Staying cool with off-peak energy

If your household is connected to an electricity grid it's a safe bet that you'd welcome a smaller power bill. At the risk of sounding a little like an advertisement for an electricity authority, we could suggest that one way you can save money is by using off-peak power to heat your bath-water.

Although some modifications to the bathing schedule may be needed, heating up water during periods when electricity is cheaper and storing it for later use is an easy way for families to economise. For managers of large buildings that's also an option, but one that's more difficult to implement: hotel guests and office- and factory-workers expect hot water on demand. But you can take advantage of off-peak energy in other ways — by making ice, for example.

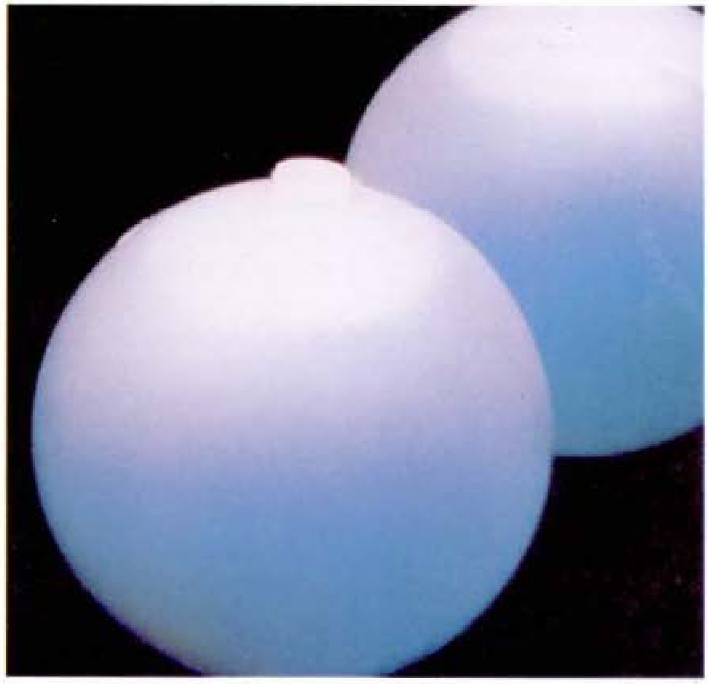
The principle is quite simple: ice is made by refrigeration systems during off-peak periods and melted to meet cooling requirements during times of high demand when energy costs are higher. According to Mr Tony Musgrove of CSIRO's Division of Building, Construction and Engineering, electricity companies in the United States recognise the value of this technology and have encouraged its installation by offering financial incentives.

Perhaps because they don't have the same inducement here, Australian companies have been slower to adopt the technology. But interest may be growing with electricity prices: several new buildings in Sydney have recently installed ice-storage systems to meet some of their peak-period cooling demands.

As part of a research program aimed at improving the efficiency of Australia's energy use, Mr Musgrove and his CSIRO colleague Mr Jurgen Ehmke, with Mr Ken Stocks of Intelligent Energy Systems Pty Ltd, have investigated the economics of using ice-storage systems in commercial buildings in Sydney and Melbourne.

Using a computer model they found that in both cities, despite different tariff structures, ice storage would significantly reduce air-conditioning costs. In all cases the extra capital costs would be paid back through savings in electricity in less than 3 years, and for the typical commercial building in less than 18 months.

As you might expect, the cost and technical characteristics of ice-storage systems vary greatly. For their model, Mr Musgrove's team selected the French CRISTOPIA STL ice-ball-storage system, which is operating successfully in France and has been introduced recently into Australia. The STL design is technically more sophisticated than most and incorporates a fully enclosed storage vessel filled with spherical polypropylene nodules. These nodules contain either water or, to allow a wide range of thermal storage temperatures, salt solutions of various types.



The polypropylene nodules, 77 mm in diameter, are filled with water or salt solutions of various types.

In a typical layout, the ice store is placed in parallel with the chiller unit that controls the temperature of the heat-transfer medium (water/glycol). During off-peak periods the thermal store is cooled by the chiller. During peak periods the melting ice works with the chiller to cool the building.

The diagram illustrates a typical air-conditioning layout involving an STL storage system. During off-peak charging, the fluid in the nodules freezes and continues to be cooled until a controlling thermostat shuts down the chiller. Then, during the peak period, the melting ice works with the chiller unit to cool the building.

By combining representative load profiles for 2-week periods of 'summer', 'winter', and an intermediate season, the team simulated a full year's operating experience for an air-conditioning plant serving a medium-sized commercial building and compared the costs incurred under the different Sydney and Melbourne off-peak tariffs.

With large consumers, the Melbourne electricity authority negotiates a yearly maximum-demand contract, with heavy penalties for excess use, while the Sydney authority operates a monthly resettable demand tariff linked to the time of day that corresponds to the system peak. However, the Melbourne tariff offers a very favourable rate for electricity purchased during an 8-hour off-peak period.

The model showed that the optimum operating strategy for a building in Melbourne is very simple. It must take maximum advantage of the 8-hour off-peak tariff by charging the ice store at full power. But, even with this approach, during weekdays there is insufficient time to fully charge the store; so, except at weekends, the full storage capacity is rarely utilised.

During discharge, the best strategy is to arrange for the chiller to operate at maximum output for just long enough to let the store fully discharge by the end of the working day. In this case, to save the most money requires a control system that can monitor and, to a certain degree, predict the day's air-conditioning load.

On the other hand, in Sydney, the model showed that the best operating strategy is to determine an optimum level of electricity demand for each month (in advance) and then to operate each day so that electricity demand is constant over the day. Again, judicious management of the ice-store and chiller operation is crucial.

The model demonstrated that to get the best out of the systems requires efficient, computerised monitoring and control. Without it, there can be loss of comfort or, at the very least, a failure to realise the potential cost savings.

It also showed that savings generated in both cities are by no means restricted to summer. In Sydney, savings are equally spread over all seasons, whereas in Melbourne the benefits are actually greater in cooler seasons because a greater proportion of the load can be shifted to off-peak.

David Brett

Optimum design and operation of ice-storage air-conditioning systems under Australian TOU tariffs. A.R. deL. Musgrove, H.J. Ehmke, and K. J. Stocks. *Energy*, 1989, **14** (in press).