 2 years, starting in January. The minimum and maximum average fluid temperatures were 5,00 °C and 18,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Load data

For the simulation, a building load was used. This means that, in order to calculate the resulting extraction and injection loads for the ground, the efficiency of the heat pump will be taken into account. Below you can find a summary of the load.

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW





Regeneration data

For the regeneration, a heat exchanger with the outside air was used (such as e.g. a dry cooler). The available power of this exchanger is 20,00 kW/K with a minimum temperature difference (pinch temperature) across the heat exchanger of 0,00 0,00unit.

The weather file that was used is: BEL_Brussels.064510_IWEC.epw.

The algorithm used is 'proceeding horizon', which regenerates only the imbalance that has already occurred. If the system is, for example, extraction dominated, it will only start to inject heat into the ground when the cumulative imbalance of the previous hours is extraction dominated. Over the entire simulation period, a small imbalance can remain, since this algorithm does not anticipate future loads.

The used horizon for the regeneration algorithm was 4380 hours and the regeneration was placed right before the borefield inlet.

4.10.2 Results

Regeneration

Over the whole simulation period, an average of 73 336 kWh/year in injection was regenerated. The maximum regeneration power was 105,84 kW. Due to the regeneration, the imbalance reduced from -88 761 kWh/year to -15 425 kWh/year.

Ground load

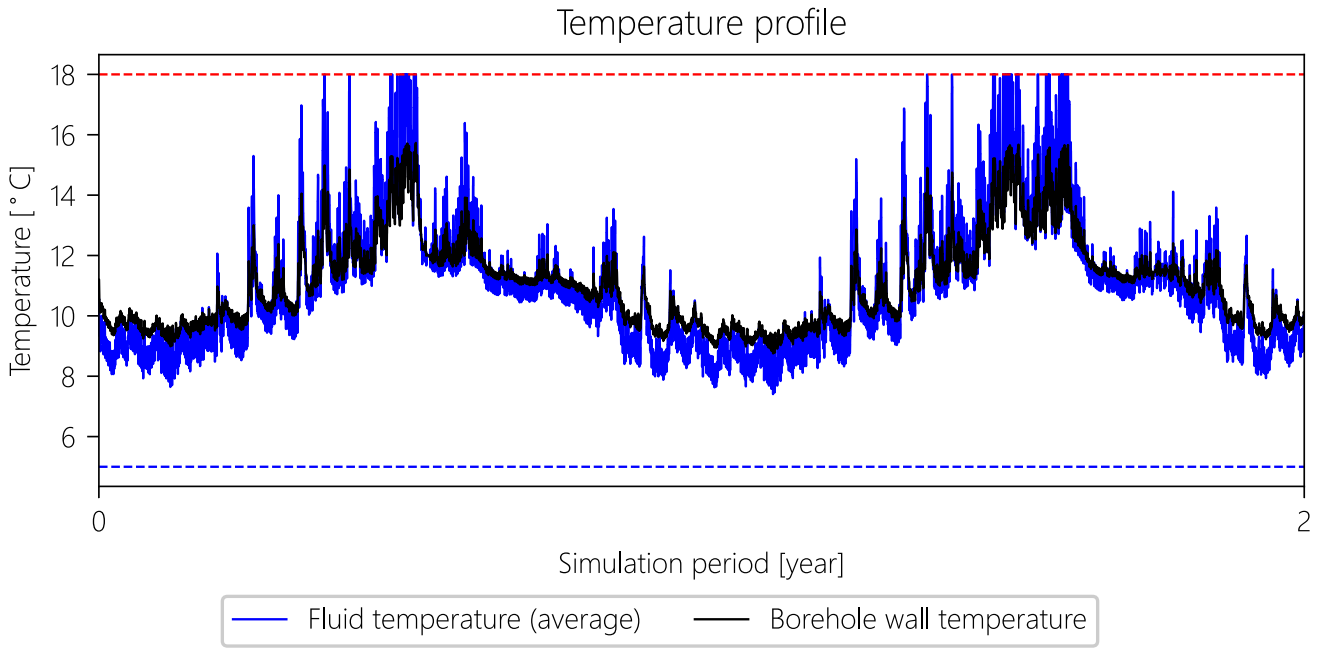
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	114 049 kWh/y	50,1 kW
Injection demand	25 288 kWh/y	101,5 kW
Regeneration (injection)	73 336 kWh/y	105,8 kW

Temperature evolution of the borefield

Using the pipe, fluid, and flow properties, the Reynolds number was calculated. Since this number depends on the fluid temperature and therefore varies over the simulation period, it was updated at every timestep to achieve the most accurate result possible.
Doing so, the Reynolds number during heat extraction was 3 472, whilst it was 4 650 during injection. This corresponds respectively to a transitional and turbulent flow regime, with an effective borehole thermal resistance of 0,1070 m·K/W and 0,1059 m·K/W during heat extraction and injection.

Below, the hourly simulation for the borefield is shown. The blue line represents the average fluid temperature between the inlet and outlet of the borehole at each hour of the simulation. The black line shows the borehole wall temperature, which is the interface between the borehole and the ground. The difference between both lines is determined by the effective borehole thermal resistance.



The maximum average fluid temperature over the whole simulation period is 18,00 °C, and the minimum average fluid temperature is 7,41 °C.

Pressure drop

The pressure drop over a single borehole is 5,63 kPa during extraction and 5,55 kPa during injection.

4.11 DC - 20 kW - inlet - 18°C - PH+

In the first subsection, the scenario-specific input parameters will be discussed. Afterwards, the simulation results are presented.

