GLD Skill Booster #4:

Benefits of 8670 Hourly Energy Modeling and Loopfield Simulations

The GLD Skill Booster Series is a series of documents that guide you through the process of performing a specific task in GLD. With this series you can hone your functional skills in only a few minutes.

More and more architectural and engineering firms are recognizing the importance of whole building energy modeling and its potential impacts on fundamental design decisions including massing and orientation, lighting, windows and energy reclamation, among others. These decisions in turn impact annual and lifetime operational energy requirements. While future building use can never be predicted with 100% accuracy (we are not fortune tellers after all), building energy modeling provide us with a powerful asset for designing buildings that reduce, among other things, the heating and cooling loads required of a geothermal system. The 8760 hourly loads profile that an energy model provides can be invaluable for geothermal design optimization.

In this Skill Booster, we will first learn how to use an 8760 hourly loads profile to design a geothermal system. After that we will run a monthly and an hourly simulation of the system and see how the detailed hourly data leads to very different loopfield temperature predictions compared to those predicted by the less-detailed monthly data.

Hourly Data Files

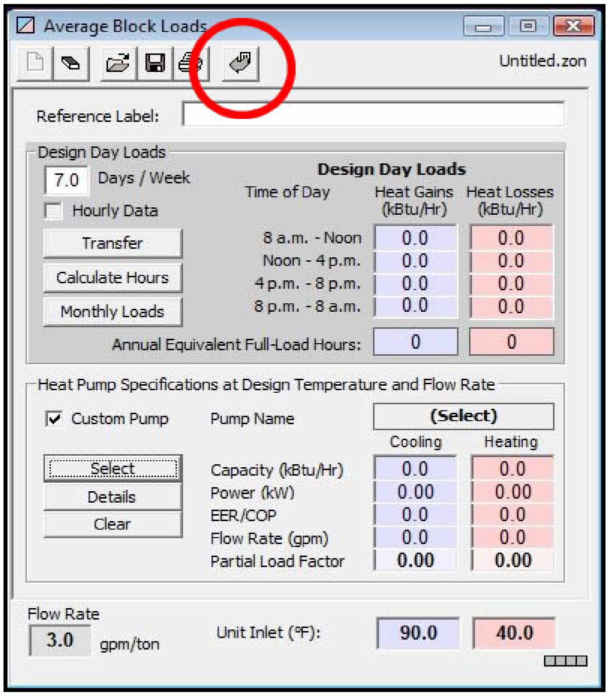
After completing a round in the building energy modeling/simulation process (for indeed the process typically involves multiple rounds of iterative improvements), one of the valuable outputs will be 8760 hours of heating and cooling loads data, typically exported out as a .csv file (note that GLD is able to read in native file types from some simulation tools such as the IES <VE>.

When in .csv format, the hourly data file should have the following format (the first hour of data should start on row 5):

	A	B
1	cooling plant load (kBtu)	heating plant load (kBtu)
2		
3		
4		
5	0	52.01
6	0	207.26
7	0	303.27
8	0	338.75
9	0	344.57
10	0	343
11	0	340.57
12	0	344.56
13	0	334.24
14	0	308.55
15	0	264.99
16	0	242.54
17	0	222.02
18	0	210.66
19	0	188.37
20	0	186.02
21	0	211.83
22	0	250.31
23	0	290.17
24	0	308.03
25	0	310.48
26	0	313.12
27	0	314.54
28	0	313.09

