

The Energy Management Manual for Arena and Rink Operators

Produced by:

SaskPower

Saskatchewan Parks and Recreation Association

Office of Energy Conservation

February 2007



A Message from SaskPower

Dear Readers:

SaskPower is pleased to announce the publication of the Energy Management Manual for Arena and Rink Operators. Through the assistance of a number of provincial agencies, the original manual produced in 1991 has been extensively updated and revised to include current technology and practices.

SaskPower continues to support energy conservation and management for two reasons. The first, and perhaps the most important, is to reduce operating costs for our customers. These facilities are vital to community growth in our province. As energy costs often increase faster than the community tax base, energy conservation can play a key role in ensuring that these facilities are able to continue operating in our communities.

The second reason is to reaffirm our commitment to the environment. Since fossil fuels remain the main source of electrical generation in our province, reducing energy consumption directly reduces greenhouse gas emissions to our environment. Improving our environment works best if we work together with our communities to promote energy conservation collectively.

Once again, we appreciate the continued support and interest in energy management from the Saskatchewan Parks and Recreation Association, and we are grateful for the participation of the Office of Energy Conservation in the production of this revised manual. We hope the manual will assist in the training and education of all facility operators and lead to an even greater enjoyment of arenas and curling rinks in communities across Saskatchewan.

Yours truly,

A handwritten signature in black ink that reads "Pat Youzwa". The signature is fluid and cursive, with the first letters of each word being capitalized and prominent.

Pat Youzwa

President and CEO

SaskPower

Acknowledgements

This revision of The Energy Management Manual for Arena and Rink Operators is a result of the efforts of a project management committee:

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Table of Contents

Section 1 Electrical and Natural Gas Rates

Electrical rates	1.1
Terminology	1.1
General service rates	1.2
Electrical consumption	1.3
Demand	1.3
Calculating your electricity bill	1.3
Saving money at season start-up and shutdown	1.6
Disconnection	1.7
Understanding your SaskPower bill	1.8
Natural gas rates	1.9
SaskEnergy natural gas rates	1.9
Calculating your natural gas consumption	1.9
Understanding your SaskEnergy bill	1.10

Section 2 Meters and Your Electrical Inventory

Reading meters	2.1
Electricity meter reading	2.1
Electrical demand	2.2
Demand meters	2.2
Reading your natural gas meter	2.6
Inventory of electrical loads	2.6
Taking your electrical inventory	2.7
Analyzing your energy usage	2.8

Section 3 Making a Financial Analysis

Considering your options	3.1
Cost/benefit analysis	3.1
Simple payback	3.2
Net present value (NPV)	3.2
Constant Dollar Value	3.5

Section 4 The Building Envelope

Components and systems	4.1
Air barrier systems	4.1
Materials to use	4.2
Where to seal	4.5
What to avoid	4.6
Ventilation	4.7
Insulation	4.7
Installing insulation	4.8
Cladding	4.8
Waterproofing	4.9
Vapour retarders	4.9

Table of Contents

Section 4 The Building Envelope (con't)

Moisture problems	.4.10
Moisture	.4.10
How moisture accumulates in buildings	.4.10
Handling moisture	.4.11
Wall types	.4.11
Studs with drywall or plywood	.4.12
Precast concrete	.4.12
Metal buildings	.4.12
Masonry with reinforced membranes	.4.12
Insulated concrete forms (ICF)	.4.13
Structural insulated panels (SIP)	.4.13
Energy efficiency of building types	.4.14
Parking lot controllers	.4.15

Section 5 Heating and Ventilation

Furnaces	.5.1
Electric	.5.2
Natural gas/propane	.5.2
Oil	.5.2
Infrared radiant heaters	.5.3
Unit heaters	.5.4
Air conditioners	.5.4
Rooftop heaters	.5.5
Heat pumps	.5.6
Hot water/steam systems	.5.7
Ventilation	.5.8
Natural ventilation	.5.8
Health issues	.5.9
Carbon monoxide safety	.5.10
Mechanical ventilation	.5.11
Heat recovery ventilators (HRVs)	.5.11
Heat reclaim	.5.11
Heating ventilation energy efficiency	.5.11
Basic concepts of energy management	.5.14
Domestic hot water	.5.14
Demand limiting	.5.15

Section 6 Refrigeration

Refrigeration energy efficiency	.6.1
Ice making	.6.2
Rink floor slab construction	.6.2
Slab preparation	.6.3
Water purity	.6.3
Water purification	.6.4

Table of Contents

Section 6 Refrigeration (con't)

Painting the ice . . . . .	.6.4
Ice thickness . . . . .	.6.4
Ice melting . . . . .	.6.5
Ice temperature . . . . .	.6.5
Mechanical refrigeration . . . . .	.6.6
The refrigeration cycle in rinks . . . . .	.6.6
Brine . . . . .	.6.7
Variable brine temperature . . . . .	.6.8
Night shutdown . . . . .	.6.8
Variable speed pumping . . . . .	.6.9
Three options for improving brine pump control . . . . .	.6.9
Liquid pressure amplifier . . . . .	.6.12
Brine line dehumidifier . . . . .	.6.12
Refrigeration dehumidifier . . . . .	.6.12
Controls . . . . .	.6.13
Switches . . . . .	.6.13
Time clocks . . . . .	.6.13
Automatic controllers . . . . .	.6.13
Computerized energy management systems . . . . .	.6.14
Integrated systems . . . . .	.6.14
Alternate heat sources/sinks . . . . .	.6.15
Heat recovery . . . . .	.6.16
Flood water heating . . . . .	.6.16
Domestic water heating . . . . .	.6.17
Space heating . . . . .	.6.17
Under slab heating . . . . .	.6.17
Ice melting . . . . .	.6.18
Electrical . . . . .	.6.19
Power factor correction . . . . .	.6.19
Motor selection . . . . .	.6.20
Demand limiting . . . . .	.6.21
Low emissivity ceilings . . . . .	.6.21
Section summary . . . . .	.6.22

Section 7 Lighting

Optimum lighting sources . . . . .	.7.1
Common lighting sources . . . . .	.7.3
T-12 Fluorescent . . . . .	.7.3
Mercury Vapour (MV) . . . . .	.7.3
Lighting levels . . . . .	.7.4
Lighting systems . . . . .	.7.6
Incandescent . . . . .	.7.6
T-8 Fluorescent . . . . .	.7.6
Metal halide (standard technology or probe-start) . . . . .	.7.7
Metal halide (pulse-start) . . . . .	.7.8

Table of Contents

Section 7 Lighting (con't)

Metal halide lamp safety	7.8
High Pressure Sodium (HPS)	7.9
Low Pressure Sodium (LPS)	7.10
Lighting ballasts	7.11
Types of fluorescent lamp ballasts	7.11
Light emitting diode (LED) lighting	7.13
Lighting applications	7.14
Converting your fixtures	7.14
Daylighting	7.15
Visibility	7.15
Lighting energy efficiency	7.16
Lighting control	7.16
Planning an automatic lighting control system	7.17
Light pollution	7.20
Sky glow	7.20
Light trespass	7.22
Glare	7.22

Section 8 Heating Effects of Electrical Equipment

Heat in the building	8.1
Indoor lighting	8.2
Outdoor or indoor lighting in unheated areas	8.4
Ice plants	8.4

Section 9 Operation and Maintenance

Skills and commitment	9.1
Maintaining the building envelope	9.1
Symptoms to look for	9.2
Maintaining the air barrier system	9.2
Insulation	9.2
Cladding - rain penetration	9.3
Vapour retarder	9.3
Heating equipment	9.4
Gas-fired	9.4
Electric	9.4
Water heaters	9.5
Boiler water systems	9.6
Ventilation equipment	9.6
Fans	9.6
Filters	9.7
Controls	9.7
Air conditioners	9.7
Heat recovery	9.8
Planned maintenance	9.8

Table of Contents

Section 9 Operation and Maintenance (con't)

Operation of mechanical systems	.9.9
Ice maintenance	.9.9
Energy saving practices	.9.9

Section 10 Project Planning

Introduction	.10.1
Project concept	.10.1
Demand forces	.10.1
Economic base analysis	.10.2
Market needs	.10.4
Planning process	.10.4
Planning for energy efficiency	.10.6
Cost avoidance	.10.6
Inflation	.10.6
Financial analysis	.10.6
Typical repair and replacement costs	.10.7
Planning checklist	.10.8

Appendix i Glossary of Terms

Appendix ii Reference Publications

Appendix iii Energy Calculations

Appendix iv Power Factor Corrections

Power factor	.iv.1
Section summary	.iv.4

Appendix v Geo-exchange Systems for Rinks and Arenas

A geo-exchange project review	.v.1
Aberdeen and District Recreation Complex	.v.3
Rink floors with thermal storage buffer	.v.12
Demand savings: A geo-exchange advantage	.v.14
Conclusion	.v.14

Appendix vi Heat Recovery and Financial Assistance

Heat recovery from refrigeration systems - CTEC	.vi.1
Financial assistance for commercial, institutional and municipal buildings	.vi.4

Electrical rates

In most skating and curling rinks, the largest single operating cost is the monthly utility bills. Knowing how you are charged will help you identify potential energy savings, which will help you save money.

Terminology

The following are some of the key terms used to describe the electrical energy billed to your facility:

Kilowatt-hours (kWh) Electrical energy consumption is measured in kilowatt-hours. For example, a 2-kilowatt appliance operating for five hours consumes 10 kWh of electrical energy.

Kilovolt-ampere (kVA) Electrical demand is measured in kilovolt-amperes. It is voltage, multiplied by current, divided by 1,000. In most facilities and applications, the total power measured in kilowatts is the same or close to the kVA demand (when the power factor equals 1, then kVA=kW).

Basic Monthly Charge The basic monthly charge is the fixed monthly amount that is charged for each service. It covers the cost of billing, meter reading and account administration.

Billing Multiplier A billing multiplier is applied to your bill when there is a difference between the units the meter uses to measure electricity consumption and the actual electricity consumed. For example, if a billing multiplier is 180, the meter would record only one kilowatt-hour for every 180 kilowatt-hours consumed.

Cost of Electricity The amount charged for total energy consumption each billing period.

First Block rate The amount charged for the first block of energy consumption for each billing period.

Balance (or runoff) rate The amount charged for the last block of energy consumption for each billing period.

Demand Charge The amount charged for the peak amount of power supplied during each billing period measured in kVA.

Municipal Surcharge Saskpower collects on behalf of urban municipalities a 5 or 10 per cent surcharge amount that is applied to the total electrical charges.

Goods and Services Tax SaskPower collects and remits the Goods and Service Tax (GST) to Canada Revenue Agency. The GST applies to the total of Electrical Charges.

General service rates

Effective February 1, 2007 there are two rate structures for Saskatchewan urban and rural skating and curling rinks – the Standard General Service and the Small General Service rates.

For information on the current rate structure for your facilities, please contact SaskPower at: 1-888-SKPOWER (757-6937).

The Small General Service rate is for facilities with a monthly electrical demand not exceeding 75 kVA. The Standard General Service rate is for all accounts that do not qualify for the Small General Service rate.

SaskPower electrical rates as of February 1, 2007

Monthly Basic Charge:	Urban	Rural
Small General Service	\$ 18.92 (E75)	\$ 27.45 (E76)
Standard General Service	\$ 33.92 (E05)	\$ 41.80 (E06)
Plus		
Energy Charge:		
Small General Service rate		
First 14,500 kWh @	8.57¢/kWh	First 13,250 kWh@9.17¢/kWh
Balance of kWh @	5.153¢/kWh	Balance of kWh@5.109¢/kWh
Standard General Service rate		
First 16,750 kWh @	8.31¢/kWh	First 15,500@8.56¢/kWh
Balance of kWh @	5.139¢/kWh	Balance of kWh@5.133¢/kWh
Plus		
Demand Charge:		
Small General Service rate		
First 50 kVA of monthly recorded demand @	No charge	No charge
Balance @	\$10.38/kVA	\$ 10.95/kVA
Standard General Service rate		
First 50 kVA of monthly recorded demand @	No charge	No charge
Balance @	\$10.71/kVA	\$ 11.08/kVA

Electrical consumption

Electrical consumption is calculated by subtracting the previous meter reading from the present meter reading and multiplying the result by the billing multiplier. The result is the actual number of kWh consumed for the billing period.

Demand

Electrical bills are not just for the accountant. As a facility operator, you should also see the bills so that you can keep track of energy and demand use in the arena and spot any unusual variations if or when they occur.

The demand portion of the bill is just as important as the consumption portion. For some arenas, demand charges can be as much, if not more, than consumption charges.

Demand is read and reset every month so there are no previous and present readings to subtract, just the actual demand reading for the billing period.

For most meters, demand is read in volt-amperes (VA) and converted to kilovolt-amperes (kVA) by dividing the reading by 1,000. The resulting value is then multiplied by the billing multiplier to get the final demand reading.

The municipal surcharge is collected by SaskPower and returned to the community. A city can ask SaskPower to collect a 10 per cent surcharge, while smaller communities can impose a 5 per cent surcharge.

Calculating your electricity bill

All examples in the manual are based on the Standard General Service rate - E05. While this rate applies to most arenas and curling rinks, those facilities where the electrical service demand does not exceed 75 kVA will be invoiced on the Small General Service rate.

Check saskpower.com for current electrical rates. If you require further information please call 1-888-SKPOWER (1-888-757-6937).

Example 1.0 - Calculating your total electricity bill

- Assumptions:
- Consume 25,000 kWh in any given billing period (about 30 days)
 - Draw 80 kVA of electrical demand
 - Run a facility that falls in the Standard General Service (E05) rate

Your monthly cost for electricity would be:		
Basic monthly charge		\$ 33.92
First - 16,750 kWh x \$0.0831	\$ 1,391.92	
Balance – 8,250 kWh x \$0.05139	\$ 423.97	
		\$ 1,815.89
Total energy charge		\$ 1,849.81
Total demand charge:		
80kVA – 50 kVA = 30 kVA x \$10.71 =		\$ 321.30
Total energy plus demand charge		\$ 2,171.11
(plus taxes and municipal surcharge where applicable)		

Please note: Your minimum monthly bill is the Basic Charge plus \$3.00/kVA of the maximum recorded demand over 50 kVA, registered during the past 11 months.

Example 1.1 - Calculating your total charges for an ice plant

If you need to start an ice plant that requires 100kVA, the electro-mechanical demand meter gradually registers that load. In this example the demand meter will reach 50 kVA after 4 1/2 minutes and 99 kVA in 30 minutes. If you run your compressor for only 30 minutes you will be charged almost all (99 per cent) of the full demand charge contributed by the refrigeration system for the billing period. In this case, the compressor demand charge would be:

Compressor demand charge

1st 50 kVA:	50 kVA @ \$0.00/kVA	\$ 0.00
Balance:	49 kVA @ \$10.71/kVA	\$ <u>524.79</u>
Total demand charge:	99 kVA	\$ 524.79

Energy charge

Assume we base the charge on the Standard General Service rate with an estimated power factor of 0.90 (100 kVA x 0.90 = 90 kW). The kWh consumption charge for running the ice plant for half an hour would be as follows:

$$90 \text{ kW for } 0.5 \text{ hours} = 45 \text{ kWh}$$

$$\text{The kWh consumption charge is: } 45 \text{ kWh} \times \$0.05139/\text{kWh} = \$2.31$$

Please note: The consumption charge is based on the balance (or runoff) rate and assumes that enough other equipment was operating in the building to use the first 16,750 kWh of energy during this billing period and at this time only the ice plant is operating.

Example 1.2 - Calculating your total charges

In Example 1.0, when you consumed 25,000 kWh of energy, the kWh consumption charge was \$1,815.89. If your maximum demand for that billing period increased to 125 kVA, then the demand charges would be calculated as follows:

Demand and consumption charges

1st 50 kVA:	50 kVA @ \$0.00/kVA	\$ 0.00
Balance:	75 kVA @ \$10.71/kVA	\$ <u>803.25</u>
Total demand charges:	125 kVA	\$ 803.25

Please note: An increase in demand would also result in an increase in consumption for the same operating time, however, for display purposes the values in Example 1.0 are used.

Total charges before taxes

Basis monthly charge:	\$ 33.92
Consumption charges:	\$ 1,815.89
Demand charge:	\$ <u>803.25</u>
Total charges:	\$ 2,653.06
	(plus taxes and municipal surcharge where applicable)

Saving money at season start-up and shutdown

Knowing when your meter is scheduled to be read may save you the demand charge for an entire month.

Most Saskatchewan rinks have only one meter which is not disconnected during the summer months. As an example, if you start your ice plant on September 15th, and your meter is read on September 17th, you will be charged the full demand charge for the billing period ending September 17th, even though you only used the ice plant for two days.

If you waited until after the meter was read on September 17, then started the ice plant, you would save one full month of demand charges contributed by the ice plant.

Your local SaskPower District Office can provide you with an approximate date for when your meter will be read.

Example 1.3 - Start-up and shutdown of the compressor

At the start of the season, if the lighting, heating and other electrical loads in the building totaled 50 kVA and you were operating a 60 hp ice plant (where 1 hp is approximately equal to 1 kVA), you could save about \$580 in demand charges plus taxes by waiting two days to start the compressor.

The same is true at the end of the season. If the meter will be read on April 17, try shutting the ice making equipment off on April 16. If the plant runs until April 19, you would be charged the full demand charge in the next billing period for only running the plant for an extra couple of days.

Shutting off the plant on April 16 could save you \$580 in demand charges.

Disconnection

At the end of each season, SaskPower will (upon request) disconnect the electric service to the ice plant, if it has a separate power service. You will receive no minimum monthly bill, which may result in significant savings during the summer months. There is no charge for disconnecting any service, but the reconnect fee (\$155 plus GST taxes in 2007) will be charged at the start of the next season and must be taken into consideration when making operating decisions.

Example 1.4 - Disconnect of the demand meter

Assume that the ice plant operates from November through March each year, and the community asks to have the service disconnected each March and reconnected in November. It is connected for five months and disconnected for seven months each year.

The amount saved is the basic monthly charge, plus \$3.00/kVA for the maximum recorded demand above 50 kVA for the preceding 11 months. If we assume a peak demand of 125 kVA occurred during the previous 11 months, then the minimum bill for each summer month is:

Basis monthly charge:	\$ 33.92
(125 kVA – 50 kVA) x \$3.00:	\$ <u>225.00</u>
Total charges:	\$ 258.92

Annually, the saving would be:

7 months @ \$258.92:	\$ 1,812.44
Reconnect fee:	\$ <u>-155.00</u>
Potential saving:	\$ 1,657.44

In this example, disconnecting the service for 7 months would save \$1,657.44 plus applicable surcharge and taxes each year based on 2007 rates. Your SaskPower Region Business Manager will assist you in calculating a potential saving for disconnecting the ice plant service each year.

Understanding your SaskPower bill

Being able to understand your electrical demand bill is just as important as being able to read your demand meter.

