Software within building physics and ground heat storage

EED version 4

Earth Energy Designer

Update manual

Current version: 4.3

Oct 21, 2024

First edition:	March 1, 2016
Revisions:	Nov 30, 2016
	March 1, 2017
	April 11, 2019
	Feb 8, 2020
	Jan 22, 2022 (benchmark updates)
	March 27, 2024
	Oct 21, 2024

See Appendix A for update news.

The latest version of this document is available at
https://www.buildingphysics.com/manuals/EED4.pdf

BLOCON

www.buildingphysics.com

Contents

1. Introduction

Blocon is proud to present a new version of EED. Many new important features have been added. Up-to-date information is given on www.buildingphysics.com.

This update manual covers new features that have been added since version 3. New users should also read the full manual for version 3 at
https://www.buildingphysics.com/manuals/EED3.pdf

Please see this pdf for tutorial:
https://buildingphysics.com/download/exampleseed.pdf

Please see this pdf for some questions/answers:
https://buildingphysics.com/download/eedfaq.pdf

This manual covers the *desktop version* of EED v4. There is also an optional *web version*: "**EED on the web**" that runs on a dedicated server with extreme calculation performance. It can be started from any operating system and/or device with an HTML5-compliant web browser, such as IE10/11, Chrome, Safari, Firefox, Opera, etc. It supports PC, Mac, iPad, iPhone, Chromebook, Android and many other popular devices. For more info, see:
https://www.buildingphysics.com/manuals/EEDONTHEWEB.pdf

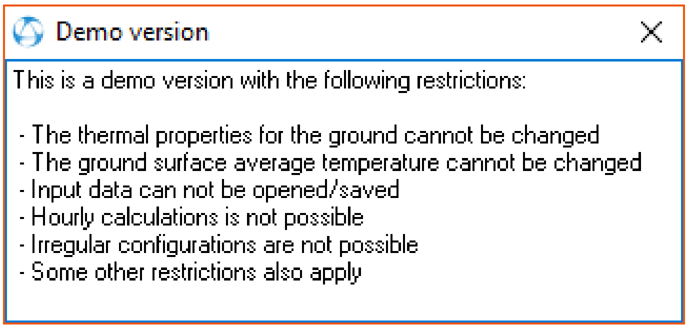
1.1 What's new in EED v4

The most important new feature is the following:

- Simulations with hourly values for load are possible. See Chapters 2 and 3.
- Approximation for irregular configurations. See Chapter 4.

1.2 Demo version

The demo version has the following restrictions:



1.3 Installation and requirements

EED v4 requires only about 0.2 GB RAM (a pc with 2 GB is recommended), and less than 30 MB hard disk space. EED runs on both 32-bit and 64-bit Windows 10, 8, and 7.

Use the setup program to install EED. The installation will automatically create correct folders. Administrators rights are needed for the setup since the setup-program writes in the registry and program folders.

This will install the EED exe-file and some other files to folder "C:\Program Files (x86)\BLOCON\EED_v4.3".

EED_v4_3.exe	2024-03-27 08:20	Program	26 149 kB
TurboActivate.dat	2016-09-12 15:25	DAT-fil	4 kB
TurboActivate.dll	2021-05-11 16:03	Programtillägg	1 098 kB
TurboActivate.exe	2021-05-11 16:06	Program	287 kB
unins000.dat	2024-03-27 08:23	DAT-fil	65 kB
unins000.exe	2024-03-27 08:23	Program	3 149 kB

Files installed to C:\Program Files (x86)\BLOCON\EED_v4.3

Note: From version 4.3 the setup file will install material files (and some other files) to the shared folder "C:\Users\Public\Documents\BLOCON\EED 4" by default. This is also the folder where the user stores project data files.

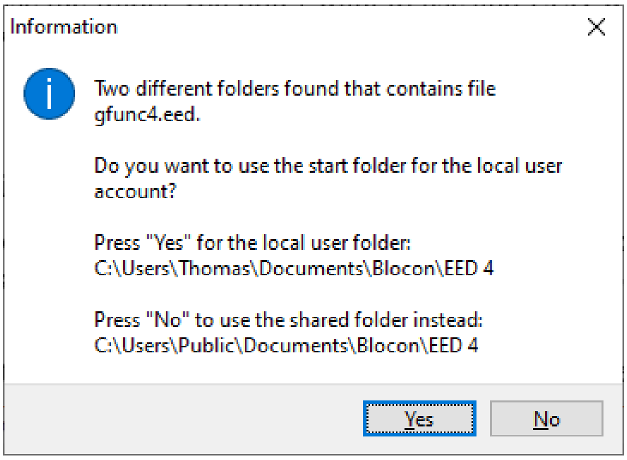
Languages	2024-03-27 08:23	Filmapp	
output	2024-03-27 08:23	Filmapp	
Projects	2024-03-27 08:23	Filmapp	
BH_coordinates_SBM.txt	2015-12-09 23:27	Textdokument	1 kB
BH_coordinates_xy.txt	2015-12-10 16:34	Textdokument	1 kB
Borediam.txt	2012-01-12 23:08	Textdokument	1 kB
cond.txt	2012-01-12 23:06	Textdokument	5 kB
EED.DES	2017-05-23 09:24	DES-fil	1 kB
Fillcond.txt	2012-01-12 23:07	Textdokument	2 kB
gfunc4.eed	2012-01-12 23:05	EED-fil	1 419 kB
GFUNC4.TXT	2012-01-12 23:07	Textdokument	28 kB
Hcdat.txt	2016-12-08 14:46	Textdokument	7 kB
Heatcap.txt	2012-01-12 23:07	Textdokument	4 kB
Heatflux.txt	2012-01-12 23:07	Textdokument	7 kB
Hourly_example_1.DAT	2016-11-28 08:58	DAT-fil	7 kB
Hourly_example_1_load.txt	2016-11-28 09:18	Textdokument	1 kB
Hourly_example_1_peakload_A1.txt	2016-10-28 12:20	Textdokument	1 kB
Hourly_example_1_peakload_A2.txt	2016-11-28 09:17	Textdokument	1 kB
Hourly_example_1_peakload_B1.txt	2016-10-28 12:20	Textdokument	1 kB
Hourly_example_1_peakload_B2.txt	2016-11-30 08:51	Textdokument	1 kB
Hourly_example_1_peakload_B3.txt	2016-11-30 08:52	Textdokument	1 kB
Hourly_example_1_peakload_B4.txt	2016-11-30 09:00	Textdokument	1 kB
Hourly_example_1_peakload_B5.txt	2016-11-30 09:00	Textdokument	1 kB
Hourly_example_1_peakload_C.txt	2016-11-28 15:01	Textdokument	1 kB
pipe.txt	2017-02-20 17:35	Textdokument	5 kB
qtest.txt	2016-09-27 14:55	Textdokument	1 kB
Surftemp.txt	2012-01-12 23:06	Textdokument	7 kB
tfluid.out	2017-02-23 15:18	OUT-fil	7 kB
tfmin.out	2017-02-23 15:18	OUT-fil	1 kB
Theme.txt	2017-05-23 09:24	Textdokument	1 kB
UNTITLED.OUT	2017-02-23 15:18	OUT-fil	9 kB

Files and folders installed to C:\Users\Public\Documents\BLOCON\EED 4

Before v4.3, the setup file installed these files to the local user documents folder “My documents\Blocon\EED 4” (e.g. ”C:\Users\[user name]\Documents\Blocon\EED 4”).

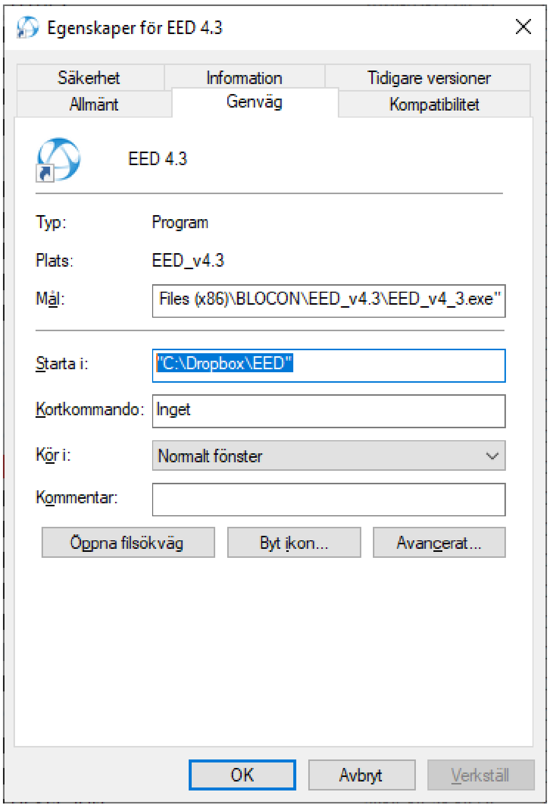
This could be a problem when an admin account was used for installation and another local user account was running the program and had no access to the (admin) document folder (where gfunc4.eed and other necessary files were present). With v4.3 different users on the same machine can now access the shared files.

This means that when you update your old version to v4.3 there may be two document folders (the old local document folder and the new shared document folder). If EED detects both folders upon start (it will actually search for the file “gfunc4.eed”) it will ask what folder you want to start in, see picture below. Simply erase (or rename) the folder you don’t want to use and EED will use the other one upon start. Remember to move your input files first if applicable.



The used folder name is shown in the EED main window. It is also shown by the menu item Info/System info in EED (see row “Start up directory”).

It is also possible to change to another start up folder (e.g. to a Dropbox folder). To do this open the shortcut for EED that is located in "C:\ProgramData\Microsoft\Windows\Start Menu\Programs\BLOCON". Right-click on the shortcut for “EED 4.3” and choose Properties and set folder name in the “Start in” field. See picture below. Make sure you copy all the files (with sub-directories) to the new folder. However, if EED finds the default shared or local user folders it will try to use them first so make sure you delete (or rename) these folders first.



1.4 Activation and deactivation of EED

The first time EED is started it requires to be activated. Administrators rights are needed for this.

In order to move the license to a new PC, you need to deactivate the old PC first:

The license will be deactivated when the software is uninstalled via the Windows control panel (make sure you have Internet access during this point). This will release the activation so that it can be used on a new machine by the same or by another user. EED will not work on the deactivated PC.

So, uninstall EED first on the old computer. After that download the latest version and install/activate it on the new computer. Then copy your data files from the old machine to the new machine.

Please note that it is not possible to swap the license back and forth between two PC:s. There is a built in limit for this and too many deactivations on the same machine will block it for further activations. A single user license should be used permanently on one PC, but can be deactivated in order to be moved to a new PC of course.

1.5 Floating network license option added in EED v4.20

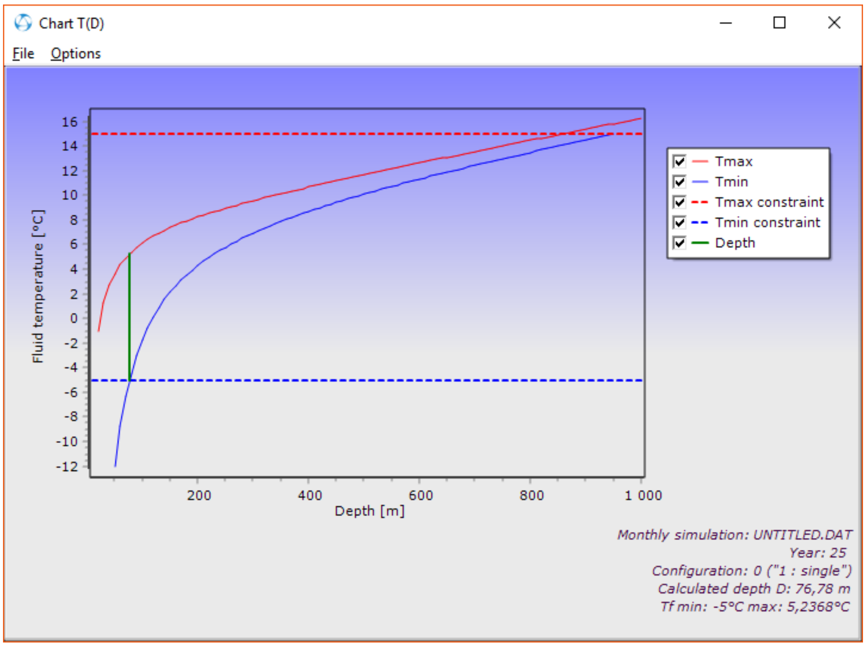
An annual subscription for multiple users with floating licenses are now offered, see https://www.buildingphysics.com/download/floatinglicenses.pdf

2. Some changes compare to EED v3

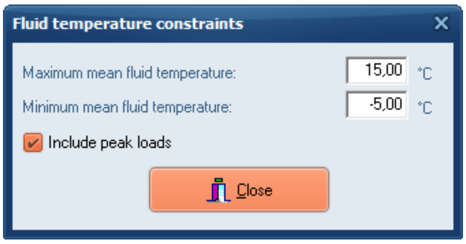
2.1 Simulations F9 and F10

Solving a case for required borehole length (F10) will show a chart "T(D)" (fluid temperatures – depth) for the chosen simulation time. The figure below shows results after 25 years.

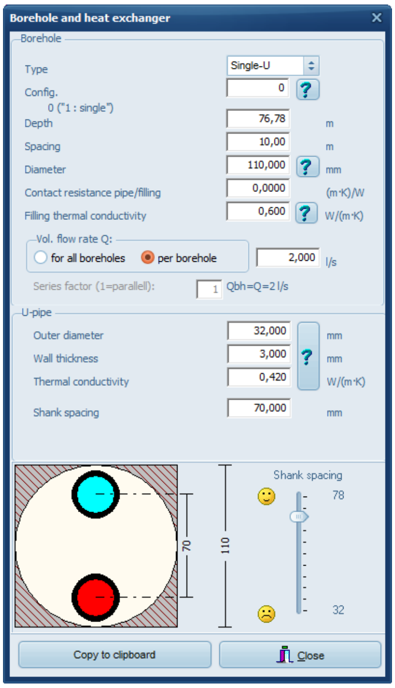
In the following case a depth D=76,78 m is found (marked in green):



The min/max fluid temperatures are here given by:

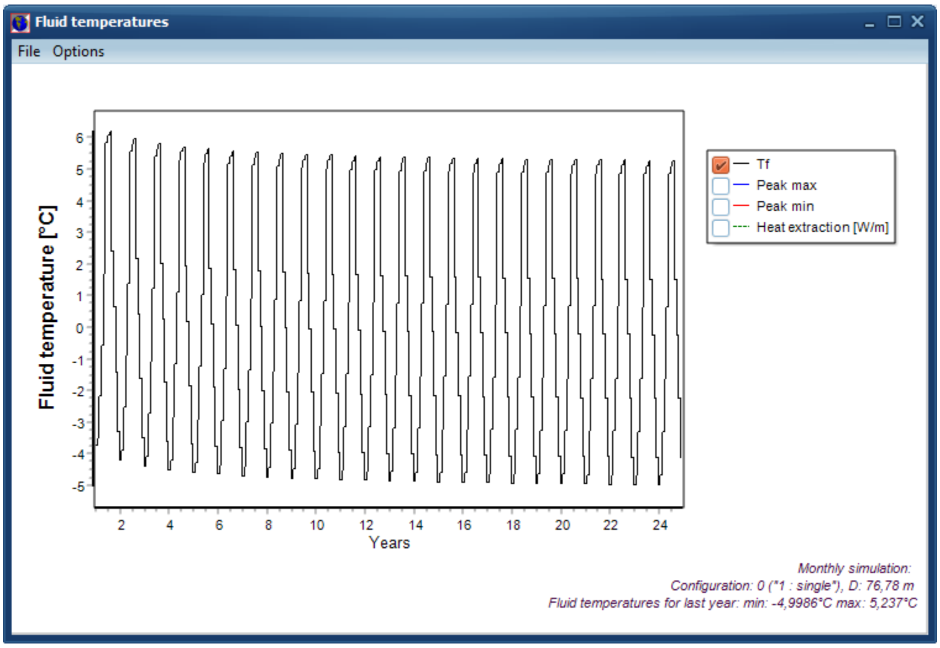


If a depth D is found, the value will be used in the "Borehole and heat exchanger" menu:

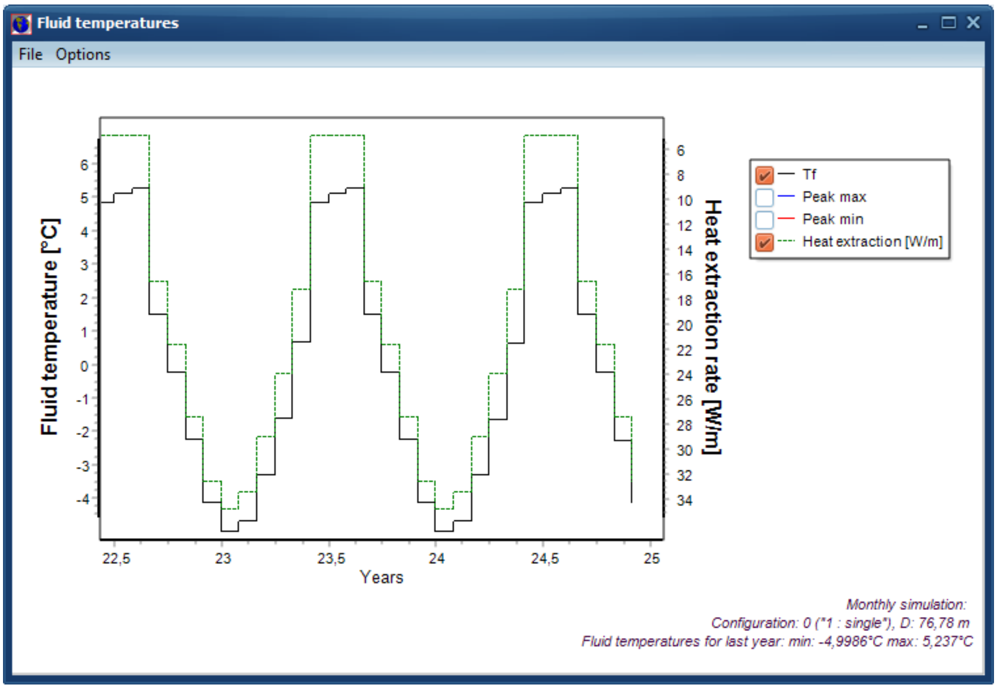


(In EED v3 this value was not automatically changed).

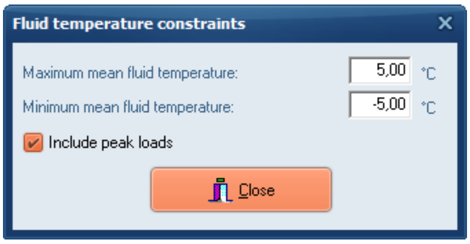
To get the fluid variation for the whole simulation time, press F9 (Solve mean fluid temperatures):

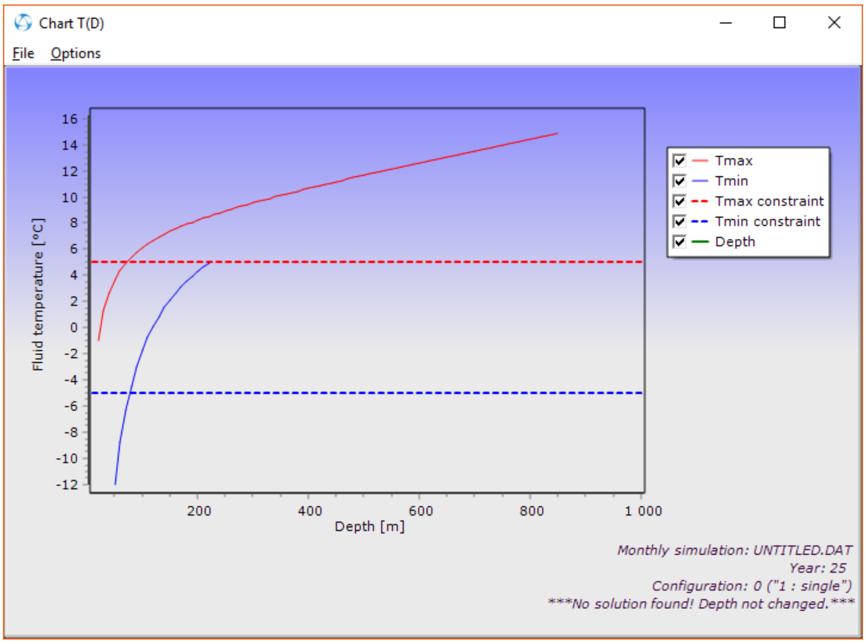


Any area can be zoomed. The heat extraction rate is also plotted here:



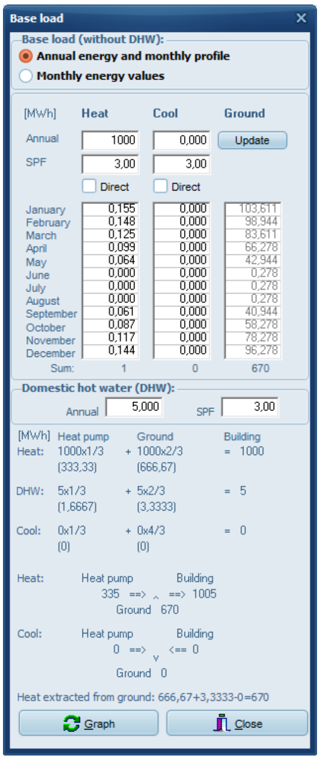
For the following case, a depth is not found:



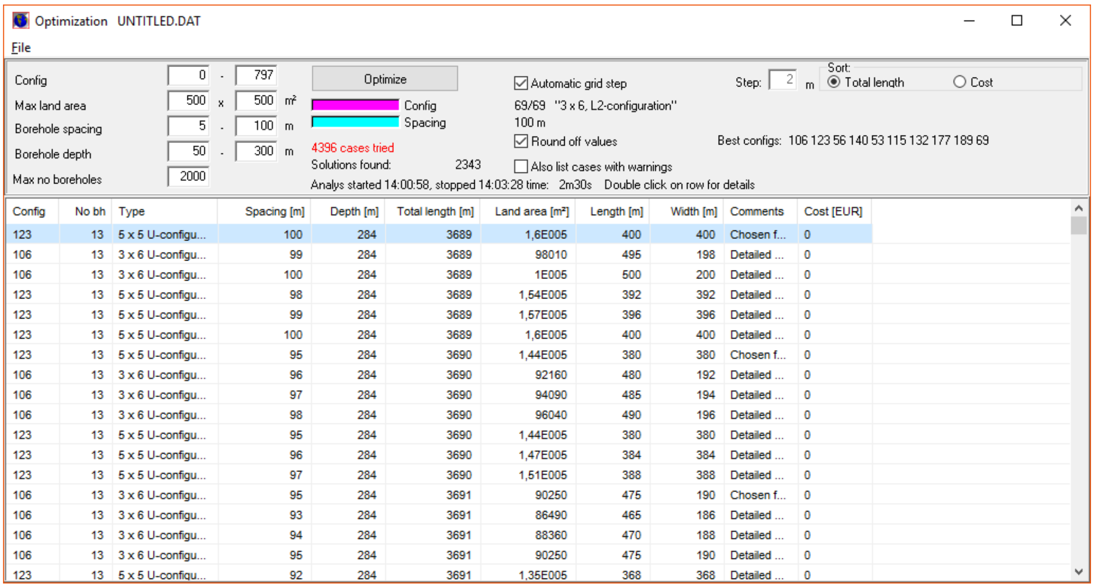


2.2 Quicker and better optimization

EED v4 will find more solutions (especially for cases with cooling loads) compared to v3 for the optimization. EED v4 is more than 50 times faster than EED v3. As an example, assume we have an annual base load value of 1000 MWh:

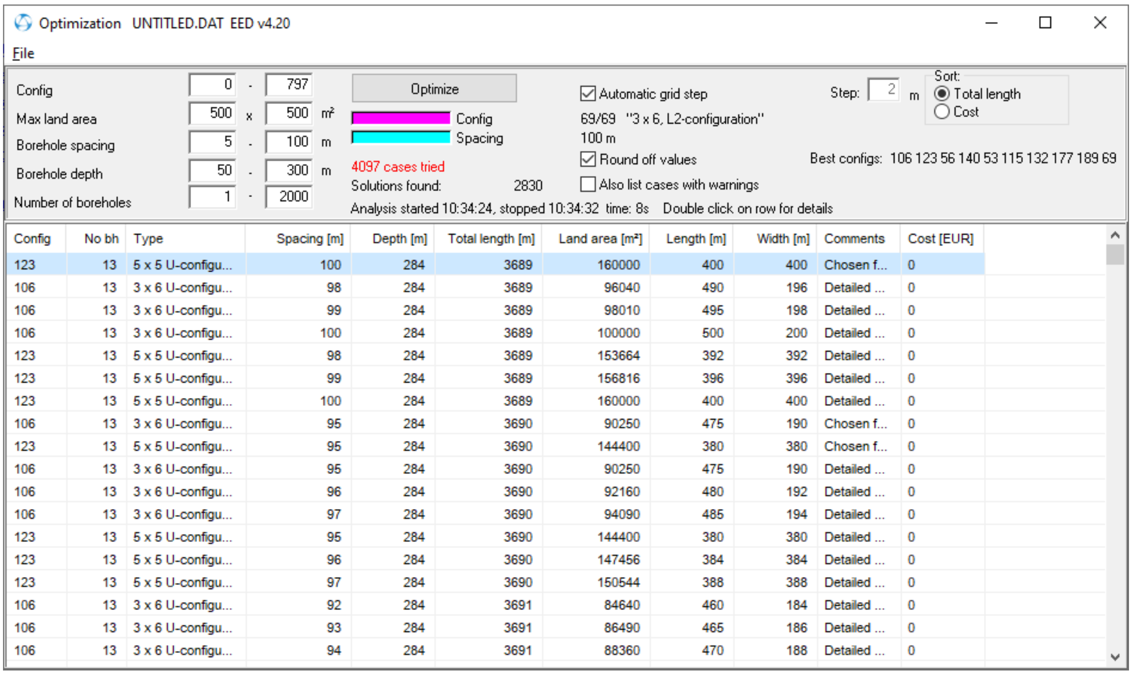


Optimization for "Max land area" of 500x500 m^2 takes 2,5 minutes using EED v3, and only 8 seconds using EED v4 (on an Intel i7 3770K @3.5Ghz CPU), see below.



