Is it Feasible?

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Is it feasible in my project?

When most home and building owners ask if it’s feasible to install a GCHP system in their project, what they’re really asking is:

“If I invest in a GCHP system, will it save me enough money to give me a good return on my investment?”
Factors to consider

There are several factors that need to be considered when determining the feasibility of installing a GCHP system for a specific project. This presentation reviews the factors that can affect the feasibility of building a system and a method of describing the relative feasibility of a project to a building owner.
Feasibility of a GCHP system for a specific project

Located in a hot climate, on approximately 15 acres (6 ha) of land
- Commercial office space: 167,700 ft$^2$ (15,585 m$^2$)
- Retail space: 12,900 ft$^2$ (1,200 m$^2$)
- Residential apartments: 601,500 ft$^2$ (55,900 m$^2$)
Integrated design process – architectural design

The orientation and type of glass specified by an architect has an impact on solar gains to a building. This affects the capacity of the cooling equipment, electrical loads. These in turn affect the size and cost of the GHX. Developing an accurate energy model and collaborating with the architect makes the project more feasible.
Internal gains from lighting and electrical equipment directly affect the cooling loads and in turn affect the capacity of the cooling equipment needed and the size (and cost) of the GHX. Working closely with the lighting and electrical systems designers will reduce the cost of the system, lower energy costs and make the system more feasible.

Is it feasible?
Project loads are cooling dominant because of warm climate and building use. Adding residential DHW use increases total heating requirements for project, but overall loads are still cooling dominant when considering compressor energy.
Total borehole length required for project with separate GHX for each building with and without DHW load compared to a common GHX for all buildings. Total building loads are more balanced when diverse types of buildings are connected to a common GHX and when large DHW load is added to a cooling dominant system. Connecting to a common GHX & adding DHW load reduces drilling by 111,000’...or 26%.
Reducing temperature lift increases heat pump capacity and efficiency. A more efficient system uses less electricity to deliver the same amount of heating or cooling, reduces operating cost and improves the owner’s return on investment...and improves the feasibility of installing a GCHP system.

<table>
<thead>
<tr>
<th>Temperature Lift (°F)</th>
<th>Heating capacity (%)</th>
<th>Cooling capacity (%)</th>
<th>Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>4%</td>
<td>19%</td>
<td>50%</td>
</tr>
<tr>
<td>50</td>
<td>104%</td>
<td>80%</td>
<td>50%</td>
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</tbody>
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**ΔT = 80°F:**
- Heating cap: 100 kBTu/hr
- Cooling cap: 63 kBTu/hr
- COP: 3.0

**ΔT = 50°F:**
- Heating cap: 104 kBTu/hr
- Cooling cap: 80 kBTu/hr
- COP: 4.5
A more efficient heat pump system rejects less compressor heat to the GHX. If the building is cooling dominant, rejecting less heat to the GHX reduces the size of the GHX. In this project drilling is reduced by 17,000’ – about 5%. This uses less land area, less drilling and is more feasible to build.
Thermally activated building systems (TABS)

A TAB System uses the mass of the building to carry it through peak heating and cooling loads. Equipment capacity is smaller and less expensive. The building can be cooled with 66°F water and heated with 78°F water…reducing temperature lift & increasing efficiency…making it more feasible to build.
Thermal energy storage (TES) for cooling

Chilled water or ice storage tanks reduce peak cooling capacity required from system reducing heat rejection to the GHX. This reduces the size and cost of the GHX.
Thermal energy storage (TES) for cooling

Cooling loads are predictable and for many utilities cause peak load issues. Shifting some of the cooling load to off-peak hours reduces cost of electricity (if TOU rates are applicable) and creates opportunities for simultaneous heating and cooling – doubling system efficiency. This improves the return on investment and increases feasibility.
DHW loads are predictable in residential buildings. Peak heating extraction from the GHX is reduced and, when combined with ice or chilled water storage to reduce cooling peaks, provide excellent an excellent opportunity for simultaneous heating and cooling. Cost of GHX is reduced and the system becomes more efficient...increasing feasibility.
Reducing peak heat rejection to the ground with a TAB System, ice or chilled water TES system and DHW storage tanks shows a reduction in the size (and cost) of the GHX of 60,000', or 19.5%
Mechanical system design can improve feasibility

This client and the entire design team kept an open mind to TABS and TES and helped make the project more feasible.
Contractor resources – GHX contractors

There are few GHX contractors in the region…but one has researched and tested a new method of installing U-tubes, using a machine normally used to install wick drains. U-tubes can be installed in less than 15 minutes to a depth of 85’ at about 50% of the cost of normal drilling. They have already conducted a TC test on a test loop.
Contractor resources – mechanical contractors

TAB Systems and thermal energy storage systems are new to the mechanical contracting firms in this region. If drawings and specifications are not clear and the design intent is not well communicated there may be a risk of higher costs because of the uncertainty…but there can be significant reductions in the size of the central plant chiller / heat pumps and the size of the GHX.
Contractor resources – mechanical contractors

There is some risk in both the installation of the GHX and the mechanical system...but discussions with contractors in the region indicate a desire to work with the client and design team.

**Contractor resources**

**GCHP System Feasibility**

- Geology
- Environmental Considerations
- Integrated Design Process
- Other Considerations
- Site Accessibility
- Utility Costs

**OTHER CONSIDERATIONS SCORE**

7 out of 10
Utility costs – availability of inexpensive heating fuels

The project is located in a hot climate…ambient ground temperature is over 70°F. The project requires some space heating in the residential apartments, but without DHW loads the project is very cooling dominant. With the potential for simultaneous heating of DHW while cooling the building and building energy storage, the need for gas is almost eliminated…even though gas is $34.46 / GJ (equivalent to $0.1224 / kWh)
Utility costs – electricity costs

Most commercial cooling systems use electricity. This project has time of use rates:

- Off-peak rates (10:00 pm – 8:00 am): $0.152 /kWh
- Peak rates (8:00 am – 10:00 pm): $0.442 / kWh
Thermal energy storage (TAB System, chilled water or ice storage, and DHW storage) reduces the capacity of equipment needed, reduces electrical peak load and shifts much of the electricity consumption to $0.15 / kWh rather than peak power at $0.44 / kWh.