4.11.1 Input

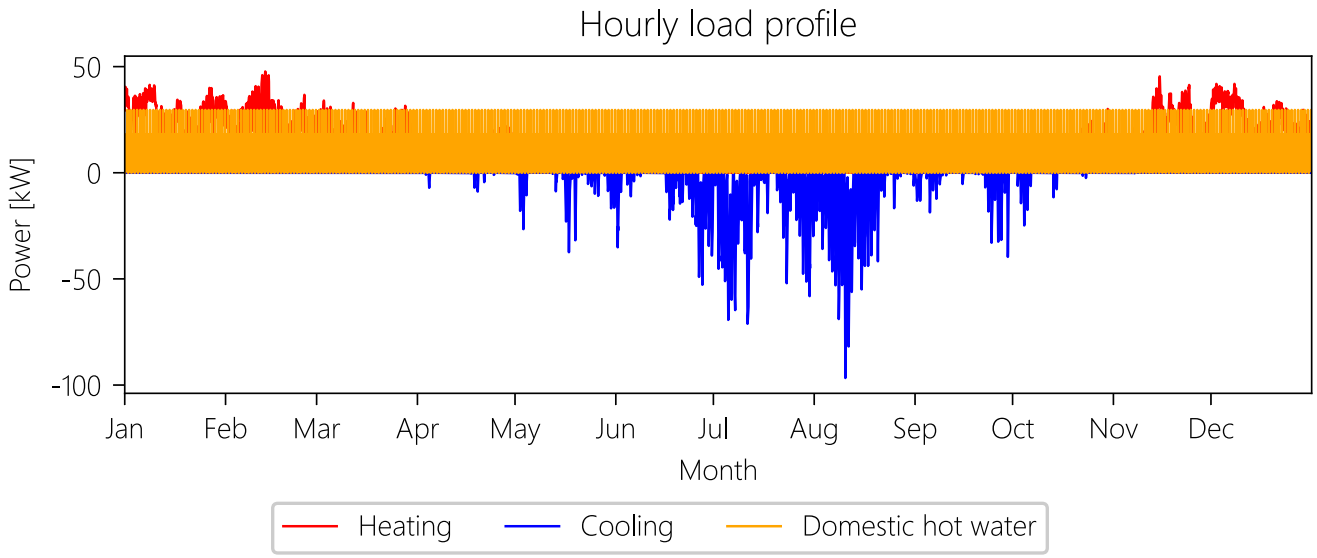
General simulation settings

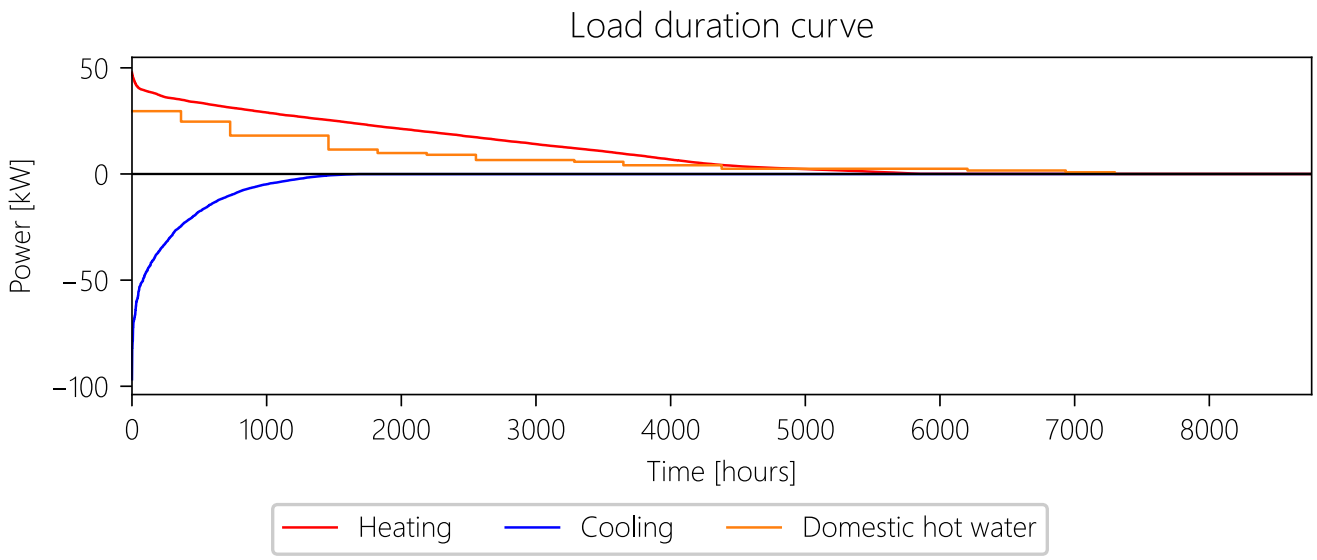
The scenarios in this report have been simulated with a simulation period of 2 years, starting in January. The minimum and maximum average fluid temperatures were 5,00 °C and 18,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Load data

For the simulation, a building load was used. This means that, in order to calculate the resulting extraction and injection loads for the ground, the efficiency of the heat pump will be taken into account. Below you can find a summary of the load.

Building demand	Yearly load	Peak power
Heating demand	92 547 kWh/y	47,7 kW
Domestic hot water demand	60 017 kWh/y	29,6 kW
Cooling demand	24 084 kWh/y	96,7 kW





Regeneration data

For the regeneration, a heat exchanger with the outside air was used (such as e.g. a dry cooler). The available power of this exchanger is 20,00 kW/K with a minimum temperature difference (pinch temperature) across the heat exchanger of 0,00 0,00unit.

The weather file that was used is: BEL_Brussels.064510_IWEC.epw.

The algorithm used is 'proceeding horizon+', which regenerates the borefield through both extraction and injection. Every hour, it checks whether there is an imbalance due to the previous ground loads and tries to counteract this imbalance. With this method, it is possible to have regeneration through both injection and extraction. Over the entire simulation period, a small imbalance can remain, since this algorithm does not anticipate future loads.

The used horizon for the regeneration algorithm was 4380 hours and the regeneration was placed right before the borefield inlet.

4.11.2 Results

Regeneration

Over the whole simulation period, an average of 73 327 kWh/year in injection was regenerated. The maximum regeneration power was 105,92 kW. Due to the regeneration, the imbalance reduced from -88 761 kWh/year to -15 434 kWh/year.

Ground load

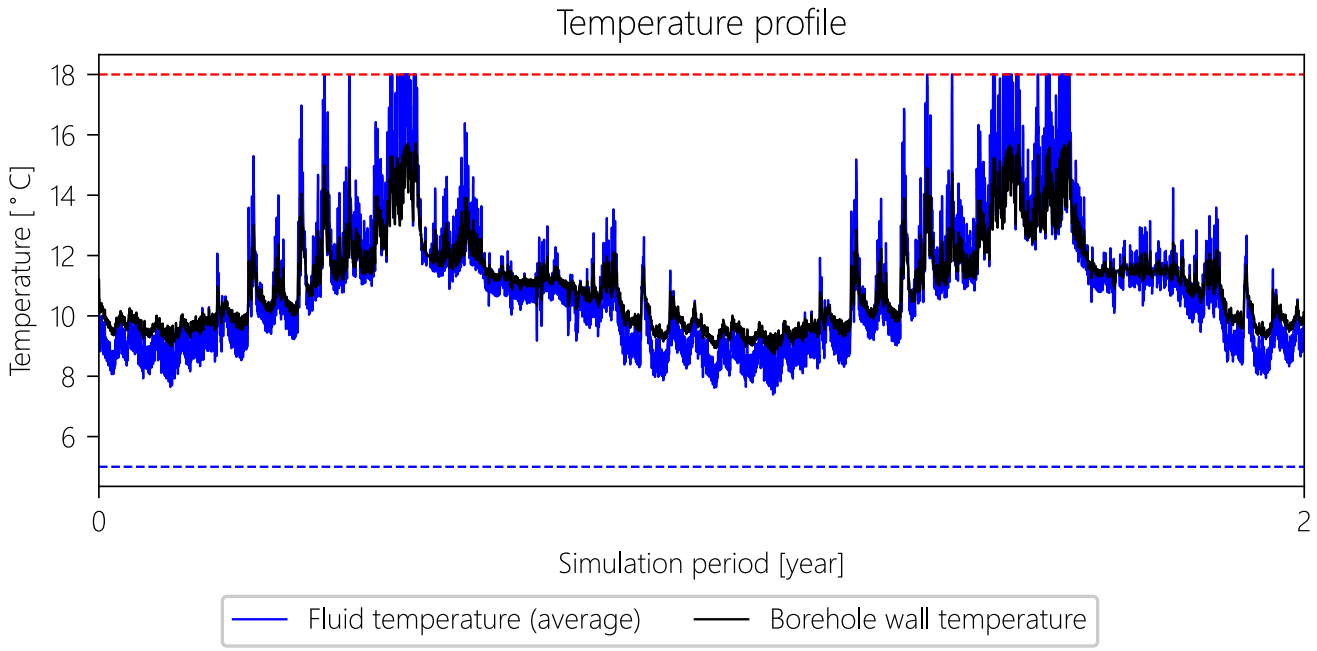
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	114 049 kWh/y	50,1 kW
Injection demand	25 288 kWh/y	101,5 kW
Regeneration (injection)	73 327 kWh/y	105,9 kW

Temperature evolution of the borefield

Using the pipe, fluid, and flow properties, the Reynolds number was calculated. Since this number depends on the fluid temperature and therefore varies over the simulation period, it was updated at every timestep to achieve the most accurate result possible.
Doing so, the Reynolds number during heat extraction was 3 470, whilst it was 4 650 during injection. This corresponds respectively to a transitional and turbulent flow regime, with an effective borehole thermal resistance of 0,1070 m·K/W and 0,1059 m·K/W during heat extraction and injection.