Config	No bh	Type	Spacing [m]	Depth [m]	Total length [m]	Land area [m²]	Length [m]	Width [m]	Comments	Cost [EUR]
123	13	5 x 5 U-configu...	100	284	3689	1,6E005	400	400	Chosen f...	0
106	13	3 x 6 U-configu...	99	284	3689	98010	495	198	Detailed ...	0
106	13	3 x 6 U-configu...	100	284	3689	1E005	500	200	Detailed ...	0
123	13	5 x 5 U-configu...	98	284	3689	1,54E005	392	392	Detailed ...	0
123	13	5 x 5 U-configu...	99	284	3689	1,57E005	396	396	Detailed ...	0
123	13	5 x 5 U-configu...	100	284	3689	1,6E005	400	400	Detailed ...	0
123	13	5 x 5 U-configu...	95	284	3690	1,44E005	380	380	Chosen f...	0
106	13	3 x 6 U-configu...	96	284	3690	92160	480	192	Detailed ...	0
106	13	3 x 6 U-configu...	97	284	3690	94090	485	194	Detailed ...	0
106	13	3 x 6 U-configu...	98	284	3690	96040	490	196	Detailed ...	0
123	13	5 x 5 U-configu...	95	284	3690	1,44E005	380	380	Detailed ...	0
123	13	5 x 5 U-configu...	96	284	3690	1,47E005	384	384	Detailed ...	0
123	13	5 x 5 U-configu...	97	284	3690	1,51E005	388	388	Detailed ...	0
106	13	3 x 6 U-configu...	95	284	3691	90250	475	190	Chosen f...	0
106	13	3 x 6 U-configu...	93	284	3691	86490	465	186	Detailed ...	0
106	13	3 x 6 U-configu...	94	284	3691	88360	470	188	Detailed ...	0
106	13	3 x 6 U-configu...	95	284	3691	90250	475	190	Detailed ...	0
123	13	5 x 5 U-configu...	92	284	3691	1,35E005	368	368	Detailed ...	0

v3



Config	No bh	Type	Spacing [m]	Depth [m]	Total length [m]	Land area [m²]	Length [m]	Width [m]	Comments	Cost [EUR]
123	13	5 x 5 U-configu...	100	284	3689	160000	400	400	Chosen f...	0
106	13	3 x 6 U-configu...	98	284	3689	96040	490	196	Detailed ...	0
106	13	3 x 6 U-configu...	99	284	3689	98010	495	198	Detailed ...	0
106	13	3 x 6 U-configu...	100	284	3689	100000	500	200	Detailed ...	0
123	13	5 x 5 U-configu...	98	284	3689	153664	392	392	Detailed ...	0
123	13	5 x 5 U-configu...	99	284	3689	156816	396	396	Detailed ...	0
123	13	5 x 5 U-configu...	100	284	3689	160000	400	400	Detailed ...	0
106	13	3 x 6 U-configu...	95	284	3690	90250	475	190	Chosen f...	0
123	13	5 x 5 U-configu...	95	284	3690	144400	380	380	Chosen f...	0
106	13	3 x 6 U-configu...	95	284	3690	90250	475	190	Detailed ...	0
106	13	3 x 6 U-configu...	96	284	3690	92160	480	192	Detailed ...	0
106	13	3 x 6 U-configu...	97	284	3690	94090	485	194	Detailed ...	0
123	13	5 x 5 U-configu...	95	284	3690	144400	380	380	Detailed ...	0
123	13	5 x 5 U-configu...	96	284	3690	147456	384	384	Detailed ...	0
123	13	5 x 5 U-configu...	97	284	3690	150544	388	388	Detailed ...	0
106	13	3 x 6 U-configu...	92	284	3691	84640	460	184	Detailed ...	0
106	13	3 x 6 U-configu...	93	284	3691	86490	465	186	Detailed ...	0
106	13	3 x 6 U-configu...	94	284	3691	88360	470	188	Detailed ...	0

V4

(The optimization using hourly values will take about 2 minutes only in v4, see section 3.6).

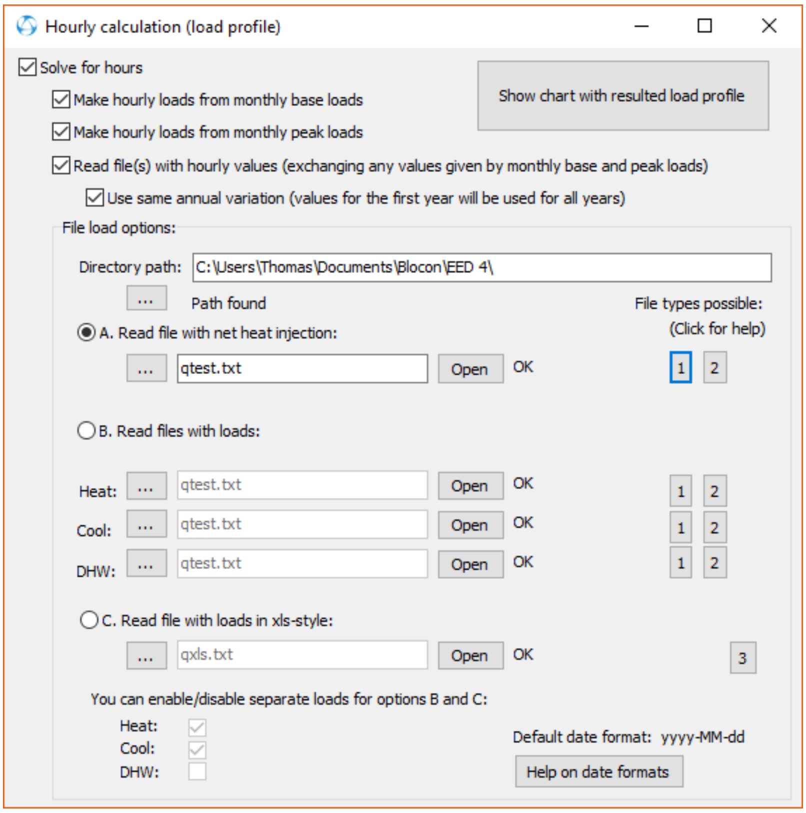
Double-click any row to get the fluid temperature variation. Note that the values for spacing and depth in the "Borehole and heat exchanger" menu will be set to new values (just as in v3).

3. Simulations with hourly values

3.1 Introduction

EED v4 can calculate the response due to any hourly load variation. This means that it handles any loads for cooling, heating, and DHW (District Heat Water), with a resolution of one hour.

To use hourly simulation, go to menu item "Input/Hourly Calculations" and check "**Solve for hours**". All calculations will then use hourly values. This affects items "*Solve mean fluid temperatures F9*", "*Solve required borehole length F10*", and "*Solve required borehole length – Optimization F11*".

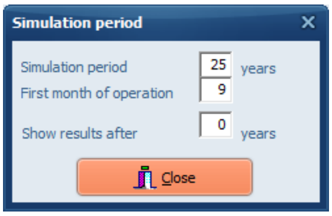


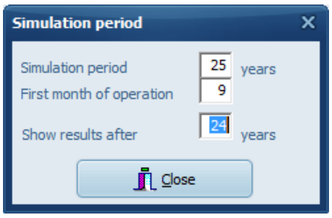
3.2 Note on calculation times

A simulation using hourly values for the load takes longer time than a simulation using monthly values, but is still very quick with the new parallel SIMD or GPU methods, see chapter 6. As an example, solving for fluid temperatures for the first 25 years may take only a few seconds on a CPU such as an Intel i3, i5, or i7. A calculation based on monthly values normally takes less than a second.

Tip to decrease the calculation time when using hourly values:

It is normally sufficient to only look at a specific year (e.g. the 25:th year if the loads are the same every year). Use "Show results after x years" in menu item "Simulation period". The CPU time in this case will just be a fraction of a second since output only will be calculated and showed for year 25 (no output will be shown for years 1-24). See examples below.





CPU-time about 2 secs on a i7 CPU-time about 0.2 seconds on a i7

3.3 Specifying data for hourly values

The given monthly base and/or peak loads for heating, cooling and DHW can be used as default hourly values (repeated for all years). Any hourly value can be changed by data given in files. It is possible to exchange any number of values (from one specified hour up to all values for 100 years which is 876000 hours). In this way, it is quite simple to use the base loads together with new hourly values for e.g. peak heat and cools loads taken from the files. *It is of course also possible to specify the complete load profile by using files only.*

Make hourly loads from monthly base loads: The monthly base loads for heating, cooling and DHW as given in menu "**Input/base loads**" can be used to create default hourly values (repeated for all years). The calculated hourly results for the mean fluid temperature will be the same as in the case with a monthly calculation for each month.

Make hourly loads from monthly peak loads: If monthly peak loads are given, the last hours of each month will be used to fill hourly values. E.g. if the power is 5kW with the duration of 5 hours in January, the 5 last hours (t=726..730) will use 5kW. *Note that if the peak load value is less than the base load value, the base load value will be used.*

The two options above make it possible to open a EED v3 project and directly run an hourly simulation based on the monthly loads. It is then quite easy to see the effect of a peak load just by defining some new values in text file(s).

Values for hourly heat injection/extraction rates to/from the borehole, or loads, can be given by three methods using files:

A. **Read file with net heat injection**: Direct hourly values [W] for net heat injection to the boreholes are given in one file. Positive values means heat injection, negative values means heat extraction.
File type 1 and 2 can be used, see description below.

B. **Read files with loads:** Values for hourly loads [W] are given in three separate files for heating, cooling, and DHW, respectively.
File type 1 and 2 can be used, see description below.

C. **Read files with loads in XLS-style:** Values for hourly loads [W] are given in one file for heating, cooling, and DHW, respectively.
File type 3 should be used, see description below.

The matrix below shows available combinations:

File Type:	**1**	**2**	**3**
Input method			
A	x	x	
B	x	x	
C			x

The heat injected to the boreholes for each hour for method B and C is calculated as
$q_{injected}=q_{heat}*(spf_h-1.0)/spf_h + q_{cool}*(spf_c+1.0)/ spf_c + q_{dhw}*(spf_{dhw}-1.0)/spf_{dhw}$

Note that all heat flows are here defined as positive from the ground to the borehole which means that the values in the files for heating and DHW loads should be negative (heat is extracted from boreholes), while the cooling load values should be positive (heat is injected).

Also note that the SPF values for heat, cooling, and DHW are the same as the ones given in menu "**Input/base loads**".

It is possible to enable/disable to use any of the loads by checking **Use**.

The heat injection rates, and loads, are given for the whole system (i.e. for all boreholes) in [W]. EED will divide the values with the number of boreholes and the depth for the current configuration and present results in W/m (i.e. per meter borehole).

If **Use same annual variation (using data for year 1)** is checked, the load profile for the first year will be used for all years (even though the file(s) have values for t>1 year).

Any text file can be opened in the Notepad editor by pressing **Open** (if it already is open press Alt-Tab to toggle between EED and Notepad). The files will be re-read whenever a simulation is started (F9, F10, or F11). Remember to save the file before starting any analysis.

Tip: *Since there are many ways to give input for loads it is a good idea to check that resulting data are correct. The chart "Show chart with resulted load profile" will show the final heat injected/extracted to/from boreholes that is used for the simulation.*

Format for files

There are three ways how to specify data in files, see **type 1, 2,** and **3** below. The first row in a file should contain the type number followed by an optional **factor** that is multiplied with the values read. Values are assumed to be in [W]. If values are given in kW, the factor should be 1000. The factor may also be negative, e.g. "-1" will change values taken from a heating load file (with negative values since heat is extracted) to positive values which means heat injection (cooling load), and vice versa. It is also quite easy to use this factor in order to see the effect if loads are raised by e.g. 10% (factor 1.1), lowered by 20% (factor 0.8), or doubled (factor 2). Comments can be added after the data, or on a separate line that starts with "%". Blocks can be commented out by "{" and "}".

Default load values are given in SI units as [W], but can also be given in Imperial units as [BTU/h].

The decimal mark for load values can be both a dot (".") or a comma (","). EED will automatically recognize e.g. "45.2" and "45,2" as the same value.

File type 1. Hourly values (q0, q1, q2…) given as a list. Maximum number is 876000 (100 years). Normally 8760 values are given in order to specify data for a year.

row 1:	[type] [factor] (optional)	example: "1 1000"
following rows:		
(optional)	[dateformat] [string]	example: "dateformat ymd"
(optional)	[dateseparator] [string]	example: "dateseparator -"
(optional)	[BTU] Input given in BTU/h instead of in W (1W=3.41214 btu/hour)	
(optional)	[date] example: "2006-03-21" or "2006-03-21 10:00"	
	[value]	example: "45.2"

The parameters [dateformat] and [dateseparator] are described in a separate section below.

The optional [date] row specifies when hourly data is started for a specific year. The date can be given as:

"*2006-03-21 00:00:00*", or "*2006-03-21 00:00*", or just "*2006-03-21*", will give start index t=1896h (it has passed 79 days, i.e. 79*24=1896h, to this date and time for year 2006) which means that the first value read (on third row) will have index q1896, the second value q1897, and so on. Since data is not given for q0..q1895, values from base loads will be used if that option is checked, otherwise zeros.

"*2006-03-21 05:00:00*", or just "*2006-03-21 5*" will give start index t=1901h which means that the first value read will have index q1901, the second value q1902, and so on.

If no row is given, the start time is assumed to be t=0, and the first value read will have index 0 ("q0"). The start time can be different in e.g. the load files for heating, cooling, and DHW.

Example A:

1	% type 1, comments can be written after "%"
-45818.6	% q0=-45818.6 W (a negative value means heat is extracted from boreholes)
-46807.9	% q1=-46807.9 W
-47203.6	% etc

Example B:

1 1000	% type 1, values are given in kW so we specify a factor 1000
-45.8	% q0=-45.8 kW=-45800 W
-46.8	% etc
-47.2	

Example B in BTU/h

```
1 1000        % type 1, values are given in kBTU/h so we specify a factor 1000
BTU
-156          % q0=-156 kBTU/h=156000 BTU/h
-160          % etc
-161
```

Example C:

```
1 -1000       % type 1, factor is negative and file values will change sign
2006-03-21    % start time for index
-45.8         % q1896=45.8 kW (heat is now injected since the factor is negative)
-46.8         % q1897=46.8 kW
-47.2         % q1898=47.2 kW
```

Example D:

```
1 1100        % type 1, values are given in kW and raised by 10% which gives factor 1100
-45.8         % q0=-45.8*1100=-50380 W will be used
{
-46.8         % many rows can be commented with a block comment
}
-47.2         % q1 now becomes -47.2*1100=-51920 W
```

File type 2. Time, value and optional duration time given on each row:

row 1:	[type] [factor] (optional)	example: “2 1000”
following rows:		
(optional)	[BTU] Input given in BTU/h instead of in W (1W=3.41214 btu/hour)	
	[time] [value] [duration] (optional)	example: “2m -2.774 1m”

The time (and duration time) can be given in hours, or by using a *time-string* which is a sequence of pairs with a number and one of the following letters:

y	year (365 days, 8760 hours)
m	month (365/12=30.417 days, 8760/12=730 hours)
d	day (24 hours)
h	hour (can be omitted)

Here are some examples of time-strings:

“1y14h”	1 year and 14 hours (can also be given as e.g. “1y14” or “8774h” or “8774”)
“14m3d15”	1 year, 2 months, 3 days and 15 hours (same as “1y2m3d15”)
“1m”	1 month
“~~1h2d~~”	Not valid. The expression must be in descending order, see next row.
“2d1h”	This string is OK, meaning 2 days and 1 hour

Example E: The time does not have to be given in any specific order:

```
2                 % type 2
1     -45818.6    % q1=-45818.6 W
4     -46807.9    % q4=-46807.9 W
55    -47203.6    % q55=-47203.6W
6     -46807.9    % q6=-46807.9W
```

Example E in BTU/h

```
2               % type 2
BTU
1   -156340    % q1=-156340  BTU/h
4   -159715    % q4=-15971 BTU/h
55 -161065     % q55=-161065 BTU/h
6   -159715    % q4=-15971 BTU/h
```

Example F: Some monthly loads:

```
2 1000               % type 2, factor is 1000 since we give data in kW
0 -3.439 1m          % -3439 W is used for q0..q729 (i.e. for Jan)
1m -3.284 1m         % -3284 W is used for q730..q1459 (i.e. for Feb)
1m721 -10 10h        % e.g. a peak load that now replaces q1450..q1459 with -10 kW
2m -2.774 1m
3m -2.197 1m
4m -1.420 1m
% no load for summer months    (comments can be added after "%)
%9m -1.931 1m        % this row is ignored since it is commented out
10m -2.596 1m
11m -3.196 1m
```

Example G A peak heat load is put at the last 10 hours in Jan:

```
2
720     -3333   10      % q720..q729 put to -3333 W
```

Example H A peak cool load is put the first two days in July after the 5th year:

```
2
5y6m   6000    2d      % q48180..q48227 put to -6000 W
                        (1st index calculated as 5*8760+6*730=48180)
                        (last index calculated as 5*8760+6*730+2*24-1=48227)
```

(Note that option **Use same annual variation (using data for year 1)** should not be checked in example H case since data are given for t>1 year in this case.)

File type 3. Hourly values for date and time, heat load, cool load, and DHW load, are given in four columns in a text file. Data can be copied from e.g. Excel into the text file.

	A	B	C	D	E
1	Date and time	Heat from the ground while heating (kW	Heat to the ground while cooling (kW)	DHW	
2	2006-03-21 00:00	-82,65	0		
3	2006-03-21 01:00	-79,51	0		
4	2006-03-21 02:00	-76,97	0		
5	2006-03-21 03:00	-92,35	0		
6	2006-03-21 04:00	-155,43	0		
7	2006-03-21 05:00	-134,94	0		
8	2006-03-21 06:00	-111,7	0		
9	2006-03-21 07:00	-66,75	0		
10	2006-03-21 08:00	-87,72	0		
11	2006-03-21 09:00	-65,02	0		
12	2006-03-21 10:00	-54,69	0		
13	2006-03-21 11:00	-42,35	0		
14	2006-03-21 12:00	-29,78	4,32		
15	2006-03-21 13:00	-0,75	8,37		
16	2006-03-21 14:00	-0,21	15,9		
17	2006-03-21 15:00	0	22,32		
18	2006-03-21 16:00	0	23,91		
19	2006-03-21 17:00	0	23,13		
20	2006-03-21 18:00	-43,98	0		
21	2006-03-21 19:00	-56,85	0		
22	2006-03-21 20:00	-61,42	0		
23	2006-03-21 21:00	-57,66	0		

row 1:	[type] [factor] (optional)	example: "1 1000"
following rows:		
(optional)	[dateformat] [string]	example: "dateformat ymd"
(optional)	[dateseparator] [string]	example: "dateseparator -"
(optional)	[BTU] Input given in BTU/h instead of in W (1W=3.41214 btu/hour)	
(optional)	[date] [q_heat] [q_cool] [q_dhw]	

The date and time can be given as "yyyy-mm-dd hh:ss" or "yyyy-mm-dd hh", e.g:

"*2006-03-21 00:00*", or "*2006-03-21 00*"

Example A:

3 1000		% type 3 factor 1000
2006-03-21 00:00	-82,6 0	% qh=-82,6 kW at t=1896, qc=0
2006-03-21 01:00	-79,5 0 -1	% qh=-79,5 kW at t=1897, qc=0 kW, qdhw=-1 kW
2006-03-21 02	-33 2 -0.1	% qh=-33 kW at t=1898, qc=2 kW, qdhw=-0.1 kW

In this case, the date 2006-03-21 00:00 gives t=31+28+20=79 days (t=24*79=1896).

Note that leap years (e.g. year 2016) have 366 days, and 29 days is February. The date 2016-03-21 00:00 gives t=31+29+20=80 days which is 1920h (t=24*80).

Note that these lines are ok:

"2006-03-21 00:00 -82,65"
Value defined for heating. No values defined for cooling and DHW.

"2006-03-21 00:00 -82,65 5,5"
Values defined for heating and cooling. No value defined for DHW.

"2006-03-21 00:00 -82,65 5,5 0"
Values defined for heating, cooling, and DHW (=0)

What does *defined* value means? Assume that "Make hourly loads from monthly base loads" and/or "Make hourly loads from monthly peak loads" is checked. Defined values in files will always override (exchange) the default values from monthly base and peak loads. If you do not want to define a value use "*x*", such as

> “2006-03-21 00:00 x 5,5 x” or   just “2006-03-21 00:00 x 5,5”
> Base load/peak load value will be used for heating and DHW, and 5,5 will be used for cooling
>
> “2006-03-21 00:00 82,65 x 0”
> 82,65 will be used for heating, base load/peak load value will be used for cooling, but value will be zero for DHW

3.4 Date formats

Different date formats can be used in file type 1 and 3. The default date format is taken from the OS settings. It is possible to force the format by using "dateformat" and "dateseparator", see examples below.

It is sufficient to give "dateformat" and "dateseparator" once (before the first date is given).

Adding "dateformat" and "dateseparator" in a load file is recommended since the file will work on all PC:s regardless of date formats in OS.

Examples file type 1:

```
dateformat ymd          % Sweden, Germany, etc
dateseparator -
date 2006-03-21 11:00

dateformat dmy          % Germany, etc
dateseparator .
date 21.03.2006 11:00

dateformat mdy          % USA, etc
dateseparator /
date 3/21/2006 11:00
```

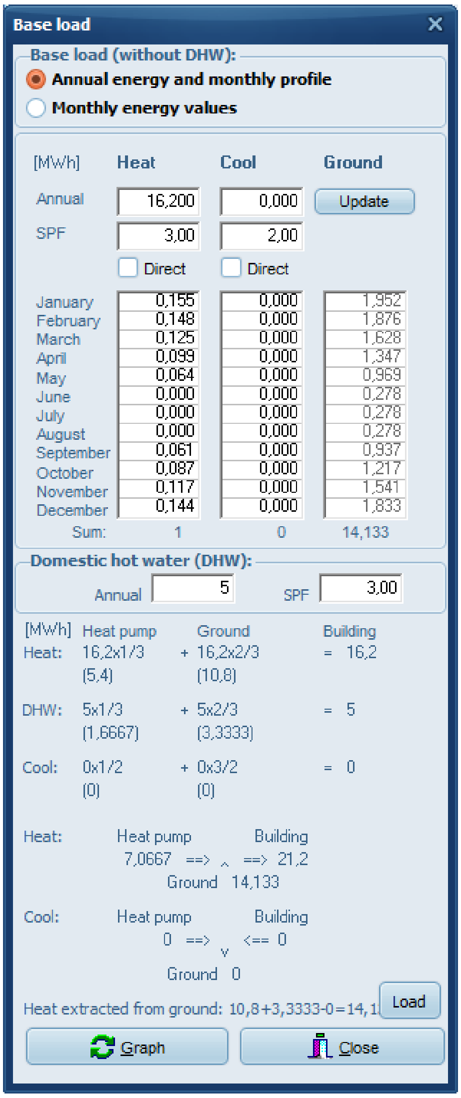
Example file type 3:

(Same input specified in three different date formats)

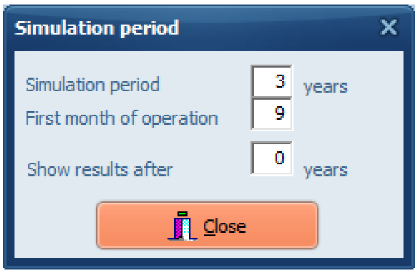
```
3 1000
dateformat ymd                          % Sweden, Germany, etc
dateseparator -
2006-03-21 00:00      -82,65 0          % (t=24*79=1896)
2006-03-21 01:00      -79,51 0 -1
2006-03-21 02         -33 2 -0.1

dateformat dmy % Germany, etc
dateseparator .
21.03.2006 00:00      -82,65 0          % (t=24*79=1896)
21.03.2006 01:00      -79,51 0 -1
21.03.2006 02         -33 2 -0.1


dateformat mdy                          % USA, etc
dateseparator /
03/21/2006 00:00      -82,65 0          % (t=24*79=1896)
03/21/2006 01:00      -79,51 0 -1
03/21/2006 02         -33 2 -0.1
```

3.5 Example (Hourly_example_1.dat)

Consider the base loads given below. The ground load (that depends on the SPF) will here be used as default values for all hours (repeated for every year). E.g., the ground load for January is calculated as 16,200*0,155*(3-1)/3+5*(3-1)/3/12=1.952 MWh (contribution from heat load and DHW load). The heat extraction from the ground will be 1,952e6/730=2674 W per hour during January. Since we have one borehole of 110 m depth, the heat extraction is 2674/110=24,31 W/m.

