GHEtool calculation report

Course 10.1



23/11/26

Licensed report by:

Enead BV

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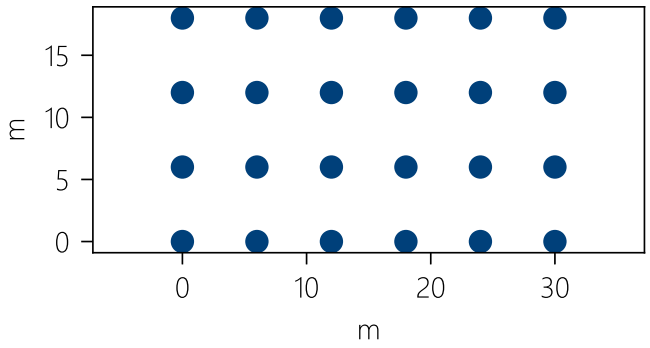
1.1 Structure of the report

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 Passive cooling - auditorium

Input



Number of boreholes: 24

Average minimum borehole spacing: 6,0 m

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

2 x U tube DN32 PN16

25,0 v/v% MPG

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

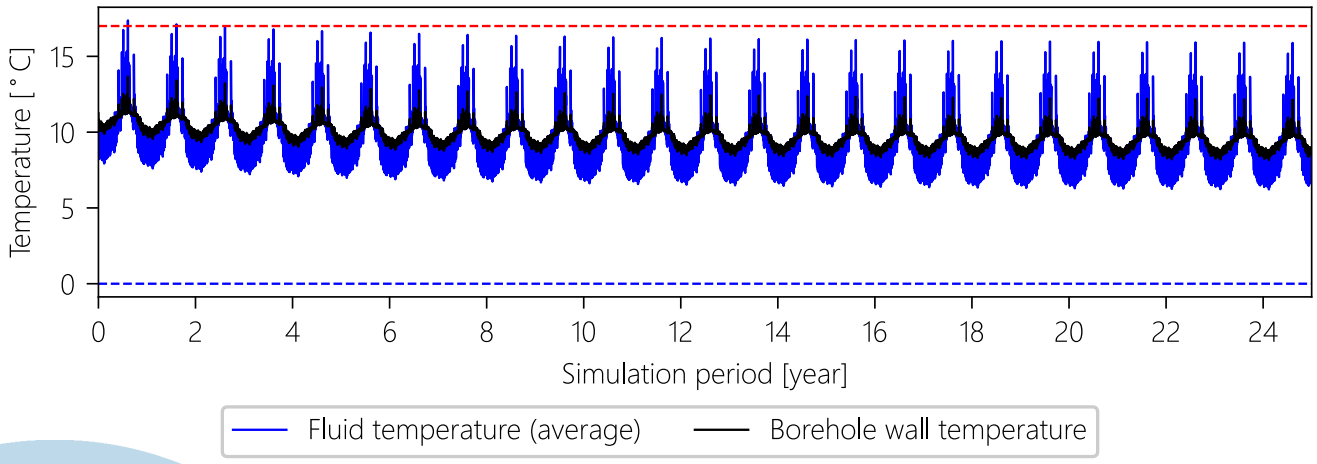
Building demand	Yearly load	Peak power
Heating demand	38 292 kWh/y	32,5 kW
Cooling demand	3 859 kWh/y	90,2 kW

Results

Effective borehole thermal resistance (extraction): 0,1959 m·K/W, Reynolds number: 533 (laminar)

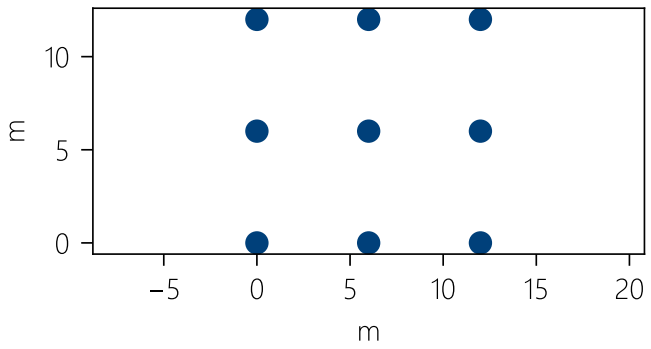
Effective borehole thermal resistance (injection): 0,0957 m·K/W, Reynolds number: 3 000 (transitional)

Maximum average fluid temperature: 17,37 °C, Minimum average fluid temperature: 6,22 °C



2.2 Active cooling - auditorium

Input



Number of boreholes: 9

Average minimum borehole spacing: 6,0 m

Borehole depth (w.r.t. surface): 120,0 m

2 x U tube DN32 PN16

25,0 v/v% MPG

SCOP heating: 5,00; SEER cooling: 5,00

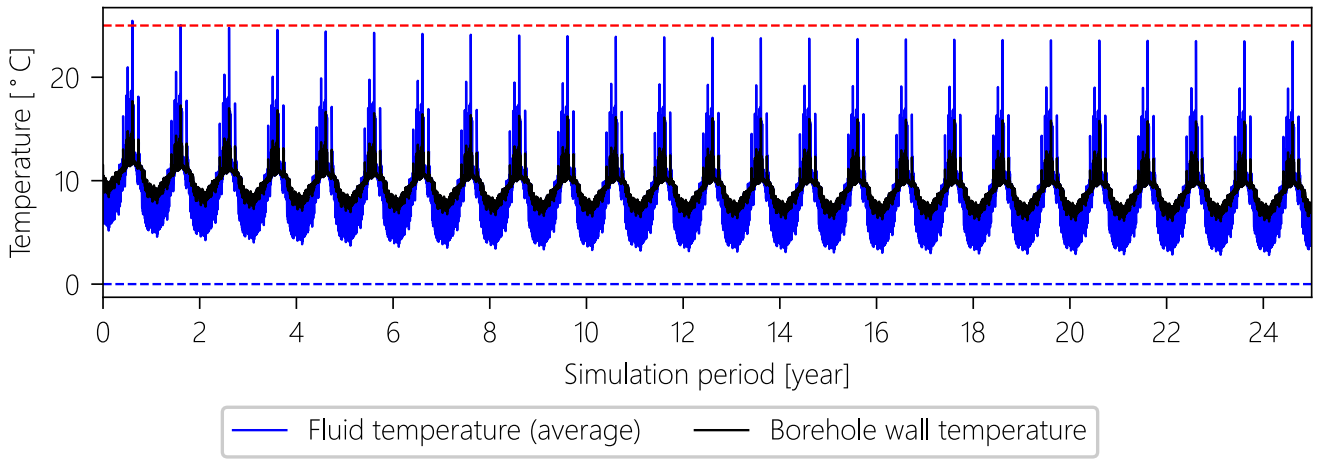
Building demand	Yearly load	Peak power
Heating demand	38 292 kWh/y	32,5 kW
Cooling demand	3 859 kWh/y	90,2 kW

Results

Effective borehole thermal resistance (extraction): 0,1467 m·K/W, Reynolds number: 1 224 (laminar)

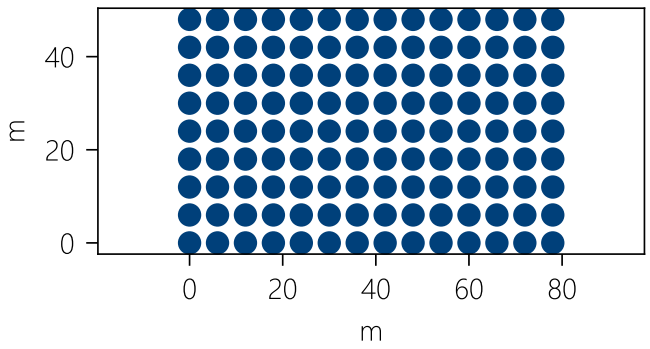
Effective borehole thermal resistance (injection): 0,0801 m·K/W, Reynolds number: 11 990 (turbulent)

Maximum average fluid temperature: 25,46 °C, Minimum average fluid temperature: 2,81 °C



2.3 Passive cooling - office

Input



Number of boreholes: 126

Average minimum borehole spacing: 6,0 m

Borehole depth (w.r.t. surface): 150,0 m

2 x U tube DN32 PN16

25,0 v/v% MPG

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

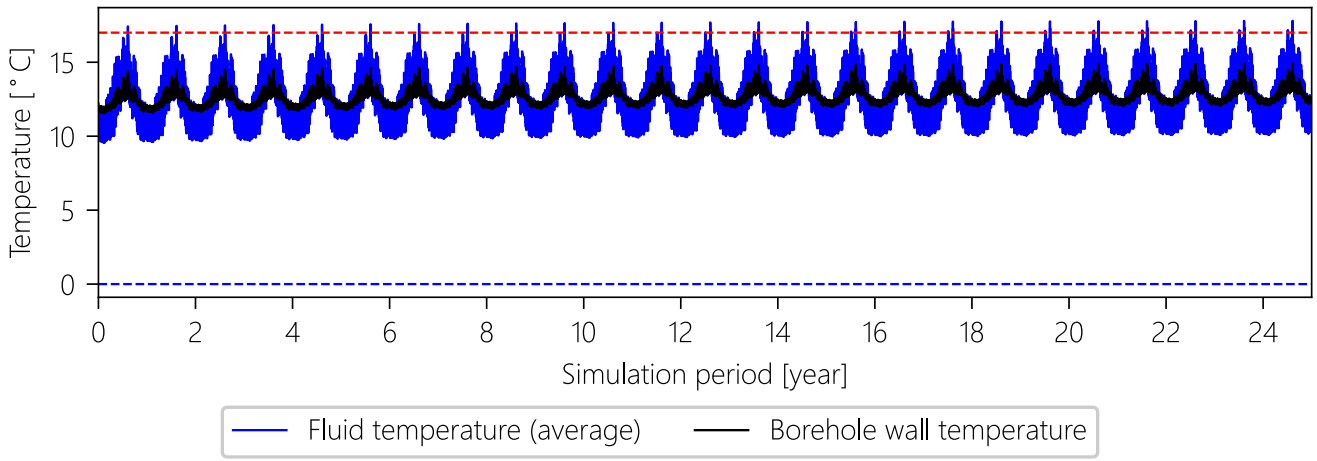
Building demand	Yearly load	Peak power
Heating demand	117 509 kWh/y	214,2 kW
Cooling demand	118 276 kWh/y	370,6 kW

Results

Effective borehole thermal resistance (extraction): 0,2204 m·K/W, Reynolds number: 768 (laminar)

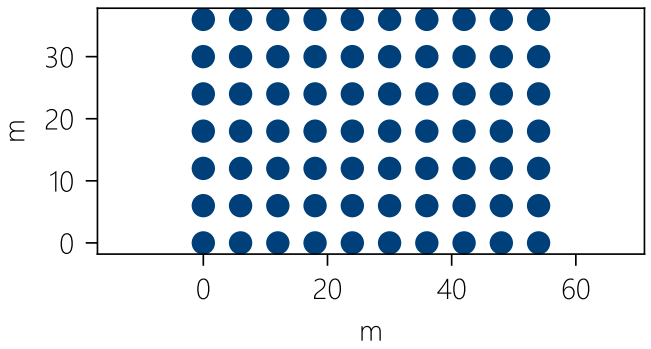
Effective borehole thermal resistance (injection): 0,1348 m·K/W, Reynolds number: 2 384 (transitional)

Maximum average fluid temperature: 17,80 °C, Minimum average fluid temperature: 9,56 °C



2.4 Active cooling - office

Input



Number of boreholes: 70

Average minimum borehole spacing: 6,0 m

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

2 x U tube DN32 PN16

25,0 v/v% MPG

SCOP heating: 5,00; SEER cooling: 5,00

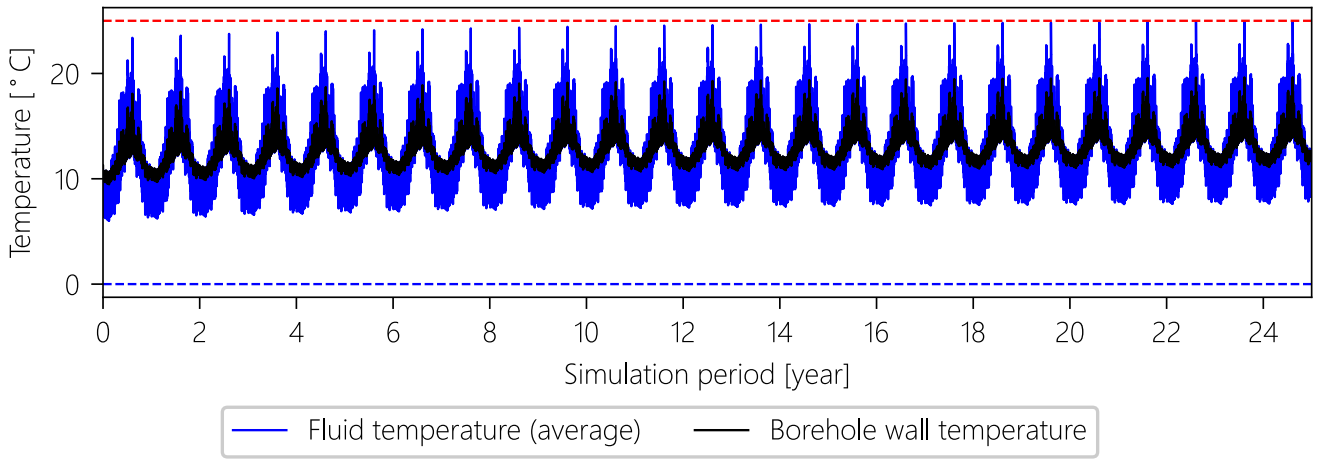
Building demand	Yearly load	Peak power
Heating demand	117 509 kWh/y	214,2 kW
Cooling demand	118 276 kWh/y	370,6 kW

Results

Effective borehole thermal resistance (extraction): 0,1459 m·K/W, Reynolds number: 1 192 (laminar)

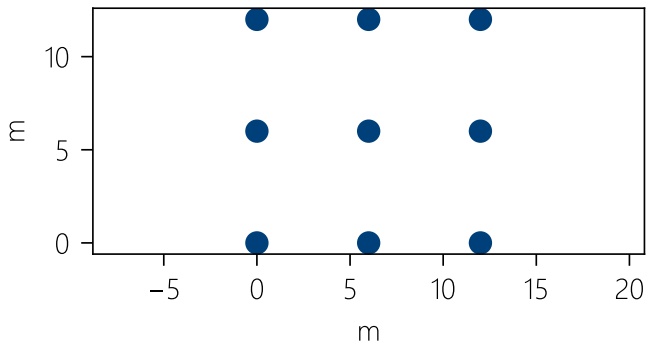
Effective borehole thermal resistance (injection): 0,0839 m·K/W, Reynolds number: 6 233 (turbulent)

Maximum average fluid temperature: 24,94 °C, Minimum average fluid temperature: 6,02 °C



2.5 Auditorium - fixed period

Input



Number of boreholes: 9

Average minimum borehole spacing: 6,0 m

Borehole depth (w.r.t. surface): 120,0 m

2 x U tube DN32 PN16

25,0 v/v% MPG

SCOP heating: 5,00; SEER active | passive cooling: 5,00 | 20,00

Building demand	Yearly load	Peak power
Heating demand	38 292 kWh/y	32,5 kW
Cooling demand	3 859 kWh/y	90,2 kW

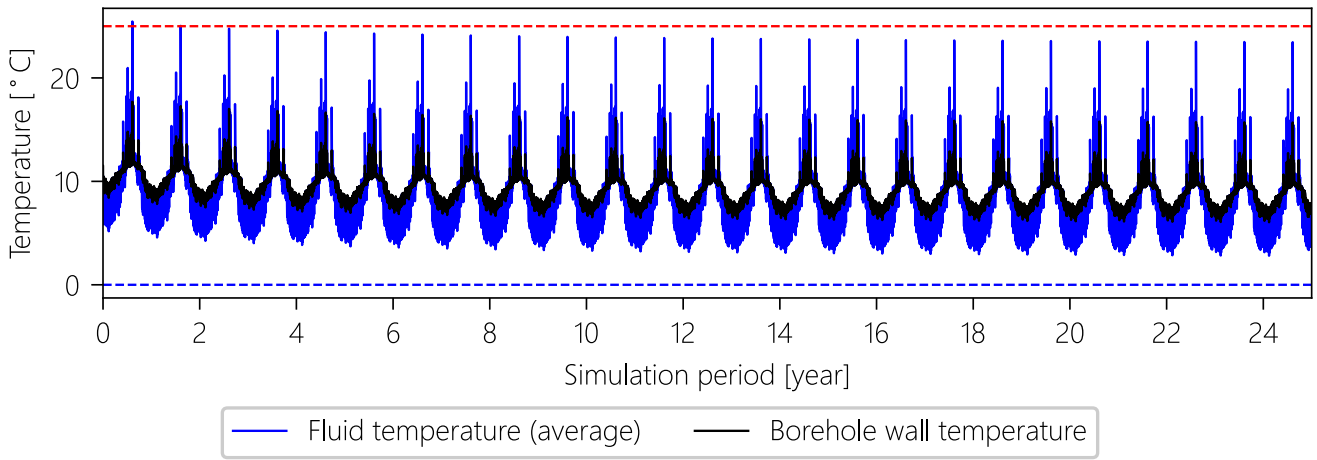
Results

Effective borehole thermal resistance (extraction): 0,1467 m·K/W, Reynolds number: 1 223 (laminar)

Effective borehole thermal resistance (injection): 0,0801 m·K/W, Reynolds number: 11 990 (turbulent)

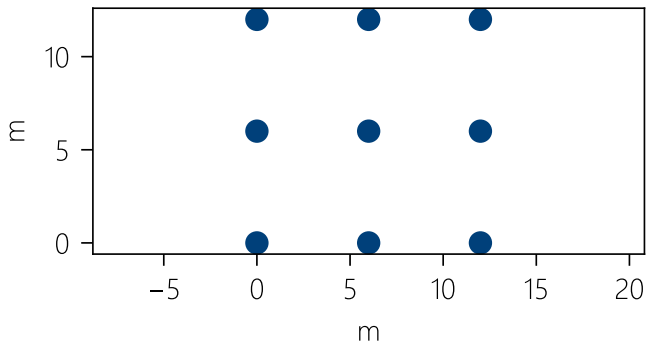
Yearly average SEER: 5,24 (share passive cooling: 6,17 %)

Maximum average fluid temperature: 25,46 °C, Minimum average fluid temperature: 2,81 °C



2.6 Auditorium - threshold

Input



Number of boreholes: 9

Average minimum borehole spacing: 6,0 m

Borehole depth (w.r.t. surface): 120,0 m

2 x U tube DN32 PN16

25,0 v/v% MPG

SCOP heating: 5,00; SEER active | passive cooling: 5,00 | 20,00

Building demand	Yearly load	Peak power
Heating demand	38 292 kWh/y	32,5 kW
Cooling demand	3 859 kWh/y	90,2 kW

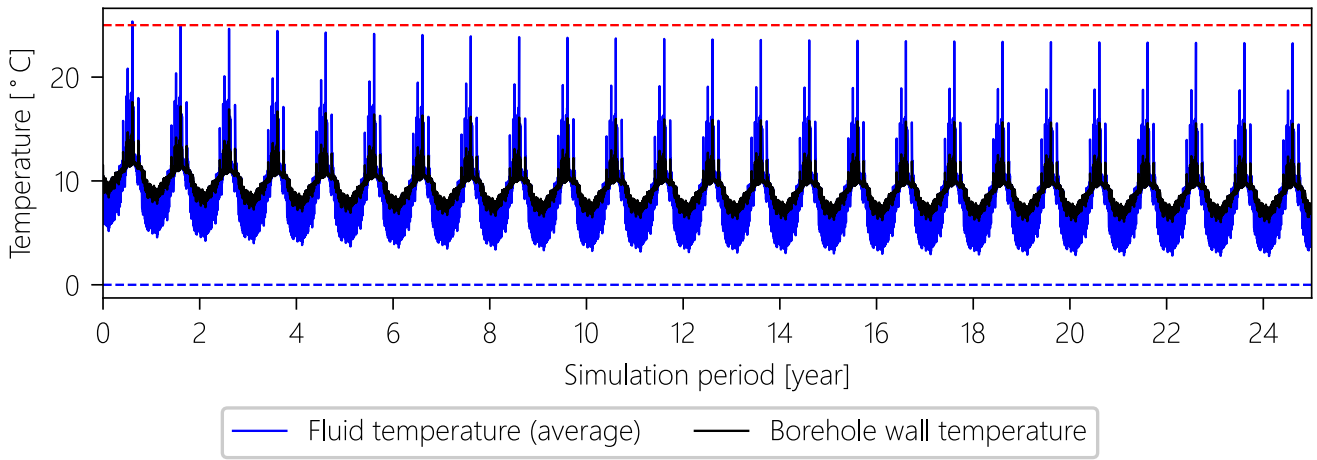
Results

Effective borehole thermal resistance (extraction): 0,1467 m·K/W, Reynolds number: 1 221 (laminar)

Effective borehole thermal resistance (injection): 0,0801 m·K/W, Reynolds number: 11 951 (turbulent)

