Sustainable Design

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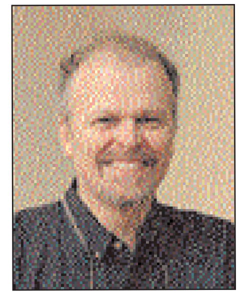

Energy-efficient plumbing technologies of the future

Some energy-efficient technologies are the holy grail of the plumbing industry. These technologies would allow a building to be a comfortable, safe place to live or work while using only the energy it generates, with no connections to the utility grid. Like the Holy Grail of history, however, these desirable technologies are just out of our reach. Hopefully, one day someone will discover the magic formula of economics, engineering, construction, maintenance and efficiency that will achieve a balanced off-grid system.

When you look at how far we have come, you might wonder what other technological achievements changed the way we design buildings. I think of the stories my mother and father told me about when they were growing up in the 1920s. At that time, it was still common to find homes with no electricity or running water. Horses were still seen on the streets, on farms and in gardens. Cheap electrical energy made municipal water systems possible and changed the quality of life.

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What are some plumbing energy technologies that may change the way we design buildings? This column looks at solar water heating systems that could alter our way of life, including one method using absorption chillers and another using thermal heat.

Photovoltaics

We are all familiar with the basic concept of solar energy and its potential to revolutionize the energy industry. It is now possible for residential and small commercial buildings to become energy independent by installing photovoltaic (PV) panels that generate electric power. In some cases it's possible to generate enough energy to sell the excess to the municipal power grid. This method is an economic net-zero in which, at the end of the year, the building owner has received more money from the utility than they paid.

Other solar PV systems use batteries to store energy when the panels do not produce it. With the proper design and maintenance, it is possible to disconnect the building from the municipal system.

A few years ago this concept was unattainable due to the state of the technology and the ability of contractors and because there were few financial models to make it possible. Now, net-zero-energy buildings are common in some areas, and more and more designers, contractors, and suppliers are gaining experience in these systems. For well-insulated residential and small commercial buildings with efficient water heaters, appliances and HVAC systems, installing PV panels to achieve net-zero energy use is very feasible. Larger, more complex facilities will require more energy than is produced just by installing PV panels.

Solar thermal

Solar systems can also be used to heat water for domestic uses. Flat panels and evacuated tubes are two ways this can be done. Most water heater manufacturers now provide proven systems that have been in operation for years. They involve solar collector devices, pumps, storage tanks, controls and, usually, a backup heating system. These systems can provide more hot water than needed for domestic hot water use. What if the spare heat could be used to power the air conditioning for the building?

Solar air conditioning

The holy grail is a system that provides air conditioning with solar collection devices at an affordable price. It makes sense, because the highest air conditioning demands occur during times with the most solar exposure. More solar energy is available on sunny summer days, which bring with them higher air conditioning demands.

Electrical grids have difficulty keeping up with demands on hot summer days, in part because of the air conditioning load on the grid. Power generation at this time is at its peak and is the most expensive. Reducing this peak load reduces the demand on the power grid, the cost of energy and the negative environmental impact of power generation.

Power suppliers have experienced "perfect storms" during summer heat and droughts when electrical demand is high. For instance, nuclear generation may have to be suspended due to high water temperatures in the water supplies next to the facility. At the same time, coal shipments cannot reach energy-generating facilities because of low river levels. These factors can cause power outages at worst and very expensive power generation at best. Buildings not dependent on municipal grid power during peak air conditioning times could help reduce electrical loads and costs, which is a win for the facility owner and a win for the utility. How can this be done?

Absorption chillers

Chillers are used to provide air conditioning in large buildings; the most common chillers use electric motors and also chill water for distribution throughout the facili-

Continued on page 40

Continued from page 38

ty. Absorption cooling is essentially an air conditioner driven by a heat source. Absorption chillers can be viewed as vapor compression systems in which the compressor has been replaced by the absorber/generator.1

These chillers can use many different fuels, including natural gas, steam and waste heat. What if it was possible to capture the heat from a solar collector to be used in an absorption chiller?

Evacuated tubes

The National Renewable Energy Laboratory (NREL) describes evacuated tube collectors as transparent glass tubes consisting of a glass outer tube and an inner tube, or absorber, covered with a selective coating that absorbs solar energy but inhibits radiative heat loss. The air is withdrawn (evacuated) from the space between the tubes to form a vacuum, which eliminates conductive and convective heat losses.2 The end result is that these solar collectors can be more efficient than flat panels, and they produce higher temperature liquids.