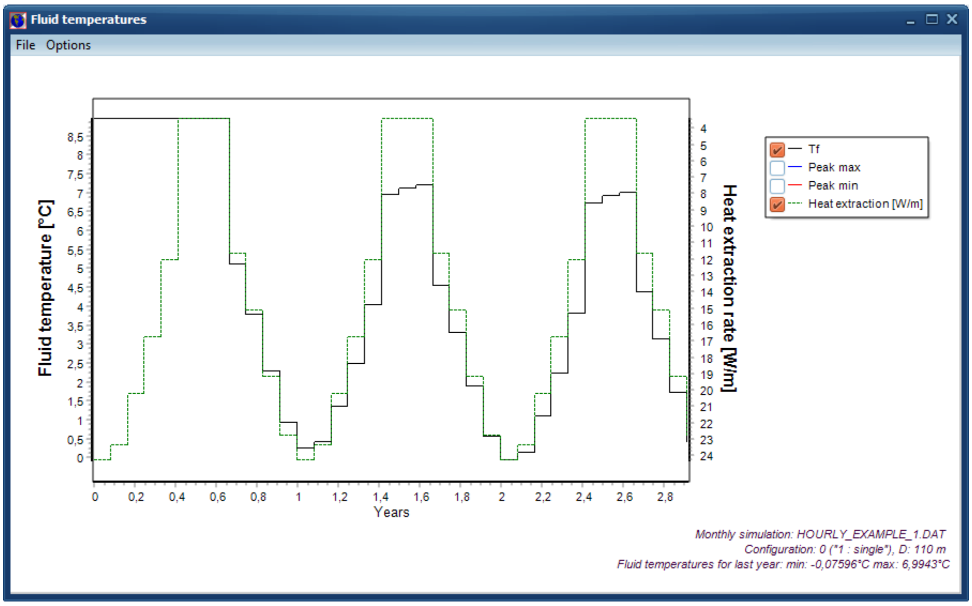


For this demonstration case we only simulate three years:



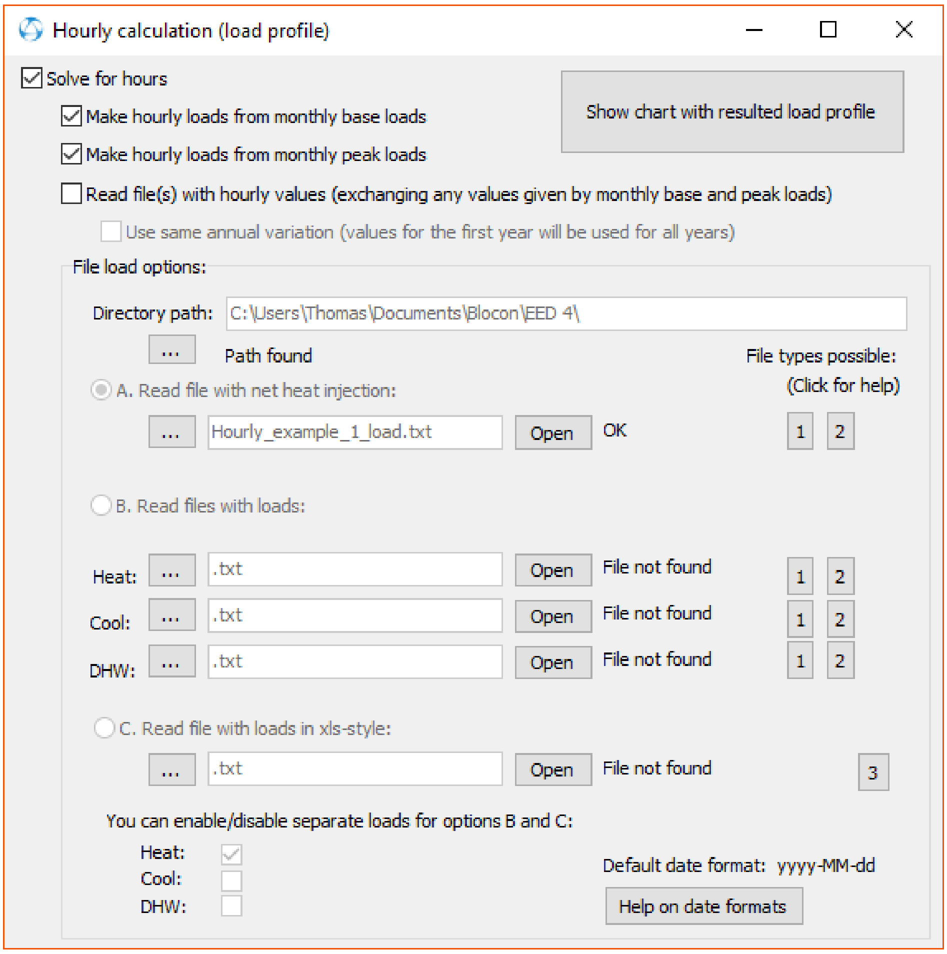
Let us first make an ordinary monthly simulation:

Press F9. The output from a monthly simulation will give Tmin=-0,076 after three years:



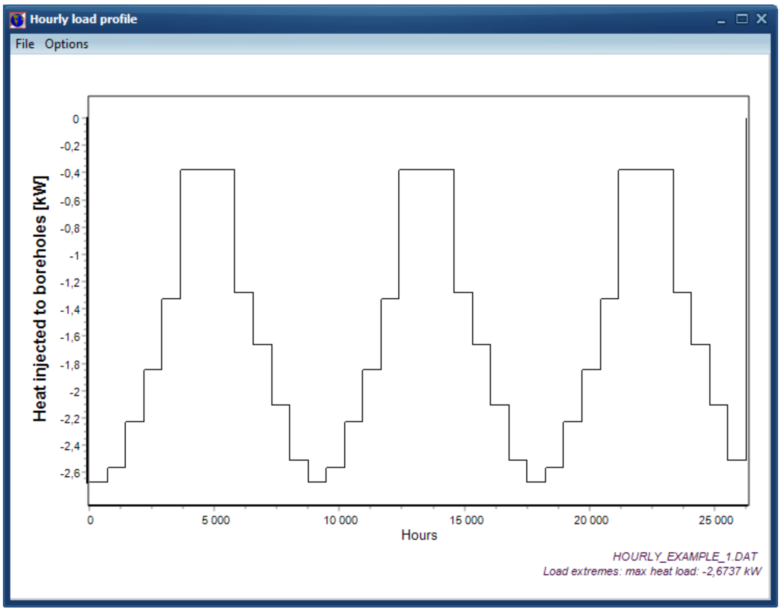
The heat extraction is 2674/110=24,31 W/m for January, just as we calculated before.

Now let us do an hourly simulation using the base load values:



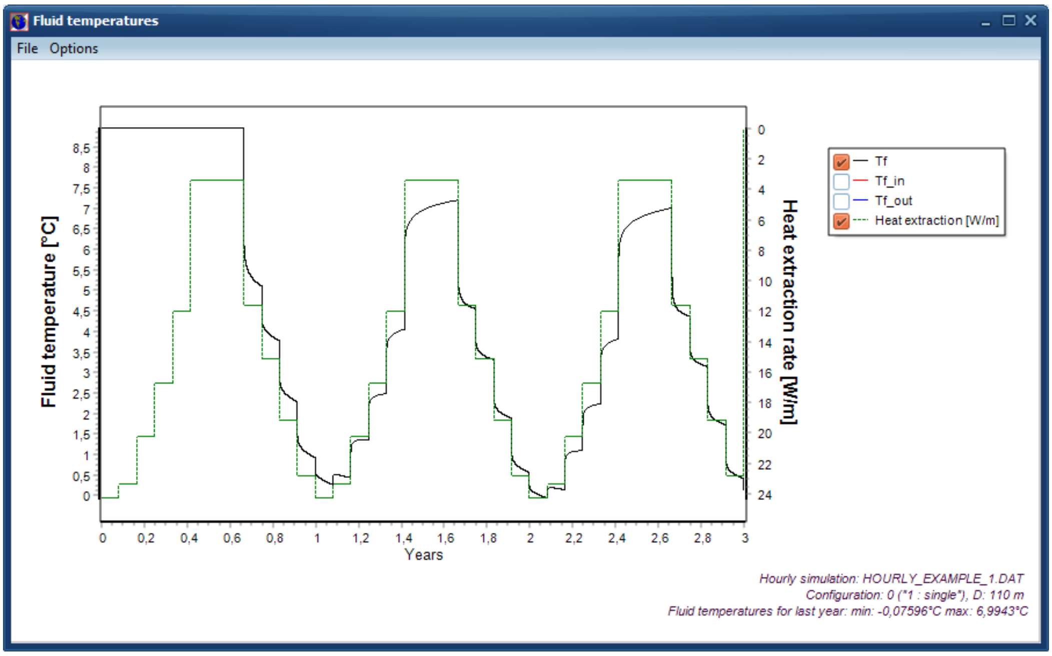
Since we do not have peak loads it does not matter whether ”Make hourly loads from monthly peak loads” is checked or not.

Press button “Show chart with resulted load profile”:

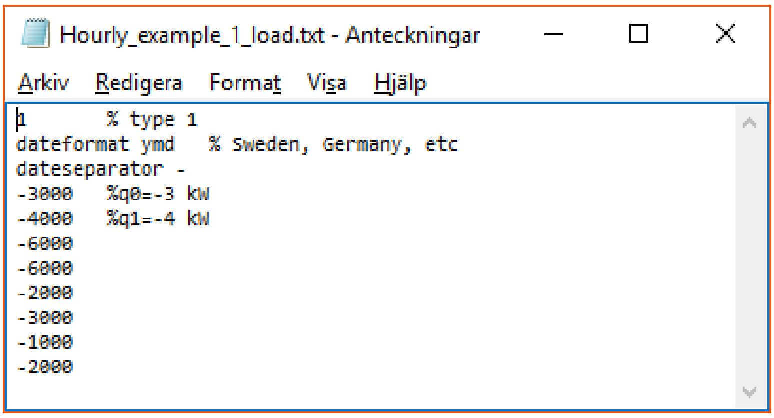


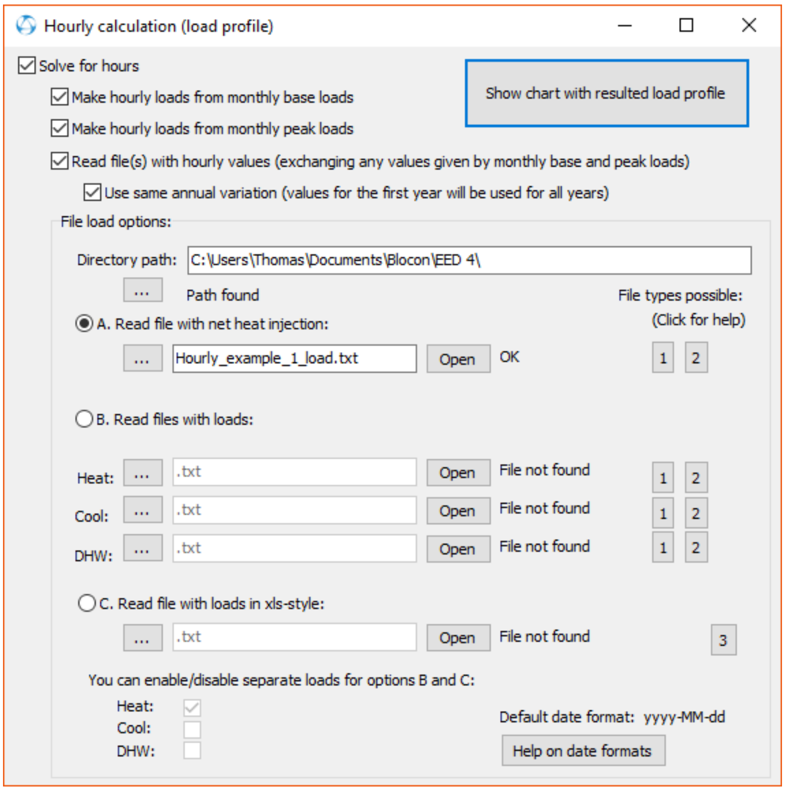
As shown above, the heat extraction from the ground is 1,952e6/730=2674 W during January.

Press F9 to start a simulation. The output from a hourly simulation will give the same minimum mean fluid temperature as the monthly simulation: Tmin=-0,076 (at t=3 years):



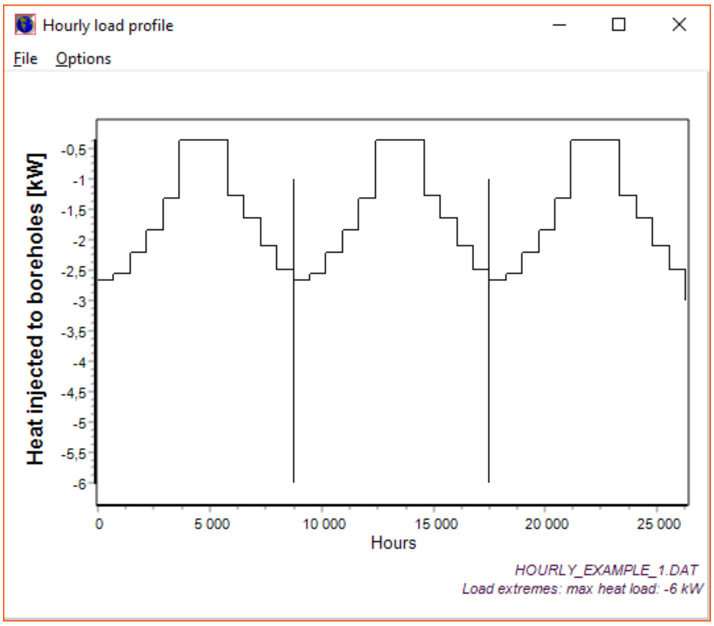
We now use the file “Hourly_example_1_load.txt” that have the following data instead (here opened in “Notepad”):

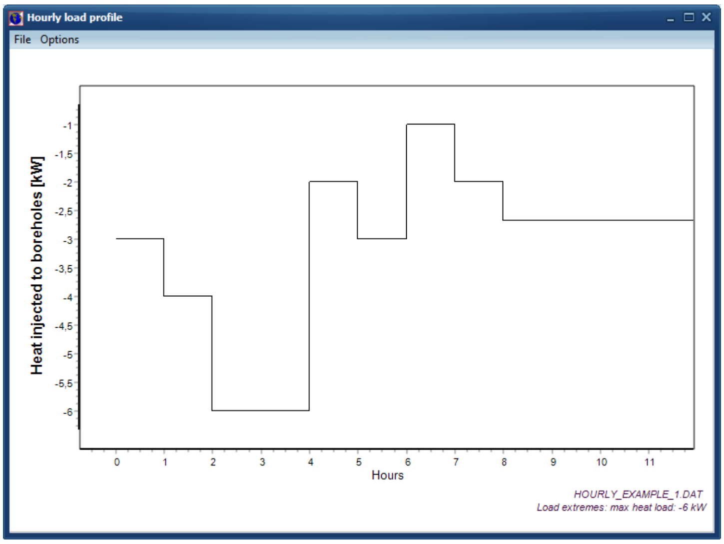




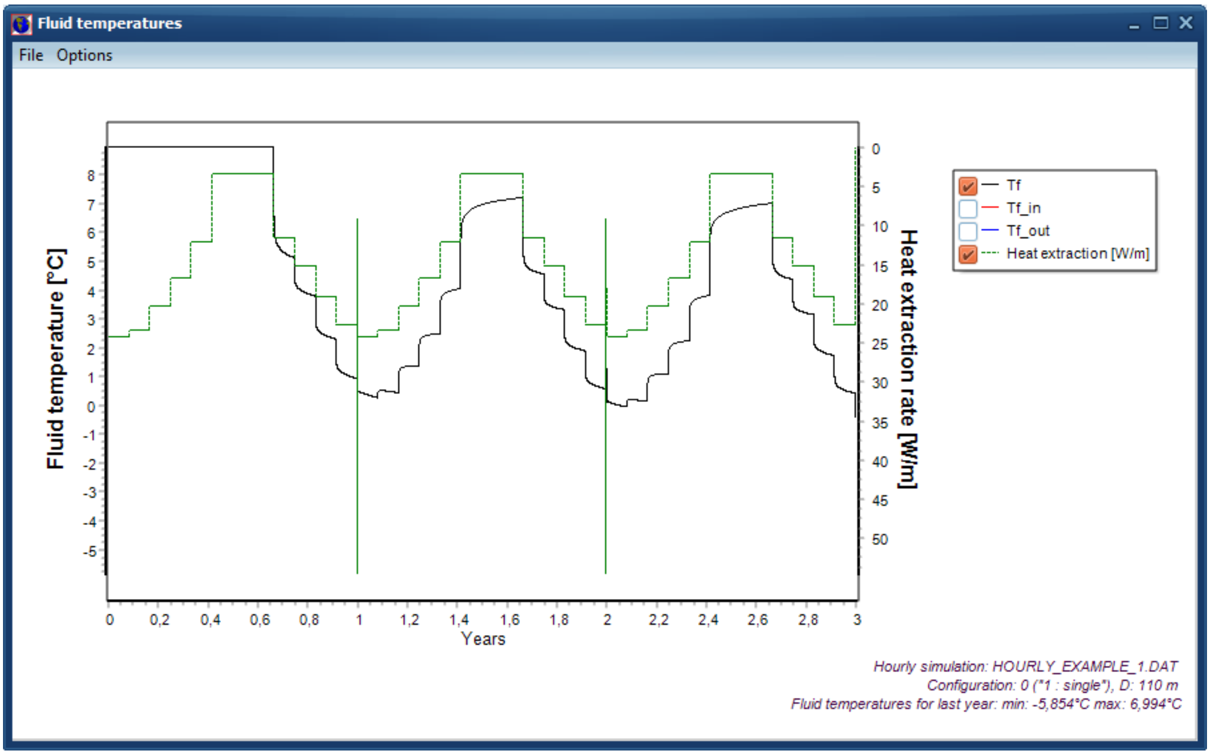
Since **Use same annual variation (using data for year 1)** is checked, the profile will be repeated year after year.

Open the hourly chart load profile. Zoom up the area for hours between e.g. 0 and 12 (click and hold down left mouse button and move cursor left/down):

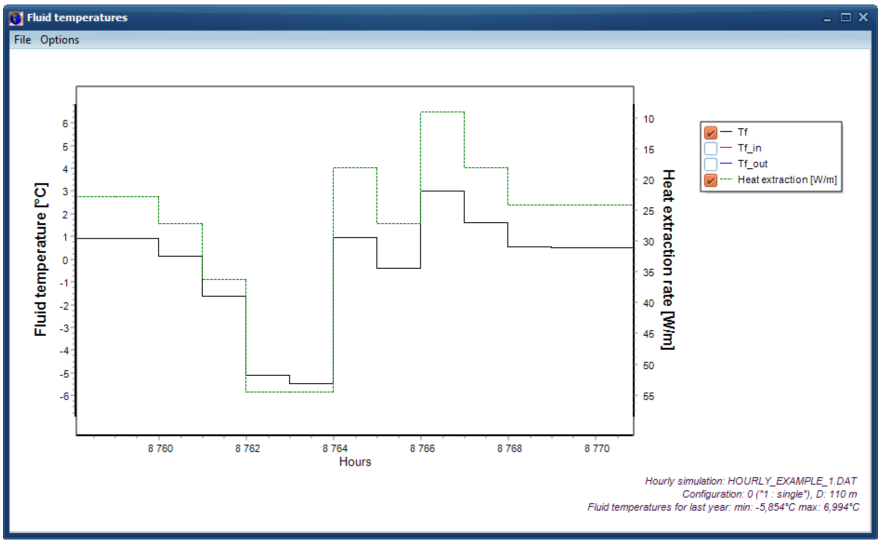




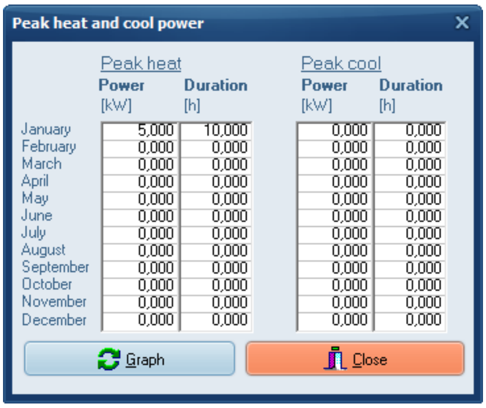
The output from the hourly simulation now gives Tmin=-5,854:



Zoom the area around t=1 year (here we have first changed the time label to hours in menu item "Options"). The ground heat injection value at e.g. t=3h (and t=8763h and so on) has the value -6000 W which gives 54,54 W/m for one borehole with depth 110m.

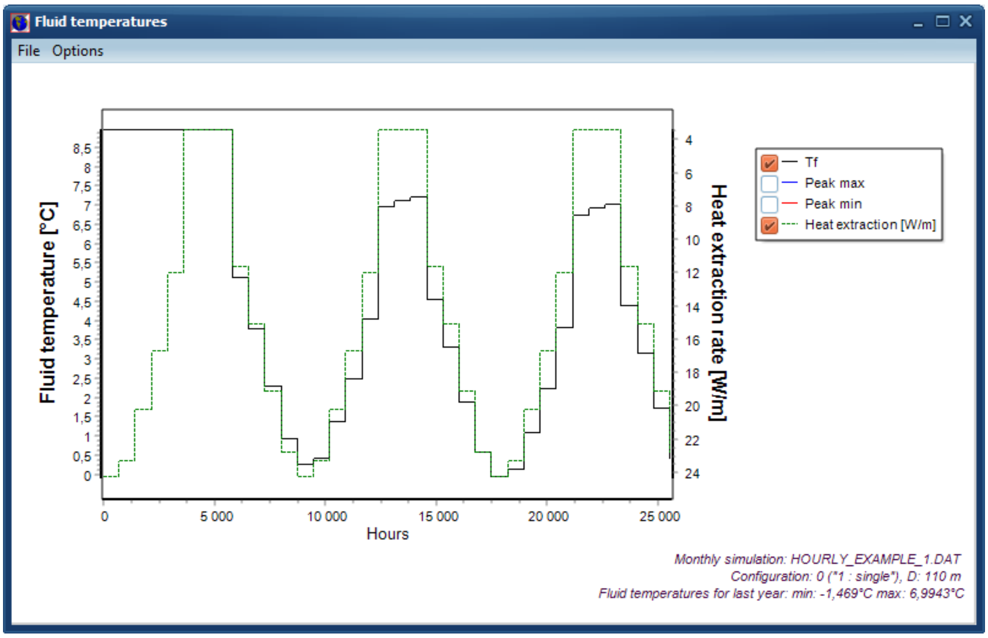


Let us see the effect from a peak load, here 5 kW during 10 hours at the end of January:

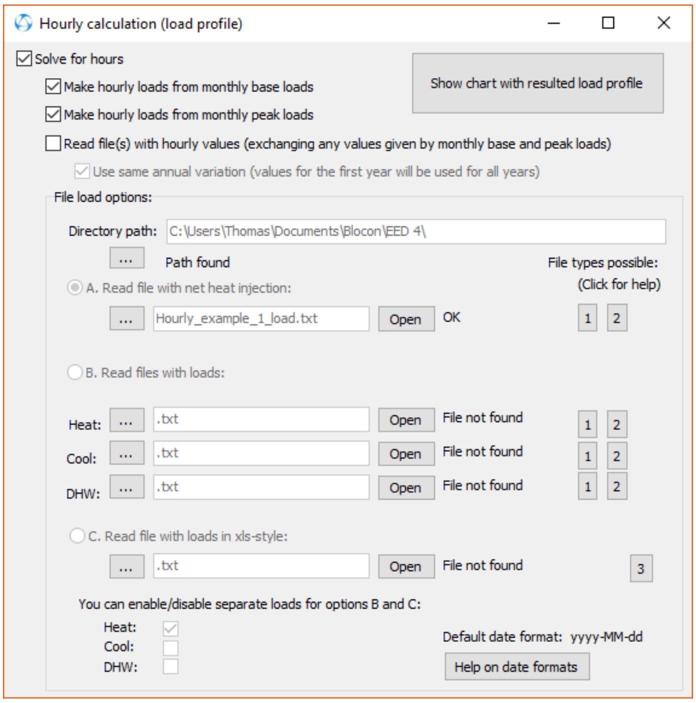


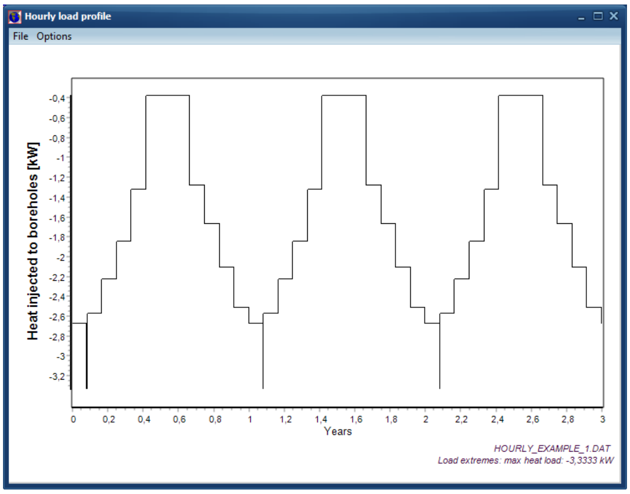
	Peak heat Power [kW]	Peak heat Duration [h]	Peak cool Power [kW]	Peak cool Duration [h]
January	5,000	10,000	0,000	0,000
February	0,000	0,000	0,000	0,000
March	0,000	0,000	0,000	0,000
April	0,000	0,000	0,000	0,000
May	0,000	0,000	0,000	0,000
June	0,000	0,000	0,000	0,000
July	0,000	0,000	0,000	0,000
August	0,000	0,000	0,000	0,000
September	0,000	0,000	0,000	0,000
October	0,000	0,000	0,000	0,000
November	0,000	0,000	0,000	0,000
December	0,000	0,000	0,000	0,000

The output from a monthly simulation (uncheck "Solve for hours") will give Tmin=-1,47 after three years:

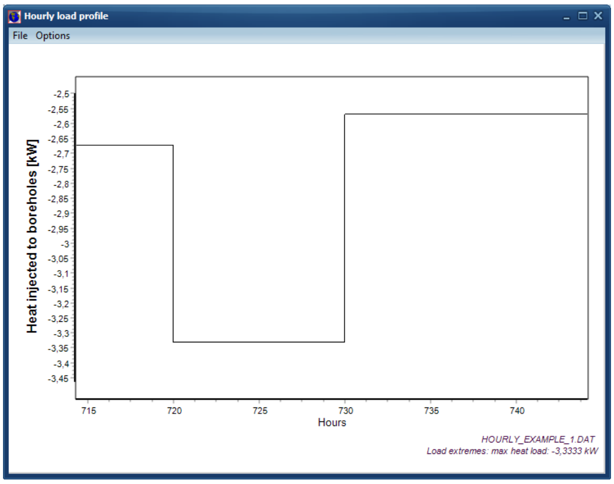


We can make an hourly simulation as follows:



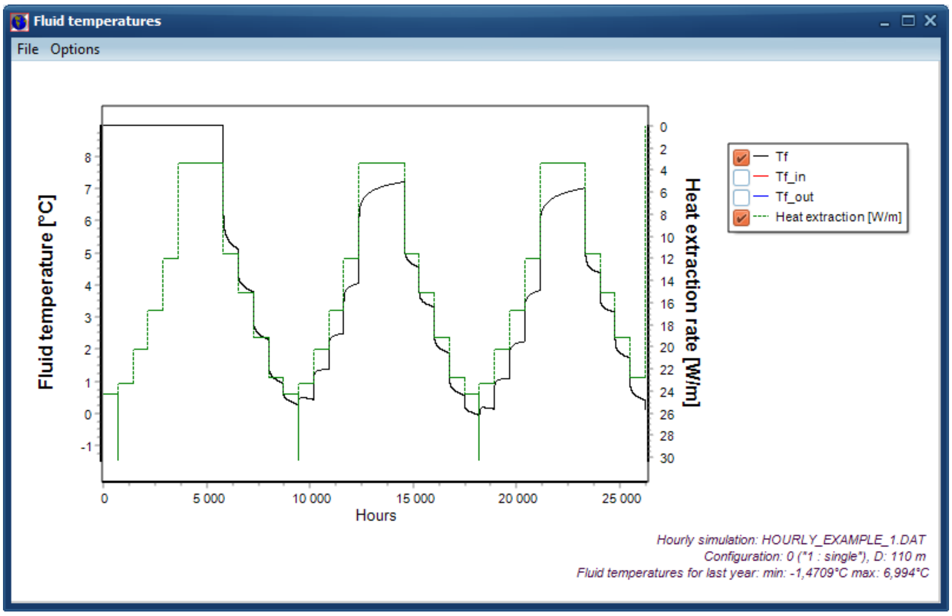


Resulted load profile



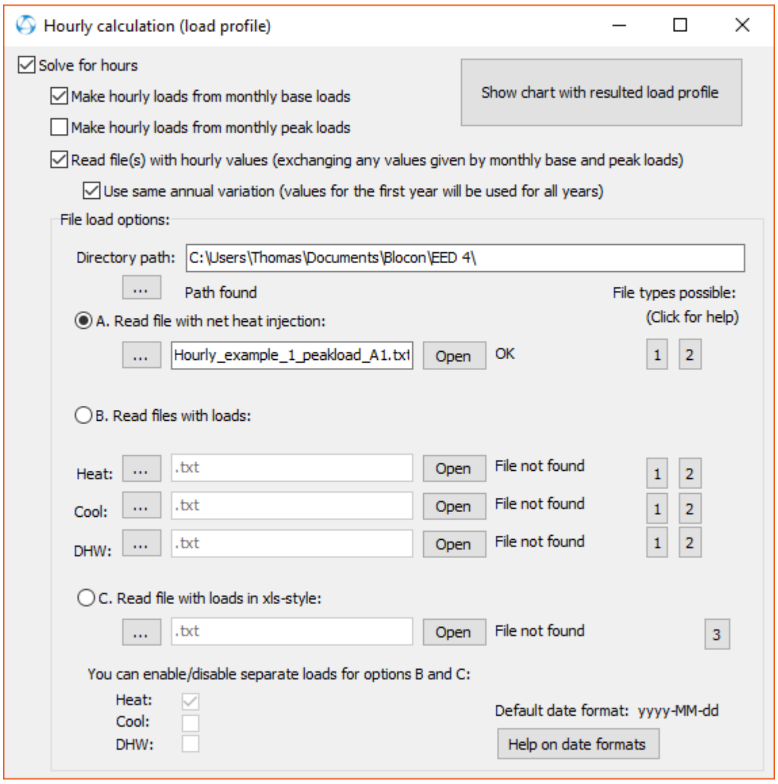
Zoomed area for end of January

Since the SPF is 3, the ground load will be 5000*2/3=3333 W for the peak. The output from an hourly simulation will also give Tmin=-1,47 after three years:

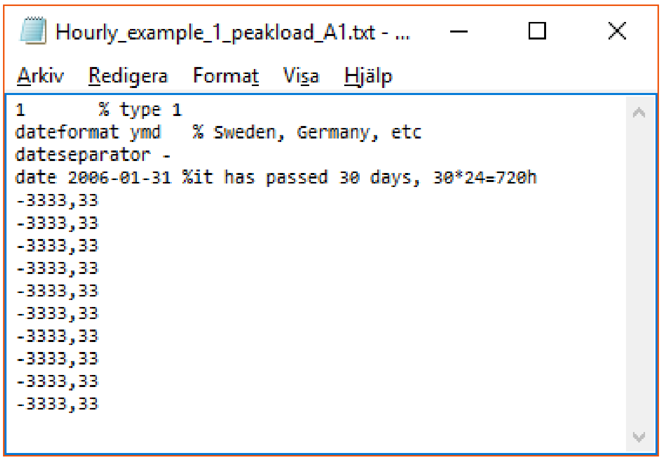


For illustration, we now define the same peak loads by using files instead. The data defined for load option A, B, and C below will all give the same load profile (see chart above) and the same calculated results for the mean temperature.