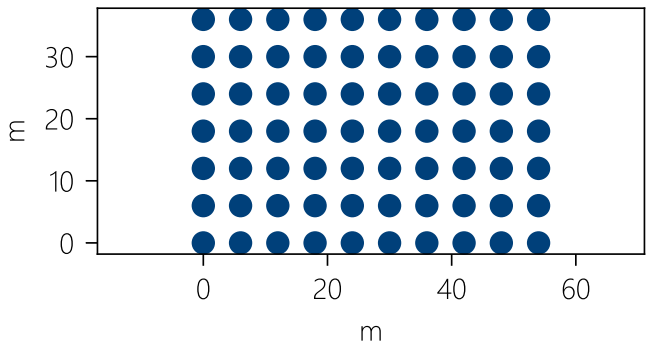
Yearly average SEER: 14,49 (share passive cooling: 87,33 %)

Maximum average fluid temperature: 25,35 °C, Minimum average fluid temperature: 2,76 °C



2.7 Office - fixed period

Input



Number of boreholes: 70

Average minimum borehole spacing: 6,0 m

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

2 x U tube DN32 PN16

25,0 v/v% MPG

SCOP heating: 5,00; SEER active | passive cooling: 5,00 | 20,00

Building demand	Yearly load	Peak power
Heating demand	117 509 kWh/y	214,2 kW
Cooling demand	118 276 kWh/y	370,6 kW

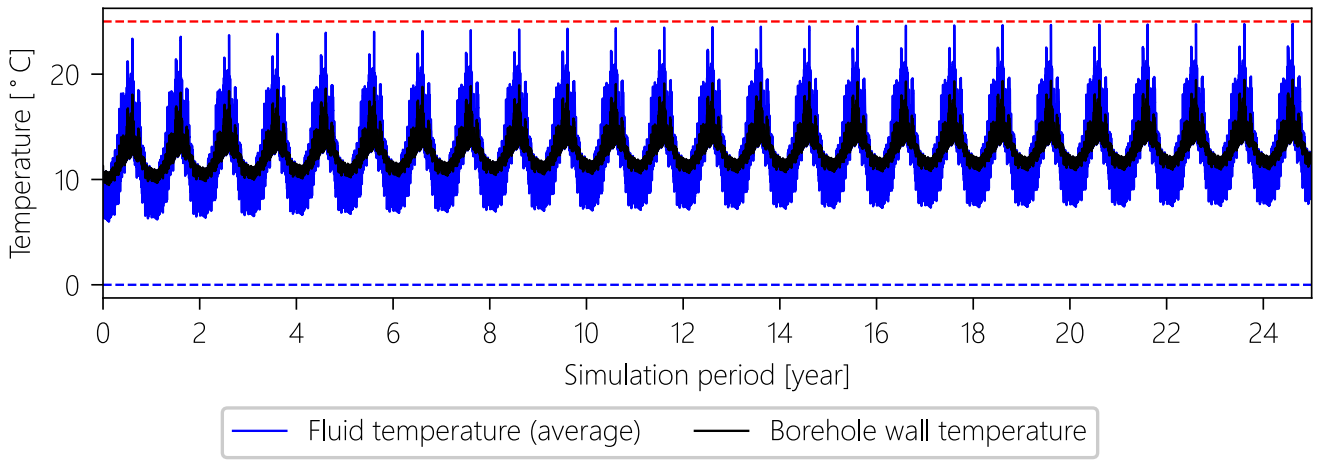
Results

Effective borehole thermal resistance (extraction): 0,1459 m·K/W, Reynolds number: 1 192 (laminar)

Effective borehole thermal resistance (injection): 0,0839 m·K/W, Reynolds number: 6 201 (turbulent)

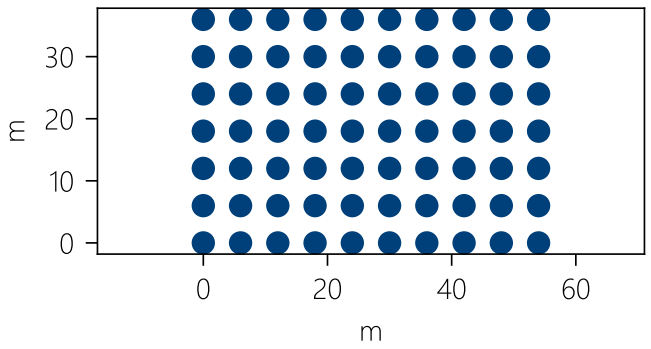
Yearly average SEER: 6,21 (share passive cooling: 26,01 %)

Maximum average fluid temperature: 24,78 °C, Minimum average fluid temperature: 6,02 °C



2.8 Office - threshold

Input



Number of boreholes: 70

Average minimum borehole spacing: 6,0 m

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

2 x U tube DN32 PN16

25,0 v/v% MPG

SCOP heating: 5,00; SEER active | passive cooling: 5,00 | 20,00

Building demand	Yearly load	Peak power
Heating demand	117 509 kWh/y	214,2 kW
Cooling demand	118 276 kWh/y	370,6 kW

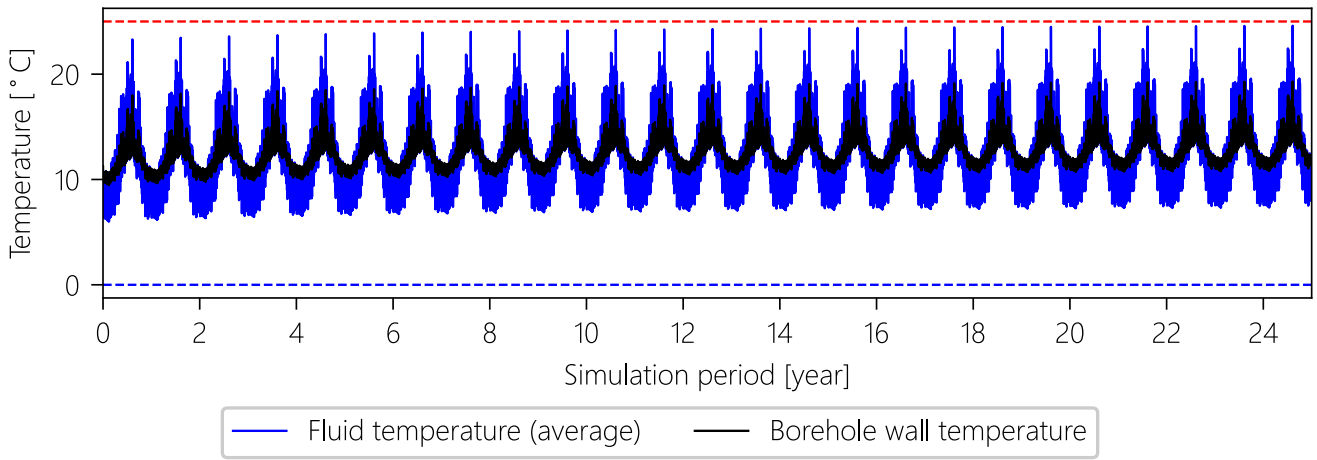
Results

Effective borehole thermal resistance (extraction): 0,1459 m·K/W, Reynolds number: 1 192 (laminar)

Effective borehole thermal resistance (injection): 0,0840 m·K/W, Reynolds number: 6 164 (turbulent)

Yearly average SEER: 8,34 (share passive cooling: 53,43 %)

Maximum average fluid temperature: 24,60 °C, Minimum average fluid temperature: 6,02 °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, pipe data, and fluid data.

3.1 Ground data

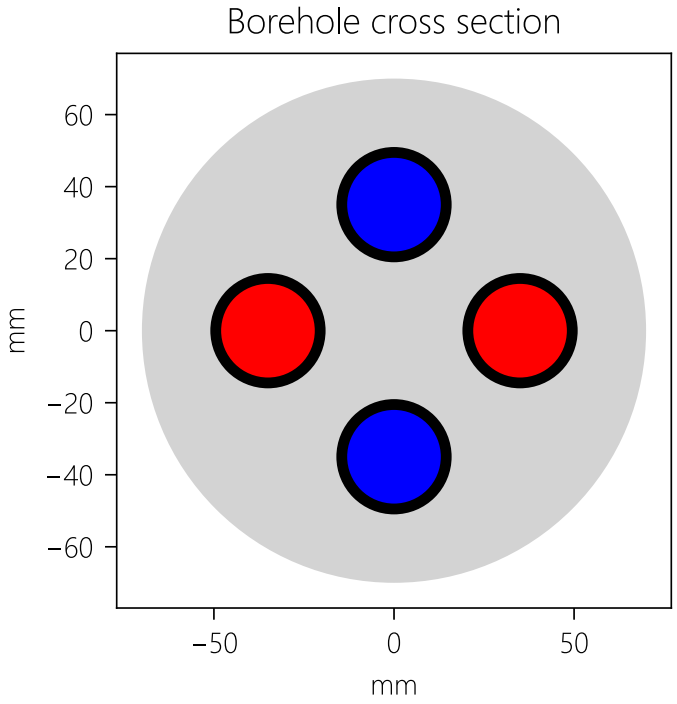
The ground is modelled as a single homogeneous layer with an average thermal conductivity of 2,00 W/(m·K) and a volumetric heat capacity of 2,40 MJ/(m^3·K). This means that the ground properties are assumed to remain constant at all depths.

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 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).



3.3 Fluid data

As a heat transfer fluid, MPG with 25,0 v/v% was selected, which provides frost protection down to approximately -10 °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.

4.1 Passive cooling - auditorium

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

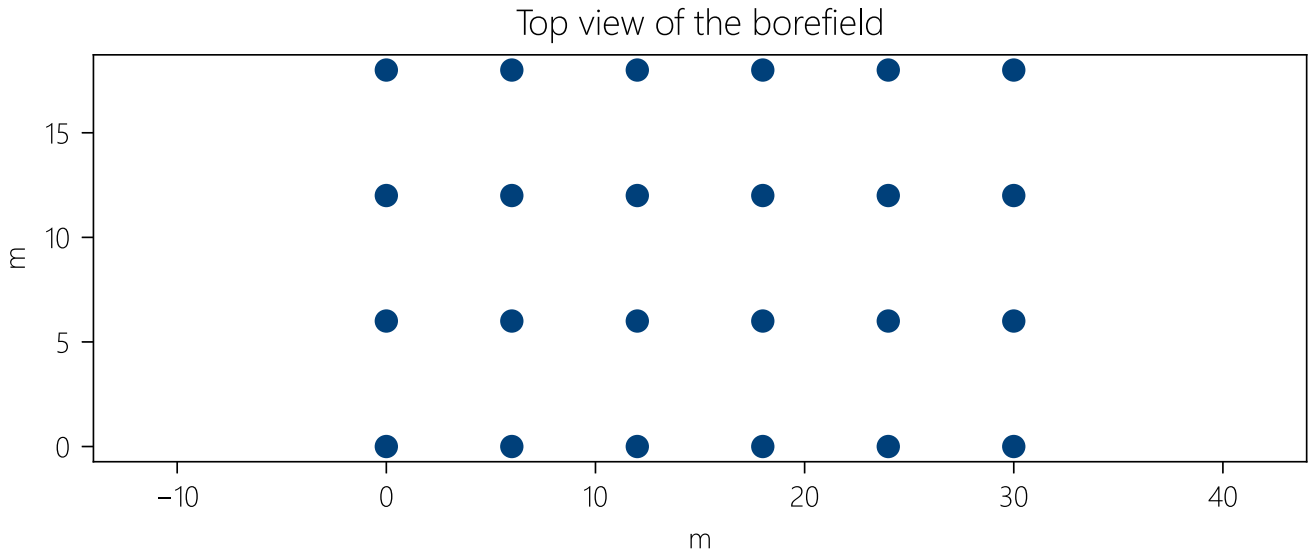
The scenarios in this report have been simulated with a simulation period of 25 years, starting in January. The minimum and maximum average fluid temperatures were 0,00 °C and 17,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Borefield configuration

The simulations were carried out with a borefield consisting of 24 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 2 376,00 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

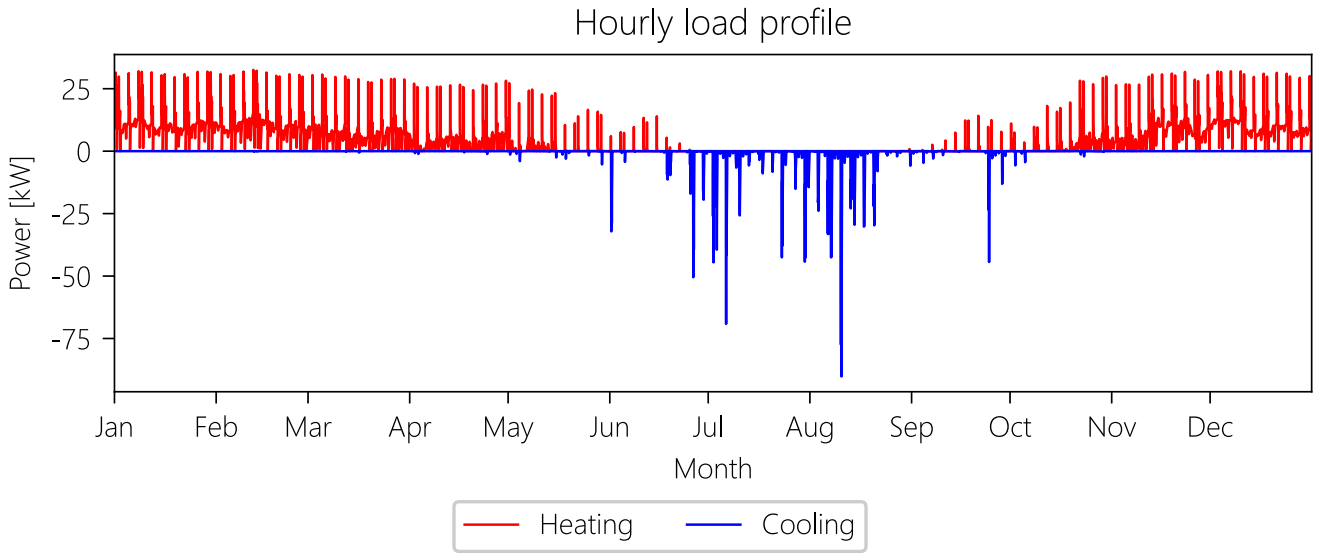
Flow data

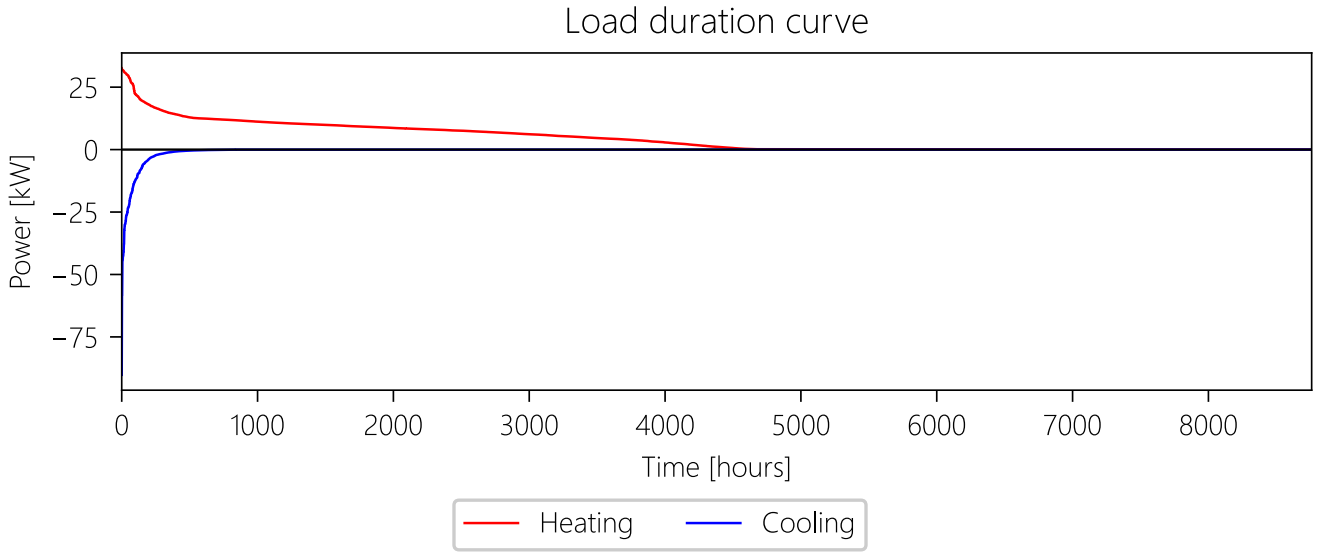
The system was simulated with a variable flow rate, where a constant temperature difference across the borefield was used of 3,00 °C in extraction and 3,00 °C in injection, with a minimum flow percentage of 30%. The resulting maximum flow rate through the borefield is 2,18 l/s and 7,91 l/s respectively.

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	38 292 kWh/y	32,5 kW
Cooling demand	3 859 kWh/y	90,2 kW





Efficiency data

To calculate the resulting geothermal load, the heat pump is modelled to have an SCOP of 5,00 in heating. The cooling is modelled with an SEER of 20,00.

4.1.2 Results

Ground load

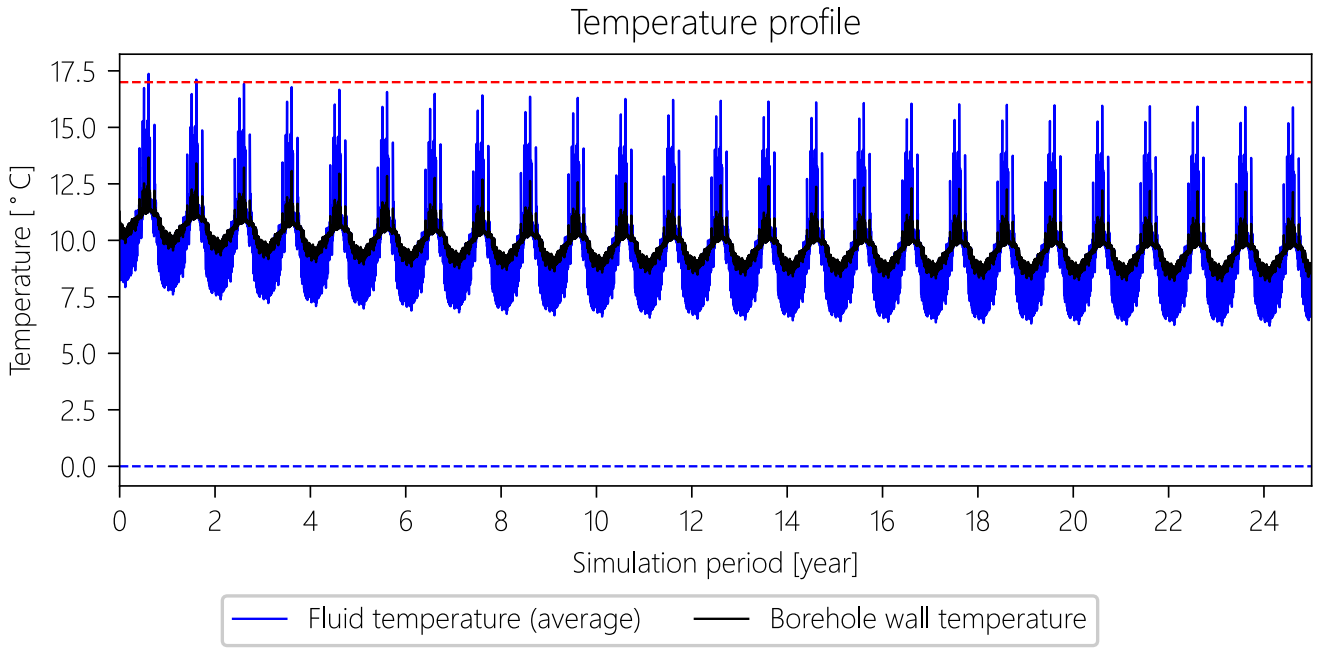
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	30 634 kWh/y	26,0 kW
Injection demand	4 052 kWh/y	94,7 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 533, whilst it was 3 000 during injection. This corresponds respectively to a laminar and transitional flow regime, with an effective borehole thermal resistance of 0,1959 m·K/W and 0,0957 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 17,37 °C, and the minimum average fluid temperature is 6,22 °C.

Pressure drop

The pressure drop over a single borehole is 3,43 kPa during extraction and 16,63 kPa during injection.

