Gaia Geothermal

This document was adapted from an original written by Terry Proffer of Major Geothermal.

The purpose of this paper is to emphasize the importance of acquiring correct energy loads - for the building itself and its occupants and activities - without including unrealistic or non-existent loads that can have adverse consequences for the final system design, economics and operation of the system.

**Peak Loads vs. Energy Loads**

We are often asked as an industry to design GSHP loopfields from the usual peak heating and cooling loads normally calculated for commercial, institutional and other large structures using conventional mechanical equipment (gas/dx pack roof top units, boiler/chiller plants, etc.). For a closed loop system installed in dirt or rock, we must have energy or hourly loads to determine the duration and capacity of energy that will be exchanged with the loopfield. If the loads are internally driven, as characterized by most commercial and institutional loads, this is mandatory for a competent, cost effective design.

An example of a 12 month energy load is described in figure 1 below. Please note that the cumulative/total monthly loads are in btu energy units for the month, *not* btu units per hour. This is the energy that needs to be rejected to/extracted from the loopfield.

**Figure 1.** Energy and peak load table example

| | **TOTAL COOLING** mbtu | **PEAK COOLING** mbtuh | **TOTAL HEATING** mbtu | **PEAK HEATING** mbtuh |
|---|---|---|---|---|
| JANUARY | **1524.0** | **10.8** | **98162.0** | **1303.3** |
| FEBRUARY | **1763.0** | **13.9** | **54623.0** | **1117.1** |
| MARCH | **4554.0** | **40.7** | **33893.0** | **914.2** |
| APRIL | **25633.0** | **301.7** | **1243.0** | **246.9** |
| MAY | **96739.0** | **600.0** | **0.0** | **0.0** |
| JUNE | **82266.0** | **805.5** | **0.0** | **0.0** |
| JULY | **98575.0** | **845.0** | **0.0** | **0.0** |
| AUGUST | **97181.0** | **830.1** | **0.0** | **0.0** |
| SEPTEMBER | **112030.0** | **752.9** | **0.0** | **0.0** |
| OCTOBER | **40779.0** | **458.3** | **786.0** | **80.0** |
| NOVEMBER | **3386.0** | **42.5** | **37370.0** | **990.8** |
| DECEMBER | **1501.0** | **13.8** | **89691.0** | **1269.4** |

Many designers, engineers and mechanical contractors "live" by peak load calculations to size mechanical equipment, ducting and other specifications of the interior mechanical system. If we did this for the closed loop heat exchanger portion of the system, we would find that many loopfields are either excessively oversized (killing the GSHP option just on economics) or severely undersized (leading to extreme entering water temperatures and equipment shutdowns). In other words, if the designer does not understand the fundamental loads requirements of GSHP applications, overpriced and/or poorly performing systems are often the result.

As an example on how the load durations can affect the design of a loopfield, consider a church and office building that have identical peak heating and cooling loads, in the same geographic location with the same geology. If the church is subjected to its peak load 1 or 2 times every Sunday and the remainder of the week the facility is mostly unoccupied and dormant, and the office building is fully occupied and operational 12 hours per day, 5 days per week, the loopfield for the office building could be required to be 2 to 4 times the size of that of the church.

**Climate vs. Internally Driven Loads**

Most residential loads are climate driven with regards to duration, and the amount of energy moved during that time. With GLD we can account for the duration of the heating and cooling loads by determining a run fraction (or annual equivalent full load hours) using what is known as "bin" climate data. If we know the peak loads for an application at the appropriate design temperatures for cooling and heating, we can use documented climate data to determine for how many hours per year at what outside temperature the amount of energy will be required to heat and cool the building.

As internally driven loads are often cooling dominated, climate is not always the dominant factor in determining how much energy is required to heat a structure, or how much should be removed for cooling, during a given amount of time.

**Scheduling**

Most commercial load programs will require a reasonable idea of occupancy and duration of use per day, and even how many days per week the structure will be in use. A reasonable amount of scheduling is necessary not just for the loop design, but for operating cost or life-cycle comparisons as well.

