

Energy Efficiency Commissioning for Municipal Buildings

System Category	Description of Cost and/or Energy Savings Method
Electrical rates and structures	<p><input type="checkbox"/> Start up your highest energy consuming appliance (e.g. ice pad) shortly after the demand meter is read since the electricity demand charge (based on peak demand) applies to the entire month in which it lands. For example, if an ice plant starts up on September 15 and the meter is read on September 17, the full demand charge is applied for the billing period ending September 17, even though the ice plant was only on for two days. If you were operating a 60 hp ice plant, you could save over \$600 in demand charges including taxes by waiting two days to start the compressor. Same is true for end of season (ie. Shut down the ice plant before the meter is read).</p>
Temperature and ventilation control	<p><input type="checkbox"/> During unoccupied hours, set back the thermostat on heating equipment to as low a temperature as is practical in most rooms. Normally 65 F (18 C) is cool enough to save 5–7% of the heating energy but still allow for a quick warm-up before occupancy. Spectator areas should be set back to 35 F (2 C) or cooler, except for games. Be careful when setting back electric heating system thermostats since heating units may all switch on at the same time, potentially increasing peak demand.</p> <p>Ventilation is necessary for indoor air quality. ASHRAE 62.1 minimum ventilation rates should be followed as a best practice. Occupancy-based demand controlled strategies can be implemented to reduce ventilation when not needed.</p> <p><input type="checkbox"/> Install a Heat Recovery Ventilator (HRV), which recovers heat from the warm air being exhausted from a building to pre-heat incoming cold, fresh air.</p> <p>Ventilation costs can be significant. Operating a 1,000 cfm exhaust fan for 2,000 hours (25% of the time over one heating season for an arena) would cost roughly \$3,000 a year for electric or \$600 a year for natural gas.</p> <p><input type="checkbox"/> Use time clocks to automatically setback thermostats, shut off ventilation systems, and shut off exhaust systems or other loads when they are not required. In addition to conserving electricity, controls can reduce demand if using electrical resistance for space or water heating (e.g. not operating the heating systems while the rink compressor is at full load).</p>
Hot water	<p>Domestic hot water systems can consume 15% of the energy for the average arena. This is for both source heat and stored heat. Up to 50% savings in domestic hot water heating costs can be realized by installing heat reclaim on refrigeration equipment. Heat reclaim consumes the least energy but has increased capital cost.</p> <p><input type="checkbox"/> Consider heat reclaim from ice making and/or heat pump for domestic hot water when current system is near end-of-life</p>

	<ul style="list-style-type: none"> <input type="checkbox"/> Install an instantaneous gas-fired water heater which requires energy only when there is a demand for hot water. Since these units do not have a high storage capacity, stand-by losses are further reduced. <input type="checkbox"/> Add insulation to storage tanks and pipes to hold the heat in the water and reduce stand-by loss. Store hot water for flooding near the re-surfacing room and shower water near the dressing rooms. A lot of heat can be lost in distribution piping. Fill the re-surfacer just before use so the water is as warm as possible. Also see Ice Making section for re-surfacing ideas. <input type="checkbox"/> Install low-flow shower heads to reduce hot water consumption.
<p>Heat pumps</p>	<ul style="list-style-type: none"> <input type="checkbox"/> Consider a Ground Source Heat Pump or Air Source Heat Pump for space heating when HVAC equipment is near end-of-life, or during construction / major renovation. A heat pump uses refrigerant circuits to move or “pump” heat from one location to another. Ground source heat pumps have coefficient of performance (COP) ratings between 2.5–3.5, which translates to an ‘efficiency’ of 250% - 350%. Ground source loops can be buried under the parking lot, ball diamond, etc. next to the complex. The ground loop can be used to chill rink brine if the soil is totally frozen. <p>New designs can integrate heat pumps with regular ice plant equipment to meet the space heating, water heating and air conditioning demands. These have a higher first cost (installed price) and lower operating costs than conventional systems. Maintenance costs may be slightly higher than conventional heating systems, but similar to air conditioning systems. Special care must be taken in the piping of the system to avoid fouling of the heat exchanger inside the unit.</p>
<p>Ice Making</p>	<p>The most important factor in reducing the cost of energy to operate an ice plant is to control ice making and ice thickness. Reductions in radiated heat loads, convective heat loads (rink temperature and humidity), brine pump work and ice re-surfacing pay the most dividends because they are the largest of the loads on the ice plant. All other loads are minor in comparison.</p> <ul style="list-style-type: none"> <input type="checkbox"/> Ensure slab under rink is flat during construction so ice is uniformly thick. Many rink slabs suffer from serious frost heaving and soil settlement due to sub surface moisture. <input type="checkbox"/> Ensure water used for flooding is pure to ensure quality of the ice produced and energy saved. Air can be removed from the water by heating it above 54 C (130 F), or a using a low-pressure system (see Cold water resurfacing). Reverse osmosis systems produce pure, demineralized water, which has a higher freezing temperature so brine temperatures can be raised. The ice produced is harder so less snow is produced and less surface maintenance required. Pure water can be applied at a lower flood water temperature, which saves on heating and refrigeration energy. Less water is required for each flood, which

