The 90-year-old St. Clair County Community College, Port Huron, Mich., replaced its 1970s vintage HVAC system with a new, state-of-the-art energy-efficient system and installed a central water-to-water heat pump system to provide heating and cooling.

GSHP for 1920s Building

By Wayne E. Kerbelis, Associate Member ASHRAE

First known as Port Huron Junior College in 1923, the St. Clair County Community College District was eventually formed in 1967. Largely providing academic programs in the 1950s, the college began to offer vocational-technical programs. Today, the college even offers alternative energy associate degree programs.

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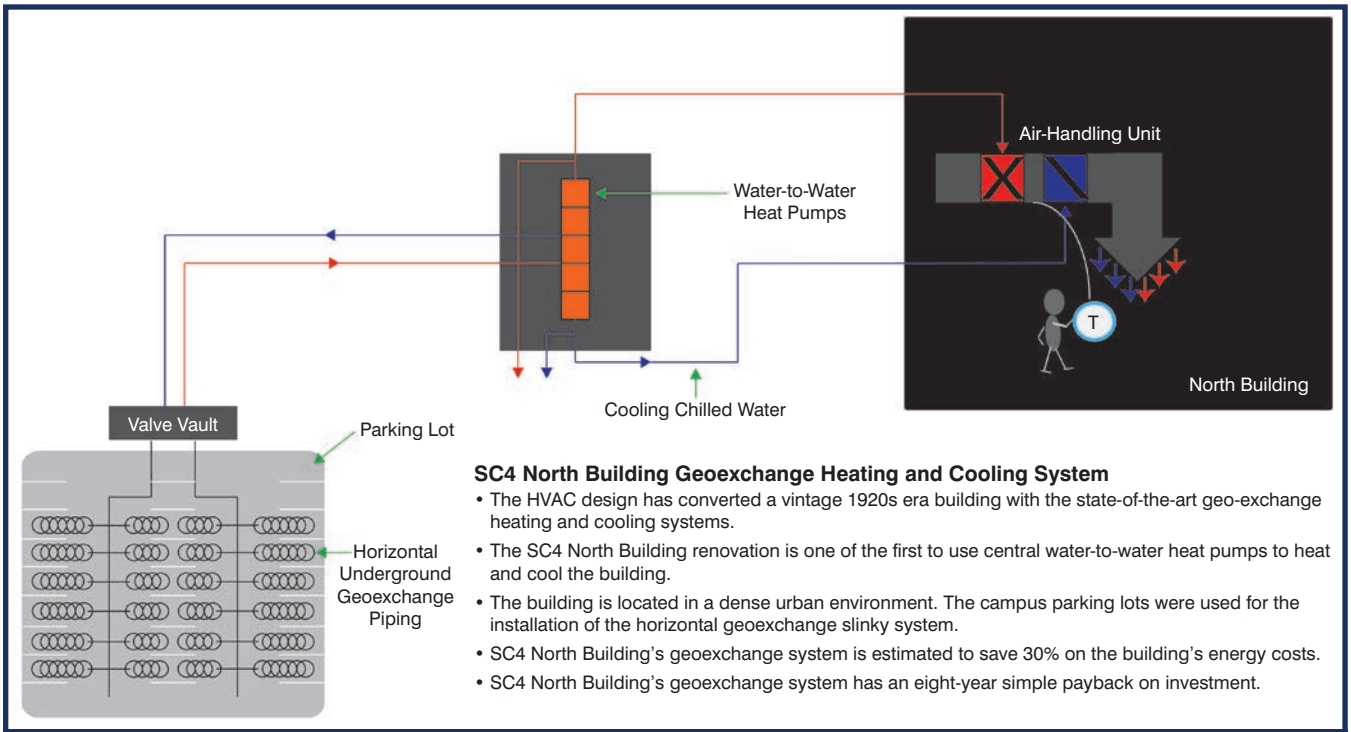


Figure 1: The water-to-water heat pump system required only six heat pump units rather than distributed water-to-air heat pumps, avoiding incorporating a compressorized heat pump into each controlled space.

Campus-wide green building initiatives began with several facility efficiency upgrades. Among the green initiative's many challenging opportunities was an ambitious HVAC replacement project for one of its older buildings on campus, the North Building, formerly known as the Old Main Building. Today, the two-story 58,885 gross ft^2 (5470 m^2) and 52,574 net ft^2 (4884 m^2) building houses faculty offices, instructional classrooms, laboratories, a gymnasium, and a fitness area.

As a multipurpose facility that had worn many hats throughout its 92-year lifespan, the building was in need of an HVAC system replacement. The existing room unitary heating and cooling system had seen its fair share of use and had begun to deteriorate, providing poor indoor climate and generating excessive noise in each space.

