

# Tuscany Design Build, Inc.

## Geothermal Guidelines

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Energy Sustainable Management

Every ground source heat pump and ground exchange system is governed by heating demand and cooling loads. When these loads are reduced by sustainable design principals-such as passive solar, thermal bridging reductions, increased insulation and lower U values with high efficient air sealing and an effective continuous air barrier, then properly designed GSHP applications shine through. When commercial and residential buildings reflect efficient ft<sup>2</sup> to population ratios without a lot wasted space, then one can say that we have put is best foot forward to reflect sustainable energy management.

The geothermal GSHP system should always be viewed as a HVAC system. It is NOT a renewable system or a conservation practice but rather a high efficient heating/cooling system. The US EPA pointed out in 1993 that geothermal heat pump systems create “the most energy-efficient, environmentally clean, and the most cost-effective space-conditioning system.” Therefore, a holistic approach needs to be applied to installing these. Not every home or building is conducive to installing GSHP systems.

First and foremost before any geothermal application is planned, proper **(A) weatherization** needs to be implemented. Air sealing is job #1 since up to 40% (DOE) of heat loss occurs through leaks in a building envelope. The ASHRAE threshold standard for air changes per hour is 0.35 ACH natural (which corresponds to 5 ACH @ 50 Pascal’s via blower door test). Anything below that number will denote an unhealthy air quality and mechanical ventilation is *recommended*. It is *required* beneath 70% of 5 ACH50. In Canada, the building standard is 0.07ACH natural and in Denmark it is 0.025 ACH. Of course mechanical ventilation is applied but the buildings are designed with tight air sealing and high insulation values. Our recommendation is that homes should be energy audited first with quantifiable data denoting measures taken to get to 0.35 ACH natural as close as possible or intense air sealing under BPI guidelines with mechanical ventilation installed.

After air sealing and proper weatherization techniques have been applied, properly installed **insulation** will reduce the heating requirements for buildings. Energy star criteria should be set so as to reduce the size of geothermal loop fields and the need for larger heat pumps. These standards are reflected under three Energy Star efficiency benchmarks for southern New England: (A) Base efficiency @ 30 Btu/hr-ft<sup>2</sup> which is the standard for an average home in temperate-cold climate, (B) High Efficiency @ 22 Btu/hr-ft<sup>2</sup> which is a well insulated home with low air leakage and (C) Premier efficiency @ 14 Btu/hr-ft<sup>2</sup> which is a well-insulated and air tight home with HRV or ERV. **(B) Building owners should go for Energy Star**

*ratings first.* Up front costs are very low and the DOE has much information as well as help for building owners. Generally, it exceeds all other organizations in focusing on one thing-energy. For example, a *typical* southern New England 2000 ft<sup>2</sup> home has a “heating” ton demand of 60,000 btu/h-which equates to providing a 5 ton GSHP system which is 30 Btu/hr -ft<sup>2</sup>. When Energy Star criteria is met for a High Efficiency building, then GSHP system would only require a 4 ton system at 24 Btu/hr-ft<sup>2</sup> and a 3 ton Premier system at 18 Btu/hr-ft<sup>2</sup>. Thus, the Energy Star benchmarks should serve as incentives to achieve effective GSHP applications. Besides, the smaller the heat pumps-the higher the COP. This strategy helps the building owner to receive a *triple dividend*-less up front capital costs, higher efficiency, lower energy costs, and increased life cycle of systems-creating value for the property owners. **This is the most effective way to reducing closed ground loop and concordantly energy costs. Solar hot water systems generally provide the most cost effective strategy for technology based systems following energy efficiency upgrades-notably the installation of an HRV or ERV along with air sealing.**

After (1) designing the building and HVAC as a cooperative system, then next step is to (2) **get the building right**. HVAC distribution systems or water-to-water radiant systems need to reflect optimum performance with sealed ductwork and ASHRAE design parameters by **(C) balancing the system**. Qualified HVAC “performance based” contractors are key. There are enough HVAC systems that are not installed properly leading to more bells and whistles and more energy costs.

After the basic recommendations above are achieved, selection of heat pumps should reflect COP over 3.5. Purchase of “type” can insure better efficiencies up to 4.5 COP for 32°F entering water temperature or EWT. For example: (1) packaged units cost less to install, have less risk of leaks and care as well as similar COP’s than comparable “split” systems made of heat pump and air handler, (2) two speed units of part and full load deliver higher COP’s than one speed units and increase the life cycle of the units. Of course, building constraints and economics determine insuring the best fit. Warranty of the heat pumps help give piece of mind to the building owner but without proper sequence, it will only increase energy usage. Remember, fan use is a big culprit in energy use, so proper design and choice of heat pump will get to the “sweet spot” in a geothermal system.

The use of geothermal or GSHP should be an integral part of the building landscape. In California, 1 of 83 homes has a GHEX system and in Sweden, 97% of all new buildings are heated by GSHP. The state of Iowa education sector recommends it exclusively for schools unless an engineer can provide a more efficient system. The New Buildings Institute compiled a data base of buildings that exceed the energy code by 50% or better. Of all the researched buildings, 20% were heat/cooled by GSHP even though they represent less than 1% of total building HVAC systems.

Designing the closed loop field or the ground exchange system requires understanding of climate, geology, and building design as well as understanding how geothermal works. This should be designed by qualified technicians. Southern New England is dramatically different from the southern states as well as further north. Loop fields need to reflect these parameters in order to be designed properly. Thus, some benchmarks are established that the CCEF should use to determine these parameters for Connecticut:

- Vertical Bore lengths should be at the least 150' ft/ton and up to 250 ft/ton. Too little loop and you have too much electricity and higher costs.
- Spacing should be 20'. Closer to 15' is OK for northern climates with higher ground recharge (such as hydraulic gradient movement) but will cause a measure of risk to drilling and damaging closer to existing bore holes. In the south, 25' apart is recommended due to 'rejected heat' capacity of the ground.
- Because of head losses, limit bore depths to: 250 ft for ¾" U tubes, 350 ft. for 1" U tubes, 500 ft. for 1.25" U tubes.
- Horizontal closed-loop should have characteristics for higher performance of 300 to 500 ft/ton of ¾" or 1" HDPE coil. To dramatically reduce ground loop size will usually result in long term temperature degradation or the inability to recharge effectively.
- Pumping power should be 5-7.5 HP as very good, 7.5-10 as OK, and 10-15 HP as poor. Less than 5hp/100 tons or *50 watts per ton would be deemed as excellent.*
- When ascertaining performance, temperature control is more reliable than a pressure rating.

In summary, *getting the building right* is key since GSHP are 1<sup>st</sup> and foremost a very effective and efficient space-conditioning system. The GHEX system should primarily focus by being in balance with these three benchmarks: (1) Efficient heat pumps, (2) low loop pumping power, and (3) well designed ground loop system.

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