Offices

New Approach Results in High Building Efficiency *Case Study*

Iowa Project Showcases Geothermal Source, Dedicated Outdoor Air, Radiant Heating and Cooling

"As a non-profit organization, it is especially important for us to conserve budget dollars. We are pleased with the comfort this system provides, and believe we are saving considerable energy expense in this new building through the design of the system." Speaking is Maddie Cafferty, Director of Support Services for Systems Unlimited, an Iowa City, Iowa organization that provides supported living services, job training and employment to adults with disabilities. The building is a 38,400 sq. ft. facility that houses administrative offices, training rooms and work areas for the organization.

At a Glance

- New 38,400 sq. ft. office building and training facility located in Iowa City, Iowa
- Owner concerned with energy costs and indoor air quality
- Solution: Combine strengths of three leading technologies: ground-source heat pumps, dedicated outdoor air system, and radiant heating and cooling panels
- System includes 8,000 cfm, 30-ton Venmar CES integrated ground-source heat pump energy-recovery ventilator with AHRI Certified™ performance from a total-energy wheel air-to-air heat exchanger; three five-ton ground source heat pumps supplying ceiling-mounted radiant heating and cooling panels.

Systems Unlimited Benefits from Use of Energy-efficient Technologies

Dedicated outdoor air ventilator uses an AHRI Certified™ total-energy wheel to recover energy between the exhaust and outdoor airstreams.

Ground-coupled heat pump comes factory packaged inside ventilator minimizing start-up time.

Ceiling mounted radiant panels provide sensible heating and cooling to the occupants. Conditioned outdoor air is delivered directly to the space to remove latent loads.

VENMAR CES

Limitations of VAV Systems

Building HVAC designers have long understood both the benefits and shortcomings of central-plant heating and cooling using forced air. Development of the VAV approach in the last half of the 20th century allowed improved efficiency through better zone control and variable rates of ventilation, but some of the limitations of forced air combined heating and cooling remain. Air is an inefficient energy transport medium, and a significant portion of a building's energy expense goes to the fan motors needed for air distribution. Large-volume recirculation of building air, as in the typical VAV system, can lead to distribution of contaminants throughout the building.

Taking a New Approach

The building in Iowa City showcases an alternative approach – one that promises to dramatically improve building HVAC plant efficiency while maintaining high comfort levels and offering improved indoor air quality. The system used in the building has three primary elements. First, the building features earth-coupled heat pumps with an underground loop system as a heat source/sink. Second, both sensible heating and cooling are principally achieved with ceiling radiant panels supplied by a highly zoned four-pipe water system. Third, building ventilation and tight control of humidity levels are achieved with a dedicated outside air system (DOAS)—an integrated package that provides building exhaust, total energy recovery from exhaust air, and outdoor air ventilation.

The Systems Unlimited building was designed by architect John F. Shaw of Iowa City, and the HVAC plant was conceived by Vic Amoroso of A&J Associates of North Liberty Iowa. Amoroso indicates he has been studying these types of advanced approaches for years, and his firm has wide experience with all of the elements in the Systems Unlimited facility. This has been the first time he has used all of these tools in a single building. He indicates that to the best of his knowledge, this is the first example of all three technologies being combined in an entire building. The overall HVAC system operation was significantly enhanced by extra insulation and joint sealing used by Shaw to create a very efficient building envelope.

An Emerging Idea

Amoroso credits a 2003 magazine article with stimulating his interest in using a system of this type. The article, by Stanley A. Mumma, Ph.D., discussed the advantages of combining DOAS with radiant ceilings and total energy recovery. Mumma is an ASHRAE Fellow and Professor Emeritus of Architectural Engineering at Penn State University.

The article explained the potential of this type of system to solve problems with poor air distribution, poor humidity control and excessive energy usage for air handling. He points out that this hybrid system also has benefits of a very low acoustic signature and excellent resistance to indoor air contamination being spread through the building by recirculated indoor air.

Combination of Concepts

According to Amoroso, his firm also has extensive experience with earth-coupled heat pump systems. It seemed logical to combine such a system with overhead radiant panels and a DOAS design for the Systems Unlimited facility. "The result," says Amoroso, "is truly a first-of-its-kind building." But he adds, "This is not untested technology. All of these elements have been used successfully for years. What makes this unique is the combination of elements."

