ABSORPTION CHILLERS FOR INTITUTIONAL OCCPANCIES

It's not necessarily a plug-and-play situation, but these chillers can play key roles and deliver meaningful savings in several scenarios. Waste heat, CCHP, standalone, and even renewable solar as part of the refrigeration cycle can all provide the setting for absorption success.

By Marcia Karr, P.E.

Owners will benefit from engineers offering a design for the central plant that includes absorption chillers for many types of buildings, such as hotels and resorts, food processing, cold storage facilities, breweries, supermarkets, health care, etc. In addition, hospitals, universities, data centers, and other institutional occupancies with a central mechanical plant offer a unique opportunity for absorption chillers.

Once we attribute the electric load for conventional cooling equipment as a thermal load via absorption chillers, an institutional occupancy can have a good balance between electric and thermal loads all year. And there are great strategies and technologies available to allow a central plant to significantly reduce operating costs by migrating absorption chiller technology into their central plant portfolio.

Absorption chillers can be weaved into the existing central mechanical plant operation in many ways, and four primary ways are presented in this article.

1. Waste heat application
2. Part of a combined cooling, heat, and power (CCHP or trigeneration) application
3. As a standalone gas fired absorption chiller application
4. Using renewable solar as the heat source for the refrigeration cycle

All four of these applications can reduce power bills, especially when electric rates are high in the summer months. In recent years, absorption chillers have evolved to a level where one can say that organizations would be remiss if they didn't consider absorption chillers in some capacity for their central plant. Factors that have led to this consideration include:

- The abundance of natural gas
- The reliability of natural gas infrastructure as compared to electricity
- The cost of natural gas relative to electricity
- The significant advances in absorption chiller technologies over the last decade
- The high attention to environmental considerations and the resultant desire to use non-ozone depleting technologies in central plant operations

Absorption chillers are quieter than electric chillers. Absorption also uses only about 10% of the electric energy of an electric chiller, which can affect electric demand charges. Conversely, since absorption chillers are less efficient than mechanical chillers, the ideal application is where there is available heat that may have otherwise been rejected to the atmosphere without the absorption chiller or where electric rates (spark spread) are relatively high. Also, a facility with combined heat and power may benefit more fully with the implementation of absorption chillers at the central plant.