Below, the hourly simulation for the borefield is shown. The blue line represents the average fluid temperature between the inlet and outlet of the borehole at each hour of the simulation. The black line shows the borehole wall temperature, which is the interface between the borehole and the ground. The difference between both lines is determined by the effective borehole thermal resistance.



The maximum average fluid temperature over the whole simulation period is 18,01 °C, and the minimum average fluid temperature is 7,39 °C.

Pressure drop

The pressure drop over a single borehole is 5,63 kPa during extraction and 5,55 kPa during injection.

5.1 Design Data - Simulation

Design parameters

- Maximum average fluid temperature: 16 °C
- Minimum average fluid temperature: 5 °C
- First month of simulation: 1
- Simulation period: 40 years

Ground parameters

- Homogeneous ground conductivity: 2 W/(m·K)
- Homogeneous volumetric heat capacity: 2,4 MJ/(m^3·K)
- Ground surface temperature: 9,6 °C
- Ground flux: 0,07 W/m^2

Borehole parameters

- Borehole diameter: 140 mm

Pipe parameters

- U tube DN32 PN16
- Grout thermal conductivity: 1,5 W/(m·K)
- Number of U-tubes: 2
- Pipe conductivity: 0,4 W/(m·K)
- Pipe roughness: 0,001 mm

Fluid properties

- Water
- Mass flow rate per borehole: 0,2 kg/s

Thermal demand

- Type of load: Hourly building load
- Domestic hot water: 60 016,95 kWh/year
- SCOP heating: 5
- SCOP domestic hot water: 3
- SEER cooling: 20

Borefield parameters

x [m]	y [m]	Length [m]	Depth [m]	Buried depth [m]	Tilt [°]	Orientation [°]
0,00	0,00	99,00	100,00	1,00	0,00	0,00
0,00	6,00	99,00	100,00	1,00	0,00	0,00
0,00	12,00	99,00	100,00	1,00	0,00	0,00

0,00	18,00	99,00	100,00	1,00	0,00	0,00
6,00	0,00	99,00	100,00	1,00	0,00	0,00
6,00	6,00	99,00	100,00	1,00	0,00	0,00
6,00	12,00	99,00	100,00	1,00	0,00	0,00
6,00	18,00	99,00	100,00	1,00	0,00	0,00
12,00	0,00	99,00	100,00	1,00	0,00	0,00
12,00	6,00	99,00	100,00	1,00	0,00	0,00
12,00	12,00	99,00	100,00	1,00	0,00	0,00
12,00	18,00	99,00	100,00	1,00	0,00	0,00
18,00	0,00	99,00	100,00	1,00	0,00	0,00
18,00	6,00	99,00	100,00	1,00	0,00	0,00
18,00	12,00	99,00	100,00	1,00	0,00	0,00
18,00	18,00	99,00	100,00	1,00	0,00	0,00
24,00	0,00	99,00	100,00	1,00	0,00	0,00
24,00	6,00	99,00	100,00	1,00	0,00	0,00
24,00	12,00	99,00	100,00	1,00	0,00	0,00
24,00	18,00	99,00	100,00	1,00	0,00	0,00
30,00	0,00	99,00	100,00	1,00	0,00	0,00
30,00	6,00	99,00	100,00	1,00	0,00	0,00
30,00	12,00	99,00	100,00	1,00	0,00	0,00
30,00	18,00	99,00	100,00	1,00	0,00	0,00
36,00	0,00	99,00	100,00	1,00	0,00	0,00
36,00	6,00	99,00	100,00	1,00	0,00	0,00
36,00	12,00	99,00	100,00	1,00	0,00	0,00
36,00	18,00	99,00	100,00	1,00	0,00	0,00
42,00	0,00	99,00	100,00	1,00	0,00	0,00
42,00	6,00	99,00	100,00	1,00	0,00	0,00
42,00	12,00	99,00	100,00	1,00	0,00	0,00
42,00	18,00	99,00	100,00	1,00	0,00	0,00
48,00	0,00	99,00	100,00	1,00	0,00	0,00
48,00	6,00	99,00	100,00	1,00	0,00	0,00
48,00	12,00	99,00	100,00	1,00	0,00	0,00
48,00	18,00	99,00	100,00	1,00	0,00	0,00
54,00	0,00	99,00	100,00	1,00	0,00	0,00
54,00	6,00	99,00	100,00	1,00	0,00	0,00
54,00	12,00	99,00	100,00	1,00	0,00	0,00
54,00	18,00	99,00	100,00	1,00	0,00	0,00

5.2 Design Data - DC - 5 kW - inlet

Design parameters

- Maximum average fluid temperature: 16 °C
- Minimum average fluid temperature: 5 °C
- First month of simulation: 1
- Simulation period: 2 years

Ground parameters

- Homogeneous ground conductivity: 2 W/(m·K)
- Homogeneous volumetric heat capacity: 2,4 MJ/(m^3·K)
- Ground surface temperature: 9,6 °C
- Ground flux: 0,07 W/m^2

Borehole parameters

- Borehole diameter: 140 mm

Pipe parameters

- U tube DN32 PN16
- Grout thermal conductivity: 1,5 W/(m·K)
- Number of U-tubes: 2
- Pipe conductivity: 0,4 W/(m·K)
- Pipe roughness: 0,001 mm

Fluid properties

- Water
- Mass flow rate per borehole: 0,2 kg/s

Thermal demand

- Type of load: Hourly building load
- Domestic hot water: 60 016,95 kWh/year
- SCOP heating: 5
- SCOP domestic hot water: 3
- SEER cooling: 20

Borefield parameters

x [m]	y [m]	Length [m]	Depth [m]	Buried depth [m]	Tilt [°]	Orientation [°]
0,00	0,00	99,00	100,00	1,00	0,00	0,00
0,00	6,00	99,00	100,00	1,00	0,00	0,00
0,00	12,00	99,00	100,00	1,00	0,00	0,00
0,00	18,00	99,00	100,00	1,00	0,00	0,00