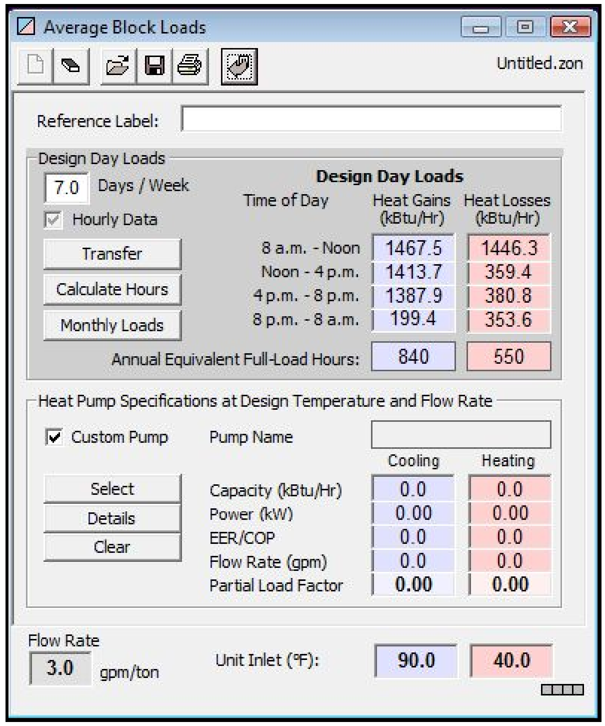
Designing with Hourly Data Files

• To import an hourly loads file, open up the Average Block Loads module (only the Average Block Loads module can accept hourly loads profiles for monthly/hourly simulations). To import the hourly loads file click the import button:

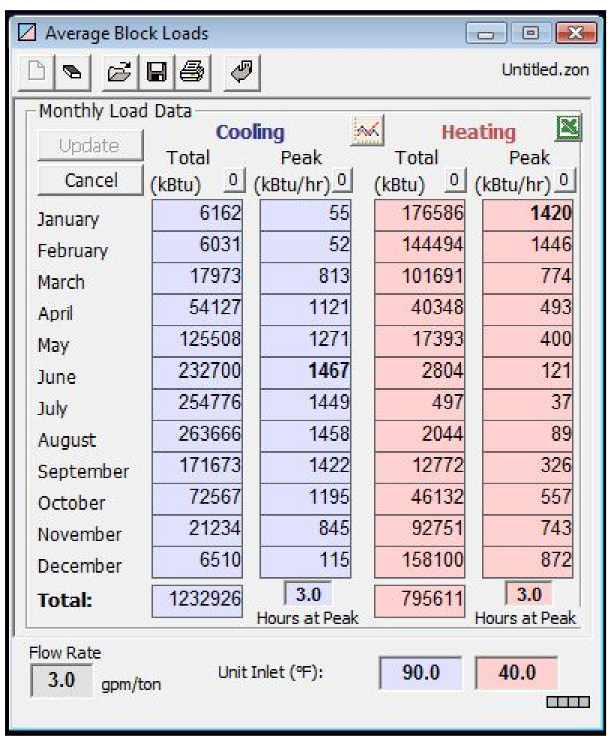


• Select the appropriate hourly loads file and import it.

• After performing the import, GLD will populate the Design Day loads interface with the peak heating day and peak cooling day data for each time block using the hourly loads data source:



• If you hit the *'Monthly Loads'* button you can see the hourly data parsed into monthly loads:



	Cooling Total (kBtu)	Cooling Peak (kBtu/hr)	Heating Total (kBtu)	Heating Peak (kBtu/hr)
January	6162	55	176586	1420
February	6031	52	144494	1446
March	17973	813	101691	774
April	54127	1121	40348	493
May	125508	1271	17393	400
June	232700	1467	2804	121
July	254776	1449	497	37
August	263666	1458	2044	89
September	171673	1422	12772	326
October	72567	1195	46132	557
November	21234	845	92751	743
December	6510	115	158100	872
Total:	1232926	3.0 Hours at Peak	795611	3.0 Hours at Peak

