Energy-saving measures at ice rink

Summary

Ontario Hydro Technologies (OHT) has carried out a study to evaluate energy-saving techniques for typical indoor artificial ice surface facilities. The Greenbriar ice arena in suburban Ontario was retrofitted with several technologies including lighting upgrades, a low-emissivity ceiling and programmable refrigeration controllers. The study also attempted to determine how much the brine temperature could be increased to generate further savings. Payback periods were as low as 1.4 years. Based on the empirical findings, several recommendations were made concerning future progress in energy savings for artificial ice.

Highlights

- Low-emissivity ceiling
- Programmable brine pump cycle controller
- Dimmable metal halide lighting
- Increased brine temperatures

Greenbriar Ice Rink.
Aim of the Project

Skating, curling and ice hockey are all Canadian winter pastimes and have deep-rooted traditions in many parts of Canada. A study by the Canadian Electricity Association (CEA) identified 2,327 ice arenas and 1,322 curling rinks throughout Canada with artificial ice surfaces; together these surfaces consume over one billion kWh of electricity annually. Despite efforts over the past decade to reduce the energy required to make artificial ice, many cost-cutting opportunities still exist. The CEA study predicted that savings of 40% are possible with investment payback periods of eight years or less. The purpose of this project was to generate empirical data which would corroborate the CEA predictions and to evaluate manufacturer estimates of energy improvements. Recognising that ice arenas and curling rinks have different energy costs, an attempt was made to use technologies which could be applied to a variety of artificial ice facilities.

The Principle

The study by the Canadian Electricity Association (CEA) identified the following three technologies as having the greatest potential for energy saving:

- ice rink hall lighting upgrade;
- low-emissivity ceiling installation;
- brine temperature and pump controls (cycling of the brine pump in sequence with the compressor).

The Situation

The Greenbriar Recreation Centre in the city of Brampton was selected as a facility best matching the demonstration criteria. The arena was built in 1972 and has had few energy upgrades, making it an ideal test site. The total floor area of the main building is approximately 5,500 m² (57,000 ft²) and it consumed around 280,000 kWh/yr before being retrofitted. The arena has a seven month operation period, from September to the beginning of April. The refrigeration plant is an ammonia/brine plant with two Mycom reciprocating compressors of 50 hp and 30 hp respectively. It also uses a 25 hp brine pump and an evaporative condenser with a 5 hp blower motor.

Before the lighting conversion, 64 mercury vapour lamps illuminated the ice hall, providing light levels of 300-400 Lux, depending on proximity. Normally they would operate at a 75% duty cycle and use around 450 kWh/day, with estimated annual seasonal energy consumption of about 100,000 kWh. The lighting upgrade consisted of a Peschel Lighting Control System with dimming ability and 48 new 400 W metal halide fixtures. The system relies on conventional ballasts and reduces the light output of the fixtures by reducing the input voltage to the ballast through a central voltage regulation controller.

The energy and demand savings realised by the new arena lighting and dimming system totalled approximately 15,700 kWh over four months of operation; the seasonally adjusted figure would be near 32,000 kWh/yr. The overall energy consumption of this system is therefore around 58,000 kWh and the demand reduction is 10 kW. One benefit of the metal halide lights is their increased luminosity; the rink now has lighting levels of over 750 Lux if required.

The low-emissivity ceiling is constructed of aluminium foil, fibreglass and fire-resistant material. This composite barrier was installed close to the existing ceiling so that it reduces the amount of heat radiating from the warm ceiling to the cold ice by 90-95%, resulting in a smaller annual refrigeration load. Low-emissivity ceilings also reduce condensation problems and improve lighting. The energy savings from the low-e ceiling for the months of December to March were 21,000 kWh; this translates into a seasonally adjusted 40,000 kWh. Refrigeration plant savings were solely attributed to the low-e ceiling. Brine temperatures could be increased by around 1°C after the low-emissivity ceiling was installed, meaning a reduced load on the refrigeration apparatus and an immediate annual saving of 8,000 kWh/yr.

The brine pump is rated for 60 L/s (950 gpm) and 210 kPa (70 ft) total head pressure. The pump previously operated continuously, with an average weekly consumption of 3,500 kWh. Energy savings are achieved by cycling the brine pump in sequence with the compressors. This was tested
using two brine pump cycling controllers; a Bassi controller and a CIMCO controller. Based on the measured savings, the seasonally adjusted savings that would be realised with a brine pump cycling control are estimated to be 44,000 kWh/yr with the Bassi and 55,000 kWh/yr with the CIMCO.

The study made several recommendations based on the findings of the Greenbriar rink project. There was a clear need to establish a prediction model which could be used to aid the design of new rinks and the retrofitting of old ones. The model would probably use a spreadsheet program and database. Another recommendation was to improve the method of predicting ceiling temperatures in order to calculate the radiant load. At Greenbriar the actual ceiling temperature was lower than the assumed values, which resulted in lower energy savings and longer payback periods. Lastly, it was recommended that a set of guidelines for optimised equipment replacement should be developed.

Figure 1: Schematic of Greenbriar ice plant.

The Company

Ontario Hydro Technologies evolved from Ontario Hydro’s Research Division, which was founded in 1912. Serving customers within and beyond Ontario Hydro, the new organisation aims to maximise customer benefits and cost savings through technological innovation and a commitment to operating as a responsive, client-driven organisation. Underlying this is a fundamental belief in the value of sustainable development. Ontario Hydro (OH) is a member of the CEA.

Economics

The following calculations are based on regional electricity costs of CAD 0.08/kWh. With lighting system energy savings of 32,000 kWh/yr and an installed lighting capital cost of CAD 37,000, the simple payback period for the system is 14.4 years. The lighting system at Greenbriar needed changing, which lowered the incremental cost. The low-emissivity ceiling saves 40,000 kWh/yr, or CAD 3,200 annually, and cost CAD 32,000 to install. This translates into a 10-year simple payback period. Both brine pump controllers showed much better simple payback periods; the energy savings of the Bassi and CIMCO controllers are 44,000 kWh/yr and 55,000 kWh/yr respectively and their installation costs are CAD 5,000 and CAD 20,000 respectively. This gives a simple payback period of 1.4 years for the Bassi, and 4.5 years for the CIMCO.
The IEA was established in 1974 within the framework of the OECD to implement an International Energy Programme. A basic aim of the IEA is to foster cooperation among the 24 IEA Participating Countries to increase energy security through energy conservation, development of alternative energy sources, new energy technology, and research and development (R&D).

This is achieved, in part, through a programme of energy technology and R&D collaboration currently within the framework of 40 Implementing Agreements, containing a total of over 70 separate collaboration projects.

The Scheme

CADDET functions as the IEA Centre for Analysis and Dissemination of Demonstrated Energy Technologies. Currently, the Energy Efficiency programme is active in 12 member countries and the European Commission.

This project can now be repeated in CADDET Energy Efficiency member countries. Parties interested in adopting this process can contact their National Team or CADDET Energy Efficiency.

Demonstrations are a vital link between R&D or pilot studies and the end-use market. Projects are published as a CADDET Energy Efficiency 'Demo' or 'Result' respectively, for ongoing and finalised projects.

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