means ice shaving isn't required as often. This saves on equipment wear of the ice surfacing machine. Consider alternate water supplies if your water source is high in impurities. Rainwater such as roof run-off or dugouts can be examined if practical. Water high in iron produces a "coloured" ice that absorbs radiant light and puts extra heat load on the ice plant.

- Consider cold water ice re-surfacing**, which uses pressure instead of temperature to remove air bubbles from ice and reduces energy to heat resurfacing water, reduces load on ice-making compressor and can improve ice hardness. – I am only aware of 2 arenas in Manitoba that do this and the savings were substantially less than advertised
- Paint the ice a reflective white to reduce refrigerant load by five to 15% compared to "dark ice"**. Reflecting light back into the rink also reduces the number of lights required for further energy savings. Choose thermally conductive ice surface paints. Paints for lines and ice colouring, as in the case of all other impurities, reduce heat transfer through the ice.
- Take your shaved ice outside to be melted, if practical**. Melting ice inside puts an extra load on the heating equipment.
- Hold the temperature of the ice surface as high as possible**. Hockey requires hard ice, figure skaters like soft ice, curlers want keen ice. Hockey rinks run with -9 C (16 F) brine returning at -8 C (18 F). Curling and figure skating ice runs with -6 C (22 F) brine returning at -4 C (24 F). Recreational skating is usually in between. Each degree Fahrenheit that you raise the ice temperature reduces the load on the ice plant by up to 2%.
- Maintain your brine at a specific gravity of 1.20 to 1.22 for optimum energy use**. Higher specific gravity means higher density and more power required to pump it. Lower specific gravity has higher freezing point than the temperature of refrigerant in the chiller so the brine would freeze.
- Maintain your brine temperature as high as possible** to reduce refrigeration loads. Equipment is available to automatically reset brine temperatures based on a schedule of events throughout the day (e.g. hockey vs. figure skating vs. recreational skating). Dropping brine temperature by 1 C (2 F) takes one to two hours if the ice is kept thin. You can save up to 8% of compressor energy with variable brine temperatures. Consider a separate slab sensor if variable temperature brine controls are installed. This will ensure that the ice performs as required, independent of other loads on the system.
- Shut off your refrigeration plant at night, including the brine pump**. Shut off all heat loads in the arena. Set space heating back to 2C (35) F . The ice temperature will rise slowly. Once the slab sensor (not brine sensor) detects that the slab has reached -4 C (25 F) , the brine pump and one compressor should be started to prevent the ice from warming any further. The soft ice in the morning will be easy to cut and groom the next day, which reduces wear and tear on your ice maintenance equipment and saves on fuel. Tip: When the compressor is cooling the ice, from -4 C to -8 C (25 F to 18 F), keep the number of lights on and other equipment to an absolute minimum to avoid setting a new peak demand.

