Green HVAC: Flattening the Learning Curve

The future of the HVAC industry is green, but building owners want energy savings and emission reductions now

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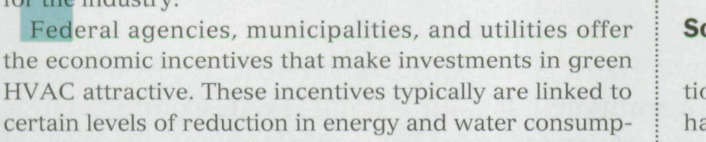
The HVAC industry is evolving as the demand for green HVAC changes the way mechanical engineers conduct business. As building owners and operators seek opportunities to reduce energy costs and their buildings' emissions, green presents a very strong growth opportunity for the industry.

Federal agencies, municipalities, and utilities offer the economic incentives that make investments in green HVAC attractive. These incentives typically are linked to certain levels of reduction in energy and water consumption. In many cases, HVAC is one of the largest consumers of both in a building, and, therefore, often is one of the first areas in which a building owner will invest.

Rebates, tax credits, energy codes, industry standards, and energy costs are driving the adoption of green HVAC technologies. These factors have ushered in a wave of innovation in the industry that requires a true understanding of available technologies and the business acumen to identify cost-effective solutions across multiple building sectors. As we will examine later, the return-on-investment (ROI) tolerance for each sector varies. Nevertheless, green HVAC plays a role in the design and construction of most new and renovated structures.



This article will explore the learning curve in innovation and the challenges of green HVAC systems in both new construction and renovation. When correctly designed and constructed, green HVAC systems provide many benefits for a building owner, not the least of which is a smaller utility bill. Owners also can expect an improvement in indoor-air quality, a quieter building, reduced maintenance costs, and extended life of installed equipment with a properly designed system and maintenance plan.

Solutions Influence Design

Green HVAC systems, such as underfloor air distribution, displacement ventilation, and active chilled beams, have widely different design and operating characteristics, and each one offers a solution to a building owner that may have a significant influence on building design. Natural ventilation is another option, but one in which the building occupants should be willing to accept a wider range of temperatures. Although the temperatures will be within the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) comfort range, they are not as predictable or controllable as traditional systems. In addition, some owners might prefer solutions that are highly visible to build a reputation as a forward-thinking owner.

Collaborating with owners and architects to understand their required ROI timeline enables contractors to identify cost-effective strategies and win support of innovative solutions. Few owners are interested in spending for spending's sake, but if there are logical, well-planned opportunities to reduce the cost of ownership, they are more likely to recognize the value.

Designing for energy efficiency is not the sole responsibility of one contractor, subcontractor, or consultant. Rather, it should be the combined effort of

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a collaborative design team that includes architects, mechanical and electrical engineers, consultants, and owners. Collaboration throughout the process helps eliminate unnecessary change orders and delays because the mechanical engineer can right-size the system with a broader understanding of the energy-performance and occupancy goals.

Big-ticket improvements and solutions might garner most of the attention, but it is important to design and construct what is right for a project. Once again, collaboration is critical. Engineers and construction teams should look for opportunities to achieve the same energy goals with the most cost-effective solutions.

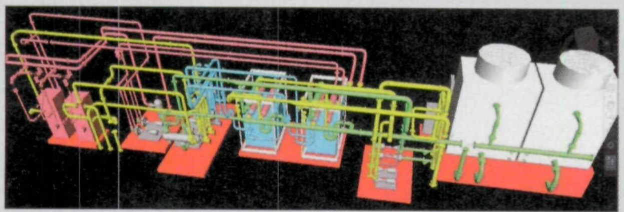
Designing Green in an Existing Structure

Your green modifications in an existing building may be limited by

SOLAR-THERMAL STORAGE BENEFITS PIERCE COLLEGE

No owner specifications were provided when implementing green HVAC technologies for the near-net-zero central-plant upgrades at Pierce College in Woodland Hills, Calif. This project was developed while a new maintenance and operations building also was being designed. This put the responsibility of the design and construction of the project on the design-build team.

The owner asked the design team to improve an existing system at a nearby campus. This required the implementation of a single underground solar-thermal hot-water storage tank. Keeping the tank insulated and protected from corrosive soils presented a challenge. The design-build team collaborated with an independent tank-fabrication company to fabricate the tank and a separate insulation company to insulate the tank off site and then set about the task of installing one of the first underground solar hot-water storage tanks used for green HVAC.



Building-information-modeling screenshot of the near-net-zero central utility plant at Pierce College.

After consulting with a chemical-corrosion specialist, the solution to designing the underground hot-water storage tank was to insulate the 42,000-gal. tank with high-temperature spray foam sealed with abrasion-resistant elastomer and perform an intensive design review. The tank was successfully fabricated, insulated, and installed to provide hot-water storage. The design team also installed a solar hot-water system that used gas-fired boilers to heat the water during periods of low sunlight.

Another challenge involved the high-temperature valves, seals, and pipe joints. Because the water from evacuated solar-thermal tubes can reach temperatures above 250°F, all of the solar-thermal system's components needed to be able to withstand those temperatures.

Photovoltaic panels installed above parking spaces provide power to the college's central plant and mainteance and operations building.

The design of the system also required a way to dissipate heat in the event the water stored in the solar storage tank was saturated to the designed temperature of 230°F. The system design also included the ability to reject excess stored heat if the tank reaches the maximum design temperature of 230°F. As long as the sun is out, the system will produce hot water. If there is low or no demand for the chillers to operate (perhaps in economizer mode), the heat from the solar tubes is rejected through a heat exchanger and cooling tower. On the other hand, on cloudy or overcast days, if the storage-tank water temperature is below the minimum operating temperature required by the absorption chillers (185°F), the implementation of a back-up system using natural-gas boilers has to be incorporated to fire the chillers for space cooling or heating hot water for space heating.