Utility costs – taking advantage of time of use rates

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**Peak and Off-peak kWh Consumption Comparison**

- Conventional HVAC (Gas Heat & DHW)
- Standard GCHP System
- GCHP with TABS
- GCHP with TABS, TES (Ice)
- GCHP with TABS, TES (Ice, DHW)

- Clg kWh (Peak)
- Clg kWh (Off peak)
- Htg kWh (Peak)
- Htg kWh (Off-peak)
Utility costs – taking advantage of time of use rates

Reducing electrical consumption during peak hours and shifting power consumption to off-peak hours reduces energy cost from $971,000 annually with a conventional HVAC system to $297,000 – 71% reduction.

Is it feasible?
High electricity costs & the ability to take advantage of TOU rates make the project more feasible. Gas costs are slightly less than the cost of off-peak electricity, but since cooling is the greater load, the utility rates in the region make the project more feasible.
Site accessibility

The project is located on approximately 15 acres of land adjacent to a river. The buildings cover approximately 15% of the site, leaving about 12.5 acres of land available for construction of a GHX. The project is being built in stages over 4 years reducing logistical problems.
Is it feasible?

Site accessibility – underground services and site work

The site is a greenfield site. There are no existing underground services that will create problems during construction of the GHX if the civil engineering team designing the services coordinates with the GHX designer. Location of construction site trailers and material storage should be considered early in the process.
Site accessibility – GHX under the building or geothermal piles

The site is large enough that resorting to drilling under the building footprint or designing geothermal piles is unnecessary.
The site is located adjacent to a large body of water…but discussions with local authorities quickly ruled out the use of a heat exchanger in the lake because of the fear of thermal pollution.
The physical size of the site allows several options. Depending on the geology found on testing, indications are that inserting shallow U-tubes to a depth of 80’, or horizontal drilling are options, as well as deeper boreholes and possibly access to an aquifer.

GCHP System Feasibility

Environmental Considerations
Integrated Design Process
Contractor Resources
Utility Costs
Site Accessibility
Geology

OTHER CONSIDERATIONS SCORE

7 out of 10
Other considerations – reduce noise, water consumption

The project is located in a region where excessive water consumption is frowned on. Being able to eliminate water use in an evaporative cooling tower and the noise associated with it demonstrates their concern about the environment.
Other considerations – green utility

The development company is very interested in developing a geothermal utility in appropriate projects. Investing in a GCHP system and GHX provides an opportunity for a large geothermal utility that sells tenants thermal energy rather than gas or electricity.
Other considerations – marketing a “green project”

The client is a large, leading edge developer who sees the value of being the first in the region to market a “green” project to residential, commercial and retail tenants.
Other considerations

There are several factors that provide the project developer an incentive to consider a GCHP system, making it, in their eyes, more feasible.

OTHER CONSIDERATIONS SCORE

10 out of 10
Environmental considerations – building codes & policies

Some jurisdictions have created policies that require developers to meet “green building standards”. These standards can create situations where it becomes unfeasible for developers to consider systems, including GCHP systems, to meet energy efficiency guidelines and regulations.
Based on geotechnical studies, the geology on the site consists of:

- 0 - 90’: silt, clay, sandy silt, marine shells
- 90’ – 120’: confining layer of clay
- 120 – 400’: layers of saturated sand, course sand
A local GHX contractor and civil engineering company have developed a method of forcing 0.75” U-tubes into soft silts and clays to a depth of 82’. This method allows the installation of up to 5,000’ of U-tubes per day. The cost is less than 50% of the cost of conventional drilling techniques (mud rotary, dual rotary, etc.) and makes the project more feasible.
The plastic clays and silts in the to 90’ are ideal for horizontal drilling. This technique may be ideal for the extended piece of property on the waterfront. The cost is expected to be similar to the cost of pushing vertical U-tubes to a depth of 80’, but may take better advantage of the configuration of the long, narrow strip of waterfront land.
Geology – integration of the aquifer with GHX

Site is above a strong aquifer. Wells can supply 200 to 400 gpm. Circulating 300 gpm through a heat exchanger allows the aquifer to dissipate up to 25% of the peak cooling load into 70°F water, or can add heat to the GHX if needed. Cost of the wells is estimated at $180,000.
The building and building system designs are a major factor in the size and cost...and feasibility of a GCHP project. The configuration of the GHX field and taking advantage of the geology of the site can also make a major difference in the cost of the system. The amount of drilling in this project dropped from 436,000’ to 111,000’ – 75% saving.
Shallow vertical pushed U-tubes

The geology of the site allows for several different GHX configurations (deep drilling, shallow insertion and horizontal directional drilling). The capacity of the closed loop GHX is supplemented by a strong aquifer that can remove excess heat from the GHX or add heat to it. A predictive control strategy helps manage the temperature of the fluid delivered to the heat pumps. Improves efficiency, lowers cost.

GEOLOGY SCORE

9 out of 10
Building owners seldom ask if it’s feasible to install a gas boiler or chiller…it’s almost a given. When they are spending more money on a new technology, most owners want to know if it’s feasible. A designer is developing the “basis of design” of the whole project at this stage to assess the feasibility…and should be charging more for this.
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