- 1) Customer name
- 2) Customer account number
- 3) Service address
- 4) Type of service
- 5) SaskPower phone number
- 6) Power interruption toll free number
- 7) Bill cycle
- 8) Previous billing and balance forward information
- 9) Present meter reading and date
- 10) Previous meter reading and date
- 11) Billing multiplier
- 12) Consumption (kWh)
- 13) Registered demand
- 14) Basic monthly charge
- 15) Consumption charge
- 16) Demand charge
- 17) Municipal surcharge
- 18) Monthly GST assessed
- 19) Total taxes and surcharge
- 20) Total amount due

After payment, keep this portion for your records

SaskPower Bill issued Mar 15, 2007

Balance from previous bill 1193.10
Payment received Feb 28, 2007 - Thank you -1193.10
Balance Forward .00 ... \$0.00

2025 Victoria Avenue,
Regina, Saskatchewan
S4P 0S1

Electricity billed for
Mar 09, 2007 actual meter reading 05901
Feb 07, 2007 actual meter reading 05807
Billing multiplier 174 X 60
Electricity billed for - 30 days 10440 kWh
Mar 09, 2007 demand meter reading 1.540
Billing multiplier X 60
Registered demand 92 KV.A

Electrical charges
Basic monthly charge \$33.92 33.92
Cost of electricity 10440 kWh x \$.08310/kWh 867.56
Demand charge 92 KV.A:
First 50 KV.A x \$.0000 KV.A/month .00
Balance 42 KV.A x \$10.7100 KV.A/month 449.82
Total electrical charges 1351.30 ... 1351.30

Surcharge and taxes
Municipal surcharge-ANYWHERE-\$1351.30 x 5% 67.57
GST \$1351.30 x 6% 81.08
Total surcharge and taxes 148.65 ... 148.65

Important messages:
Visit our booth at the March 15 - 18 Saskatoon HomeStyle 2007 show, and the March 30 - April 1 Regina Spring Home & Garden Show. Enter to win a power-saving prize package.

Bill Cycle 10
GST registration number: R119429678
3303 M03C00 E05

Late Payment Charge Assessed on Amounts Unpaid as of Apr 12, 2007
At The Rate of 1.50% Monthly (18.5% per year)

Payment due upon receipt of bill
See reverse side for terms of payment and payment options

Total Due \$1,499.95

SaskPower 00 1234 56789 01234 0001499950000000000001499950

ANYWHERE ARENA
123 MAIN ST
ANYWHERE SK S4P 0S1

Before this portion with your payment

SaskPower Account Number	00 1234 56789 01234		
Balance forward	\$.00	Cheque <input type="checkbox"/>	Debit <input type="checkbox"/>
Current	\$1499.95	Cash <input type="checkbox"/>	Other <input type="checkbox"/>
Total due	\$1499.95	Amount paid	

Please enter the amount paid in the area provided

Natural gas rates

Your SaskEnergy natural gas bill will display the following charges. The total cost of a monthly natural gas bill is determined by adding the charges for each of these components:

Basic Monthly Charge. This is the fixed costs of your service line, natural gas meter, and customer account administration.

Gas Delivery Service Charge. The charge (in cents per cubic metre) to transport and deliver your natural gas through the gas distribution system.

Gas Consumption Charge. The charge (in cents per cubic metre) to acquire your natural gas. If you purchase natural gas from a supplier other than SaskEnergy, the supplier's name and phone number are identified on the bill.

Municipal Payments. 3 or 5 per cent of the total gas charges collected in accordance with *The SaskEnergy Act* and remitted to your local municipal governments.

Goods and Services Tax. SaskEnergy collects and remits the Goods and Service Tax (GST) to Canada Revenue Agency. The GST applies to the total of Gas Charges and Municipal Payments, if applicable.

SaskEnergy natural gas rates

Effective June 1, 2007, the following proposed natural gas rates will apply to rinks and arenas.

Small General Service (GSII)

Basic Monthly Charge	\$ 20.65	} Rate G02 - 0 to 100,000 cubic meters per year.
Delivery charge (\$/m ³)	\$ 0.0631	
Consumption charge (\$/m ³)	\$ 0.2683	

Large General Service (GSIII)

Basic Monthly Charge	\$ 43.50	} Rate G03 - 100,001 cubic meters to 660,000 cubic meters per year.
Delivery charge (\$/m ³)	\$ 0.0551	
Gas consumption charge (\$/m ³)	\$ 0.2683	

Calculating your natural gas consumption

To measure natural gas usage over a specific period of time, subtract the previous reading from the present reading.

SaskEnergy meters register natural gas in hundreds of cubic feet. A metric factor and billing multiplier (indicated on your bill) is used to convert the hundreds of cubic feet to cubic metres in order to calculate your natural gas consumption.

The metric factor is determined by the atmospheric pressure and the elevation for the given location.

The SaskEnergy website at www.saskenergy.com has current natural gas rates. If you purchase your gas from a natural gas broker, please contact them to obtain your gas consumption charge.

Understanding your SaskEnergy bill

- 1) Customer name and address
- 2) Customer account number
- 3) Type of Billing (actual or estimate)
- 4) Type of service
- 5) Billing days
- 6) Present meter reading and dates
- 7) Previous meter reading and date
- 8) Metric factor (cubic feet to cubic metres)
- 9) Billing multiplier
- 10) Consumption in cubic metres
- 11) Previous billing and balance forward information
- 12) Basic monthly charge
- 13) Delivery charge
- 14) Gas supplied by name
- 15) Gas consumption charge
- 16) Municipal payment
- 17) Monthly GST assessed
- 18) SaskEnergy number
- 19) Total amount due

SaskEnergy
YOUR NATURAL CHOICE®

Account Number: 11111 11111 11 111 Type of Billing: ACTUAL Rate: GENERAL SERVICE Days of Billing: 30 4305 0001R H03C08 G02

SERVICE SUPPLIED TO: ANYWHERE, SK

Present Reading: (1939) Previous Reading: 16729 Metric Factor: 2.735 Billing Multiplier: 1 Usage in m³: 7296.980

VALUED SASKENERGY CUSTOMER

CUSTOMER REFERENCE: SKATING RINK

IMPORTANT MESSAGES: Save energy, save money. If your furnace is working at peak efficiency, it will use less energy and cost you less to operate. Book your SaskEnergy Home Check-Up or SaskEnergy Network Home Heating Tune-Up before April 15 and save \$10!

CUSTOMER INQUIRIES: PRICE ALERT
PHONE: 1-800-567-8899
3855 5TH AVE E
PO BOX 5005
PRINCE ALBERT S6V 7V6

BILL ISSUED: MAR 12, 2007

Item	Amount	Amount	Amount
Balance from Previous Bill		1322.29	\$
Payment Received - Thank You	MAR 6, 2007	-1322.29	
Balance Forward		0.00	0.00
GAS DELIVERY SERVICE			
Basic Monthly Charge	\$17.00/month	17.00	
Delivery Charge	7296.980 M3 X \$0.0631/M3	460.44	
		477.44	
GAS SUPPLY COST			
Gas Supplied by SaskEnergy			
Gas Consumption Charge	7296.980 M3 X \$0.2683/M3	1957.18	
		2435.22	
MUNICIPAL PAYMENT			
Paid to Town of ANYWHERE	\$2435.22 X 5.0%	121.76	
		2556.98	2556.98
FEDERAL GST R119429751	\$2556.98 X 6.0%	153.42	153.42
			2710.40

Amount Due: \$2710.40

BILL IS DUE AND PAYABLE ON DATE OF ISSUE: APR 10, 2007

LATE PAYMENT CHARGES WILL BE ASSESSED AFTER: APR 10, 2007

SaskEnergy 11 1111 11111 11111 00027104080000000000000271040

VALUED SASKENERGY CUSTOMER (\$)

ANYWHERE SK S4P 4K5

PAYABLE AT MOST FINANCIAL INSTITUTIONS

Item	Amount	Amount
BALANCE FORWARD		
CURRENT AMOUNT	\$2710.40	
TOTAL DUE	\$2710.40	

Post Due: Late Payment Charge is 1.17% compounded monthly (15% per year)

Late Payment Charges will be assessed after APR 10, 2007

Amount Paid

Cash ☐ Cheque ☐ Interac ☐

Reading meters

Understanding how to read your meters will help you trace energy use to specific areas or functions. This section includes a generic inventory sheet that can be adapted to keep track of your electrical loads. The three major energy users – the building, heating, and refrigeration systems – are covered in later sections.

Charges for electricity and natural gas represent from 40 to 60 per cent of the average rink or arena’s annual operating expenses, so it is very important to manage these costs.

Most rinks and arenas have electricity demand meters, which are capable of reading two distinctly different values: consumption and demand.

Electricity consumed is measured in kilowatt-hours (kWh). Demand is the rate at which electrical energy is delivered to a load and is expressed in kilovolt-amperes (kVA).

Electricity meter reading

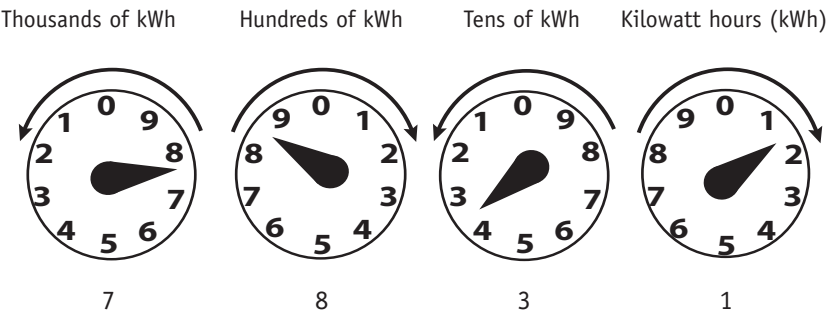
On electro-mechanical demand meters, the dials at the top of your electricity meter show your energy consumption in kWh. Figure 2.1 below represents an electricity meter with four dials. Larger users may have five dials on their meters.

Each dial pointer rotates in the opposite direction from the one beside it. Dial 1 rotates clockwise, dial 2 counter clockwise, dial 3 clockwise, and dial 4 counter clockwise.

As dial 1 completes a full revolution, dial 2 will rotate one tenth of a revolution, from 0 to 1, or 1 to 2, etc. When dial 2 completes 1 full revolution, dial 3 will rotate one tenth of a revolution.

Read the dials from right to left. When the pointer on the dial is between two digits, it is read as the smaller number, just as you would read an ordinary clock. For example, the meter reading in the figure below is 7831.

Figure 2.1 - Electricity meter dials



Electrical demand

Demand is the peak amount of power supplied to the customer during a specific billing period, usually about one month time period. It is expressed on the bill as registered demand in kilovolt-amperes (kVA).

Rinks and arenas with ice plants require large supplies of electricity. The electrical service must have the capacity to supply the maximum amount of power required to operate all electrical loads in the building as required by the rink operator.

SaskPower must ensure that it has the capacity to supply the maximum amount of energy demanded. As a result, it charges for demand as well as electricity consumed. Reducing your demand will help you to lower your charge.

Demand meters

There are two types of demand meters: solid-state (electronic) and electro-mechanical (thermal).

Figure 2.2 - Solid-state meter



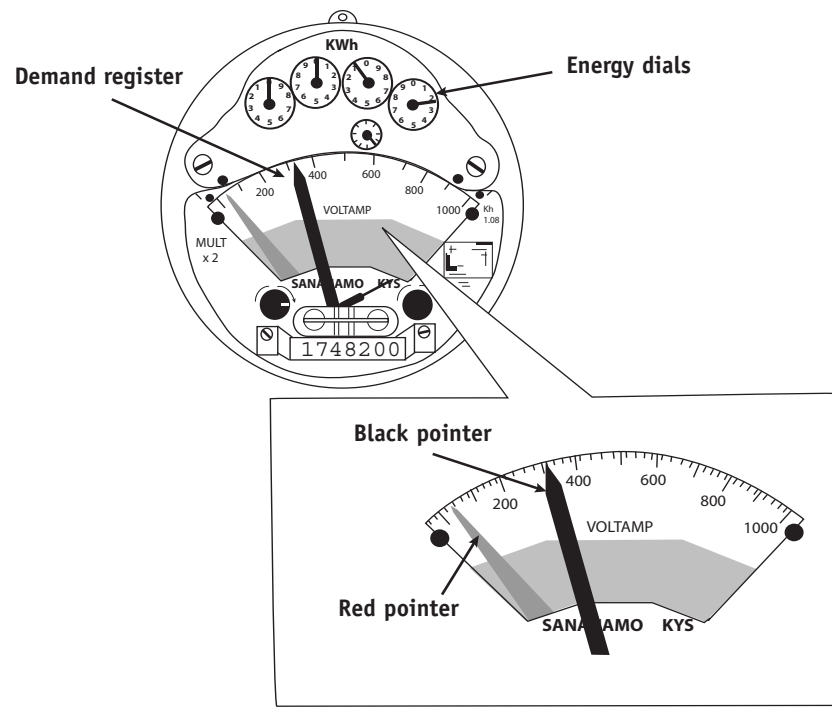
Figure 2.3 - Electro-mechanical meter



Reading an electro-mechanical demand meter. An electro-mechanical demand meter has two pointers: one is red and the other black. The red pointer is controlled by a thermal coil. As energy passes through the meter, the coil heats, expands, and moves the red pointer up the scale. When the red pointer advances, it drives the black pointer forward at the same rate.

Figure 2.4 - Electro-mechanical demand meter

Understanding the energy dials and demand register of your meter requires a little effort – but it's an effort worth making. Contact your local SaskPower office for additional information on your demand meter.



When electricity passing through the meter starts to drop, the thermal coil cools and contracts, and moves the red pointer back down the scale. Meanwhile, the black pointer remains behind at whatever peak it was pushed to by the red pointer. In this way, the black pointer records the maximum demand during the billing period.

Heating and cooling of the thermal coil does not happen instantaneously. There is a time lag. In this example, after two minutes, the demand reading is 25 per cent of the actual demand; after 4 1/2 minutes it registers 50 per cent of actual demand; after nine minutes, 75 per cent; after 15 minutes, 90 per cent; and after half an hour, 99 per cent.

After the meter is read, the meter reader manually resets the demand by moving the black pointer to rest against the red pointer. This procedure is repeated every time the meter is read.

The actual voltage and current is often too large to be registered directly by your meter. The meter's registering capacity is only a small per cent of your actual load, similar to the scale on a map, where a distance of 500 kilometres may be represented by one centimetre.

The meter multiplier relates the meter's scaled-down reading to actual consumption. A meter has both an inherent (internal) and external multiplier. When the inherent and external multipliers are multiplied together, the result is the billing multiplier.

Electrical and gas meters are calibrated and verified for their accuracy within the legal requirements of Measurement Canada under the *Electricity and Gas Inspection Act*.

Example 2.1 - Determining the billing multiplier

Assume the supply voltage is about 360 volts in a three phase, four wire 347/600V service and the main switch at the service entrance is 400 amps. The voltage and current must be reduced or stepped down by a potential transformer (PT) and current transformer (CT) respectfully, before entering the meter. This is required because the maximum capacity of the meter is only 120 volts (V) and 5 amps (A) used. The factor by which they are reduced is known as the external multiplier. In this example:

The voltage multiplier: $360V \div 120V = 3$ (PT ratio)

The current multiplier: $400A \div 5A = 80$ (CT ratio)

The external multiplier: $3 \times 80 = 240$

The billing multiplier is documented on the monthly bill and may be indicated on your power meter and is the product of the meter multiplier, PT ratio and CT ratio.

Example 2.2 - Using Kh value to estimate consumption

The Kh value shown on the right side of the meter face (Figure 2.4) relates the energy consumption to the number of disk revolutions and can be used to estimate the amount of electricity used.

Assume Kh = 7.2 watt-hours per revolution, 10 = number of disk revolutions, 360 = number of seconds which equals $360/3600 = 0.1$ hours

$$\text{Watts} = (\text{Kh} \times \text{revolutions})/(\text{hours})$$

$$\text{Watts} = (7.2 \times 10)/(0.1)$$

$$\text{Watts} = 720$$

While the Kh value is used to relate disk revolutions to consumption, it is not directly used in the calculation of the billing multiplier.

Reading a solid-state demand meter with digital display. Solid-state meters are replacing older style electro-mechanical meters. Solid-state meters scroll through a series of windows to provide energy consumption and demand readings for billing purposes.

The first window in each type will display, for example, 8.8.8., which shows the meter is functioning properly. That display is followed by consumption (in kWh) and peak demand in (VA or kVA depending upon the meter manufacturer). Some show the recent demand and power factor, but all meters will display consumption and peak demand. The demand meters installed in ice plants can be either solid-state or electro-mechanical.

Values for consumption and demand are read off a digital display, such as in the following:

Code	Displayed Value	Description
NONE	8's + SUB TITLES	Meter check
02	6197 kWh	Consumption
03	631 VA Max	Peak demand
04	00 RST	Number of resets

Example 2.3 - Determining consumption and demand from a solid-state meter

Assume the meter was reading 6152 a week ago and the billing multiplier in this case is 480. To determine the quantity of electricity in kilowatt-hours that your facility consumed over the past week, make the following calculation:

Current reading (kWh):	6,197 kWh
Reading one week ago:	<u>6,152 kWh</u>
Difference:	45 kWh

Actual energy consumption for the week is:

$$45 \text{ kWh} \times 480 \text{ (billing multiplier)} = 21,600 \text{ kWh}$$

To determine peak demand from the meter, you would select the proper code to display the VA Peak Demand (Code 03 above). Multiply the number displayed by the billing multiplier and then divide the result by 1,000 to obtain peak demand in kVA since the meter was last reset:

$$[(631 \text{ VA Max}) \times 480] / 1,000 = 302 \text{ kVA}$$

With solid-state meters, to calculate VA Peak Demand, SaskPower uses block demand based on a 20-minute interval length. The VA demand is the total VA-hour accumulated during the interval divided by the length of the interval, 20-minutes. It is an average demand over the 20-minute time block. At the end of each interval (EOI), demand calculations are made and the value is displayed on the meter's digital display.

The maximum demand in a billing period is determined by comparing the demand value of the most recent completed interval to the respective readings stored in the peak demand register. If the current demand reading is greater than the value in the peak demand register, the lower demand value is replaced. However, if the current demand is less than the value in the peak demand register, the maximum demand value remains unchanged.

Your local SaskEnergy office will be pleased to answer any questions you have about your gas meter.

Reading your natural gas meter

Your natural gas meter measures the volume of natural gas supplied to your facility. Always read the smaller number when the dial hand is between numbers.

Small commercial customers are scheduled to have their meter read every third month by a meter reader. To have an accurate monthly bill you can read your meter each month and submit the read using SaskEnergy’s convenient online service *My Account*. You can access *My Account* at saskenergy.com. You may also submit your meter read by calling your local SaskEnergy office at 1-800-567-8899. *My Account* online or your local SaskEnergy office can provide you with the appropriate date range so you know when to read and submit your read each month.

Inventory of electrical loads

To estimate electricity consumed by the various connected pieces of equipment (loads), review the name plate on each unit, then keep an accurate inventory of the loads. Doing so will help you understand how electricity is being used in your facility.

The following table lists the major loads for a typical rink with an all-electric kitchen.

Table 2.1 - Major loads: rink with an all-electric kitchen			
	Demand Load (kW)	Average Run Time /week (h)	Consumption /week (kWh)
Compressor (ice plant)	75	100	7,500
Evaporative condenser	10	75	750
Brine circulation pump	15	168	2,520
Arena lights	25	112	2,800
Public area lights	10	112	1,120
Fryer	15	30	450
Range	25	30	750
Totals	175 kW		15,890 kWh

In Table 2.1, the single largest energy user is the compressor (ice plant), then the lights and the brine pump. Kitchen consumption (fryer and range totaling 40 kW) is near the bottom of the kWh consumed.

The demand side of this equation presents a different picture. In this example, a high power factor value for the facility is assumed, where the kW would be approximately equal to the kVA. Based on \$10.71/kVA over 50 kVA, an additional 40 kVA from the kitchen actually costs \$428.40 per month despite operating for only 30 hours per week (120 hours per month). The corresponding consumption cost in the kitchen for the 30 hours per week would be \$61.67 at the \$0.05139/kWh balance (or runoff) rate. It may be cost-effective to replace the electric deep fryer and grill with a natural gas unit.