Amoroso explains that the use of overhead radiant heating-cooling panels has been in widespread use in Europe for quite a few years. In North America, some

designers have resisted the idea because of concerns about condensation on cool panels from building humidity. "But in an installation like this, we use the DOAS system to tightly control building humidity, keeping levels below the dew point at all times." He explains that by using a four-pipe arrangement, the same panel can heat or cool. Normally in the cooling mode, the circulating water temperature is around 60° F, so it is well above the dew point, further limiting the condensation potential.

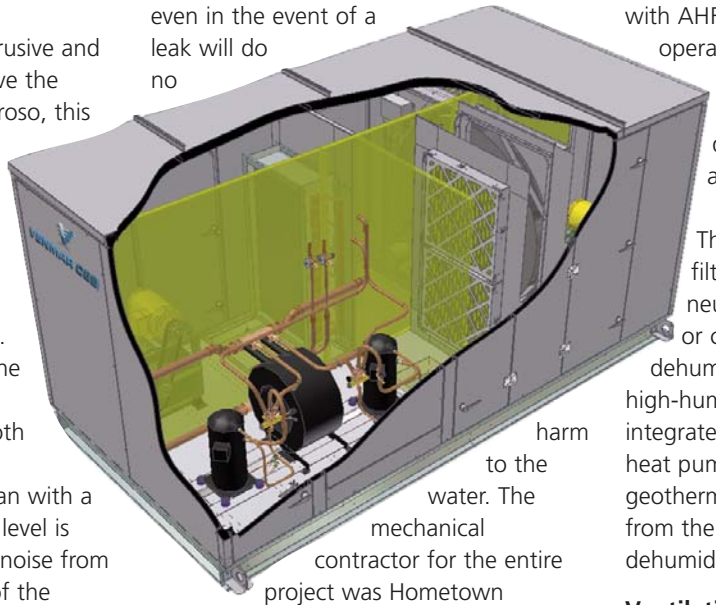
Overhead Panels Unobtrusive and Conserve Space

The overhead panels are unobtrusive and take up little vertical space above the ceiling level. According to Amoroso, this shallow profile, along with the much smaller distribution ducts needed for the DOAS system, means overhead building space can be reduced. This allows for higher ceilings and the use of indirect lighting in certain areas. The indirect lighting improves the overall lighting efficiency and reduces energy use. Because both the volume and velocity of the ventilation air is much lower than with a VAV system, the ambient noise level is reduced. There is no detectible noise from the ventilation air coming out of the diffusers. This is ideal for a work environment.

The operating heart of the system is in the basement of the building. Here is the termination for the underground loop piping for the heat pump system, where the multiple circuits connect to three 5-ton water-to-water heat pumps for cooling and two 15-ton heat pumps for heating. These supply hot and cold water for the radiant panels. According to Amoroso, the system is designed so that two of the three cooling units can carry the entire building load on a design cooling day, and one of the two heating units can carry the entire building on a design heating day. The operating hours for the three units are balanced by the building control system.

Loop System Uses Earth Energy

The underground loop system that feeds the heat pumps was installed by A-One Geothermal of Earlham, Iowa, a regional earth-coupled heat pump loop specialist. The loop is a deep horizontal system that was installed using directional drilling techniques. The circulating fluid in the loop is a glycol-water, treated with chemical stabilizers. The glycol used was a food grade biodegradable product that even in the event of a leak will do no harm to the water. The mechanical contractor for the entire project was Hometown Plumbing and Heating of Davenport, Iowa.



The key to the building air system is the Venmar CES packaged heat recovery and ventilation unit. Venmar CES Inc. has been manufacturing energy recovery equipment since 1952 in manufacturing facilities located in Canada at Saskatoon, Saskatchewan and St-Léonard-d'Aston, Quebec. The indoor unit installed for this project is 19 feet in length, and is designed with dual airflow tunnels – one for outdoor air intake, treatment and supply to the building ventilation system, and the second for return air energy recovery and exhaust. According to Amoroso, "We were attracted to this solution because we had experience with the Venmar CES product, and we like the fact that the entire unit is factory-assembled."

Outdoor Air Treated Before Use

Under normal operating conditions, a high proportion of the building supply air is from outdoors. The building controls have CO_2 sensors to provide an input to control the amount of building air that is recirculated after treatment. Heat recovery from return air is accomplished in the Venmar CES unit using an enthalpy wheel with AHRI Certified™ performance, which operates between the supply and exhaust air flows. The wheel is 63 inches in diameter and 10 inches deep. It handles the entire system airflow of 8,000 cfm.