6,00	0,00	99,00	100,00	1,00	0,00	0,00
6,00	6,00	99,00	100,00	1,00	0,00	0,00
6,00	12,00	99,00	100,00	1,00	0,00	0,00
6,00	18,00	99,00	100,00	1,00	0,00	0,00
12,00	0,00	99,00	100,00	1,00	0,00	0,00
12,00	6,00	99,00	100,00	1,00	0,00	0,00
12,00	12,00	99,00	100,00	1,00	0,00	0,00
12,00	18,00	99,00	100,00	1,00	0,00	0,00
18,00	0,00	99,00	100,00	1,00	0,00	0,00
18,00	6,00	99,00	100,00	1,00	0,00	0,00
18,00	12,00	99,00	100,00	1,00	0,00	0,00
18,00	18,00	99,00	100,00	1,00	0,00	0,00
24,00	0,00	99,00	100,00	1,00	0,00	0,00
24,00	6,00	99,00	100,00	1,00	0,00	0,00
24,00	12,00	99,00	100,00	1,00	0,00	0,00
24,00	18,00	99,00	100,00	1,00	0,00	0,00
30,00	0,00	99,00	100,00	1,00	0,00	0,00
30,00	6,00	99,00	100,00	1,00	0,00	0,00
30,00	12,00	99,00	100,00	1,00	0,00	0,00
30,00	18,00	99,00	100,00	1,00	0,00	0,00
36,00	0,00	99,00	100,00	1,00	0,00	0,00
36,00	6,00	99,00	100,00	1,00	0,00	0,00
36,00	12,00	99,00	100,00	1,00	0,00	0,00
36,00	18,00	99,00	100,00	1,00	0,00	0,00
42,00	0,00	99,00	100,00	1,00	0,00	0,00
42,00	6,00	99,00	100,00	1,00	0,00	0,00
42,00	12,00	99,00	100,00	1,00	0,00	0,00
42,00	18,00	99,00	100,00	1,00	0,00	0,00
48,00	0,00	99,00	100,00	1,00	0,00	0,00
48,00	6,00	99,00	100,00	1,00	0,00	0,00
48,00	12,00	99,00	100,00	1,00	0,00	0,00
48,00	18,00	99,00	100,00	1,00	0,00	0,00
54,00	0,00	99,00	100,00	1,00	0,00	0,00
54,00	6,00	99,00	100,00	1,00	0,00	0,00
54,00	12,00	99,00	100,00	1,00	0,00	0,00
54,00	18,00	99,00	100,00	1,00	0,00	0,00

5.3 Design Data - DC - 5 kW - outlet

Design parameters

- Maximum average fluid temperature: 16 °C
- Minimum average fluid temperature: 5 °C
- First month of simulation: 1
- Simulation period: 2 years

Ground parameters

- Homogeneous ground conductivity: 2 W/(m·K)
- Homogeneous volumetric heat capacity: 2,4 MJ/(m^3·K)
- Ground surface temperature: 9,6 °C
- Ground flux: 0,07 W/m^2

Borehole parameters

- Borehole diameter: 140 mm

Pipe parameters

- U tube DN32 PN16
- Grout thermal conductivity: 1,5 W/(m·K)
- Number of U-tubes: 2
- Pipe conductivity: 0,4 W/(m·K)
- Pipe roughness: 0,001 mm

Fluid properties

- Water
- Mass flow rate per borehole: 0,2 kg/s

Thermal demand

- Type of load: Hourly building load
- Domestic hot water: 60 016,95 kWh/year
- SCOP heating: 5
- SCOP domestic hot water: 3
- SEER cooling: 20

Borefield parameters

x [m]	y [m]	Length [m]	Depth [m]	Buried depth [m]	Tilt [°]	Orientation [°]
0,00	0,00	99,00	100,00	1,00	0,00	0,00
0,00	6,00	99,00	100,00	1,00	0,00	0,00
0,00	12,00	99,00	100,00	1,00	0,00	0,00
0,00	18,00	99,00	100,00	1,00	0,00	0,00

6,00	0,00	99,00	100,00	1,00	0,00	0,00
6,00	6,00	99,00	100,00	1,00	0,00	0,00
6,00	12,00	99,00	100,00	1,00	0,00	0,00
6,00	18,00	99,00	100,00	1,00	0,00	0,00
12,00	0,00	99,00	100,00	1,00	0,00	0,00
12,00	6,00	99,00	100,00	1,00	0,00	0,00
12,00	12,00	99,00	100,00	1,00	0,00	0,00
12,00	18,00	99,00	100,00	1,00	0,00	0,00
18,00	0,00	99,00	100,00	1,00	0,00	0,00
18,00	6,00	99,00	100,00	1,00	0,00	0,00
18,00	12,00	99,00	100,00	1,00	0,00	0,00
18,00	18,00	99,00	100,00	1,00	0,00	0,00
24,00	0,00	99,00	100,00	1,00	0,00	0,00
24,00	6,00	99,00	100,00	1,00	0,00	0,00
24,00	12,00	99,00	100,00	1,00	0,00	0,00
24,00	18,00	99,00	100,00	1,00	0,00	0,00
30,00	0,00	99,00	100,00	1,00	0,00	0,00
30,00	6,00	99,00	100,00	1,00	0,00	0,00
30,00	12,00	99,00	100,00	1,00	0,00	0,00
30,00	18,00	99,00	100,00	1,00	0,00	0,00
36,00	0,00	99,00	100,00	1,00	0,00	0,00
36,00	6,00	99,00	100,00	1,00	0,00	0,00
36,00	12,00	99,00	100,00	1,00	0,00	0,00
36,00	18,00	99,00	100,00	1,00	0,00	0,00
42,00	0,00	99,00	100,00	1,00	0,00	0,00
42,00	6,00	99,00	100,00	1,00	0,00	0,00
42,00	12,00	99,00	100,00	1,00	0,00	0,00
42,00	18,00	99,00	100,00	1,00	0,00	0,00
48,00	0,00	99,00	100,00	1,00	0,00	0,00
48,00	6,00	99,00	100,00	1,00	0,00	0,00
48,00	12,00	99,00	100,00	1,00	0,00	0,00
48,00	18,00	99,00	100,00	1,00	0,00	0,00
54,00	0,00	99,00	100,00	1,00	0,00	0,00
54,00	6,00	99,00	100,00	1,00	0,00	0,00
54,00	12,00	99,00	100,00	1,00	0,00	0,00
54,00	18,00	99,00	100,00	1,00	0,00	0,00

5.4 Design Data - DC - 5 kW - inlet - 2°C

Design parameters

- Maximum average fluid temperature: 16 °C
- Minimum average fluid temperature: 5 °C
- First month of simulation: 1
- Simulation period: 2 years

Ground parameters

- Homogeneous ground conductivity: 2 W/(m·K)
- Homogeneous volumetric heat capacity: 2,4 MJ/(m^3·K)
- Ground surface temperature: 9,6 °C
- Ground flux: 0,07 W/m^2

Borehole parameters

- Borehole diameter: 140 mm

Pipe parameters

- U tube DN32 PN16
- Grout thermal conductivity: 1,5 W/(m·K)
- Number of U-tubes: 2
- Pipe conductivity: 0,4 W/(m·K)
- Pipe roughness: 0,001 mm

Fluid properties

- Water
- Mass flow rate per borehole: 0,2 kg/s

Thermal demand

- Type of load: Hourly building load
- Domestic hot water: 60 016,95 kWh/year
- SCOP heating: 5
- SCOP domestic hot water: 3
- SEER cooling: 20

Borefield parameters

x [m]	y [m]	Length [m]	Depth [m]	Buried depth [m]	Tilt [°]	Orientation [°]
0,00	0,00	99,00	100,00	1,00	0,00	0,00
0,00	6,00	99,00	100,00	1,00	0,00	0,00
0,00	12,00	99,00	100,00	1,00	0,00	0,00
0,00	18,00	99,00	100,00	1,00	0,00	0,00