Taking your electrical inventory

Tables 2.2 and 2.3 will help you to create your own electrical inventory and calculate energy costs. By adjusting the run times or connected load, you can re-calculate the potential saving for scheduling or replacing equipment.

Table 2.2 - Electrical inventory worksheet

Load	Size		Operating Time		Energy Consumption
Refrigeration <i>(to get approximate kW, multiply name plate horsepower of motor (hp) x 0.746)</i>					
Compressor	_____ kW	x	_____ hrs	=	_____ kWh
Brine pump	_____ kW	x	_____ hrs	=	_____ kWh
Evaporative condenser	_____ kW	x	_____ hrs	=	_____ kWh
Condenser pump	_____ kW	x	_____ hrs	=	_____ kWh
Other Refrigeration	_____ kW	x	_____ hrs	=	_____ kWh
Lighting					
Arena lights	_____ kW	x	_____ hrs	=	_____ kWh
Other lights	_____ kW	x	_____ hrs	=	_____ kWh
Electrical					
Kitchen range	_____ kW	x	_____ hrs	=	_____ kWh
Kitchen fryer	_____ kW	x	_____ hrs	=	_____ kWh
Kitchen fan	_____ kW	x	_____ hrs	=	_____ kWh
Other	_____ kW	x	_____ hrs	=	_____ kWh
Other Electrical loads	_____ kW	x	_____ hrs	=	_____ kWh
HVAC Equipment					
Water heaters	_____ kW	x	_____ hrs	=	_____ kWh
Furnace motors	_____ kW	x	_____ hrs	=	_____ kWh
Electric space heaters	_____ kW	x	_____ hrs	=	_____ kWh
Ventilation units	_____ kW	x	_____ hrs	=	_____ kWh
Air conditioning	_____ kW	x	_____ hrs	=	_____ kWh
Other	_____ kW	x	_____ hrs	=	_____ kWh
Totals	_____ kW				_____ kWh
	Demand (2)				Energy (1)

Table 2.3 - Energy calculations - E05 rate

Total energy consumption from (1)	= _____ kWh
First 16,750 kWh x \$0.0831/kWh	= \$ _____
Balance: (Total _____ - 16,750 kWh) x \$0.05139/kWh	= \$ _____
Total energy costs	= \$ _____ (3)
Demand calculation from line (2) (assuming a high power factor where kW = kVA)	= _____ kW (or kVA)
First 50 kVA: No charge	= \$ 0.00
Balance: (Total _____ kVA - 50 kVA)	= _____ kVA (Billed demand)
Billed demand cost: _____ kVA x \$10.71 (if greater than zero)	= \$ _____ (4)
Basic charge (monthly, see your electrical bill)	= \$ _____ (5)
Total of (3) + (4) + (5)	= \$ _____
Total billing costs plus applicable surcharge and tax.	

Analyzing your energy usage

Natural gas consumption can be estimated easily for stable loads such as domestic hot water heating and gas-fired cooking appliances. Heating or ventilation loads that vary with weather and occupancy require a more sophisticated analysis.

Remember that fuel-fired appliances must be pro-rated, depending on their steady-state and seasonal efficiencies, to determine their actual fuel consumption.

Computer-based simulations may be used to estimate energy conservation measures. Many engineering design companies have software programs that calculate how and where energy is used in a facility. They also audit the energy consumption to determine potential savings for cost-effective retrofits. Computer models of the building shell, heating systems, ventilation system, lighting, weather, occupants, plus other internal and external loads are used to complete the energy analysis. This analysis is balanced against actual metered consumption (both natural gas and electric).

This section covers three simplified methods – simple payback, net present value and constant dollar value – to gain a quick feel for the value of your planned energy efficiency and building projects. If you are interested in an in-depth analysis, financial consultants will assist you in determining whether the dollars you spend are put to their best use and work as hard for you as your community has worked for them.

Each facility takes a different approach to finances, depending upon where you get your funds, how you spend them, the people involved, and the traditions established in your community. Financial priorities will influence when and what you spend your money on, as well as the types of projects you undertake, from repair to replacement. Some communities take out loans; others insist that all money is in the bank first.

Considering your options

When considering project options, look at your current facilities and plan for the future. Remember that all buildings and facilities require regular maintenance and up-keep to ensure a long life, but eventually everything wears out and needs to be replaced. (See Section 10 for detailed project and facility planning options and analysis.) Energy efficiency projects are a realistic way to save dollars and reduce expenses. Analyze your options to determine their impact on facility operation and cost.

Simple operating adjustments can yield savings without cash outlay. It costs money up front to modify, replace, or add equipment, but doing so saves dollars in the long run. Before acting on opportunities to implement measures to reduce operating costs significantly, consider them carefully to avoid costly mistakes.

If your facility relies on fund-raising or government grants for money, you will appreciate that it is far easier to raise money to cover new projects than it is to cover operating and maintenance costs.

Cost/benefit analysis

A cost/benefit analysis is simply a way of looking at an investment to determine if the benefit justifies the cost. The value of the benefit is often difficult to establish, especially in public facilities. For example, a remodeled entry-way will not generate revenue by itself, but, if the improvement makes the facility more accessible and attractive to the public and can lead to increased attendance, the benefit becomes real.

Energy efficiency projects generally show a direct benefit in reduced operating costs. The cost of the project can be directly compared to the savings in utility costs. Lowering facility maintenance costs is another type of benefit; 50 to 60 per cent of a rink's annual expenditures typically go toward wages and maintenance. Projects that reduce the need for maintenance or extra staff will have a significant effect on the bottom line.

For example, installing plastic coverings over pipes and tanks that are customarily painted every year will eliminate annual painting and reduce maintenance requirements. Similarly, installing a low emissivity ceiling may eliminate the need to paint the ceiling every 10 years.

Simple payback

Simple payback is a quick analysis that looks only at paying back the capital cost. Although simple payback is commonly used to evaluate energy efficiency projects, it must be used with caution because it over-simplifies often complex financial and economic situations.

Example 3.1 - Simple payback of a project

If a new heating system cost of \$28,000 could save \$5,600 a year in energy costs, the simple payback is:

$$28,000 / 5,600 = 5.0 \text{ years}$$

In roughly five years you will have saved enough money through reduced energy costs to pay back the capital cost of the installation. Note that this approach excludes financing costs and energy inflation costs.

Net present value (NPV)

Net present value (NPV) measures the excess or shortfall of cash flows, taking the time value of money into account. The time value of money is the cost of capital, or financing costs, if the project is financed.

NPV is the sum of all cash flows associated with an investment, with each cash flow discounted back to a base year (usually the current year). The discount rate used is the cost of capital.

Any money manager expects a specific minimum return on an investment. (A return of 12 per cent is used throughout these guidelines.)

NPV indicates how much better or worse than the specified return (12 per cent) your proposed investment will be. A positive calculation indicates better than a 12 per cent return on investment. A negative value indicates worse than a 12 per cent return on investment. The larger the value is positive, the greater the financial benefit the project will provide.

Example 3.2 - NPV calculation

Referencing Example 3.1, if an owner invests the required \$28,000 using a 12 per cent annual rate over the 10-year useful life of the project, then an NPV can be calculated using the annual savings of \$5,600:

$$\text{NPV} = (-28,000) + 5,600/(1.12) + 5,600/(1.12)^2 + \dots + 5,600/(1.12)^{10}$$

$$\text{NPV} = + 3,641$$

After accounting for the 12 per cent financing costs, the project will generate a gain of \$3,641.

Note that the analysis has not escalated annual savings, however as utility rates go up, so should savings. If the rates were to go up 5 per cent per year, the NPV would become:

$$\text{NPV} = (-28,000) + 5,600 \times (1.05/1.12) + 5,600 \times (1.05/1.12)^2 + \dots + 5,600 \times (1.05/1.12)^{10}$$

$$\text{NPV} = + 11,945$$

If utility rates increase at 5 per cent, the project will generate a gain of \$11,945, accounting for the 12 per cent cost of capital.

This analysis ignores a number of key factors:

- » How does the new equipment interact with existing equipment? Will existing equipment operate less and therefore last longer?
- » Delaying replacement of expensive equipment should be of some value, shouldn't it? How about maintenance costs; are these affected as well?
- » A proper financial analysis considers all related costs and benefits, direct and indirect, over the project life.

Table 3.1 - Net present value: capital reserves

Year	Future energy savings (\$)	Present net annual cash flow (\$)	Present cumulative cash flow (\$)
0	0.00	-28,000.00	-28,000.00
1	5,880.00	5,250.00	-22,750.00
2	6,174.00	4,921.88	-17,828.13
3	6,482.70	4,614.26	-13,213.87
4	6,806.84	4,325.87	-8,888.00
5	7,147.18	4,055.50	-4,832.50
6	7,504.54	3,802.03	-1,030.47
7	7,879.76	3,564.40	2,533.94
8	8,273.75	3,341.63	5,875.56
9	8,687.44	3,132.78	9,008.34
10	9,121.81	2,936.98	11,945.32

Future energy savings values are based on the formula $5,600 \times (1 + 0.05)^n$ where n = year number and utility rates increasing at 5 per cent.

For example, in year 5, the future energy savings will be:

$$5,600 \times (1 + 0.05)^5 = 7,147.18$$

Present dollar net annual cash flow values for this example in year 5, using the 12 per cent financing costs, will be:

$$7,147.18 / (1 + 0.12)^5 = 4,055.50$$

Payments in year zero represent the purchase price.

Constant Dollar Value

The Constant Dollar Value method takes inflation into account. All costs and prices are discounted by the assumed rate of inflation to express the dollar values in terms of the starting year's dollar. The cost of money is not considered in this analysis.

Example 3.3 - Constant Dollar Value

An item worth \$1,000 today will cost \$1,040 a year from now, if inflation is 4 per cent per year. Conversely a payment of \$1,000 due a year from now is worth \$961.54 in today's dollars. You can calculate this with the following formula:

$$\text{CDV} = \frac{\text{FDV}}{(1 + i) \times n}$$

Where:

CDV = Constant Dollar Value

FDV = Future Dollar Value

i = Inflation Rate

n = Number of Years in the Future

Under this equation, if inflation is 4 per cent per year:

$$\begin{aligned}\text{CDV in Year 1} &= \frac{1,000}{(1 + 0.04) \times 1} \\ &= 961.54\end{aligned}$$

The escalation rate of energy costs can be different than inflation and will modify the Future Dollar Value. Multiply the current costs by the price escalation rate to get the Future Dollar Value. Be sure to take each year's rate into account.

Let's consider the previous example of a \$28,000 investment with annual energy savings of \$5,600. Energy costs escalate at 5 per cent and inflation is at 4 per cent. Table 3.2 shows the cash flow and cumulative cash flow in constant year zero dollars. In year zero, \$28,000 is taken from capital reserves to pay for the project.

Table 3.2 - Constant Dollar Value: capital reserves

Year	Energy savings	Net annual cash flow constant (\$)	Cumulative cash flow constant (\$)
0	00.00	-28,000.00	-28,000.00
1	5,653.85	5,653.85	-22,346.15
2	5,708.21	5,708.21	-16,637.94
3	5,763.10	5,763.10	-10,874.85
4	5,818.51	5,818.51	-5,056.34
5	5,874.46	5,874.46	818.12
6	5,930.94	5,930.94	6,749.07
7	5,987.97	5,987.97	12,737.04
8	6,045.55	6,045.55	18,782.59
9	6,103.68	6,103.68	24,886.26
10	6,162.37	6,162.37	31,048.63

Energy savings in constant dollar values are based on the formula $5,600 \times [(1 + 0.05)^n / (1 + 0.04)^n]$ where n = year number. For example, in year 3, the energy savings based on the escalating energy costs of 5 per cent and inflation at 4 per cent will be:

$$5,600 \times [(1 + 0.05)^3 / (1 + 0.04)^3] = 5,763.10$$

Cash flow payment in year zero represents the purchase price.

This analysis indicates a positive cumulative cash flow in constant dollar occurs in year five. There is a positive net annual cash flow in all years after year zero, when the project was initially paid.

Consider the following example, which is simplified to deal in current year dollars and does not take inflation, opportunity costs nor return on investment into account.

In reality, this simplified analysis is the way most rink and arena operators or managers would analyze an investment. The example looks at borrowing money for the project from a financing institution that requires a payment of interest on the money borrowed. It assumes that the owner borrows 80 per cent of the \$28,000 investment amount in Example 3.3, at 12 per cent interest rate charge, 5 per cent escalation on the cost of energy and \$5,650 annual energy savings. The current dollar value of this investment is represented in Table 3.3. The dollar values represented are not discounted to constant dollars.

Table 3.3 - Constant Dollar Value: energy rate escalation

Year	Bank payment Current(\$)	Energy savings Current(\$)	Net annual cash flow Current(\$)	Cumulative cash flow Current(\$)
0	5,600.00	00.00	-5,600.00	-5,600.00
2	6,213.98	5,880.00	-333.98	-5,933.98
3	6,213.98	6,174.00	-39.98	-5,973.96
4	6,213.98	6,482.70	268.72	-5,705.24
5	6,213.98	6,806.84	592.86	-5,112.39
6	6,213.98	7,147.18	933.20	-4,179.19
7		7,504.54	7,504.54	3,325.35
8		7,879.76	7,879.76	11,205.11
9		8,273.75	8,273.75	19,478.86
10		8,687.44	8,687.44	28,166.30
11		9,121.81	9,121.81	37,288.11
	\$36,669.90	\$73,958.02	\$37,288.12	\$66,958.97

Payments in year zero represent the down payment. In year three, the installation begins to show a positive net annual cash flow. The cumulative cash flow is not positive until year six.

The table shows that to finance a \$28,000 purchase, you paid \$36,669.90 to the bank and saved \$73,958.02 in energy costs, resulting in a total saving of \$37,288.12. All values are in current dollars.

With both capital funded and financed project funding, the cumulative cash flow is not positive until year five or six.

Components and systems

Energy requirements to heat and cool buildings depend on two major factors. The first is the building envelope – roof, walls, windows, doors, and the floor of the building. The second is the installation and operation of the building's mechanical and electrical equipment to provide a proper indoor environment.

This section explains how the building envelope affects energy consumption.

The function of any building is to provide heated or cooled space away from the wind and the weather. The building envelope is what separates you from the wind and the weather outside. It is your job to see that it does this in the most cost-effective and energy efficient manner possible.

Each part of the building envelope has at least four basic systems. These are the systems that have to be improved to reduce energy consumption. The four systems are as follows:

- » Air barrier system
- » Insulation
- » Cladding, or the waterproofing for roofs
- » Vapour retarder

It is especially important to control air leakage because it effects the performance of the building in many different ways. For example, if you install extra insulation without first stopping all leaks, you will probably start or increase a problem of moisture accumulation in the walls and ceiling.

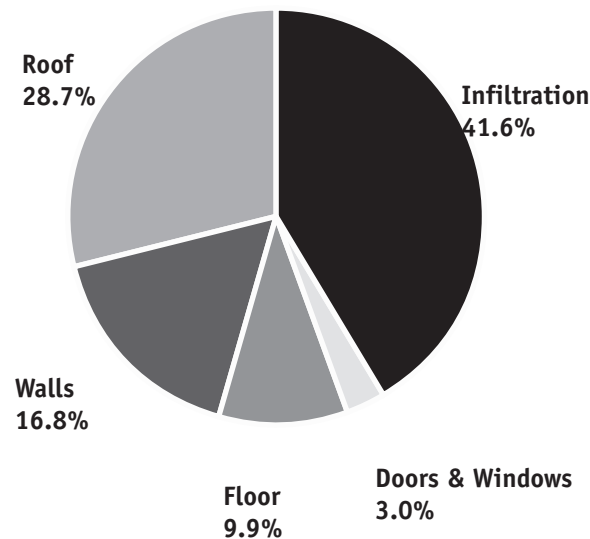
Air barrier systems

Uncontrolled air leakage through the building envelope is typically responsible for up to 33 per cent of the total heat loss of smaller buildings, such as detached houses.

Air leakage out of the building is called exfiltration and air leakage into the building is called infiltration. The common term to describe both is simply infiltration.

Air leakage can affect moisture accumulation in the walls and ceiling, building temperature control and energy consumption.

Your building has an air barrier system to reduce uncontrolled air leakage. The air barrier system is the most important part of the building envelope. It literally separates the indoor from the outdoor. The heat loss due to air leakage is a high percentage of your energy dollars, so you should retrofit your air barrier system before tackling anything else.

Figure 4.1 - Building heat loss**Materials to use**

An air barrier is not something you can simply buy from a store and apply to a building. You need to build an air barrier system during the construction or renovation of a building.

Many different materials can be converted to become part of the air barrier system as long as the materials are reasonably impermeable to air leakage. Drywall, plywood, concrete and many common construction materials are relatively impermeable to air leakage.

Leaks can be sealed with tapes, caulking or gaskets, including foam gaskets around electrical switches and outlets. Many different types of caulking suitable for a variety of purposes and types of building material are available.

Remember to ask if the caulking will set up like rubber or a compressible gasket. You don't want to have the caulking remain liquid when it is supposed to stay in place for a long time. Materials like acoustic sealants are NOT good for this purpose because they do not set up properly and are very messy to use. Materials like silicones, polysulphide and urethanes are better suited.

You should also ask how the caulking stands up to the cold and moisture of a rink or arena.

Do not use caulking that will quickly become brittle and crack or shrink, as it will lose its effectiveness. Make sure to use non-toxic sealants in sensitive areas such as kitchens.

