Cool alternatives

by James Piper, P.E.

A new era in facilities means managers must rethink their approach to cooling alternatives, including hybrid plants.

Building chillers represent a significant investment for engineering and maintenance managers. Chillers cost $200-$800 per ton to install, but over their 15-25 years of expected service, they will use many times that initial installation cost in energy. In fact, chillers represent the single largest electrical load in most facilities, accounting for 25-35 percent of a facility's total annual electricity use. With the exception of a few facilities that have ready access to steam, waste heat or another alternative energy source, the backbone of most facilities' cooling system has been electrically driven chillers. Simple, efficient and easy to maintain, electrically driven chillers have been the systems of choice for more than 25 years. In the past, when an existing chiller broke down or wore out, the biggest decision engineering and maintenance managers faced was whose electrically driven chiller to buy as a replacement unit.

The situation certainly has changed. Electricity supplies and rate structures are not what they have been. And, as a result, the economics of the electrically driven chiller is no longer what it had been. In today's deregulated electricity marketplace, managers must consider a wider range of options when it comes to selecting chiller systems. They must examine alternative energy sources and alternative chiller plant configurations when evaluating replacement chillers if the organization is to control operating costs and remain competitive.

There are two basic alternatives to the conventional electrically driven chiller - absorption units and gas engine driven chillers. These chiller systems can be used independently, or they can be combined into central hybrid plants, capable of generating chilled water from multiple energy sources.

Absorption chillers

Absorption chillers are not new to facilities. Long used in applications that offered a steady supply of steam or waste heat, these chillers have been used for decades. But they long ago fell out of favor with engineering and maintenance managers, due to their relatively low efficiency and high maintenance requirements.

Today, absorption chillers are making a comeback as a result of technology developments and facilities' need to use alternative energy sources for air conditioning. Absorption units - with their ability to be fueled by steam, waste heat or natural gas - are ideal candidates. Available in capacities as high as 5,000 tons, managers can specify absorption chillers for a wide range of applications.

The improved performance of today's absorption units is the result of changes in their design. Higher-quality materials and better manufacturing processes have created tighter absorber shells that resist air leaks. Also, microprocessor-based control systems provide more accurate control of absorber processes, including solution flow and fuel input.

Finally, better control operation allows the units to more closely track varying loads, improving efficiency while avoiding crystallization problems that can result in lengthy shutdowns of systems.

Absorption chillers are available as single- or two-stage units. The single-stage unit is the smaller, simpler type of absorption chiller, generating refrigerant vapor in a single step. Two-stage units are larger and more complex, requiring two refrigerant generators, but they offer improved operating efficiency. Single-stage units typically require 18 pounds of steam per hour for each ton of refrigeration produced, while two-stage units require about I I pounds of steam per hour for each ton of refrigeration produced. The two

most significant drawbacks of absorption chillers are size and cost. Absorbers tend to be large typically, one and one-half times larger than similar capacity centrifugal units.
Similarly, absorption chillers are 25 to 50 percent more expensive to buy than centrifugal chillers. But the higher first costs can be rapidly recovered through reduced operating costs in a deregulated electricity marketplace, given a relatively inexpensive, reliable supply of steam or natural gas.

Natural gas chillers

Natural gas, engine-driven chillers can be cost-effective alternatives to electrically driven chillers. The chillers use a low-speed, heavy-duty natural gas-fueled engine to drive a centrifugal or a rotary chiller. By using natural gas as the energy source, they reduce energy costs significantly as peak cooling loads occur, when electricity rates are at their seasonal highest and natural gas rates are at their seasonal lowest. Typical payback for the units is three-five years.
As with absorption chillers, developments in natural gas technology have resulted in improved system performance and reliability. Microprocessor-based controls provide close monitoring and control of system parameters, with the ability to match system output to a range of cooling loads.
By using lean-burn technology, the engines operate at higher efficiency while producing lower emissions levels. Technicians can vary engine speed to match the cooling load without significant losses in efficiency common with electrically driven chillers when operated at low cooling loads.
Only 30 percent of the energy input to a gas-driven chiller is converted to useful work to drive a system's compressor. The rest of the energy ends up as waste heat in the engine's exhaust and cooling system, which can be recovered in the form of hot water or low-pressure steam.
This low-pressure steam can be used to produce additional cooling with an absorber, while the hot water can be used to satisfy energy requirements for heating domestic hot water in the facility. With heat recovery, the overall efficiency of the gas-driven chiller improves to 70-75 percent.
Natural-gas-driven chillers are roughly the same size as their electrically driven counterparts, so they can be readily installed as replacements. The units are significantly heavier than electrically driven chillers, however typically 50 percent heavier. So, it is essential that managers investigate the load-carrying capacities of any floor where the chiller is installed to determine if modifications are needed to support the additional weight.
The biggest drawbacks of this system are its first costs and maintenance requirements. Engine-driven chillers carry a first-cost premium, running 25-50 percent more than conventional electrically driven chillers. Maintenance requirements for engine-driven chillers are significantly higher than for electrically driven chillers because they require more frequent routine maintenance and scheduled engine overhauls.

Hybrid plants

Most existing chiller plants are designed to operate with one type of chiller- centrifugal, reciprocating or rotary. While chillers with different cooling capacities often are used to help with part-load efficiency, rarely are different chiller types configured into one plant. Using one chiller type simplifies plant design and reduces operating costs. Hybrid plants take a different approach by mixing not only different chiller types but also different fuel sources for those chillers. A typical hybrid plant combines electrically driven centrifugal chillers with a gas-engine-driven centrifugal unit, a gas-fired absorption unit, or a steam driven absorption unit.
Hybrid plants allow operators to select the most cost-effective chiller based on pricing and availability of fuel at any given time. When electricity prices are high, such as during periods of high electrical demand, operators can elect to use chillers powered by alternative fuels.
Similarly, when the cost of electricity is lower than that of other fuels, operators select the electrically driven chillers. With facilities facing real-time pricing of electricity, as well as shortages, a hybrid plant allows them to continue to operate without having to pay excessive rates for electricity.

Hybrid plants, however, are more expensive to install and are more difficult to design and operate than conventional chiller plants. Also, operators must be trained in the startup and operational procedures of each chiller type. Operators also must closely track energy costs associated with each fuel source, sometimes on an hourly basis. And operating schedules can change hourly based on the cost of operating each available cooling system. But despite these limitations, hybrid plants offer a fairly quick payback in a deregulated electricity marketplace, particularly one that bases rates on real-time pricing.
Alternative fuel chillers give engineering and maintenance managers options. With careful planning, those options can be used to effectively reduce the cost of providing cooling in their facilities.

The Economics of Alternative Cooling

To gain the benefits of using alternative cooling, engineering and maintenance managers must carefully investigate the economics of the options based on the conditions found in their facilities, as well as the current and projected rates for energy.
In most cases, this process includes performing an hour by-hour analysis that relates cooling load to the energy rates that are in effect for that particular hour. It is essential to remember that the analysis must be site specific.
Driving this analysis will be the energy costs of the various systems, but energy costs are not the only factors that need to be evaluated. Different chiller systems have different maintenance requirements and costs, and they also have different environmental impacts and, as a result, might require special permitting and monitoring. Managers also will have to factor these costs into any economic analysis of the options.

Above article appeared previously in the May 2001 issue of Maintenance Solutions. James Piper, P.E., is a consultant with more than 20 years of experience in facilities management issues.