Capital Manor Retirement Community, Salem, USA

Renovation and monitoring of the sanitary hot water system in a multi storey retirement home by installing a high temperature gas engine heat pump in the central technical room on an existing installation.

Key facts

Building

Location	Salem, OR, USA
Construction	2017
Heat distribution	in building
Heated area	17,190 m² living
Level of insulation	average

Heat pump and source

Number of heat pumps	1
Installed capacity	117 0 175 kW
Operation mode	monoenergetic
Heat source	Air source
Brand and type	Tecogen Ilios HEW 500 AS
Refrigerant	R134a
Sound level	72 dB

Heating system

Heat demand	300 MW
Heating temperature	37°C

Domestic hot water

Type of system	see overview
Max. Temperature	71°C
Demand	289 MW
Circulation system	
Legionella measures	thermal
Storage size	455 litres
Number of storage tanks	
Storage losses	
Temperature control	

Other information

A monitoring study has been done by ENERGY 350 for NEEA and reported upon in 'Natural Gas Internal Combustion Engine Heat Pump Field Trial' - Final Report

The Capital Manor Retirement Community in Salem, OR is comprised of the Manor Care building and Main Tower building, each of which have separate mechanical systems. It is a 10-story, 17,190 m² building. The first floor contains a lobby, kitchen, dining hall, auditorium, and various other common areas. The basement contains storage space and maintenance offices. The remaining floors in the Main Tower are common areas and individual tenant spaces. An additional attractive attribute of Capital Manor is that there is a heating loop in close proximity to the DHW loop. This allows for the heat pump to be used for both DHW and HHW via a hydronic loop.

An ideal site is one with a large DHW load, significant DHW storage capacity and reasonable installation logistics. Storage capacity is important because it smooths out peaks in usage, allowing for less heating capacity to be installed. This allows the heat pump to be sized closer to the base load rather than the peak, dramatically increasing loading and run hours. Additionally, by smoothing out peaks in DHW use, a larger portion of the heating loads can be met by the heat pump, relying less on the backup boilers (or other heating source) to cover peaks in load.

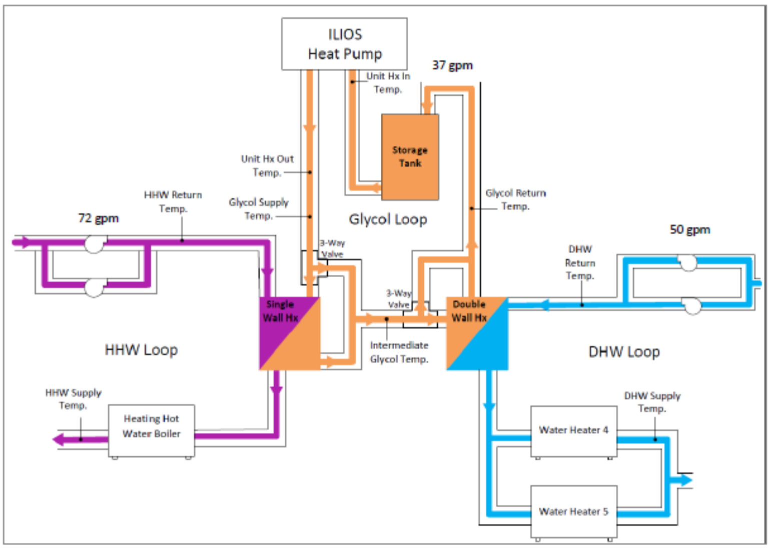
The Northwest Energy Efficiency Alliance identified a natural gas internal combustion engine heat pump water heaters as a candidate with the primary advantage its ability to provide domestic hot water at significantly higher efficiencies than natural gas boilers. This report summarizes actions and performance results from the installation, operation and testing of this product in the field. This report includes analysis of two months of collected data from the baseline system and over eight months from the retrofitted system. Field data from the retrofitted system was collected from April through December of 2017.

There are several ways to configure a system that integrates the heat pump with the existing DHW and HHW loops, while leaving the existing boilers in place for backup and to cover peaks in load. The capacity of the heat pump is smaller than their peak demand, and only a fraction of the capacity of the existing boilers, which necessitates that the existing boilers remain in place and active to supplement the heat pump during times of high load. Leaving the boilers in place is ideal in that it allows the heat pump to be sized closer to the base load, which maximizes the use and efficiency of the heat pump.

Additionally, the heat pump performance is best when operating at or near full load.

Since the DHW loop is significantly cooler than the HHW loop, a cascading loop control strategy was selected to integrate the two loops in series. This allows the hottest supply water from the heat pump to first heat the HHW loop. Then, the exiting water from the HHW loop is cooler, but still hot enough to heat the DHW loop.

Two plate and frame heat exchangers transfer heat from the heat pump loop to the DHW and HHW loops. To maximize heat transfer and minimize the heat pump supply temperature, low approach heat exchangers, with approximately a 5°F approach were selected. Approach is the difference between the heat pump loop supply temperature and the building loop supply temperature. For example, with a 5°F approach heat exchanger and 150°F heat pump supply temperature, 145°F HHW supply to the building is achievable. Since the heat pump loop requires glycol for freeze protection, a double walled heat exchanger was selected for the DHW loop. This is required by code and adds increased protection against potential contamination of potable water from the glycol.