4.2 Active cooling - auditorium

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

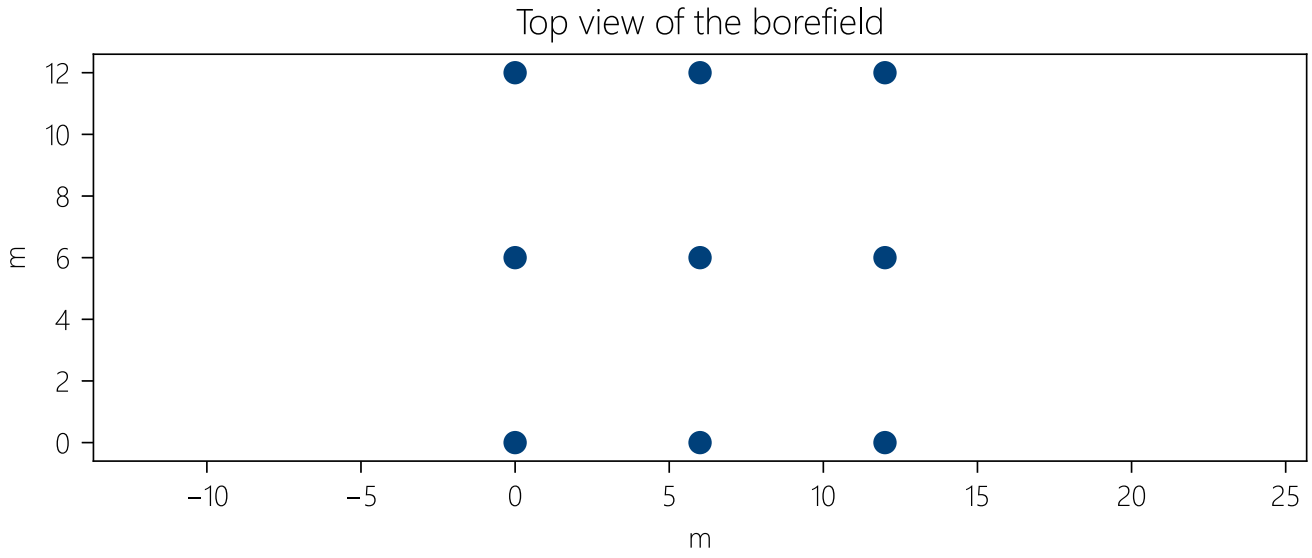
The scenarios in this report have been simulated with a simulation period of 25 years, starting in January. The minimum and maximum average fluid temperatures were 0,00 °C and 25,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Borefield configuration

The simulations were carried out with a borefield consisting of 9 boreholes, with an average buried depth of 1,00 m, an average borehole depth of 120,00 m and an average borehole length of 119,00 m. This results in a total borehole length of 1 071,00 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	119,00	120,00	1,00	0,00	0,00
0,00	6,00	119,00	120,00	1,00	0,00	0,00
0,00	12,00	119,00	120,00	1,00	0,00	0,00
6,00	0,00	119,00	120,00	1,00	0,00	0,00
6,00	6,00	119,00	120,00	1,00	0,00	0,00
6,00	12,00	119,00	120,00	1,00	0,00	0,00
12,00	0,00	119,00	120,00	1,00	0,00	0,00
12,00	6,00	119,00	120,00	1,00	0,00	0,00
12,00	12,00	119,00	120,00	1,00	0,00	0,00

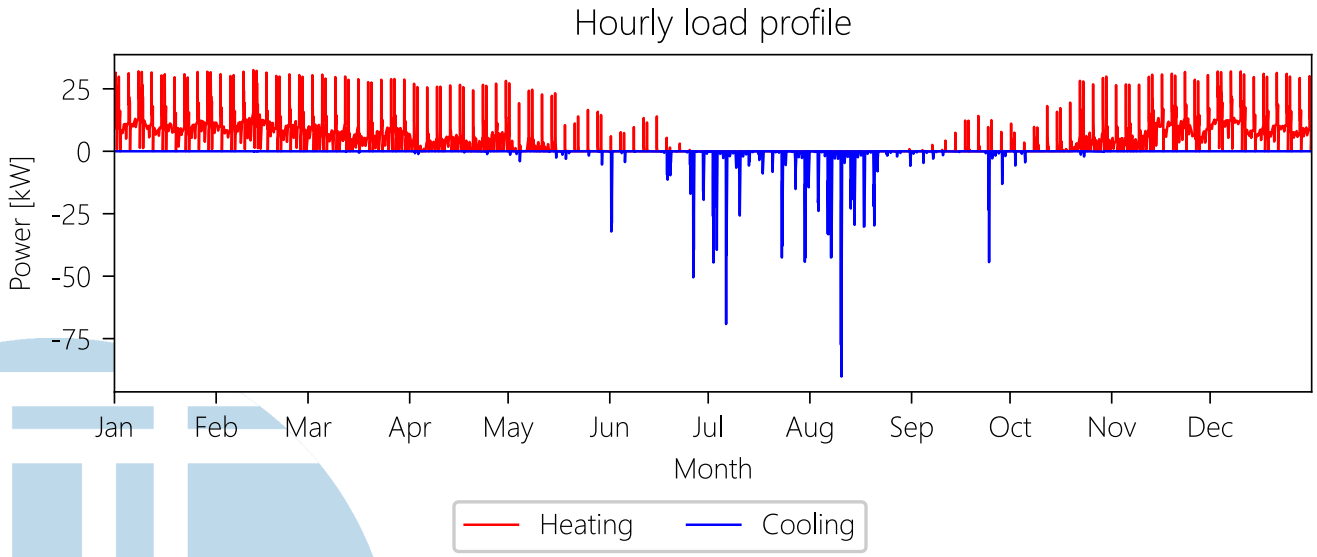
Flow data

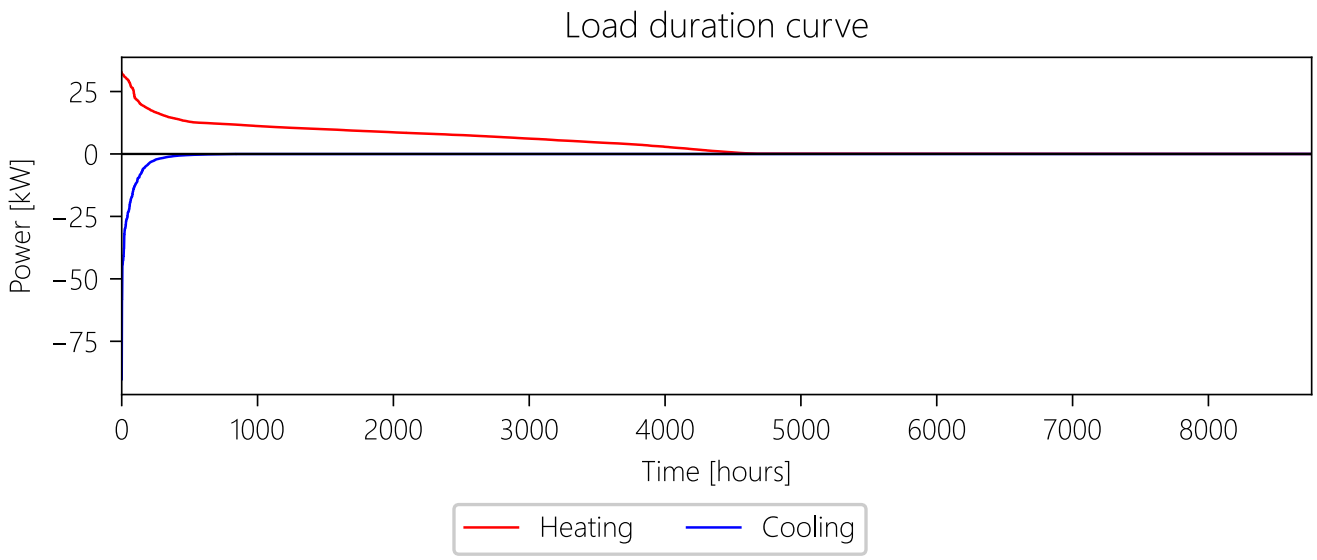
The system was simulated with a variable flow rate, where a constant temperature difference across the borefield was used of 3,00 °C in extraction and 3,00 °C in injection, with a minimum flow percentage of 30%. The resulting maximum flow rate through the borefield is 2,19 l/s and 9,03 l/s respectively.

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	38 292 kWh/y	32,5 kW
Cooling demand	3 859 kWh/y	90,2 kW





Efficiency data

To calculate the resulting geothermal load, the heat pump is modelled to have an SCOP of 5,00 in heating. The cooling is modelled with an SEER of 5,00.

4.2.2 Results

Ground load

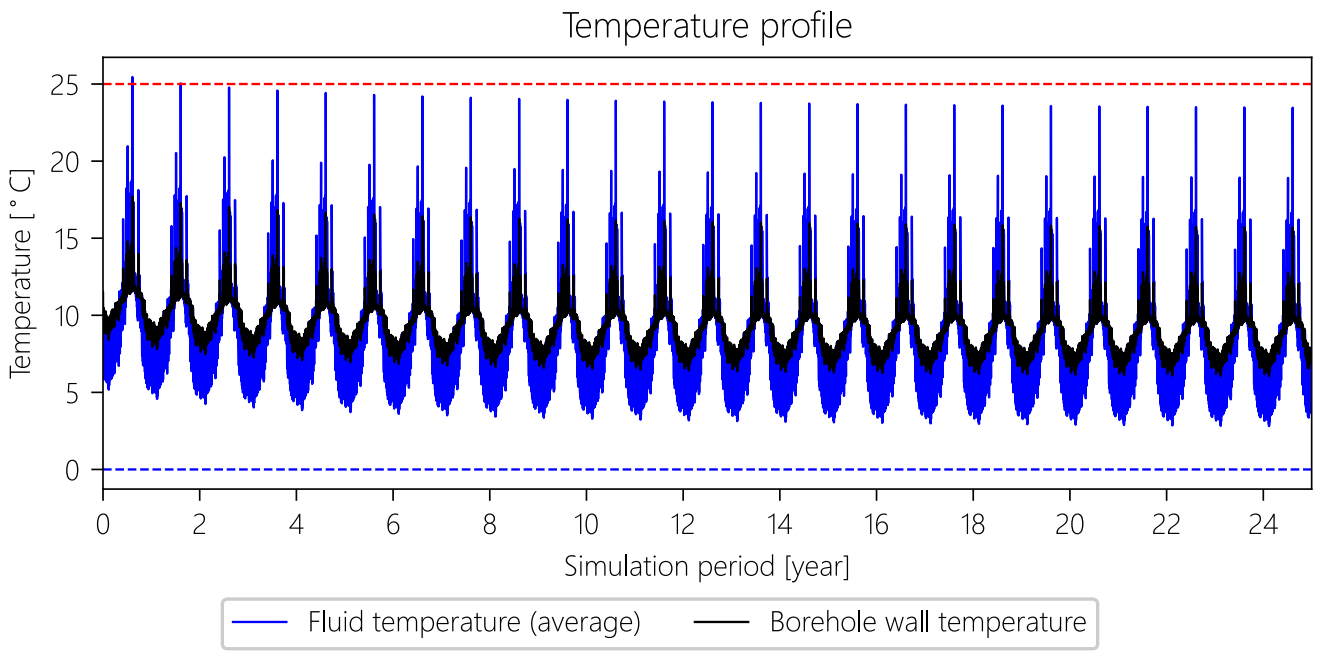
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	30 634 kWh/y	26,0 kW
Injection demand	4 631 kWh/y	108,2 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 1 224, whilst it was 11 990 during injection. This corresponds respectively to a laminar and turbulent flow regime, with an effective borehole thermal resistance of 0,1467 m·K/W and 0,0801 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 25,46 °C, and the minimum average fluid temperature is 2,81 °C.

Pressure drop

The pressure drop over a single borehole is 12,79 kPa during extraction and 125,01 kPa during injection.

4.3 Passive cooling - office

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

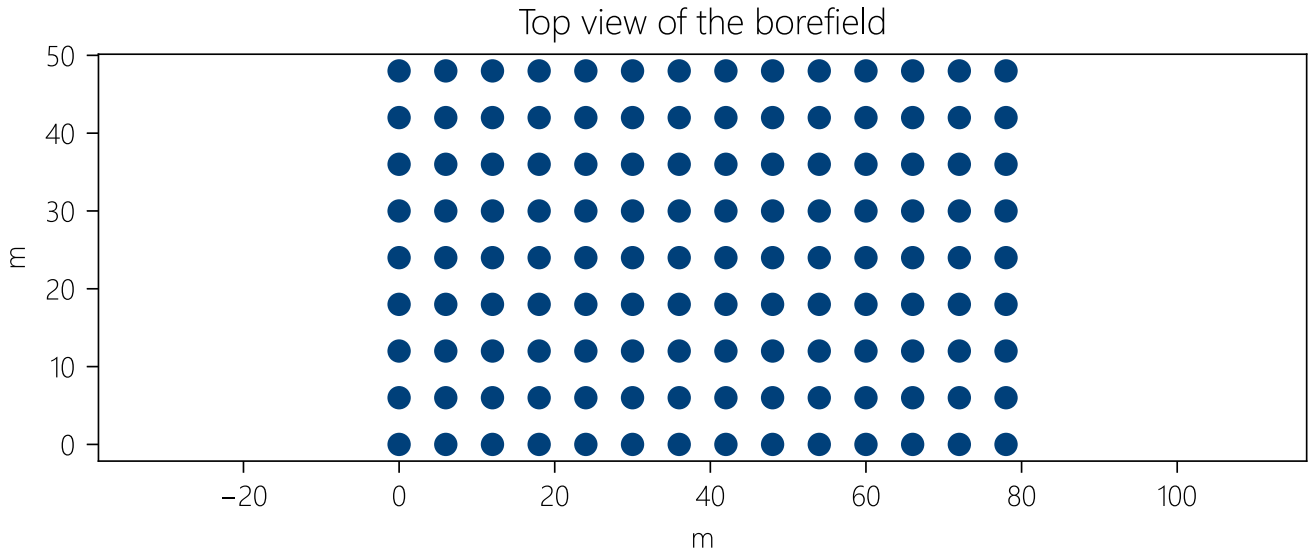
The scenarios in this report have been simulated with a simulation period of 25 years, starting in January. The minimum and maximum average fluid temperatures were 0,00 °C and 17,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Borefield configuration

The simulations were carried out with a borefield consisting of 126 boreholes, with an average buried depth of 1,00 m, an average borehole depth of 150,00 m and an average borehole length of 149,00 m. This results in a total borehole length of 18 774,00 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	149,00	150,00	1,00	0,00	0,00
0,00	6,00	149,00	150,00	1,00	0,00	0,00
0,00	12,00	149,00	150,00	1,00	0,00	0,00
0,00	18,00	149,00	150,00	1,00	0,00	0,00
0,00	24,00	149,00	150,00	1,00	0,00	0,00
0,00	30,00	149,00	150,00	1,00	0,00	0,00
0,00	36,00	149,00	150,00	1,00	0,00	0,00
0,00	42,00	149,00	150,00	1,00	0,00	0,00
0,00	48,00	149,00	150,00	1,00	0,00	0,00
6,00	0,00	149,00	150,00	1,00	0,00	0,00
6,00	6,00	149,00	150,00	1,00	0,00	0,00
6,00	12,00	149,00	150,00	1,00	0,00	0,00
6,00	18,00	149,00	150,00	1,00	0,00	0,00
6,00	24,00	149,00	150,00	1,00	0,00	0,00
6,00	30,00	149,00	150,00	1,00	0,00	0,00
6,00	36,00	149,00	150,00	1,00	0,00	0,00
6,00	42,00	149,00	150,00	1,00	0,00	0,00
6,00	48,00	149,00	150,00	1,00	0,00	0,00
12,00	0,00	149,00	150,00	1,00	0,00	0,00
12,00	6,00	149,00	150,00	1,00	0,00	0,00
12,00	12,00	149,00	150,00	1,00	0,00	0,00
12,00	18,00	149,00	150,00	1,00	0,00	0,00
12,00	24,00	149,00	150,00	1,00	0,00	0,00
12,00	30,00	149,00	150,00	1,00	0,00	0,00
12,00	36,00	149,00	150,00	1,00	0,00	0,00
12,00	42,00	149,00	150,00	1,00	0,00	0,00
12,00	48,00	149,00	150,00	1,00	0,00	0,00
18,00	0,00	149,00	150,00	1,00	0,00	0,00
18,00	6,00	149,00	150,00	1,00	0,00	0,00
18,00	12,00	149,00	150,00	1,00	0,00	0,00
18,00	18,00	149,00	150,00	1,00	0,00	0,00
18,00	24,00	149,00	150,00	1,00	0,00	0,00

18,00	30,00	149,00	150,00	1,00	0,00	0,00
18,00	36,00	149,00	150,00	1,00	0,00	0,00
18,00	42,00	149,00	150,00	1,00	0,00	0,00
18,00	48,00	149,00	150,00	1,00	0,00	0,00
24,00	0,00	149,00	150,00	1,00	0,00	0,00
24,00	6,00	149,00	150,00	1,00	0,00	0,00
24,00	12,00	149,00	150,00	1,00	0,00	0,00
24,00	18,00	149,00	150,00	1,00	0,00	0,00
24,00	24,00	149,00	150,00	1,00	0,00	0,00
24,00	30,00	149,00	150,00	1,00	0,00	0,00
24,00	36,00	149,00	150,00	1,00	0,00	0,00
24,00	42,00	149,00	150,00	1,00	0,00	0,00
24,00	48,00	149,00	150,00	1,00	0,00	0,00
30,00	0,00	149,00	150,00	1,00	0,00	0,00
30,00	6,00	149,00	150,00	1,00	0,00	0,00
30,00	12,00	149,00	150,00	1,00	0,00	0,00
30,00	18,00	149,00	150,00	1,00	0,00	0,00
30,00	24,00	149,00	150,00	1,00	0,00	0,00
30,00	30,00	149,00	150,00	1,00	0,00	0,00
30,00	36,00	149,00	150,00	1,00	0,00	0,00
30,00	42,00	149,00	150,00	1,00	0,00	0,00
30,00	48,00	149,00	150,00	1,00	0,00	0,00
36,00	0,00	149,00	150,00	1,00	0,00	0,00
36,00	6,00	149,00	150,00	1,00	0,00	0,00
36,00	12,00	149,00	150,00	1,00	0,00	0,00
36,00	18,00	149,00	150,00	1,00	0,00	0,00
36,00	24,00	149,00	150,00	1,00	0,00	0,00
36,00	30,00	149,00	150,00	1,00	0,00	0,00
36,00	36,00	149,00	150,00	1,00	0,00	0,00
36,00	42,00	149,00	150,00	1,00	0,00	0,00
36,00	48,00	149,00	150,00	1,00	0,00	0,00
42,00	0,00	149,00	150,00	1,00	0,00	0,00
42,00	6,00	149,00	150,00	1,00	0,00	0,00
42,00	12,00	149,00	150,00	1,00	0,00	0,00
42,00	18,00	149,00	150,00	1,00	0,00	0,00

42,00	24,00	149,00	150,00	1,00	0,00	0,00
42,00	30,00	149,00	150,00	1,00	0,00	0,00
42,00	36,00	149,00	150,00	1,00	0,00	0,00
42,00	42,00	149,00	150,00	1,00	0,00	0,00
42,00	48,00	149,00	150,00	1,00	0,00	0,00
48,00	0,00	149,00	150,00	1,00	0,00	0,00
48,00	6,00	149,00	150,00	1,00	0,00	0,00
48,00	12,00	149,00	150,00	1,00	0,00	0,00
48,00	18,00	149,00	150,00	1,00	0,00	0,00
48,00	24,00	149,00	150,00	1,00	0,00	0,00
48,00	30,00	149,00	150,00	1,00	0,00	0,00
48,00	36,00	149,00	150,00	1,00	0,00	0,00
48,00	42,00	149,00	150,00	1,00	0,00	0,00
48,00	48,00	149,00	150,00	1,00	0,00	0,00
54,00	0,00	149,00	150,00	1,00	0,00	0,00
54,00	6,00	149,00	150,00	1,00	0,00	0,00
54,00	12,00	149,00	150,00	1,00	0,00	0,00
54,00	18,00	149,00	150,00	1,00	0,00	0,00
54,00	24,00	149,00	150,00	1,00	0,00	0,00
54,00	30,00	149,00	150,00	1,00	0,00	0,00
54,00	36,00	149,00	150,00	1,00	0,00	0,00
54,00	42,00	149,00	150,00	1,00	0,00	0,00
54,00	48,00	149,00	150,00	1,00	0,00	0,00
60,00	0,00	149,00	150,00	1,00	0,00	0,00
60,00	6,00	149,00	150,00	1,00	0,00	0,00
60,00	12,00	149,00	150,00	1,00	0,00	0,00
60,00	18,00	149,00	150,00	1,00	0,00	0,00
60,00	24,00	149,00	150,00	1,00	0,00	0,00
60,00	30,00	149,00	150,00	1,00	0,00	0,00
60,00	36,00	149,00	150,00	1,00	0,00	0,00
60,00	42,00	149,00	150,00	1,00	0,00	0,00
60,00	48,00	149,00	150,00	1,00	0,00	0,00
66,00	0,00	149,00	150,00	1,00	0,00	0,00
66,00	6,00	149,00	150,00	1,00	0,00	0,00
66,00	12,00	149,00	150,00	1,00	0,00	0,00

66,00	18,00	149,00	150,00	1,00	0,00	0,00
66,00	24,00	149,00	150,00	1,00	0,00	0,00
66,00	30,00	149,00	150,00	1,00	0,00	0,00
66,00	36,00	149,00	150,00	1,00	0,00	0,00
66,00	42,00	149,00	150,00	1,00	0,00	0,00
66,00	48,00	149,00	150,00	1,00	0,00	0,00
72,00	0,00	149,00	150,00	1,00	0,00	0,00
72,00	6,00	149,00	150,00	1,00	0,00	0,00
72,00	12,00	149,00	150,00	1,00	0,00	0,00
72,00	18,00	149,00	150,00	1,00	0,00	0,00
72,00	24,00	149,00	150,00	1,00	0,00	0,00
72,00	30,00	149,00	150,00	1,00	0,00	0,00
72,00	36,00	149,00	150,00	1,00	0,00	0,00
72,00	42,00	149,00	150,00	1,00	0,00	0,00
72,00	48,00	149,00	150,00	1,00	0,00	0,00
78,00	0,00	149,00	150,00	1,00	0,00	0,00
78,00	6,00	149,00	150,00	1,00	0,00	0,00
78,00	12,00	149,00	150,00	1,00	0,00	0,00
78,00	18,00	149,00	150,00	1,00	0,00	0,00
78,00	24,00	149,00	150,00	1,00	0,00	0,00
78,00	30,00	149,00	150,00	1,00	0,00	0,00
78,00	36,00	149,00	150,00	1,00	0,00	0,00
78,00	42,00	149,00	150,00	1,00	0,00	0,00
78,00	48,00	149,00	150,00	1,00	0,00	0,00