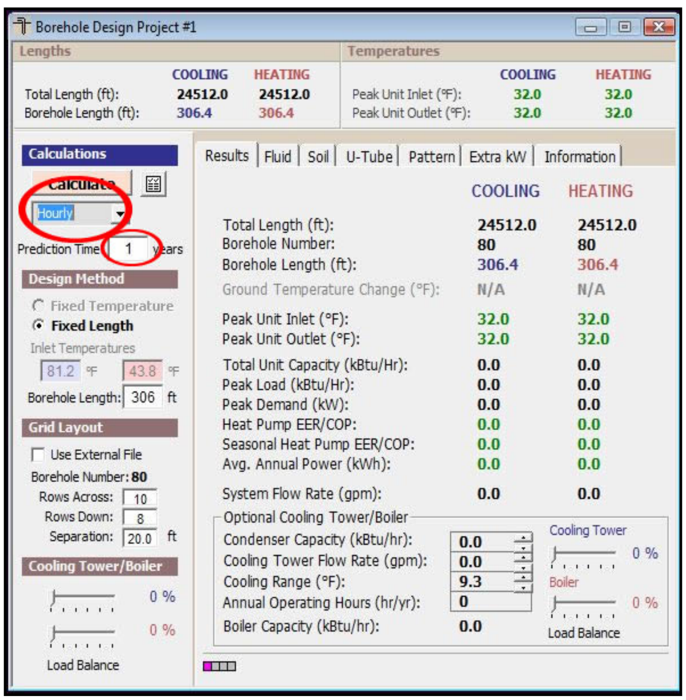
Note that the "Hours at Peak" are defaulted to 3.0 hours. Many users ask about the meaning behind "Hours at Peak." *(although this Skill Booster relates mainly to hourly simulations, we discuss this monthly simulation function now because it becomes pertinent later on in this document)* The monthly simulation engine uses monthly total and monthly peak heat pulses for cooling and heating to predict fluid temperatures, loopfield performance and the like. However, the monthly data does not indicate the duration of the peak loads (1 hr, 2 hrs, 3 hrs, 4 hrs, etc). The duration of the peak load will influence calculated results so it behooves the designer to consider adjusting the "Hours at Peak" away from the default 3.0 value if there is justification to do so.

- In the monthly loads image above notice how the *'Update'* button is deactivated. Making modifications to monthly data that are based on detailed hourly loads is not possible.

- Following the standard design processes, select the average heat pump for the project, open a borehole design module, link the design and loads modules together, and design a preliminary system using the Design Day and Monthly methods. It is recommended that you fine tune your design as much as possible using the Design Day and Monthly Modes prior to using the Hourly Mode because the Hourly Mode is computationally time intensive.

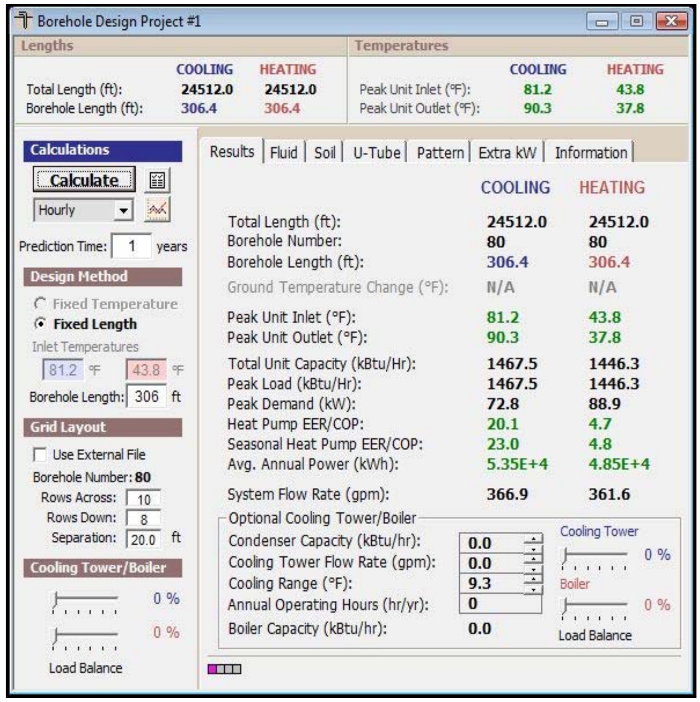
- When you are ready to run an Hourly Simulation, select hourly mode and set the prediction time to one year initially (since hourly simulations are time intensive, it is useful to begin with a short simulation duration). The basic set up can be seen here:

(Note: the previous version GLD2010 was limited to approximately a 3-5 year hourly simulation. GLD2012 has no such limitation)

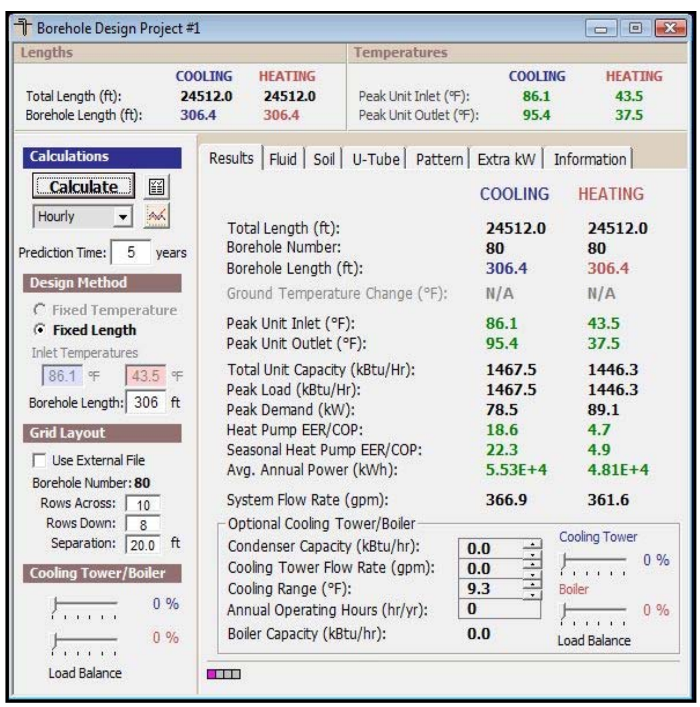


• When you hit the *'Calculate'* button a warning message will appear indicating that simulation may take some time. Hit *'OK'* to begin the simulation.

• During the simulation, the "linking" indicator lights at the bottom of the module will flash. If you need to cancel the simulation prior to completion, hit the *'Cancel'* button that appears at the bottom of the module during the hourly simulation process. When the simulation is complete, results will appear in green:



• Let's now do a five year simulation to see how results vary between the one year hourly simulation and the five year hourly simulation. Note that this five year simulation took approximately 96 minutes to run:



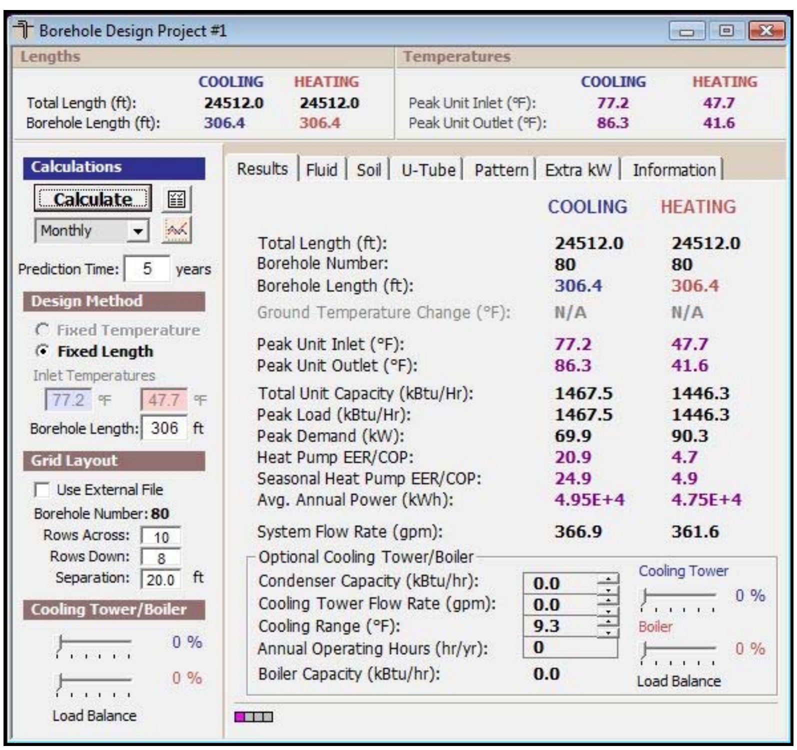
Because the system is cooling-dominant, we see the peak inlet temperatures have increased from 81.20˚F (the one year simulation result) to 86.1˚F on the cooling side over five years. If we did a 10 year simulation, which would take hours to complete, we would see the temperatures increase even more.