Again using the church/office building example, the duration and intensity of these loads will be vastly different based on nothing more then the usage profile of the respective applications. The size, and cost, of the loopfield installation will reflect these input variables.

**Equipment Loads**

With most commercial load calculation software programs, additional heat gain from the mechanical equipment itself is often added into the equipment cooling capacity. This is true of large chiller plants, which can account for a significant heat gain impact relative to the actual load of the building. *With a GSHP system this component will not even exist.*

The same goes for the heating side. Some software programs just assume that a boiler or auxiliary heat source is required, even for a GSHP system. *Again, this can affect the loads in a way that can be harmful to the economics, execution and operation of the system.*

For a commercial closed loop design, all we want are the actual building loads. Equipment gains, such as those from the compressor energy within the heat pumps, are calculated by and integrated into the loopfield design by GLD.

If we add in energy gains twice for mechanical equipment by (1) using a load calculation from software that already includes equipment gains and by 2) using the heat pump compressor energy calculated by GLD, the loopfield increases in scope and cost proportionately. Furthermore, the equipment gains from purpose-built GSHP equipment will usually be less than that of conventional equipment.

In summary, the energy load calculations should be for the building and profile of activity only and exclude gains and losses from the mechanical equipment. GLD takes care of the mechanical equipment gains so there is no need to double count them.

**Default and Non-Existent Loads**

Most commercial heating and cooling load programs offer several default settings, such as heat generated from lighting. These often are not adjusted for actual lighting schedules and add in phantom loads that do not exist. If these critical inputs are not adjusted to better reflect reality, the result is more ground loop than is necessary and consequently, greater installation costs.

Some programs that offer a geothermal load calculation template assume a boiler or other auxiliary heat source will always be necessary. In reality, most commercial loads that are driven by internal gains result in a loopfield size that will never require any backup heating system. If a boiler or other heat source is retained in the load profile, the ground loop will be oversized. The key is to eliminate any backup heat source in the load calculation. The loop design can be modified later to account for backup heat if it is needed.

Another concern is the introduction of outside air for maintaining good indoor air quality. If not addressed using energy reclamation equipment, sensor-controlled air dampers, and/or appropriate blending with internal air in the duct system back to the heat pump(s), the loopfield will again end up being excessively oversized.

Some in the mechanical professions claim this is not necessary for conventional mechanical applications. As the argument goes, makeup air and other factors are not a critical concern for pricing of non-GSHP configurations since oversizing conventional mechanical systems is not particularly expensive. However, oversizing does not take into account the additional operating costs, higher life-cycle costs, maintenance and potential short-cycling costs that logically result from this design philosophy. This design method is a disservice to the end-user, i.e., the person or entity paying the bills. In other words, properly controlling makeup air by energy reclamation, sensor-controlled dampers, etc., makes sense for even a conventional system. The load calculations and overall system design should reflect this, and make for a more even comparison when considering multiple mechanical options.

There may be other defaults or design approaches that could add non-existent loads or miss loads that do exist. It is the responsibility of the person calculating the heating and cooling loads to generate a fair and actual representation of the actual usage and load profile of the building.

**Equipment and Geology**

The GSHP equipment and geologic values are the two remaining variables that are necessary to complete the loop design, but are directly and indirectly dependent upon the loads for the final field configuration and parameters.

The equipment specifications must be known to determine fluid flow rates required by the heat pumps. The peak fluid flow rate is necessary for specifying the preliminary size of the field for number of circuits and pipe size. As the equipment is selected primarily for the loads required for heating and cooling (and other variables such as airflow or other delivery system requirements), the load calculations are always the starting point in the design process.

The depth and spacing of the circuits will be dependent upon the thermal performance of the geology. As the performance of the geology is dependent upon the duration and amount of energy exchanged with the building, and thermal performance values can change relative to the amount of energy extracted or rejected during a given amount of time, the designer has to include the loads in the field model to run preliminary field ranges.

When all of these elements are combined, a determination can be made if a thermal conductivity test is warranted or not, usually determined if the cost of the test is less then the difference between smallest and largest field options modeled. For this reason, a thermal conductivity test should never be guessed at with regards to pipe size and depth until the load calculations and equipment specifications are determined.

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