Figure 4.2 - Typical brick and block construction

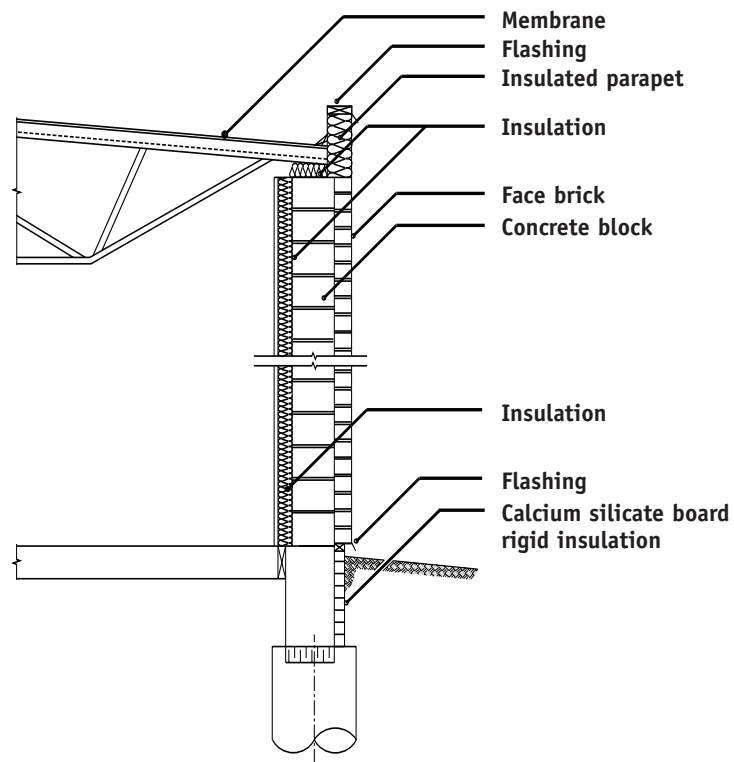


Figure 4.3 - Typical stud wall construction with fibreglass batt insulation

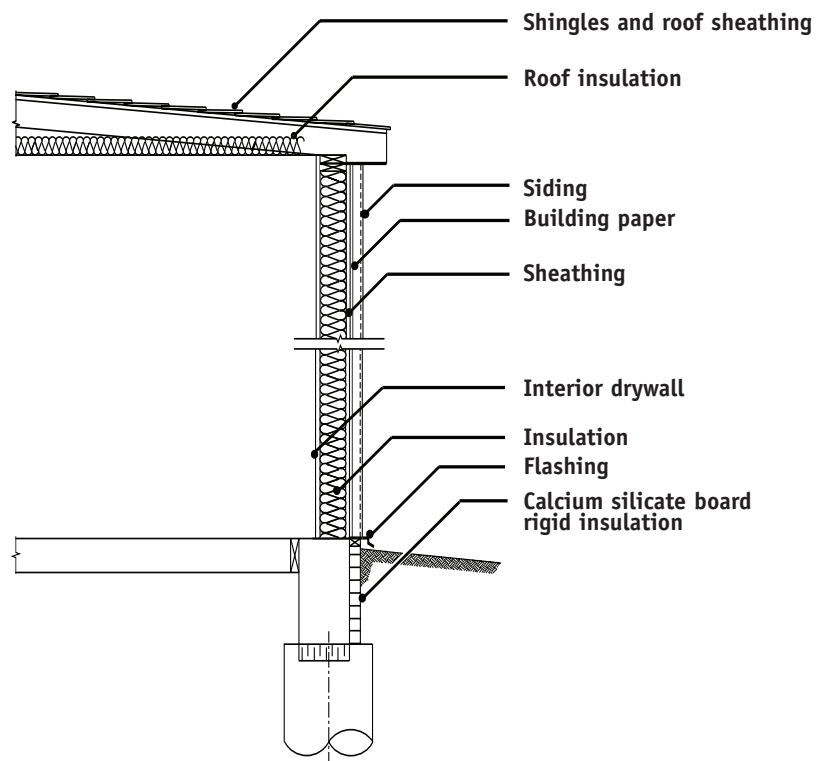


Figure 4.4 - Conventional metal building

Conventional metal building with blanket insulation compressed between the girts and the outer skin.

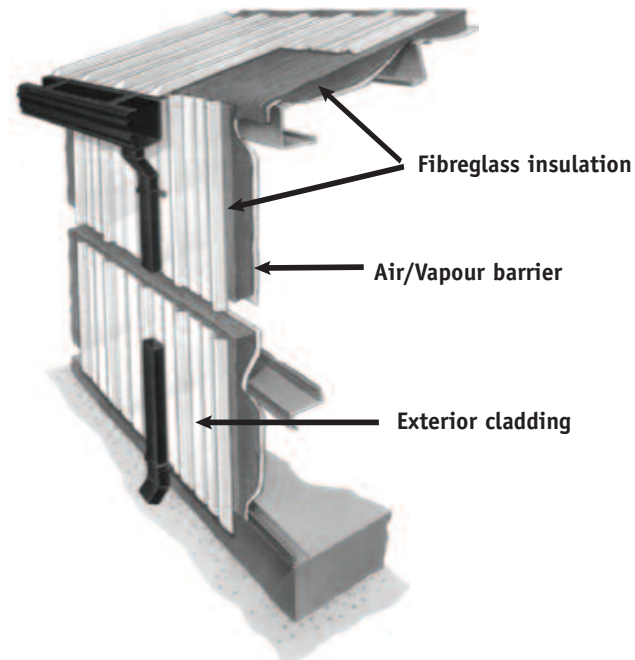
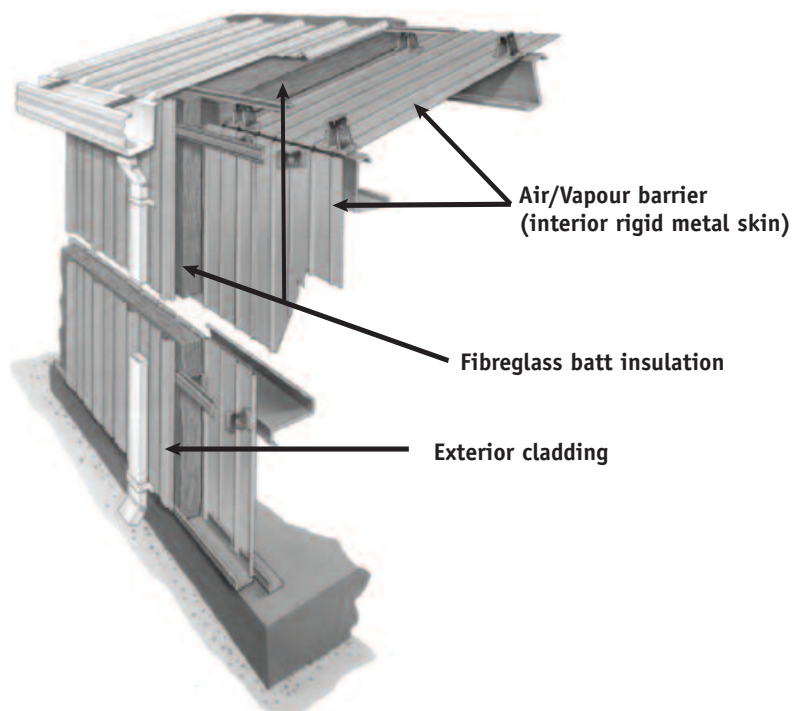


Figure 4.5 - Energy efficient metal building

Standoffs between the interior metal liner and the exterior metal skin keep the insulation sandwiched but not compressed. The metal liner also serves as an air/vapour barrier.



Where to seal

Leaks occur at joints between components, cracks in materials, and in openings such as electrical boxes.

When you discover a leak in a wall or ceiling, you will probably find there are several layers of construction. At best only one of them will be sealed. This is the layer where you will have to seal the leak.

Figure 4.6 - Stack effect

Leakage in a building is caused by the stack effect. Air is drawn into the bottom half of a building to replace air leaving through the upper half.

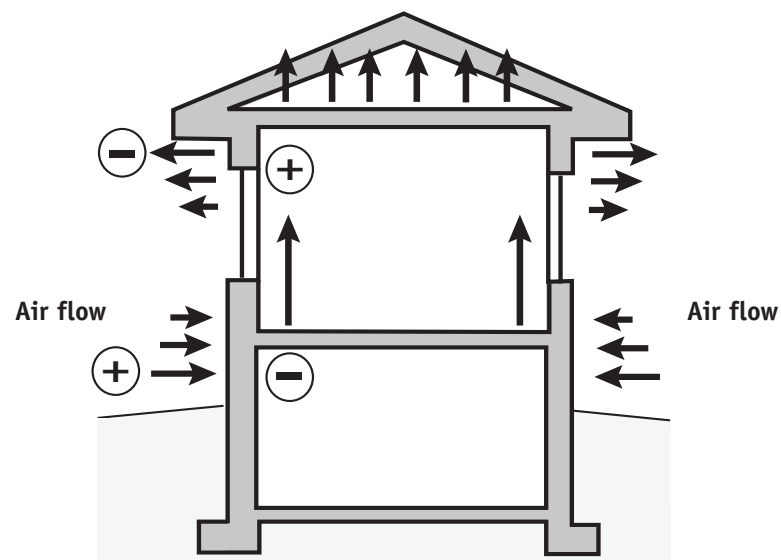
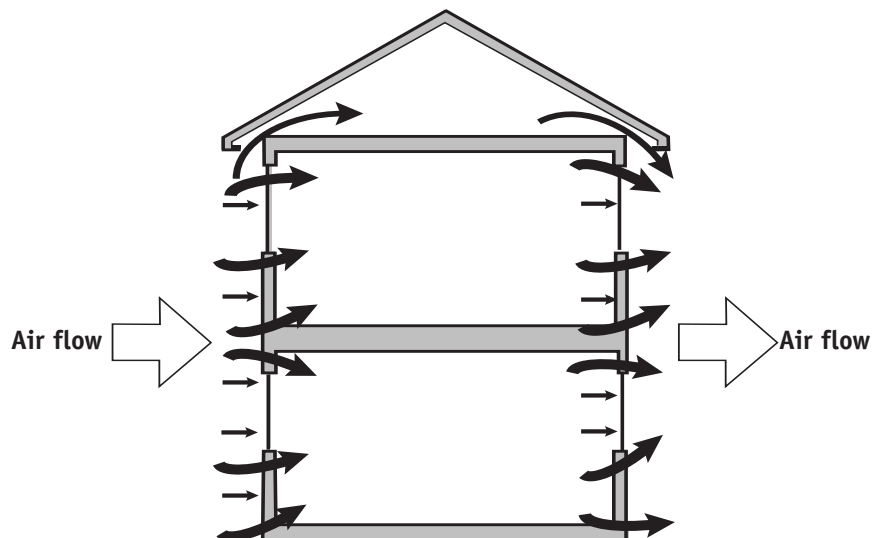


Figure 4.7 - Where air leaks develop

Leaks develop at joints between components, through cracks in materials, and through openings such as electrical boxes.



If you seal the wrong layer of construction you won't stop air leakage. It will be redirected through some other crack or opening.

For example, if you find a leak at an electrical box in a building that was sealed using polyethylene, it may not do you any good to seal the drywall. Air will still leak through the poly and past another crack through the drywall – often at the floor. For some penetrations, the fixture penetrating the wall or ceiling may move in relation to the wall.

To fix a leak, the first thing to do is figure out where the leak is best sealed. Then, identify the make-up of your air barrier and determine what you should use to build it up.

The building's interior finish is usually the easiest element to convert to an air barrier as it can be easily caulked and repaired. Pay special attention to the details of the building – such as corners and joints with the ceiling, floor or partitions – to make sure there are no leaks.

If you are using something inside the wall to make it airtight, like polyethylene or another membrane, consider the following four points before you start, regardless of the type of system you use:

- » The air barrier membrane must be continuous throughout the whole building.
- » The air barrier must be fastened to the structure so it can resist high wind loads - inward and outward. Deflection of poly between studs must be kept to a minimum to avoid tearing.
- » The air barrier membrane must have the same life expectancy as the building or be accessible for repairs.
- » The membrane should be in contact or sandwiched between solid materials on both faces to prevent movement and possible tearing. Being located between drywall or sheathings and insulating batts or sheets may not supply adequate protection.

What to avoid

In recent years people have focused on sealing the vapour barrier when they really mean to stop all air leaks. This has worked for many cases, particularly wood frame buildings, but there are many situations where the vapour barrier has not remained sealed.

The vapour barrier, properly named the vapour retarder, may not be the best material to seal. It may not be strong enough to remain sealed after a wind storm, or it may not be possible to seal it around structural braces or metal ties in metal buildings.

Polyethylene, a common vapour retarder, can be used in wood frame buildings where it can be stapled and held between the interior wall board and the insulation and studs.

For other types of construction it is best to use materials such as wallboard, plywood, metal liner panels, or reinforced membranes. There are now special membranes that can be used to make an air barrier system for many types of buildings.

Ventilation

Some outside air is required for indoor air quality and the comfort of occupants. This should be provided either by the building mechanical system or by vents/openings through the walls and roof of the building.

The fresh air can be heated or cooled as necessary and part of the energy in the stale exhaust air can be recovered to lower space heating energy consumption. This is covered in Section 5 on heating and ventilation.

Insulation

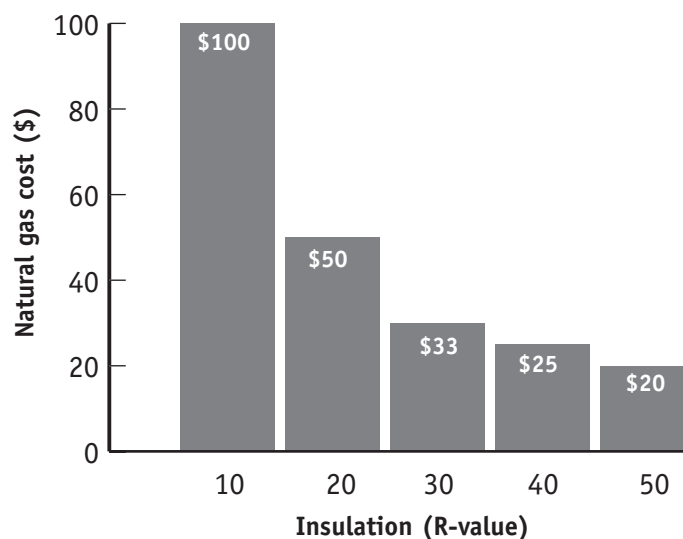
Insulation is installed to control heat conduction through the building envelope. It is rated according to its resistance to conduction. This is commonly called its R-value (RSI in metric units).

If two different types of insulation have the same R-value, they will perform the same. There may be differences in the requirements for installation or protection. One type of insulation may be more susceptible to moisture or some other hazard. But there will be no difference in thermal performance if each is installed and protected according to the manufacturer's instructions. Other factors such as durability and cost should be used to determine preferences for insulation purchases.

Wood or metal studs, steel columns, beams, girts, and ties all have lower R-values than the insulation. As a result, they act to partially short-circuit the value of the insulation. In a building with bulky metal girts or beams coming through the walls and ceiling, you will not get full value for any extra insulation you install in the wall or ceiling cavity. The girts or beams will limit how much insulation you can economically put in the wall. Their placement may make it more effective (although also more expensive) to put insulation elsewhere on the inside or outside of the wall.

Figure 4.8 - Costs versus R-values

Heating costs decrease as the amount of insulation increases.

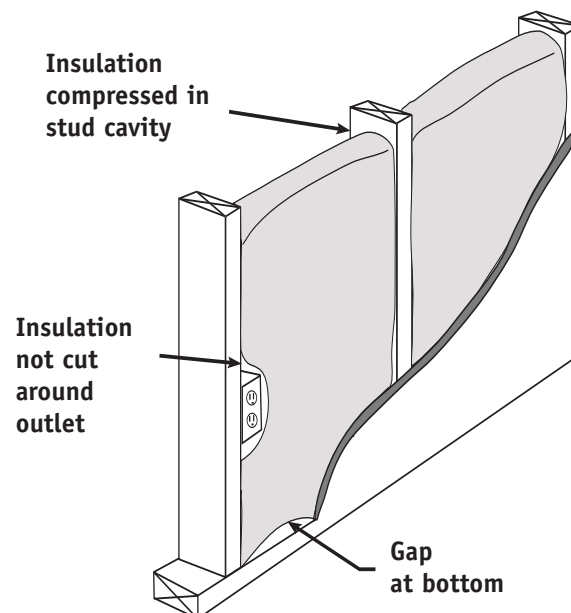


Installing insulation

Insulation must be held in place in the walls and ceilings so that it is not blown out by the wind, or shifted if the polyethylene billows. If you are using fiberglass or other types of batt insulation, be careful not to compress the batts too much. Doing so allows air to circulate in the wall or ceiling cavity, making the insulation less effective.

Compressed insulation also reduces its insulating value (R-value) by reducing the size and number of air pockets. All types of insulation must be carefully cut and closely fitted around obstacles, such as electrical boxes or structural supports. Insulation should always be placed tight against the air barrier system, as outlined in the previous section.

Figure 4.9 - Insulation problems in wall cavity



Cladding

The cladding of the building protects interior elements from weathering and exposure to sun and rain. Normally this requires protection against wind gusts, sometimes with a type of building paper.

The cladding itself need not be sealed. In fact it is best to leave it unsealed so that any water trapped inside the wall can drain to the exterior. This is exactly what happens with hardboard, vinyl, or metal siding. Some cladding systems, like brick or stucco, have weep holes purposely drilled through the exterior to allow moisture to drain. These must not be sealed.

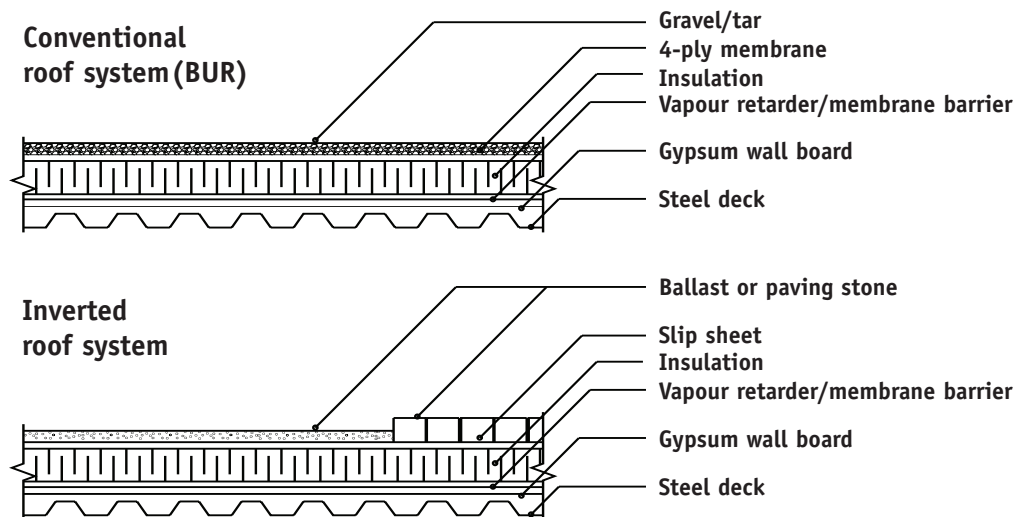
Waterproofing

Waterproof the roof with shingles or a membrane. Membrane systems are commonly used on flat roofs, however no roof should be built totally flat. The more slope, the less chance there is for ponding of water on the roof, which can eventually lead to leaks and further damage.

Membrane systems installed in the conventional manner, (over the top of the insulation), are subject to deterioration due to traffic and extremes of temperature and solar radiation. If you have this system – generally referred to as a built-up roof or BUR – and must access the roof for equipment maintenance, consider built up walkways. However, BURs are fairly easy to repair.

A more recent innovation is the inverted roof system, which places the roof membrane under the insulation. Many insulation companies and roofing suppliers provide these systems. A ballast of gravel or paving stones is often used to hold the insulation in place. Some roofing products will have a concrete layer bonded to the top of the insulation to hold it in place.

Figure 4.10 - Roof systems



Vapour retarders

Vapor retarders (still commonly called vapour barriers) are sometimes thought to be the only defence against air leaks. Polyethylene is often used in housing to provide air tightness, but it is not the only defence or even the best defence against air leaks.

However, a vapour retarder is still needed on the warm side of the insulation. This can be poly, or even two or three coats of an oil-based paint (not latex). If the building uses dry-wall, plywood, or some other system to stop all air leakage, it is not absolutely necessary to seal the vapour retarder (see page 4.1 on air barrier systems).

Moisture problems

Moisture problems in rink and arena buildings can cause energy losses as well as construction material deterioration.

Moisture

If buildings have an enemy it can be defined in one word: moisture. Moisture problems in rink and arena buildings can cause energy losses as well as construction material deterioration. Moisture affects the thermal performance of the building envelope by reducing the resistance of insulation. Only a small amount of moisture in the insulation cuts the R-value by far more than anyone thought just a few years ago. This costs extra heating and cooling dollars.

Problems due to moisture are often very difficult to discover in the first place and may be even harder to track down and stop. Moisture that accumulates in the building envelope can lead to a variety of serious performance problems not directly related to energy consumption. This is especially true if the moisture attacks the building's structural integrity, such as when it rots structural members.