File load option A



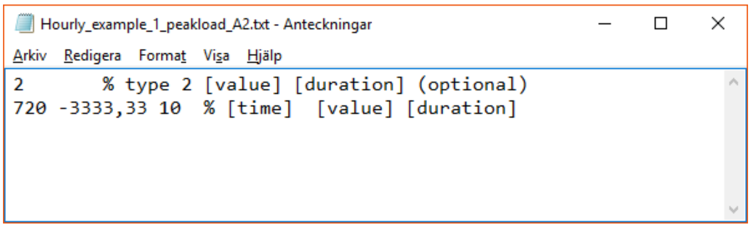
See load file “Hourly_example_1_peakload_A1.txt”:




```
1       % type 1
dateformat ymd   % Sweden, Germany, etc
dateseparator -
date 2006-01-31 %it has passed 30 days, 30*24=720h
-3333,33
-3333,33
-3333,33
-3333,33
-3333,33
-3333,33
-3333,33
-3333,33
-3333,33
-3333,33
```

Pressing F9 gives Tmin=-1,47.

We can also use file type 2, see “Hourly_example_1_peakload_A2.txt”.



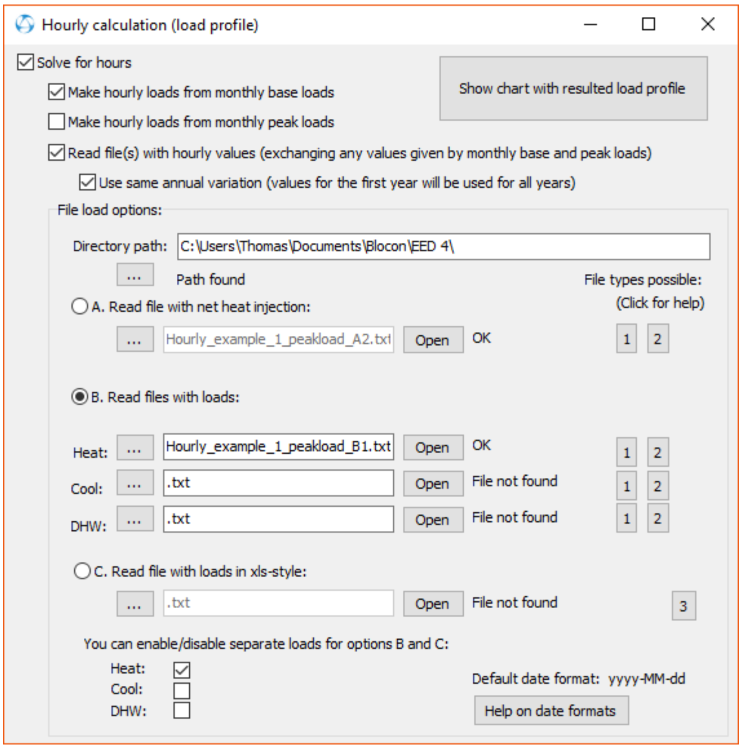

```
2       % type 2 [value] [duration] (optional)
720 -3333,33 10  % [time]  [value] [duration]
```

Pressing F9 gives Tmin=-1,47.

In this case we have replaced the same hourly loads from the monthly peak load with data from file, so it does not matter whether “Make hourly loads from monthly peak loads” is checked or not,

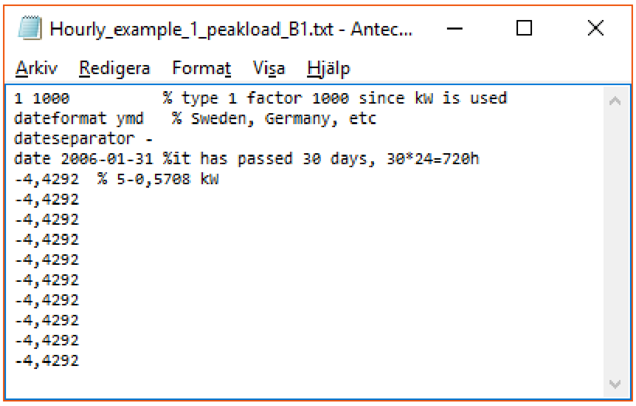
File load option B

Make sure to disable the import of “Cool” and “DHW” values at the bottom:



See file “Hourly_example_1_peakload_B1.txt”. In this case we have the peak load 5 kW. However, since the value in menu item “Peak load” replaces the base load value (heating + DHW) we need to subtract the DHW (5e6/8760=0,5708 kW) since it is included in the base load from “Make hourly loads from monthly base loads). (This is ok since the SPF-value is the same for the heat load and the DHW load in this case.)

See file “Hourly_example_1_peakload_B1.txt”:


Hourly_example_1_peakload_B1.txt - Antec...

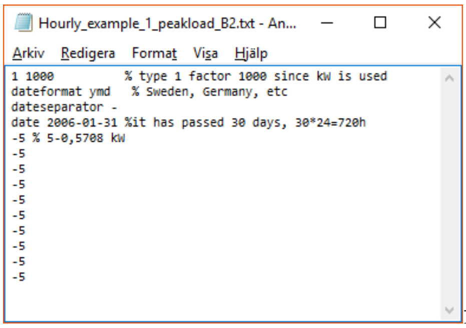
Arkiv Redigera Format Visa Hjälp

```
1 1000          % type 1 factor 1000 since kW is used
dateformat ymd   % Sweden, Germany, etc
dateseparator -
date 2006-01-31 %it has passed 30 days, 30*24=720h
-4,4292  % 5-0,5708 kW
-4,4292
-4,4292
-4,4292
-4,4292
-4,4292
-4,4292
-4,4292
-4,4292
-4,4292
```

for heating

Pressing F9 gives Tmin=-1,47.

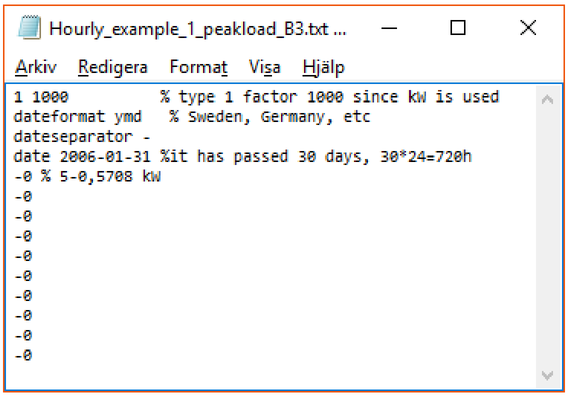
Another, perhaps simpler way, would be to use 5 kW for the heat load and just put zero for the DHW load (with use DHW enabled):


Hourly_example_1_peakload_B2.txt - An...

Arkiv Redigera Format Visa Hjälp

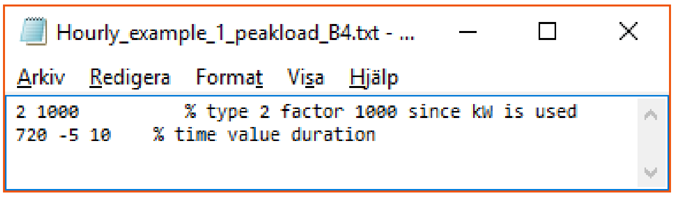
```
1 1000          % type 1 factor 1000 since kW is used
dateformat ymd   % Sweden, Germany, etc
dateseparator -
date 2006-01-31 %it has passed 30 days, 30*24=720h
-5 % 5-0,5708 kW
-5
-5
-5
-5
-5
-5
-5
-5
-5
```

for heating

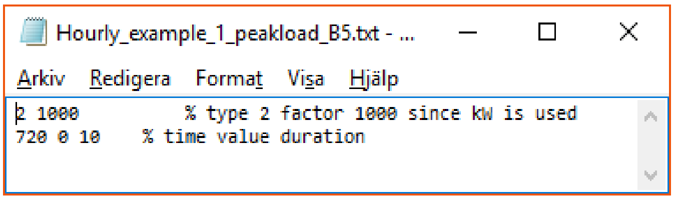


for DHW

Or by using file type 2:

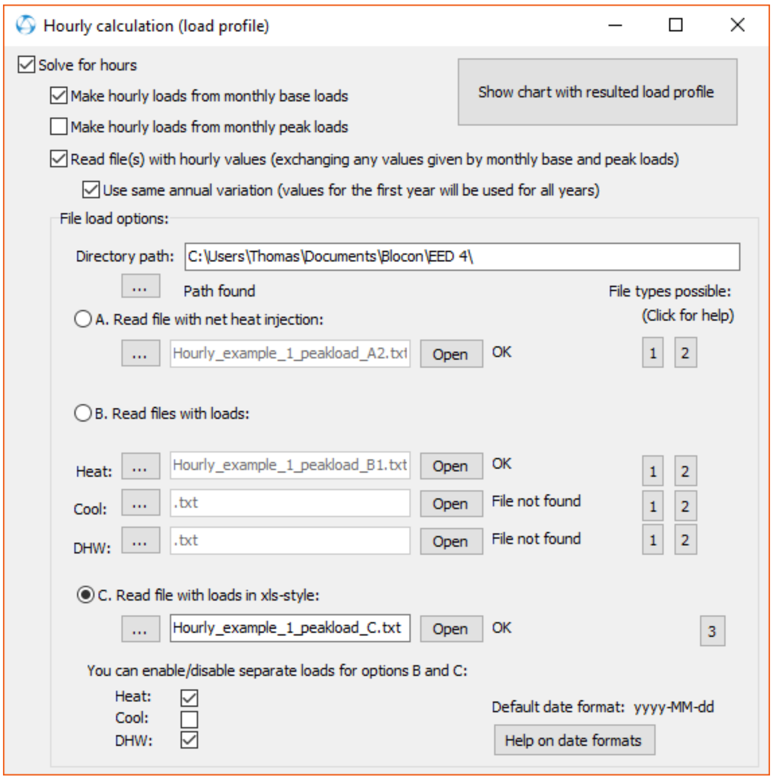


for heating



for DHW

File load option C



Hourly_example_1_peakload_C.txt - ...

Arkiv Redigera Format Visa Hjälp

```
3 1000 % type and factor
dateformat ymd   % Sweden, Germany, etc
dateseparator -
2006-01-31 00:00        -5      0       0
2006-01-31 01:00        -5      0       0
2006-01-31 02:00        -5      0       0
2006-01-31 03:00        -5      0       0
2006-01-31 04:00        -5      0       0
2006-01-31 05:00        -5      0       0
2006-01-31 06:00        -5      0       0
2006-01-31 07:00        -5      0       0
2006-01-31 08:00        -5      0       0
2006-01-31 09:00        -5      0       0
```

Here we have just copied the following rows from an Excel sheet:

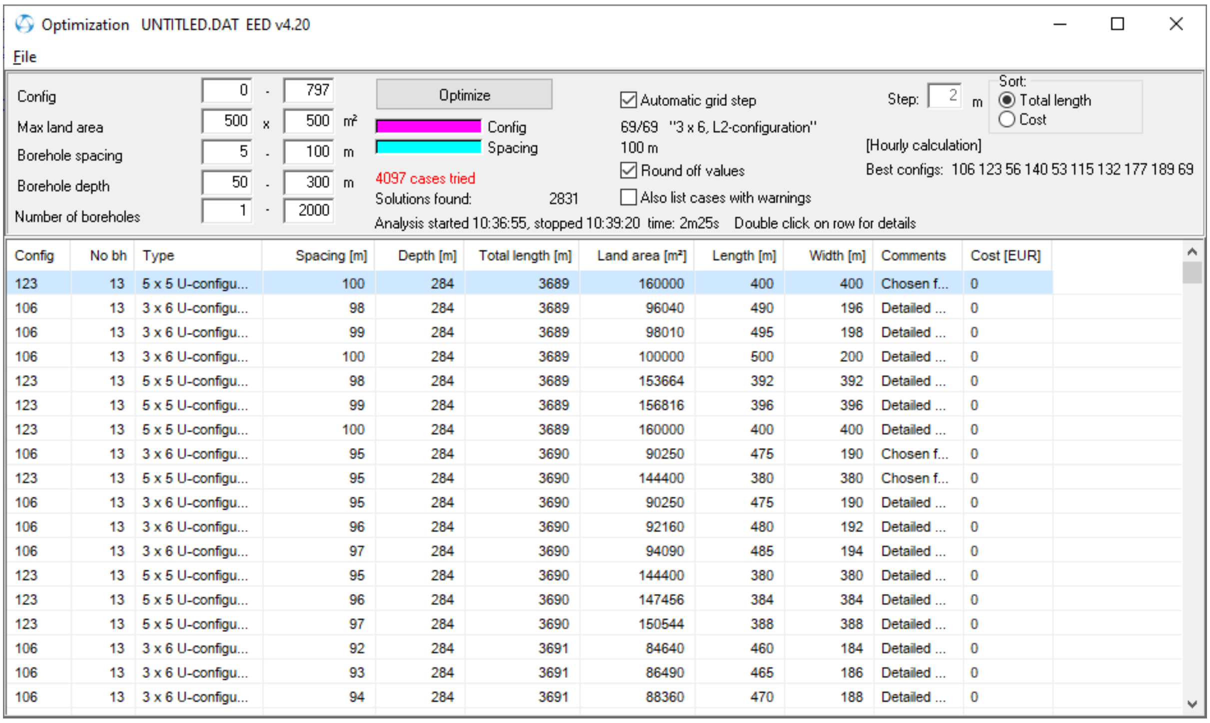
	A	B	C	D	E
1					
2	2006-01-31 00:00	-5	0	0	
3	2006-01-31 01:00	-5	0	0	
4	2006-01-31 02:00	-5	0	0	
5	2006-01-31 03:00	-5	0	0	
6	2006-01-31 04:00	-5	0	0	
7	2006-01-31 05:00	-5	0	0	
8	2006-01-31 06:00	-5	0	0	
9	2006-01-31 07:00	-5	0	0	
10	2006-01-31 08:00	-5	0	0	
11	2006-01-31 09:00	-5	0	0	
12					

See file “Hourly_example_1_peakload_C.txt”.

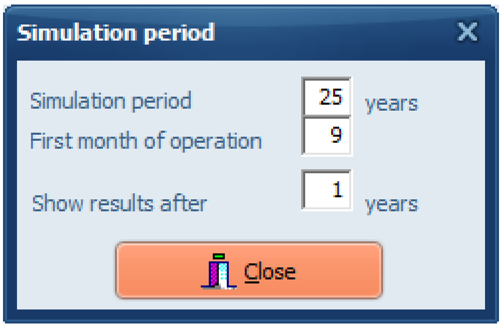
Pressing F9 gives Tmin=-1,47.

3.6 Optimization for hourly values

The optimization will take longer time using hourly values compared to monthly ones but is still quite quick. Consider the example in section 2.2 where the optimization with monthly values during 25 years took 2 seconds to complete (on an Intel i7 3770K @3.5Ghz CPU). The same optimization takes about 2 minutes [updated value for v4.20] using hourly values, see below. The analysis involves 4097 different configurations which means that about 30 configurations are analyzed every second.



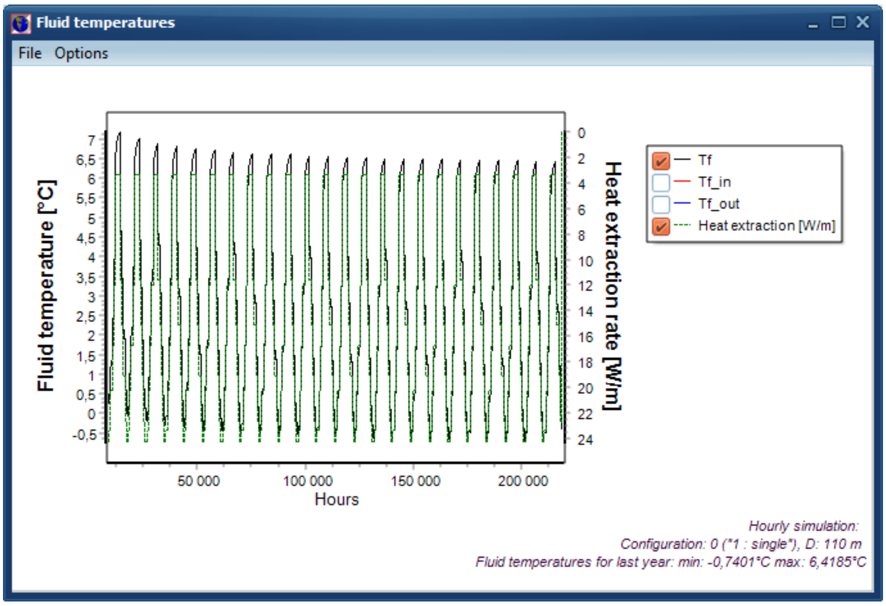
Note that the optimization is made for the last year that is assumed to be the worst one. However, since it is possible to define (peak) hourly values for any year, the worst year might be another than the last one. It is up to the user to run a case to see what year is worst if this is the case, and then use that year as "Simulation period" for the optimization, see below.



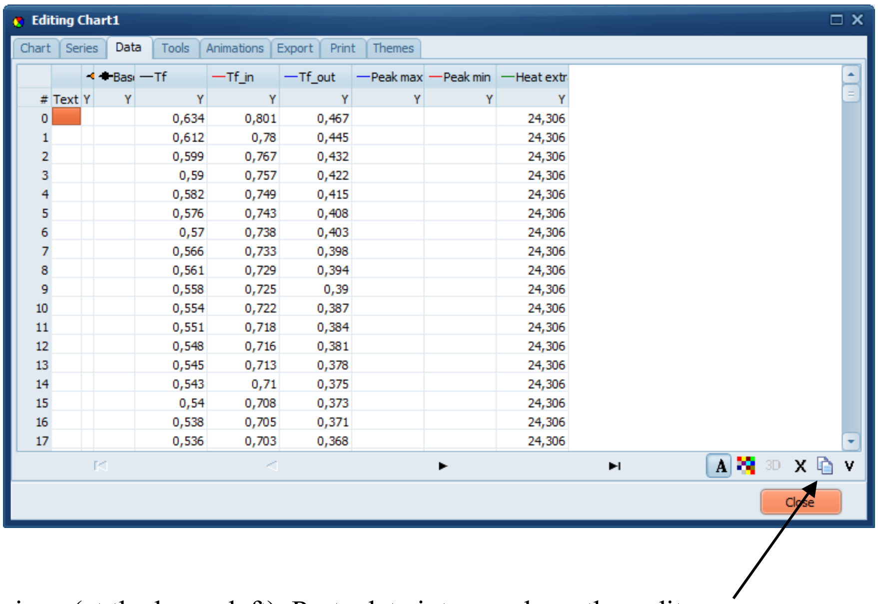
3.7 Exporting data

Hourly data (such as mean fluid temperatures, heat extraction rate, inlet/outlet fluid temperatures) can be previewed and exported to e.g. Excel.

As an example, all data shown in the chart window below can be exported. Choose “Options/Use hours” to label the x-axis in hours:

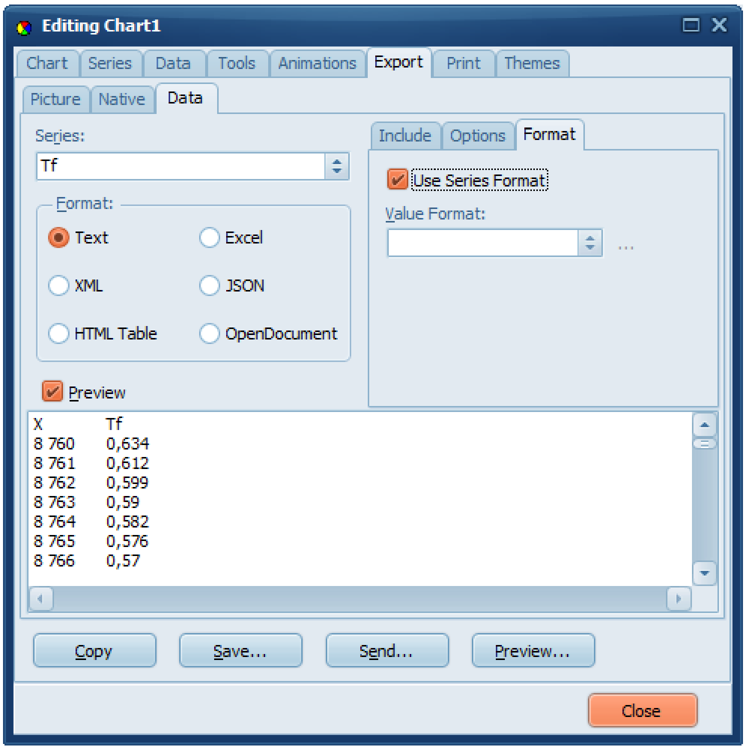


Press Options/Edit chart to get to the editing menu. Choose “Data” for preview:

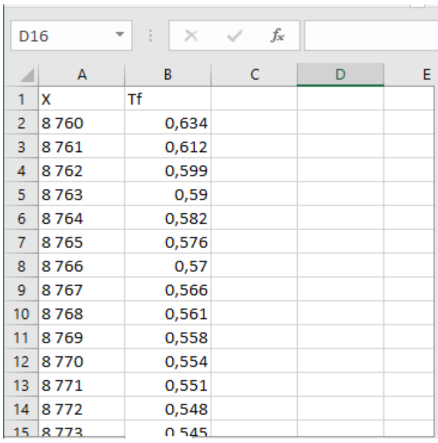


Press the copy icon (at the lower left). Paste data into excel or other editor.

Another option is to use the ”Export” tab, and ”Data” to export values. You can choose to export all series, or just one. The example below shows Tf (mean fluid temperatures).

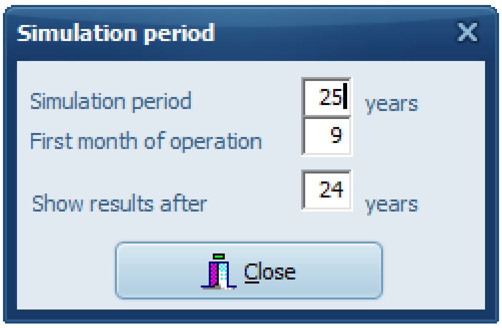


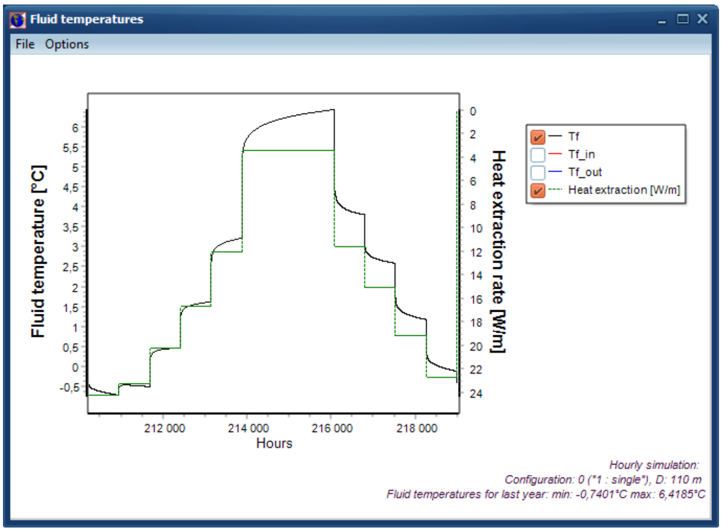
Use the copy button to copy the text. Below it is pasted into Excel.



