Gas Cooling in the Era of Deregulation

BY William Ryan, PH.D., PE,

Gas and electric deregulation give customers new choices in cooling

The world of the electric customer is changing drastically. But, as before, decisions made about chiller plants will continue to affect the owners and occupants of buildings 20 years into the future. Owners often do not have the luxury of postponing chiller plant decisions until the electric market becomes more stable and predictable. Instead, they must assume new risks associated with making decisions about chiller plants in today's environment.

Old and New Models

The relation between the electric supplier and the customer will undergo radical change in the next few years as the electric market reregulates. In the past, in the regulated market, the electric customer had only one possible source for all electric services:

- Electric service was comprehensive (electricity, billing, delivery, etc. were all provided in one uniform package)
- Regulated electric suppliers were obligated to serve customers, no matter what the characteristics of the load
- All components of the price of electricity were controlled by the local regulatory commission
- In the deregulated market, customers should see:
- Numerous vendors offering supply contracts
- Electric supply contract offerings with a wide diversity of options and features
- Deregulated electric vendors vying for the "customer relationship"
- Local regulated electric systems supplying the delivery service as part of any vendor's package
- None of the deregulated vendors having an "obligation to serve"

Although electric deregulation may offer the customer a new universe of options and lower overall prices, the end of the obligation to serve may affect more customers just as dramatically. Given the economics of electric deregulation, vendors will have little incentive to give the best prices to unprofitable customers. Vendors will avoid customers having facilities with low load factors, which lowers the load factor and the profitability of generati on.

In the past, such customers were simply carried under the overall regulated ratebase. However, this practice effectively transferred costs from low load factor facilities, such as office buildings and other daytime, weekday-only commercial loads, to high load factor facilities, especially industrial facilities. As a result, owners of industrial facilities stand to benefit from electric deregulation.

At first, some electric suppliers may continue to market to all customer classes, regardless of load factor. In a competitive environment, however, other suppliers will quickly skim the high load factor-and more profitable-customers of these suppliers. The tendency is clear-different classes of customer will pay different rates, depending on the desirability of their load to a free market supplier. These low load factor customers must take steps to improve their load profiles.

Design Under the Shield of Regulation

In the past, customers exploited this unconditional obligation to serve, and unless demand charges were high, largely ignored load factor as an element in their costs. Customers developed poor load profile habits spurred by the convenience of using low capital cost electric equipment even on the most intermittent of loads-and the largest intermittent load is cooling.

For various reasons, it is unlikely that common efficiency improvements will improve the load factor of most facilities. Most commercial buildings are already completely equipped with fluorescent lighting. The increased use of electronic ballasts, modern luminaires, and LED exit signs may reduce overall lighting loads. In general, these load reductions will not be large.

Occupancy sensors controlling lights, though useful in reducing total energy consumption, tend only to reduce the load factor further as they often ensure that lighting is off at night.

Tenants expect power to be available at any time, even when plugging new loads into a receptacle.

Tenants are generally very sensitive to elevator shutdowns.

Air distribution is likely to already be handled by a reasonably efficient VAV system. Reducing ventilation minimums or outdoor air intake raises indoor air quality concerns.

Only the chiller load remains. Tenants are not usually concerned about the workings of this system-as long as the air system continues to provide cooling and dehumidification.

Alternatives

The designer of the chiller plant load for a typical 1,000 refrigerated tons (RT) office building has an array of chiller alternatives that can be used to control the load factors in the chiller plant, including:

- High-efficiency electric chillers
- Electric chillers with improved load following capability
- Gas-fired absorption chillers
- Gas-fired engine chillers
- Chilled water storage
- Ice storage

High-Efficiency

Electric Chillers

High-efficiency electric chillers are available with electric consumption values as low as 0.48 kilowatts (kW) per ton, as compared to the 0.6 to 0.68 kW/ton of standard chillers. These chillers can be as much as 50% more expensive than standard chillers.

