Save big on heating, cooling costs with efficiency controls

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PNNL researchers found commercial buildings could substantially cut their power bills if they retrofitted their packaged rooftop heating, ventilation and air-conditioning units, such as those shown here in the Seattle area.

U.S. commercial building owners could save an average of 38 percent on their heating and cooling bills if they installed a handful of energy efficiency controls that make their heating, ventilation and air conditioning, also known as HVAC, systems more energy efficient, according to a recent report from the Department of Energy's Pacific Northwest National Laboratory. The estimated savings were based on computer modeling and simulation of building energy usage. The controls that could provide these savings are not widely available commercially, but the report's authors hope their analysis will encourage manufacturers to expand their production.

"Investing in an American economy that is built to last includes taking advantage of all of America's energy resources while working to improve efficiency," said U.S. Energy Secretary Steven Chu. "By making heating, ventilation and air conditioning systems in buildings more energy efficient, American businesses can save a significant amount of money by saving energy."

Completed for the Department of Energy, the report examines options for improving the efficiency of commercial rooftop systems called packaged HVACs, which combine compressors, fans and heat exchangers into one unit. Packaged HVACs regulate temperatures inside more than 60 percent of the commercial building floor space in the United States, where commercial buildings consume as much energy as about 90 million typical American homes each year. And about 35 percent of that is used by HVAC systems, which are often poorly maintained or ignored, causing them to run inefficiently.

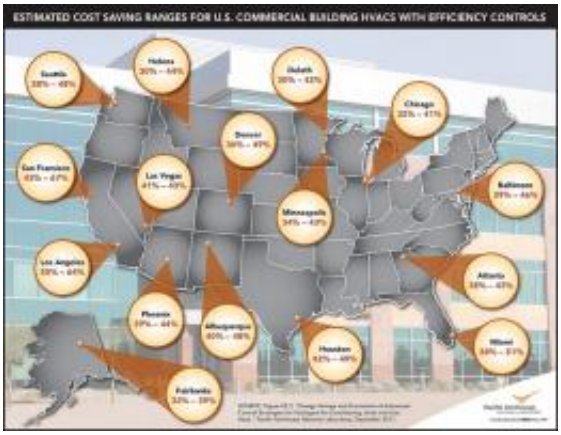
"The potential savings from adding advanced controls to existing packaged air conditioners with gas furnaces is enormous," said PNNL engineer Srinivas Katipamula, who led the study. "The estimated savings depend on local climate and energy prices and range from a whopping 67 percent cost savings in San Francisco to a still-substantial 28 percent in Seattle."

For the report, Katipamula and his PNNL colleagues considered implementing four different control methods to existing rooftop packaged HVACs:

- Air-side economizers use cool outside air to chill the building instead of creating cool air with the HVAC compressor. Some building codes already require cooling systems to include these, unlike the three other controls examined by the PNNL team.
- Supply fan speed controls slow or speed up the ventilation fan

that circulates the building's air based on whether or not a desired temperature or amount of fresh air has been reached instead of continually running the fan at full speed.

- Cooling capacity controls run the HVAC compressor at different speeds based on need.
- Demand-controlled ventilation slows or speeds up fans and air intake based on carbon dioxide levels inside the building instead of running ventilation fans at a constant rate.



A Pacific Northwest National Laboratory study found that U.S. commercial building owners could save between 28 and 67 percent on their heating and cooling bills if they added four efficiency controls to their packaged rooftop heating, ventilation and air-conditioning systems, also known as HVACs. Estimated savings varied according to local climate and energy costs.

The study team tracked the effects of using these methods with a building energy simulation software called EnergyPlus. The software created computer simulations that took into account 15 climate zones in 16 major U.S. cities.

They studied four types of commercial buildings: small offices of 5,500

square feet, stand-alone retail buildings of 25,000 square feet, strip malls of 22,500 feet and supermarkets of 45,000 square feet. More than 1,400 different simulations estimated the potential savings in electricity used to power fans and cooling compressors, as well as the gas used to produce heat. Energy savings were then translated into dollars and cents.

Different climates, different controls

In general, the researchers found that installing a multi-speed fan control had the greatest impact on energy savings in hot cities such as Miami. And demand-controlled ventilation created the best possible energy savings in colder cities such as Chicago, Duluth and Seattle.

The team reasoned that because ventilation fans generate some heat when they move, slowing fans with multi-speed fan control in hot climates could reduce the amount of chilling needed. And in colder climates, they suspected that demand-controlled ventilation prevents unnecessarily sending warm air outside, which then prompts HVAC system to create more warm air to maintain desired temperatures inside.

Big savings

When the research team added up all the numbers, they found the best possible percentage cost savings was 67 percent, which could occur when all four controls are added to a rooftop packaged HVAC at a small office building in San Francisco. And the minimum percentage cost savings was 28 percent and could come from adding all four controls to a supermarket in Seattle. The table below shows the team's calculations on each building types' average cost savings.

Their research also showed that Fairbanks, Alaska, could be home to the maximum annual dollar savings for all four building types. Fairbanks could experience savings as high as $52,217 per year at a supermarket

and as low as $923 at a small office. The team reasoned that Fairbanks' dollar-saving advantage was due to its cold climate, which benefits more from the decreased ventilation that occurs with demand-controlled ventilation, as well as the city's relatively high energy costs. The table below shows the average dollar savings that each building type could experience by installing all four controls.

But savings weren't limited to cash and energy use. The team also found that a substantial amount of carbon emissions could be avoided if HVAC energy efficiency is increased. As many as sixteen 200-MW coal power plants — which generate enough energy to power 3,000 to 4,000 American homes — could sit idle if just half of the nation's packaged rooftop HVAC units on commercial buildings were retrofitted with controls, the simulations revealed.

Return on investment

Three companies currently manufacturer HVAC controllers, but only one company offers a product with all the control options that resemble the team's simulations, Katipamula said. To help the manufactures better understand their market, the report also examines potential prices for the controllers and how long it would take for building owners to recoup that cost.

Based on the estimated dollar savings, the team predicted a building owner could recoup his or her investment in a few years. For example, they looked at adding supply fan speed control and demand-controlled ventilation to a supermarket. If that store spends $7,523 to equip its HVAC system, it would see a return in three years, while it would take the same supermarket five years to see a return if the controls had a higher price tag of $12,539.

"Our report makes a convincing case for manufacturers to produce more

advanced HVAC controllers and for building owners to adopt these energy-saving methods," Katipamula said.

Next, the team will test the estimated savings in the field. They're installing controllers into HVAC systems used on two rooftop units at an office building on PNNL's own campus in Richland, Wash. They're also planning to install several controllers in various commercial buildings across the United States. Once installed, the controllers will allow the researchers to measure real energy and costs savings.

The PNNL team will also expand its simulations to include more variables, such as looking at heat pumps to calculate potential energy savings. Heat pumps are more common in mild climates than the gas furnaces simulated for this report.

More information: W. Wang, et al, "Energy Savings and Economics of Advanced Control Strategies for Packaged Air-Conditioning Units with Gas Heat," December 2011, PNNL Report No. 20955 for U.S. Department of Energy.

Provided by Pacific Northwest National Laboratory