One emerging technology uses evacuated tube solar collectors to provide heat for an absorption chiller. An example of this technology is the Steinway piano facility in Queens, New York. In 2010 Steinway installed 38 tracking parabolic trough solar energy collectors on the facility's roof. The collectors generate 340 F pressurized hot water. During the summer, this solar fluid drives a 100-ton, double-effect absorption chiller, which is used to manage humidity levels in a moisture-sensitive assembly area. During the winter, the dual-fuel chiller uses natural gas. When dehumidification is not needed and the collectors can generate hot water above 275 F, the fluid is used to develop 15-pounds-per-square-inch (psig) steam to offset a portion of the plant's load. The system also supports simultaneous dehumidification and steam generation when necessary.3

Absorption systems have their problems, however, and may not be the easy answer. They are mechanically complicated, require specialized training of staff to keep the system in operation and costs for equipment, construction and design are high. (The Steinway installation received funding from outside sources to offset some of these costs.)

The development of adsorption (spelled with an ad, not an ab) chillers may solve some of these problems. The adsorption process works with the interaction of gases (water vapor) and solids (silica gel). These systems are a simple mechanical construction and should not require the degree of special maintenance training needed for an absorption system. They can operate at temperatures as low as 140 F and have no internal pump.

On the downside, adsorption chillers are still in development; items such as the controls need more time to fully evolve. The systems can be heavy and large, requiring additional shipping and installation challenges. Also, not many manufacturers currently produce them.

Adsorption systems are close, but not quite ready for most installations. While not discussed in this column, other systems also are on the horizon for cooling, including desiccant cooling and geothermal heat storage. While these systems are in development, what can be done now?

PV, thermal, and heat pump water heaters

Our industry could be getting close to the holy grail with less expensive PV and more efficient heat pump water heaters. Will these two products change the way we design domestic hot water systems?

For years, installations included PV panels and a separate solar water heater, because the cost and low efficien-

Continued on page 42

Fusion: The Holy Grail of Energy … but what about water?

Lawrence Livermore National Laboratory is developing Laser Inertial Fusion Energy (LIFE), which could be the energy-generation technology of the future (Learn more at life.llnl.gov). Fusion energy has been discussed for decades but has never been developed to a point where it is practical to use. While we are talking about holy grails, we should take a moment to pause and wonder, what if?

The world my father was born into in the early 1900s had no national power grids, and running water in every home was a dream of the future. During the next few decades, however, that all changed. Coal and hydropower made electrical power cheap, obtainable and reliable. Large water and wastewater distribution systems were made possible. Cheap power changed lives.

We are still tweaking those old coal and wastewater technologies from 100 years ago. For the most part, coal is still our No. 1 electrical power generation fuel, and water-based wastewater processing technologies are still in use.

If a new technology breakthrough lowers the cost of energy, would we worry about energy conservation anymore? Will cheap power bring cheap water with new water and wastewater technologies? A century ago, plumbing systems dramatically changed with the advent of readily available power. Running water and sanitary systems became commonplace in homes. Would it change again this time? Would we lose our respect for water?

If water was cheap, people would add more water to their processes. The problem is that, while energy sources evolve and change, a limited amount of water is available. Energy sources are renewable, but water is not. It must be reused.

However, cheap power could change the practice of using water to carry away solid waste, and new technologies could result in ways to keep waste out of water, reducing the chances of people leaving harmful elements in the water stream and increasing the chances to reuse water. The bottom line is that, while energy sources may change, the need to respect water will never end.

Continued from page 40

cy of PV made it too expensive to heat water. Things are different now, due to the greater capacity and lower cost of PV and the energy efficiency of heat pump water heaters. Now PV systems can be installed that include a heat pump water heater, and the total cost of such a system can be less than a thermal hot water system. Also, a PV system can be easier to operate, because no pumps or backup water heater systems are required.

The costs vary for different regions and solar exposures, so it is important to check out the energy model and utility costs in the particular area for each project. In many cases PV may be a better option in residential and small commercial projects.

A common thread in these new developments is that plumbing, mechanical, electrical and civil engineers, architects, contractors, regulators and operators will have to work together to determine the most appropriate systems in the facilities of the future. The lines between these disciplines will blur. As a result, the plumbing engineer will have to become more familiar with the demands of the other disciplines.

Will the Holy Grail of plumbing systems ever be found? Will we ever design a box that is installed on the roof of a building and provides all of the facility's hot and chilled water needs? The good news is that we may be getting close.

References

1 Ali Al-Karaghouli, "Conventional and Solar Cooling & Heating Technologies in Buildings," National Renewable Energy Laboratory, Oman ECO-House Workshop, October 15–17, 2011.

2 "Solar Water Heating," Energy Efficiency and Renewable Energy Clearinghouse, National Renewable Energy Laboratory, March 1996.

3 Mark D'Antonio, LEED AP, John Maxwell, PE, William Rigos, and Gregory Pedrick, CEM, "Post-Installation Performance Characteristics of a Solar-Driven System for Industrial Dehumidification and Steam Generation," 2011 ACEEE Summer Study on Energy Efficiency in Industry, July 2011. ■

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