Design Challenge

The design team had their hands full with the challenge of retrofitting a circa 1920 building using the state-of-the-art HVAC technologies.

The college had no additional funds to upgrade existing windows or provide additional insulation on the exterior wall of the building, so the existing building shell was to remain as-is and be factored into the new HVAC design.

Following weeks of analysis, cost estimating and discussions with the owner, the engineering design team determined the best fit for the college, as far as energy efficiency and creating a demonstration piece for the academic learning community, was to incorporate a central geoexchange water-to-water heat pump system to serve the North Building.

Finding a location for a ground source central geoexchange water-to-water heat pump system's expansive geoexchange field proved difficult in such a tight urban area. Additionally, the design team was faced with applying such a system to a 92-year-old building without affecting the building's aesthetics and having to complete construction during the summer: May 3 to August 20, in time for the start of the fall semester.

The original thought was to use deep vertical bores in the earth around the building to minimize ground surface area. However, the City of Port Huron denied the vertical bore plan citing the city's location over a lake bed with large deposits of methane gas. Based on the

Building at a Glance

St. Clair County Community College: North Building

Location: Port Huron, Michigan

Owner: St. Clair County Community College

Principal Use: Administrative and instructional

Includes: Faculty offices and instructional classrooms

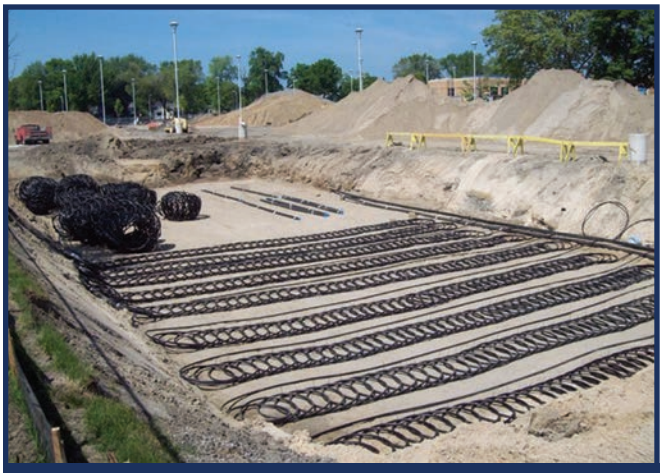
Employees/Occupants: 1,050

Occupancy: 100%

Gross Square Footage: 58,885

Conditioned Space: 52,823 ft^2

Substantial Completion/Occupancy: 2010



Two hundred and seventy slinky coils were buried 8 ft (2 m) below the 97,590 ft^2 (9066 m^2) parking lot.

The parking lot is sloped to direct water to green islands, where vegetative filters and groundwater infiltration treats the runoff.

city's experience with the issue of vertical boring, it decided it was not a feasible or a desirable option. However, a suggestion was made to use an adjacent parking lot, which coincidentally, was in poor shape and in need of replacement; this offered the option to use a horizontal geoexchange field, and ultimately, led to the college's decision to go with this option.

New System Description

For the new geoexchange field, a total of 270 slinky coils, which produces 210 tons (739 kW) of cooling, were buried an average depth of 8 ft (2 m) below the 97,590 ft^2 (9066 m^2) parking lot, avoiding any potential for frost heave conditions. High density fusion welded polyethene distribution piping, which

holds an environment-friendly, propylene glycol-based antifreeze solution, would enable the coils to absorb heat from the earth in the winter and reject heat to the ground in the summer.

Located below green space and parking lot surface, the closed loop piping system enters into an underground concrete vault, which houses piping manifolds that distribute separate 4 in. (102 mm) supply and return piping to each of the three sets of branch piping run outs in the parking lot. The piping manifolds are arranged to balance flow to each slinky coil section.

The selected water-to-water heat pump system uses six 35 ton (123 kW) water-to-water heat pumps connected together where one end of the heat pump system provides chilled water for cooling the building, and the other end provides hot water heating. All six heat pumps have the capability for reversing heat/cooling cycling. Depending on the building load, one heat pump is dedicated to heating or cooling. The five remaining heat pumps can either heat or cool to meet the building demand.

Heating hot water or chilled water from the heat pumps is supplied (variable flow) to two central rooftop variable air volume energy recovery air handling units equipped with demand ventilation carbon dioxide sensors, providing further energy-efficient operation.

In addition to the HVAC system replacement, all fluorescent T-12 lamps were replaced with fluorescent T-8 lighting with occupancy sensor control.