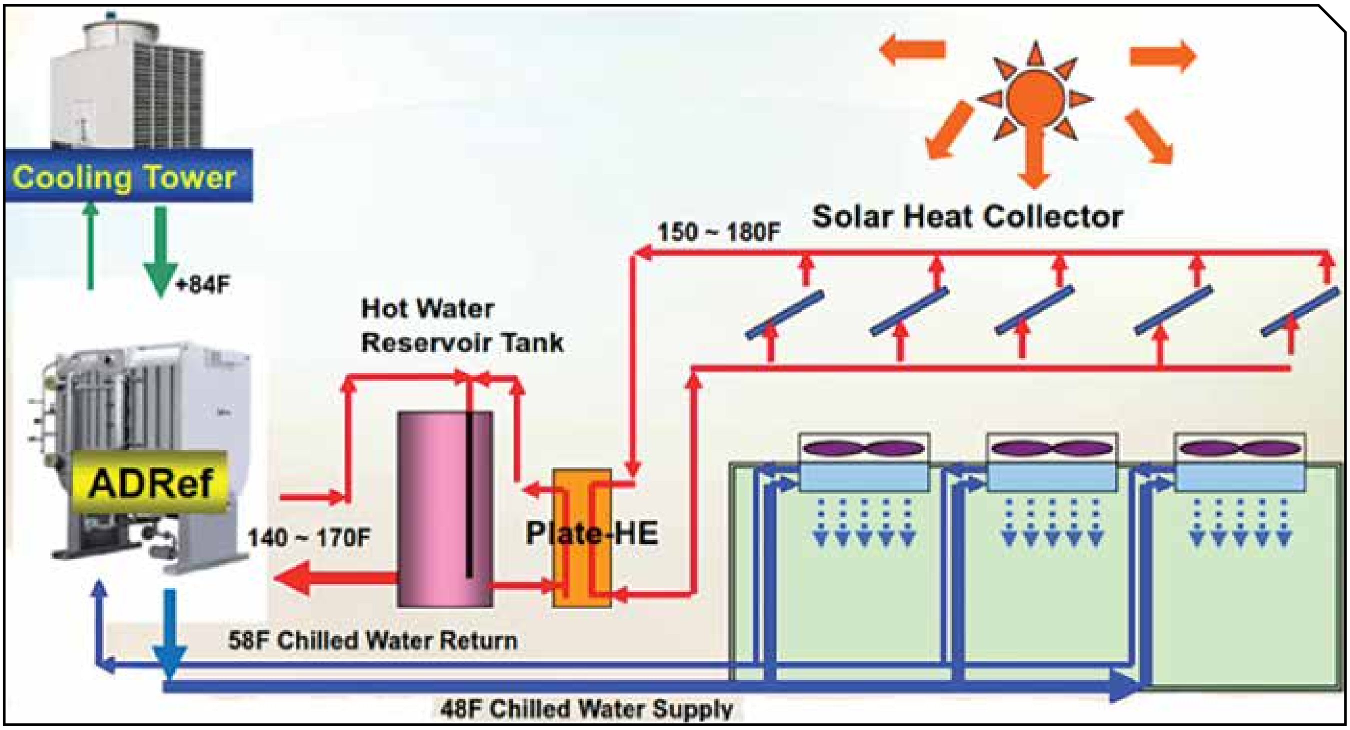

FIGURE 1. Low-temperature adsorption waste heat chiller (Source: Mayekawa).

WASTE HEAT APPLICATION

Institutional occupancies usually need to throttle down on their steam boiler operation in the summer, and summer is when there is a need for space cooling/chilled water. However, they may need to operate their boiler for some load all year. Operating a boiler at less than full capacity compromises boiler efficiency; the boiler is operated at minimal firing rate, and the excess steam is discharged to the atmosphere. On the other hand, if we used the steam or hot water from the boiler in an absorption chiller instead of in an electric chiller, we could operate our boilers at a more efficient level, even in the summer. Utilizing an absorption chiller in this capacity is highlighted in a case study by Carnegie Mellon, *www.cmu.edu/iwess/components/steam_absorption_chiller/*.

This application lends itself nicely to the higher-efficiency, double-effect absorption chillers that need steam for the absorption cycle. If your site has to vent steam during the summer months because of the mismatch between minimum steam load and the boiler minimum firing rate, then consideration of a steam fired absorption chiller is certainly warranted. This will save

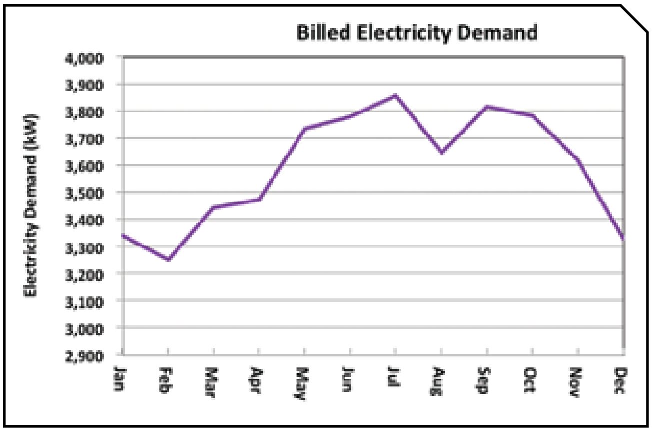

FIGURE 2. Electric demand profile

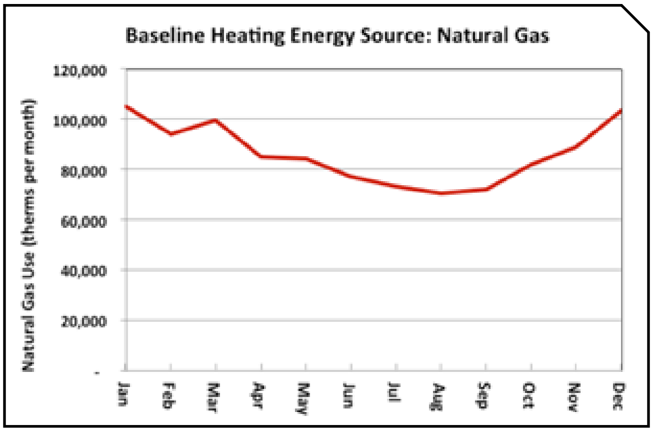

FIGURE 3. Thermal demand profile.

significant electric energy and can have a prolonged effect on the life of the boiler.

COMBINED COOLING, HEAT AND POWER APPLICATION

Adding absorption chillers to the central plant opens up the opportunity to install natural gas emergency generators used for every day power, and use the waste heat off the generator for "free" cooling in the summer, as well as hot water in the winter. This path ultimately provides a vital role in improving the ability of a facility to remain operational in the event of a man-made or natural disaster and will also accomplish the following:

- Reduce energy costs
- Stabilize risks associated with fluctuating energy costs
- Improve equipment reliability
- Reduce greenhouse gas emissions by up to 50% for the power generated
- Reduce grid congestion
- Reduce electrical demand charges
- Provide reliable power supply

Furthermore, absorption chillers use low-global warming and ozone-safe natural refrigerants (existing in nature) like R717 (NH3) and R744 (CO_2), water and air, which are promoted through the LEED certification program, ASHRAE, EPA, DOE, and GSA. (CHP can be shown to offer 5-9 LEED points, see *www3.epa.gov/chp/documents/treatment_of_chp_in_leed_building_design.pdf.*)

There are numerous case studies where this potential is achieved in institutional facilities such as universities, hospitals, data centers, and military operations with the implementation of CCHP using absorption chillers. ICF International published a great document of some case studies to exemplify this direction (*www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_critical_facilities.pdf*).