Given the expense, high-efficiency chillers are best used as lead chillers in a multi-chiller plant to maximize operating hours and electric energy savings. Unfortunately, peak demand reduction will only be in the 20 to 25% range for the lead chiller. For load leveling or demand charge avoidance, high-efficiency electric chillers are not very effective per unit of cost. If a high-efficiency chiller (0.54 kW/RT) were used to replace standard chillers (0.65 kW/RT), the $70 to $80/RT premium would amount to roughly $75,000. Chiller power demand would drop 110 kW, and all other factors being equal, demand reduction would cost $680/kW, higher than any other alternative posed. Similar calculations for other options are listed in Table 1.

Plant Type	Total Demand (kW)	Cost of Demand Reduction ($/kW)
All Electric	800	Base Case
High Efficiency Electric	690	680
All DFDE Absorption	250	413
All Engine	200	475
Full Ice Storage	0	611
Cost of On-Site Gen.		>500

Table 1:
Comparative cost of reducing demand with various chiller types. Each technology is assumed to be used throughout the chiller plant to meet all cooling loads for a 1,000-RT office building. Usage includes allocations for tower pumps, fans, and other auxiliaries. The chilled water system is assumed to be identical in all cases; chilled water pumps are not included.

Electric Chillers with Improved Load Following Capability

Given the extremely variable nature of the cooling load, improved efficiency at low loads will significantly decrease overall electric energy use. Technical solutions include variable-speed drives, screw compressors with slide valves, and multi-compressor chillers. Although significant electric energy savings may be achieved, these chillers will not improve demand load profiles. In some cases, they will increase demand compared to standard chillers at full load.

Absorption Chillers

Completely eliminating the electric drive from the chiller will obviously eliminate the chiller's electric demand. Absorption chillers do need electricity to operate solution pumps, in the 0.05 kW/RT range. Traditionally absorbers also used larger cooling towers and larger condenser water flows, in the 4.5 gallons per minute (gpm)/ton range (double-effect absorbers). However, some newer double-effect absorber designs are advertised at 3.6 gpm/ton and can operate as low as 3.0 gpm/ton with little loss of capacity. Auxiliaries for heat rejection are generally on the order of 0.2 kW/ton rather than the 0.15 kW/ton assumed for electric chillers. Absorption chillers are significantly more expensive than electric chillers.

Engine Chillers

Engine chillers are rapidly gaining popularity both for their low operating costs and for demand avoidance. Heat rejection from an engine chiller is higher than for electric chillers, due to heat removed from the engine's cooling jacket. However, engine heat is at such a high temperature that condenser water flows may be left at electric chiller levels, once again with higher temperature water sent to the tower. Of course, this high-grade heat from the engine, typically above 200°F, may also be rejected to water heating or some other practical application.

Chilled Water Storage

Storage technologies have been gaining popularity, and they address the load leveling issue head on, focusing entirely on demand reduction. Storage of chiller water allows the chiller to operate at the same efficiency level as a standard chiller. Chiller water storage requires sizable storage tanks which have significant construction costs, making these systems expensive.

Ice Storage

Ice storage significantly reduces the size of the storage tanks needed for thermal storage and, like chilled water storage, is tailored to reducing demand costs. The plant must be operated properly to guard against running out of ice on days when the capacity is needed. Also, the chillers themselves will require 0.9 to 1.0 kW/ton, substantially more power than the 0.65 kW/ton of standard chillers. Finally, the low evaporator temperatures will reduce the output capacity of chiller equipment to 60 to 70% of normal rating for 45°F chilled water production.

Distributed Generation

Many believe that having on-site generation available to shave load as needed solves the problem. Distributed generation tends to be a fairly high cost solution, in the $500 to $600 per kW range when the required paralleling gear is included. The cost-effective use of on-site generation involves truly integrating the generator into the facility. The generator serves the electric base load (lights, plug loads, etc.) which has high operating hours per year. Both heating and cooling can then be accomplished with waste heat from the prime mover directly.