Moisture corrodes and rusts metal components in the wall. This may become an unsightly nuisance or lead to failure of some part of the arena structure. Replacing a rotted stud costs money, uses raw materials, and uses energy in production of the stud.

Masonry and brick buildings can suffer additional problems with moisture. Efflorescence is the white marking that often appears on these buildings. Caused by salt that makes up part of the bricks, it is deposited on the surface by moisture. Surface staining by other materials may also occur. Moisture can cause cracking of the walls in brick and masonry buildings, and also in stucco and wood veneer buildings.

How moisture accumulates in buildings

Moisture can get into the materials and assemblies of the building from the outside and from the inside. Rain or snow can infiltrate from the outside. Interior humidity can infiltrate from the inside, which can condense in the walls and ceiling spaces.

Frost and ice can accumulate in spaces within the walls and ceiling of a rink or arena. Ice build-ups can cause deformation and deterioration of interior and exterior finishes. Icicles hanging from the outside of the building may be a hazard to occupants below. When the ice and frost melt in spring, some of the melt-water may run back inside where it is a nuisance and further hazard.

Moisture condensation occurs primarily because of air leakage, but also because of vapour diffusion (which will be reduced by the vapour retarder). It is not absolutely necessary to seal the vapour retarder, because this will allow an increased amount of diffusion (a slow process) over a small area only. It is far more important to control air leakage, which may or may not be possible with the vapour retarder.

Handling moisture

The most effective strategy is to prevent moisture from accumulating in the first place. However, almost all buildings have some form of moisture deposition or accumulation and it is impossible to achieve a 100 per cent perfect building. As a result, there has to be some consideration for handling the moisture.

A number of approaches are used to minimize condensation in buildings, including some unique ones in rinks and arenas. In retrofit situations, these basically involve reducing the amount of airflow through cracks and openings, reducing the humidity level of indoor air, or warming condensation surfaces to reduce or eliminate the condensation.

To reduce the indoor humidity levels, try using ventilation fans to exhaust moist air from the building and bring in cold dry air. Heat recovery could be part of the ventilation to reduce energy costs.

Another strategy is passive ventilation, using the wind to induce airflow through ducts and planned openings or increasing natural ventilation through a chimney by increasing its size.

Preventing deterioration of buildings by controlling moisture is economical and conserves the environment. The building will last longer and energy costs will not be incurred in the fabrication of the building's raw materials.

Wall types

The most common wall designs for new construction, renovations and additions fall into most of these categories:

- » wood or metal studs with drywall or plywood
- » precast concrete or sandwich panels
- » metal buildings
- » masonry with reinforced membranes
- » insulated concrete forms
- » structural insulated panels

These walls range from the expensive and durable to the inexpensive and temporary. They all include the four systems outlined at the beginning of this section—an air barrier system, insulation, cladding and a vapour retarder. Many of the problems associated with these designs happen at joints with other assemblies and at intersections with floors and ceilings.

Studs with drywall or plywood

Drywall is one of the most common materials in construction, both for finish materials and as part of the air barrier system. Isolate any openings, such as electrical outlets, to prevent air leakage at these points. Use rigid airtight enclosures around the electrical outlet, or eliminate penetration through the drywall or plywood by moving all services to interior partitions.

With metal studs, thermal bridges can develop between the interior and exterior faces of the wall because of the low insulation resistance of the studs. Consider using exterior rigid insulation to keep the cold side of the studs warm.

Plywood can also be sealed on the outside of the stud system. The stud space can be used only as a service race for plumbing and electrical. Insulation should be placed on the exterior of the plywood. Any air leaks that develop could be difficult to seal or to even find. Ensure good durable construction and inspect the plywood joints before the stud system is enclosed. With this kind of air barrier system there are fewer seals between assemblies and usually fewer intersecting partitions.

Precast concrete

Precast concrete is usually very expensive but it also makes one of the most durable walls. You will be purchasing the whole wall as a system from a supplier or manufacturer (see the telephone directory under Concrete). The wall will include all four systems mentioned at the front of this section. Anchoring systems for precast concrete panels, particularly large ones, are often widely spaced and have to be engineered by a consultant.

Metal buildings

Metal buildings can be purchased in package form and be built on site by local labour, with some assistance from the supplier or general contractor. Pay strict attention to the air barrier. Many manufacturers use reinforced foil-backed insulation taped at the joints. This almost always causes problems somewhere down the line when the tape no longer sticks or the foil is punctured.

It is best to mechanically clamp the joints together or to cover the foil with drywall, plywood or metal, then seal the covering layer. This is especially important in areas with high traffic or where the layer can be easily damaged.

Double gasket and sealing systems have been devised to join separate sheet metal panels. The technique includes sealing each fastener that penetrates the metal. Movement joints must be designed into any metal system placed on the exterior of the building.

Masonry with reinforced membranes

Designs using masonry must account for the large amount of air leakage through such systems and for the movement characteristics of block and brick systems. Concrete block will shrink initially due to drying out of the material. Clay-fired brick will expand slightly as the brick absorbs moisture.

Some of the newest techniques for sealing masonry or other infill panels use reinforced bituminous membranes. The membranes are usually applied as sheet materials, with a thick cross-section and reinforcing fabric between two layers of bitumen. They combine air impermeability and the ability to bridge gaps with increased strength and movement capability. Similar membranes have been in use on roofing for many years.

Masonry buildings that are built in a single width or layer with insulation poured in the core of the block make a lot of money for the people selling energy! They use enormous amounts of energy because the insulation is not continuous and because the walls tend to collect moisture that wets the insulation.

If you are retrofitting one of these buildings, consider the block as the structure only. You will still have to apply an air barrier system, a continuous layer of insulation on the inside or outside, and a vapour retarder. You will have to install either an interior finish (which could also act as the air barrier if properly sealed) or exterior cladding.

Insulated concrete forms (ICF)

The insulated concrete forms are based on the concept of modular interlocking blocks. The blocks consist of hollow core forms of flat expanded polystyrene forms connected with plastic bridge connector webs that hold reinforcing steel in place and are also used to attach interior and exterior finish materials.

The forms are used as permanent formwork to create pre-insulated solid reinforced concrete walls. The forms remain in place after setting of concrete and protected by an approved interior and exterior finish material. ICF walls can be used as load bearing and non-load bearing, residential and commercial, below- and above-grade walls.

The forms can be used in the construction of plain and reinforced concrete beams, lintels, exterior and interior walls, foundation and retaining walls, and are available in standard construction sizes.

Structural insulated panels (SIP)

Structural insulated panels are high-performance building panels for floors, walls and roofs. SIPs are used in both residential and commercial buildings. Each panel is typically made using expanded polystyrene (EPS), or polyisocyanurate rigid foam insulation sandwiched between two structural skins of oriented strand board (OSB).

Because the panels are the structural elements, there are no studs or braces to cause thermal breaks. SIP buildings are more energy efficient, stronger, quieter, and more draft free than other building systems, such as stud framing with fibreglass insulation. Less air leakage means fewer drafts, less noise, lower energy bills, and a much more comfortable indoor environment.

Energy efficiency of building types

Any building can be made energy efficient, but there are differences between the types of buildings discussed above. Costs of energy efficient construction or retrofitting will be the biggest difference. The costs will dictate the economics of energy efficiency.

The least expensive buildings to make energy efficient are generally wood frame buildings or buildings with studs and drywall or plywood. The cost of materials, including insulation, is usually lowest. Skilled labourers familiar with this type of construction can generally be found. As a result, labour rates may be less expensive and labourers more efficient on the job. The downsides are that these buildings are generally stick built (built up on site) and use traditional construction methods. Workers may not be aware of all the details of insulation or air tightness. Still, with proper supervision and consultants, you can get a good and fairly inexpensive building.

Precast concrete buildings are at the other end of the cost spectrum. They will be the most expensive to build and will be hardest to retrofit with insulation in later years. However because they are so heavy, and are manufactured and installed professionally, they can provide a very stable and comfortable indoor temperature. They may also be very energy efficient if designed properly.

Metal buildings are fairly common and relatively inexpensive. Energy efficiency varies widely between different manufacturers, as well as between similar buildings from the same supplier. Metal buildings are sensitive to the workmanship used in construction. Once complete, they could be difficult to retrofit, depending upon the complexity of structural components. Often one should go back to the supplier or a competent consultant. Some newer designs can be very energy efficient.

Labour savings and readily available materials make insulated concrete forms a cost competitive wall system. Recently, price increases in other materials have not affected concrete as much, resulting in increased interest in ICF building systems.

Building with structural insulated panels generally costs about the same as building with wood frame construction, when factoring in the labour savings resulting from shorter construction time and less job-site waste. Other savings are realized because less expensive heating and cooling systems may be required with SIP construction.

Masonry buildings can range from the best to the worst in terms of energy efficiency. If the building is a single width of block, it will definitely require retrofitting. It may be fairly simple to do this by adding a membrane air barrier to the exterior, then extra insulation and a new exterior cladding. This would be quite expensive but it would complete all basic systems required for the building.

The building envelope may be a prime user of energy in your facility. To reduce energy consumption and improve the durability of your building, it is essential to build in four basic systems: air barrier, insulation, vapour retarder, and cladding/waterproofing. These should be part of every building, no matter what its construction. In most cases where retrofitting is required, hire competent consultants to assist you in assessing your needs, determining possible solutions, estimating the economics of different options, and planning the final implementation of any retrofit.

Parking lot controllers

Parking lot controllers can slash your arena plug-in expenses by up to 50 per cent, and also ensure trouble-free starts for staff or guests. Parking lot control can be as simple as a timer and temperature device or have built-in circuitry for demand and consumption control.

In contrast to earlier types of controllers, new models save energy by automatically adjusting power at the electrical outlet as a function of outside temperatures.

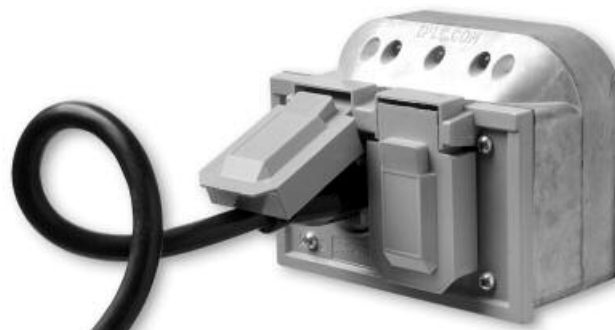
Above 23°F (-5 C) for instance, outlets receive no power. As the temperature drops, progressively more power is cycled to the outlets. Below -4°F (-20 C) power stays on all the time.

The power for the electrical outlet is controlled either from a central panel or by circuitry built inside the receptacle—the intelligent parking lot controller uses tell-tale lights to show if there is a problem with block heaters or cords.

Power saver cords can also provide cost-effective benefits where only a few vehicles are parked.

Figure 4.11 - Intelligent parking lot controller

The IPLC won Natural Resources Canada's 2000-2002 Energy Management Technology Award from the Office of Energy Efficiency. More information available at IPLC.com



There are an unlimited variety of ways to heat and ventilate buildings. The choice of systems is based on a number of factors.

You need an energy source (electricity, natural gas, propane, or fuel oil) and a heat transfer medium (air, water, or steam) that flows through a heat delivery system (pipes and ducts). Typically air or water is used as the heat transfer medium because both are in abundant supply. The heat arrives in the room through grilles and diffusers or convectors, unit heaters, and radiators.

The exception is an infrared or radiant heater which heats objects and people by direct radiation (like the sun) rather than through pipes or ducts.

Heat flow is always from warm to cool. The rate is based on the temperature differences between the hot side and the cool side, as well as the resistance to flow (created by walls, insulation, air films, and other building components).

The basic heating and ventilation system takes the heat from the heat source and distributes it to the places that need it, using fans and ducts for air-based systems or pumps and pipes for water-based systems.

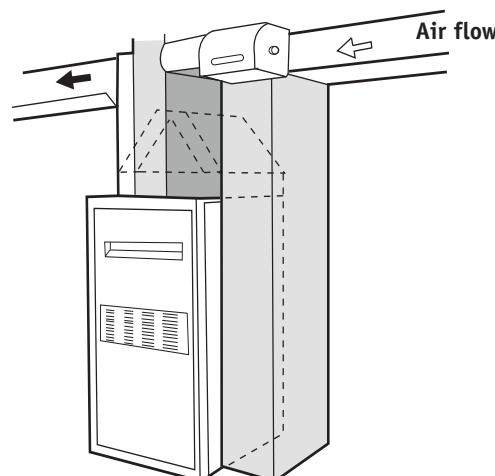
Furnaces

A furnace is a typical inexpensive heating unit. Furnaces are widely available using electricity, natural gas, propane or oil as a fuel source. Furnaces come in various configurations to suit various applications. They are inexpensive to own, operate and maintain.

Furnaces use air to distribute the heat to the rooms they serve. Furnaces rarely have capacities in excess of 200,000 Btu/h (60 kW). The term Btu/h is British thermal unit per hour.

Although furnaces are relatively inexpensive to operate and maintain, they suffer from the drawback that only one thermostat controls many rooms with different heating or cooling requirements. Furnaces are generally installed in mechanical or furnace rooms. Their efficiencies vary depending on type, operation, and the fuel they use.

Figure 5.1 - Typical forced-air furnace



Electric

An electric furnace has an annual fuel utilization efficiency (AFUE) of 100 per cent meaning that essentially 100 per cent of the electrical energy supplied to the furnace is converted to heat in the building.

Natural gas/propane

Standard. A standard natural gas or propane furnace with a standing pilot has an AFUE of 55 to 65 per cent, despite a 75 to 80 per cent combustion efficiency. This means that only 55 to 65 per cent of the energy supplied to the furnace is realized as useable heat in the building. The AFUE is lower than the combustion efficiency because heated building air is constantly flowing out of the chimney through the draft hood on the furnace. The efficiency is lowered further by the standing pilot that generally operates throughout the year (the pilot light can often be shut off if it is not required for the entire year). Standard efficiency units are no longer available on the market.

Mid-Efficiency. A mid efficient natural gas or propane furnace has an AFUE rating of approximately 80 per cent. The efficiency is improved over the standard furnace by replacing the draft hood with an induced draft fan. This eliminates the constant flow of heated building air out through chimney. The furnace also employs electronic ignition, eliminating the standing pilot.

High Efficiency. High efficiency condensing natural gas furnaces are very popular as replacements for old gravity vented furnaces. Choose an Energy Star® qualified high efficiency condensing furnace with a high efficiency variable speed fan motor for both natural gas and electricity savings. The Energy Star units extract at least 92 per cent of the available heat from the burned gas mixture. With a variable speed brushless DC motor, an improvement of 90 per cent can be achieved over a single speed AC fan motor.

Efficiency is further enhanced over a mid-efficient furnace by utilizing a secondary heat exchanger that extracts the latent heat from the water vapour in the flue gases produced during the combustion process. The flue gases are then vented outside and the condensed water vapour is drained to a sewer.

High efficiency furnaces should not be installed in locations where the temperature may drop below the freezing point. There is a condensate trap on the furnace and the water in the trap could freeze. The furnace will not operate if the water in the trap freezes.

Oil

Older standard oil furnaces have an AFUE rating of 60 to 70 per cent. This is due to warm air passing through the heat exchanger. Older heat exchangers offer little resistance to air flow, allowing room air to freely exit the building through the chimney even when the furnace is not operating.

Newer mid-efficiency oil furnaces are equipped with more efficient burners and offer more resistance to air flow when the burner is not firing. The AFUE rating of these furnaces is about 80 to 86 per cent. High efficiency condensing oil furnaces have an AFUE rating of about 86 to 90 per cent. They are expensive and not commonly available.

Infrared radiant heaters

Infrared heaters use a different principle than furnaces, unit heaters, or boilers to warm occupants and rooms. The method is similar to sunshine or camp fires.

Radiant heaters use gas, propane, or electricity to produce a high temperature radiating body. Heat is radiated via infrared rays from the heater to any object visible to the heater. Since these heaters heat objects, not the air, they are sometimes advantageous in an arena application when you want to heat spectators in the viewing stands but do not want to heat the rink itself. They may reduce heating costs since the air does not have to be heated to keep occupants comfortable.

Radiant heaters come in two basic types: high intensity and low intensity.

Low intensity heaters are generally radiant tube heaters. The combustion efficiency of low intensity heaters is about 80 per cent. The infrared efficiency (amount of energy supplied to the heater that is transferred to infrared energy) is as low as 35 per cent.

As a result, 35 per cent of the energy emitted by low intensity heaters is infrared, 45 per cent is convection and 20 per cent is lost out the exhaust (vent).

High intensity infrared heaters have an exposed burner that increases infrared efficiency up to 80 per cent. Since the units are not vented, combustion efficiency is higher than for low intensity heaters. The heaters must be interlocked with an exhaust fan to ensure people are not exposed to harmful levels of carbon monoxide.

High intensity infrared heaters generally require a high ceiling to accommodate the necessary clearances from combustible material.

Figure 5.2 - Radiant tube heater



Unit heaters

Commercial unit heaters are a variation on residential style furnaces and are available in standard and mid-efficiency models. They are popular for heating large rooms with high ceilings.

A louvered diffuser on the discharge directs the air around the room. Generally no ductwork is installed on the unit. If ductwork is to be attached, the unit heater must be certified to be installed with ductwork.

Unit heaters are economical to install and easy to relocate, but have limited applications and do not provide for ventilation. As a result of building code regulations, unit heaters are not allowed in assembly areas, such as meeting rooms or community halls. They are well suited for storage areas, garages, and work shops.

Figure 5.3 - Typical suspended unit heater



Air conditioners

In rinks and arenas, air conditioning is normally restricted to lounge and viewing areas in summer when outdoor temperatures and humidity exceed comfort levels. The air conditioner can be part of a rooftop unit or built into a forced-air furnace system.

Air conditioners are rated in Btu/h. They may also be rated in tons, an old-fashioned term used to describe the cooling effect felt by melting one ton of ice over a 24-hour period. One ton of cooling is equal to 12,000 Btu/h.

The efficiency of an air conditioner is expressed in two ways. One is the EER or Energy Efficiency Ratio, which is expressed as:

$$\text{EER} = \frac{\text{Btu/h cooling}}{\text{watts input}}$$

The EER efficiency ratings are applied to room air conditioners.

The second rating is SEER or Seasonal Energy Efficiency Ratio—essentially the EER averaged out over the entire season. The SEER is expressed as:

$$\text{SEER} = \frac{\text{Total cooling during season, in Btu/h}}{\text{Total energy consumed, in watt-hours}}$$

The SEER efficiency ratings are applied to central air conditioners.

When shopping for a central air conditioner, look for a SEER performance rating above the allowed minimum of 13. An EER rating of at least 10 should be chosen for room air conditioners. Air conditioners above these ratings will ensure energy consumption is not excessive.