	A	B	C	D	E
1	X	Tf			
2	8 760	0,634			
3	8 761	0,612			
4	8 762	0,599			
5	8 763	0,59			
6	8 764	0,582			
7	8 765	0,576			
8	8 766	0,57			
9	8 767	0,566			
10	8 768	0,561			
11	8 769	0,558			
12	8 770	0,554			
13	8 771	0,551			
14	8 772	0,548			
15	8 773	0,545			

Tip: If you only want to export data for the last year, e.g. the 25th year, change “Show results after 24 years:





3.8 EWT and LWT

The calculated resulting temperatures are the mean fluid temperatures (Tf) inside the pipe, at half of the depth of the borehole. Typically in heating mode the Entering Water Temperature (EWT) (which is the temperature out of the borehole into the heat pump) is about 1.5-2.0 °C higher, the return temperature Leaving Water Temperature (LWT) the same value lower than the mean temperature.

In cooling mode, EWT is about 2 °C lower than the mean, return higher. This values depend upon flow rate, but also borehole depth, pipe diameter, filling, shank spacing, etc.

For hourly calculations, EED presents a simplified calculation of Tf_in (EWT) and Tf_out (LWT) as

Tf_in=Tf-0.5*Q/(Cf*Vf)

Tf_out=Tf+0.5*Q/(Cf*Vf)

where

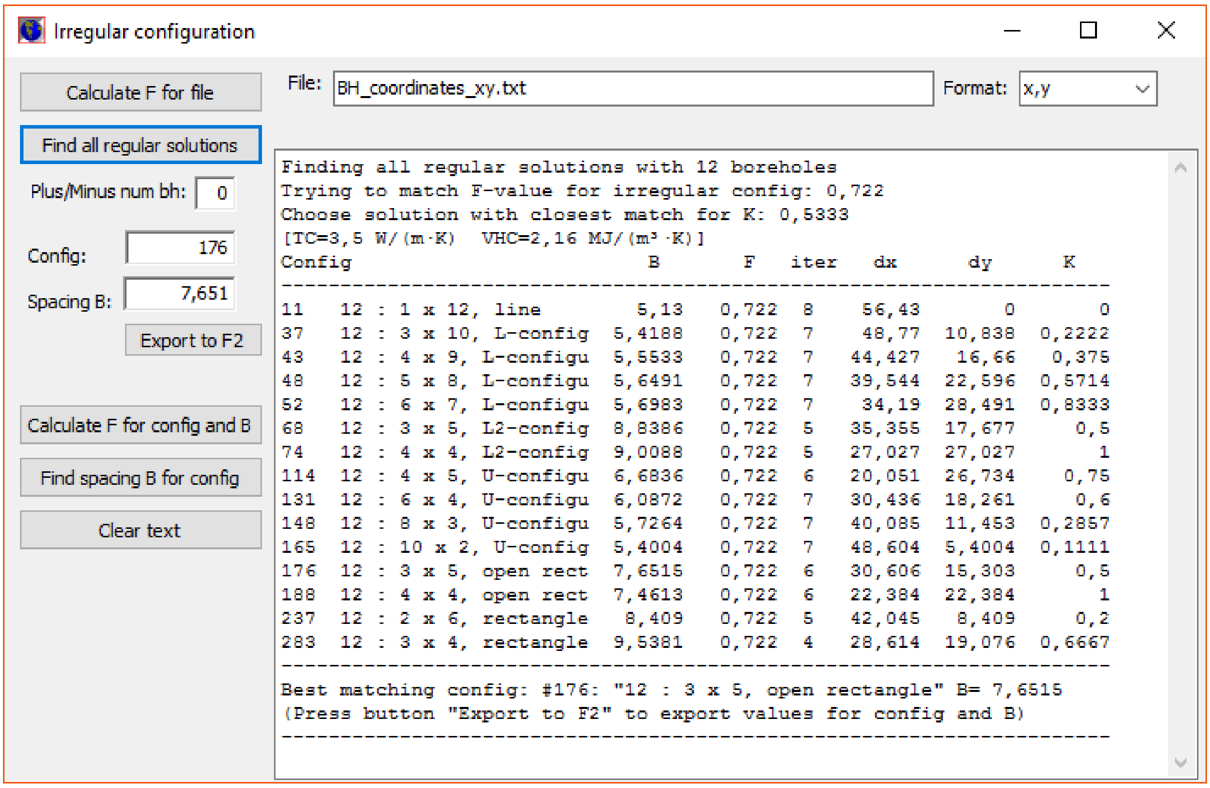
Q: total effect [W]
Cf: Volumetric heat capacity [J/(m^3,K)]
Vf: Flow [m^3/s]

4. Approximation for irregular configurations

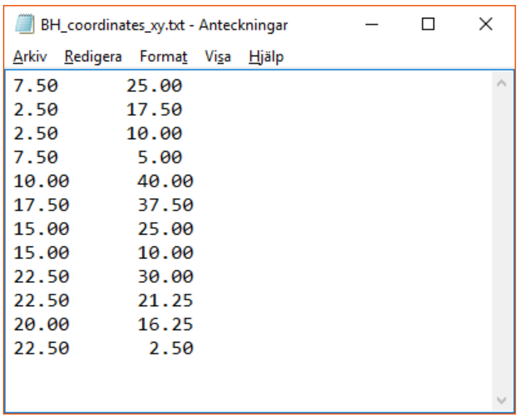
[Updated in v4.14]

4.1 Introduction

EED v4 can approximate an irregular configuration with a regular one in order to calculate corresponding fluid temperatures. A file with borehole configuration can be read and a list of best matching regular configuration and borehole spacing B is presented ("Find all regular solutions"). See example below for which an explanation will follow.



In the above example, the following configuration is read (example file "BH_coordinates_xy.txt"):



Format "x,y"

The file shows data (x,y) for 8 boreholes.

Important: Please note that EED reads the values in the format of a "single" data type that normally has 7-8 significant digits and some data might be lost here (decimals).

Assume coordinates are

393606.08 5827825.6

393611.96 5827824.21

etc.

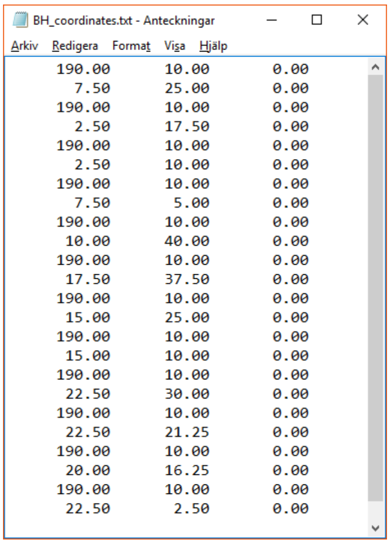
Then remove “3936” (or deduct 393600) from the first column, and “5827” (or deduct 5827000) in the second one, you will get

606.08 825.6

611.96 824.21

etc.

The file can also be read in another format (used by SBM software, example file “BH_coordinates_SBM.txt”):

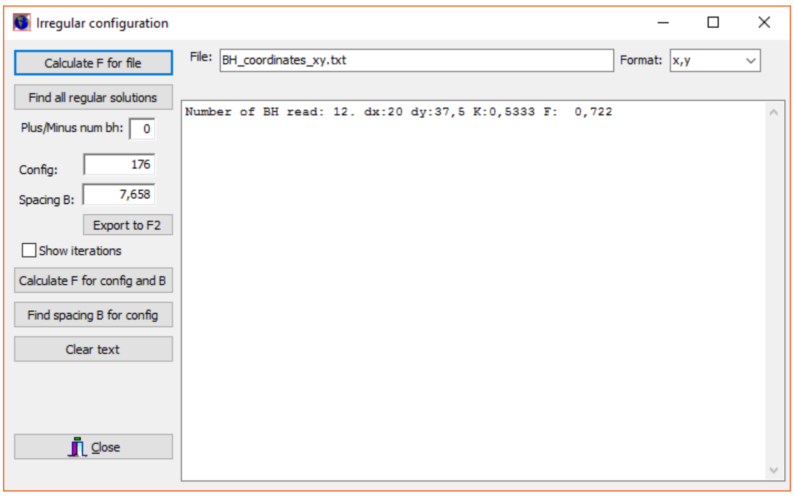

BH_coordinates.txt - Anteckningar

Arkiv Redigera Format Visa Hjälp

190.00	10.00	0.00
7.50	25.00	0.00
190.00	10.00	0.00
2.50	17.50	0.00
190.00	10.00	0.00
2.50	10.00	0.00
190.00	10.00	0.00
7.50	5.00	0.00
190.00	10.00	0.00
10.00	40.00	0.00
190.00	10.00	0.00
17.50	37.50	0.00
190.00	10.00	0.00
15.00	25.00	0.00
190.00	10.00	0.00
15.00	10.00	0.00
190.00	10.00	0.00
22.50	30.00	0.00
190.00	10.00	0.00
22.50	21.25	0.00
190.00	10.00	0.00
20.00	16.25	0.00
190.00	10.00	0.00
22.50	2.50	0.00

Format ”SBM”

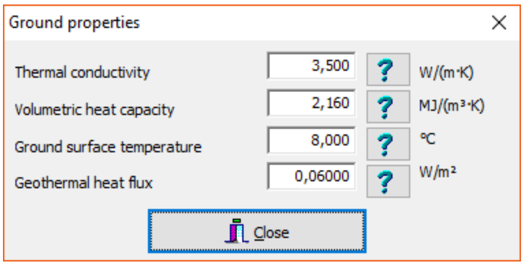
Pressing “Calculate F for file” shows data for the irregular configuration:



K is the smallest value of dx/dy or dy/dx, e.g.

“Number of BH read: 12. dx:20 dy:37,5 K:0,5333 F: 0,722”   gives K=20/37,5= 0,5333.

F is a conservation value that should be the same for the original irregular config and the matching regular config. Note that the F-value depends on the thermal conductivity and volumetric heat capacity of the ground. These values are taken from the “Ground properties” window:



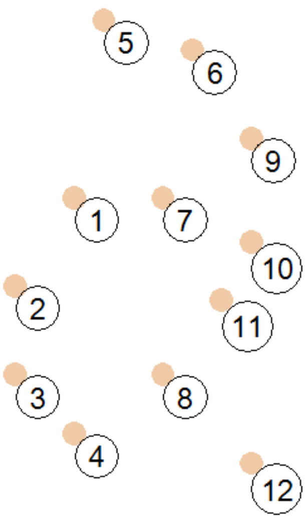
A matching regular configuration with the same number of boreholes with spacing B is found when the F-value matches the F-value for the irregular configuration.

The best matching configuration is then choosen looking at the nearest K-value (we want the land area shape to match as good as possible). For the above example. The K-value for the irregular configuration was 0,5333. The best matching regular configuration is “#176: "12 : 3 x 5, open rectangle” with B=7,6582 since K is 0.5 (15,316/30,633=0,5), see first window in this section:

Config	B	F	iter	dx	dy	K
176 12 : 3 x 5, open rect	7,6515	0,722	6	30,606	15,303	0,5

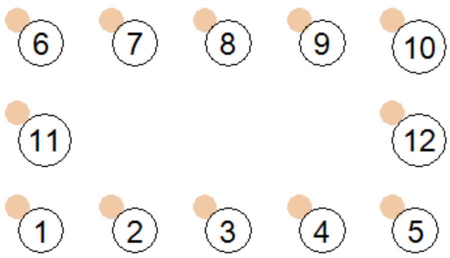
Here, the difference of K is 0,5333-0,5=0,0333. The second best match (with difference 0,5714-0,5=0,0381) would be #48:

48 12 : 5 x 8, L-configu	5,6491	0,722	7	39,544	22,596	0,5714



Original configuration

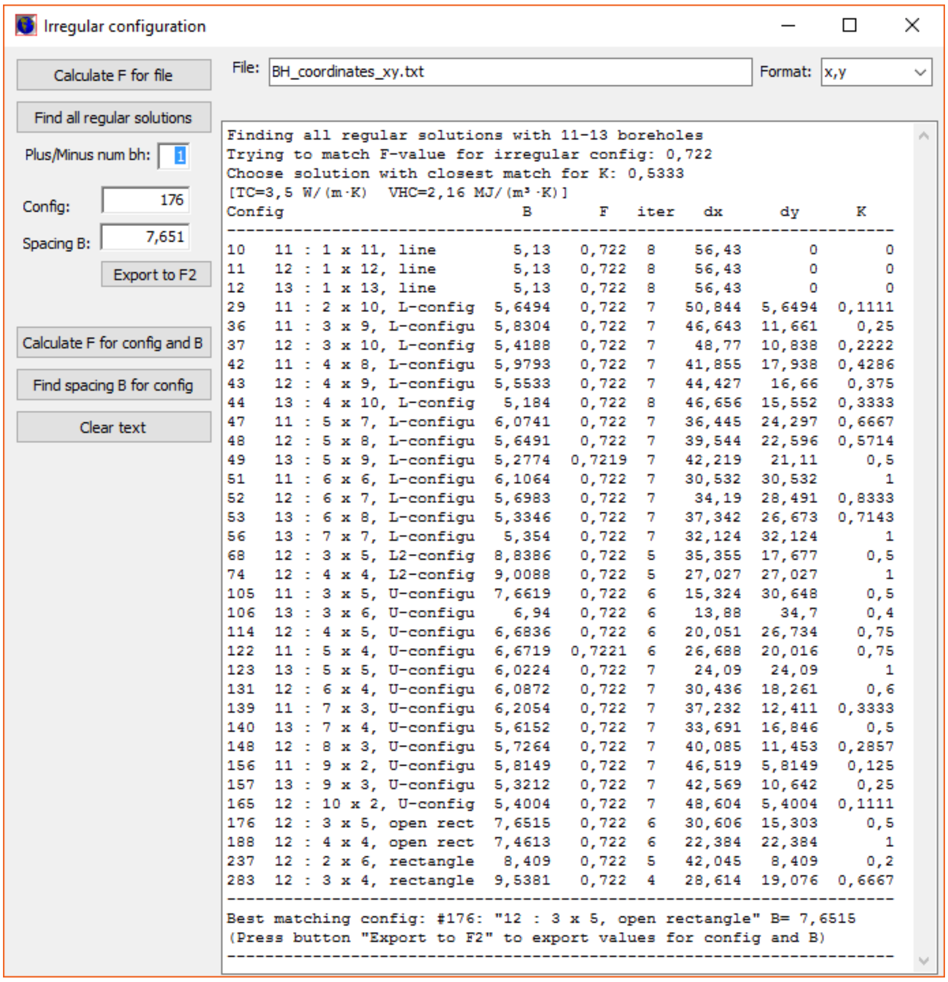
dx=20 m dy=37,5 m



Approximation: config #176: "12 : 3 x 5, open rectangle", B=7,66

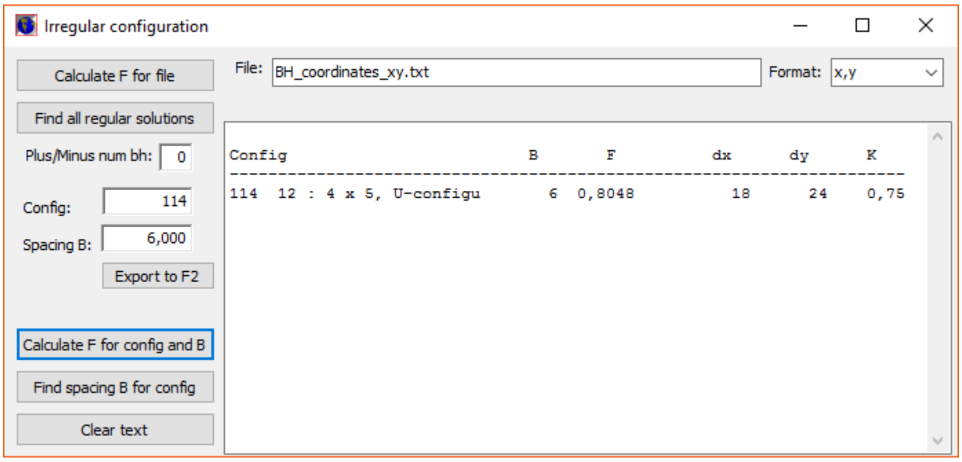
dx=30,6 m dy=15,3 m

The number of boreholes in the matching configuration should normally be the same as in the irregular configuration. However, it is possible to allow (+/-) number of boreholes:

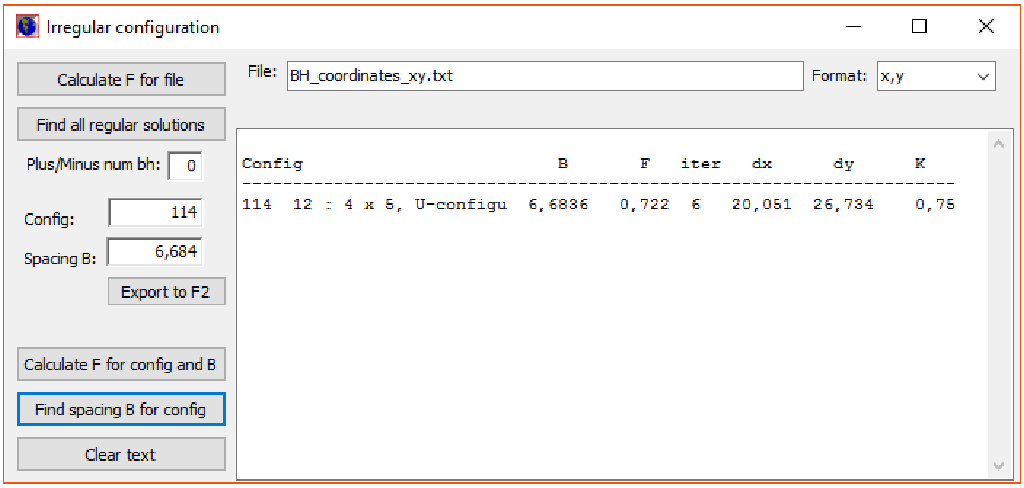


"Export to F2" will copy the values for configuration number and spacing B to window "Borehole and heat exchanger" (F2).

It is possible to calculate F for any configuration and B, see below:

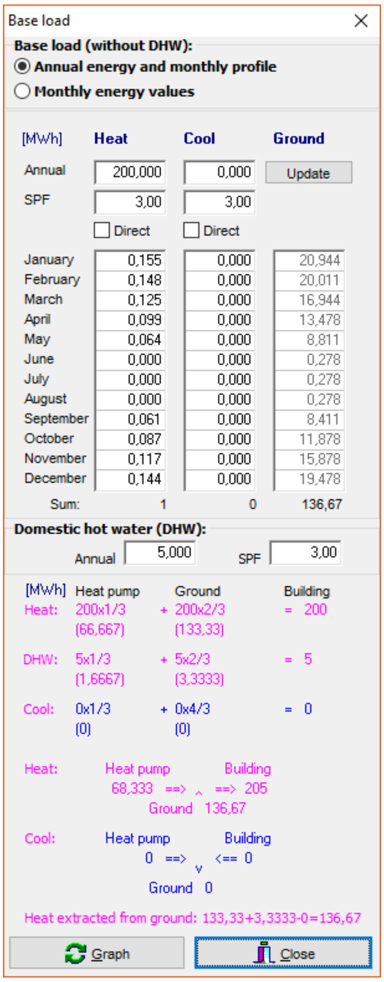


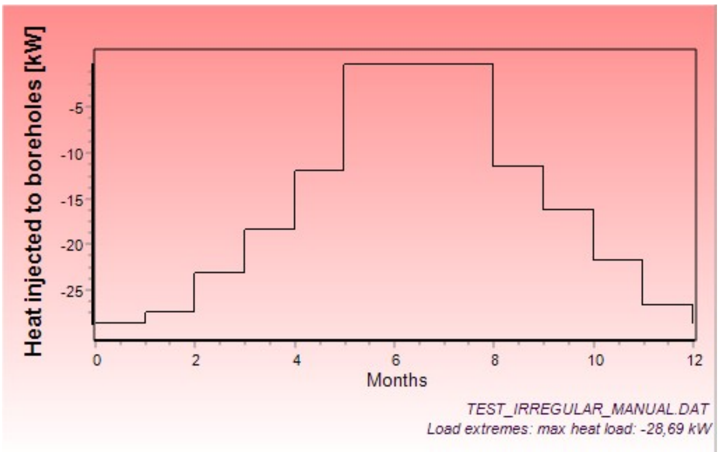
It is also possible to find spacing B for any configuration that will match the F-value taken from the current file, see below:



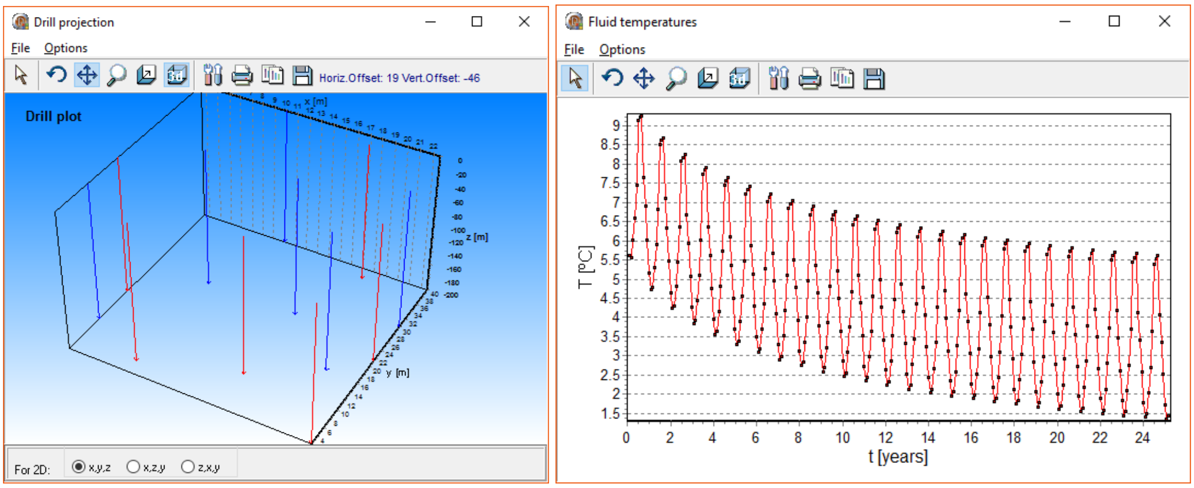
4.2 Test of approximation, example 1

Consider the above example with an original irregular configuration of 12 boreholes that has been analyzed using SBM ("Superposition borehole model") described by "*Eskilson, P, 1987. Thermal analysis of heat extraction boreholes. Department of Mathematical Physics, PhD Thesis, (Lund University.) Sweden*". We use depth=190 m for all boreholes and the following load for the example:





The results below shows that all approximations gives an error of less than about 0.1 °C compared with the results for the original configuration.



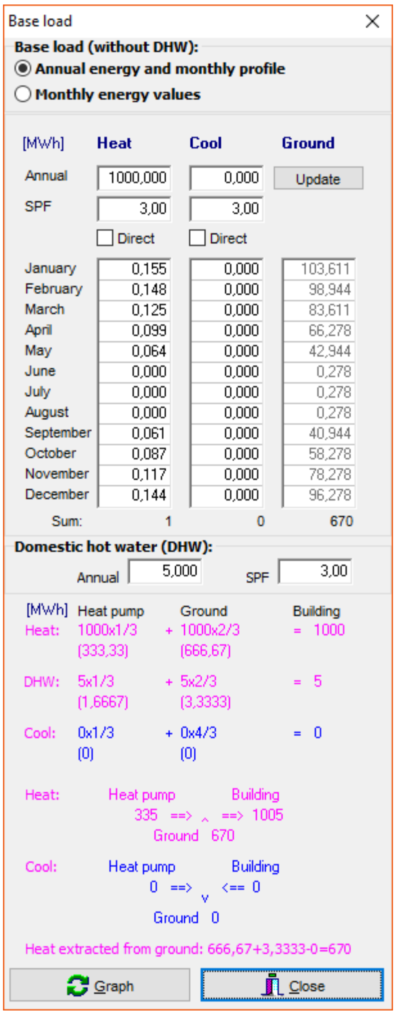
Irregular configuration and calculation (25 years) in SBM.

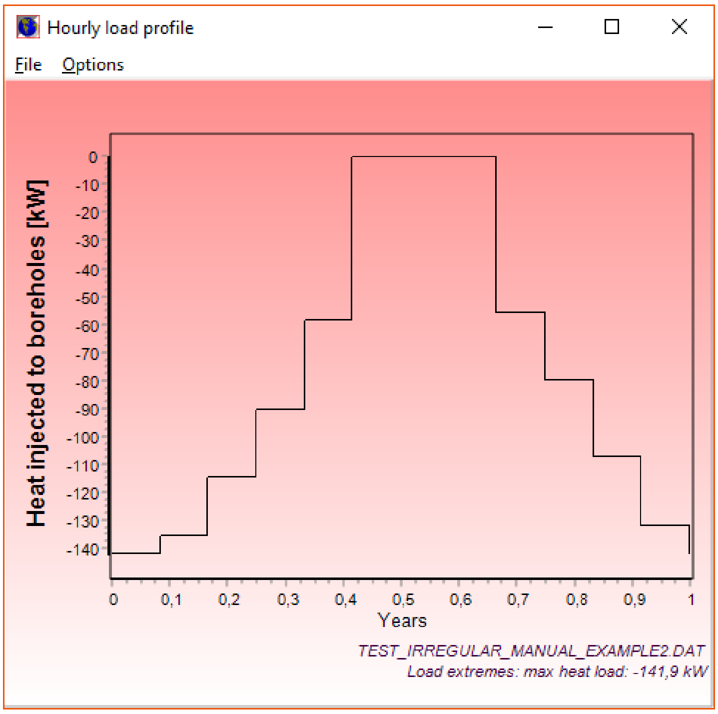
		SBM		EED	
	B	Tf_min	Tf_max	Tf_min	Tf_max
Original irregular configuration (SBM)	**-**	**1,39**	**5,62**	-	-
Regular approximation with “176 12 : 3 x 5, open rect”	7,65	1,33	5,55	1,35	5,57
Regular approximation with “11 12 : 1 x 12, line”	5,13	1,34	5,76	1,40	5,75
Regular approximation with “37 12 : 3 x 10, L-config”	5,42	1,33	5,71	1,38	5,70
Regular approximation with “48 12 : 5 x 8, L-configu”	5,65	1,38	5,69	1,39	5,68
Regular approximation with “68 12 : 3 x 5, L2-config”	8,84	1,34	5,59	1,42	5,60
Regular approximation with “114 12 : 4 x 5, U-configu”	6,68	1,30	5,58	1,35	5,60
Regular approximation with “237 12 : 2 x 6, rectangle”	8,41	1,35	5,60	1,42	5,63

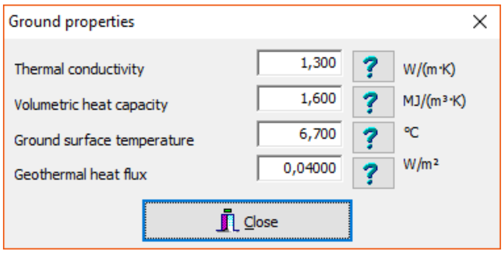
Fluid temperatures after 25 years.

