Homeport Ashore Housing

Efficiency via TOC Process

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Project Summary

Willis Manor, named for the WWII Medal of Honor Winner, was procured as Design-Build P-123 Bachelor Quarters, Homeport Ashore Norfolk Naval Station (N40085-11-C-4572). The Clark Construction/ LS3P design team was awarded the project as the first NAVFAC MIDLANT project evaluated for Total Ownership Cost (TOC). For the design-build team, P-123 represents the culmination of 12 years of involvement in design-build competition and delivery for NAVFAC and USACE. Many Clark Construction/ LS3P projects have included BEQs and barracks, and the team has developed a wealth of knowledge in appropriate systems selection and implementation.

The facility includes state of the art energy efficiency systems selected via analyzing the TOC over the 40 year life cycle in the design/build award evaluation. This strategy allowed trade-off of first cost saving versus long-term energy costs. The resulting mechanical systems included a hybrid geothermal water source heat pump system. The hybrid system optimized energy savings from ground-coupled heat exchangers for the majority of hours, without sizing the expensive well field for peak loads that only occur for a few hours of the year. The system also rejects energy from the dominant cooling load of the facility to preheat domestic water.

Architectural Goals and Features

The architectural massing with linear wings on the east/west axis takes advantage of effective passive solar design, with only one side of the building receiving direct solar exposure at a time. This orientation allows individual dwelling unit heat pumps to share a common condenser water loop with beneficial load equalization. During the moderate parts of the annual solar/seasonal cycle, one side of the building is contributing heat to the loop and the other side is drawing heat from the loop.

A high-performance building envelope with air barrier and insulation performs 40% better than ASHRAE A90.1 requirements. The air barrier blower test completed at commissioning provided significantly better results than RFP requirements.

Integrated project delivery

The design-build team developed an Integrated Project Delivery protocol to bring together all elements of the project in an intensive multi-day design charrette, hosted at the geographically central Atlanta office of MEP consultant Newcomb & Boyd.

The mechanical system was conceived as a total system that would optimize energy efficiency, first cost, and operating cost to provide the best TOC. The initial design integrated all mechanical spaces and distribution paths.

Civil engineers mapped the geothermal well field for several scenarios, with the geothermal field contribution at 30, 50, 75, and 100% of the total load. At 100%, the well field consumed the total site area including planned contractor work/lay down areas, creating construction sequence and schedule issues which would have disrupted construction sequences and overall schedule.

State of the Art Energy Systems

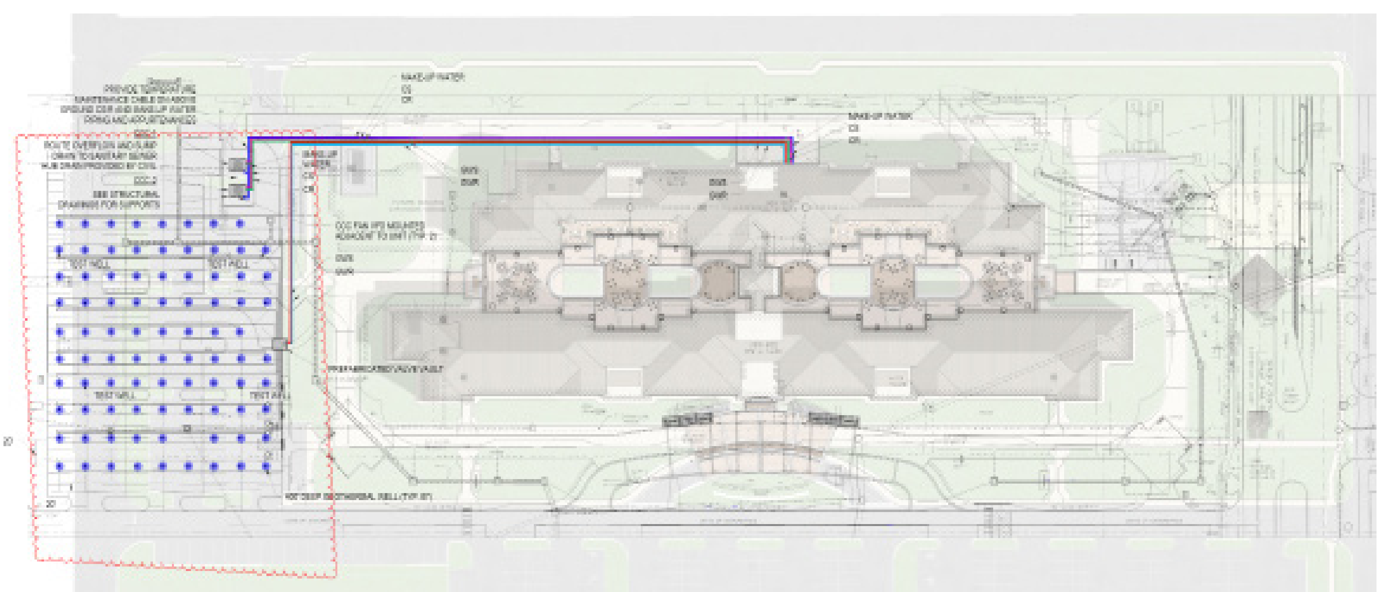
The HVAC system is a Hybrid Ground Source Heat Pump (HGSHP) with geothermal well field, supplemental closed circuit cooling tower, and back-up boiler. The fully integrated solution takes advantage of the east-west building orientation and geothermal water source heat pump technology to produce optimum performance, minimum energy usage, minimum maintenance, and lowest TOC.