Rooftop heaters

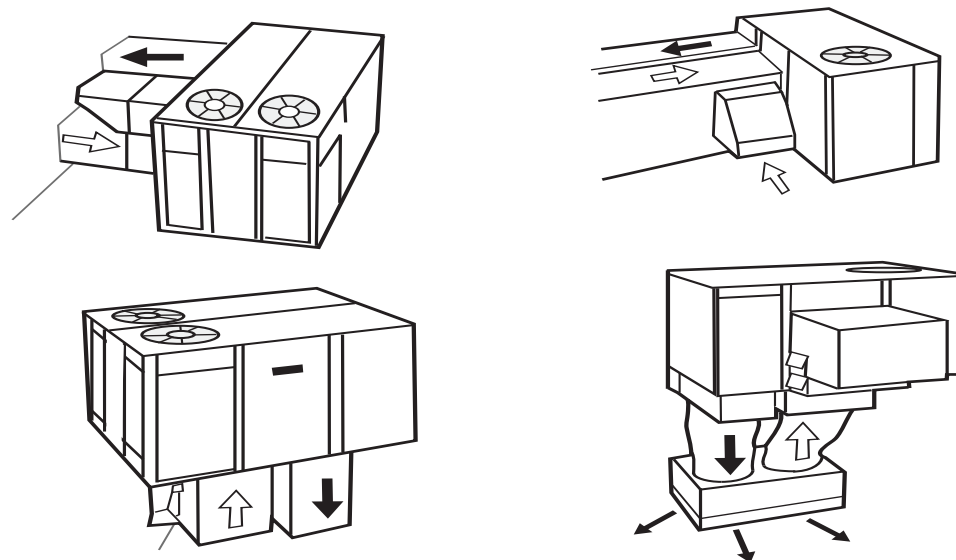
Rooftop units will have a seasonal efficiency rating between 60 to 75 per cent. The rating depends on the type of pilot, burner, unit location, cabinet insulation, and hours of operation.

As the name suggests, rooftop units put the equipment on the roof, freeing up valuable floor space. Rooftop equipment for general space heating is usually supplied with an air conditioning system, including ventilation.

Rooftop heaters with economizers use cool outside air instead of mechanical cooling to provide free cooling. When compared to furnaces with cooling coils, rooftop heaters use less electricity to cool your rooms.

Rooftop heaters distribute air through ductwork, normally above the ceiling. They cost more than a furnace but provide cooling and ventilation in a single packaged unit. Installation costs are lower or the same as installation costs of furnaces of similar capacity.

Figure 5.4 - Rooftop heaters



Heat pumps

A heat pump uses refrigerant circuits to move or pump heat from one location to another rather than using an electric heating element or burning fossil fuels.

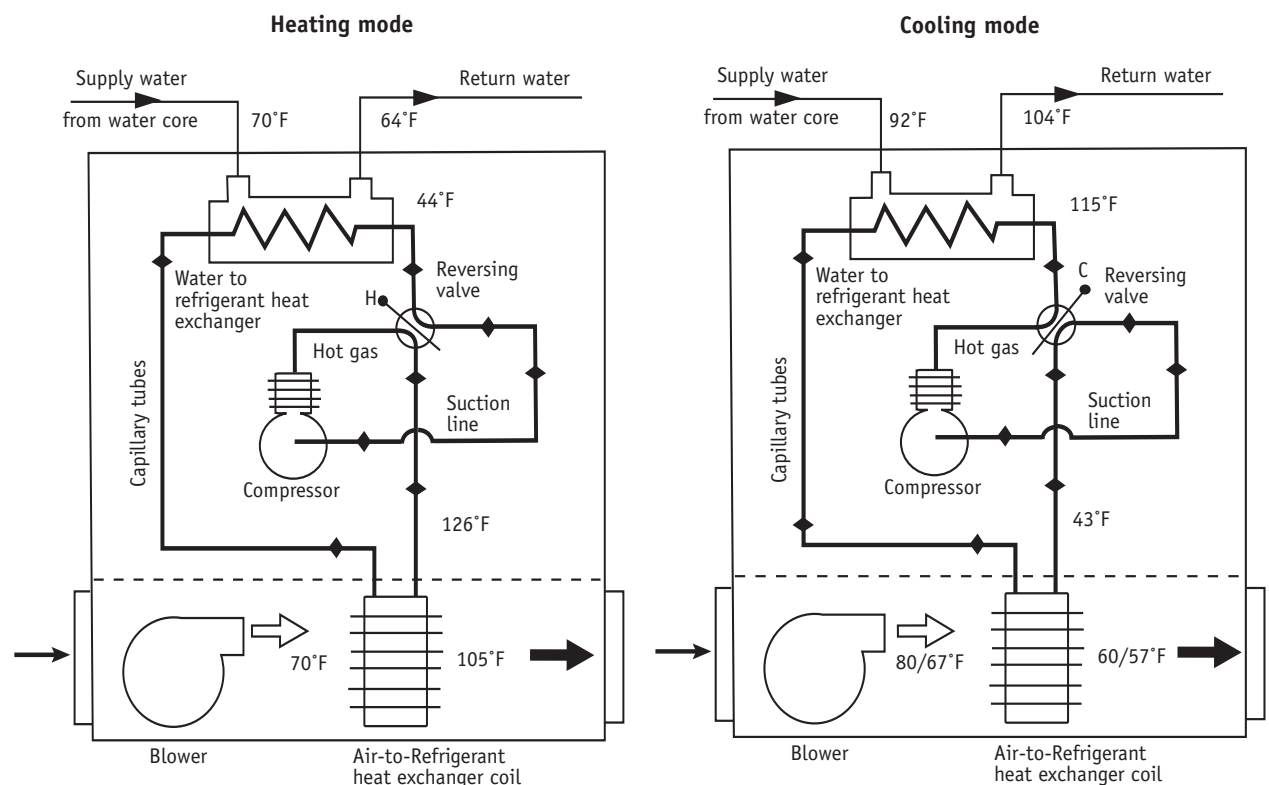
Heat pumps can heat or cool depending on the requirement of the space they serve. Depending on whether the pump is in heating or cooling mode, an internal four-way reversing valve redirects refrigerant flow and reverses the function of the evaporator and condenser coils (a coil that absorbs heat in one case rejects heat in the reversed position).

Ground source heat pumps have coefficient of performance (COP) ratings between 3.1 and 4.9. As a result they can produce 3.1 – 4.9 kilowatts of heat energy for every kilowatt of electrical energy supplied to the unit. Check current federal government regulations for minimum efficiency ratings for heat pumps.

Heat pump systems can be used for space heating and cooling, as well as for water heating. Special care must be taken in the piping of the system to avoid fouling of the heat exchanger inside the unit. Several new designs use an integrated heating and cooling system for rinks and arenas, incorporating heat pumps with regular ice plant equipment to meet the space heating, water heating, and air conditioning demands of the complex.

For arenas, these systems 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 are similar to air conditioning systems.

Figure 5.5 - Heat pump operation



Hot water/steam systems

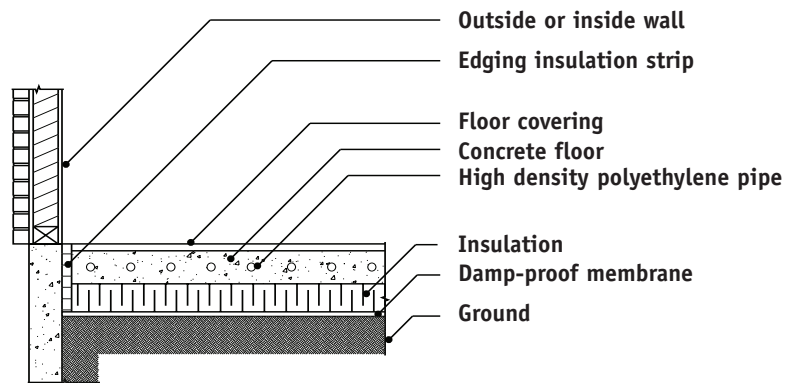
Central boilers can heat a building. The AFUE rating of older, natural draft fuel-fired boilers is 45 to 55 per cent—slightly lower than the 55 to 65 per cent AFUE of a furnace. The difference is because of greater heat loss from the high temperature water stored in the boiler. Newer condensing boilers with electronic ignition and power vents or vent dampers have high AFUE ratings of 90 to 96 per cent. Boilers can employ baseboard radiators, convection radiators, and coils in air handlers to transfer heat to the building via convection. Heat can also be transferred by radiation through hot water tubing installed in a concrete slab. A combination of all of these techniques can also be used.

In buildings with large concrete slabs and relatively low heat loss, radiant slab heating systems can be considered an alternative to other heating systems. Pipes embedded in the slab circulate hot water or use electric resistance heat to warm the concrete. The mass of the slab holds the heat in the floor for long periods and maintains the heat at floor level where it is needed. This is especially important in rooms with high ceilings where stratification can keep much of the heat high in the room and cause cool drafts at the floor.

Slab heating systems are well suited to heating lobbies and entranceways, viewing areas, and dressing rooms. A separate ventilation system may also be required to provide air flow. Extreme care must be taken in the installation and long term maintenance of in-slab heating systems to ensure good operation. Improper care may lead to leaks and costly repairs since a large area of floor may need to be torn up to find one small leak. It is important to install R-10 to R-15 insulation under the heated slab to reduce the amount of heat lost to the ground.

When properly installed, slab heating systems have shown energy savings. It is possible to lower space temperature and lower ceiling temperatures while maintaining occupant comfort, due to the warm floor and occupant zones. Tubing can also be installed in speculative seating, if it is a poured concrete slab. This technique further increases overall system efficiency since only the occupants are heated and the seating areas can be zoned. It is therefore possible to heat only certain sections of the seating area when the entire arena is not used.

The installation cost of this system is much higher than it is for a furnace or rooftop systems, especially when the cost of the air circulation system is added to the cost of the slab heat and boiler system. In-floor heating systems can be problematic in some parts of Saskatchewan where soil heaving is common. An option may be to apply rigid insulation to the footings (or grade beam) and extend that insulation about 3 feet below the footings at a 45° angle below horizontal to about 3 feet out from the building. Rigid insulation on the outside of a building must be enclosed to protect it from the sun and from rodents.

Figure 5.6 - In-slab heating system

Ventilation

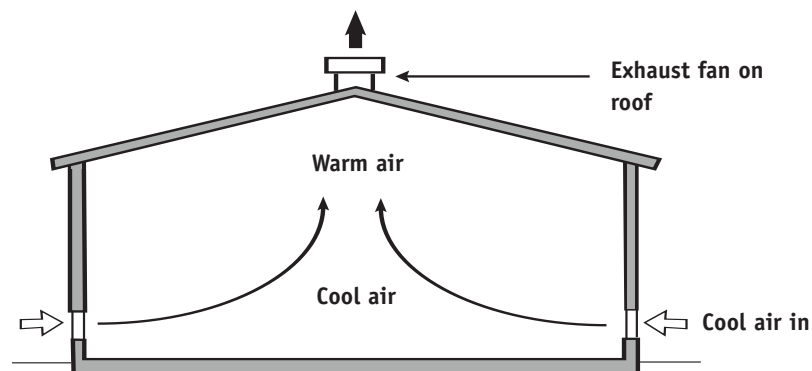
Ventilation of buildings, whether natural or mechanical, is critical for the health and safety of occupants.

Natural ventilation

When an occupied room gets too hot we like to open a window for some fresh air. This is an example of natural ventilation for thermal comfort. Outside air comes into the room through the window and cools off that area. It is intentional and we are controlling it. In warm weather, we save energy by reducing heat gain through the walls and by not operating cooling equipment. In cold weather, opening a window will increase the load on your heating system and cost money.

In rinks it is very common to ventilate the arena in winter to freeze the ice when a refrigeration plant is not in place.

Natural ventilation of a rink or arena in winter saves energy by reducing the run time of the refrigeration equipment in artificial ice facilities. This is also covered in the following section.

Figure 5.7 - Natural ventilation in a rink

Health Issues

To ensure the safety of occupants, ventilation is required. The American Society of Heating, Refrigerating and Air Conditioning Engineers [ASHRAE] has established a table of suggested ventilation rates. The rate of ventilation is a function of activity, the number of people in the room and the odours associated with the activity. For example, the lounge in a curling rink can have a lot of people in a small space. Ventilation is required to dilute the odours and bring in clean fresh air for the occupants.

Arenas need ventilation. There are a number of cases where the carbon dioxide and carbon monoxide produced by the ice cleaning equipment was not removed properly and the vapours made members of hockey teams ill. Ventilation dilutes and removes those vapours and provides a healthy atmosphere for users.

Increased levels of activity accelerate the rate at which occupants are affected by these air pollutants. Essentially, these pollutants deprive users of the oxygen necessary for activities such as skating, curling, and dancing.

Occupational Health and Safety standards have set acceptable maximum levels for carbon monoxide at 50 parts per million (ppm). Exposure above these levels may produce symptoms including cherry red lips and finger nails, reddening of the skin, headaches, giddiness, shortness of breath, faintness, or collapse.

Maximum acceptable levels for carbon dioxide are recommended at 1,000 ppm. Exposure above these levels for extended periods may produce carbon dioxide narcosis. Symptoms include fatigue, headaches, stupor, and loss of sensation.

If you observe people in the rink or arena with the symptoms listed above, immediately move them outside into fresh air and administer oxygen if available. Keep victims warm and contact a doctor or transport victims to a hospital.

Carbon monoxide safety

Carbon monoxide (CO) is a colourless, odourless gas that is released when natural gas, gasoline, diesel, propane, kerosene, heating oil, or wood burns without enough oxygen. Dangerous accumulations of CO can result from a faulty appliance, clogged chimney, inadequate venting, or a buildup of engine exhaust. To reduce the amount of toxic gases produced while the arena is in use, follow these guidelines:

1. Make sure the arena is well ventilated by fans, doors, and louvered vents. Turn on the exhaust fan. Open doors and louvered vents before, during, and after the time when the ice-resurfacing machine is operating. To increase air flow through the arena, make sure the fresh air intakes are at the opposite end of the building from the exhaust outlet. Ceiling fans may help reduce the level of exhaust gases at ice level, so run them continuously.
2. Install three-way catalytic converters on ice resurfacers, which reduce levels of hydrocarbons, CO and NO₂. Consider buying electric or battery-operated resurfacers, which reduce, and in some cases eliminate, concerns about air quality.
3. Warm up resurfacing machines outside or in a well-ventilated and specifically designed room; or attach a hose to the exhaust pipe to draw the toxic gases outside. Most vehicles must be warmed up for at least five minutes for catalytic converters to work properly.
4. Extend the exhaust pipe of the ice-resurfacing machine upwards so it is at least one foot higher than the top of the rink safety barrier. This will reduce the build-up of CO and NO₂ at ice level.
5. Service the ice resurfer regularly, according to the manufacturer's recommended schedule. Tune up at least after every 100 hours of use. Analyze the gas content of the engine exhaust to make sure the engine is properly tuned. Ensure catalytic converters are working properly.
6. Connect louvered vents electrically to exhaust fans so they operate at the same time. Exhaust fans can be set to turn on automatically to make sure they are used properly. Timers can be installed to control the operation of infrared heaters.
7. Open rink barriers while resurfacing the ice. This allows greater air flow across the resurfaced area, again reducing gas build-up. Make sure spectators and players stay clear of gate openings during resurfacing.
8. Install carbon monoxide detectors near the ice surface, and test them regularly. Consider testing the arena air regularly for CO and NO₂ to ensure gas levels are acceptable.
9. Levels should not exceed 25 ppm for CO and 0.25 ppm for NO₂. Test results exceeding these levels should trigger an immediate response to rectify the cause, as outlined in points 1 to 7 above. Arenas should strive to keep their exhaust gas levels as low as possible. Levels exceeding 125 ppm for CO and 2.5 ppm for NO₂ require occupants to leave the building immediately.
10. Any illness among skaters, regardless of the gas levels, should trigger immediate ventilation of the arena, a stop to all skating activities and a full investigation that involves the local Medical Health Officer.
11. Make the arena a smoke-free environment. Provincial regulations require your rink or arena to be smoke free. Cigarette smoke contains CO.

Mechanical ventilation

Use mechanical ventilation to remove vapours, heat, smoke and other air-borne contaminants. This produces positive, measurable air movement in spaces to improve indoor air quality and/or provide the desired room temperatures.

Rooftop exhaust fans are installed on arenas and rinks to help freeze ice in suitable weather conditions as well as to remove smoke, heat, and possibly dust during indoor rodeos or dances held in the rink.

Lounges, lobbies, and kitchens use fans to remove smoke and odours.

Ventilation costs can be significant. Operating a 3 hp exhaust fan for 2,000 hours (25 per cent of the time over one heating season) would cost roughly \$500 a year at 2006 rates.

Heat recovery ventilators (HRVs)

An HRV is an air-to-air heat recovery unit that removes heat from warm stale air being exhausted from a building and uses it to heat incoming cold fresh air. The recovery of heat saves energy by reducing the load on the heating system. See more on heat recovery in Section 9 and Appendix vi.

Heat reclaim

Up to 50 per cent savings in domestic hot water heating costs can be realized by installing heat reclaim on refrigeration equipment. Pre-heating of the water is relatively easy and produces water up to 90°F (32 C). The water heater only needs to boost the water to 140°F (60 C).

For a detailed discussion of financing and cost/benefit analysis, please see Section 3.

Heating ventilation energy efficiency

Energy is defined as power multiplied by time. To reduce energy you must reduce the power or reduce the time you are using the power.

Reducing a heating thermostat setpoint maintains the same power requirement for that heating unit but reduces its run time. Similarly, shutting off motors reduces run time but does not change the motor power. Both actions take the same approach to conserving energy.

Adding insulation, reducing infiltration, and installing triple glazed windows are all examples of building envelope energy efficiency that reduce the energy requirement of the heating system. If, at the same time, some heaters are disconnected, or a smaller furnace is installed, the power draw will be reduced. Here are some additional examples of energy efficiency improvements:

Programmable Thermostats. Program the thermostat to set back the temperature during unoccupied hours. A seven-day programmable thermostat will allow you to control multiple temperature set points for each individual day of the week. 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 to 7 per cent 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 systems. Operating setback thermostats may increase your electrical demand if they control electric heaters and multiple units that all come on at the same time during warm-up.

Time Clocks. Time clocks can be used to automatically setback thermostats, shut off ventilation or exhaust systems, and other electrical loads when they are not required.

Equipment Efficiency. When replacing equipment, install high efficiency versions.

The equipment itself consumes a lot of power. Firing efficiencies of boilers, furnaces, and unit heaters have a direct effect on the total energy bill.

If a furnace is 80 per cent efficient, then 80 per cent of the energy to it is used to heat the building and 20 per cent of the energy is wasted. With high-efficiency condensing furnaces, there are no standing pilots or chimney heat losses. A 92 per cent efficient furnace puts 92 per cent of its input energy into the building and wastes only 8 per cent.

Electric heaters are nearly 100 per cent efficient; all heat ends up inside the building. However, current natural gas heating costs for commercial facilities are one-quarter to one-third cheaper than electricity when using the electricity balance rate of \$0.05139/kWh.

Ventilation. Shut down ventilation systems when they are not required.

Ventilation is required when a building is occupied. Heating outside air to room temperature can consume a lot of energy. By reducing ventilation rates during periods of low occupancy, or shutting off ventilation during unoccupied hours, power requirements and the time required for heating are both reduced. The overall effect is lower energy consumption.

Ventilation systems are generally set up to bring in a minimum amount of fresh air. That outside air must be heated up to room temperature. If no one is in the area, the heat is wasted. Shut off your ventilation systems during unoccupied hours. You can often accomplish this by installing a switch, spring wound timer, or time clock to your ventilation controls.

Exercise caution when working with gasoline-powered equipment in a building. Ventilate the building long after the work is completed to make sure that all products of combustion are exhausted or diluted. Contact the authority having jurisdiction to confirm appropriate ventilation rates and duration.

Air Traps. Control the flow of natural ventilation in all areas.

In natural ice arenas, ice is sometimes created by bringing in sub-freezing outside air and exhausting warmer inside air. But at some point, you may need to start heating the arena to provide a uniform climate for occupants. This is particularly true in curling rinks where the air temperature is maintained at 35°F (2 C), while the outdoor air temperature can be -22°F (-30 C).

