Engineering White Paper

HVAC Strategies For Saving Energy
What is the main advantage of the CGC Hybrid Heat Pump System?

The answer is quite simple: Energy Savings.

The CGC Hybrid Heat Pump System is designed to use considerably less electricity than traditional reversing WSHP systems, since the compressors only operate in the cooling mode and NOT in the heating mode. The rejected energy from the cooling units is transferred directly to a hydronic heating coil located in the unit similar in operation to a simple fan coil. There are no reversing valves in the CGC Hybrid Heat Pump units. In order to determine how much electrical energy can be saved by not operating the compressors for heating, consideration must be given to the amount of annual operating hours in both the heating & cooling modes.

**Figure 1: Electrical consumption, kw-hr (100 - 1 ton heat pumps operating for 1 hr.)**

![Graph showing electrical consumption](image)

**Total Energy Consumption**

**Figure 2: BTUH consumption (Electricity & Natural Gas) (100 - 1 ton heat pumps operating for 1 hr.)**

![Graph showing BTUH consumption](image)

Figure 2 depicts total energy consumption measured in BTUH. Taking into account electricity and natural gas consumption, the CGC Hybrid system shows a net reduction in total energy usage.
Energy costs – CGC vs traditional WSHP

When the costs of energy (electricity and natural gas) as well as the quantity of energy consumed are factored in, the CGC Hybrid Heat Pump System consumes less energy and shows a net reduction in operating costs over traditional reversing Water Source Heat Pumps (WSHP).

Figure 3: Energy Costs (Gas & Electricity combined) (100 - 1 ton heat pumps operating for 1 hr.)

![Energy Costs Graph]

(Electricity @ $0.08/kw-hr, Gas $ 1.28 therm, $ 0.0127/cu.ft., $ 0.45/cu.m)

Geothermal savings

An independent analysis by Caneta Energy confirms that a CGC Geothermal system installed in a Toronto area office building will result in 23.8% energy savings over a conventional GSHP system.

<table>
<thead>
<tr>
<th>System type</th>
<th>HVAC Only (Annually)</th>
<th>ENTIRE Building (Annually)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Energy Use (KWh)</td>
<td>Operating costs ($)</td>
</tr>
<tr>
<td>Conventional GSHP</td>
<td>619,963</td>
<td>$ 55,169</td>
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<tr>
<td>CGC Hybrid</td>
<td>472,309</td>
<td>$43,311</td>
</tr>
<tr>
<td>Savings</td>
<td>147,654 (23.8%)</td>
<td>$ 11,858 (21.5%)</td>
</tr>
</tbody>
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“Caneta Energy has modeled heat pump systems in a significant number of buildings over the past number of years. We have seldom seen a concept as promising as the CGC Group hybrid system particularly when used in a ground coupled system with water-to-water heat pumps between the building loop and ground heat exchanger. When the building is balanced thermally, the ground heat exchanger can be by-passed, to maximize heat recovery and minimize pumping. This provides the benefits of conventional water-loop and ground source concepts in one system.”

Caneta Research Inc
R.L. Douglas Cane, P.Eng, Principal

April 24, 2007
The CGC design utilizes the building’s rejected energy from cooling units to directly satisfy various building heating loads.

This process eliminates the wasteful rejection of heat to a fluid cooler or geo-thermal loop. This benefit is realized whenever there is an excess amount of heat from the cooling units (typically shoulder seasons). In a traditional reversing WSHP system operating in the heating mode, the fluid loop is used as evaporator water and must be maintained to less than 90°F. In such cases, fluid coolers may be required to maintain this temperature which is a needless waste of energy.

With the CGC Hybrid design operating in heating, the warmer the water the better since the water is used directly for building heating purposes. Heat rejection to a fluid cooler or ground loop is the very last resort.

Rejected heat from the cooling units used as a direct heating source is referred to as FreeHeat™.

In some cases FreeHeat™ can eliminate the requirement for a separate high temperature water loop and can be used in the following applications:

- Fresh Air pre-heating
- In-floor radiant heating
- Zone heating
- Snow melting
- Pool heating
- Low grade heat for unit heaters

The CGC Hybrid make up air unit (Varipak) is a hybrid heat pump with heating and cooling capabilities that does not use natural gas as the heating source.

Whenever there is excess rejected heat in the fluid loop, the Varipak unit pre-treats the fresh air with this FreeHeat™. With a traditional reversing WSHP, it is not uncommon to have heat injection and heat rejection operating simultaneously. Gas-fired make up air units regularly operate while fluid coolers reject unusable heat.