6,00	0,00	99,00	100,00	1,00	0,00	0,00
6,00	6,00	99,00	100,00	1,00	0,00	0,00
6,00	12,00	99,00	100,00	1,00	0,00	0,00
6,00	18,00	99,00	100,00	1,00	0,00	0,00
12,00	0,00	99,00	100,00	1,00	0,00	0,00
12,00	6,00	99,00	100,00	1,00	0,00	0,00
12,00	12,00	99,00	100,00	1,00	0,00	0,00
12,00	18,00	99,00	100,00	1,00	0,00	0,00
18,00	0,00	99,00	100,00	1,00	0,00	0,00
18,00	6,00	99,00	100,00	1,00	0,00	0,00
18,00	12,00	99,00	100,00	1,00	0,00	0,00
18,00	18,00	99,00	100,00	1,00	0,00	0,00
24,00	0,00	99,00	100,00	1,00	0,00	0,00
24,00	6,00	99,00	100,00	1,00	0,00	0,00
24,00	12,00	99,00	100,00	1,00	0,00	0,00
24,00	18,00	99,00	100,00	1,00	0,00	0,00
30,00	0,00	99,00	100,00	1,00	0,00	0,00
30,00	6,00	99,00	100,00	1,00	0,00	0,00
30,00	12,00	99,00	100,00	1,00	0,00	0,00
30,00	18,00	99,00	100,00	1,00	0,00	0,00
36,00	0,00	99,00	100,00	1,00	0,00	0,00
36,00	6,00	99,00	100,00	1,00	0,00	0,00
36,00	12,00	99,00	100,00	1,00	0,00	0,00
36,00	18,00	99,00	100,00	1,00	0,00	0,00
42,00	0,00	99,00	100,00	1,00	0,00	0,00
42,00	6,00	99,00	100,00	1,00	0,00	0,00
42,00	12,00	99,00	100,00	1,00	0,00	0,00
42,00	18,00	99,00	100,00	1,00	0,00	0,00
48,00	0,00	99,00	100,00	1,00	0,00	0,00
48,00	6,00	99,00	100,00	1,00	0,00	0,00
48,00	12,00	99,00	100,00	1,00	0,00	0,00
48,00	18,00	99,00	100,00	1,00	0,00	0,00
54,00	0,00	99,00	100,00	1,00	0,00	0,00
54,00	6,00	99,00	100,00	1,00	0,00	0,00
54,00	12,00	99,00	100,00	1,00	0,00	0,00
54,00	18,00	99,00	100,00	1,00	0,00	0,00

5.5 Design Data - DC - 10 kW - inlet

Design parameters

- Maximum average fluid temperature: 16 °C
- Minimum average fluid temperature: 5 °C
- First month of simulation: 1
- Simulation period: 2 years

Ground parameters

- Homogeneous ground conductivity: 2 W/(m·K)
- Homogeneous volumetric heat capacity: 2,4 MJ/(m^3·K)
- Ground surface temperature: 9,6 °C
- Ground flux: 0,07 W/m^2

Borehole parameters

- Borehole diameter: 140 mm

Pipe parameters

- U tube DN32 PN16
- Grout thermal conductivity: 1,5 W/(m·K)
- Number of U-tubes: 2
- Pipe conductivity: 0,4 W/(m·K)
- Pipe roughness: 0,001 mm

Fluid properties

- Water
- Mass flow rate per borehole: 0,2 kg/s

Thermal demand

- Type of load: Hourly building load
- Domestic hot water: 60 016,95 kWh/year
- SCOP heating: 5
- SCOP domestic hot water: 3
- SEER cooling: 20

Borefield parameters

x [m]	y [m]	Length [m]	Depth [m]	Buried depth [m]	Tilt [°]	Orientation [°]
0,00	0,00	99,00	100,00	1,00	0,00	0,00
0,00	6,00	99,00	100,00	1,00	0,00	0,00
0,00	12,00	99,00	100,00	1,00	0,00	0,00
0,00	18,00	99,00	100,00	1,00	0,00	0,00

6,00	0,00	99,00	100,00	1,00	0,00	0,00
6,00	6,00	99,00	100,00	1,00	0,00	0,00
6,00	12,00	99,00	100,00	1,00	0,00	0,00
6,00	18,00	99,00	100,00	1,00	0,00	0,00
12,00	0,00	99,00	100,00	1,00	0,00	0,00
12,00	6,00	99,00	100,00	1,00	0,00	0,00
12,00	12,00	99,00	100,00	1,00	0,00	0,00
12,00	18,00	99,00	100,00	1,00	0,00	0,00
18,00	0,00	99,00	100,00	1,00	0,00	0,00
18,00	6,00	99,00	100,00	1,00	0,00	0,00
18,00	12,00	99,00	100,00	1,00	0,00	0,00
18,00	18,00	99,00	100,00	1,00	0,00	0,00
24,00	0,00	99,00	100,00	1,00	0,00	0,00
24,00	6,00	99,00	100,00	1,00	0,00	0,00
24,00	12,00	99,00	100,00	1,00	0,00	0,00
24,00	18,00	99,00	100,00	1,00	0,00	0,00
30,00	0,00	99,00	100,00	1,00	0,00	0,00
30,00	6,00	99,00	100,00	1,00	0,00	0,00
30,00	12,00	99,00	100,00	1,00	0,00	0,00
30,00	18,00	99,00	100,00	1,00	0,00	0,00
36,00	0,00	99,00	100,00	1,00	0,00	0,00
36,00	6,00	99,00	100,00	1,00	0,00	0,00
36,00	12,00	99,00	100,00	1,00	0,00	0,00
36,00	18,00	99,00	100,00	1,00	0,00	0,00
42,00	0,00	99,00	100,00	1,00	0,00	0,00
42,00	6,00	99,00	100,00	1,00	0,00	0,00
42,00	12,00	99,00	100,00	1,00	0,00	0,00
42,00	18,00	99,00	100,00	1,00	0,00	0,00
48,00	0,00	99,00	100,00	1,00	0,00	0,00
48,00	6,00	99,00	100,00	1,00	0,00	0,00
48,00	12,00	99,00	100,00	1,00	0,00	0,00
48,00	18,00	99,00	100,00	1,00	0,00	0,00
54,00	0,00	99,00	100,00	1,00	0,00	0,00
54,00	6,00	99,00	100,00	1,00	0,00	0,00
54,00	12,00	99,00	100,00	1,00	0,00	0,00
54,00	18,00	99,00	100,00	1,00	0,00	0,00

5.6 Design Data - DC - 20 kW - inlet

Design parameters

- Maximum average fluid temperature: 16 °C
- Minimum average fluid temperature: 5 °C
- First month of simulation: 1
- Simulation period: 2 years

Ground parameters

- Homogeneous ground conductivity: 2 W/(m·K)
- Homogeneous volumetric heat capacity: 2,4 MJ/(m^3·K)
- Ground surface temperature: 9,6 °C
- Ground flux: 0,07 W/m^2

Borehole parameters

- Borehole diameter: 140 mm

Pipe parameters

- U tube DN32 PN16
- Grout thermal conductivity: 1,5 W/(m·K)
- Number of U-tubes: 2
- Pipe conductivity: 0,4 W/(m·K)
- Pipe roughness: 0,001 mm

Fluid properties

- Water
- Mass flow rate per borehole: 0,2 kg/s

Thermal demand

- Type of load: Hourly building load
- Domestic hot water: 60 016,95 kWh/year
- SCOP heating: 5
- SCOP domestic hot water: 3
- SEER cooling: 20

Borefield parameters

x [m]	y [m]	Length [m]	Depth [m]	Buried depth [m]	Tilt [°]	Orientation [°]
0,00	0,00	99,00	100,00	1,00	0,00	0,00
0,00	6,00	99,00	100,00	1,00	0,00	0,00
0,00	12,00	99,00	100,00	1,00	0,00	0,00
0,00	18,00	99,00	100,00	1,00	0,00	0,00

