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EMERGING TECHNOLOGIES PROGRAM

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THERMAL STORAGE SYSTEM CUTS CHILLED WATER PLANT ELECTRICITY USE IN HALF

Every year since 1981, the IBM Canada Ltée semiconductor assembly plant at Bromont, Quebec, has met IBM Corporation's challenge of reducing by four percent its annual energy consumption. To meet its 2005 quota, the plant installed a Novanergy® TES (thermal energy storage) system — a smart phase change thermal storage (PCTS) system developed and patented by Groupe Énerstat, Inc. of Sherbrooke, Quebec. Novanergy® TES is ground-breaking technology that could yield large energy savings if widely adopted. Both Natural Resources Canada (NRCan) and Hydro Québec helped fund the project.

The Problem

In 2005, the challenge for IBM Bromont was to optimize the energy efficiency of its chilled water plant while replacing two 3.5 MW (1,000-ton), 25-year-old water chillers that used ozone-depleting CFC-12 refrigerants. The chilled water plant also included six 3.5 MW (1,000-ton) chillers and one 2.8 MW (800-ton) free-cooling heat exchanger that operated during the winter months.

The Solution

The Novanergy TES system levels out demand on the plant's chillers during the day and shifts operation of chilled water equipment to the night to take advantage of off-peak electrical rates and lower condensing temperatures. Novanergy technology also stores extra heat or cold produced by various operations at the IBM plant and redistributes it for other uses. Improving the overall efficiency of chilled-water production reduces energy consumption, cuts greenhouse gas emissions and saves the company money.

The Process

Novanergy — the PCTS technology — stores heat or cold in synthetic phase change materials (PCMs) inside hermetically sealed, thermal storage reservoirs. As the PCMs melt or freeze, large quantities of thermal energy are absorbed or released at constant temperature. The PCMs in the thermal storage reservoirs are specially formulated to change phase at temperatures that are optimum for the process at hand.

Thermal energy is transferred into and out of the thermal storage reservoirs by a water/glycol thermal fluid circulated through heat exchange coils in the thermal storage reservoirs. The thermal fluid also transports thermal energy to other components of the system.

Novanergy's thermal energy storage reservoirs at IBM Bromont

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The Components

The Novanergy system installed at IBM consisted of:

- two 20 GJ (1,600-ton-h nominal capacity) Novanergy TES reservoirs;
- a 5.3 MW (1,500-ton) YORK variable-frequency drive (VFD) chiller to charge the thermal storage reservoirs;
- a thermal fluid (water/glycol mixture) loop with two circulating pumps;
- a 8.8 MW (2,500-ton) thermal-fluid to cooling-water heat exchanger; and,
- an existing 2.8 MW (800-ton) free-cooling heat exchanger.

The operation of the Novanergy system can be divided into two main modes. The discharging mode is used during the day when demand for cooling water is high and the TES reservoirs are charged with cold. If the lead chiller (the VFD chiller) cannot meet the cooling water demand, rather than bringing one of the plant's 1000-ton chillers on line, cold is discharged from the TES reservoirs. The charging mode is used at night when cooling water demand and outside temperatures are lower. At night the VFD chiller is run at near peak capacity when it is most efficient, and the cold energy produced is stored in the TES reservoirs.

The Benefits

It is simpler to operate and maintain the Novanergy system than a standard chiller system because:

- only one thermal fluid is needed to charge and discharge thermal energy;
- most of the process is automated, which relieves operators from making control decisions;
- equipment is operated in a stable manner, reducing wear and tear; and
- thermal storage can respond quickly to demand.

By using a circulating pump, a heat exchanger and a modulating valve, "efficient" energy is carried from the thermal storage reservoirs to the cooling water loop, providing the integrated system with an instant capacity of 8.8 MW (2,500 ton), which can modulate to as low as 350 kW (100 ton). Since, the PCM is in a sealed enclosure and the TES operates on a stable basis, it requires only minimal maintenance.

Energy savings = greenhouse gas reductions

Before implementation, electrical energy input per ton of cooling capacity was over 0.89 kW/ton. After implementation it was less than 0.5 kW/ton. This amounts to a 47-percent reduction in energy used for chilled water production, and an electrical energy saving of 5,312 MWh per year. Assuming the average emissions factor of 232 g CO_2/ kWh for electrical energy in Canada, greenhouse gas emissions for chilled water production were reduced by 35 percent or in the order of 1,200 tonnes per year.

The IBM Bromont project clearly demonstrates the environmental benefits of the TES system. Running a smaller chiller during the day means lower demand for peak-rate electricity; and with heat recovery on the condenser side of the chiller, less natural gas is burned to heat de-ionized water.

Payback in less than five years

IBM Bromont's total cost for the project was $2.6 million including the cost of dismantling two existing R-12 chiller units. The cost of the thermal storage system itself was less than $1.6 million. The company's total energy cost saving was approximately $351,000/yr including electrical energy cost savings of $145,500/yr (5,312 MWh/yr at $0.0274/kWh on average) and electrical demand cost savings of $205,500/yr ($11.96/kW demand per month). This puts the payback period at around 4.5 years, without considering cost savings associated with upkeep, pumping, maintaining water temperature during electrical fluctuations, reduced maintenance (cycling) on the chillers, and reduced natural gas use.

Leveraging funding to foster innovation

Hydro-Québec contributed $300,000 and NRCan contributed $99,800 toward Énerstat's engineering and monitoring costs for the $2.6-milion project.

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