RENEWABLE ENERGY

Earth Energy Systems

Case Study

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Geothermal Ice Plant Efficiently Replaces Aging Ammonia System — Oliver Curling Club, Oliver, B.C.

The Oliver Curling Club, in Oliver BC, was built in 1974. The conventional ice plant and electric heating system was replaced with an integrated geothermal refrigeration and heating system in 1994. Inset: View of the 4 sheets of curling ice in the Oliver Curling Club.

After almost three decades in operation, the Oliver Curling Club in British Columbia was deteriorating. The ammonia refrigeration system used to make ice was failing and electric heating bills were cutting into profits. After the 1993/94 season, the ice plant condenser had to be replaced. Several of the electric heaters, the steel rink pipe header and the chiller also needed replacement.

A geothermal heat pump system was a viable solution.

The installation cost paid for itself in energy savings alone in just three years, and enabled the club to reduce labour costs. At the same time, the geothermal system provided a more comfortable indoor environment that was immediately noticed by members, resulting in increased rentals of the lounge. Since its installation in 1994, the system has improved the overall efficiency and comfort of the club.

- Energy consumption nearly halved
- Reduced environmental impact
- Increased indoor comfort
- Specialists are no longer required and local refrigeration companies can service the equipment
- Reduction in daily operating and maintenance procedures and costs
- Short payback period
- Electric utilities offer incentives for geothermal systems

Oliver Curling Club

The Oliver Curling Club is a two-storey, wood frame building constructed in 1974. There are approximately 167 square metres per floor, in addition to the 836 square metre, four-sheet ice surface. The walls are insulated to R12 and the ceiling to R20. There are few windows. An ammonia refrigeration system was installed to make ice, and electric heaters warmed the viewing area and locker rooms, second floor lounge and the ice area.

Reducing energy consumption for ice-making

The existing 22.3 kW ice plant, rink pipe and header system and cooling tower were replaced with five water-water heat pumps with a nominal cooling capacity of 5 tons* each (ice-making temperatures require actual chilling capacity of about 2.4 tons). The rink headers and pipe were removed and replaced with a new rink pipe layout designed to reduce the flow needed to maintain good heat transfer from the ice. This allowed the 7.5 kW brine pump to be replaced with a 2.2 kW pump. The water-water heat pumps draw heat from the ice, rejecting it into the vertical earth loop, rather than through a cooling tower to the atmosphere.

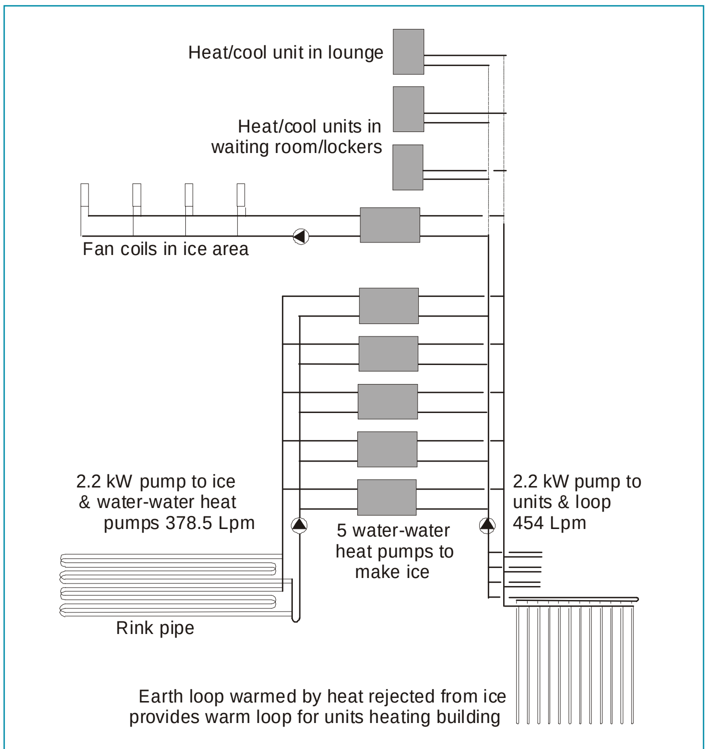


FIGURE 1: Piping schematic illustrates how ice making and space heating are integrated in Oliver Curling Club.

Space Heating complements refrigeration system

The earth loop is the energy source for space-heating heat pumps. Two 4-ton forced air heat pumps were installed on the second floor and a 4-ton heat pump was installed for the main floor locker rooms and lobby. A 5-ton water-water heat pump provides warm water to fan coils installed to heat the ice area.