6,00	0,00	99,00	100,00	1,00	0,00	0,00
6,00	6,00	99,00	100,00	1,00	0,00	0,00
6,00	12,00	99,00	100,00	1,00	0,00	0,00
6,00	18,00	99,00	100,00	1,00	0,00	0,00
12,00	0,00	99,00	100,00	1,00	0,00	0,00
12,00	6,00	99,00	100,00	1,00	0,00	0,00
12,00	12,00	99,00	100,00	1,00	0,00	0,00
12,00	18,00	99,00	100,00	1,00	0,00	0,00
18,00	0,00	99,00	100,00	1,00	0,00	0,00
18,00	6,00	99,00	100,00	1,00	0,00	0,00
18,00	12,00	99,00	100,00	1,00	0,00	0,00
18,00	18,00	99,00	100,00	1,00	0,00	0,00
24,00	0,00	99,00	100,00	1,00	0,00	0,00
24,00	6,00	99,00	100,00	1,00	0,00	0,00
24,00	12,00	99,00	100,00	1,00	0,00	0,00
24,00	18,00	99,00	100,00	1,00	0,00	0,00
30,00	0,00	99,00	100,00	1,00	0,00	0,00
30,00	6,00	99,00	100,00	1,00	0,00	0,00
30,00	12,00	99,00	100,00	1,00	0,00	0,00
30,00	18,00	99,00	100,00	1,00	0,00	0,00
36,00	0,00	99,00	100,00	1,00	0,00	0,00
36,00	6,00	99,00	100,00	1,00	0,00	0,00
36,00	12,00	99,00	100,00	1,00	0,00	0,00
36,00	18,00	99,00	100,00	1,00	0,00	0,00
42,00	0,00	99,00	100,00	1,00	0,00	0,00
42,00	6,00	99,00	100,00	1,00	0,00	0,00
42,00	12,00	99,00	100,00	1,00	0,00	0,00
42,00	18,00	99,00	100,00	1,00	0,00	0,00
48,00	0,00	99,00	100,00	1,00	0,00	0,00
48,00	6,00	99,00	100,00	1,00	0,00	0,00
48,00	12,00	99,00	100,00	1,00	0,00	0,00
48,00	18,00	99,00	100,00	1,00	0,00	0,00
54,00	0,00	99,00	100,00	1,00	0,00	0,00
54,00	6,00	99,00	100,00	1,00	0,00	0,00
54,00	12,00	99,00	100,00	1,00	0,00	0,00
54,00	18,00	99,00	100,00	1,00	0,00	0,00

5.7 Design Data - DC - 20 kW - inlet - 500h

Design parameters

- Maximum average fluid temperature: 16 °C
- Minimum average fluid temperature: 5 °C
- First month of simulation: 1
- Simulation period: 2 years

Ground parameters

- Homogeneous ground conductivity: 2 W/(m·K)
- Homogeneous volumetric heat capacity: 2,4 MJ/(m^3·K)
- Ground surface temperature: 9,6 °C
- Ground flux: 0,07 W/m^2

Borehole parameters

- Borehole diameter: 140 mm

Pipe parameters

- U tube DN32 PN16
- Grout thermal conductivity: 1,5 W/(m·K)
- Number of U-tubes: 2
- Pipe conductivity: 0,4 W/(m·K)
- Pipe roughness: 0,001 mm

Fluid properties

- Water
- Mass flow rate per borehole: 0,2 kg/s

Thermal demand

- Type of load: Hourly building load
- Domestic hot water: 60 016,95 kWh/year
- SCOP heating: 5
- SCOP domestic hot water: 3
- SEER cooling: 20

Borefield parameters

x [m]	y [m]	Length [m]	Depth [m]	Buried depth [m]	Tilt [°]	Orientation [°]
0,00	0,00	99,00	100,00	1,00	0,00	0,00
0,00	6,00	99,00	100,00	1,00	0,00	0,00
0,00	12,00	99,00	100,00	1,00	0,00	0,00
0,00	18,00	99,00	100,00	1,00	0,00	0,00

6,00	0,00	99,00	100,00	1,00	0,00	0,00
6,00	6,00	99,00	100,00	1,00	0,00	0,00
6,00	12,00	99,00	100,00	1,00	0,00	0,00
6,00	18,00	99,00	100,00	1,00	0,00	0,00
12,00	0,00	99,00	100,00	1,00	0,00	0,00
12,00	6,00	99,00	100,00	1,00	0,00	0,00
12,00	12,00	99,00	100,00	1,00	0,00	0,00
12,00	18,00	99,00	100,00	1,00	0,00	0,00
18,00	0,00	99,00	100,00	1,00	0,00	0,00
18,00	6,00	99,00	100,00	1,00	0,00	0,00
18,00	12,00	99,00	100,00	1,00	0,00	0,00
18,00	18,00	99,00	100,00	1,00	0,00	0,00
24,00	0,00	99,00	100,00	1,00	0,00	0,00
24,00	6,00	99,00	100,00	1,00	0,00	0,00
24,00	12,00	99,00	100,00	1,00	0,00	0,00
24,00	18,00	99,00	100,00	1,00	0,00	0,00
30,00	0,00	99,00	100,00	1,00	0,00	0,00
30,00	6,00	99,00	100,00	1,00	0,00	0,00
30,00	12,00	99,00	100,00	1,00	0,00	0,00
30,00	18,00	99,00	100,00	1,00	0,00	0,00
36,00	0,00	99,00	100,00	1,00	0,00	0,00
36,00	6,00	99,00	100,00	1,00	0,00	0,00
36,00	12,00	99,00	100,00	1,00	0,00	0,00
36,00	18,00	99,00	100,00	1,00	0,00	0,00
42,00	0,00	99,00	100,00	1,00	0,00	0,00
42,00	6,00	99,00	100,00	1,00	0,00	0,00
42,00	12,00	99,00	100,00	1,00	0,00	0,00
42,00	18,00	99,00	100,00	1,00	0,00	0,00
48,00	0,00	99,00	100,00	1,00	0,00	0,00
48,00	6,00	99,00	100,00	1,00	0,00	0,00
48,00	12,00	99,00	100,00	1,00	0,00	0,00
48,00	18,00	99,00	100,00	1,00	0,00	0,00
54,00	0,00	99,00	100,00	1,00	0,00	0,00
54,00	6,00	99,00	100,00	1,00	0,00	0,00
54,00	12,00	99,00	100,00	1,00	0,00	0,00
54,00	18,00	99,00	100,00	1,00	0,00	0,00

5.8 Design Data - DC - 20 kW - inlet - 18°C - yearly

Design parameters

- Maximum average fluid temperature: 18 °C
- Minimum average fluid temperature: 5 °C
- First month of simulation: 1
- Simulation period: 2 years

Ground parameters

- Homogeneous ground conductivity: 2 W/(m·K)
- Homogeneous volumetric heat capacity: 2,4 MJ/(m^3·K)
- Ground surface temperature: 9,6 °C
- Ground flux: 0,07 W/m^2

Borehole parameters

- Borehole diameter: 140 mm

Pipe parameters

- U tube DN32 PN16
- Grout thermal conductivity: 1,5 W/(m·K)
- Number of U-tubes: 2
- Pipe conductivity: 0,4 W/(m·K)
- Pipe roughness: 0,001 mm

Fluid properties

- Water
- Mass flow rate per borehole: 0,2 kg/s

Thermal demand

- Type of load: Hourly building load
- Domestic hot water: 60 016,95 kWh/year
- SCOP heating: 5
- SCOP domestic hot water: 3
- SEER cooling: 20