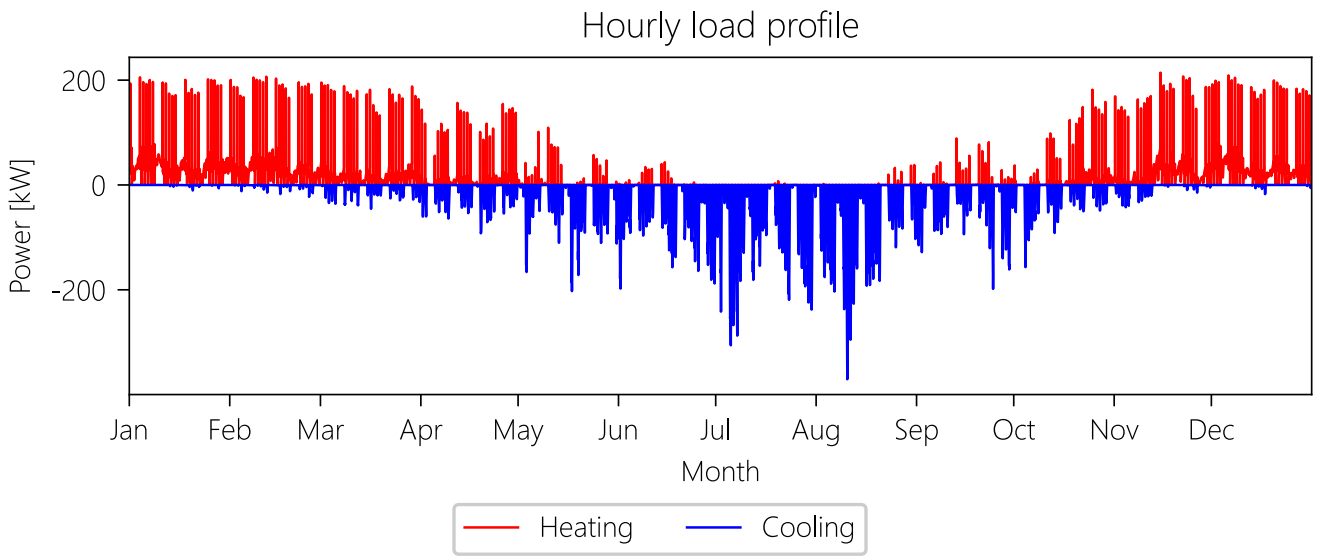
Flow data

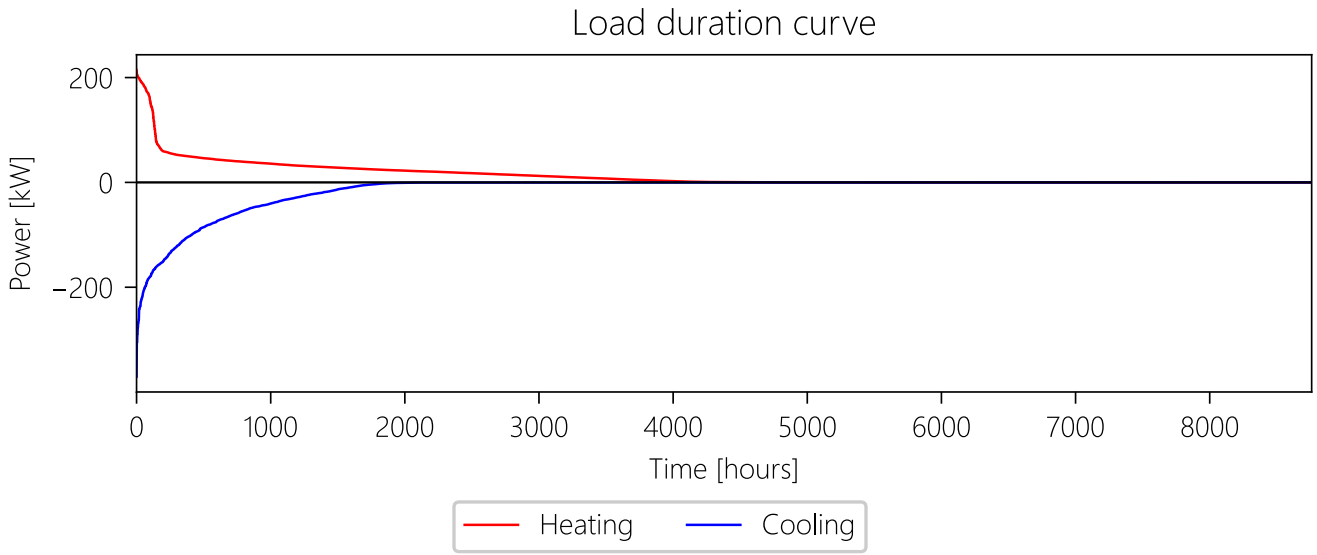
The system was simulated with a variable flow rate, where a constant temperature difference across the borefield was used of 3,00 °C in extraction and 3,00 °C in injection, with a minimum flow percentage of 30%. The resulting maximum flow rate through the borefield is 14,36 l/s and 32,52 l/s respectively.

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	117 509 kWh/y	214,2 kW
Cooling demand	118 276 kWh/y	370,6 kW





Efficiency data

To calculate the resulting geothermal load, the heat pump is modelled to have an SCOP of 5,00 in heating. The cooling is modelled with an SEER of 20,00.

4.3.2 Results

Ground load

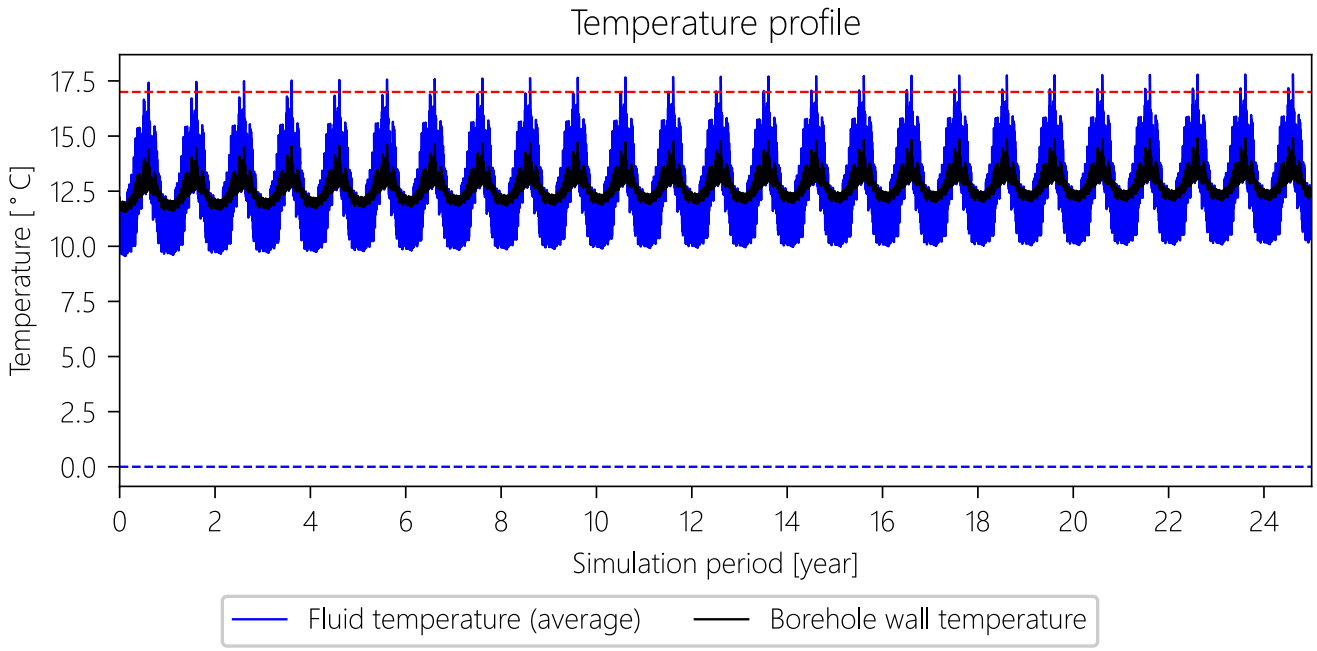
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	94 007 kWh/y	171,4 kW
Injection demand	124 190 kWh/y	389,1 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 768, whilst it was 2 384 during injection. This corresponds respectively to a laminar and transitional flow regime, with an effective borehole thermal resistance of 0,2204 m·K/W and 0,1348 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 17,80 °C, and the minimum average fluid temperature is 9,56 °C.

Pressure drop

The pressure drop over a single borehole is 5,58 kPa during extraction and 16,29 kPa during injection.

4.4 Active cooling - office

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

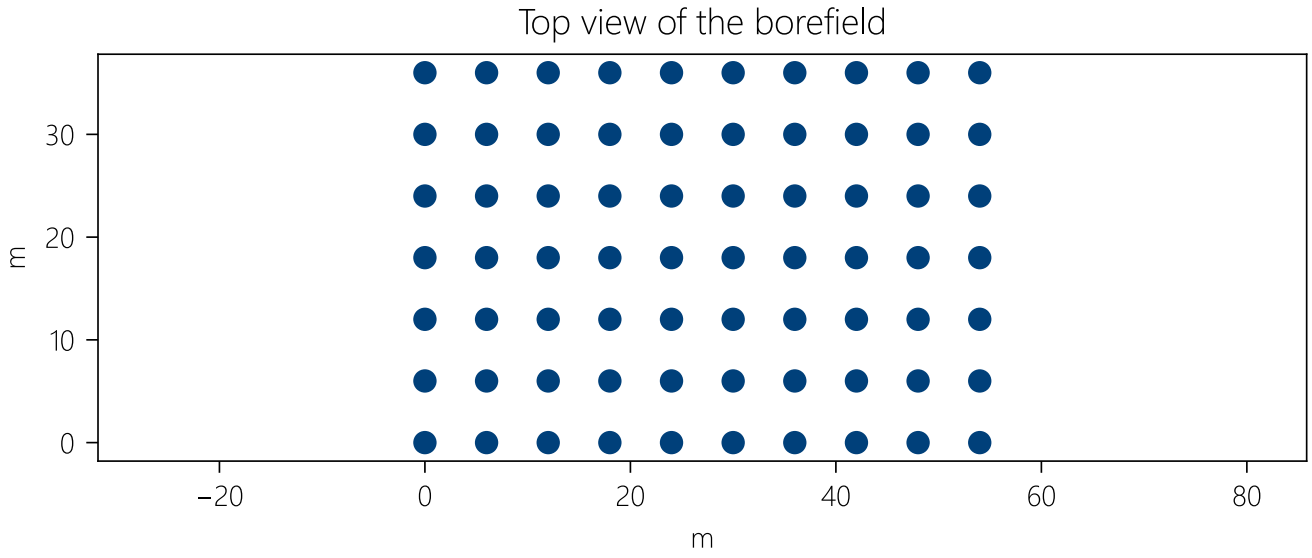
The scenarios in this report have been simulated with a simulation period of 25 years, starting in January. The minimum and maximum average fluid temperatures were 0,00 °C and 25,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Borefield configuration

The simulations were carried out with a borefield consisting of 70 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 6 930,00 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
0,00	24,00	99,00	100,00	1,00	0,00	0,00
0,00	30,00	99,00	100,00	1,00	0,00	0,00
0,00	36,00	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
6,00	24,00	99,00	100,00	1,00	0,00	0,00
6,00	30,00	99,00	100,00	1,00	0,00	0,00
6,00	36,00	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
12,00	24,00	99,00	100,00	1,00	0,00	0,00
12,00	30,00	99,00	100,00	1,00	0,00	0,00
12,00	36,00	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
18,00	24,00	99,00	100,00	1,00	0,00	0,00
18,00	30,00	99,00	100,00	1,00	0,00	0,00
18,00	36,00	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

24,00	24,00	99,00	100,00	1,00	0,00	0,00
24,00	30,00	99,00	100,00	1,00	0,00	0,00
24,00	36,00	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
30,00	24,00	99,00	100,00	1,00	0,00	0,00
30,00	30,00	99,00	100,00	1,00	0,00	0,00
30,00	36,00	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
36,00	24,00	99,00	100,00	1,00	0,00	0,00
36,00	30,00	99,00	100,00	1,00	0,00	0,00
36,00	36,00	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
42,00	24,00	99,00	100,00	1,00	0,00	0,00
42,00	30,00	99,00	100,00	1,00	0,00	0,00
42,00	36,00	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
48,00	24,00	99,00	100,00	1,00	0,00	0,00
48,00	30,00	99,00	100,00	1,00	0,00	0,00
48,00	36,00	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

54,00	24,00	99,00	100,00	1,00	0,00	0,00
54,00	30,00	99,00	100,00	1,00	0,00	0,00
54,00	36,00	99,00	100,00	1,00	0,00	0,00

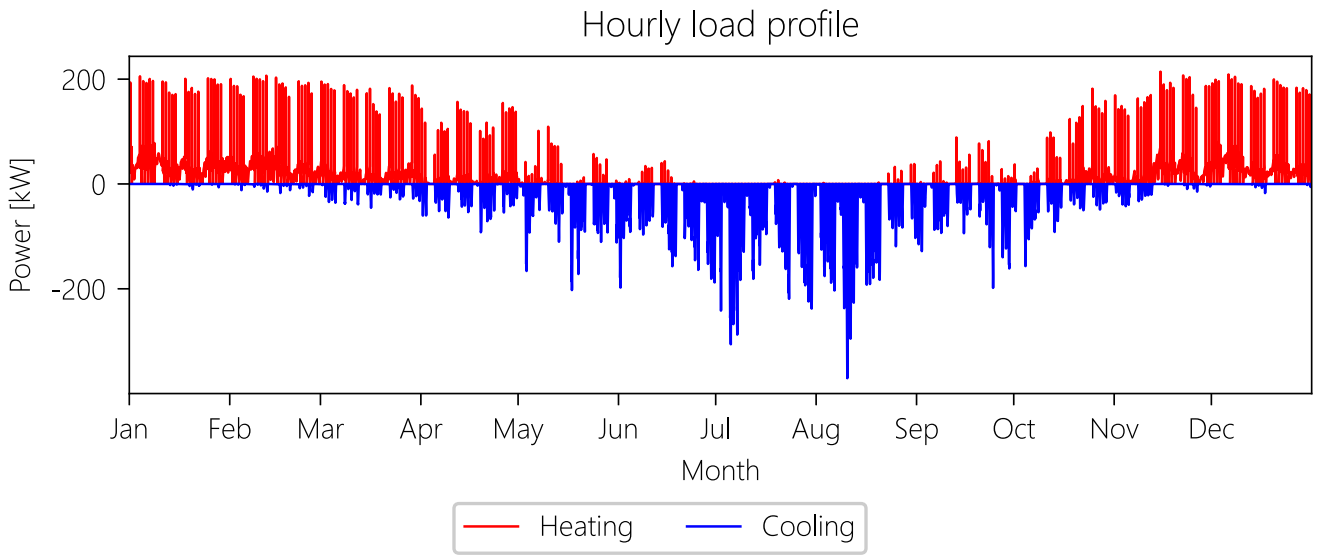
Flow data

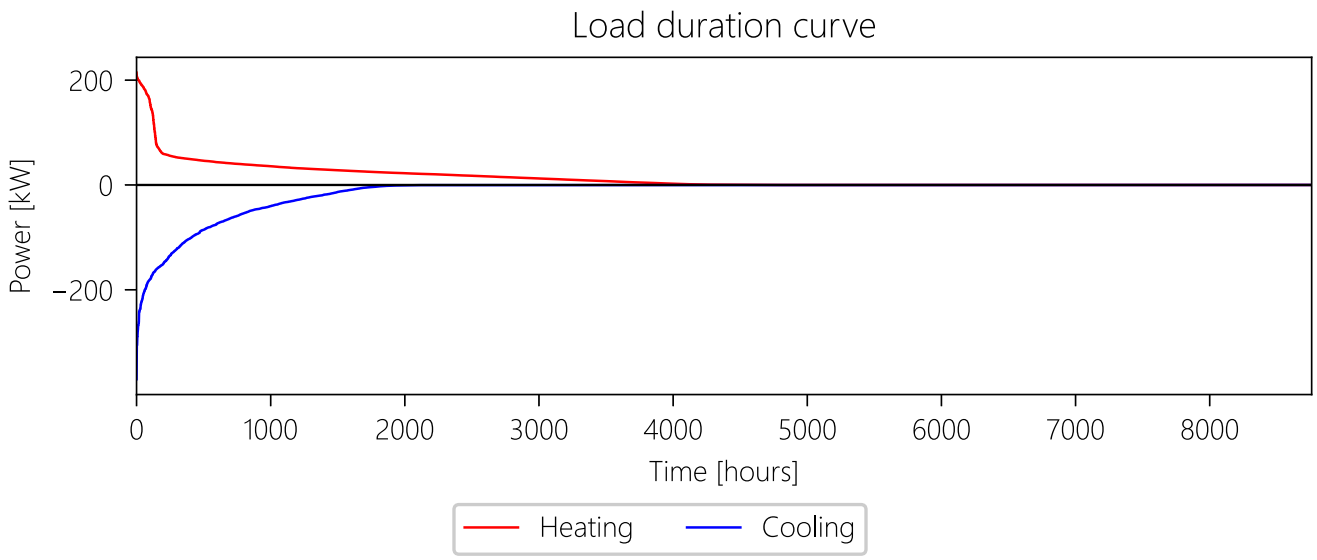
The system was simulated with a variable flow rate, where a constant temperature difference across the borefield was used of 3,00 °C in extraction and 3,00 °C in injection, with a minimum flow percentage of 30%. The resulting maximum flow rate through the borefield is 14,37 l/s and 37,10 l/s respectively.

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	117 509 kWh/y	214,2 kW
Cooling demand	118 276 kWh/y	370,6 kW





Efficiency data

To calculate the resulting geothermal load, the heat pump is modelled to have an SCOP of 5,00 in heating. The cooling is modelled with an SEER of 5,00.

4.4.2 Results

Ground load

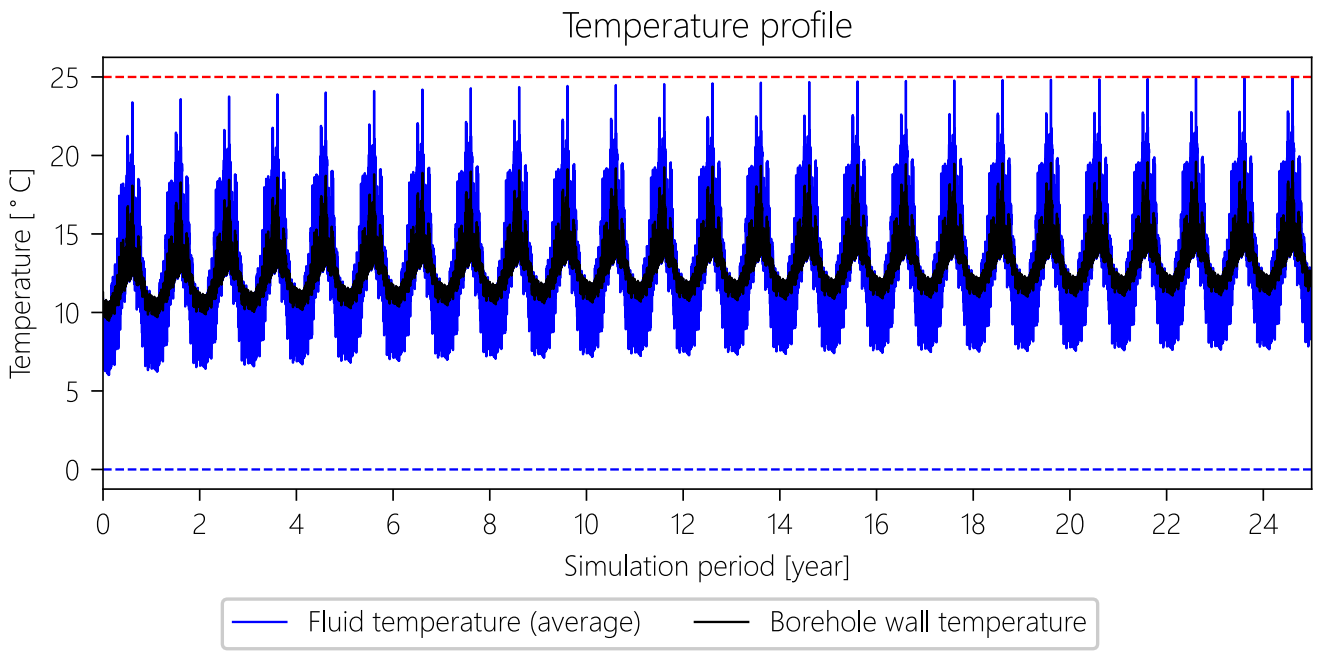
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	94 007 kWh/y	171,4 kW
Injection demand	141 931 kWh/y	444,7 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 1 192, whilst it was 6 233 during injection. This corresponds respectively to a laminar and turbulent flow regime, with an effective borehole thermal resistance of 0,1459 m·K/W and 0,0839 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 24,94 °C, and the minimum average fluid temperature is 6,02 °C.

Pressure drop

The pressure drop over a single borehole is 7,64 kPa during extraction and 34,64 kPa during injection.