4.3 Test of approximation, example 2

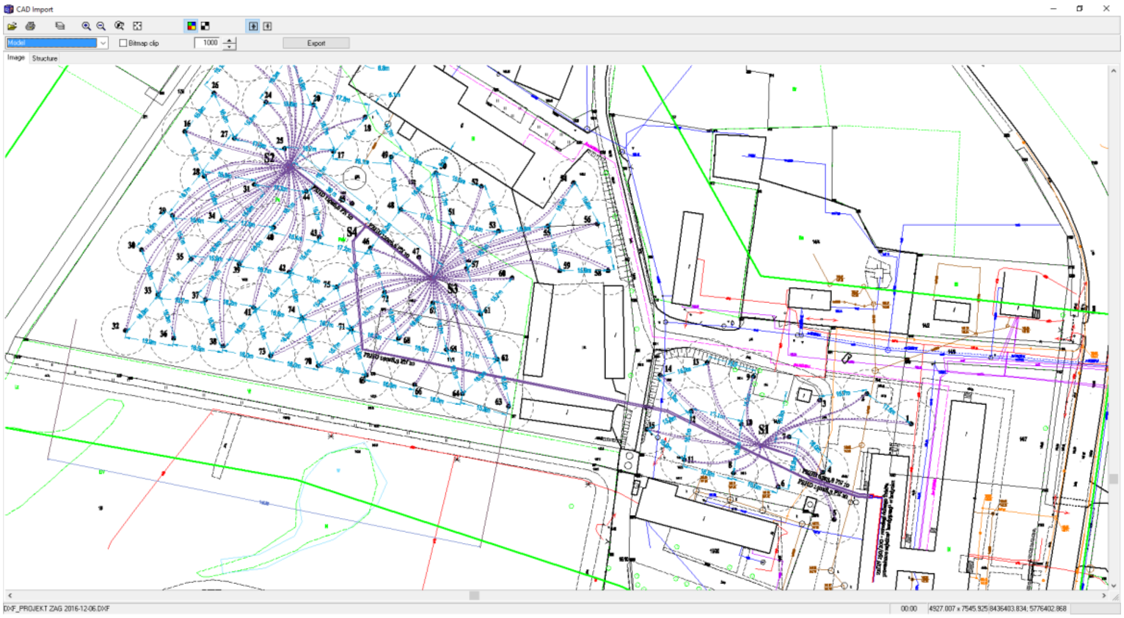
For this example we use the following load, ground thermal conductivity and volumetric heat capacity:

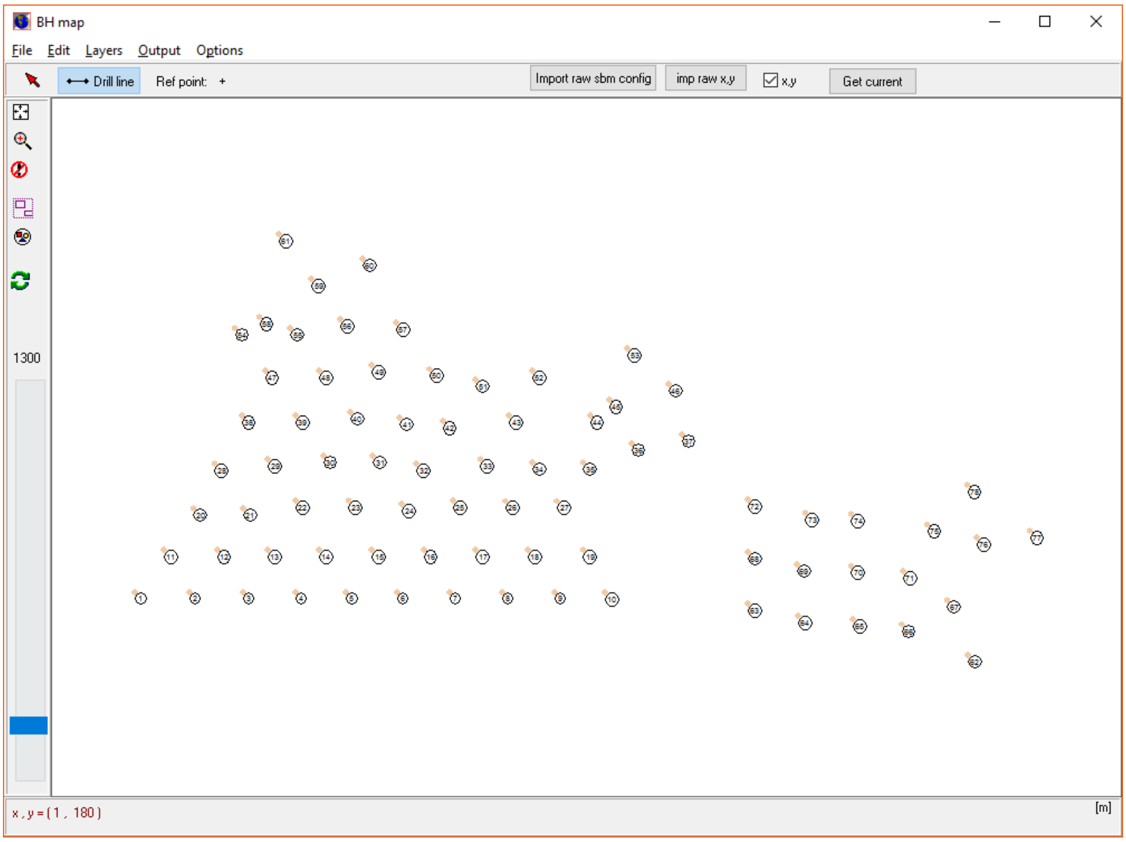


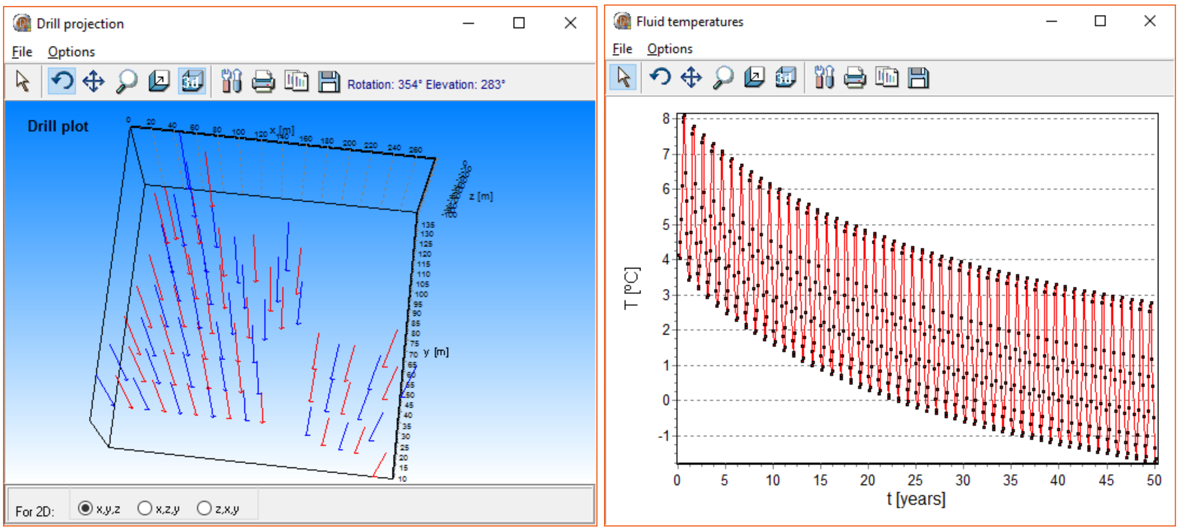




The configuration with 78 boreholes (D=100 m) is as follows:

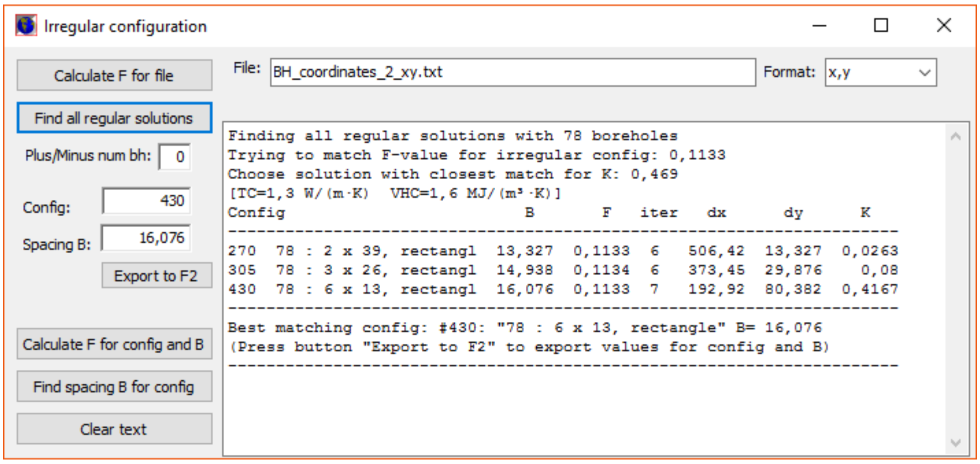






Irregular configuration and calculation (50 years) in SBM.

The matching regular configurations with 78 boreholes are:



The best matching configuration 430 gives an error of about 0.4 °C compared with the results for the original configuration using SBM. This case is a bit more difficult to approximate due to that the configuration has two “groups”.

		SBM		EED	
	B	Tf_min	Tf_max	Tf_min	Tf_max
Original irregular configuration (SBM)	**-**	**-1,70**	**2,79**	-	-
Regular approximation with “270 78 : 2 x 39, rectangl”	13,3	-0,93	3,57	-0,82	3,74
Regular approximation with “305 78 : 3 x 26, rectangl”	14,94	-1,39	3,10	-1,22	3,35
Regular approximation with “430 78 : 6 x 13, rectangl”	5,42	-2,11	2,38	-1,82	2,73

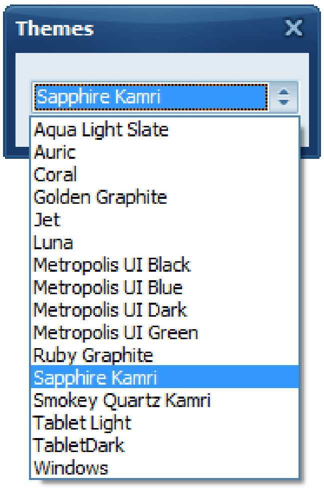
Fluid temperatures after 50 years.

5. Changeable user interface of EED

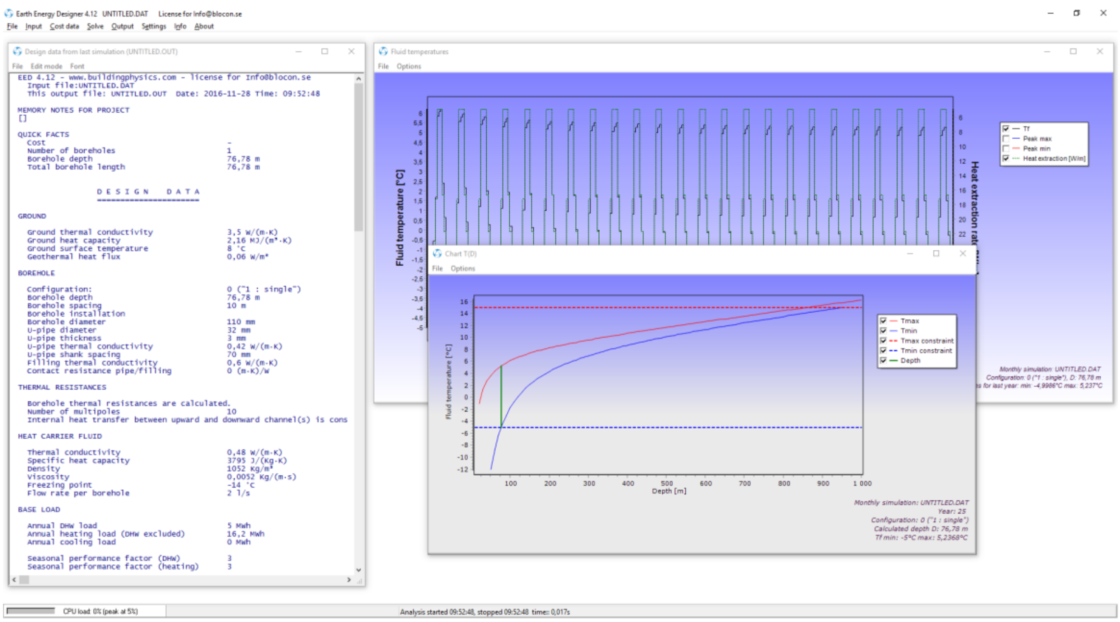
5.1 Introduction

The user interface of EED can now be “personalized” using different windows style themes. A style is a collection of painting rules you can dynamically apply to an entire Windows application, changing the size and appearance of various elements, the fonts, and the color scheme. One example of the available styles is the so-called Modern UI (originally known as “Metro”).

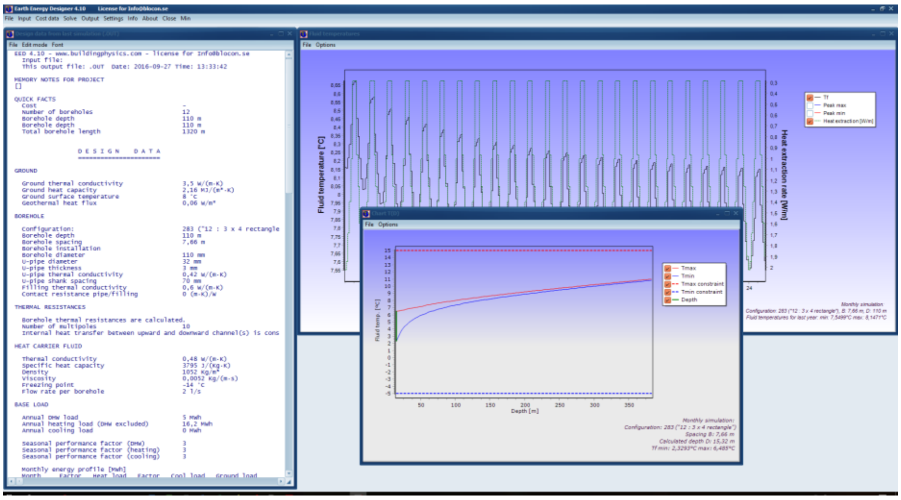
Goto menu item *Options/Themes* to change current appearance:



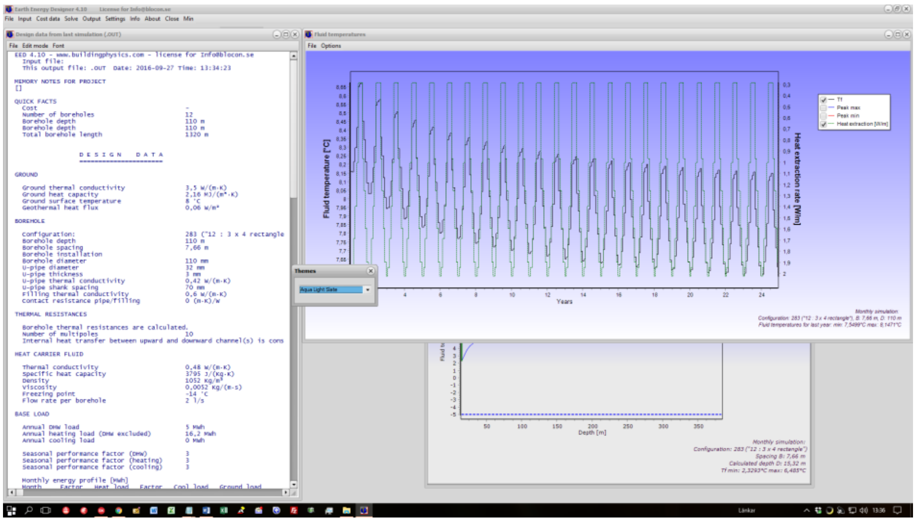
The default theme is “Windows”:



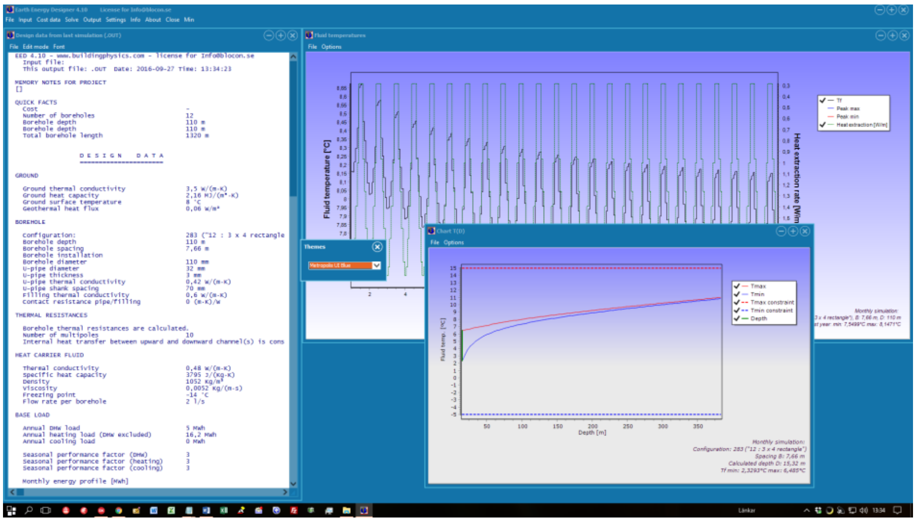
Below are examples of a couple of other themes.



Sapphire Kamri



Aqua Light Slate



Metropolis UI blue:

The theme is saved to file “Theme.txt” in folder “C:\Users*username*\Documents\Blocon\EED v4 every time EED is closed.

6. Faster hourly simulations

[Available in v4.14]

6.1 Introduction

Hourly simulations of borehole fluid temperatures are time consuming. There are several methods reported in literature that decreases the calculation time by using so-called load aggregation schemes that lump the hourly loads on a borehole heat exchanger into larger blocks of time in order to reduce the number of operations needed. One example is shown in "A load-aggregation method to calculate extraction temperatures of borehole heat exchangers" [1], see
http://publications.lib.chalmers.se/records/fulltext/163661/local_163661.pdf or
https://buildingphysics.com/download/local_163661.pdf

EED v4.14 uses a different approach that is very fast (and does not introduce an error as in the load aggregation case). Solving 25 years of hourly fluid temperatures takes less than a second on a hi-end CPU, and only a few seconds when solving for 100 years.

This impressive speed is due to the capabilities of modern CPU:s. The calculation of fluid temperatures using the g-function is well suited for multiple CPU processing that performs the same operation on multiple data points simultaneously. This method is sometimes called "single instruction, multiple data" (**SIMD**), see e.g.
https://en.wikipedia.org/wiki/SIMD

Instead of using traditional ("serial") programming where floating point operations are performed on an element in a vector one by one, modern CPU:s can make these calculations for the whole vector at the same time. In addition to this, most modern computers have multiple cores that will accelerate the calculation speed even further (roughly speaking; if we e.g. have a PC with 4 cores we can do calculations for 4 different hours at the same time). The total speed gain is typically 10-150 times higher compared to using conventional serial implementation. The higher number of cores, the faster speed increase.

As described above, EED can use the CPU ("central processing unit") for fast SIMD calculations. As an alternative, EED can also use the GPU ("graphics processing unit") to speed up calculations. Architecturally, a CPU is composed of just a few cores that can handle a few software threads at a time. In contrast, a GPU is composed of hundreds, or thousands, of cores that can handle thousands of threads simultaneously. Also, the GPU achieves this acceleration while often being more power- and cost-efficient than a CPU. The gain using a hi-end graphics card (GPU) might be 200-300 times. In the benchmarks below, one example shows that it is possible to solve for 100 years in just 4 seconds on a $300 graphics card (Radeon RX 480).

EED can uses GPU:s (and other devices) that are conformant with OpenCL, see
https://en.wikipedia.org/wiki/OpenCL

For OpenCL compliant devices (such as graphics cards), see
https://www.khronos.org/conformance/adopters/conformant-products#opencl

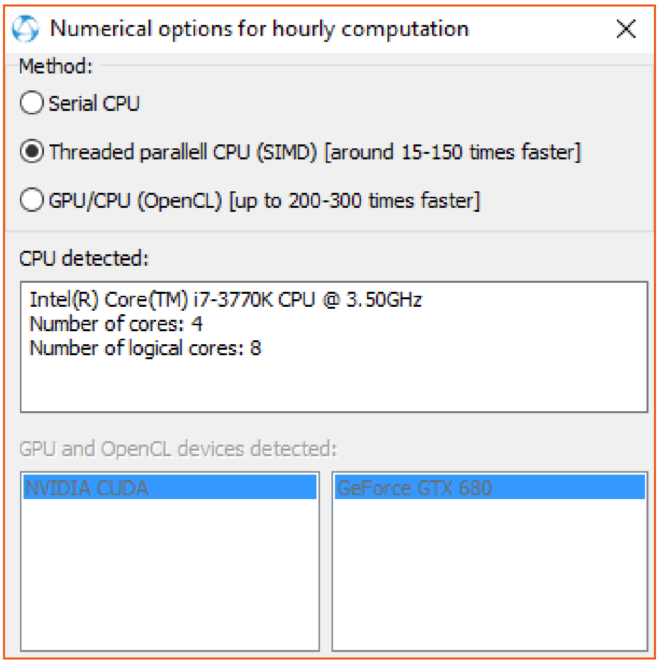
EED uses the CPU as the default choice since some graphics cards (GPU:s) are not compatible. It is up to the user to test the GPU method.

References:

[1] Claesson, J, Javed, S, 2012. A load-aggregation method to calculate extraction temperatures of borehole heat exchangers. ASHRAE Transactions, vol. 118(1), pp. 530-539.

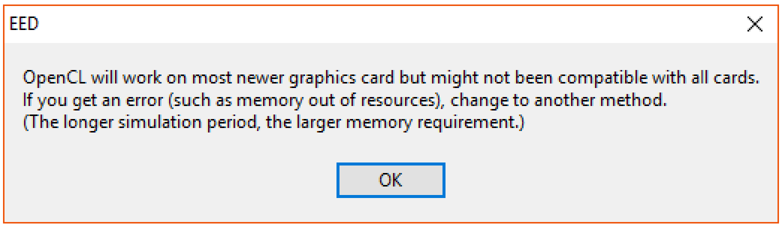
6.2 Options for calculations

Several options for hourly calculations can be chosen in EED (menu item Settings/Numerical options for hourly calculations), see below. All options will give the same results, it is only the calculation times that will differ.

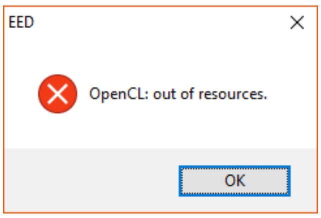


The default (and recommended) method is "**Threaded parallel CPU SIMD**" which is 15-150 times faster than "Serial CPU" (as used in previous versions EED v1.0-v4.13).

The "GPU/CPU (OpenCL)" method might be even faster but requires a modern graphics card with sufficient memory, and OpenCL compliance. Calculations may work for e.g. 25 years, but not for e.g. 50 years or more due to too little memory and compatibility problems. This warning below is displayed when this method is chosen.



This error will be displayed if the calculation does not work on a specific graphics device:



6.3 Benchmarks for F9 ("Solve mean fluid temperatures")

The tables below show calculation times (in seconds) for different PC:s for hourly analysis.

As an example, the calculation of hourly fluid temperatures for 100 years ($Tf_0..Tf_{876000}$) only takes 5 seconds on a "High-end PC" from 2021 using "Threaded CPU SIMD", and 2 seconds using the "GPU OpenCL". With the standard "serial" method it would take 733 seconds.

Below are descriptions for used PC:s.

Hi-end PC 2021 (price Dec-2021: 1500 USD)

CPU: 11th Gen Intel(R) Core(TM) i7-11700F @ 2.50GHz, 8 cores, 16 threads, released Q1-21
GPU: GeForce RTX 3070@ 1.50GHz, 8 GB RAM, 5888 cores, FP32: 20 TFLOPS

Hi-end PC 2016 (price Nov-2016: 3300 USD)

CPU: Intel i7-6900K@3.2GHz Broadwell-E, 8 cores, 16 threads
GPU: Radeon RX 480, 8 GB ram, 2304 cores, FP32: 5.8 TFLOPS
This is the PC used as a server for "EED on the WEB", see
https://www.buildingphysics.com/manuals/EEDONTHEWEB.pdf

Hi-end PC 2012

CPU: Intel i7-3770K, 4 cores, 8 threads, @3.5GHz Ivy Bridge
GPU: GeForce GTX 680, 2 GB ram, 1536 cores, FP32: 3.2 TFLOPS

Hi-end PC 2009

CPU: Intel Core 2 Duo P7450, 2 cores, @2.13GHz Penryn
GPU: Graphics card not compliant with OpenCL

Below are benchmarks for hourly calculations for EED v4.20. To repeat the cases just open EED and use the default data. Open menu "Input/Hourly calculation" and check "Solve for hours". Change the simulation time in menu "Simulation period".

Hi-end PC 2021:

Simulation time	Serial CPU	Threaded CPU SIMD	GPU OpenCL
10 years	6 sec.	<1 sec.	<1 sec.
25	44	<1	<1
50	180	2	1
100	733	5	2

Hi-end PC 2016:

Simulation time	Serial CPU	Threaded CPU SIMD	GPU OpenCL
10 years	9 sec.	<1 sec.	<1 sec.
25	61	<1	<1
50	244	3	3
100	966	6	4

Hi-end PC 2012:

Simulation time	Serial CPU	Threaded CPU SIMD	GPU OpenCL
10 years	10 sec.	<1 sec.	<1 sec.
25	64	2	<1
50	251	5	4
100	983	20	Not enough RAM

Hi-end PC 2009:

Simulation time	Serial CPU	Threaded CPU SIMD	GPU OpenCL
10 years	15 sec.	2 sec.	Not compatible
25	99	9	Not compatible
50	410	35	Not compatible
100	1681	278	Not compatible

In reference [1] above, the simulation time on an "Intel dual core 2.10 GHz processor" was 25 seconds for a simulation time of 20 years using a load aggregation method. Using "Threaded CPU SIMD" on an Intel Core 2 Duo P7450 as comparison takes 6 seconds with EED v4.14. The "Serial CPU" method takes 63 seconds.