- Start variable speed pumping for the brine pump.** Arena and curling rinks typically rely on in-line, centrifugal brine pumps, which waste 90% of the energy consumed as heat in the circulating brine, putting a large load on the ice plant compressor. Consider these three solutions: 1. (lowest cost): Install ice slab thermostat 3–6 ft. from the edge of the concrete slab to ensure pump comes on only when the ice temperature rises above the thermostat set point. It costs an estimated \$2,500 to \$3,500 to install a slab thermostat. Payback would be two to three years for a seasonal ice arena, and five to six years for a curling rink.
 2. Buy a new 2-speed pump or a smaller secondary pump to install in parallel with the old pump. You would also have to install an ice slab thermostat. (Brine pumps are sized to deliver enough flow to satisfy peak cooling needs that occur only during warm weather operation. So either the 2-speed pump, or the smaller secondary pump, would operate most of the time on low speed for major savings. It costs an estimated \$5,000 to \$7,000 to install a slab thermostat and 2-speed pump. Payback would be two to three years for a seasonal ice arena, and four to six years for a curling rink.
 3. Buy a new variable speed drive for the brine pump and install an ice slab thermostat. It costs an estimated \$15,000 to \$25,000 to install a variable speed pumping system with slab thermostat. Payback would be five to eight years for a seasonal ice arena, and 10 to 17 years for a curling rink.

- Dehumidify the arena using brine line return coil** (which will condense moisture out of arena air), or get a dehumidifier.

- Install controls for refrigeration system/ brine pump:** 1. Manual control (ie. Shut off equipment when not required). Issue is human error. 2. Time clocks as controls 3. Automatic controllers (with inputs to drive outputs e.g. brine pump controller receives input from slab thermostat and turns off based on set point. Costs vary from \$1,000 to \$20,000 installed, depending on the complexity of the function and the amount of power controlled 4. Computerized energy management system is the most sophisticated control method. A computer controls: refrigeration, brine pump; ice temperature; lighting, ventilation, space heating, water heating, demand functions etc. Many are also capable of maintenance notices, inventory, accounting, bookkeeping, invoicing and security. Best suited for very sophisticated owners with large facilities and high energy consumption.

- Recover heat from ice making (condenser) to heat the indoor space or water.** In most cases the ice plant can remain as is. Two 50 hp compressors in the ice plant are used to produce chilled brine at -8 C (18 F). In new construction, consider parallel refrigeration units comprising four, 25 hp machines. This strategy provides increased number of load capacity steps, redundancy in the system, and use of refrigeration compressors for summer air conditioning. Downside is that, in cold weather the ice plant rarely runs so there is little heat when you need it most. In spring and fall, the refrigeration plant runs a lot yet the need for heating is minimal. These situations point out the need for alternate heat sources and alternate heat sinks. Some facilities store the heat in insulated water tanks to be used at a later time. This is thermal storage.

- Reduce humidity levels** inside the rink using brine line dehumidifier (return loop of brine at -6 C), or refrigeration dehumidifier

Recovery from refrigeration equipment

You can save significant amounts of energy by recovering heat from refrigeration equipment.

An average of 25 tons (88 kW) of refrigeration heat is typically available throughout the day. As a result, up to 7.2 million Btu (2110 kWh) per day of rejected heat energy from the ice plant is available for other heating requirements

Reclaimed heat from the condenser loop is generally used for:

- flood water heating; - If rink flooding requires 2,271 litres (600 U.S. gallons) of water a day at 60 C (140 F), assuming a 5 C (40 F) inlet water temperature, then 500,000 Btu (146.5 kWh) is required to heat the water every day. Can connect a heat exchanger to the discharge line from the compressor (very hot gas). Must size equipment properly and have back up source in case compressor isn't on between floods.
- domestic water heating; - heating requirement varies between facilities. Assume a daily consumption of 3,180 litres (840 U.S. gallons) of 49 C (120 F) water. This results in a total heating requirement of 560,000 Btu/day (164 kWh), based on an inlet water temperature of 4 C (40 F). Condenser heat is only practical for pre-heating because the highest discharge temperature would be about 32 C (90 F) . Still, this would save about 63% of the total energy required for domestic water heating. Standard fuel fired water heaters would be required to provide adequate temperature for shower water.
- space heating; Heat reclaim is available for space heating but the quality of the heat is low grade. Heat pumps are now able to use this low-grade heat to provide space heating and summertime cooling. If compressor superheat is available from a freon refrigeration plant, there may be ways to produce 71 C (160 F) hot water to supplement boiler water heat. Relatively few facilities have hot water heating systems, so applications are limited except in new construction or major heating system renovations
- under slab heating; Extended use facilities install heating pipes below the insulated rink floor slab. Water circulated in the loop should be kept at 2 to 5 C (35 to 40 F) to prevent the formation of ground frost and heaving of the slab. Because of the low temperatures necessary, heat reclaim is an excellent source of heat for under slab heating. The total heat required is 50–100 MBH (15–30 kW) to prevent freezing of the floor foundation and frost heaving. The operating heat from a circulating pump is often enough. A small gas or electric heater can be installed to provide some heat if necessary.
- ice melting. Melting shaved ice and snow with a condenser heat loop saves energy in space heat and evaporative condenser operation. If it is impractical to take the snow outside, then heat reclaim is a good way to melt the snow in a drain pit.

The heat available may or may not be at a temperature that is useful for applications. Condenser heat is available at 35 C (95 F). Compressor discharge refrigerant is at 116 C (240 F) in a freon system. Installing certain energy efficiency systems and modifications to the refrigeration equipment will change the total amount of heat available for heat recovery. Be sure to consider all measures in total before purchasing heat recovery systems.

<p>Electrical</p>	<ul style="list-style-type: none"> <input type="checkbox"/> Increase power factor correction for electric motor in refrigeration system using capacitor . <input type="checkbox"/> Reduce lighting loads to reduce refrigeration load using dimmers, LED bulbs and/or other methods. <input type="checkbox"/> Install energy efficient motor for refrigeration system at time of replacement (long payback period) <input type="checkbox"/> Use controller to reduce peak demand for large non-refrigeration electrical loads like cooking, large A/C, electric heating <input type="checkbox"/> Install two smaller independent refrigeration plants at time of replacement for demand management. One size to handle average loads and the other size to handle peak loads. One motor running fully loaded is more efficient than one large motor running half loaded. With two smaller independent refrigeration plants, you can limit demand at peak demand times by shutting one plant off. Capital costs are substantially higher with this method, but it saves energy over the life of the facility. <input type="checkbox"/> Install low-emissivity ceiling, which is a highly reflective paint or curtain at the ceiling. Arena ceilings can radiate heat increasing load on ice refrigeration system. This can be mitigated by up to 80% with a low emissivity ceiling system, If the ice arena is unheated or the arena is operated for six months or less, the effect of a low emissivity ceiling system can be minimal
<p>Interactive Effects</p>	<ul style="list-style-type: none"> <input type="checkbox"/> When considering the overall savings of an energy efficient product, consider the interactive effects of the product on building heating, cooling and refrigeration systems The percentage of heat that is useful in your building or room will depend on several factors including: • the location of light fixtures; • the locations of heaters and their thermostats; • type of ceiling; • size of the building; • whether the room is an interior space or an exterior space (perimeter) • the seasons the building is used; • type of HVAC used in each room. Interactive effects can be complex so may require mechanical engineer or technologist
<p>Maintenance</p>	<ul style="list-style-type: none"> <input type="checkbox"/> Reseal cracks and joints on the interior of the building every year, during summer or early fall. Maintenance for insulation is rarely required unless displacement or dampness is detected. <input type="checkbox"/> Caulk unplanned cracks or openings in the exterior cladding with good quality exterior grade caulks. Don't seal planned openings, like weep holes through the wall.

Sources: Efficiency Manitoba "[Energy Efficiency Guide for Municipal Recreation Facilities](#)"; FCM "[Taking Your Indoor Ice Rink to Net Zero](#)"