4.5 Auditorium - fixed period

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

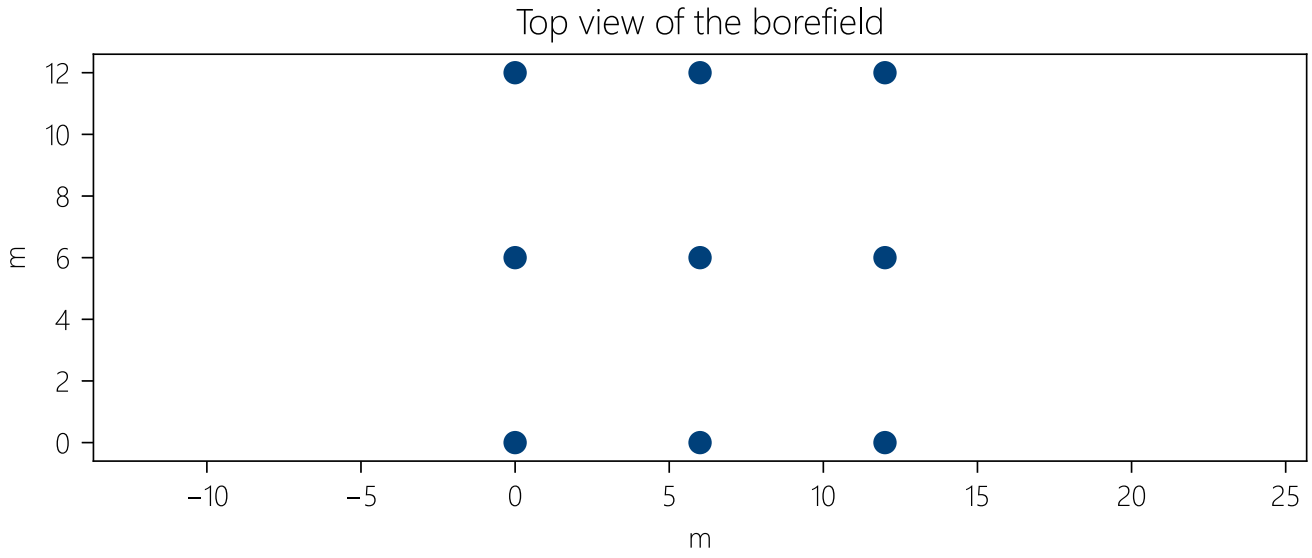
The scenarios in this report have been simulated with a simulation period of 25 years, starting in January. The minimum and maximum average fluid temperatures were 0,00 °C and 25,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Borefield configuration

The simulations were carried out with a borefield consisting of 9 boreholes, with an average buried depth of 1,00 m, an average borehole depth of 120,00 m and an average borehole length of 119,00 m. This results in a total borehole length of 1 071,00 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	119,00	120,00	1,00	0,00	0,00
0,00	6,00	119,00	120,00	1,00	0,00	0,00
0,00	12,00	119,00	120,00	1,00	0,00	0,00
6,00	0,00	119,00	120,00	1,00	0,00	0,00
6,00	6,00	119,00	120,00	1,00	0,00	0,00
6,00	12,00	119,00	120,00	1,00	0,00	0,00
12,00	0,00	119,00	120,00	1,00	0,00	0,00
12,00	6,00	119,00	120,00	1,00	0,00	0,00
12,00	12,00	119,00	120,00	1,00	0,00	0,00

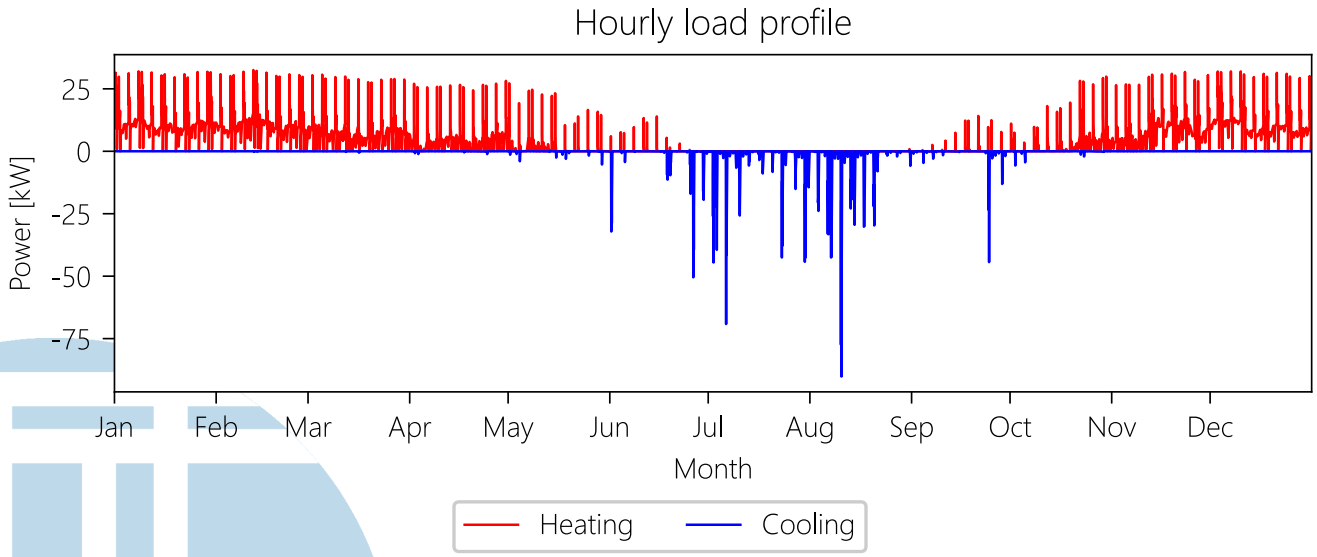
Flow data

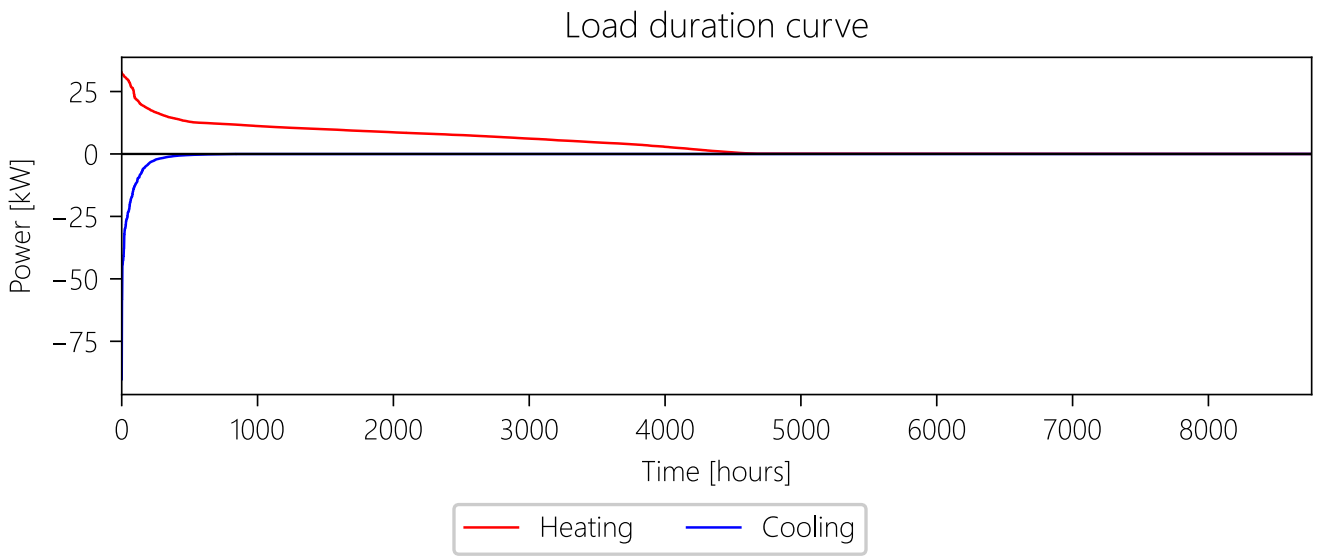
The system was simulated with a variable flow rate, where a constant temperature difference across the borefield was used of 3,00 °C in extraction and 3,00 °C in injection, with a minimum flow percentage of 30%. The resulting maximum flow rate through the borefield is 2,19 l/s and 9,03 l/s respectively.

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	38 292 kWh/y	32,5 kW
Cooling demand	3 859 kWh/y	90,2 kW





Efficiency data

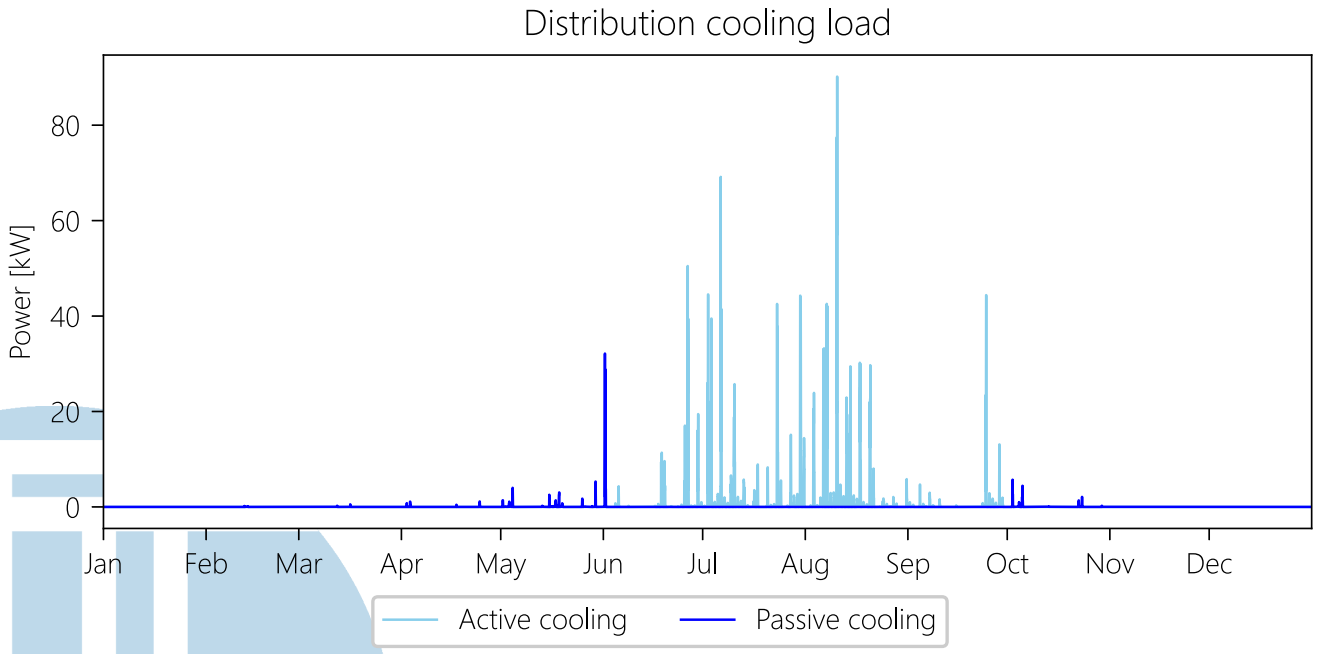
To calculate the resulting geothermal load, the heat pump is modelled to have an SCOP of 5,00 in heating. For the cooling, a combination of both passive (i.e. free) and active cooling is used, with an SEER of respectively 20,00 and 5,00. From June to September, active cooling is used by default. Outside of these months, passive cooling is used.

4.5.2 Results

Active and passive cooling

A combination of active and passive (or free) cooling on the borefield was used. Over the entire simulation period, an average SEER of 5,24 was achieved due to a 6 % share of passive cooling.

Below one can find the distribution of the active and passive load for one year. Since a fixed period for active cooling was selected, every year, the distribution is identical.



Ground load

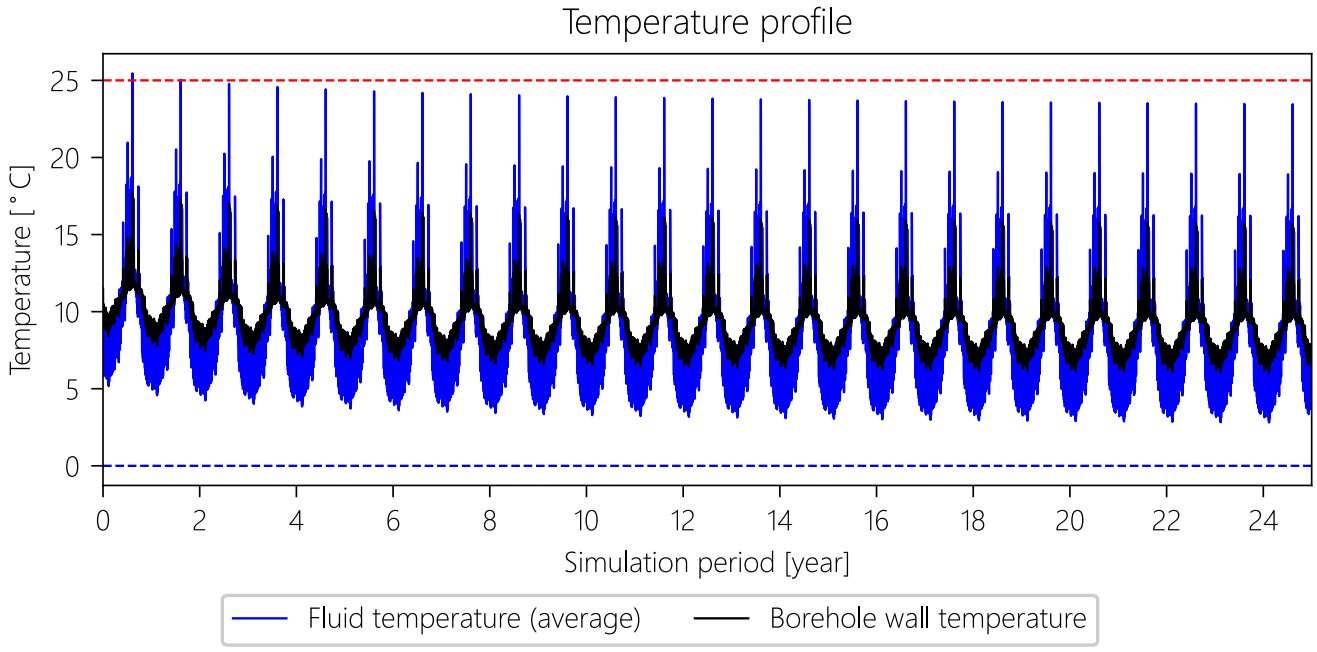
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	30 634 kWh/y	26,0 kW
Injection demand	4 595 kWh/y	108,2 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 1 223, whilst it was 11 990 during injection. This corresponds respectively to a laminar and turbulent flow regime, with an effective borehole thermal resistance of 0,1467 m·K/W and 0,0801 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 25,46 °C, and the minimum average fluid temperature is 2,81 °C.

Pressure drop

The pressure drop over a single borehole is 12,79 kPa during extraction and 125,02 kPa during injection.

4.6 Auditorium - threshold

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

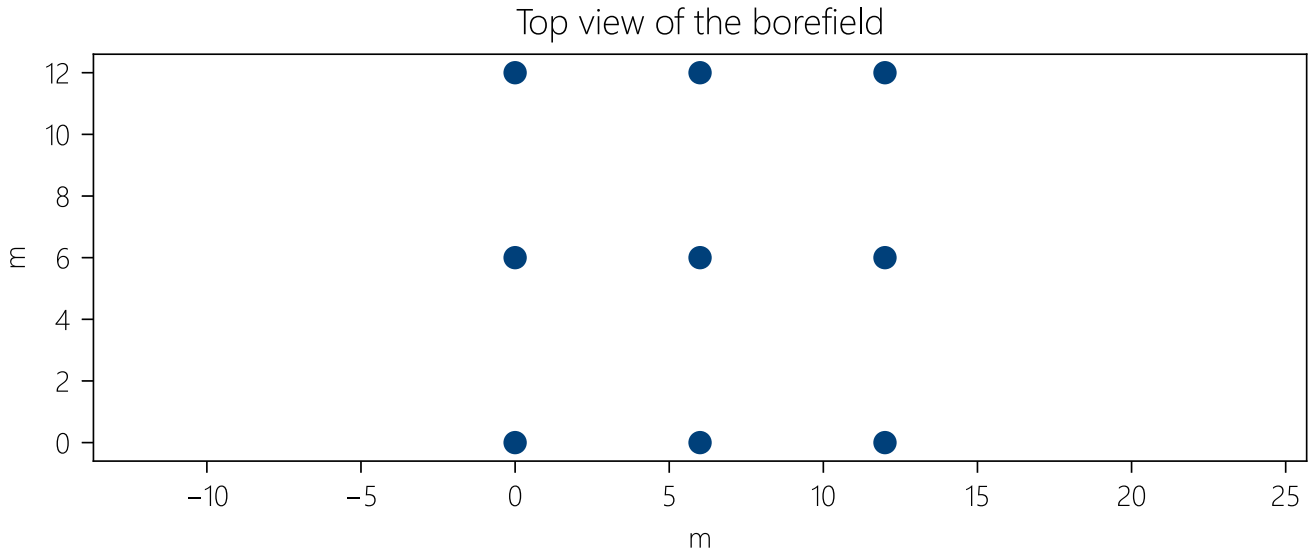
The scenarios in this report have been simulated with a simulation period of 25 years, starting in January. The minimum and maximum average fluid temperatures were 0,00 °C and 25,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Borefield configuration

The simulations were carried out with a borefield consisting of 9 boreholes, with an average buried depth of 1,00 m, an average borehole depth of 120,00 m and an average borehole length of 119,00 m. This results in a total borehole length of 1 071,00 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	119,00	120,00	1,00	0,00	0,00
0,00	6,00	119,00	120,00	1,00	0,00	0,00
0,00	12,00	119,00	120,00	1,00	0,00	0,00
6,00	0,00	119,00	120,00	1,00	0,00	0,00
6,00	6,00	119,00	120,00	1,00	0,00	0,00
6,00	12,00	119,00	120,00	1,00	0,00	0,00
12,00	0,00	119,00	120,00	1,00	0,00	0,00
12,00	6,00	119,00	120,00	1,00	0,00	0,00
12,00	12,00	119,00	120,00	1,00	0,00	0,00

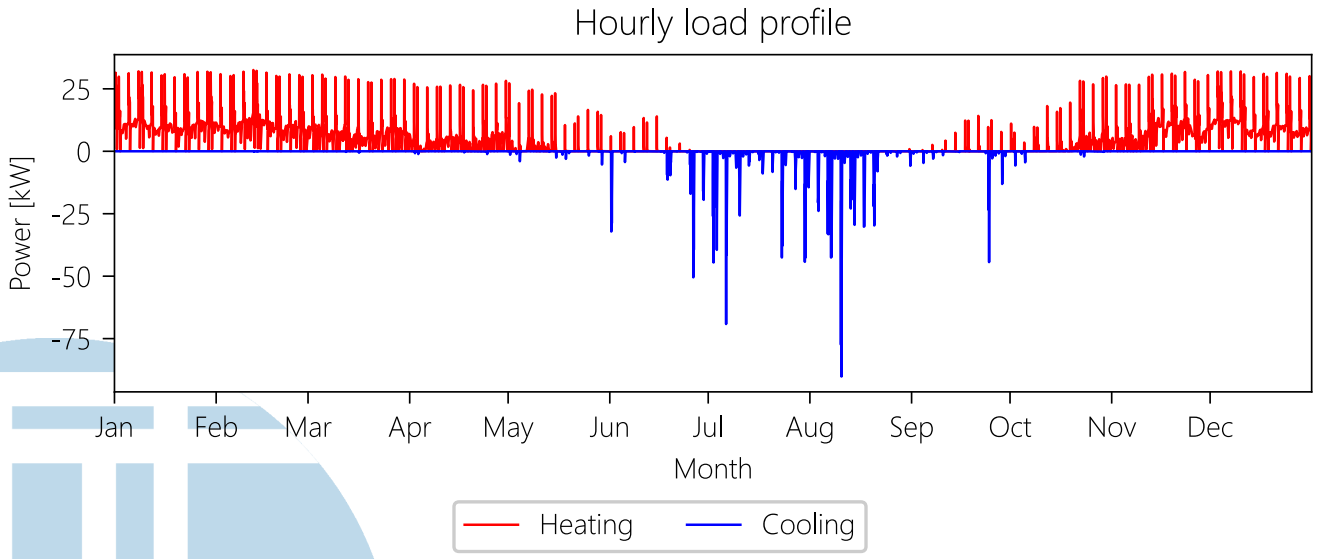
Flow data

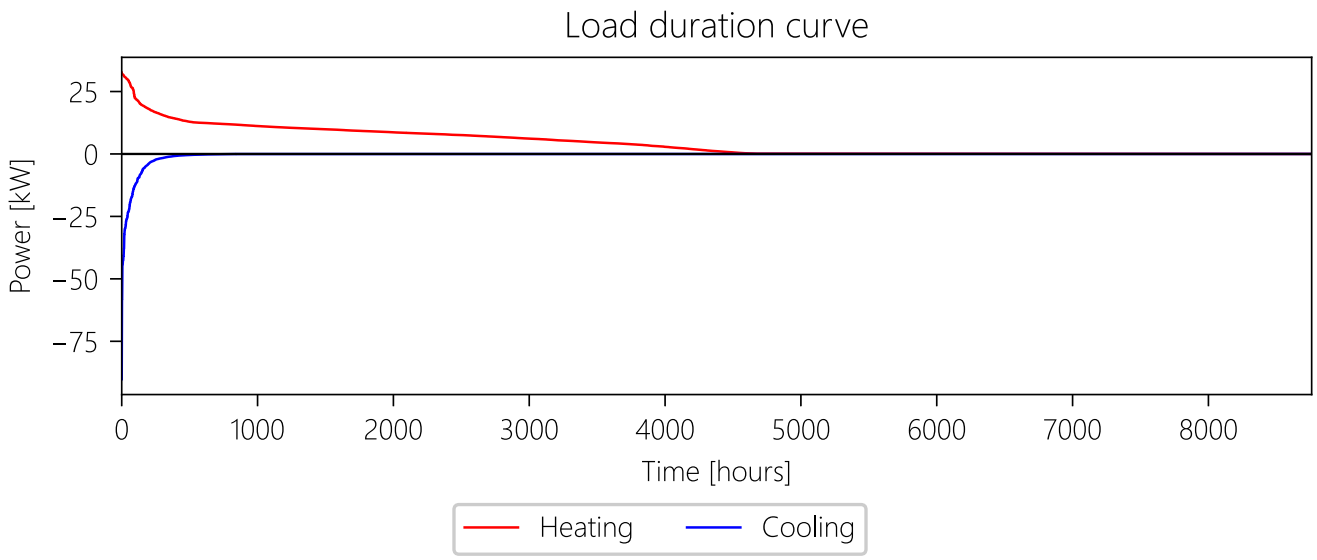
The system was simulated with a variable flow rate, where a constant temperature difference across the borefield was used of 3,00 °C in extraction and 3,00 °C in injection, with a minimum flow percentage of 30%. The resulting maximum flow rate through the borefield is 2,19 l/s and 9,03 l/s respectively.