Assessing Risks

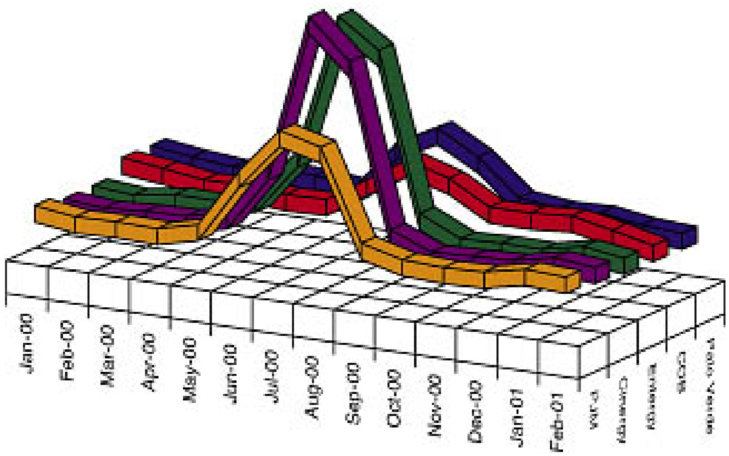
Lead Chiller	Lag Chiller	Demand (kW)	Cost of Demand Reduction ($/kW)
500 RT Electric	500 RT SFSE Absorber	525	289
500 RT DFDE Absorber	500 RT Electric	525	408
500 RT Engine Chiller	500 RT Electric	475	488
500 RT Electric	150 RT Ice Stor. Chiller	550	485
500 RT DFDE Absorber	150 RT Ice Storage Chiller	270	448
500 RT Engine Chiller	150 RT Ice Storage Chiller	230	486
Cost of On-Site Gen.			>500

Table 2:
Total cost of redecing demand with various chiller types. n this table, two chillers of differing types are assumed in a hybrid plant to meet all cooling loads. Note that the ice storage option has now been optimized (see footnote), but still does not surpass the lower cost of using absorption chillers.

In a traditional energy analysis, costs are calculated, and a payback or rate-of-return is determined for differing options. However, the operating cost assessment depends on local energy prices.

To look to the deregulated future, the following analysis takes a standard all-electric chiller plant as a base for describing how cost effectively the different technologies reduce peak demand. The results gives plant designers an indication of the costs of each technology and can be adapted to local rates and conditions. The results of these calculations are shown in Tables 1 and 2 for a 1,000-RT office building load. Table 3 also includes a sample of operating cost for a specific utility rate.

Conclusions



If cooling is the problem, deregulated summer prices should be higher-and they are. Note the dramatic rise in July / August price. This trend has appeared consistently over the last 3 years. Prices are wholesale at the exchange point and do not include subsequent transmission and delivery costs. COB is California - Oregon.

The high demand profile of today's commercial buildings leaves the facility owner at considerable risk in the deregulated future. Numerous options exist for reducing that risk. However, some of the most cost effective of these options are available equipment used in new ways rather than radically new systems. Some specific conclusions include:

- The cooling plant is the most important and controllable factor in the overall load factor of a commercial building.
- The cost of electric generating systems including the needed paralleling gear-$500 to $600/kW- suggest that these systems be used to reduce the demand of those loads that must be electrically driven, such as lights and plug loads.
- The use of full ice storage systems-recharged only at night-will reduce cooling demand dramatically, but at a very high cost-over $600/kW.
- If ice storage systems are used only as a lagging or peaking chiller and are optimized in first cost by reducing chiller size and charging continuously, the cost of demand reduction still remains in the $480/kW range.
- Whether used for all or part of the load, direct-fired double-effect absorption chillers can reduce demand in the $400 to $420/kW range, making these systems a logical choice for demand reduction. Given that these systems also provide comparable or lower operating costs in most areas makes these systems doubly attractive.
- Although engine chillers are more expensive to use for purely demand reduction purposes than absorption chillers or an optimized ice storage system, their very high efficiency and the low cost of gas fuel used generally makes the operating cost of engine chillers quite low. This combination of low operating cost and reduction in demand makes engine chillers desirable in many locations.
- The cheapest mechanism for demand avoidance is the single-effect absorber in the $280 to $300/kW range. However, due to the higher operating cost of this option, a single-effect absorber should be used as a lag chiller, unless the chiller is powered by waste heat.

Overall, these conclusions indicate that finding a technical solution to the problem of risk exposure for the large commercial customer will require diversifying the chiller plant away from the strict electric chiller focus of the past to a larger universe, including widely available but generally less often used thermally driven equipment.

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