Our design-build team reviewed the solar-thermal water temperatures to develop the most effective solutions. Welded pipe systems were used inside the central plant, while high-temperature sealing elements were used on the distribution piping systems and all of the valves, accessories, etc., including high-temperature flouroelastomer sealing elements. Gas-fired boilers were used as the back-up system for building heating and cooling. This solution has lower energy consumption when compared with centrifugal chillers, which were used on previous projects of this nature.

Installation of the 42,000-gal. insulated solar hot-water storage tank at Pierce College.

PLANNING NETS REBATES FOR GOLDEN WEST COLLEGE

Golden West College in Huntington Beach, Calif., used California Legislature Government Code 4217 to conduct a campuswide energy-savings project. A new central plant needed to be built with 1,400 tons of cooling and 400 mbh of heating, with room for future expansion. A campuswide centralized energy-management system and controls system was essential. Eighteen existing buildings needed HVAC retrofits and lighting upgrades. Furthermore, 6,400 linear feet of trenching needed to be dug and 26,000 linear feet of heating and chilled-water piping needed to be installed to interconnect existing buildings and the central plant.

The trench for installation of the chilled-water loop at Golden West College.

Chiller water pumps in the new central utility plant at Golden West College.

The chilled-water loop for the retrofit at Golden West College provided more than just a way to connect the 18 existing buildings to the new central utility plant; it also provided a source of thermal energy storage. Because of the amount of underground chilled-water piping installed, approximately 30,000 gal. of chilled water was designated to provide cooling upon start-up in the morning. A bypass loop that allowed the pumps to run in the morning without going through the chillers was installed in the central plant. Water was circulated in the loop until the return to the central plant reached 60°F. This provided the owner with two to four hours of cooling, depending on the time of year, before the chillers were required to start. In doing so, the owner was granted additional energy savings. The chillers were required only when the system had depleted the cooling of underground chilled water in the loop.

Boiler room in the new central utility plant at Golden West College.

Thanks to extensive pre-planning and great communication with Golden West College, the project was completed on schedule, under budget, and with minimal impact to the school. Directly relating to the goal of the project, Golden West College received $500,000 in energy rebates through California Edison and will save thousands in monthly electricity costs.

the building's structural integrity. For example, although a rainwater-harvesting system may be beneficial for reducing water consumption, the roof of the building might not support the necessary infrastructure for such a system. Therefore, changes to the structure could alter the estimated ROI to a point where it no longer is cost-effective.

Ceiling height is another potential limitation. For example, if the ceiling is opened for a renovation project, adjusting the ceiling height can add an unrecoverable construction cost. A simpler solution that does not alter the ceiling height might have a shorter payback analysis.

It is possible that necessary HVAC equipment may need to be placed on the side of a building, rather than in the legacy equipment's location, because of weight or vibration differences.

Working in Operating Buildings

Be prepared to work with the building owner to develop an accurate and safe schedule and communicate with all stakeholders throughout the process. This exchange needs to be coordinated, discussed, and documented early in the project to mitigate any interruption to the building's operations and its core business. Changes will occur, but a documented schedule will provide the framework within which the project takes place. Short-term changes will be more easily accommodated if there are open channels of communication.

Safety and comfort are primary concerns for an owner and construction team. Anything that could jeopardize safety must be scheduled at a time that minimizes the risk to occupants and construction teams. Plans should be in place for temporary mechanical accommodations and continuity for mission-critical HVAC needs, such as those of data centers and hospital operating rooms.

Depending on the sector (health care, education, government, etc.), the choreography could be a challenge. Education projects offer a brief window in the summer when the site is nearly vacant, but deadlines still are critical for the safe return of students in the fall.

Consider the Maintenance Requirements

Green HVAC success is not only determined by the design and construction of a system, but also maintenance. ROI and payback analysis are based on the assumption that a system is maintained properly. In many cases, however, systems are not maintained properly and inefficiencies result.

Inefficiencies in a system can cause the owner to undershoot the estimated ROI. Unfortunately, this often goes unnoticed until it is too late. As the systems installed in today's buildings increase in complexity, it is critical that maintenance personnel have the expertise and background knowledge of the installed systems to operate them at peak efficiency. Engaging the maintenance departments of a mechanical design-build partner can alleviate this learning curve, as there is prior knowledge of the installed systems. In a design-build-maintain model, there is a single source of accountability for the green HVAC system, providing greater assurance that energy goals will be realized.

Owners must be involved in the decision-making, as realizing their vision requires a whole-building design process. The whole-building design process requires the responsible team members to work together to set and understand the energy-performance goals. The purpose of the holistic design approach is to enable the entire design team to interact throughout the process and understand system interdependencies. A systematic analysis of these interdependencies can help ensure that an efficient and cost-effective building is produced.

The design-build method also spurs innovation and collaboration among the design team to identify previously unrecognized synergies and solutions, leading to an efficient construction project that saves the owner time and money.

Where is the Industry Headed?

Future demand and innovation in green HVAC will continue to be one of the most important aspects for new building and renovation. The innovative solutions generated by design teams also will influence the energy-consumption standards for future construction while raising the bar for the next generation of buildings, as the prospect of net-zero buildings becomes more prevalent. New innovation in software for direct digital controls could unlock even more flexibility and scalability that can change the way energy is consumed. By virtually any criteria, the future of the HVAC industry is a green one.

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