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	38 292 kWh/y	32,5 kW
Cooling demand	3 859 kWh/y	90,2 kW





Efficiency data

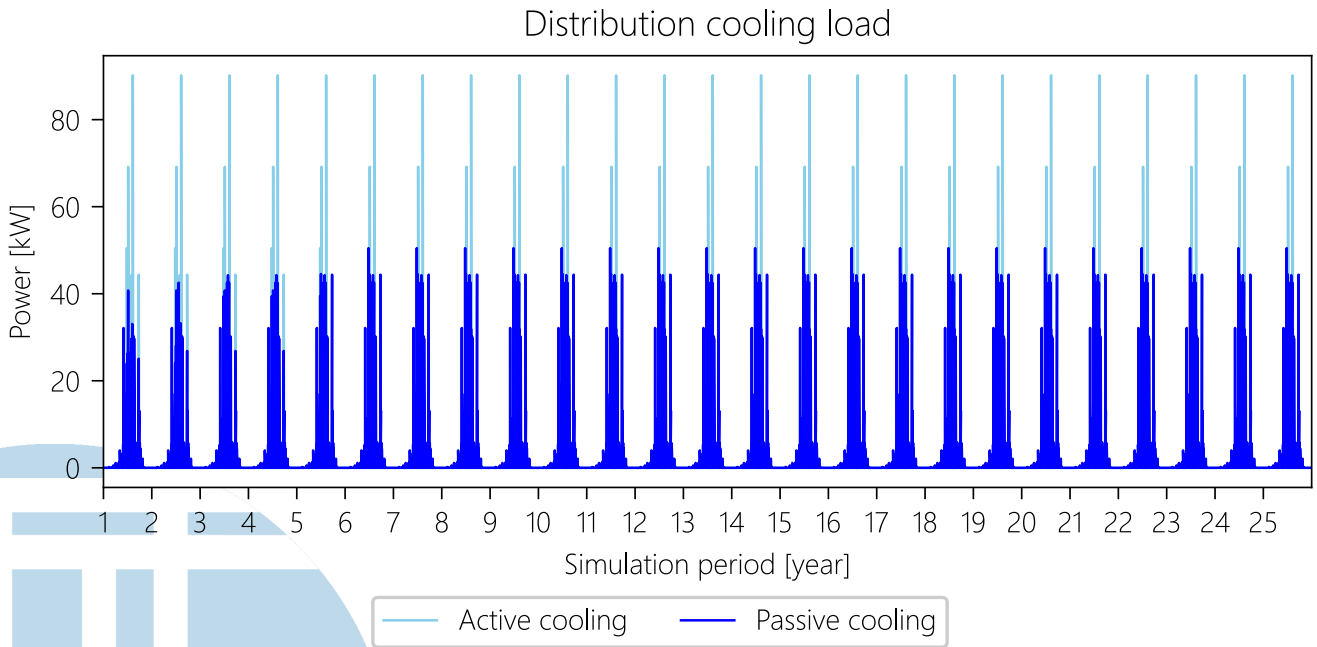
To calculate the resulting geothermal load, the heat pump is modelled to have an SCOP of 5,00 in heating. For the cooling, a combination of both passive (i.e. free) and active cooling is used, with an SEER of respectively 20,00 and 5,00. When the average fluid temperature is above 17,00 °C, active cooling is used. When it is below this threshold, passive cooling is used.

4.6.2 Results

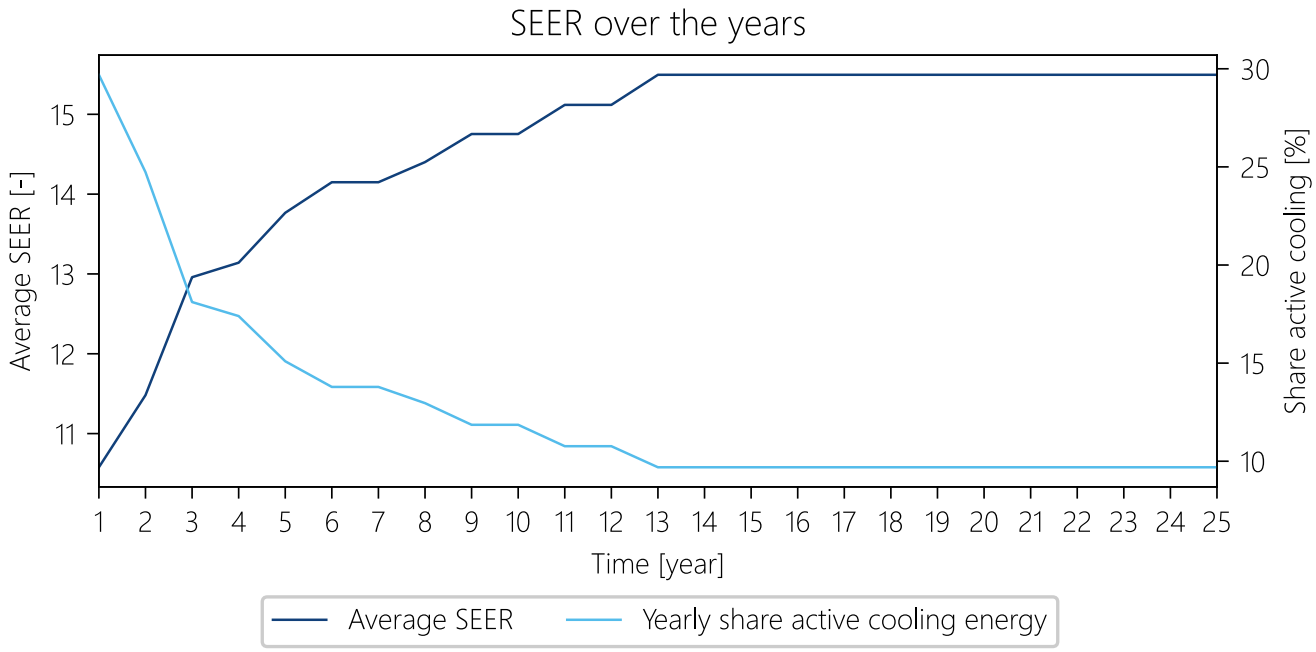
Active and passive cooling

A combination of active and passive (or free) cooling on the borefield was used. Over the entire simulation period, an average SEER of 14,49 was achieved due to a 87 % share of passive cooling.

Below one can find the distribution of the active and passive load over the simulation period.



Since the distribution between active and passive cooling is based on a temperature threshold, this ratio varies over time. The graph below shows how the SEER and the active cooling share vary over the simulation period.



Year	Average SEER	Yearly share active cooling energy
1	10,6	29,7 %
2	11,5	24,7 %
3	13,0	18,1 %
4	13,1	17,4 %
5	13,8	15,1 %
6	14,1	13,8 %
7	14,1	13,8 %
8	14,4	13,0 %
9	14,8	11,9 %
10	14,8	11,9 %
11	15,1	10,8 %
12	15,1	10,8 %
13	15,5	9,7 %
14	15,5	9,7 %
15	15,5	9,7 %
16	15,5	9,7 %
17	15,5	9,7 %
18	15,5	9,7 %
19	15,5	9,7 %
20	15,5	9,7 %
21	15,5	9,7 %
22	15,5	9,7 %
23	15,5	9,7 %
24	15,5	9,7 %
25	15,5	9,7 %

Ground load

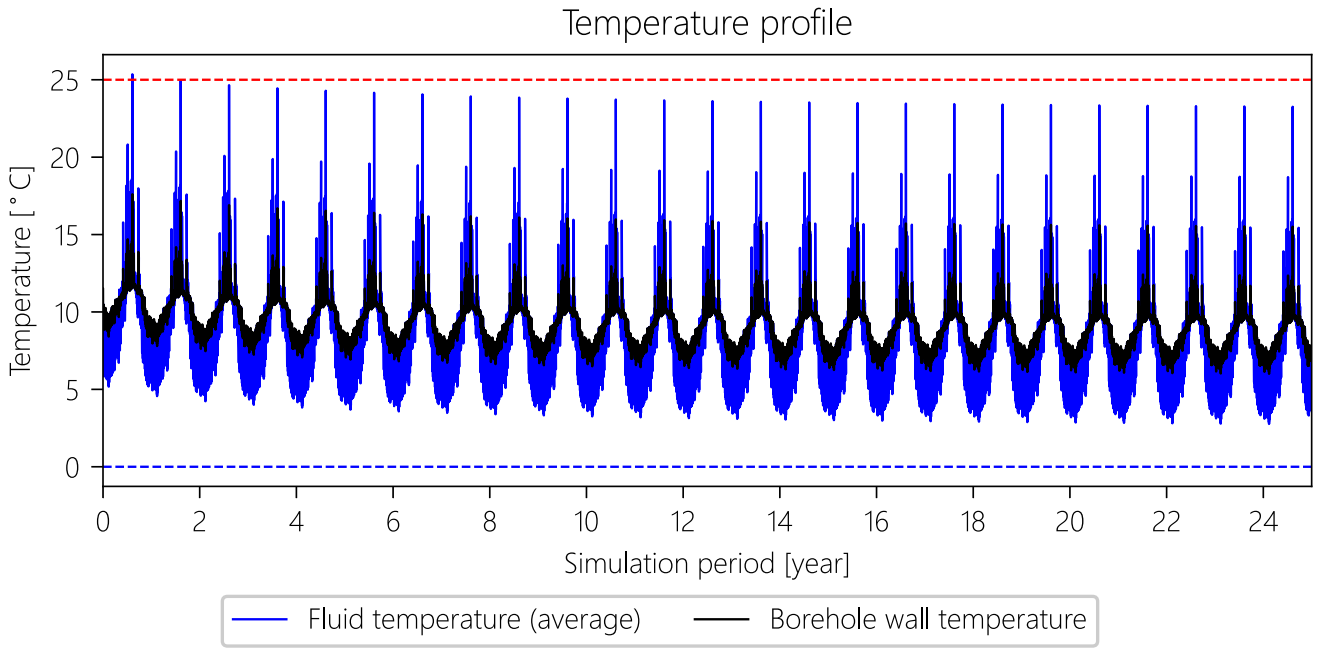
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	30 634 kWh/y	26,0 kW
Injection demand	4 126 kWh/y	108,2 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 1 221, whilst it was 11 951 during injection. This corresponds respectively to a laminar and turbulent flow regime, with an effective borehole thermal resistance of 0,1467 m·K/W and 0,0801 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 25,35 °C, and the minimum average fluid temperature is 2,76 °C.

Pressure drop

The pressure drop over a single borehole is 12,81 kPa during extraction and 125,25 kPa during injection.

4.7 Office - fixed period

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

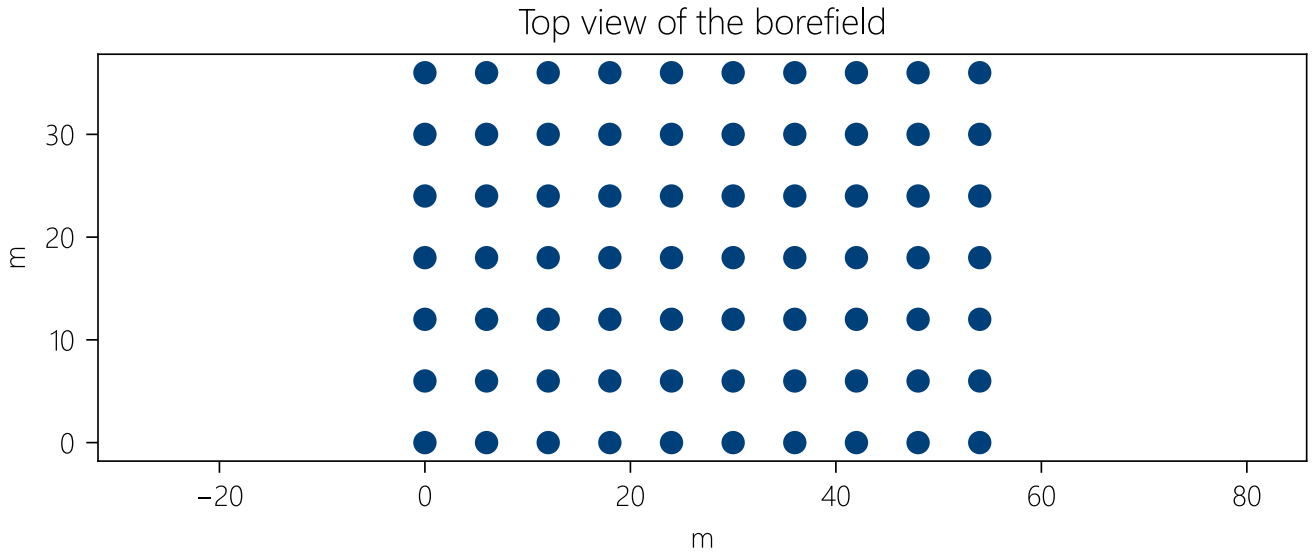
The scenarios in this report have been simulated with a simulation period of 25 years, starting in January. The minimum and maximum average fluid temperatures were 0,00 °C and 25,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Borefield configuration

The simulations were carried out with a borefield consisting of 70 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 6 930,00 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
0,00	24,00	99,00	100,00	1,00	0,00	0,00
0,00	30,00	99,00	100,00	1,00	0,00	0,00
0,00	36,00	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
6,00	24,00	99,00	100,00	1,00	0,00	0,00
6,00	30,00	99,00	100,00	1,00	0,00	0,00
6,00	36,00	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
12,00	24,00	99,00	100,00	1,00	0,00	0,00
12,00	30,00	99,00	100,00	1,00	0,00	0,00
12,00	36,00	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
18,00	24,00	99,00	100,00	1,00	0,00	0,00
18,00	30,00	99,00	100,00	1,00	0,00	0,00
18,00	36,00	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

24,00	24,00	99,00	100,00	1,00	0,00	0,00
24,00	30,00	99,00	100,00	1,00	0,00	0,00
24,00	36,00	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
30,00	24,00	99,00	100,00	1,00	0,00	0,00
30,00	30,00	99,00	100,00	1,00	0,00	0,00
30,00	36,00	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
36,00	24,00	99,00	100,00	1,00	0,00	0,00
36,00	30,00	99,00	100,00	1,00	0,00	0,00
36,00	36,00	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
42,00	24,00	99,00	100,00	1,00	0,00	0,00
42,00	30,00	99,00	100,00	1,00	0,00	0,00
42,00	36,00	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
48,00	24,00	99,00	100,00	1,00	0,00	0,00
48,00	30,00	99,00	100,00	1,00	0,00	0,00
48,00	36,00	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

54,00	24,00	99,00	100,00	1,00	0,00	0,00
54,00	30,00	99,00	100,00	1,00	0,00	0,00
54,00	36,00	99,00	100,00	1,00	0,00	0,00

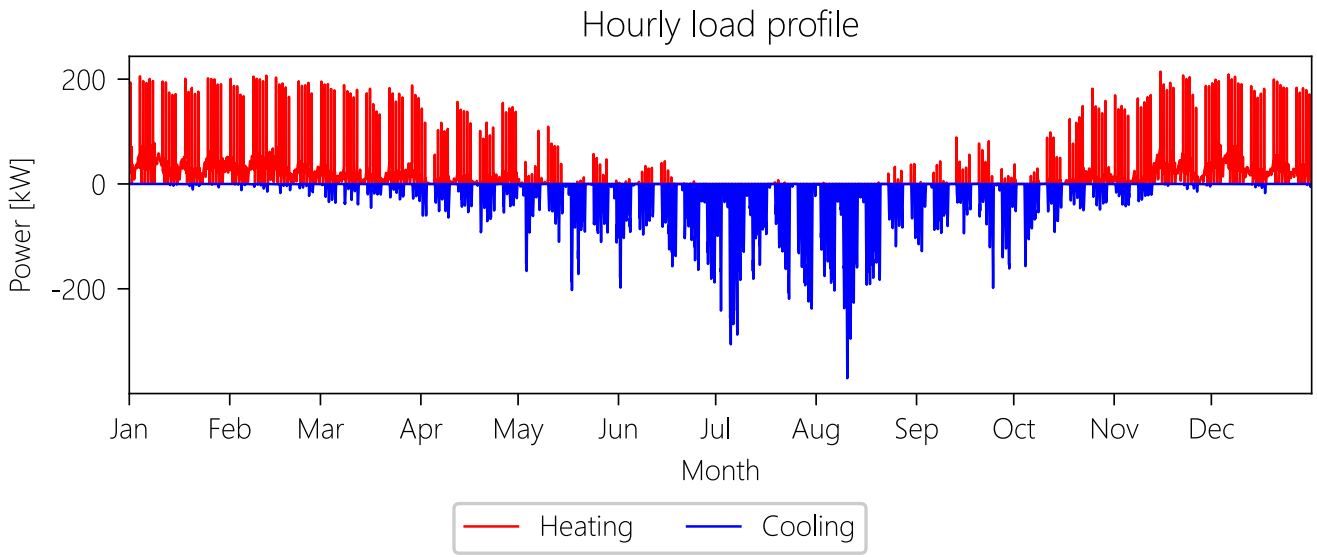
Flow data

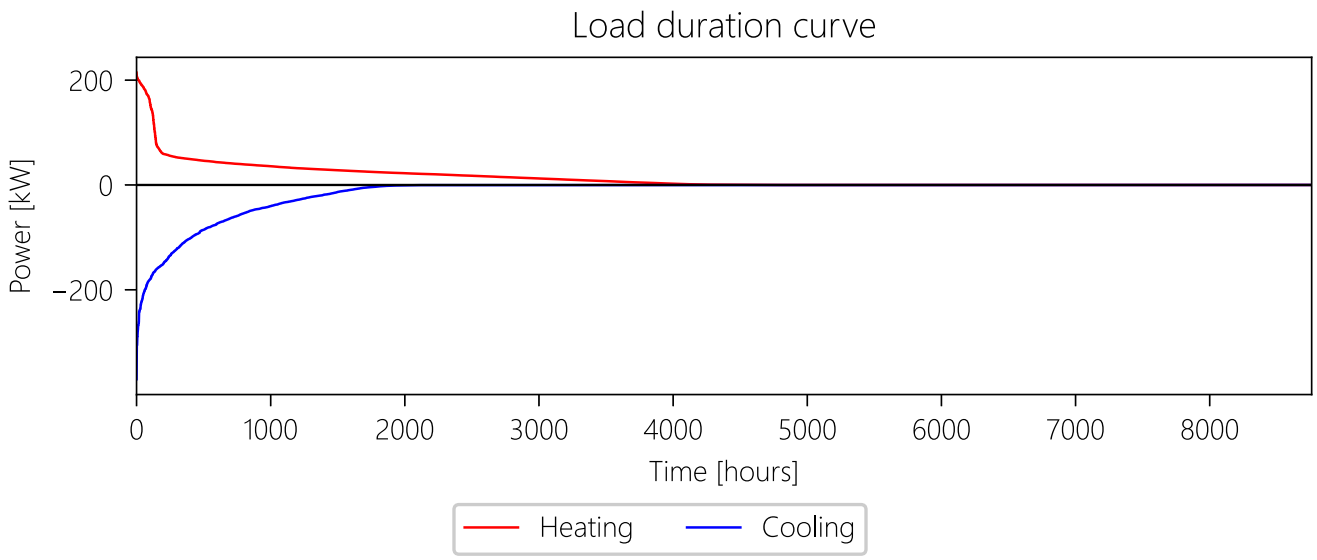
The system was simulated with a variable flow rate, where a constant temperature difference across the borefield was used of 3,00 °C in extraction and 3,00 °C in injection, with a minimum flow percentage of 30%. The resulting maximum flow rate through the borefield is 14,37 l/s and 37,11 l/s respectively.