It should be noted that the speed increase between e.g. "Threaded CPU SIMD" and "Serial CPU" is higher for newer PC:s (due to newer SIMD options and higher number of cores), such as on i3/i5/i7/i9 etc. CPU:s.

6.4 Benchmarks for F10 ("Solve required borehole length")

For this calculation, the "Threaded CPU SIMD" will always be used unless "Serial CPU" is chosen.

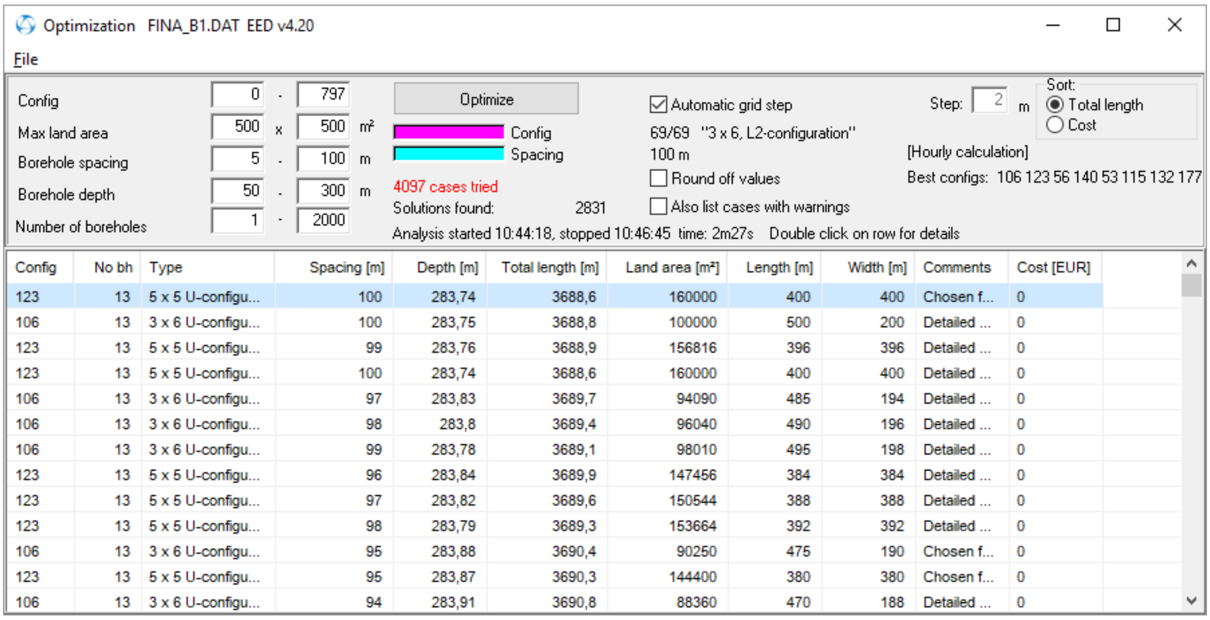
Hi-end PC 2021:

Simulation time	Serial CPU v4.20	Threaded CPU SIMD v4.20	GPU OpenCL
10 years	2 sec.	1 sec.	**"Threaded CPU SIMD"** will be used for all calculations
25	6	1	
50	11	2	
100	22	6	

Hi-end PC 2012:

Simulation time	Serial CPU v4.20	Threaded CPU SIMD v4.20	GPU OpenCL
10 years	4 sec.	2 sec.	**"Threaded CPU SIMD"** will be used for all calculations
25	8	3	
50	15	7	
100	29	19	

There will also be a speed increase by using parallel methods for "*Solve required borehole length – Optimization F11*". The example in section 3.6 now takes 147s on "Hi-end PC 2012" and 76s on "Hi-end PC 2012".



Hi-end PC 2021:

Simulation time	Serial CPU v4.20	Threaded CPU SIMD v4.20	GPU OpenCL
25 years	208 sec.	76 sec.	**"Threaded CPU SIMD"** will be used for all calculations

Hi-end PC 2012:

Simulation time	Serial CPU v4.20	Threaded CPU SIMD v4.20	GPU OpenCL
25 years	400 sec.	147 sec.	**"Threaded CPU SIMD"** will be used for all calculations

7. Appendix A. List of new update features

For update info, see also section "Version update info" at ahttps://buildingphysics.com/eed-2/

Update 4.14 *(Jan 4, 2017)*

Faster hourly simulations. See Chapter 6.

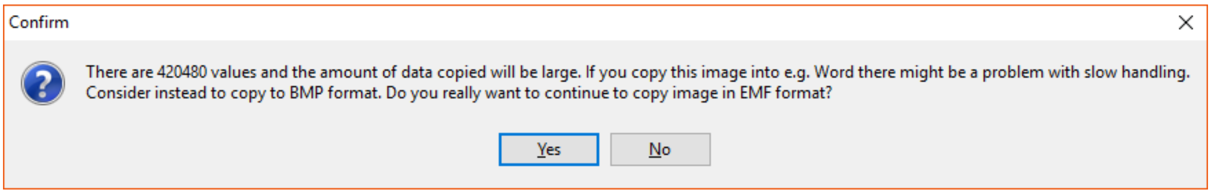
Approximation for irregular configurations. Updated solver. See Chapter 4.

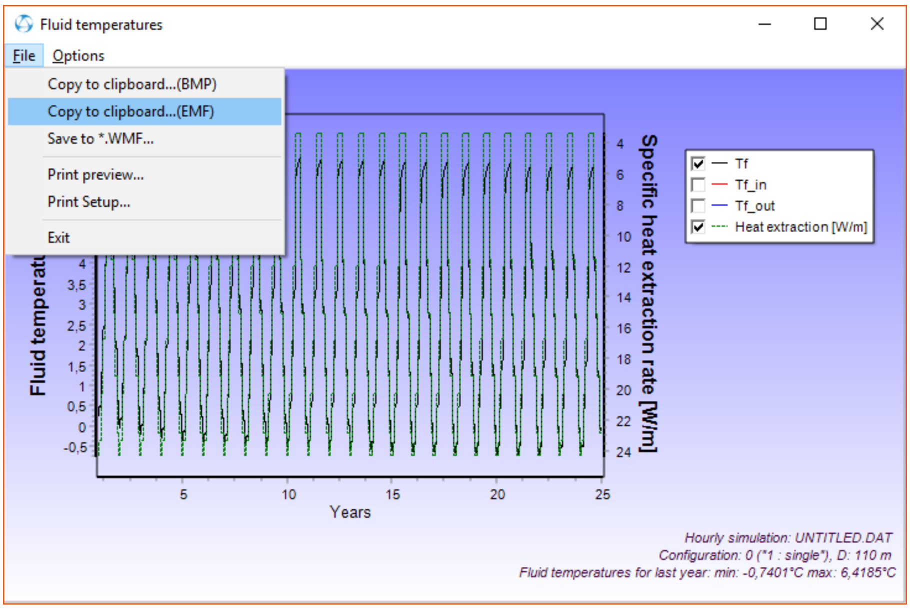
Copy images to clipboard

The old option "File/Copy to clipboard" in the charts for fluid temperatures and load profile copied the chart image with data as an enhanced metafile (EMF). Using hourly values would result in a very large image which could be hard (slow) to handle in e.g. Word.

Chart images can now be copied in bitmap format to clipboard via menu item "File/Copy to clipboard…(Bitmap)".

The old metafile option is still available as "File/Copy to clipboard…(EMF)" but there will be a warning if there are many data values:





Use copy to clipboard in bitmap format for smaller image size.

Date format

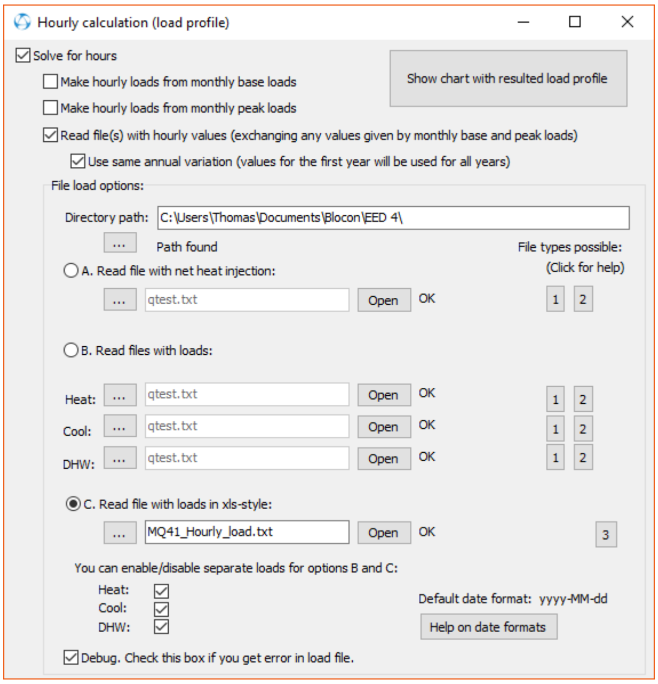
Dates can now be written in short format in the xls-style option, e.g. as for a German date type:

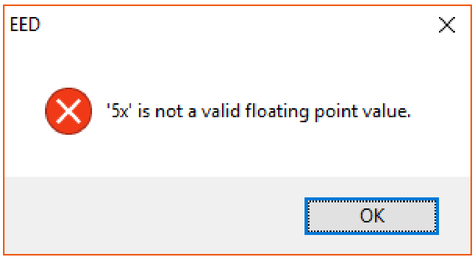
“1.9.2015 4 -18,6 0,0 0” (short format “m.d.yyyy h is now ok)

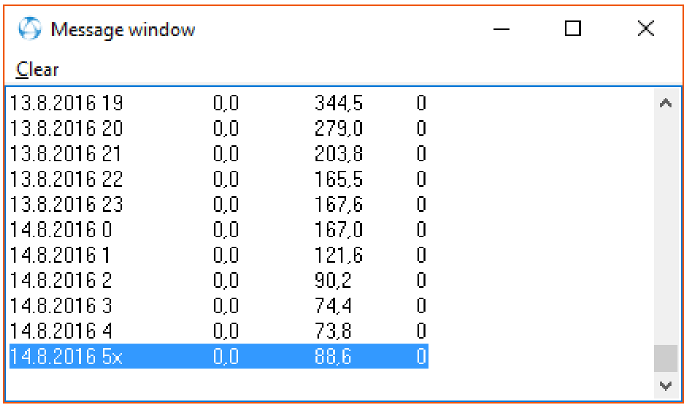
“01.09.2015 04 -18,6 0,0 0” (the standard long format “mm.dd.yyyy hh”)

Debug check box for hourly values

There is now a debug option (see below) that can be used if there is an error message when a load file is used. A message window will show rows that are read from the load file. The last row will indicate the error, see example below, when e.g. “Show chart with resulted load profile” is pressed, or when a simulation is started.







Miscellaneous

- Fixed error "List index out of bounds" that sometimes occurred when clicking in the configuration list.
- Values for heat extraction are now shown as zeros before first month of operation.

Update 4.15 *(Jan 4, 2017)*

Fix: Graph for fluid temperatures was sometimes not updated when hidden.

Update 4.16 *(Feb 22, 2017)*

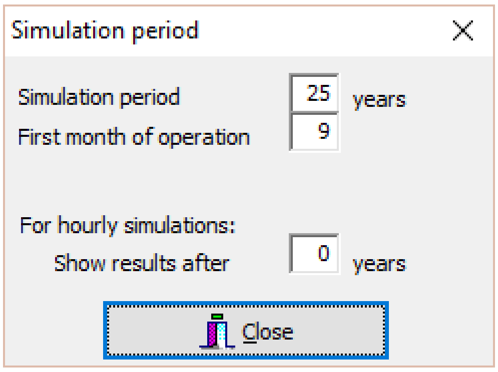
· Fix: EED showed an error message when started on systems with decimal separator "."

· Fix: Last hourly value for temperature was sometimes zero using GPU-calculation

· New "pipe.txt" file: names such as "PE DN25 PN6" changed to "PE DN25 SDR-17"
PE DN45 SDR-17 added

Update 4.17 *(March 1, 2017)*

· EED v4 now always shows results from first year (0) for monthly simulations (same as in v3). The option "Show results after x years" is now only valid for hourly simulations (in order to make these calculations quicker). The default value has also been changed from "1" to "0".



· EED v4 now shows output temperatures and heat extraction rates with a precision of three digits. More digits can be chosen by checking "Show results with more digits" in the Settings menu.

Update 4.18 *(April 13, 2017)*

· Compatibility with Windows 10 "Creators update" added.
Earlier versions of EED will not start if your OS is updated to Windows 10 "Creators update". There is however a quick fix that will make old versions of EED run under this OS: Go to folder C:Program Files (x86)BLOCONEED_v4.17, right-click "EED_v4_17.exe" and choose Properties. In the Compatibility tab, change "Compatibility mode" to "Windows 7".

· New version of TurboActivate (4.0.9.6).

Update 4.18b *(April 21, 2017)*

· For admins/superusers: It is now possible to silently install, uninstall, activate, and deactivate EED using a command line in a batch-file, see
https://www.buildingphysics.com/download/silent_eed.pdf

Update 4.19 *(May 23, 2017)*

· Pipe thermal conductivity can now be larger than 100 W/(m·K), see menu "Borehole and heat exchanger".

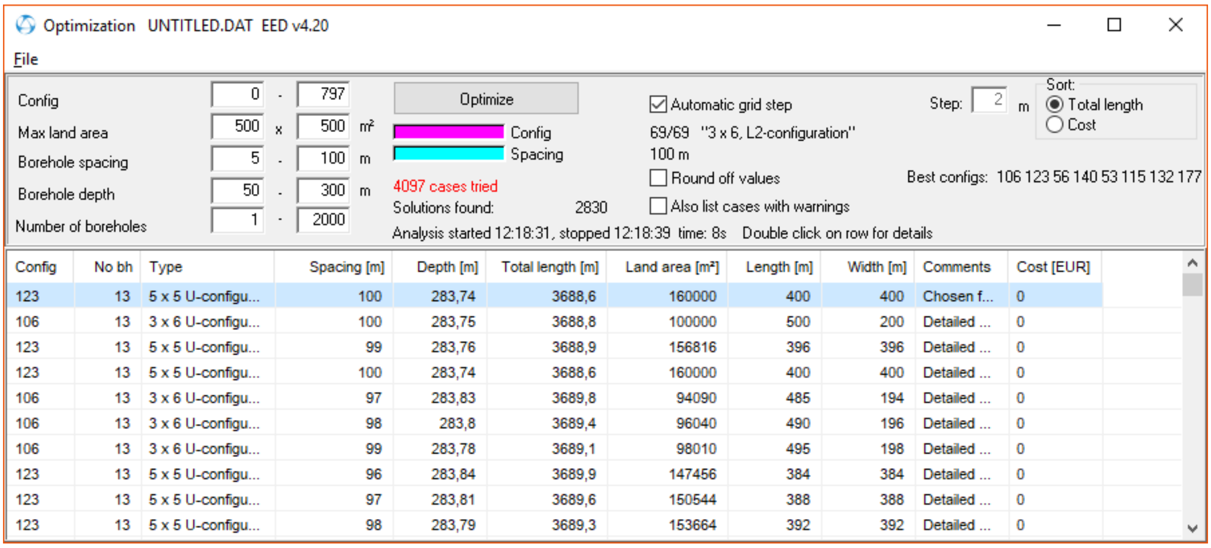
Update 4.20 *(April 11, 2019)*

- Improved accuracy for optimizations

The convergence for required fluid temperatures is now enhanced.

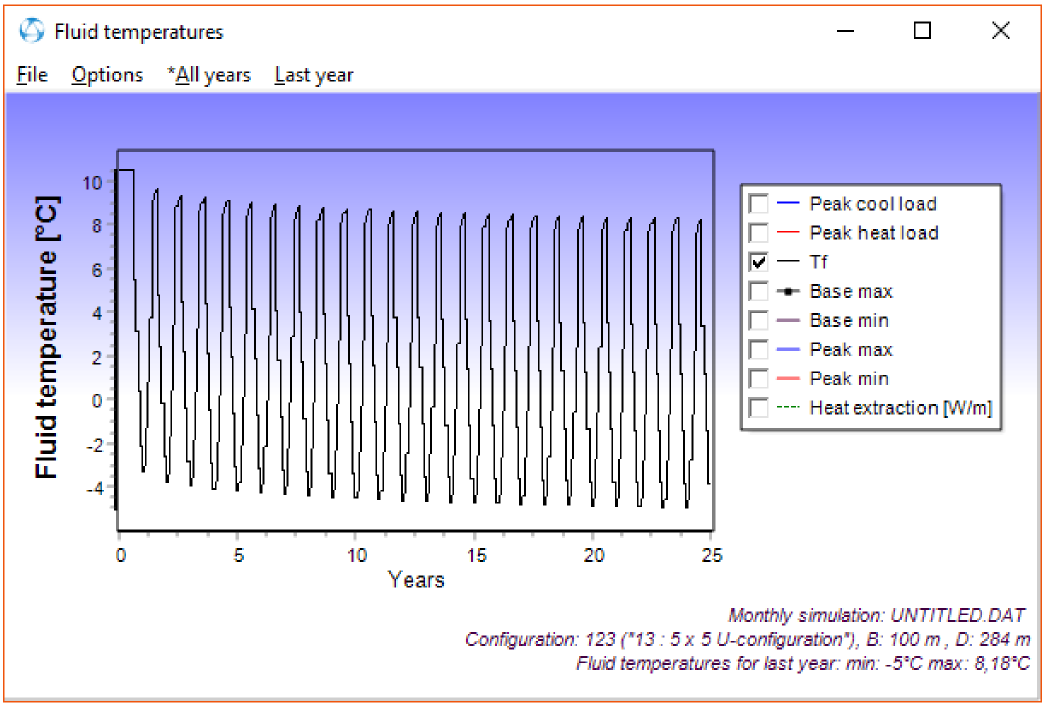
<u>Example with monthly heat loads</u>

As a typical way of using the optimization consider example in section 2.2 with an annual base load value of 1000 MWh. The optimization for ”Max land area” of 500x500 m^2 takes 8 seconds (on an Intel i7 3770K @3.5Ghz CPU), see below.

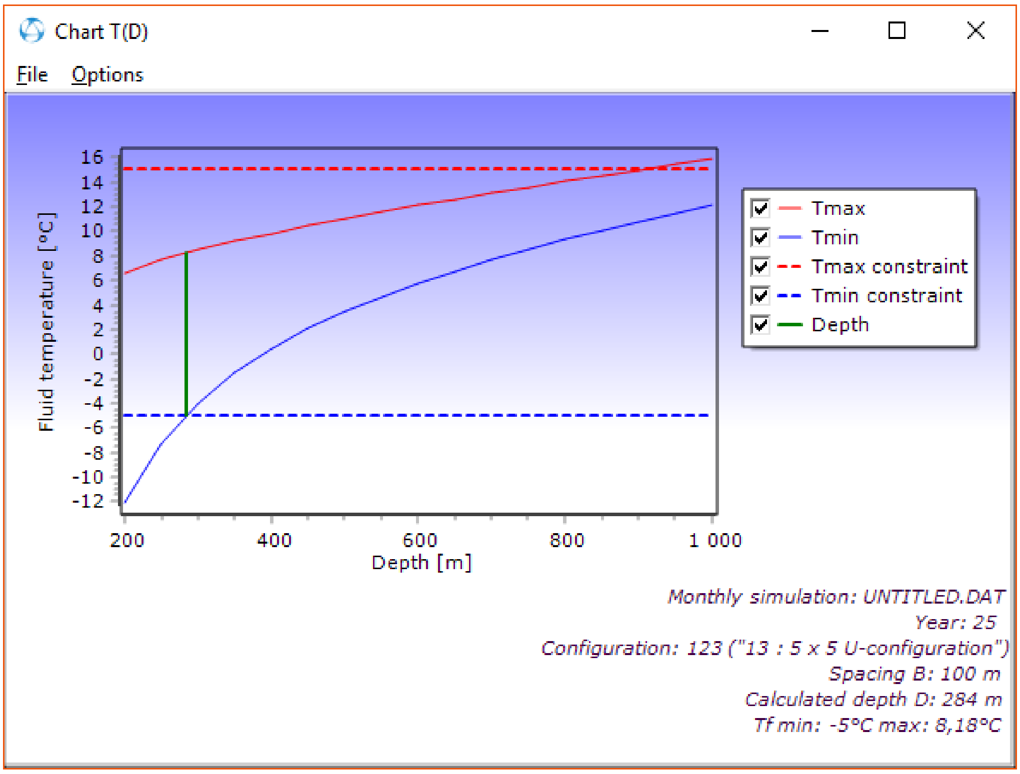


Config	No bh	Type	Spacing [m]	Depth [m]	Total length [m]	Land area [m²]	Length [m]	Width [m]	Comments	Cost [EUR]
123	13	5 x 5 U-configu...	100	283,74	3688,6	160000	400	400	Chosen f...	0
106	13	3 x 6 U-configu...	100	283,75	3688,8	100000	500	200	Detailed ...	0
123	13	5 x 5 U-configu...	99	283,76	3688,9	156816	396	396	Detailed ...	0
123	13	5 x 5 U-configu...	100	283,74	3688,6	160000	400	400	Detailed ...	0
106	13	3 x 6 U-configu...	97	283,83	3689,8	94090	485	194	Detailed ...	0
106	13	3 x 6 U-configu...	98	283,8	3689,4	96040	490	196	Detailed ...	0
106	13	3 x 6 U-configu...	99	283,78	3689,1	98010	495	198	Detailed ...	0
123	13	5 x 5 U-configu...	96	283,84	3689,9	147456	384	384	Detailed ...	0
123	13	5 x 5 U-configu...	97	283,81	3689,6	150544	388	388	Detailed ...	0
123	13	5 x 5 U-configu...	98	283,79	3689,3	153664	392	392	Detailed ...	0

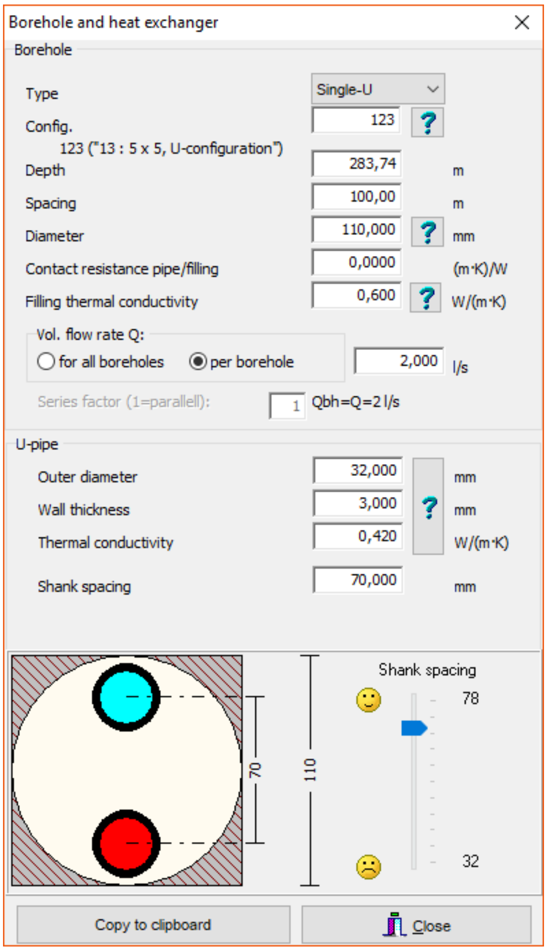
Now double-click the first row. This will show the fluid temperatures.



Press F10. This will again confirm the required borehole length:

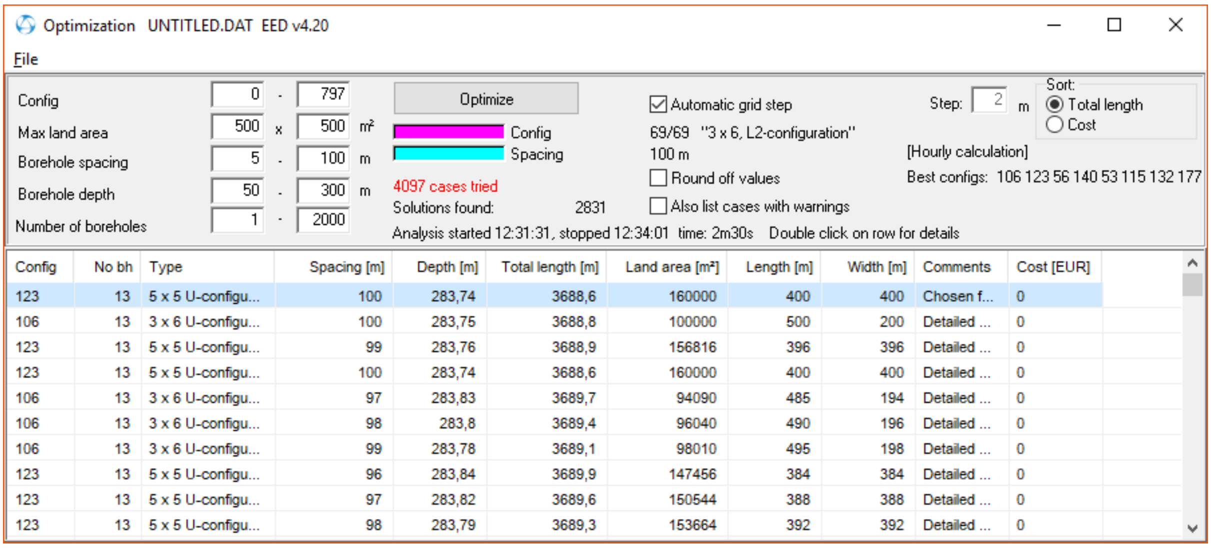


The calculated length 284 m (or more exact 283,74 m which is the same value from the optimization list) will be inserted in the menu below.



Example with hourly heat loads

Go to menu item Input/Hourly calculation and check "Solve for hours". The optimization now takes 2m30s, see below.