Energy recovery from simultaneous heating and cooling of the common water loop contributes to energy savings. In addition, compressor efficiency from low lift by transferring heat to the moderate earth temperatures further increases energy savings. The high-efficiency envelope design and the reduction of lighting loads also substantially reduce energy loads.

Energy Recovery Units recover heat from the exhaust air to pre-condition outside air. In the Willis Manor design, the Energy Recovery Units are also water cooled heat pumps connected to the geothermal loop, so they have the same efficiency improvements from the earth as the heat sink/source for the balance of outside air heating and cooling. The system includes variable speed drives for all pumps and fans.

The geothermal loop also produces domestic hot water pre-heating; dual use of the system to both increase HVAC performance and provide hot water pre-heating further enhances the benefits of this system. Compared with other systems such as VAV and VRF, the team found the HGSHP system to have the lowest 40-year life-cycle cost.

Adoption of ground-coupled heat pump systems has suffered over the years due to the high cost of the well field. Drilling, piping and grouting of the wells is expensive. When systems are designed to meet 100% of the peak heating and cooling load, the cost is often more than the project can bear. Also, in the southern states, cooling loads far exceed winter heating loads. This disparity leads to an imbalance of heat transferred to the earth in summer versus heat extracted from the earth in winter. Over the 40 year life of this project,



Hybrid Geothermal System Well Locations the differential can lead to substantial increases in average earth temperature at the well field, which lowers the energy efficiency of the heat pumps and reduces system cooling capacity. A better, hybrid, approach uses fewer wells which are sized based on the goal of more evenly balancing annual heating and cooling heat transfer, with supplemental evaporative fluid coolers picking up the peak cooling loads and supplemental boilers picking up the peak heating load when the well field is unable to meet the demand.