Borefield parameters

x [m]	y [m]	Length [m]	Depth [m]	Buried depth [m]	Tilt [°]	Orientation [°]
0,00	0,00	99,00	100,00	1,00	0,00	0,00
0,00	6,00	99,00	100,00	1,00	0,00	0,00
0,00	12,00	99,00	100,00	1,00	0,00	0,00
0,00	18,00	99,00	100,00	1,00	0,00	0,00

6,00	0,00	99,00	100,00	1,00	0,00	0,00
6,00	6,00	99,00	100,00	1,00	0,00	0,00
6,00	12,00	99,00	100,00	1,00	0,00	0,00
6,00	18,00	99,00	100,00	1,00	0,00	0,00
12,00	0,00	99,00	100,00	1,00	0,00	0,00
12,00	6,00	99,00	100,00	1,00	0,00	0,00
12,00	12,00	99,00	100,00	1,00	0,00	0,00
12,00	18,00	99,00	100,00	1,00	0,00	0,00
18,00	0,00	99,00	100,00	1,00	0,00	0,00
18,00	6,00	99,00	100,00	1,00	0,00	0,00
18,00	12,00	99,00	100,00	1,00	0,00	0,00
18,00	18,00	99,00	100,00	1,00	0,00	0,00
24,00	0,00	99,00	100,00	1,00	0,00	0,00
24,00	6,00	99,00	100,00	1,00	0,00	0,00
24,00	12,00	99,00	100,00	1,00	0,00	0,00
24,00	18,00	99,00	100,00	1,00	0,00	0,00
30,00	0,00	99,00	100,00	1,00	0,00	0,00
30,00	6,00	99,00	100,00	1,00	0,00	0,00
30,00	12,00	99,00	100,00	1,00	0,00	0,00
30,00	18,00	99,00	100,00	1,00	0,00	0,00
36,00	0,00	99,00	100,00	1,00	0,00	0,00
36,00	6,00	99,00	100,00	1,00	0,00	0,00
36,00	12,00	99,00	100,00	1,00	0,00	0,00
36,00	18,00	99,00	100,00	1,00	0,00	0,00
42,00	0,00	99,00	100,00	1,00	0,00	0,00
42,00	6,00	99,00	100,00	1,00	0,00	0,00
42,00	12,00	99,00	100,00	1,00	0,00	0,00
42,00	18,00	99,00	100,00	1,00	0,00	0,00
48,00	0,00	99,00	100,00	1,00	0,00	0,00
48,00	6,00	99,00	100,00	1,00	0,00	0,00
48,00	12,00	99,00	100,00	1,00	0,00	0,00
48,00	18,00	99,00	100,00	1,00	0,00	0,00
54,00	0,00	99,00	100,00	1,00	0,00	0,00
54,00	6,00	99,00	100,00	1,00	0,00	0,00
54,00	12,00	99,00	100,00	1,00	0,00	0,00
54,00	18,00	99,00	100,00	1,00	0,00	0,00

5.9 Design Data - DC - 20 kW - inlet - 18°C - SP

Design parameters

- Maximum average fluid temperature: 18 °C
- Minimum average fluid temperature: 5 °C
- First month of simulation: 1
- Simulation period: 2 years

Ground parameters

- Homogeneous ground conductivity: 2 W/(m·K)
- Homogeneous volumetric heat capacity: 2,4 MJ/(m^3·K)
- Ground surface temperature: 9,6 °C
- Ground flux: 0,07 W/m^2

Borehole parameters

- Borehole diameter: 140 mm

Pipe parameters

- U tube DN32 PN16
- Grout thermal conductivity: 1,5 W/(m·K)
- Number of U-tubes: 2
- Pipe conductivity: 0,4 W/(m·K)
- Pipe roughness: 0,001 mm

Fluid properties

- Water
- Mass flow rate per borehole: 0,2 kg/s

Thermal demand

- Type of load: Hourly building load
- Domestic hot water: 60 016,95 kWh/year
- SCOP heating: 5
- SCOP domestic hot water: 3
- SEER cooling: 20

Borefield parameters

x [m]	y [m]	Length [m]	Depth [m]	Buried depth [m]	Tilt [°]	Orientation [°]
0,00	0,00	99,00	100,00	1,00	0,00	0,00
0,00	6,00	99,00	100,00	1,00	0,00	0,00
0,00	12,00	99,00	100,00	1,00	0,00	0,00
0,00	18,00	99,00	100,00	1,00	0,00	0,00

6,00	0,00	99,00	100,00	1,00	0,00	0,00
6,00	6,00	99,00	100,00	1,00	0,00	0,00
6,00	12,00	99,00	100,00	1,00	0,00	0,00
6,00	18,00	99,00	100,00	1,00	0,00	0,00
12,00	0,00	99,00	100,00	1,00	0,00	0,00
12,00	6,00	99,00	100,00	1,00	0,00	0,00
12,00	12,00	99,00	100,00	1,00	0,00	0,00
12,00	18,00	99,00	100,00	1,00	0,00	0,00
18,00	0,00	99,00	100,00	1,00	0,00	0,00
18,00	6,00	99,00	100,00	1,00	0,00	0,00
18,00	12,00	99,00	100,00	1,00	0,00	0,00
18,00	18,00	99,00	100,00	1,00	0,00	0,00
24,00	0,00	99,00	100,00	1,00	0,00	0,00
24,00	6,00	99,00	100,00	1,00	0,00	0,00
24,00	12,00	99,00	100,00	1,00	0,00	0,00
24,00	18,00	99,00	100,00	1,00	0,00	0,00
30,00	0,00	99,00	100,00	1,00	0,00	0,00
30,00	6,00	99,00	100,00	1,00	0,00	0,00
30,00	12,00	99,00	100,00	1,00	0,00	0,00
30,00	18,00	99,00	100,00	1,00	0,00	0,00
36,00	0,00	99,00	100,00	1,00	0,00	0,00
36,00	6,00	99,00	100,00	1,00	0,00	0,00
36,00	12,00	99,00	100,00	1,00	0,00	0,00
36,00	18,00	99,00	100,00	1,00	0,00	0,00
42,00	0,00	99,00	100,00	1,00	0,00	0,00
42,00	6,00	99,00	100,00	1,00	0,00	0,00
42,00	12,00	99,00	100,00	1,00	0,00	0,00
42,00	18,00	99,00	100,00	1,00	0,00	0,00
48,00	0,00	99,00	100,00	1,00	0,00	0,00
48,00	6,00	99,00	100,00	1,00	0,00	0,00
48,00	12,00	99,00	100,00	1,00	0,00	0,00
48,00	18,00	99,00	100,00	1,00	0,00	0,00
54,00	0,00	99,00	100,00	1,00	0,00	0,00
54,00	6,00	99,00	100,00	1,00	0,00	0,00
54,00	12,00	99,00	100,00	1,00	0,00	0,00
54,00	18,00	99,00	100,00	1,00	0,00	0,00

5.10 Design Data - DC - 20 kW - inlet - 18°C - PH

Design parameters

- Maximum average fluid temperature: 18 °C
- Minimum average fluid temperature: 5 °C
- First month of simulation: 1
- Simulation period: 2 years

Ground parameters

- Homogeneous ground conductivity: 2 W/(m·K)
- Homogeneous volumetric heat capacity: 2,4 MJ/(m^3·K)
- Ground surface temperature: 9,6 °C
- Ground flux: 0,07 W/m^2