The unit is designed to supply dry, filtered air to the facility at building-neutral temperatures. Energy to heat or cool incoming outdoor air and to dehumidify the air stream during the high-humidity months is provided by an integrated dual-compressor water source heat pump, also connected to the geothermal loop system. Hot gas reheat from the compressors contributes to the dehumidification cycle.

Ventilation Energy Savings Using Energy Recovery Ventilation

At Design Conditions	Outdoor Air Temperature	Savings
Summer Cooling Energy Savings	83°F DB 76°F WB	24 tons
Heat Energy Saved in Winter	-11°F DB -11°F DB	671 MBh

Constant-Volume Ventilation

The treated supply air is distributed throughout the building using low velocity constant volume supply air fans, distribution ducts and overhead diffusers. Exhaust air is moved using variable speed fans. Amoroso explains that the Venmar CES unit manages the latent aspect of heating and cooling operations, allowing the overhead radiant panels to handle the sensible element only. Using this approach, a much smaller volume of air needs to be moved, dramatically reducing the fan energy cost for the building.

According to Amoroso, when the building was in the design phase, he explained the benefits of this proposed system to the Executive Director, Bill Gorman and to the Board of Directors. He also showed them an alternative plan using a conventional chiller and VAV distribution arrangement. "I explained that the more conventional system would have a somewhat lower first cost, but would have higher operating costs and certain comfort disadvantages. After considering the options, they chose the most efficient option." According to Amoroso, the "green" aspect of the project was important to the agency. "They take pride in the exceptional efficiency of the system."

Utility Supportive of Concept

Amoroso points out that the local electric utility, Mid-America Energy, was supportive of the energy-efficiency elements of the building design. The utility provided an energy-efficiency rebate to offset some of the costs of the project.

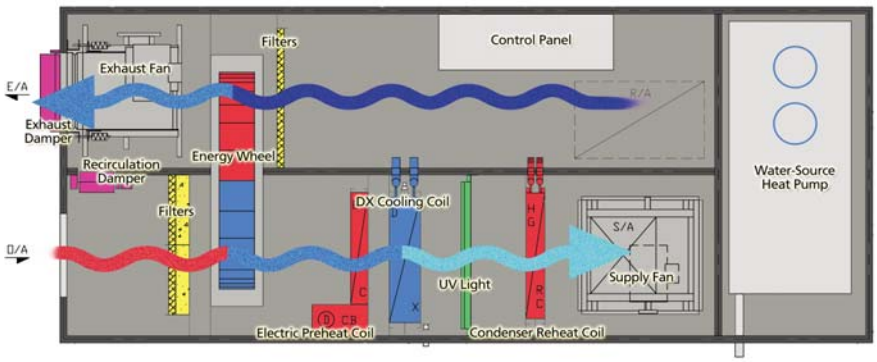
After a year of operation, the system has proven to be an effective and efficient solution. Amoroso says, "We've been through extremes of heat, cold and humidity, and the system has done a great job of maintaining comfortable indoor conditions." He notes that he was especially pleased how well the system handled periods of exceptionally high humidity in July.

"We know energy usage levels are low, because the utility company came in to check their meter because we were using so little energy."

System Well-Accepted by Occupants

Maddie Cafferty from Systems Unlimited, notes, "People just don't mention anything about comfort levels anywhere in the building. To me, that means they are comfortable." Cafferty adds, "Overall the system has operated well. It's been great." Plans are currently underway to install metering equipment on the HVAC plant to document actual energy usage. Cafferty says, "We know energy usage levels are low, because Mid-America came in to check their service meter because we were using so little energy."

Amoroso feels that the combination of concepts used in the HVAC plant at Systems Unlimited has wide application in other buildings. "The things we did here can be much more broadly used. With the rising costs of energy and the need for high indoor air quality, this is a great approach. I think we'll be seeing more of it in the future."



Unit schematic of factory packaged 8,000 cfm Venmar CES WSHP energy-recovery ventilator showing the total-energy wheel, heating and cooling heat exchangers, supply and exhaust fans and integrated ground-source heat pump

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www.venmarces.com
info@venmarces.com

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