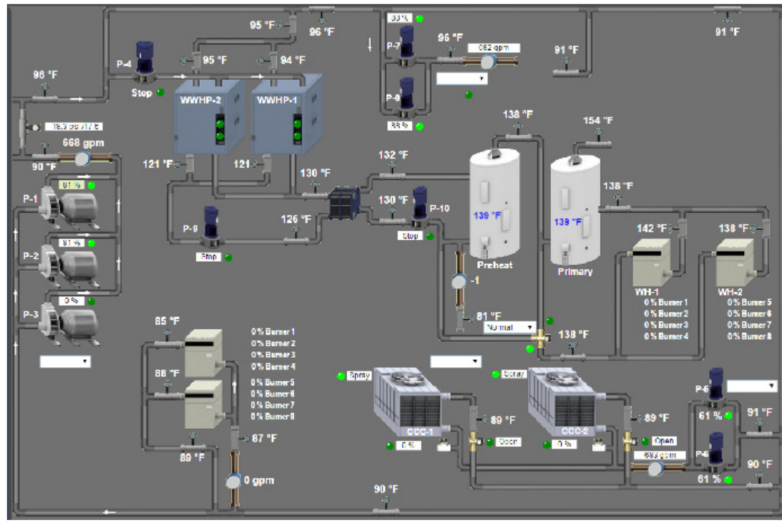
The lowest TOC resulted from a system with a well field sized for approximately 50% of peak cooling loads. This approach cut the size of the well field in half, substantially reducing first cost while maintaining most of the energy savings since the number of hours the system operates at peak cooling or heating load is relatively small as a 24/7 operations building.

Sustainment

In addition to substantial energy savings, the HGSHP system offers numerous advantages from a sustainment cost viewpoint. First, all cooling is provided by the geothermal well field in conjunction with a supplemental evaporative fluid cooler. The geothermal well field is a network of underground fused polymer piping that requires no maintenance and is considered to have a life of 50 years. Similar to a closed chilled water system, only normal periodic closed water loop water treatment is required. By the nature of its occupancy and use patterns, a BQ will rarely operate at full cooling capacity. Most of the time the geothermal well field should be able to handle the load, reducing the run time and maintenance cost of the fluid cooler. Stainless steel basin construction will extend the life of the fluid cooler.

The water source heat pumps are installed in corridor-accessible closets for easy maintenance. Each heat pump is connected to geothermal loop piping risers via isolation valves and flexible hoses. If a problem develops that cannot be readily repaired in place, the heat pump can easily be disconnected and replaced by a spare unit by maintenance personnel with a hand truck, without draining and refilling the entire system.

Energy recovery outside air units are provided with fully hinged, easy-access doors for service and include clearances meeting or exceeding manufacturer's recommendations. With heat pumps connected to the geothermal loop, the refrigeration systems are subject to less extreme operating conditions. Cooling/heating



Hybrid Geothermal Loop Commissioning Screenshot

is done by refrigerant DX cooling and reheat coils, thus avoiding concerns for freeze protection of the outdoor air coils.

Water Heating Systems

Domestic hot water heating comprises a very significant portion of the total energy consumption for this type of facility. Water-to-water heat pumps connected to the geothermal loop will handle a significant portion of heating of domestic water. During cooling mode, which is most of the time, the energy extracted from the geothermal loop is actually recovered from the space-cooling heat rejection without imposing a load on the well field. Supplemental domestic water heating needed during morning peak conditions will be provided with modular condensing boiler type natural gas water heaters with no less than 95% efficiency. Supplemental condensing water heaters are stand-alone boilers with separate large hot water storage tanks. This system allows simple replacement of the boiler at the end of its life without disturbing piping or large storage tanks.

Start-up and Commissioning

The official ribbon cutting for the facility took place on September 3, 2015 so actual operating data is not yet available. During system start-up and commissioning the system performed exactly as expected. During mid-July with outdoor conditions exceeding ASHRAE design day conditions, the system can be seen in Figure X (loop screen shot) to be experiencing a temperature rise of 6 degrees on the supply loop to the building (from 90 degrees

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to 96 degrees). The water is then pumped to the geothermal field by pumps P-7 and P-8, where is cooled from 96 down to 91. The closed circuit coolers, with no fan energy expended, cool the loop the remaining one degree from 91 to 90. At this condition, the well field is handling 83% of the cooling load with the conventional cooling system finishing off the balance. While the building was not yet occupied, the facility was experiencing full outside air conditioning and solar load. When fully occupied, the hybrid system should more closely split the load 50/50 under peak cooling conditions. This approach provides excellent energy efficiency while lowering first cost, exactly as the TOC process was intended to achieve.

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Special Thanks to all who contributed to this issue of the APC Quarterly Journal.

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