Borehole parameters

- Borehole diameter: 140 mm

Pipe parameters

- U tube DN32 PN16
- Grout thermal conductivity: 1,5 W/(m·K)
- Number of U-tubes: 2
- Pipe conductivity: 0,4 W/(m·K)
- Pipe roughness: 0,001 mm

Fluid properties

- Water
- Mass flow rate per borehole: 0,2 kg/s

Thermal demand

- Type of load: Hourly building load
- Domestic hot water: 60 016,95 kWh/year
- SCOP heating: 5
- SCOP domestic hot water: 3
- SEER cooling: 20

Borefield parameters

x [m]	y [m]	Length [m]	Depth [m]	Buried depth [m]	Tilt [°]	Orientation [°]
0,00	0,00	99,00	100,00	1,00	0,00	0,00
0,00	6,00	99,00	100,00	1,00	0,00	0,00
0,00	12,00	99,00	100,00	1,00	0,00	0,00
0,00	18,00	99,00	100,00	1,00	0,00	0,00

6,00	0,00	99,00	100,00	1,00	0,00	0,00
6,00	6,00	99,00	100,00	1,00	0,00	0,00
6,00	12,00	99,00	100,00	1,00	0,00	0,00
6,00	18,00	99,00	100,00	1,00	0,00	0,00
12,00	0,00	99,00	100,00	1,00	0,00	0,00
12,00	6,00	99,00	100,00	1,00	0,00	0,00
12,00	12,00	99,00	100,00	1,00	0,00	0,00
12,00	18,00	99,00	100,00	1,00	0,00	0,00
18,00	0,00	99,00	100,00	1,00	0,00	0,00
18,00	6,00	99,00	100,00	1,00	0,00	0,00
18,00	12,00	99,00	100,00	1,00	0,00	0,00
18,00	18,00	99,00	100,00	1,00	0,00	0,00
24,00	0,00	99,00	100,00	1,00	0,00	0,00
24,00	6,00	99,00	100,00	1,00	0,00	0,00
24,00	12,00	99,00	100,00	1,00	0,00	0,00
24,00	18,00	99,00	100,00	1,00	0,00	0,00
30,00	0,00	99,00	100,00	1,00	0,00	0,00
30,00	6,00	99,00	100,00	1,00	0,00	0,00
30,00	12,00	99,00	100,00	1,00	0,00	0,00
30,00	18,00	99,00	100,00	1,00	0,00	0,00
36,00	0,00	99,00	100,00	1,00	0,00	0,00
36,00	6,00	99,00	100,00	1,00	0,00	0,00
36,00	12,00	99,00	100,00	1,00	0,00	0,00
36,00	18,00	99,00	100,00	1,00	0,00	0,00
42,00	0,00	99,00	100,00	1,00	0,00	0,00
42,00	6,00	99,00	100,00	1,00	0,00	0,00
42,00	12,00	99,00	100,00	1,00	0,00	0,00
42,00	18,00	99,00	100,00	1,00	0,00	0,00
48,00	0,00	99,00	100,00	1,00	0,00	0,00
48,00	6,00	99,00	100,00	1,00	0,00	0,00
48,00	12,00	99,00	100,00	1,00	0,00	0,00
48,00	18,00	99,00	100,00	1,00	0,00	0,00
54,00	0,00	99,00	100,00	1,00	0,00	0,00
54,00	6,00	99,00	100,00	1,00	0,00	0,00
54,00	12,00	99,00	100,00	1,00	0,00	0,00
54,00	18,00	99,00	100,00	1,00	0,00	0,00

5.11 Design Data - DC - 20 kW - inlet - 18°C - PH+

Design parameters

- Maximum average fluid temperature: 18 °C
- Minimum average fluid temperature: 5 °C
- First month of simulation: 1
- Simulation period: 2 years

Ground parameters

- Homogeneous ground conductivity: 2 W/(m·K)
- Homogeneous volumetric heat capacity: 2,4 MJ/(m^3·K)
- Ground surface temperature: 9,6 °C
- Ground flux: 0,07 W/m^2

Borehole parameters

- Borehole diameter: 140 mm

Pipe parameters

- U tube DN32 PN16
- Grout thermal conductivity: 1,5 W/(m·K)
- Number of U-tubes: 2
- Pipe conductivity: 0,4 W/(m·K)
- Pipe roughness: 0,001 mm

Fluid properties

- Water
- Mass flow rate per borehole: 0,2 kg/s

Thermal demand

- Type of load: Hourly building load
- Domestic hot water: 60 016,95 kWh/year
- SCOP heating: 5
- SCOP domestic hot water: 3
- SEER cooling: 20

Borefield parameters

x [m]	y [m]	Length [m]	Depth [m]	Buried depth [m]	Tilt [°]	Orientation [°]
0,00	0,00	99,00	100,00	1,00	0,00	0,00
0,00	6,00	99,00	100,00	1,00	0,00	0,00
0,00	12,00	99,00	100,00	1,00	0,00	0,00
0,00	18,00	99,00	100,00	1,00	0,00	0,00

6,00	0,00	99,00	100,00	1,00	0,00	0,00
6,00	6,00	99,00	100,00	1,00	0,00	0,00
6,00	12,00	99,00	100,00	1,00	0,00	0,00
6,00	18,00	99,00	100,00	1,00	0,00	0,00
12,00	0,00	99,00	100,00	1,00	0,00	0,00
12,00	6,00	99,00	100,00	1,00	0,00	0,00
12,00	12,00	99,00	100,00	1,00	0,00	0,00
12,00	18,00	99,00	100,00	1,00	0,00	0,00
18,00	0,00	99,00	100,00	1,00	0,00	0,00
18,00	6,00	99,00	100,00	1,00	0,00	0,00
18,00	12,00	99,00	100,00	1,00	0,00	0,00
18,00	18,00	99,00	100,00	1,00	0,00	0,00
24,00	0,00	99,00	100,00	1,00	0,00	0,00
24,00	6,00	99,00	100,00	1,00	0,00	0,00
24,00	12,00	99,00	100,00	1,00	0,00	0,00
24,00	18,00	99,00	100,00	1,00	0,00	0,00
30,00	0,00	99,00	100,00	1,00	0,00	0,00
30,00	6,00	99,00	100,00	1,00	0,00	0,00
30,00	12,00	99,00	100,00	1,00	0,00	0,00
30,00	18,00	99,00	100,00	1,00	0,00	0,00
36,00	0,00	99,00	100,00	1,00	0,00	0,00
36,00	6,00	99,00	100,00	1,00	0,00	0,00
36,00	12,00	99,00	100,00	1,00	0,00	0,00
36,00	18,00	99,00	100,00	1,00	0,00	0,00
42,00	0,00	99,00	100,00	1,00	0,00	0,00
42,00	6,00	99,00	100,00	1,00	0,00	0,00
42,00	12,00	99,00	100,00	1,00	0,00	0,00
42,00	18,00	99,00	100,00	1,00	0,00	0,00
48,00	0,00	99,00	100,00	1,00	0,00	0,00
48,00	6,00	99,00	100,00	1,00	0,00	0,00
48,00	12,00	99,00	100,00	1,00	0,00	0,00
48,00	18,00	99,00	100,00	1,00	0,00	0,00
54,00	0,00	99,00	100,00	1,00	0,00	0,00
54,00	6,00	99,00	100,00	1,00	0,00	0,00
54,00	12,00	99,00	100,00	1,00	0,00	0,00
54,00	18,00	99,00	100,00	1,00	0,00	0,00



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