GUIDANCE ON GSHP MONITORING
Ground Source Heat Pump Systems

NYSERDA strongly recommends that ground source heat pump (GSHP) systems installed under the program have some level of monitoring to confirm that system performance is in line with expectations. This document provides guidance on the relative benefits and costs of various monitoring options. Small systems (systems having less than or equal to 10 tons of capacity) and large systems (systems having greater than 10 tons of capacity) are treated separately.

What is Monitoring?

Monitoring includes adding sensors or meters to measure key parameters to track system performance and then recording that data at regular intervals over a season or year. This record of historic performance data over the long term can be used to confirm the GSHP system functions as expected (or according to the original design intent for commercial systems). Several technology options are available to collect monitored data, ranging from low-cost, battery-powered data loggers to the building management systems (BMS) used in large commercial buildings. New, quickly expanding technologies are low-cost gateways that connect to home WiFi systems to allow sensors to send data directly to cloud servers where it is stored and analyzed. Each of these approaches have pluses and minuses.

Why do GSHP Monitoring?

GSHP monitoring is especially important because ground loop temperatures vary throughout the year in response to seasonal changes in ground temperatures as the GSHP system extracts or rejects heat to the ground heat exchanger. In addition, loop temperatures are affected by how the ground loop is sized to serve the GSHP equipment and building loads. Daily performance depends on current conditions as well as cumulative loads imposed on the loop and recent weather trends.

Monitoring Small Systems

Small systems normally include one or two GSHP units on a single ground loop heat exchanger in a home or small building. For small systems, the most important parameters to monitor are listed below, starting with the vital data that can be collected for the least cost and continuing to more comprehensive data to provide more accurate determinations of performance:

- Entering loop temperature. The loop temperature entering the heat pump drives the efficiency and capacity of the unit. Loop temperatures indicate the sizing of the ground loop exchanger relative to the building load. This is the single most important parameter to measure.
- Heat pump runtime (and speed). Heat pump performance tables from the manufacturer can be combined with the loop temperature data to find the heating (or cooling) capacity. Capacity readings can be combined with measured equipment runtimes and speeds to estimate annual heating/cooling loads, along with heat pump electric use. The runtime of the auxiliary resistance element can also be important to measure.
- Heat pump power. Heat pump power measurements provide a more accurate determination of total electric energy use. When combined with Coefficient of Performance (COP) data estimated using measured loop temperatures along with the manufacturers performance tables, the heat pump power can also be used to determine heating (and cooling) loads.
- Loop thermal measurements. Adding the leaving loop temperature and the loop flow allows the ground loop heat extraction and rejection rates to be determined. Thermal meters (i.e., BTU meters) combine high accuracy differential temperature measurements with flow measurements that are integrated at small time increments to determine thermal energy. Knowing the loop thermal performance (heat extraction or heat rejection) and combining it with power data, allows the efficiency and heating capacity of the GSHP system to be directly determined.
- Other useful performance data. Several other parameters can be useful for fully understanding performance of the GSHP system. They include:
  - power for pumps and resistance elements
  - speeds or staging for compressors, fans, and pumps
  - operating temperatures or status/runtimes for the desuperheater
  - refrigeration temperatures and pressures

Some of these points are useful for further understanding system performance. Other data points can help installers and contractors to identify and diagnose issues or failures with the heat pump unit.

Various low-cost monitoring options are available for tracking the performance of residential systems. Low-cost, battery-powered data loggers can be used to measure loop temperatures. The external temperature probe from these credit card-sized units can be strapped onto pipes (and insulated) to determine loop temperatures. Most units can collect continuous interval data for at least 12 months before they are retrieved, and the data downloaded. Similarly, a battery-powered runtime logger can be used with a status CT to collect 12 months of runtime data. These loggers are less than $100 and can be redeployed at other sites many times.

New options are also available that connect sensors to low-cost gateways that can transmit data to cloud servers via the homeowner's WiFi connection. These devices provide contractors and homeowners with real-time access to the data via web sites at a modest cost (in the range of $400 to $1,000). These web-based systems analyze and present real-time and historic data in a way that is useful to both homeowners and contractors. While this gateway-cloud monitoring approach can sometimes result in intermittent data loss on some poor-quality home WiFi internet connections, it seems to collect adequate data in most cases. Installing a slightly more expensive device with on-board data storage can address data loss issues. This type of monitoring system was developed by GSHP manufacturers as an optional part of their product. Other third-party monitoring systems are also available. In some cases, power measurements are true power readings. In other cases, true power is inferred from other low-cost readings (such as current).

Table 1. Monitoring System Resources Available for Small GSHP Systems

Provider	Description
GxTracker (Third party)	Gxtracker www.groundenergysupport.com (packages: GxT-Basic, GxT-Power, GxT-PowerPlus)
Web Energy Logger (Third party)	www.welserver.com targeted at geothermal and solar systems
Water Furnace (Manufacturer)	Symphony system for select products (packages: energy, refrigeration, performance)
Brultech (Third party)	Brultech www.mypowerpanel.com Residential power monitoring

Monitoring Large Systems

Most large buildings have a BMS installed to control major equipment in the building. These systems often have data logging or trending capabilities. Readings are typically recorded or logged at 5- or 15-minute intervals. In some cases, data collection and transfer processes can be fully automated (i.e, transferred by email or FTP). In other situations, logged data must be extracted manually on-site using the control system's proprietary software interface. GSHP systems in large buildings often have several dozen individual heat pumps tied to a common ground loop. A single central pumping station typically provides flow through the system. Individual heat pumps usually have two-way valves to shut off flow when the unit is off.

The most important performance parameters to measure for large systems are the ground loop flows and temperatures. This allows the net heat extraction and heat rejection to be directly measured. Other important performance parameters are the pumping power and pump speed. Generally, it is very difficult and expensive to measure the power consumption for every individual heat pump. However, it is often possible to measure the status, runtime, or staging of each heat pump to understand which units are operating at any given time –and whether the units are in heating or cooling mode. If total building power is measured, that data can be correlated with outdoor temperature on a daily basis to infer the magnitude of the temperature-dependent electric load. In most buildings, the temperature-dependent portion of the electric load is the heat pump power used for space conditioning.