Cooling Technologies Update

Cooling and ventilating commercial and industrial facilities consumes a lot of energy. For example, in an office building these systems account for about 33 percent of the building's electricity use. In this pamphlet, we discuss two technologies that can help reduce this load. One is for chillers, which typically consume more electricity than any other single energy-consuming device in a building, except for an occasional extremely large fan. The other is primarily used with packaged rooftop units, which cool approximately half of all U.S. commercial floorspace.

The Danfoss Turbocor Chiller Compressor

Danfoss Turbocor is the name of both a company and a revolutionary new centrifugal chiller compressor that primarily serves the under-300-tons chiller market. It uses a technology similar to that of magnetic-levitation (mag-lev) trains. Magnetic fields levitate the compressor shaft so that it needs no mechanical bearings. Because there is no mechanical friction, no oil is needed for lubrication; thus, the oil-management system used by other types of compressors is eliminated.

Danfoss Turbocor currently sells its compressors for retrofits through authorized contractors and to chiller manufacturers such as McQuay, Smardt, and Axima, who have incorporated the compressor into new chillers. Direct Energy, an energy service provider, distributes and services the chillers made by Smardt, a Canadian chiller manufacturer, in North America.

Benefits

New water-cooled chillers under 300 tons that use the Turbocor have attained the best certified integrated part-load value (IPLV, a standardized measure of part-load efficiency) in the industry—approximately 30 percent better than the best screw chiller in the same size range. Their full-load performance is also better than that of most screw chillers by 10 to 16 percent; the exceptions are Trane's best screw chillers, which have approximately the same full-load efficiency. While the large part-load efficiency improvements are due in part to the elimination of mechanical friction, an even bigger factor is the use of a variable-speed drive (VSD) for the compressor. Since screw compressors dominate this size range and are difficult to operate with a VSD, variable-speed operation is not a readily available option for this size range. The Turbocor uses centrifugal technology, which is much easier to implement with a VSD.

The lack of mechanical bearings and an oil-management system for the compressor and the presence of only one major moving part (the compressor shaft) delivers several other benefits. Maintenance costs, noise, and vibration are all reduced compared to other compressors, and reliability is likely to be increased. In addition, the ability to stage multiple compressors together on a single chiller can increase chiller plant reliability because if one goes down or is being replaced, the others will continue to operate.

Best Applications

The Turbocor compressor and new chillers that use it primarily serve the under-300-ton chiller market in both commercial and industrial applications. Danfoss Turbocor also manufactures larger chiller systems of up to 540 tons. However, variable-speed centrifugal chillers using traditional technology are also available from other manufacturers in this size range, and those chillers are competitive in efficiency and price with Turbocor systems.

The best applications for any size range are facilities that have high cooling loads—such as those with high occupancies or that are located in hotter climates—and that spend a large portion of time operating at part load, which includes most chiller plants. Facilities where a low noise level is valued can also benefit from the Turbocor; for example, hotels may be able to use more rentable space close to the chiller room if noise levels are low enough.

Economics

New Turbocor-based chillers from McQuay and Smardt carry approximately a 30 to 35 percent price premium over screw chillers. Energy and demand savings will provide the greatest means for offsetting this cost, though reduced maintenance costs or increased revenue (for example, because of the realization of more rentable space in a building due to the Turbocor's low noise and vibration levels) can also contribute to payback. The most accurate way to evaluate the cost-effectiveness of a chiller is to run simulations based on a facility's actual loads. **Table 1** provides a rough approximation of how the capital cost and energy savings of Turbocor systems balance out in four cities.

Table 1: Hotter climates produce shorter paybacks

This shows a rough approximation of the annual kilowatt-hour (kWh) usage of a 150-ton typical screw chiller (IPLV 0.575) and McQuay's 150-ton WMC (IPLV 0.375), the energy savings between them, and the resulting payback period for the incremental cost difference. Colder climates generate fewer kWh savings to pay for the expense of Turbocor-based chillers.

	City[a]			
	Miami, FL	Phoenix, AZ	Stockton, CA	Minneapolis, MN
Equivalent full-load cooling hours	3,931	2,141	1,148	662
Energy use of an average screw (kWh)	339,049	184,661	99,878	57,098
Energy use of McQuay WMC-150 (kWh)	221,119	120,431	65,138	37,238
Savings (kWh)	117,930	64,230	34,740	19,860
Simple payback period (years)	1.6	2.9	5.3	9.3

Notes: IPLV = integrated part-load value; kWh = kilowatt-hours.
a. These examples assume a screw chiller cost of $280/ton, a cost premium of 35 percent for the WMC-150, and an electricity rate of $0.08/kWh.