Indoor Air Quality

Fresh air intake airflow measuring stations were installed on each air-handling unit to measure, control and maintain the required ventilation to the building. In addition, carbon dioxide sensors were installed in each space to measure and eliminate space contaminants.

Innovation

To successfully integrate a state-of-the-art, energy-efficient central water-to-water heat pump system into a 1920 vintage building, the design team looked at all available options. The team's selection to go with a geoexchange water-to-water heat pump system resolved many of the potential challenges a unitary heat pump unit system may present. For example, the decision to go with this type of system required only six heat pump units, rather than 60 distributed water-to-air heat pumps. This also avoided incorporating a compressorized heat pump into each controlled space.

At 30°F (1°C) ground source water temperature, the heat pumps can provide 130°F (54°C) hot water for heating and, at

85°F (29°C) ground water source temperature, the heat pumps can provide 42°F (6°C) chilled water.

The SC4 North Building's location in a central urban environment required a certain amount of innovation, when it came to locating the geoexchange system. The installation of the geoexchange pipe system under the parking lot offered a solution that allowed full functionality of the parking lot for students, faculty and visitors, while serving its purpose as a field for the new underground pipe system. In addition, the parking lot asphalt pavement was sloped to direct water drainage from the parking lot to multiple green islands, where vegetation filters water runoff. The runoff to the islands soaks into the ground, aiding to cool the underground geoexchange field in the hot summer.

Operation & Maintenance

Operation and maintenance is superior with the central heat pump system to the distributed heat pump system. With only six heat pumps located in a central accessible mechanical room versus 60 compressorized heat pumps spread throughout the building, O&M is greatly reduced.

Air-to-air energy recovery heat exchangers were provided in air-handling units that have no motorized parts to maintain.

All mechanical equipment has direct digital controls monitored by the campus energy management system (EMS). The EMS monitors runtimes of the mechanical equipment, as well as static pressure drop across unit filters for preventive maintenance scheduling based on unit operation. The EMS notifies the users of any sudden changes in the system, such as loss of temperature or pressure for troubleshooting and quick responses before a serious event occurs.

Cost Effectiveness

A value engineering and energy analysis was performed on the North Building. The cost-effective design with major annual energy and operational cost savings will result in an eight-year payback for the added investment in the energy efficient systems over the less efficient conventional boiler, chiller and air-handling systems. The North Parking lot was slated for a complete replacement, which was funded separately from the building renovation project, and that funding helped factor into the attractive payback of the building's efficient heating and cooling system.

Environmental Impact

The SC4 North Building geoexchange central water-to-water system provides heating and cooling for the North Building without producing carbon emissions.

The new HVAC system eliminated the excessive noise generated by the previous HVAC system, thereby producing a quiet learning-conducive environment.

St. Clair County Community College uses the geoexchange central water-to-water heat pump system as a teaching tool for its students and displays the technology of the system on monitors and on the Web to show the college's commitment to energy conservation and sustainability.

Conclusion

Since the onset of its green initiatives program, SC4 has incorporated green roofs (the first community college to do so in Michigan); alternative transportation opportunities (including the use of electric cars by campus patrol officers); a 60% green retaining wall, which reduces water runoff, filters pollutants and adds natural vegetation to campus; sustainable parking lots with rain gardens and bioswales; associate degrees in alternative energy; an established green team made up of faculty, staff and students, with the goal of developing new environmental conservation ideas for campus.

The SC4 North Building used one of the most energy-efficient systems available to the college: a ground source water-to-water central heat pump system with variable airflow energy recovery air-handling units, carbon dioxide sensors in every space for demand ventilation, variable flow hydronic pumping systems, and high efficient lighting and occupancy sensors for lighting control.

The project was completed on a budget of approximately $4.5 million and was complete from start to finish over an accelerated construction schedule for use at the start of fall classes. The energy savings for the geoexchange central heat pump system based on actual metered reading in the first full year of use was 34,590 MBtus (36 494 MJ) in natural gas and a cost savings of $26,980. Due to the heat pumps providing both heating and cooling needs of the building the electrical usage increased, but was offset by the electrical savings of the new efficient lighting systems. The North Building's total energy consumption prior to the HVAC renovation averaged 156,531 Btu/ft^2 (9743 MJ/m^2) per year and after the renovation was 101,337 Btu/ft^2 (8061 MJ/m^2), which equated to a 38% reduction in energy consumption.

As the first college in Michigan to form a green initiatives program, the HVAC renovation project kick-started an onset of green initiatives at Saint Clair County Community College, including the establishment of a Green Team and associate degree programs in alternative energy, but also led to other efficiency programs in colleges and universities throughout Michigan. ■