With the CGC design the simultaneous operation of a gas-fired make up air unit and a fluid cooler is eliminated.

As the outdoor ambient temperature falls, the water loop temperature is scheduled with boiler operation to meet the heating requirements.
Thermal balanced comparison for a commercial Heat Pump application

Traditional Reversing WSHP System

- 40°F Ambient
- Typical Shoulder Season
- 336,000 BTU/h Excess heat rejected
- 5,000 CFM @ 70°F
- Energy Bills
  - Electricity
    - Cooling: 30 compressors @ 1 kW = 30 kW
    - Heating: 10 compressors @ 1 kW = 10 kW
- Natural Gas
  - 204,000 BTU/h INPUT

CGC Hybrid Heat Pump System

- 40°F Ambient
- Typical Shoulder Season
- 162,750 BTU/h
- Loop at 95°F
- FreeHeat™
  - 137 MBH Available
- Energy Bills
  - Electricity
    - Cooling: 10 compressors @ 1 kW = 10 kW
    - Heating: 0 compressors
  - Natural Gas
    - 5 BTU/h

204,000 BTU/h IN/OUT

Energy in Motion
**What about heat injection?**

In either system (traditional reversing WSHP & CGC Hybrid), heat injection will be required whenever there is insufficient heat in the fluid loop to satisfy the heating load. This will typically occur when there is greater than 50% of the units calling for heat. Therefore, a boiler is always required.

Since the traditional reversing WSHP system generates some heat from the compressors, it may require less input from the fluid loop. The CGC Hybrid design may require more boiler load since it does not generate heat from the compressors. When a CGC Hybrid make up air unit (Varipak) is used to pre-treat the fresh air with FreeHeat™, the total building annual natural gas consumption should be less than if gas-fired make up air units were used.

An important consideration to take into account is that both systems will require boiler operation at some point in order to introduce heat into the water loop.

**Figure 4: Boiler energy consumption, BTUH (100 - 1 ton heat pumps operating for 1 hr.)**

![Boiler energy consumption graph]

**Energy Efficiency Ratio**

The CGC refrigeration system is optimized for cooling operation only and NOT for heating. The results are considerably higher EER’s when compared with a reversing WSHP that has to operate in both heating and cooling modes. Furthermore, there are no reversing valves in the CGC design which further improves the efficiency. The shell and tube condenser is much more effective and efficient at removing heat than coaxial condensers. Strictly from an EER perspective, the CGC unit is significantly more efficient. Typical EER’s for the CGC product line are 15 and higher, while standard reversing WSHP have EER’s in the 12 to 14 range.

Most manufacturers do have optimal high efficient models, but appear to be seldom provided due to their significant higher premiums.
Does the cost of natural gas affect the CGC advantages?

The answer is NO. It would not affect the advantages of the CGC Hybrid System.

The CGC Hybrid system actually reduces the amount of energy consumed.
The costs of the energy source can affect the operating costs but it will have no impact on the amount of energy required for either system.

An important point to consider is that the cost to generate heat with electricity is typically higher than the costs to generate heat with natural gas. The CGC system reduces the amount of electricity consumed which is the most expensive source of energy.

CGC compared the energy costs to generate a million BTUH with electricity and with natural gas.

Electricity was assumed to have a somewhat modest cost of $ 0.07/kwhr, while natural gas was assumed to have a cost of $1.25/therm. Still, the cost to generate heat with natural gas is lower than with electricity.

![Cost Comparison Graph]

Boiler efficiency=85%

The CGC Hybrid Heat Pump design has many inherent design benefits:

- High EER’s, due to unidirectional refrigerant flow.
- Maintain ASHRAE 90.1 minimum EER level with a low flow rate of 2 gpm/ton and high water loop temperatures.
- Low flow rate of 2 gpm/ton vs 3 gpm/ton will result in lower pumping energy as well as smaller pipe sizes and possibly smaller pumps.
- Lower flow rates and higher operating temperatures can reduce the fluid cooler size.
- Better heating comfort. The heating requirements are satisfied by scheduling the water loop temperature (heat injection) with the ambient conditions. The CGC heating algorithm calls for low fan speed operation for the first 10 minutes. A traditional reversing WSHP has full compressor operation.
- Less compressor cycling = less maintenance + longer compressor life.
- Very quiet operation even with compressor operation (cooling), fan coil sound levels on heating.
- Significantly lower MCA is some cases may warrant a smaller electrical infrastructure.
- A separate high temperature water heating loop is regularly eliminated with the CGC design.
- Gas-fired make up air units are not required if the CGC design incorporates a Hybrid Heat Pump make up air Unit (Varipak).