Source: E SOURCE; data from manufacturers

To retrofit an existing chiller with a Turbocor compressor costs roughly $500 to $600 per ton of capacity. In cases where the existing compressor must be replaced anyway, the incremental cost to use a Turbocor instead of a compressor of the same type as the previous one could be half this amount or less. In retrofit applications, Turbocor claims that its compressor achieves an energy savings of 40 to 50 percent compared to reciprocating compressors and 30 percent compared to screw compressors. Furthermore, the incremental costs and these savings produce a less-than-three-year payback in most cases where there are 2,000 or more equivalent full-load hours (EFLH, a metric often used to estimate the annual energy use for cooling in a building). However, it is difficult to give a generic payback period for retrofit situations because chiller plants are complicated, and each has a host of historical design, installation, and maintenance practices that affect its actual efficiency.

The EER+ for High-Efficiency Air Conditioning

The EER+ is a heat-exchange module that can be retrofitted onto existing air-cooled air conditioners and heat pumps—including packaged rooftop units (RTUs), split systems, and air-cooled chillers—to increase their efficiency. Made by Global Energy Group (GEG), a manufacturer of energy-efficient cooling equipment, the EER+ technology will also be available in late 2007 in GEG's Inventor Series 1400 new RTUs. Preliminary tests show these new units to have the highest efficiency of any commercial units currently available.

The EER+ works by capturing waste condensate water from an air conditioner and routing it over evaporative cooling pads. Exhaust air from the building or outdoor air is blown across the pads (see **Figure 1**, next page). The resulting evaporative cooling removes heat from the air conditioner's refrigerant, increasing the efficiency and capacity of the RTU.

Benefits

The EER+ increases the output capacity of a unit without using a significant amount of energy to do so. Thus, it increases the unit's efficiency—for RTUs, it can increase the efficiency by 25 to 40 percent, and for air-cooled chillers, it can increase the efficiency by 18 to 30 percent. For both, the lower the efficiency in the existing system, the more impact the EER+ can have.

Best Applications

EER+ works with any packaged rooftop air-conditioning unit or air-cooled chiller and is available in capacities from 6 up to 100 tons. Larger capacities can be accommodated by connecting multiple units together.

When exhaust air from the building is used, the EER+ is not significantly affected by outdoor humidity. However, if outside air is used, then its performance in humid climates will not be as good as in drier climates.

Economics

The EER+ costs from $400/ton to $1,100/ton installed, depending on the size of the unit (smaller units are more expensive per ton). Paybacks will vary based on the cooling load of the building. In one case study, a process-plant operator retrofitted the EER+ onto RTUs in several locations throughout the U.S. (see **Table 2**). Based on the savings that the operator measured, it determined that the payback for the overall project was just over four years.

Resources

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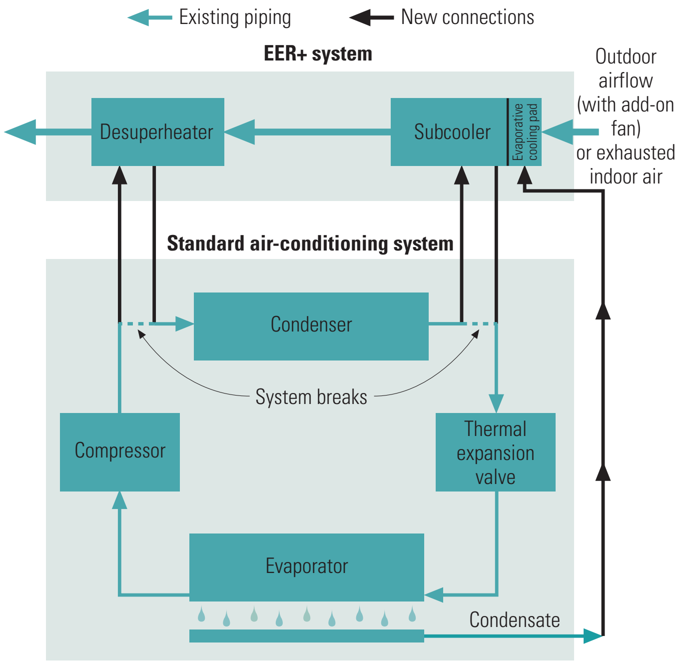
Figure 1: The EER+ system

In the EER+ system, an evaporative cooling pad uses condensate water to subcool and desuperheat the refrigerant. The new system, which is available as a retrofit item, has been incorporated into Global Energy Group's RTU product line.



Source: E SOURCE; adapted from Global Energy Group

Table 2: Paybacks for the EER+ for one company

Paybacks for the installation of the EER+ varied from 3.6 to 4.8 years for an operator of process plants. In several cases, multiple EER+ units were used on a single HVAC unit.

Location	HVAC units retrofitted	EER+ units installed	Savings (US$)	Installed cost (US$)	Payback (years)
Arizona	13	19	46,485	202,138	4.3
California	14	18	63,254	240,631	3.8
Georgia	21	27	41,707	200,012	4.8
Missouri	5	9	24,632	87,873	3.6
Tennessee	4	8	34,342	130,789	3.8
Texas (A)	4	4	12,461	52,724	4.2
Texas (B)	8	8	20,543	92,341	4.5
Total	69	93	243,424	1,006,508	**Avg. 4.1**

Note: Texas data are from two processing plants, A and B.

Source: E SOURCE; data from process plants operator