A typical thermal energy load profile shows a significant drop in thermal heating need in the summer. If, however, we can add the cooling load with a technology that uses heat for refrigeration, our thermal load profile becomes more flat across the year. The more the CCHP plant is used throughout the year, the more energy we save, the lower the pollution emitted on site, and the more money saved.

CCHP systems also open up the opportunity to use absorption chillers/heaters. This technology offers both chilled water and hot water in a single piece of equipment, saving on floor space, reducing the number of boilers, and thus decreasing capital and maintenance costs. Engineers like this concept where dehumidification is desired or needed.

GAS FIRED ABSORPTION CHILLER APPLICATION

The gas fired absorption chiller is the perfect consideration in areas where the electric costs rise in the summer. This technology allows us to use the more stable fuel cost of natural gas instead of electricity to serve our cooling loads.

A good case study highlighting the financial value of gas fired absorption chillers can be found at a hospital in New York (*www.nyhq.org/oth/Page.asp?PageID=OTH001604*). This study shows about a five-year payback by weaving absorption chillers into their central plant operations. The introduction of this single gas fired absorption chiller resulted in reducing this large institutional site's carbon emissions by 7%.

SOLAR ADSORPTION CHILLER APPLICATION

There are many parts of the country where solar energy is quite dependable during the hours when space cooling is needed. The solar adsorption chiller is an ideal addition for these sites. The solar adsorption chiller has been manufactured and successfully installed by three or four global manufacturers. This chiller only needs hot water input of 140˚F to 176˚F (an ideal temperature for cooling an engine in CCHP or from a solar collector) and can provide 41˚F chilled water outlet temperature, which is perfect for HVAC cooling. The adsorption chiller has COP's from .5 to .68. It is the best option when a low-heat source temperature is available, such as a reciprocating engine prime mover or free heat from solar hot water panels (Figure 1).

From the electric demand profile, we see that we might attribute the electric load over about 3,400 kW toward cooling loads. These cooling loads can be served with an absorption chiller using waste heat off a boiler, or off a genset with a gas turbine, thereby saving electric use kWh (and as importantly, demand penalties). At this site, the demand penalties totaled well over $200,000 per year. Part of this penalty can be considered an avoided cost in the payback analysis for absorption chillers. Meeting the cooling load with an absorption chiller with heat from a boiler or genset has the potential of reducing or eliminating demand charges/penalties, as well as reducing pollution and saving energy costs all year.

COMMISSIONING AND MAINTENANCE

Proper selection of the best type of absorption chiller can be tricky. Choosing an experienced engineering firm should consider input from a chiller manufacturer, as they know who has received the training necessary to commission the chiller and integrate it into the plant seamlessly.

Manufacturer's representatives will echo the thought that just because one understands electric chillers does not mean they necessarily understand the absorption chiller technology. However, they will be quick to say a person who understands electric chillers definitely has the aptitude to learn the operation and maintenance needs of an absorption chiller. As a parallel, just because one can work on carburetors does not mean than he can work on fuel injection, but it does mean that he has the aptitude to learn how to work on fuel injection systems.

Absorption chillers are relatively simple machines. There are not many moving parts, and operating temperatures and pressures can be relatively low making them a work horse item in the central plant. However, manufacturer's representatives strongly advocate remote monitoring features to alert trained persons on any anomalies.

Incorporating or weaving an absorption chiller into your central plant requires manufacturer and engineering experts to assure the central plant is commissioned as a system. Typically, each piece of equipment in the central plant is commissioned as a standalone unit. However, waste heat and CCHP absorption chiller applications require interaction with many other pieces of equipment.

There are considerations for emissions, generators, grid interconnection, waste heat recovery, desiccant air dryers, building systems integration, etc., all requiring a sophisticated control logic for optimal interdependent operation. Many features need to be controlled based on dynamic conditions within the facility. It cannot be emphasized strongly enough that integrating absorption chillers into an existing central plant will require the commissioning team to be equipped with a plant-wide comprehensive detailed points list from the design engineer to identify adjustments needed based on a variety of input conditions. Manufacturers of equipment in the sophisticated central plant will encourage 24-hr monitoring and preventative diagnostic services to address any issues promptly and efficiently.

Some information in this article was obtained from:

- Combined Heat and Power Partnership, *http://www3.epa.gov/chp/*
- New Buildings Institute, *http://web.stanford.edu/group/narratives/classes/08-09/CEE215/ReferenceLibrary/Chillers/AbsorptionChillerGuideline.pdf*
- Trane, *http://internal.trane.com/COMMERCIAL/DNA/View.aspx?i=976* **ES**

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