Air traps installed on air intakes allow good air flow into the space when you need it. The rest of the time they trap cold air and reduce uncontrolled infiltration.

Because cold air is denser than warmer room air, the cold air does not rise up the inside leg of the trap (see Figure 5.8) but remains trapped inside the duct. When the exhaust fans start, the air is easily drawn through the ductwork.

The same net effect can be created by equipping inlets with motorized dampers that physically shut off the opening. An air trap costs about \$300 installed (see Figure 5.8). A motorized damper of similar total capacity would cost about \$1,200 (see Figure 5.9).

Figure 5.8 - Typical air trap

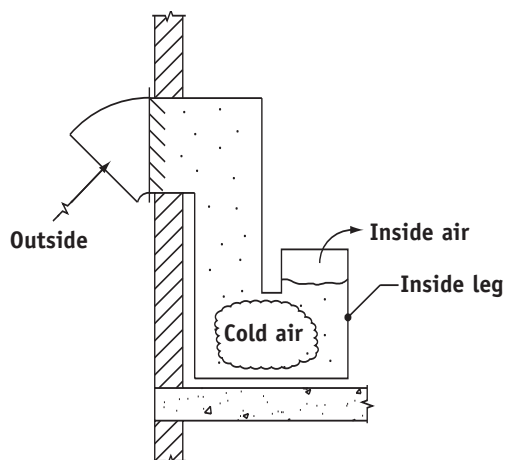
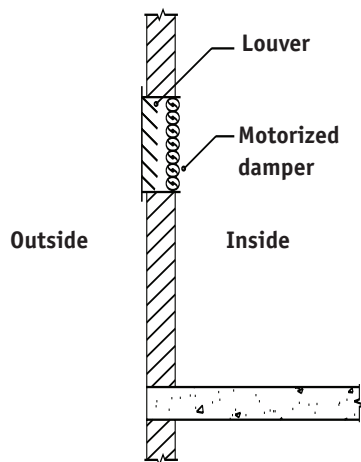


Figure 5.9 - Typical motorized damper



A Look at Maintenance Costs. It is best to install mechanical systems that are easy to maintain and operate. Neglected systems operate poorly and waste energy. It is very important to maintain mechanical equipment to ensure long trouble-free equipment life, optimum performance, and minimum energy costs.

Furnaces, water heaters and electric heaters all provide simple, reliable heat and are easy to maintain. Nearly every community has qualified people to operate this type of equipment.

Air conditioning equipment is somewhat more complex, but refrigeration mechanics are normally available within a reasonable distance of your community.

Installing highly sophisticated equipment and systems may reduce certain energy costs, but they may cost more to maintain. Specialists are normally required to provide maintenance for these systems, at a cost greater than the cost of a local volunteer.

Basic concepts of energy management

If You Don't Need It, Shut It Off. The most common and well understood energy management concept is: if you don't need it, turn it off. This applies to fans, exhaust systems, and ventilation systems.

Identify functions in your building that have limited use; for example, toilet exhaust fans in public washrooms. If the public areas are closed, shut down the washroom exhaust fans.

Domestic hot water

Domestic hot water systems can consume 15 per cent of the total energy for the average arena. Hot water needs are well defined and seldom flexible.

Water for flooding should be at least 130°F (54 C). Some ice-makers prefer temperatures of 150°F (65 C), but for energy savings, set the water temperature as low as possible while still maintaining good ice quality.

Water for showers and lavatories is mixed to 104°F (40 C). However, do not reduce hot water tank temperatures to below 130°F (54 C). A risk of bacterial growth, such as legionella, could occur with cooler temperatures. Water for kitchens may need to be 180°F (82 C) to meet health standards. These standards are based on recommended practice and health codes. Management of energy for domestic water heating falls into two basic categories; management of the source of heat and management of the stored heat.

Our choices for a heat source are:

- » Gas-fired
- » Electric
- » Heat reclaim

Most facilities choose gas-fired heating or electric heat. The relative merits of each choice are explained earlier in this section. Heat reclaim consumes the least energy but is offset by increased capital cost.

We can look at a number of ways to manage heated water. Once the water is hot, the idea is to keep it hot until it is needed. Add insulation to storage tanks and pipes to hold the heat in the water and reduce stand-by loss. Keep storage tanks at the lowest possible temperature that will still provide adequate water volume and temperature for all applications. Do not store hot water below 130°F (54 C) or you will run the risk of promoting biological and bacteriological activities in the water.

Store hot water for flooding near the ice resurfacing equipment room and shower water near the dressing rooms. A lot of heat can be lost in distribution piping. Examine the relative costs of each option carefully. Fill the ice resurfacing equipment just before use to keep the water as warm as possible.

Another technique to avoid stand-by losses is to 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.

Demand limiting

If you have chosen electrical heating for your domestic hot water heating or space heating system, your energy management strategy should include demand limiting.

Explanations of demand are included in Section 1 and in Section 6. Demand limiting will save a lot of money by not allowing the heating systems to operate while the rink compressor is operating at full load.

In summary, the use of natural ventilation to freeze ice is very common and very practical. It saves on compressor run time and in the off season can be used to remove heat. Ventilation is critical in all areas of a facility, particularly in high occupancy areas like seating, dining rooms, and lounges.

Energy efficiency measures should include reviews of operating times and power levels of equipment being used. Time clocks, night set back controls, and equipment efficiencies all help reduce energy consumption.

Energy management involves the analysis and selection of operating schedules, efficient use of fuel, and informed choices on equipment and type of energy.

Rinks, arenas, and recreational facilities in general are often referred to as complexes. There is good reason for this. The facilities and the operating of the facilities is complex. The operation of one system affects the operation of another system, and the net effect can be difficult to fully analyze or predict. Operators must understand the often contradictory requirements of cost and comfort to satisfy the needs of the facility and the people who use it.

Refrigeration energy efficiency

This section deals with energy efficiency in refrigeration systems. To appreciate the impact of energy efficiency measures, consider the total heat input to a typical rink before energy efficiency.

As Figure 6.1 below shows, radiant heat loads plus rink temperature and humidity can account for almost two-thirds of the total heat gain load on the refrigeration system in heated rinks.

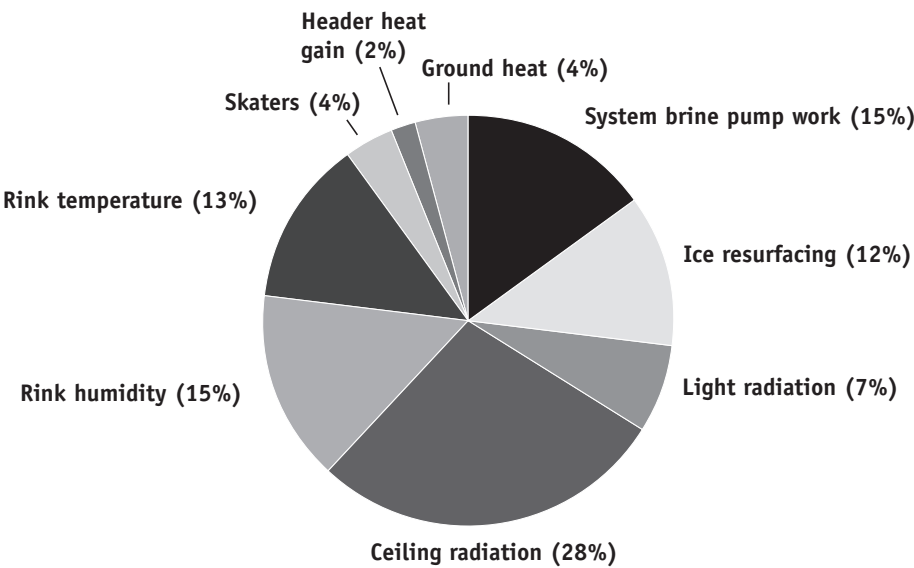
The most important factor in reducing the cost of energy to operate an ice plant is to control ice making and ice thickness.

Reductions in radiated heat loads, convective heat loads (rink temperature and humidity), brine pump work, and ice resurfacing pay the most dividends because they are the largest of the loads on the ice plant. All other loads are minor in comparison.

The reductions, reflected in shorter run times for refrigeration equipment, save energy and therefore reduce energy charges.

To reduce electrical demand charges, you would need to modify the equipment in response to reduced system loads. These measures are covered later in this section.

Figure 6.1 - Heat loads on a refrigeration system



Ice making

The sole function of the refrigeration system in rinks and arenas is to make ice. There are a lot of different things you can do to make ice. Some are better than others. Some cost more than others. Here are some details on ways to make high quality ice at the lowest reasonable cost.

Rink floor slab construction

Construction of the rink floor slab is a critical element in the operation of the complex. A wide variety of floor constructions can be utilized depending on the building function and project budget.

The flatness of the slab is of primary importance. Many rink slabs suffer from serious frost heaving and soil settlement due to sub surface moisture. The floor in one corner may sit 2-3 in. (50-75 mm) below other points on the floor. During flooding, the water runs to the low point, building up more than 3-4 in. (75-100 mm) of ice in that area and leaving only an inch (25 mm) of ice in the rest of the rink.

Because the ice plant has to work harder to keep the 3-in. thick section of ice cold, it overcools the rest of the ice surface, wasting energy. It is critically important to ensure that your rink slab is installed perfectly level and that it remains level throughout the years.

Rinks with ice 12 months of the year do not require concrete slabs but must have heating installed below the slab—a heat deck—to prevent frost heaving.

Artificial ice rinks used for rodeos or as community halls in summer must have concrete floors, but may not need heat decks. Rinks built on soil prone to heaving will probably require a structural slab to support the ice and avoid movement.

An all-purpose floor with sub-floor heating allows for heavy loads, maximum flexibility and year-round use, depending upon the scheduling of the facility.

The open or sand fill floor is the least expensive type of rink floor. It can be used in facilities where initial cost is a major factor and the floor is not intended for any other function.

To get the best value for the money spent on your rink floor, install a general purpose concrete floor so that other functions can be scheduled after the ice is removed. The floor should be designed to withstand average street loads and the cooling pipe installed in a reinforced concrete slab. Thermal expansion and contraction of the slab must be anticipated and designed into the floor, particularly in facilities where the ice may be removed frequently.

Sub floor insulation. Install a minimum of R-15 insulation below the slab in facilities where there are quick change-overs, high soil moisture content or if the rink will be operated continuously for more than nine months a year.

This level of insulation reduces the amount of heat absorbed from the ground, thus reducing the load on the ice plant. It also reduces the cooling of the sub grade and the formation of frost below the slab.

Sub floor heating. Testing has shown that rink slabs with 3 in. (75 mm) of sub floor insulation that are refrigerated for eight to nine months can create frost 2 to 3 feet (0.6 to 0.9 meters) below the insulation. If there is no insulation, frost will penetrate 7 to 8 feet (2.1 to 2.4 meters) and usually cause heaving. In extreme cases, frost has been found 28 feet (8.4 meters) below ground.

To counteract the formation of frost in extended-use rinks, install a heating system below the insulated slab. Circulating a 40°F (5 C) glycol/water mixture through the pipe network embedded in the sand base ensures a frost-free sub-grade while adding very little extra cooling load to the rink slab. Control the pump with a remote-bulb thermostat installed under the slab to keep the sub-grade temperature above freezing.

The heat source can be from rejected condenser heat or a separate gas boiler, electric boiler or heat pump.

Sub soil drainage. Whether your rink floor is sand or concrete, the drainage of your sub soil is important. Frost heaving can only occur in the presence of sub-soil moisture, so if you can remove the water you should be able to avoid the problem.

Depending on the sub-grade condition, drainage channels should be installed below the rink to remove any water that migrates into the sub-base. Since every location has unique conditions, each drainage system must be designed by a qualified professional engineer or geotechnical consultant.

Slab preparation

Start with a clean floor slab. Ice must bond to the slab to ensure good heat transfer. Any impurities such as oil and dirt will affect the bonding of the ice to the slab. Other impurities will affect the freezing point of the water, making it difficult to freeze the affected zones.

The refrigeration system must be capable of freezing the most difficult areas of the ice surface. If you are keeping the rest of the ice colder than necessary, you are wasting energy.

Water purity

The purity of the water used for flooding is critical to the quality of the ice produced. Any impurity in the water adversely affects the making of ice. The normal ions found in water disrupt the hydrogen bonding which normally occurs when water freezes. This creates ice that breaks up more easily.

Salts in the flood water will lower the natural freezing point. Lower refrigerant brine temperatures are required to freeze the ice, using more energy.

Air in the water acts like insulation, which makes it harder for the brine in the slab to freeze the top layer of ice. Air can be removed from the water by heating it above 130°F (54 C). Such water is warm enough to bond with the base ice, but not so hot that it imposes a huge load on the refrigeration system.

Heating flood water above 130°F (54 C) produces a potential double penalty because you use energy to heat the water, then more energy to freeze it. Consider the use of alternate water supplies if your present water source is high in impurities. Rain water sources, such as roof run-off or dug-outs, can be examined if practical.

Water purification

If your water supply is bad it may pay to clean it up. Water high in iron, for example, produces a coloured ice that absorbs radiant light energy and puts an extra heat load on the ice plant.

Reverse osmosis water purification systems produce pure, demineralized water, free of impurities such as organics, colour, bacteria and silica. Because pure water has a higher freezing temperature than softened water, brine temperatures can be raised. The ice produced is harder so less snow is produced and less ice surface maintenance is required.

Pure water can be applied at a lower flood water temperature, which saves on heating and refrigeration energy. Each flood requires less water, which means ice shaving isn't required as often. This saves on equipment wear of the ice surfacing machine. Reverse osmosis machines are available from many water conditioning companies. These units cost roughly \$25,000 for a 5 gpm unit.

Generally hockey players, figure skaters, and curlers agree that ice quality is better for their sport when pure water is used. Impurities collect at the upper surface of the ice. If left uncontrolled, the level of salts and minerals could build-up and put an extra load on the refrigeration equipment.

Painting the ice

Painting the ice a reflective white reduces the refrigerant load by 5 to 15 per cent compared to dark ice. Radiant heat energy from lights and heat is reflected away from the ice by the paint.

If the slab is the colour of dark sand or grey concrete, heat and light energy would be more readily absorbed and would have to be removed by the ice plant. Reflecting light back into the rink also reduces the amount and number of lights required to provide adequate illumination, generating further energy savings.

Choose ice surface paints designed to be thermally conductive. Paints for lines and ice colouring, as in the case of all other impurities, reduce heat transfer through the ice.

Ice thickness

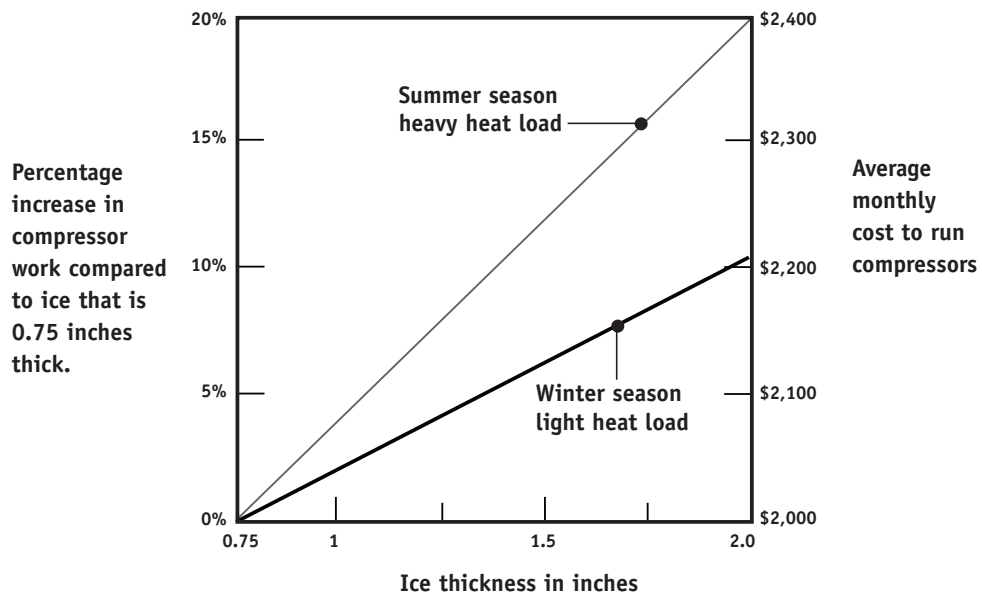
Keep the ice thin. One inch (25 mm) is considered optimum for energy efficiency. Because the ice acts as an insulator, excessive ice thickness will increase compressor load for higher energy costs. Figure 6.2 shows the relationship between compressor work and ice thickness for a hockey rink.

Note that ice 2 in. (50 mm) thick forces the compressor to run an extra 10 per cent and costs an estimated additional \$250/month.

Shaving ice is critical for reducing ice thickness and removing concentrations of impurities in the ice.

Ice sublimation, the process where ice turns directly to water vapour from the solid, reduces the amount of water in the ice, increasing the proportion of impurities. The impurities collect at the upper surface of the ice. If left uncontrolled, the level of salts and minerals could build-up and put an extra load on the refrigeration equipment, as explained earlier.

Figure 6.2 - Thickness in ice versus monthly cost of ice production



Ice melting

Melting ice inside the building puts an extra load on the heating equipment. If practical, take your shaved ice outside to be melted. Paint often contains substances which are not environmentally friendly. Always check environmental regulations in your area for regulations on dumping snow with paint in it outside. Perhaps the best solution for snow removal is to melt it with reclaimed heat from the condenser (see Heat recovery, page 6.16).

Ice temperature

Hold the temperature of the ice surface as high as possible. Hockey requires hard ice, figure skaters like soft ice, and curlers want keen ice. Hockey rinks run with 16°F (-9 C) brine returning at 18°F (-8 C). Curling and figure skating ice runs with 22°F (-6 C) brine returning at 24°F (-4 C). Recreational skating is usually somewhere in between.

Each degree Fahrenheit that you raise the ice temperature reduces the load on the ice plant by up to 2 per cent. The drop is because of the combined effects of conductive, convective, and radiant heat loads on the ice surface. The higher the ice temperature, the lower the potential for heat transfer. For more details on night setback, see Controls on page 6.13.

Mechanical refrigeration

“Refrigeration is the process of moving heat from one location to another by use of refrigerant in a closed refrigeration cycle.” (ASHRAE 1990 Refrigeration Handbook).

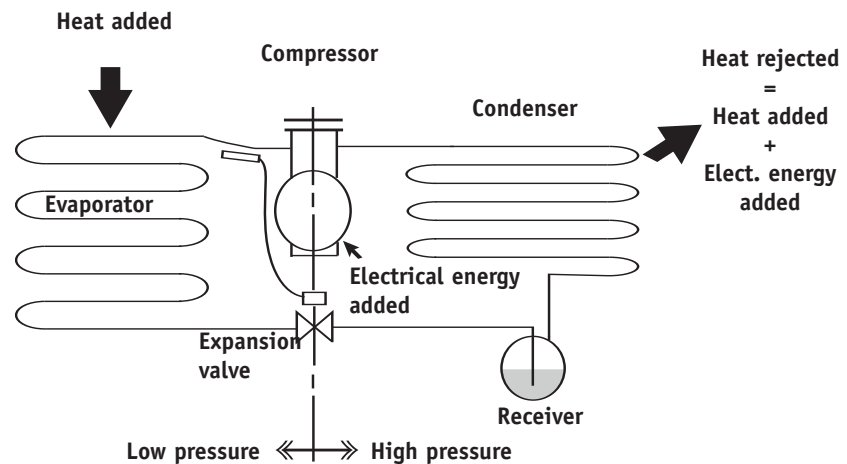
Ice rinks and arenas use refrigeration to create ice for skating or curling. Refrigeration is a major financial commitment for any facility, in terms of capital investment as well as the costs of energy and maintenance.