The cooling units reject heat into the loop, allowing the heating units to operate more efficiently, while the heating units cool the loop (the condenser), increasing the efficiency of the refrigeration units. The earth loop is simply a sponge absorbing excess heat from the ice and storing it until the heating units wring it out.

Typically, the temperature of the earth loop rises to about 24°C to 27°C when the ice is being made in October. As winter arrives, the heating units draw more and more heat from the loop as they heat the building. Loop temperatures stabilize at 13°C to 18°C during mid-winter, rise slightly in spring and return to normal ground temperatures (11°C) when the system is not used in the summer. The warm loop temperatures allow the heating units to operate at a coefficient of performance of about 4.6 most of the winter.

A return line temperature sensor controls the operation of the ice making units, and digital thermostats operate the heat/cool units. A 2.2 kW pump circulates 454 litres per minute through the earth loop and heat pumps when a heat pump is running. A second 2.2 kW pump circulates antifreeze through the rink pipe when chilling is needed.

The earth loop is like a heat-absorbing sponge, holding excess heat until the heating units wring it out

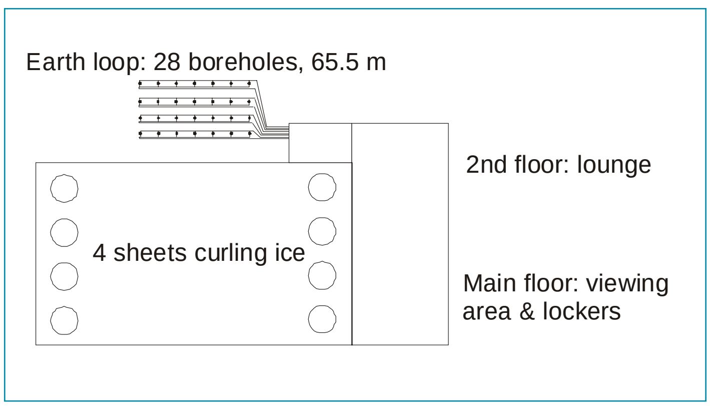


FIGURE 2: Layout of building. The vertical earth loop was built by boring 28 holes 65.5 metres deep into the clay and till soil.

* 1 ton of cooling equates to 211 kilojoules per minute or 200 BTU per minute of energy.

Operating costs – the geothermal advantage

Actual energy cost savings have been $8,724 annually, compared to the energy cost for a conventional ice plant and electric heaters. This results in a simple payback of less than three years for the geothermal system. Even if the electric heaters had been replaced with gas, the geothermal system would have saved $6,510 in energy costs.

Energy use in the curling club has decreased by approximately 50 percent since the integrated system was installed in 1994. The following chart shows the average consumption, peak demand and the cost of energy over a four-year period with the conventional system compared to a four year average with the geothermal system.

	ELECTRIC & AMMONIA	GEOTHERMAL	% REDUCTION
Peak Demand (kW)	131	67	49%
Consumption (kW.h)	312,160	167,200	46%
Energy Cost	$17,568	$8,844	50%

When other costs of operating and maintaining a conventional system are compared with a geothermal system the payback is even quicker. The geothermal system is easier to operate and cheaper to maintain. Specialists are required to service refrigeration equipment using ammonia or freon, but in-house personnel can easily handle the geothermal system. Rigorous fall start-up and spring shut-down procedures necessary with ammonia systems are not required for geothermals.

Even daily operating procedures, hence cost and labour, have been reduced significantly. For example, oil in an ammonia refrigeration system tends to collect in the chiller and must be drained regularly, with new oil added to replace it. This requires a half-hour a day and is not necessary in the geothermal system. In addition, regulations require a conventional system to be monitored every two hours.