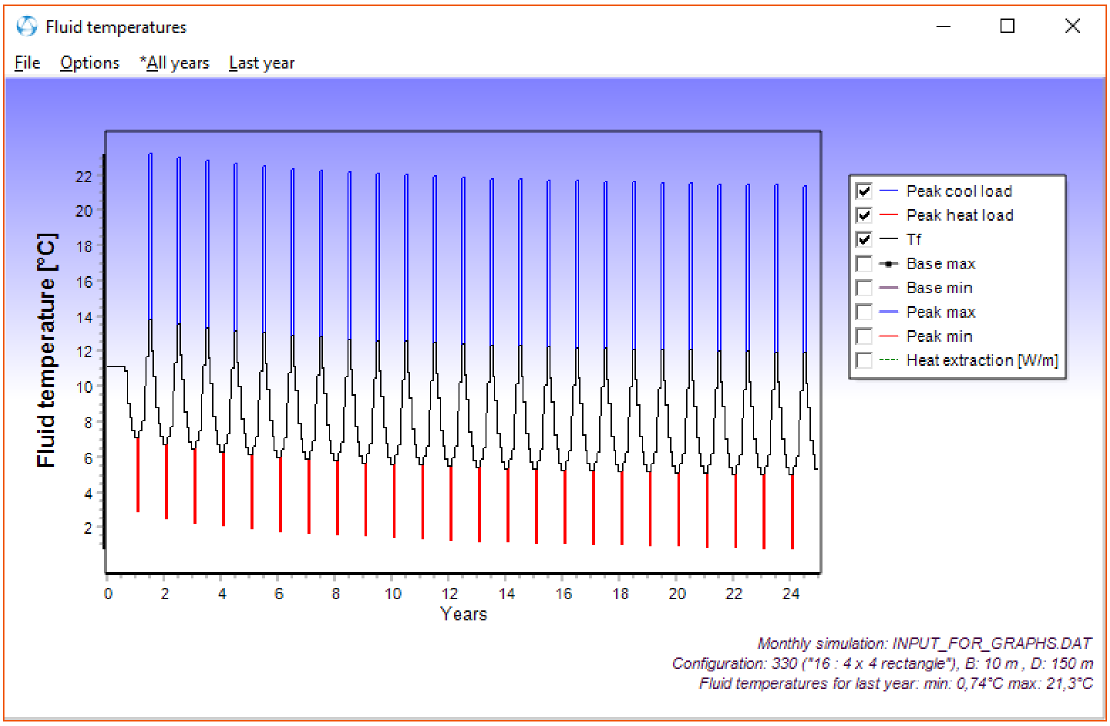


- Improvements for graphs for monthly calculations

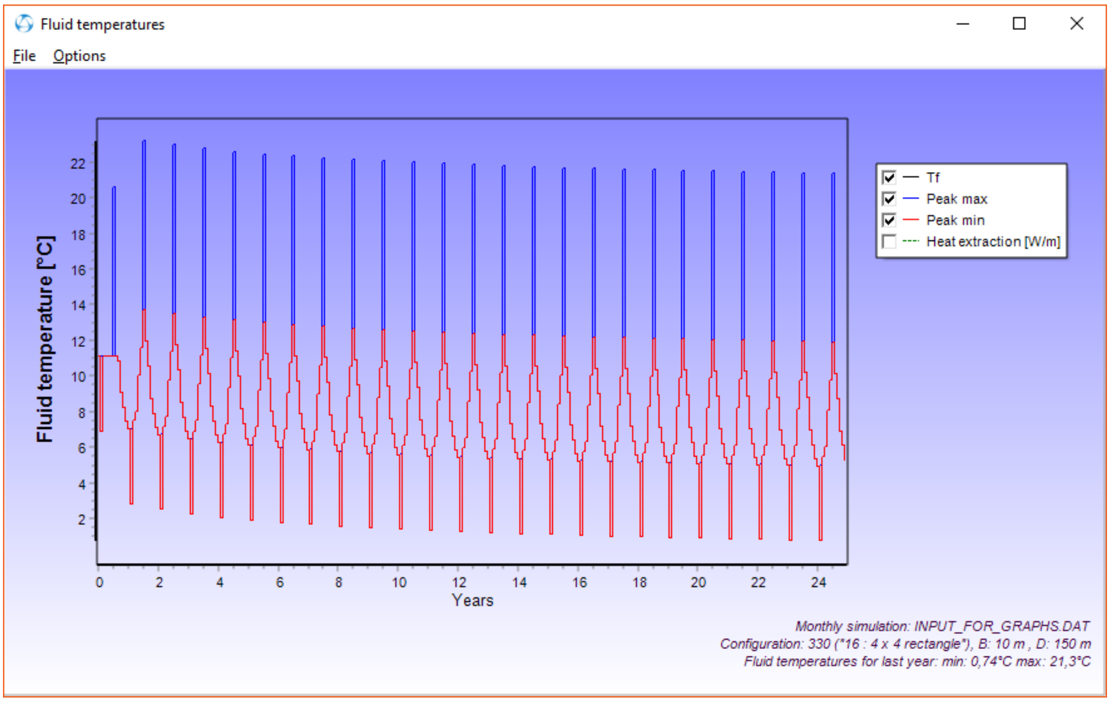
Graphs similar to those presented in EED v3 has now been added to v4. There are also a few more options/changes:

New legends added (base min/max, peak min/max)
Legend “peak max” changed to “peak cool load”
Legend “peak min” changed to “peak heat load”

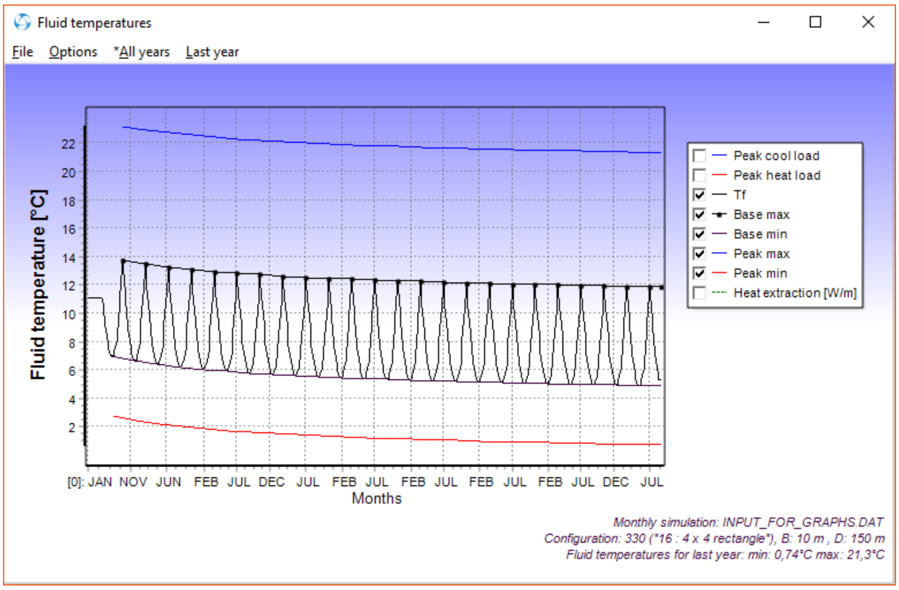
See example below (input file at https://buildingphysics.com/download/input_for_graphs.dat):



v4.20

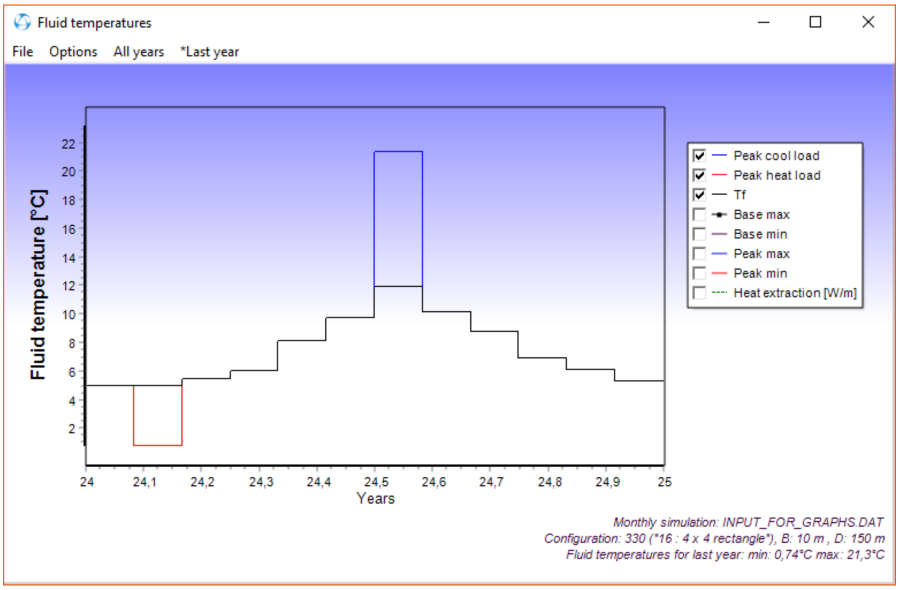


v4.19



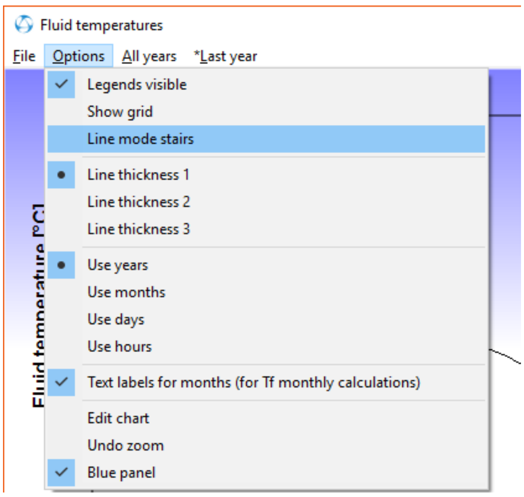
v4.20

“Last year” can be chosen from the menu:



v4.20

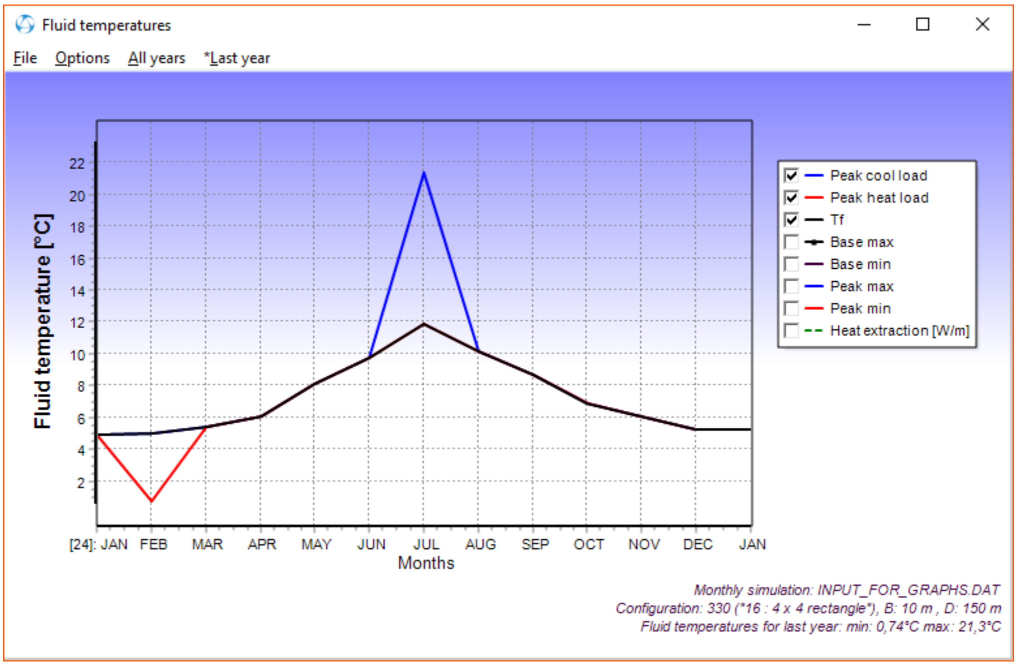
There are new menu options:
Line thickness (1,2,3)
Text labels for months (for Tf monthly calculations)



To get the picture below for file "input_for_graphs.dat" (similar as in EED v3) do as follows:

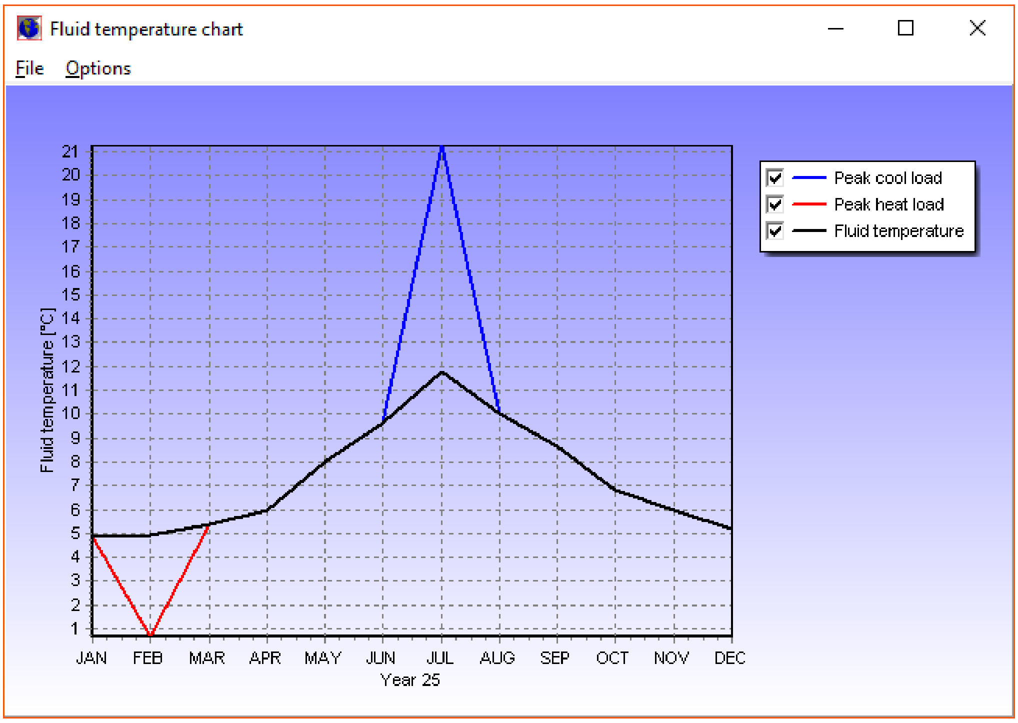
Open the dat-file and solve (F9)
Press menu item "Last year"
Uncheck Options/Line mode stairs
Check Options/Show grid
Check Options/Line thickness 3
Check Options/Use months

Text labels for months is according to
Options/Text labels for months...



v4.20

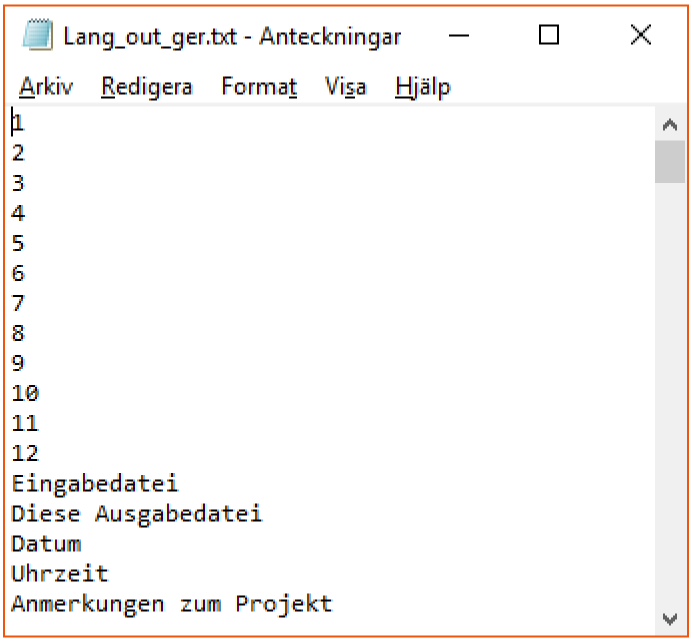
Here is the EED v3 graph:



v3.22

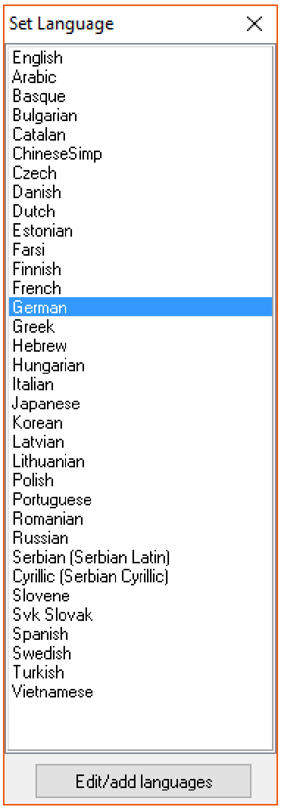
Note. The labels for months are for some languages currently set to 1,2,3... The labels for months is defined in file “Lang_out_***.txt” where *** is the language (e.g. “Lang_out_ger.txt” for German). This file is located in folder “…\Documents\Blocon\EED 4\Languages”. Below is an example how to change the labels in German.

You can edit the labels in this file using Notepad directly:

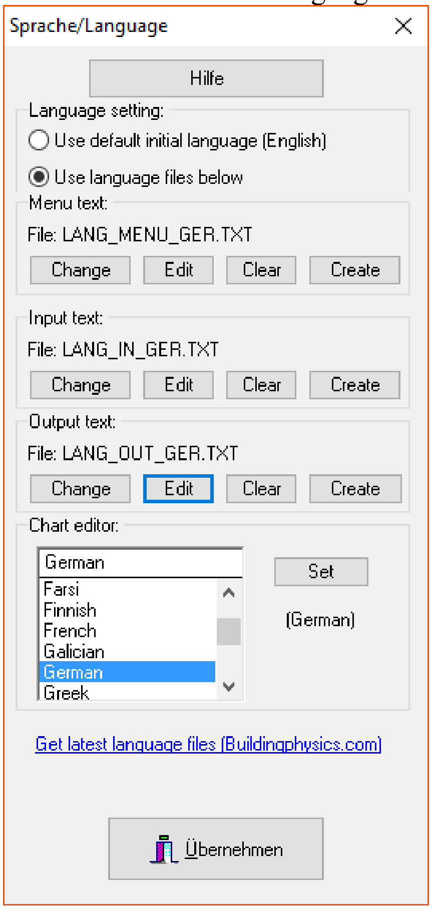


Lang_out_ger.txt opened in Notepad

It is also possible to edit the file in EED. Go to menu item “EED Settings/Language”:

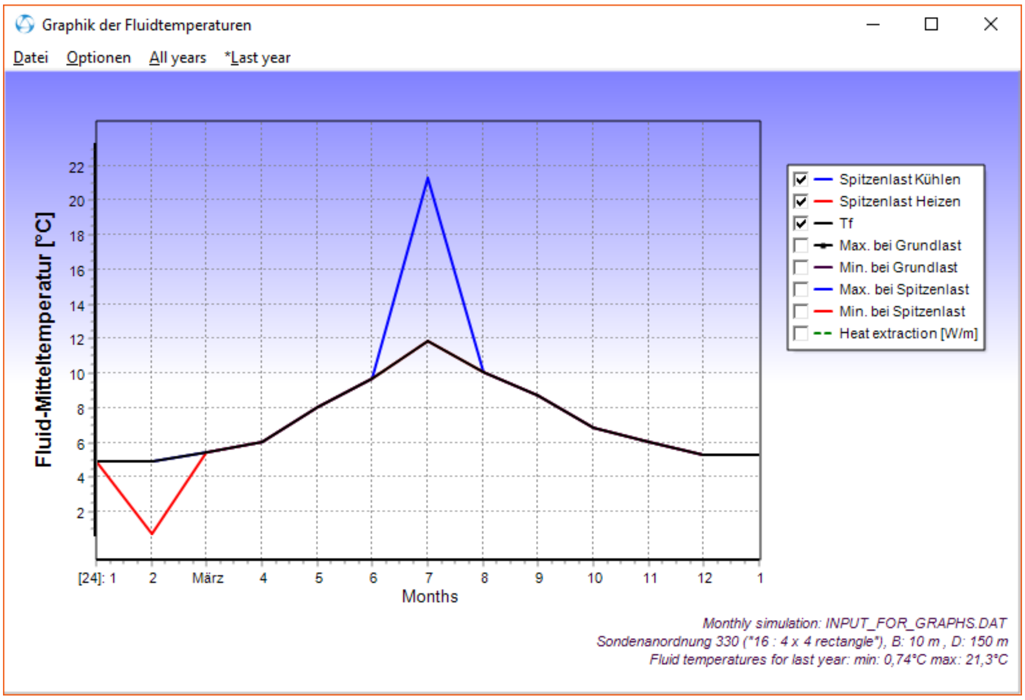


Press button “Edit/add language”:



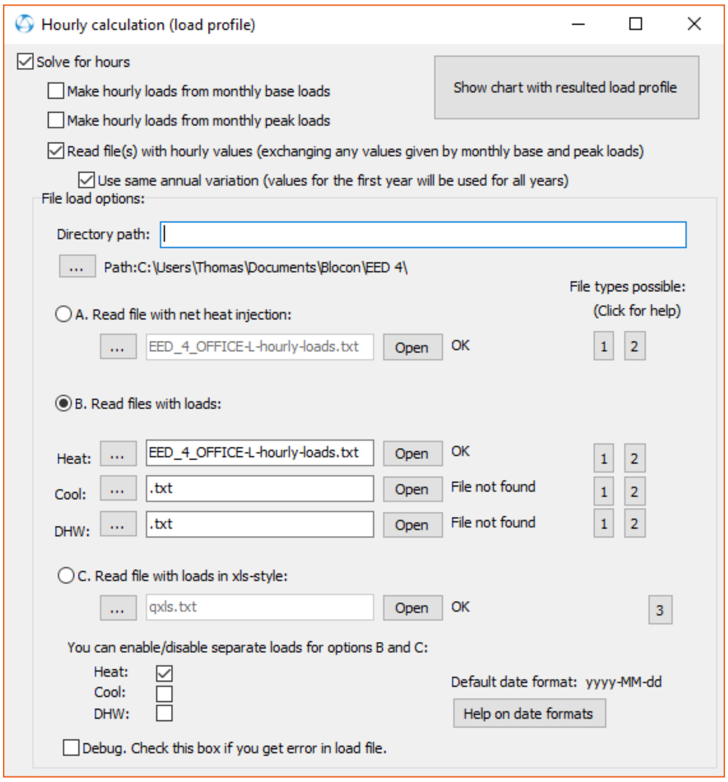
Press button “Edit” for Lang_out_ger.txt.

This will give the following picture:


Graphik der Fluidtemperaturen
Datei Optionen All years *Last year
Fluid-Mitteltemperatur [°C]
22
20
18
16
14
12
10
8
6
4
2
[24]: 1 2 März 4 5 6 7 8 9 10 11 12 1
Months
Spitzenlast Kühlen
Spitzenlast Heizen
Tf
Max. bei Grundlast
Min. bei Grundlast
Max. bei Spitzenlast
Min. bei Spitzenlast
Heat extraction [W/m]
Monthly simulation: INPUT_FOR_GRAPHS.DAT
Sondenanordnung 330 ("16 : 4 x 4 rectangle"), B: 10 m , D: 150 m
Fluid temperatures for last year: min: 0,74°C max: 21,3°C

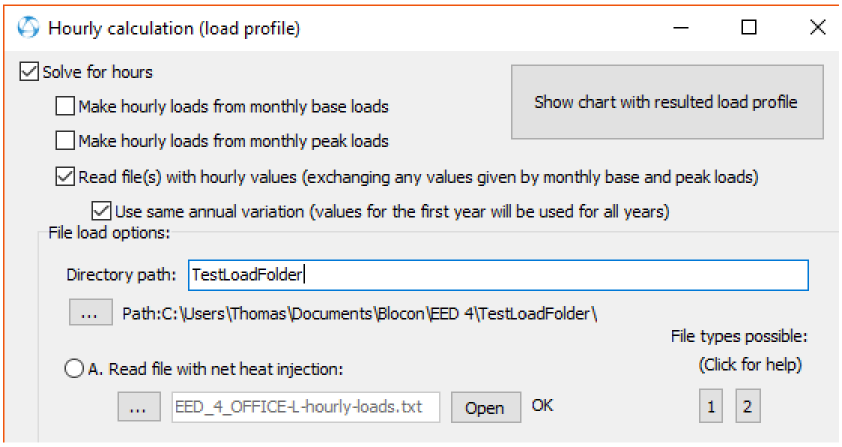
- Directory path for load files set to current working directory by default

If the *directory path* for file load options is empty the current working directory will now be used. In the example below the working directory is “C:\Users\Thomas\Documents\Blocon\EED 4\”.

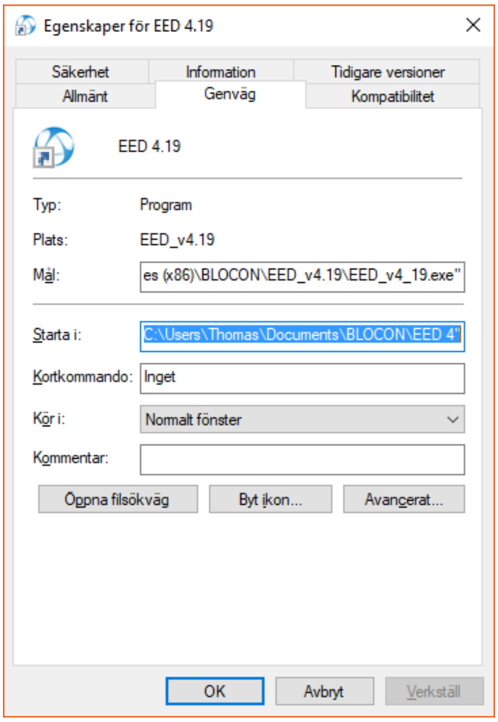


In version 4.19 (and earlier) the absolute path had to be given. If the input file was used on another system with a different working directory it would be a problem to find the load file(s) and a new path had to be given.

It is also possible to use a relative path. All load files could e.g. be in the same folder “\Documents\Blocon\EED 4\TestLoadFolder” se below.



The working folder is given in “properties” (right-click start menu item of EED), see below.



Ps. If you change the working directory (“Start in”) make sure you copy all essential files (such as gfunc4.eed and .txt-files) and folder “Languages” to the new directory.

- Unicode format for load files added

Older versions of EED could sometimes not read load files saved in Unicode or UTF-8 format (these files had to be saved in ANSI to be read). Unicode and UTF-8 format are now also supported.

- Floating network license option added

An annual subscription for multiple users with floating licenses is now offered, see https://www.buildingphysics.com/download/floatinglicenses.pdf

Update 4.3 *(March 27, 2024)*

- The license manager has been updated with many performance improvements.

- EED now install gfunc4.eed (and some other files) to the common folder C:\Users\Public\Documents\BLOCON\EED 4 by default so that the files can be shared by different users. See also Section 1.3 “Installation”.

- Modern design for the open/save file dialog.

- New version for setup program.

- Data for flow rate, and for values given in mm, are now saved with three decimals (e.g. 0,234), earlier it was saved with two decimals (0,23).