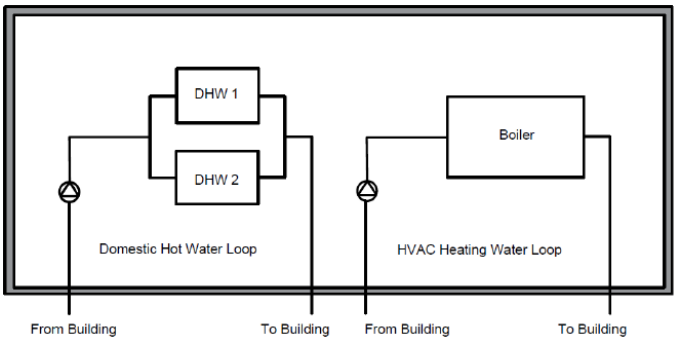


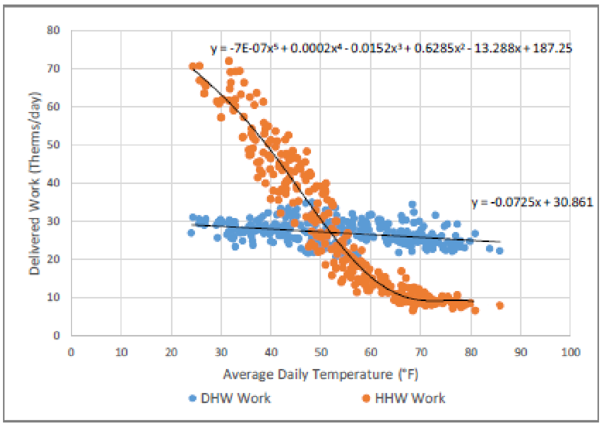
The Figure shows the system design. The glycol loop from the heat pump heats the HHW and DHW loops in series via plate-and-frame heat exchangers. The series design takes advantage of the differential in temperature requirements of the two loops. The HHW loop requires approximately 145°F, while the DWH loop requires approximately 130°F. Based on these offset temperatures, the glycol loop still has a high enough temperature to heat the DHW loop even after heating the HHW loop. Both heat exchangers are controlled with a 3-way valve that either allows flow through the heat exchanger or bypasses it. Under this configuration, if one of the loops does not need heat, the heat exchanger is simply bypassed, preserving the flow and temperature for the loop that does need heating.

Additional equipment required includes temperature and pressure sensors throughout, strainers, a glycol feeder, pressure tank, air separator and a storage tank. The storage tank is required because the heat pump continues to run for two minutes after receiving a stop command. The storage tank simply provides additional thermal mass to store the additional two minutes' worth of heating without causing overheating at the heat pump.

An additional control panel, two actuating valves (one for each loop), temperature sensors at various points, heat pump status, heat pump start/stop command and graphics were added to the existing control system. This allows control of the supply temperature of each loop and a custom sequence of operations that allows fine tuning of the controls to maximize performance. An example of the performance optimization that controls allow is that the heat pump efficiency is greatest when the load is close to full capacity. Often either the HHW or DHW loop is calling for heating, but not both, which can create low load operation for the heat pump and reduce efficiency. Because of this, we programmed the heat pump to start when either loop calls for heating, but when running, the heat pump will heat both loops as long as neither is overheated. This allows the heat pump to run closer to full load and at increased efficiency. This control strategy has allowed the heat pump to operate 69% of its run-time at greater than 80% load.

Capital Manor Retirement Community, Salem, USA, Technical details



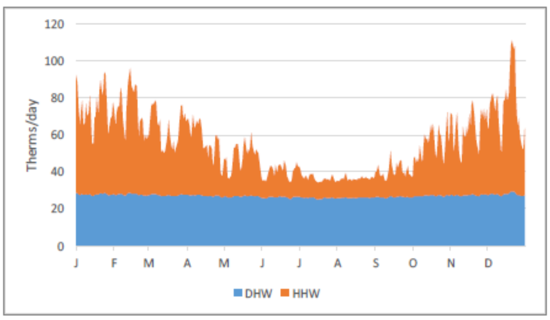


Daily deliver hot water loads

Count	Equipment	Manufacturer	Model	Capacity	Notes
1	ICE Heat Pump	Ilios	HEW-500-AS	400-600 kBtu	160 °F Setpoint
1	DHW Heat Exchanger	Bell & Gossett	GPX P20 - DW	472 kBtu/hr	Double Wall
1	HHW Heat Exchanger	Bell & Gossett	GPX P20	472 kBtu/hr	Single Wall
1	Storage Tank	Lochinvar	RJA120	120 gal	Glass Lined

Description of the technical concept

During the performance period (April through May 2017), the glycol flow was measured and heat pump supply and return temperatures to calculate total work done by the unit. Additionally, an intermediate glycol temperature was measured (after HHW heat exchanger and before DHW heat exchanger) to calculate the respective hot water load of the individual HHW and DHW loops. The figure above shows the delivered DHW and HHW load over the baseline and performance periods over a range of daily average ambient outside temperatures. By applying the DHW and HHW regressions shown in the figure to typical meteorological year (TMY311) average daily temperatures, we calculate an annual hot water load profile for the site. Figure below shows the daily load to the facility on a typical weather year.



The heat pump by Tecogen-Ilios has a rated capacity range of 117 – 175 kW, depending on outside temperature. It has a manufacturer rated Coefficient of Performance (COP) range of 1.2 to 2.2, also depending on outside temperature. The heat pump delivers 190 litres/hour of hot water between 38° to 71°C, which is user selectable. The packaged unit includes the following components:

- 50 hp, 4-cylinder natural gas or propane fuelled engine, manufactured by Ford.
- Open-drive reciprocating compressor, belt-driven by the engine, utilizing refrigerant R-134a.
- Compact brazed-plate condenser.
- Air-cooled evaporator coils.
- 5 kW internal generator for parasitic load.
- Heat recovery system that recovers heat from the engine jacket and exhaust as well as the heat rejected from the condenser.
- 1.5 hp water pump for hot water delivery.
- Internal controllers, sensors, etc.