Comfort has increased, but energy use is down almost 50 percent

Greenhouse gas emission reductions

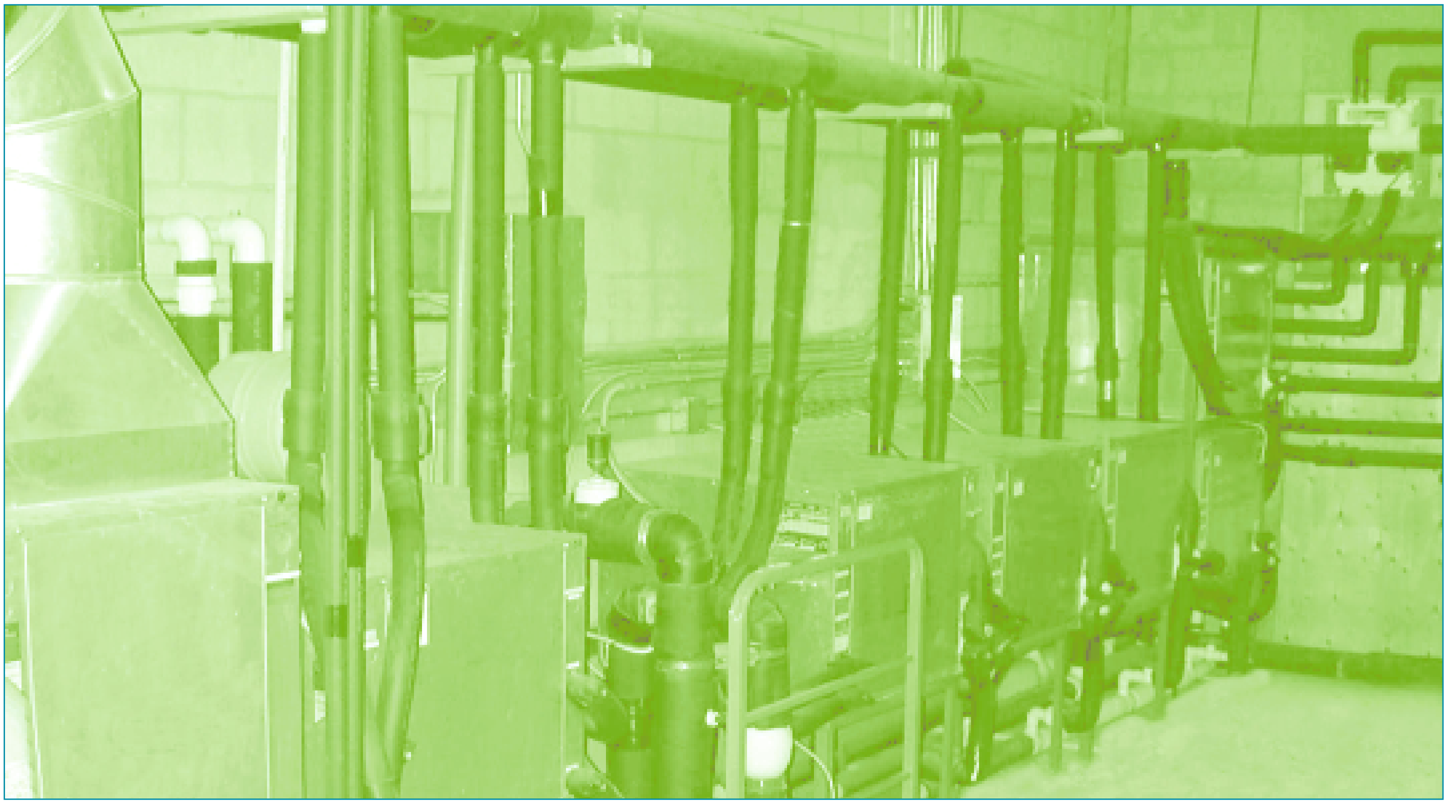
Virtually all electricity produced in British Columbia is generated by hydro-electric generating stations, which do not contribute to the greenhouse effect. A reduction in energy consumption indirectly reduces greenhouse gas emissions, however, because energy not used in British Columbia is sold outside the province to consumers who may otherwise use fossil fuel generated power. A large producer of greenhouse gases may also wish to purchase carbon credits.

Compared to operating a conventional ice plant using electric heat, the Oliver Curling Club reduced consumption by approximately 144.96 MW.h It is estimated that each MW.h of electricity saved in Canada reduces CO_2 emissions by 187 kg. Oliver's geothermal conversion thus avoided 27.1 tonnes of CO_2 emissions annually!

TABLE 2 Annual Cost Comparison

	CONVENTIONAL SYSTEM	GEOTHERMAL SYSTEM
Annual Service (startup & shutdown)	$2,500	$400
Energy Cost	$17,568	$8,844
Daily Maintenance (half hour/day)	$2,700	–
Oil (for ammonia compressor)	$800	–
6,000 hour check (cost/year)	$1,250	–
12,000 hour check (cost/year)	$1,250	–
Heat pump replacement (once in 20 yrs)	–	$985
Circ. Pump replacement (once in 20 yrs)	$175	$130
Chiller, header, condenser (once in 20 yrs)	$2,300	–
Replace HVAC system (once in 20 yrs)	$450	
Total Cost per Year	$28,993	$10,359

This table compares the annual costs of a conventional system versus a geothermal system in today's dollars, based on a twenty-year life cycle. (The club can expect to replace the major components in the system about once in twenty years.)



Mechanical room with water-water heat pumps to make ice, water-water unit to heat ice area and forced air unit used to heat lobby.

Project costs

Three options were considered: repairing the ammonia unit and replacing the electric heaters; repairing the ammonia unit and installing a gas heating system; and, installing the integrated geothermal system. The geothermal system was more economical in the long term than either of the alternatives.