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	117 509 kWh/y	214,2 kW
Cooling demand	118 276 kWh/y	370,6 kW





Efficiency data

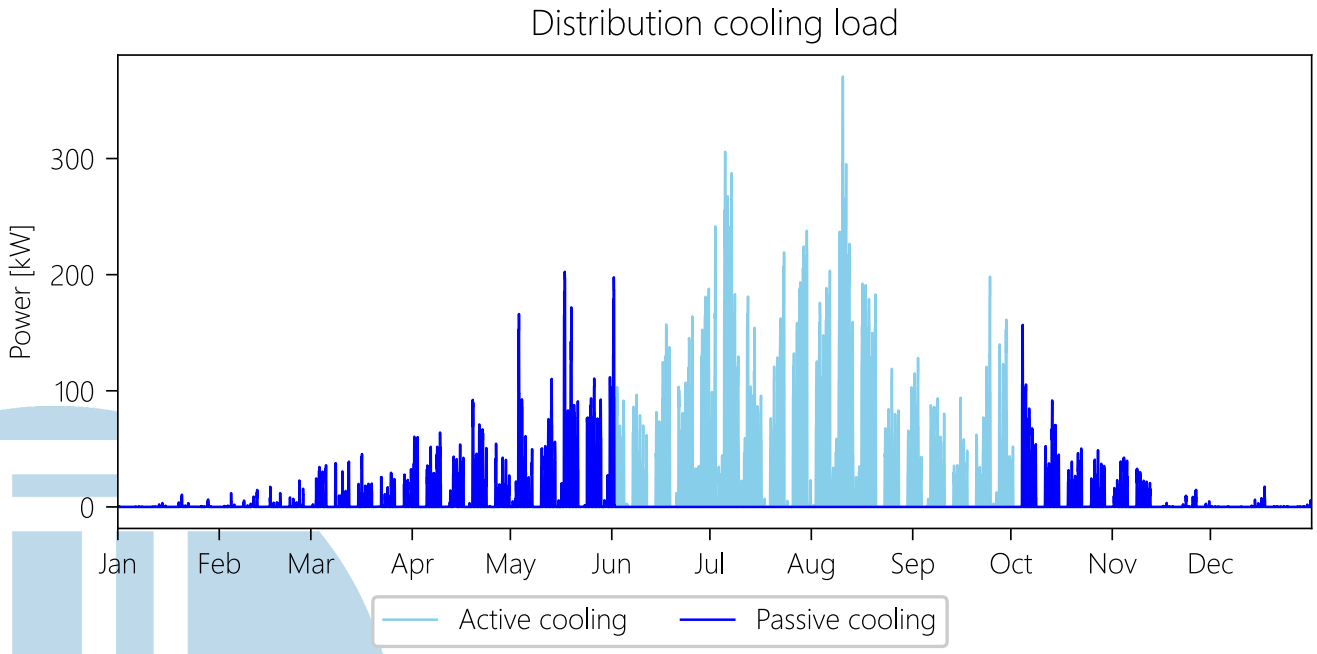
To calculate the resulting geothermal load, the heat pump is modelled to have an SCOP of 5,00 in heating. For the cooling, a combination of both passive (i.e. free) and active cooling is used, with an SEER of respectively 20,00 and 5,00. From June to September, active cooling is used by default. Outside of these months, passive cooling is used.

4.7.2 Results

Active and passive cooling

A combination of active and passive (or free) cooling on the borefield was used. Over the entire simulation period, an average SEER of 6,21 was achieved due to a 26 % share of passive cooling.

Below one can find the distribution of the active and passive load for one year. Since a fixed period for active cooling was selected, every year, the distribution is identical.



Ground load

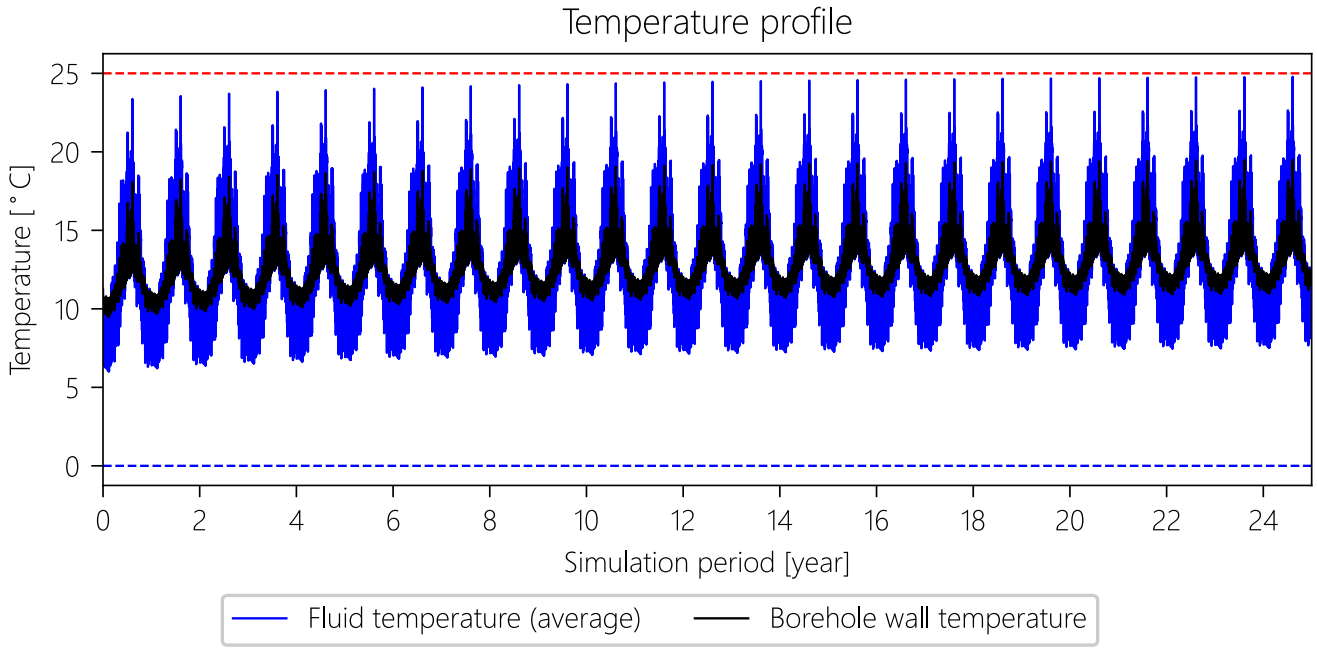
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	94 007 kWh/y	171,4 kW
Injection demand	137 317 kWh/y	444,7 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 1 192, whilst it was 6 201 during injection. This corresponds respectively to a laminar and turbulent flow regime, with an effective borehole thermal resistance of 0,1459 m·K/W and 0,0839 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 24,78 °C, and the minimum average fluid temperature is 6,02 °C.

Pressure drop

The pressure drop over a single borehole is 7,65 kPa during extraction and 34,65 kPa during injection.

4.8 Office - threshold

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

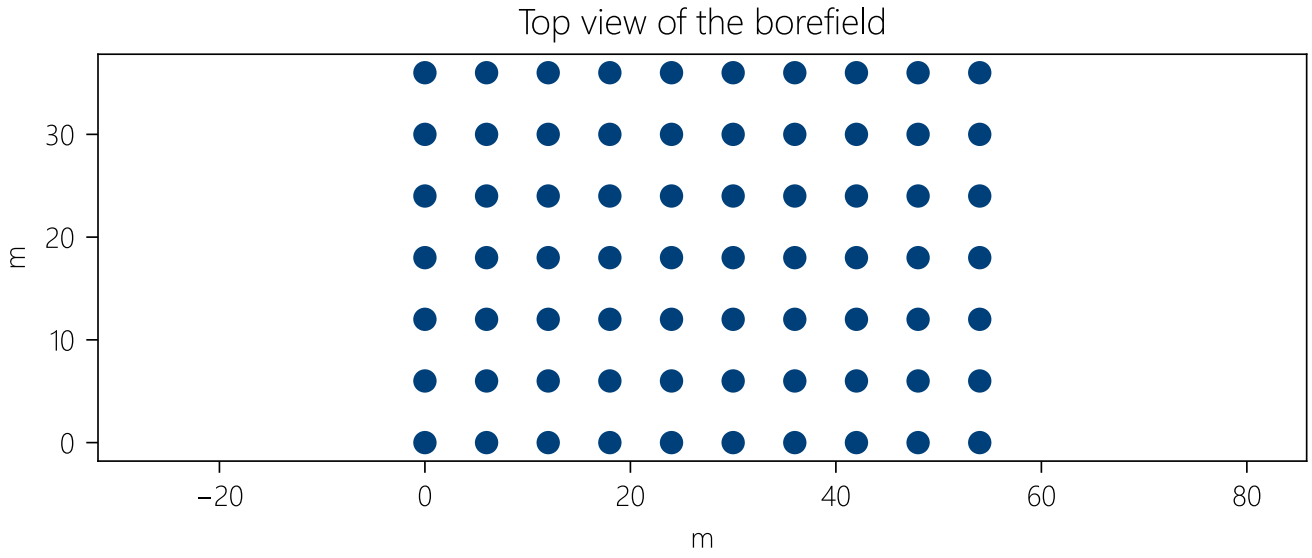
The scenarios in this report have been simulated with a simulation period of 25 years, starting in January. The minimum and maximum average fluid temperatures were 0,00 °C and 25,00 °C respectively. The simulations were carried out with GHEtool Cloud v2.9.5.2.

Borefield configuration

The simulations were carried out with a borefield consisting of 70 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 6 930,00 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
0,00	24,00	99,00	100,00	1,00	0,00	0,00
0,00	30,00	99,00	100,00	1,00	0,00	0,00
0,00	36,00	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
6,00	24,00	99,00	100,00	1,00	0,00	0,00
6,00	30,00	99,00	100,00	1,00	0,00	0,00
6,00	36,00	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
12,00	24,00	99,00	100,00	1,00	0,00	0,00
12,00	30,00	99,00	100,00	1,00	0,00	0,00
12,00	36,00	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
18,00	24,00	99,00	100,00	1,00	0,00	0,00
18,00	30,00	99,00	100,00	1,00	0,00	0,00
18,00	36,00	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

24,00	24,00	99,00	100,00	1,00	0,00	0,00
24,00	30,00	99,00	100,00	1,00	0,00	0,00
24,00	36,00	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
30,00	24,00	99,00	100,00	1,00	0,00	0,00
30,00	30,00	99,00	100,00	1,00	0,00	0,00
30,00	36,00	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
36,00	24,00	99,00	100,00	1,00	0,00	0,00
36,00	30,00	99,00	100,00	1,00	0,00	0,00
36,00	36,00	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
42,00	24,00	99,00	100,00	1,00	0,00	0,00
42,00	30,00	99,00	100,00	1,00	0,00	0,00
42,00	36,00	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
48,00	24,00	99,00	100,00	1,00	0,00	0,00
48,00	30,00	99,00	100,00	1,00	0,00	0,00
48,00	36,00	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

54,00	24,00	99,00	100,00	1,00	0,00	0,00
54,00	30,00	99,00	100,00	1,00	0,00	0,00
54,00	36,00	99,00	100,00	1,00	0,00	0,00

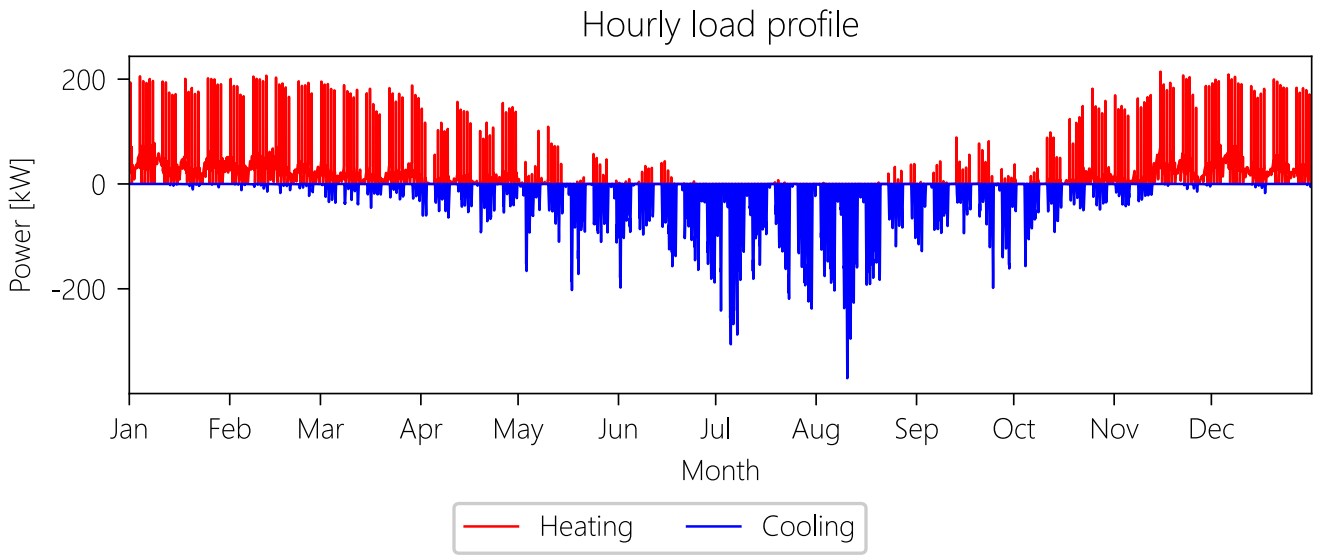
Flow data

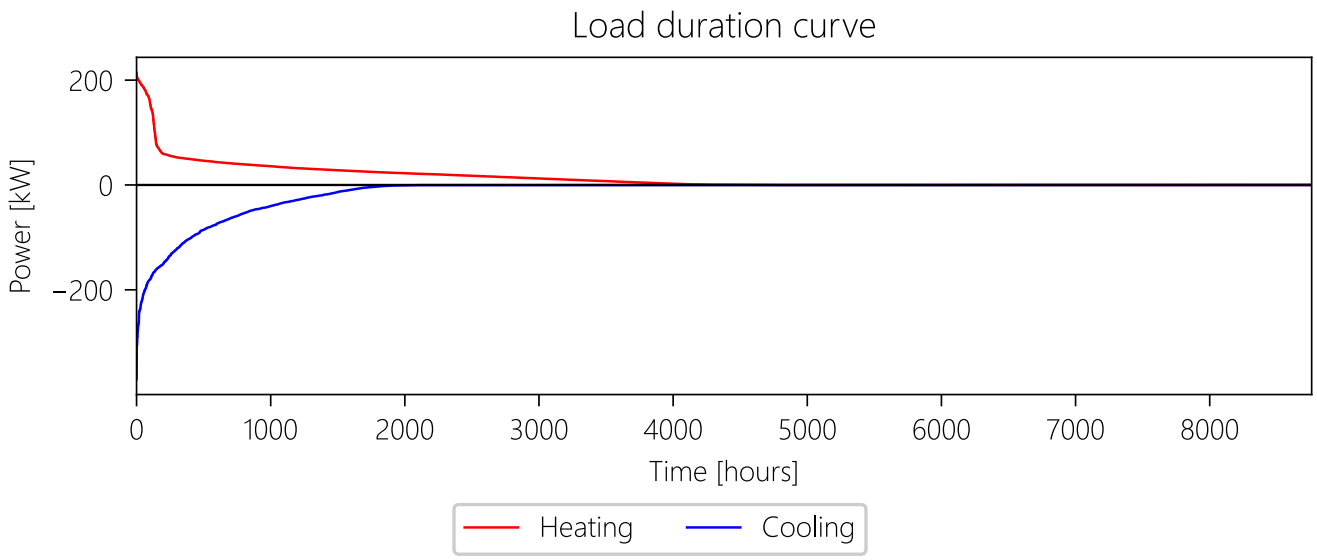
The system was simulated with a variable flow rate, where a constant temperature difference across the borefield was used of 3,00 °C in extraction and 3,00 °C in injection, with a minimum flow percentage of 30%. The resulting maximum flow rate through the borefield is 14,37 l/s and 37,11 l/s respectively.

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	117 509 kWh/y	214,2 kW
Cooling demand	118 276 kWh/y	370,6 kW





Efficiency data

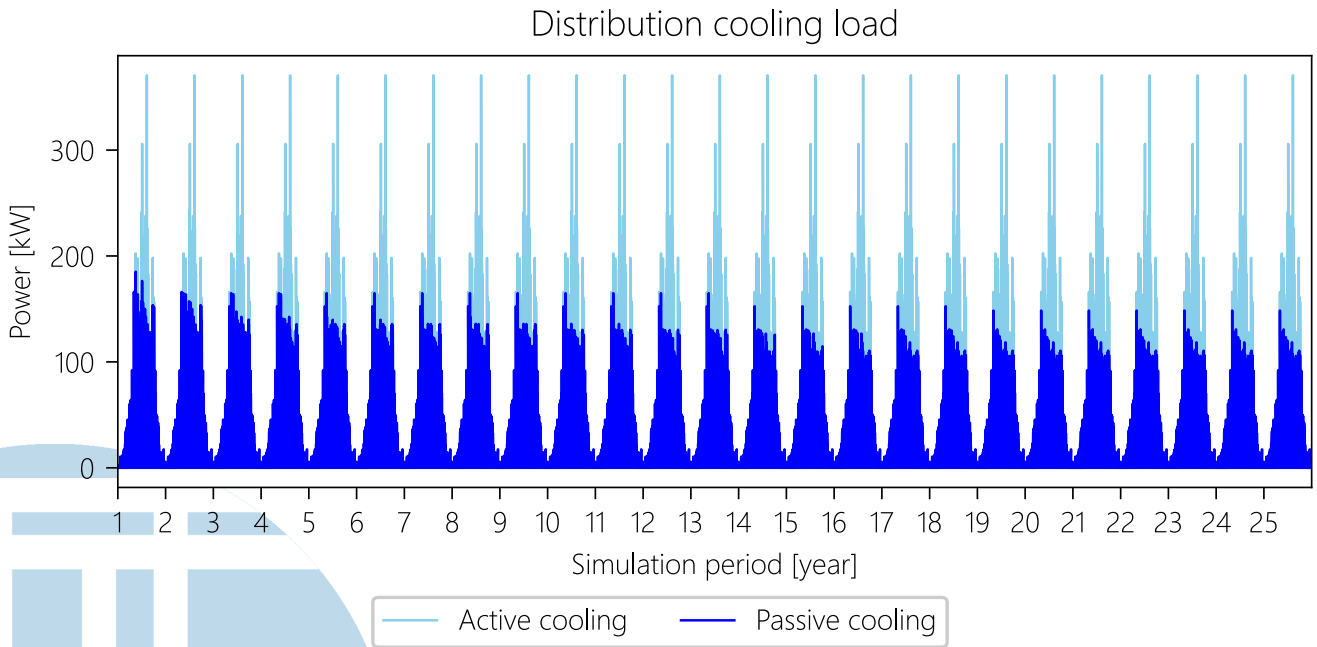
To calculate the resulting geothermal load, the heat pump is modelled to have an SCOP of 5,00 in heating. For the cooling, a combination of both passive (i.e. free) and active cooling is used, with an SEER of respectively 20,00 and 5,00. When the average fluid temperature is above 17,00 °C, active cooling is used. When it is below this threshold, passive cooling is used.

4.8.2 Results

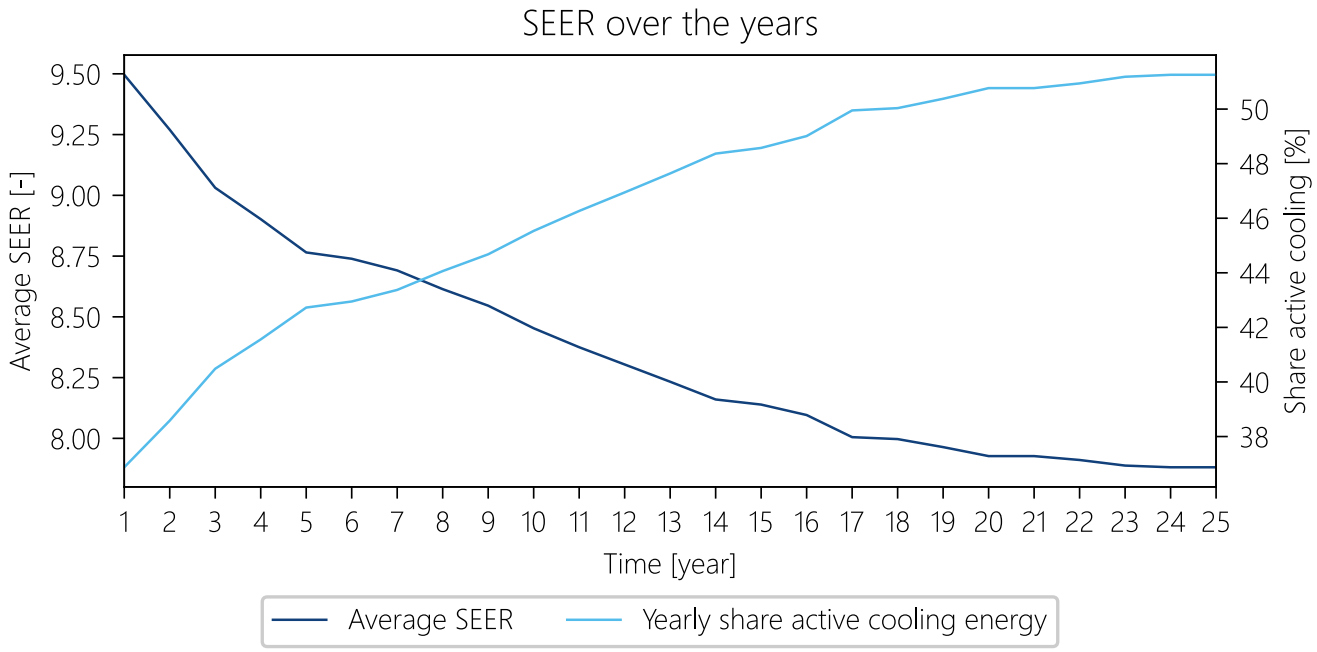
Active and passive cooling

A combination of active and passive (or free) cooling on the borefield was used. Over the entire simulation period, an average SEER of 8,34 was achieved due to a 53 % share of passive cooling.