The Value of Hourly Data

In many cases the monthly simulation and hourly simulation methods, which are based on the same heat transfer theory, provide substantially similar results. However, this is not always the case (and as a result, may make it well worth a designer's time to always run at least a short term hourly simulation to confirm that monthly and hourly results generally match).

In the remainder of this Skill Booster, we will compare monthly and hourly results from a particular hourly loads profile and explore a situation in which monthly and hourly results are decidedly different.

The previous image shows results from a five year hourly simulation. If we run a five year monthly simulation based off the same loopfield design we get the following results:



Key differences between the monthly and hourly simulations can be found in the table below:

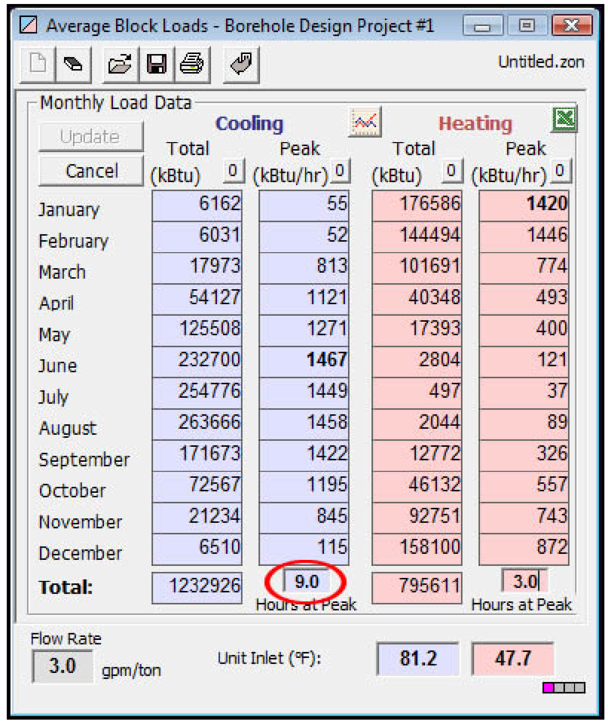
Result	Monthly	Hourly
Peak Cooling Inlet (˚F)	77.2	86.1
EER	20.9	18.6
Seasonal EER	24.9	22.3
Avg. Annual Power	49,500 kWh	55,300kWh

Notice that at the end of the five year simulation, the hourly peak cooling inlet temperature is nearly 10˚F warmer than the monthly peak cooling inlet temperature. A 10˚F difference, over a relatively short five year simulation, is significant. Let's try to understand why the hourly results are more extreme (and less efficient) than the monthly performance. To do so, we will open the hourly loads profile in Excel and begin exploring:

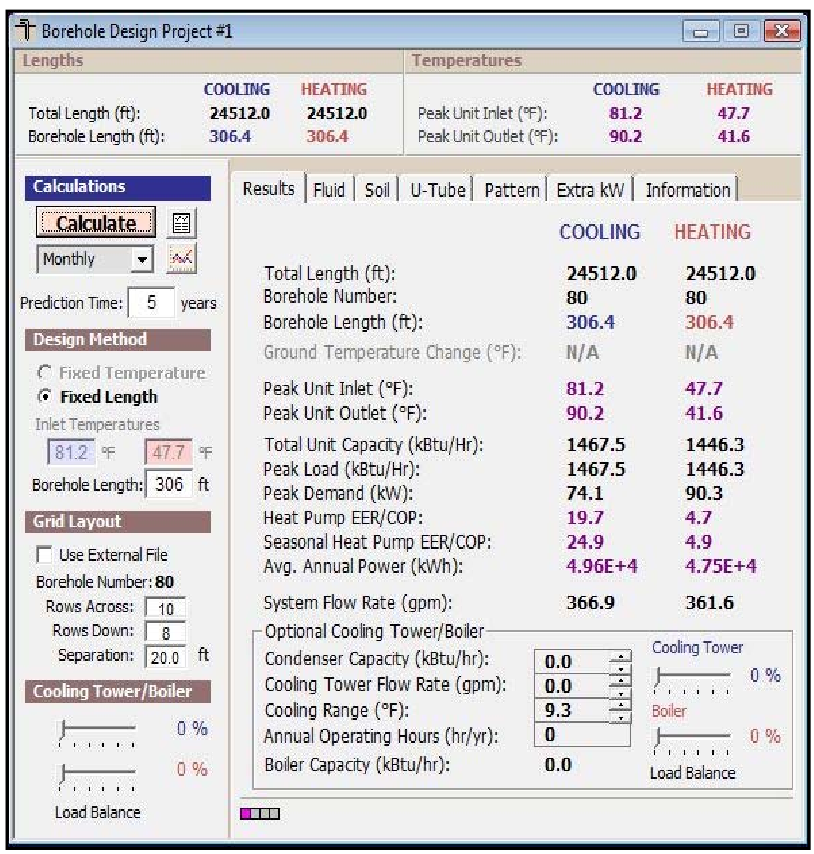
Notice that the hourly simulation data indicates that the building is running at or near peak load for nine straight hours day after day (see numbers in blue). The monthly simulation on the other hand was run at 3.0 "Hours at Peak" (see page 4 for a description of "Hours at Peak."). Three hours at peak is very different from nine hours at peak.

4261	1467.46	0
4262	1420.79	0
4263	1415.12	0
4264	1413.66	0
4265	1399.87	0
4266	1407.86	0
4267	1400.3	0
4268	1387.86	0
4269	1350.8	0
4270	271.62	0
4271	315.03	0
4272	199.38	0
4273	94.97	0
4274	32.25	0
4275	0	0
4276	0	0
4277	0	0
4278	0	0
4279	0	2.37
4280	0	3.72
4281	0	3.51
4282	0	0
4283	15.92	0
4284	167.63	0
4285	1401.17	0
4286	1349.21	0
4287	1377.54	0
4288	1351.55	0
4289	1348.33	0
4290	1357.54	0
4291	1362.69	0
4292	1383.08	0
4293	1357.26	0
4294	143.71	0
4295	271.88	0
4296	140.29	0
4297	65.83	0

When we change the monthly "Hours at Peak" to 9.0 (as can be seen here) and then rerun the monthly simulation, we get a peak cooling inlet temperature that is closer to the hourly peak cooling inlet temperature:



After changing the "Hours at Peak" to 9.0, the monthly simulation peak cooling inlet temperature is still 5˚F lower than the hourly simulation peak cooling inlet temp. (81.20˚F vs 86.10˚F). In the hourly simulation, nine sustained hours of peak load day after day drive the fluid temperature up, a result that the monthly simulation method, with its more limited loads data set, cannot match.



At this stage in the design, the designer might return to the energy model to confirm if the peak load really will be sustained for nine hours in a row, day after day. If it turns out that the energy model is correct, then the value of the hourly simulation cannot be overestimated. In this design, the monthly simulation results do not have access to the details of sustained peak loads and their subsequent impact on the fluid temperatures.

Five years after system startup, the default (with “Hours at Peak” set to 3.0) monthly simulation predicts peak temperatures of 77.20˚F while the hourly simulation predicts temperatures of 86.10˚F. Ten years out it is likely the difference will be even more pronounced (15˚F difference?) Based on the heat transfer theory, a design based on the monthly simulation alone will result in an underperforming (and possibly undersized) loopfield. Without hourly data, the designer will never know that there is a loopfield design problem until the fluid temperature in the system begins heating up faster and higher than anticipated.