Total cost for the geothermal refrigeration, heating and air conditioning system, including the earth loop, was approximately $90,000. This was reduced by a $16,000 incentive from the electric utility (West Kootenay Power).

After the incentive, this cost was identical to repairing the ammonia ice plant and replacing the electric heaters with gas heaters and installing air conditioning in the lounge.

The initial cost of the geothermal system was $25,500 higher than repairing the ammonia ice plant and purchasing new electric heaters, but the energy costs would be reduced by fifty percent.

TABLE 1 Project Costs

	INTEGRATED GEOTHERMAL SYSTEM	MAINTENANCE & REPLACE ELECTRIC HEATERS	MAINTENANCE & GAS & A/C
Heat Pumps - Rink	11,200	–	–
Heat Pumps - HVAC	8,500	–	–
Circulation Pumps	2,600	–	–
Earth Loop	42,500	–	–
Controls	2,400	–	–
Rink Pipe	4,000	–	–
Floor Insulation	8,600	–	–
Ductwork	7,200	–	–
Fan Coil Units (rink)	3,000	–	–
Chiller	–	20,000	20,000
Cooling Tower	–	15,000	15,000
Rink Pipe Header	–	11,000	11,000
Replace Elec. Heaters	–	2,500	–
Install Gas Furnace & A/C	–	–	28,000
Utility Incentive	(16,000)	–	–
Total	$74,000	$48,500	$74,000

Initial operating difficulties easily remedied

The system has performed well with two exceptions. A compressor problem was encountered during the second season in the water-water heat pumps used to make ice. It was a manufacturing defect, and the compressors were replaced under warranty. However, because of its modular design, the system did not have to be shut down while a compressor was replaced; the other heat pumps were able to maintain the ice during repairs.

The length of time needed to make ice during the fall start-up was longer than anticipated. A fifth 5-ton unit was added and the system has performed well, requiring no repairs.

Increased comfort leads to increased revenues

After five years of operation, Oliver Curling Club's board of directors is completely satisfied with the integrated geothermal system. It has proven simpler to operate, reliable and has improved the overall comfort of the building. But most importantly, club members are satisfied. According to them, the lounge, viewing area and locker room are significantly more comfortable compared to the electric system. In addition, air conditioning has allowed increased rental of the second floor lounge and provided additional revenue for the club.

Most importantly club members are satisfied... more comfort plus increased rental revenues!

Viewing area of the lobby.

Building Description

OCCUPANCY: 4 Sheet curling rink

LOCATION: Oliver, British Columbia

GROSS FLOOR AREA:

ARENA:
334 square metres heated (lobby & lounge)
725 square metres heated ice shed
TOTAL: 1,059 square metres

NUMBER OF STORIES:
Viewing area/lounge....... 2
Ice Area............................ 1

TYPE OF BUILDING CONSTRUCTION:
Wood frame

COMPLETION DATE:
Arena built in 1974,
system installed in 1994

DEGREE-DAYS:

- Cooling (10°C) 0
- Heating (18.3°C) 6,522

Ground-Source Description

OVERBURDEN DEPTH: 43 metres

OVERBURDEN MATERIAL: Clay and till

MEAN ANNUAL GROUND TEMPERATURE: 11°C

Type of Ground-Source System

VERTICAL CLOSED LOOP:
28 boreholes to 65.5 metres

TOTAL BOREHOLE LENGTH: 1,835 metres

TOTAL HEAT EXCHANGER LENGTH: 3,670 metres

HEAT EXCHANGER PIPE: 1.25" HDPE

SECONDARY HEAT EXCHANGER FLUID:
Water and 27 % methanol (volume)

FLOW RATE THROUGH LOOP: 454 Lpm

Interior System

TOTAL INSTALLED HEAT PUMP CAPACITY:
REFRIGERATION: .... 25 tons
HEATING/COOLING: .... 17 tons
TOTAL: .... 42 tons

NUMBER OF HEAT PUMPS: 9

INTERNAL FLUID DISTRIBUTION SYSTEM:
Fluid circulated through heat pumps and earth loop with a single circulation pump

FLOW RATE / INSTALLED CAPACITY: 11 Lpm / ton

INSTALLED PUMP SIZES:

REFRIGERATION UNITS:
Loop: 2.2 kW / unit
Ice: 2.2 kW / unit

OPERATING PUMP SIZES:
Refrigeration units: ice: 90 W / ton
Heating/Cooling units: Loop: 52 W / ton

ADDITIONAL SYSTEMS AND FEATURES:

- Optimized rink pipe layout to reduce pump power requirements
- Ground loop used to store heat rejected from ice making

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