Below one can find the distribution of the active and passive load over the simulation period.



Since the distribution between active and passive cooling is based on a temperature threshold, this ratio varies over time. The graph below shows how the SEER and the active cooling share vary over the simulation period.



Year	Average SEER	Yearly share active cooling energy
1	9,5	36,9 %
2	9,3	38,6 %
3	9,0	40,5 %
4	8,9	41,6 %
5	8,8	42,7 %
6	8,7	42,9 %
7	8,7	43,4 %
8	8,6	44,1 %
9	8,5	44,7 %
10	8,5	45,5 %
11	8,4	46,3 %
12	8,3	46,9 %
13	8,2	47,6 %
14	8,2	48,4 %
15	8,1	48,6 %
16	8,1	49,0 %
17	8,0	50,0 %
18	8,0	50,0 %
19	8,0	50,4 %
20	7,9	50,8 %
21	7,9	50,8 %
22	7,9	50,9 %
23	7,9	51,2 %
24	7,9	51,3 %
25	7,9	51,3 %

Ground load

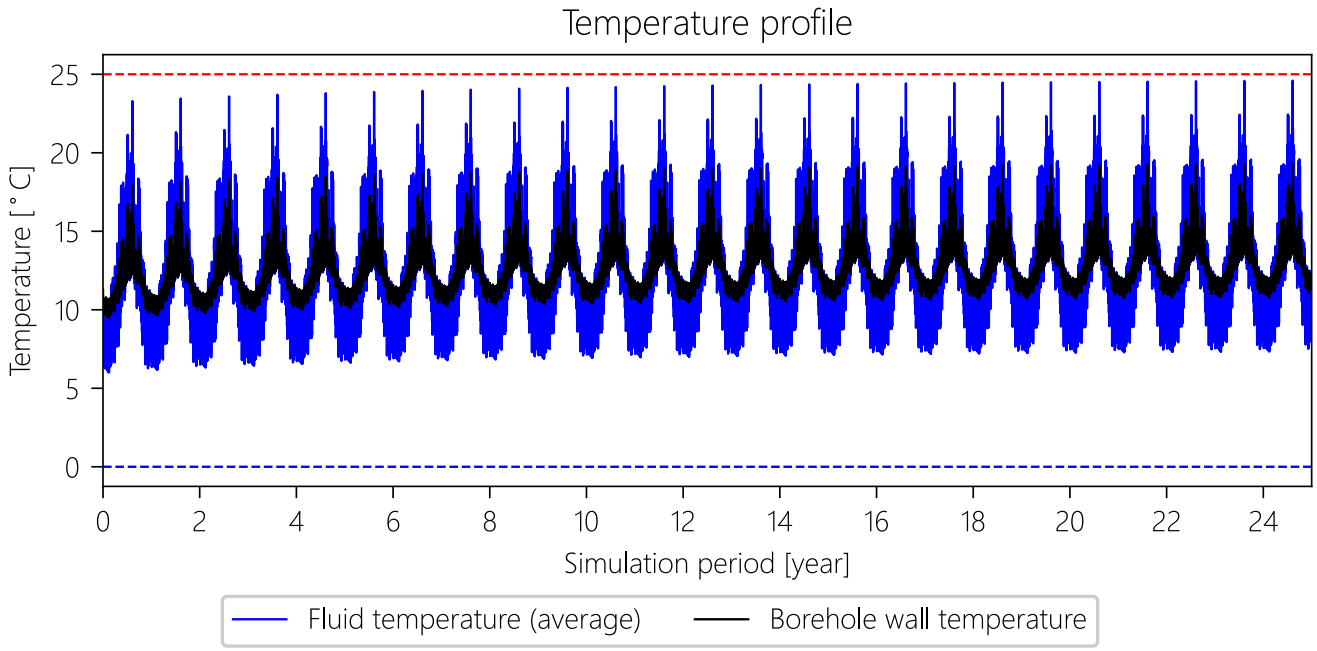
Because we are working with building loads (i.e. secondary loads), these must be converted into injection and extraction loads using the efficiency data. A summary of the resulting yearly ground load is given in the table below.

Ground demand	Yearly load	Peak power
Extraction demand	94 007 kWh/y	171,4 kW
Injection demand	132 451 kWh/y	444,7 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 1 192, whilst it was 6 164 during injection. This corresponds respectively to a laminar and turbulent flow regime, with an effective borehole thermal resistance of 0,1459 m·K/W and 0,0840 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 24,60 °C, and the minimum average fluid temperature is 6,02 °C.

Pressure drop

The pressure drop over a single borehole is 7,66 kPa during extraction and 34,67 kPa during injection.

5.1 Design Data - Passive cooling - auditorium

Design parameters

- Maximum average fluid temperature: 17 °C
- Minimum average fluid temperature: 0 °C
- First month of simulation: 1
- Simulation period: 25 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

- 25.0 v/v% MPG
- Temperature difference in extraction: 3 °C
- Temperature difference in injection: 3 °C
- Minimum flow percentage: 30
- Flow rate through borefield in extraction: 2,18 l/s
- Flow rate through borefield in injection: 7,92 l/s
- Number of boreholes in series: 1

Thermal demand

- Type of load: Hourly building load
- SCOP heating: 5
- 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

5.2 Design Data - Active cooling - auditorium

Design parameters

- Maximum average fluid temperature: 25 °C
- Minimum average fluid temperature: 0 °C
- First month of simulation: 1
- Simulation period: 25 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

- 25.0 v/v% MPG
- Temperature difference in extraction: 3 °C
- Temperature difference in injection: 3 °C
- Minimum flow percentage: 30
- Flow rate through borefield in extraction: 2,19 l/s
- Flow rate through borefield in injection: 9,03 l/s
- Number of boreholes in series: 1

Thermal demand

- Type of load: Hourly building load
- SCOP heating: 5
- SEER cooling: 5

Borefield parameters

x [m]	y [m]	Length [m]	Depth [m]	Buried depth [m]	Tilt [°]	Orientation [°]
0,00	0,00	119,00	120,00	1,00	0,00	0,00

0,00	6,00	119,00	120,00	1,00	0,00	0,00
0,00	12,00	119,00	120,00	1,00	0,00	0,00
6,00	0,00	119,00	120,00	1,00	0,00	0,00
6,00	6,00	119,00	120,00	1,00	0,00	0,00
6,00	12,00	119,00	120,00	1,00	0,00	0,00
12,00	0,00	119,00	120,00	1,00	0,00	0,00
12,00	6,00	119,00	120,00	1,00	0,00	0,00
12,00	12,00	119,00	120,00	1,00	0,00	0,00

5.3 Design Data - Passive cooling - office

Design parameters

- Maximum average fluid temperature: 17 °C
- Minimum average fluid temperature: 0 °C
- First month of simulation: 1
- Simulation period: 25 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

- 25.0 v/v% MPG
- Temperature difference in extraction: 3 °C
- Temperature difference in injection: 3 °C
- Minimum flow percentage: 30
- Flow rate through borefield in extraction: 14,35 l/s
- Flow rate through borefield in injection: 32,52 l/s
- Number of boreholes in series: 1

Thermal demand

- Type of load: Hourly building load
- SCOP heating: 5
- SEER cooling: 20

Borefield parameters

x [m]	y [m]	Length [m]	Depth [m]	Buried depth [m]	Tilt [°]	Orientation [°]
0,00	0,00	149,00	150,00	1,00	0,00	0,00

0,00	6,00	149,00	150,00	1,00	0,00	0,00
0,00	12,00	149,00	150,00	1,00	0,00	0,00
0,00	18,00	149,00	150,00	1,00	0,00	0,00
0,00	24,00	149,00	150,00	1,00	0,00	0,00
0,00	30,00	149,00	150,00	1,00	0,00	0,00
0,00	36,00	149,00	150,00	1,00	0,00	0,00
0,00	42,00	149,00	150,00	1,00	0,00	0,00
0,00	48,00	149,00	150,00	1,00	0,00	0,00
6,00	0,00	149,00	150,00	1,00	0,00	0,00
6,00	6,00	149,00	150,00	1,00	0,00	0,00
6,00	12,00	149,00	150,00	1,00	0,00	0,00
6,00	18,00	149,00	150,00	1,00	0,00	0,00
6,00	24,00	149,00	150,00	1,00	0,00	0,00
6,00	30,00	149,00	150,00	1,00	0,00	0,00
6,00	36,00	149,00	150,00	1,00	0,00	0,00
6,00	42,00	149,00	150,00	1,00	0,00	0,00
6,00	48,00	149,00	150,00	1,00	0,00	0,00
12,00	0,00	149,00	150,00	1,00	0,00	0,00
12,00	6,00	149,00	150,00	1,00	0,00	0,00
12,00	12,00	149,00	150,00	1,00	0,00	0,00
12,00	18,00	149,00	150,00	1,00	0,00	0,00
12,00	24,00	149,00	150,00	1,00	0,00	0,00
12,00	30,00	149,00	150,00	1,00	0,00	0,00
12,00	36,00	149,00	150,00	1,00	0,00	0,00
12,00	42,00	149,00	150,00	1,00	0,00	0,00
12,00	48,00	149,00	150,00	1,00	0,00	0,00
18,00	0,00	149,00	150,00	1,00	0,00	0,00
18,00	6,00	149,00	150,00	1,00	0,00	0,00
18,00	12,00	149,00	150,00	1,00	0,00	0,00
18,00	18,00	149,00	150,00	1,00	0,00	0,00
18,00	24,00	149,00	150,00	1,00	0,00	0,00
18,00	30,00	149,00	150,00	1,00	0,00	0,00
18,00	36,00	149,00	150,00	1,00	0,00	0,00
18,00	42,00	149,00	150,00	1,00	0,00	0,00
18,00	48,00	149,00	150,00	1,00	0,00	0,00
24,00	0,00	149,00	150,00	1,00	0,00	0,00
24,00	6,00	149,00	150,00	1,00	0,00	0,00
24,00	12,00	149,00	150,00	1,00	0,00	0,00
24,00	18,00	149,00	150,00	1,00	0,00	0,00

24,00	24,00	149,00	150,00	1,00	0,00	0,00
24,00	30,00	149,00	150,00	1,00	0,00	0,00
24,00	36,00	149,00	150,00	1,00	0,00	0,00
24,00	42,00	149,00	150,00	1,00	0,00	0,00
24,00	48,00	149,00	150,00	1,00	0,00	0,00
30,00	0,00	149,00	150,00	1,00	0,00	0,00
30,00	6,00	149,00	150,00	1,00	0,00	0,00
30,00	12,00	149,00	150,00	1,00	0,00	0,00
30,00	18,00	149,00	150,00	1,00	0,00	0,00
30,00	24,00	149,00	150,00	1,00	0,00	0,00
30,00	30,00	149,00	150,00	1,00	0,00	0,00
30,00	36,00	149,00	150,00	1,00	0,00	0,00
30,00	42,00	149,00	150,00	1,00	0,00	0,00
30,00	48,00	149,00	150,00	1,00	0,00	0,00
36,00	0,00	149,00	150,00	1,00	0,00	0,00
36,00	6,00	149,00	150,00	1,00	0,00	0,00
36,00	12,00	149,00	150,00	1,00	0,00	0,00
36,00	18,00	149,00	150,00	1,00	0,00	0,00
36,00	24,00	149,00	150,00	1,00	0,00	0,00
36,00	30,00	149,00	150,00	1,00	0,00	0,00
36,00	36,00	149,00	150,00	1,00	0,00	0,00
36,00	42,00	149,00	150,00	1,00	0,00	0,00
36,00	48,00	149,00	150,00	1,00	0,00	0,00
42,00	0,00	149,00	150,00	1,00	0,00	0,00
42,00	6,00	149,00	150,00	1,00	0,00	0,00
42,00	12,00	149,00	150,00	1,00	0,00	0,00
42,00	18,00	149,00	150,00	1,00	0,00	0,00
42,00	24,00	149,00	150,00	1,00	0,00	0,00
42,00	30,00	149,00	150,00	1,00	0,00	0,00
42,00	36,00	149,00	150,00	1,00	0,00	0,00
42,00	42,00	149,00	150,00	1,00	0,00	0,00
42,00	48,00	149,00	150,00	1,00	0,00	0,00
48,00	0,00	149,00	150,00	1,00	0,00	0,00
48,00	6,00	149,00	150,00	1,00	0,00	0,00
48,00	12,00	149,00	150,00	1,00	0,00	0,00
48,00	18,00	149,00	150,00	1,00	0,00	0,00
48,00	24,00	149,00	150,00	1,00	0,00	0,00
48,00	30,00	149,00	150,00	1,00	0,00	0,00
48,00	36,00	149,00	150,00	1,00	0,00	0,00

48,00	42,00	149,00	150,00	1,00	0,00	0,00
48,00	48,00	149,00	150,00	1,00	0,00	0,00
54,00	0,00	149,00	150,00	1,00	0,00	0,00
54,00	6,00	149,00	150,00	1,00	0,00	0,00
54,00	12,00	149,00	150,00	1,00	0,00	0,00
54,00	18,00	149,00	150,00	1,00	0,00	0,00
54,00	24,00	149,00	150,00	1,00	0,00	0,00
54,00	30,00	149,00	150,00	1,00	0,00	0,00
54,00	36,00	149,00	150,00	1,00	0,00	0,00
54,00	42,00	149,00	150,00	1,00	0,00	0,00
54,00	48,00	149,00	150,00	1,00	0,00	0,00
60,00	0,00	149,00	150,00	1,00	0,00	0,00
60,00	6,00	149,00	150,00	1,00	0,00	0,00
60,00	12,00	149,00	150,00	1,00	0,00	0,00
60,00	18,00	149,00	150,00	1,00	0,00	0,00
60,00	24,00	149,00	150,00	1,00	0,00	0,00
60,00	30,00	149,00	150,00	1,00	0,00	0,00
60,00	36,00	149,00	150,00	1,00	0,00	0,00
60,00	42,00	149,00	150,00	1,00	0,00	0,00
60,00	48,00	149,00	150,00	1,00	0,00	0,00
66,00	0,00	149,00	150,00	1,00	0,00	0,00
66,00	6,00	149,00	150,00	1,00	0,00	0,00
66,00	12,00	149,00	150,00	1,00	0,00	0,00
66,00	18,00	149,00	150,00	1,00	0,00	0,00
66,00	24,00	149,00	150,00	1,00	0,00	0,00
66,00	30,00	149,00	150,00	1,00	0,00	0,00
66,00	36,00	149,00	150,00	1,00	0,00	0,00
66,00	42,00	149,00	150,00	1,00	0,00	0,00
66,00	48,00	149,00	150,00	1,00	0,00	0,00
72,00	0,00	149,00	150,00	1,00	0,00	0,00
72,00	6,00	149,00	150,00	1,00	0,00	0,00
72,00	12,00	149,00	150,00	1,00	0,00	0,00
72,00	18,00	149,00	150,00	1,00	0,00	0,00
72,00	24,00	149,00	150,00	1,00	0,00	0,00
72,00	30,00	149,00	150,00	1,00	0,00	0,00
72,00	36,00	149,00	150,00	1,00	0,00	0,00
72,00	42,00	149,00	150,00	1,00	0,00	0,00
72,00	48,00	149,00	150,00	1,00	0,00	0,00
78,00	0,00	149,00	150,00	1,00	0,00	0,00

78,00	6,00	149,00	150,00	1,00	0,00	0,00
78,00	12,00	149,00	150,00	1,00	0,00	0,00
78,00	18,00	149,00	150,00	1,00	0,00	0,00
78,00	24,00	149,00	150,00	1,00	0,00	0,00
78,00	30,00	149,00	150,00	1,00	0,00	0,00
78,00	36,00	149,00	150,00	1,00	0,00	0,00
78,00	42,00	149,00	150,00	1,00	0,00	0,00
78,00	48,00	149,00	150,00	1,00	0,00	0,00

5.4 Design Data - Active cooling - office

Design parameters

- Maximum average fluid temperature: 25 °C
- Minimum average fluid temperature: 0 °C
- First month of simulation: 1
- Simulation period: 25 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

- 25.0 v/v% MPG
- Temperature difference in extraction: 3 °C
- Temperature difference in injection: 3 °C
- Minimum flow percentage: 30
- Flow rate through borefield in extraction: 14,37 l/s
- Flow rate through borefield in injection: 37,12 l/s
- Number of boreholes in series: 1

Thermal demand

- Type of load: Hourly building load
- SCOP heating: 5
- SEER cooling: 5

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

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

5.5 Design Data - Auditorium - fixed period

Design parameters

- Maximum average fluid temperature: 25 °C
- Minimum average fluid temperature: 0 °C
- First month of simulation: 1
- Simulation period: 25 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

- 25.0 v/v% MPG
- Temperature difference in extraction: 3 °C
- Temperature difference in injection: 3 °C
- Minimum flow percentage: 30
- Flow rate through borefield in extraction: 2,19 l/s
- Flow rate through borefield in injection: 9,03 l/s
- Number of boreholes in series: 1

Thermal demand

- Type of load: Hourly building load
- SCOP heating: 5
- SEER active cooling: 5
- SEER passive cooling: 20
- With active cooling in months: 6, 7, 8 & 9 °C

Borefield parameters

x [m]	y [m]	Length [m]	Depth [m]	Buried depth [m]	Tilt [°]	Orientation [°]
0,00	0,00	119,00	120,00	1,00	0,00	0,00
0,00	6,00	119,00	120,00	1,00	0,00	0,00
0,00	12,00	119,00	120,00	1,00	0,00	0,00
6,00	0,00	119,00	120,00	1,00	0,00	0,00
6,00	6,00	119,00	120,00	1,00	0,00	0,00
6,00	12,00	119,00	120,00	1,00	0,00	0,00
12,00	0,00	119,00	120,00	1,00	0,00	0,00
12,00	6,00	119,00	120,00	1,00	0,00	0,00
12,00	12,00	119,00	120,00	1,00	0,00	0,00

5.6 Design Data - Auditorium - threshold

Design parameters

- Maximum average fluid temperature: 25 °C
- Minimum average fluid temperature: 0 °C
- First month of simulation: 1
- Simulation period: 25 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

- 25.0 v/v% MPG
- Temperature difference in extraction: 3 °C
- Temperature difference in injection: 3 °C
- Minimum flow percentage: 30
- Flow rate through borefield in extraction: 2,19 l/s
- Flow rate through borefield in injection: 9,03 l/s
- Number of boreholes in series: 1

Thermal demand

- Type of load: Hourly building load
- SCOP heating: 5
- SEER active cooling: 5
- SEER passive cooling: 20
- With active cooling above: 17 °C

Borefield parameters

x [m]	y [m]	Length [m]	Depth [m]	Buried depth [m]	Tilt [°]	Orientation [°]
0,00	0,00	119,00	120,00	1,00	0,00	0,00
0,00	6,00	119,00	120,00	1,00	0,00	0,00
0,00	12,00	119,00	120,00	1,00	0,00	0,00
6,00	0,00	119,00	120,00	1,00	0,00	0,00
6,00	6,00	119,00	120,00	1,00	0,00	0,00
6,00	12,00	119,00	120,00	1,00	0,00	0,00
12,00	0,00	119,00	120,00	1,00	0,00	0,00
12,00	6,00	119,00	120,00	1,00	0,00	0,00
12,00	12,00	119,00	120,00	1,00	0,00	0,00

5.7 Design Data - Office - fixed period

Design parameters

- Maximum average fluid temperature: 25 °C
- Minimum average fluid temperature: 0 °C
- First month of simulation: 1
- Simulation period: 25 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

- 25.0 v/v% MPG
- Temperature difference in extraction: 3 °C
- Temperature difference in injection: 3 °C
- Minimum flow percentage: 30
- Flow rate through borefield in extraction: 14,37 l/s
- Flow rate through borefield in injection: 37,12 l/s
- Number of boreholes in series: 1

Thermal demand

- Type of load: Hourly building load
- SCOP heating: 5
- SEER active cooling: 5
- SEER passive cooling: 20
- With active cooling in months: 6, 7, 8 & 9 °C

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

5.8 Design Data - Office - threshold

Design parameters

- Maximum average fluid temperature: 25 °C
- Minimum average fluid temperature: 0 °C
- First month of simulation: 1
- Simulation period: 25 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

- 25.0 v/v% MPG
- Temperature difference in extraction: 3 °C
- Temperature difference in injection: 3 °C
- Minimum flow percentage: 30
- Flow rate through borefield in extraction: 14,37 l/s
- Flow rate through borefield in injection: 37,12 l/s
- Number of boreholes in series: 1

Thermal demand

- Type of load: Hourly building load
- SCOP heating: 5
- SEER active cooling: 5
- SEER passive cooling: 20
- With active cooling above: 17 °C

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



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