The refrigeration cycle in rinks

Heat from flooding, lights, people, heating, equipment, the ground, and the building is absorbed by the ice surface. The heat is transferred to the brine circulating through the floor. The brine is cooled in the evaporator of the ice plant. The compressor draws the gaseous refrigerant into its cylinders and compresses it. This raises the temperature and pressure of the refrigerant. The discharged gas moves to the condenser, which rejects the heat from the brine plus the compressor heat.

Ultimately, all this heat is rejected through the evaporative condenser to the outside air. The gaseous refrigerant condenses to liquid. This liquid is expanded through an expansion valve before it enters the evaporator to cool the brine and complete the cycle.

Figure 6.3 - The refrigeration cycle



Brine

Maintain your brine at a specific gravity of 1.20 to 1.22 for optimum energy use. Brine solutions, which consist of water and calcium chloride (CaCl₂), are circulated in the rink floor slab to remove heat from the ice.

Consider insulating the brine storage tank to reduce cooling losses and heating costs in the compressor room. The header trench should also be insulated if ice is maintained during the spring and fall seasons (a six month or longer season).

Figure 6.4 - Brine storage tank

The brine storage tanks at Martensville (Figure 6.4) are insulated with black rubber material to reduce cooling losses in the compressor room. Note the frost build-up where insulation is not applied.



The brine must be maintained so its freezing temperature is always lower than the temperature of the refrigerant (ammonia, Freon) in the chiller, usually about -10°F (-23 C), but as high as possible. The lower the freezing point of the brine, the stronger the calcium chloride concentration, the higher the specific gravity. Higher specific gravity results in higher pumping horsepower.

Table 6.1 - Brine specific gravity versus pumping horsepower required

Specific gravity	Freezing point	Required pumping horsepower
1.18	-8.03°F (-22.24 C)	11.8 h.p.
1.20	-15.23°F (-26.24 C)	12.0 h.p.
1.22	-24.43°F (-31.35 C)	12.2 h.p.

Variable brine temperature

Given that a higher brine temperature produces higher ice temperatures and lower refrigeration loads, maintain your brine temperature as high as possible.

Equipment is available to automatically reset brine temperatures based on a schedule of events throughout the day. A typical daily cycle may be as follows:

Table 6.2 - Typical daily brine cycle

Period [2400 clock]	Brine Temperature	Rink Function
0:00-6:00	25°F (-4 C)	Night setback
6:00-8:00	25°F (-4 C)	Ice maintenance
8:00-16:00	22°F (-6 C)	Low load
16:00-18:00	20°F (-7 C)	Figure skating
18:00-24:00	18°F (-8 C)	Hockey

To drop brine temperature 2°F (1 C) takes only one to two hours if the ice is kept thin. It is possible to save up to 8 per cent of compressor energy consumption when variable brine temperatures are implemented.

It is recommended that a separate slab sensor be installed to monitor slab ice temperatures if variable temperature brine controls are installed. This will ensure that the ice performs as required, independent of other loads on the system.

Night shutdown

Night shutdown is an effective method of energy efficiency involving very little capital outlay. Simply shut off your refrigeration plant at night, including the brine pump. All heat loads in the arena or rink should be shut off. Space heating must also be set back to 35°F (2 C). The ice temperature will rise slowly during the night. Once the slab sensor detects that the slab has reached 25°F (-4 C), the brine pump and one compressor should be started to prevent the ice from warming any further.

You must use a slab sensor to restart the system since a brine return sensor will be ineffective while the pump is shut-off.

The soft ice in the morning will be easy to cut and groom for the new day. This reduces wear and tear on your ice maintenance equipment and saves on fuel.

Here is a key point to remember if you decide to use night shutdown or vary your ice temperature. When the compressor is bringing the temperature of the ice down, from 25°F to 18°F (-4 C to -8 C), keep to a minimum the number of lights on and other pieces of equipment operating to avoid setting a new peak electrical demand. If you fail to avoid a demand peak, you will still save energy but your demand charges could increase and cancel or overshadow any gains in energy savings.

Variable speed pumping

Arena and curling rinks typically rely on in-line, centrifugal brine pumps to circulate a cold brine solution through the pipes under the ice. Because the action of brine pumps introduces surprisingly large amounts of heat to the brine, major energy savings are available through improved brine pump control.

Brine pumps are typically 20 hp in arenas and 15 hp in curling rinks. They generally run 24 hours a day, 20 weeks a year. Operating these pumps adds to your energy costs in two ways. One is the energy consumed by the pump itself; the other is that 90 per cent of the energy consumed by the pump appears as heat in the circulating brine, putting a large load on the ice plant compressor. Operating the pump is like running a 15 kW (20 hp) or 11 kW (15 hp) heater in the brine.

For example, most operators of rinks and arenas would not install a 15 kW heater in their brine loop, run it continuously, and then pay to remove all that heat in the chiller. But that is essentially what they are doing when they leave their brine pumps running continuously at full speed. A 20 hp brine pump puts 15 kW of heat into the brine loop in the form of friction in the piping.

Three options for improving brine pump control

1) Brine Pump Cycling with an Ice Thermostat. This is the lowest cost option of the three. It involves installing an ice slab thermostat about 3 ft. to 6 ft. (0.9m-1.8 m) from the edge of the concrete slab. The thermostat allows the pump to come on only when the ice temperature rises above the ice thermostat set point.

This approach basically restricts the operation of the brine pump to the operation of the compressor. Once all cooling needs are met, all refrigeration equipment shuts down.

Of the savings achieved with an ice thermostat, about 87 per cent are from reduced operation of the brine pump. The remaining 13 per cent are from related compressor operation savings.

Using an ice slab thermostat reduces brine pump power by about 30 per cent because it reduces run time to 10-12 hours a day. In a seasonal ice arena, yearly savings would be 34,000 kWh, which at \$0.05139/kWh would be worth \$1,747 (plus applicable taxes). In a curling rink, yearly savings would add up to 15,000 kWh, which at \$0.05139/kWh would save \$770 (plus applicable taxes).

It costs an estimated \$2,500 to \$3,500 to install a slab thermostat. Payback would be less than two years for a seasonal ice arena, and about four years for a curling rink.

2) Two-Speed/Secondary Pumping in Combination with Brine Pump Cycling with an Ice Thermostat. Under this higher cost option, you would need to buy a new 2-speed pump or a smaller secondary pump that you would install in parallel with the old pump. If your old pump needs replacement anyway, this option would present an opportunity to install a 2-speed system. You would also have to install an ice slab thermostat.

The basis for this option is that brine pumps are sized to deliver enough flow to satisfy peak cooling needs that occur only during warm weather operation. This means that either the 2-speed pump, or the smaller secondary pump, would operate most of the time on low speed for major savings.

Savings are roughly twice what they are with brine pump cycling because the brine pump load increases/decreases with the cube of flow. A 50 per cent reduction in flow means an 87.5 per cent reduction in power consumed. In a seasonal ice arena, operating the two speed/secondary brine pump would yield annual savings of 68,000 kWh, worth about \$3,494 at \$0.05139/kWh. In a curling rink, annual savings would add up to 30,000 kWh, worth approximately \$1,542 at \$0.05139/kWh.

It costs an estimated \$5,000 to \$7,000 to install a slab thermostat and 2-speed pump. Payback would be two years for a seasonal ice arena, and four to five years for a curling rink.

3) Variable Flow Pumping. Another higher cost option, this one involves buying a new variable speed drive (VSD) for the brine pump, as well as installing an ice slab thermostat.

As in the previous option, the brine pumps are sized to satisfy peak cooling needs that occur only during warm weather operation. This means that for most of the time, a variable speed pump would operate the brine pump at a lower speed for major savings.

Savings are even greater than for 2-speed pumping since the brine pump will operate at its optimum speed at all times. In a seasonal ice arena, variable speed brine pumping would yield annual savings of 79,000 kWh, worth \$4,060 at \$0.05139/kWh. In a curling rink, yearly savings would add up to 35,000 kWh, worth \$1,798 at \$0.05139/kWh.

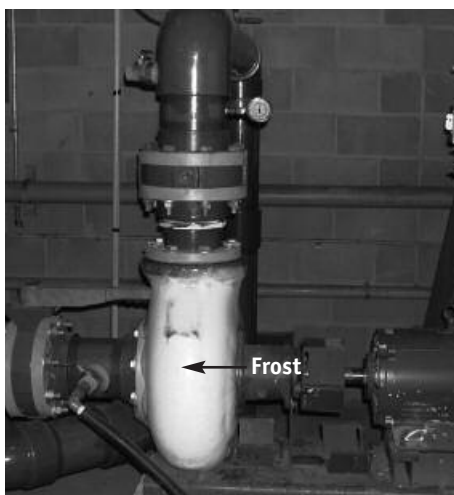
It costs an estimated \$15,000 to \$25,000 to install a variable speed pumping system with slab thermostat. Payback would be four to six years for a seasonal ice arena, and about 10+ years for a curling rink.

Table 6.3 - Comparing efficient brine pumping systems

Arenas			
	Cycling	2-Speed	VSD
Cost	\$2,500-3,500	\$5,000-7,000	\$15,000-25,000
Savings	\$1,747/year	\$3,494/year	\$4,060/year
Payback	2 years	2 years	4-6 years
Curling rinks			
	Cycling	2-Speed	VSD
Cost	\$2,500-3,500	\$5,000-7,000	\$15,000-25,000
Savings	\$770/year	\$1,732/year	\$1,798/year
Payback	3-4 years	4-5 years	8-13 years

Figure 6.5 - Variable speed drive

Variable speed drive shown here, located at Martensville, SK. The speed of the brine pump is set by an in-ice temperature sensor.

Figure 6.6 - Brine pump

Brine pump on the skating rink at Martensville, SK. This brine pump is controlled by the VSD. It was about 10°F (-12 C) outside when the picture was taken and the motor was operating at about 30 Hz (half the normal electrical distribution frequency of 60 Hz) and the motor felt much cooler than the brine pump on the curling rink ice.

Figure 6.7 - Brine pump controller

Note: 29.7 Hz is shown as the frequency at the Martensville, SK brine pump when the outside temperature was 10°F (-12 C).

Liquid pressure amplifier

A liquid pressure amplifier (LPA), a little-known technology in refrigeration, can cut power costs in Freon equipment up to 400 per cent with a simple retrofit.

An LPA pumps liquid Freon into the evaporator of the ice plant. This allows the compressor to operate at a significantly lower head pressure. Since a compressor's work is proportional to the amount of pressure that it produces, a reduction in output pressure creates lower input horsepower requirements for major energy savings.

Typically, the LPA is a 1/5 hp (150 W) pump delivering 8 gpm (0.5 L/s) with a 12 psi (80 KPa) pressure rise. Units greater than 27 tons require multiple liquid pumps.

A possible drawback is that lower pumping condenser and refrigerant temperatures will make less heat available for heat recovery applications. If you are currently using some form of heat recovery system, an LPA may decrease the effectiveness of those systems dramatically. But the electrical savings will offset the extra heating costs.

Brine line dehumidifier

Reduce your refrigerant load by reducing the humidity level inside your rink.

Some rinks use a clever method to accomplish this at minor cost. They set up a return brine line loop in a corner of the rink. Brine at 22°F (-6 C) in the line causes frost to form on the line, limiting the amount of water that can stay in the air to a 22°F (-6 C) dew point. A rink with a 35°F (2 C) space temperature will have a maximum relative humidity of 52 per cent, which is desirable.

A defrost cycle is required to melt the frost and drain the melt water into a drain pit. The cooling of water in the air of a typical rink accounts for up to 15 per cent of the total refrigeration load. If humidity levels exceed the recommended level of 50 per cent R.H., the load increases significantly. Save energy by keeping humidity under control.

Refrigeration dehumidifier

Some arenas use a refrigeration dehumidifier to reduce humidity levels in the rink area. Working exactly like a free-standing home dehumidifier, a refrigeration dehumidifier removes moisture by cooling the air on cooling coils until the moisture condenses out. The water is routed to a drain.

Controls

Adding controls to the refrigeration system can produce substantial savings in energy if the controls are carefully considered and well analyzed. Control options run from inexpensive time clocks, to specialized controllers, to extensive computerized facility management systems. Under certain circumstances, some or all of these options may be appropriate for your facility.

Switches

The simplest way to control equipment and save energy is to shut the equipment off when it is not required. All equipment has a disconnect that can be used, but the installation of switches, timers, and thermostats is recommended whenever possible.

The problem with switches is that somebody has to remember to switch the equipment off to start the savings, and then somebody needs to restart the equipment to avoid a melt down. Remember that your energy savings will be lost if the facility cannot be used as a result of bad management.

Time clocks

Time clocks ensure that switching is automatic and savings will occur automatically on a pre-determined schedule. They come in various styles, including 6-hour timers, 24-hour time clocks, and 7-day time clocks. Electronic, electric and electro-mechanical models are available to suit your control requirements.

Time clocks are well suited to night setback and night shutdown. Lighting and ventilation systems can also be controlled effectively in this manner. It is important to provide override controls in some cases, such as night shutdown of refrigeration equipment, to ensure that problems do not result from shutdown.

Critical functions should have safety switches that over-ride the time clock to avoid unwanted situations.

Automatic controllers

Refrigeration control packages are specialized automatic controllers with multiple inputs to serve a specific function, such as a brine pump control. In this case, the controller senses ice temperature and controls the pump according to the controller set point for the required ice temperature.

These controllers serve a single function that is independent of other system functions. Costs vary from \$1,000 to \$20,000 installed, depending upon the complexity of the function and the amount of power controlled.

Computerized energy management systems

A computerized energy management system is the most sophisticated, most complex way to control your facility. This class of controls uses a personal computer control station and is capable of controlling the following:

- » Refrigeration system
- » Brine pump
- » Ice temperature
- » Lighting and illumination levels
- » Ventilation equipment
- » Heating systems
- » Other electric equipment
- » Domestic water heating
- » Demand functions

They perform a range of functions, including:

- » On/off switching
- » Dimming and setback
- » Thermostat adjustments
- » Time of day scheduling
- » Demand limiting
- » Equipment monitoring
- » Alarm functions

Integrated systems

Many computerized energy management systems are also capable of doing registrations, maintenance notices, inventory, accounting, bookkeeping, invoicing and security. Cost generally starts at \$10,000 and can easily run up to \$30,000, depending upon the complexity and number of control functions required.

This type of system is best suited for very sophisticated owners with large facilities and high energy consumption. The economic feasibility of this equipment must be carefully analyzed, with input from control system and refrigeration equipment specialists. Facility management should also look at other possible applications for the computer.

There may be instances when evaporative condensers and heating systems run simultaneously throughout the winter. The evaporative condenser rejects heat to the outdoors while the heating system adds heat to the building or to water. The rink pays to run the evaporative condenser and the heating energy.

Rinks and arenas with high energy costs are sometimes built with integrated heating and refrigeration systems that eliminate this waste of energy. A number of rinks have been built in the last several years with these systems incorporated into their plans.

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 18°F (-8°C). The plant cycles on and off to meet ice-making needs.

In new construction, it is wise to consider parallel refrigeration units consisting of four, 25 hp machines. The strategy provides for an increased number of load capacity steps, redundancy in the system, and use of refrigeration compressors for summer air conditioning.

In either case for integrated systems, rejected heat is used for space heating, domestic water heating (or pre-heating), or any other heating applications. Please refer to Appendix vi for more heat recovery information from Natural Resources Canada.

Care must be exercised in the design of integrated systems. In very cold weather the ice plant rarely runs. If it is the heat source, you won't have any heating when you need it most. In spring and fall, the refrigeration plant runs almost continuously, yet the need for heating is minimal. These situations point out the need for alternate heat sources and alternate heat sinks (heat rejection systems). Some facilities store the heat in insulated water tanks to be used at a later time. This is known as thermal storage.

Integrated heating and cooling systems are inherently efficient if they are well designed and controlled. But control of the system can become complex. The level of complexity should match the skills and knowledge of the operator(s) and the availability of qualified service personnel. In some cases, especially multiple parallel compressor installations, computerized controls are recommended for optimum efficiency.

The addition of heat pump units can create other interesting possibilities for providing a higher temperature heating source plus summer cooling. When integrated into a heat recovery system, savings in operating costs are possible. The savings must be weighed against the purchase price and maintenance costs.

Alternate heat sources/sinks

Geothermal energy can be used as an alternate heat source or heat sink. Examples include the use of ground water and ground source heat loops.

Ground water loops circulate well water through heating/cooling systems and return it to a second well. Heat is added to the water (heat sink) or heat is removed from the water (heat source) as required.

Ground source loops circulate water or brine in a closed loop through horizontal pipes buried in the soil under the parking lot, ball diamond, etc. next to the complex or vertically in deep bore holes. A ground loop, when placed horizontally a few feet below the surface, can be used to chill rink brine if the soil is totally frozen. However, when the loop is connected to a heat pump, the ground source loops can be used as heat sources or heat sinks depending on the specific soil conditions, depth of the ground loop and ambient temperatures.

Heat recovery

You can save significant amounts of energy by recovering heat from refrigeration equipment. Reclaimed heat from the condenser loop is generally used for:

- » Flood water heating
- » Domestic water heating
- » Space heating
- » Under slab heating
- » Ice melting

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 (2,110 kWh) per day of rejected heat energy from the ice plant is available for other heating requirements.

The heat available may or may not be at a temperature that is useful for applications. Condenser heat is available at 95°F (35 C). Compressor discharge refrigerant is at 240°F (116 C) 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. (Also see Appendix vi).

Flood water heating

Freezing flood water represents a large portion of the load on an ice plant. It makes good sense to heat flood water from reclaimed heat.

If rink flooding requires 600 U.S. gallons (2,250 litres) of water a day at 140°F (60 C), assuming a 40°F (5 C) inlet water temperature, then 500,000 Btu (146.3 kWh) is required to heat the water every day.

A heat exchanger can be connected to the discharge gas line of the compressor to heat the water with 240°F (116 C) ammonia or Freon. A thermostat in the tank can cycle the water circulation pump to maintain water temperatures. It is important to size all equipment carefully and provide adequate back-up heating capacity if the compressor is not operating between floods.

Condenser heat can be used to preheat water but the relatively low water temperature limits the discharge temperature. The maximum discharge temperature for this system would be about 80 per cent of the temperature difference between the inlet domestic water temperature and condenser water temperature. Standard fuel-fired water heaters would be required to provide 140°F (60 C) water for flooding.

Domestic water heating

The total heating requirement is subject to wide variations based on the actual usage of your facility. For example, assume a daily consumption of 840 U.S. gallons (3,200 litres) of 120°F (49 C) water. This results in a total heating requirement of 560,000 Btu/day (164 kWh), based on an inlet water temperature of 40°F (5 C).

Since ammonia is a toxic substance, direct contact with potable water in a heat exchanger is not allowed. A specialized heat transfer unit must be installed.

Condenser heat is only practical for pre-heating because the highest discharge temperature would be about 90°F (32 C). Still, this would save about 78 per cent 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 low grade heat is rarely used. Heat pumps are now able to use this low grade heat to provide space heating and summer-time cooling.

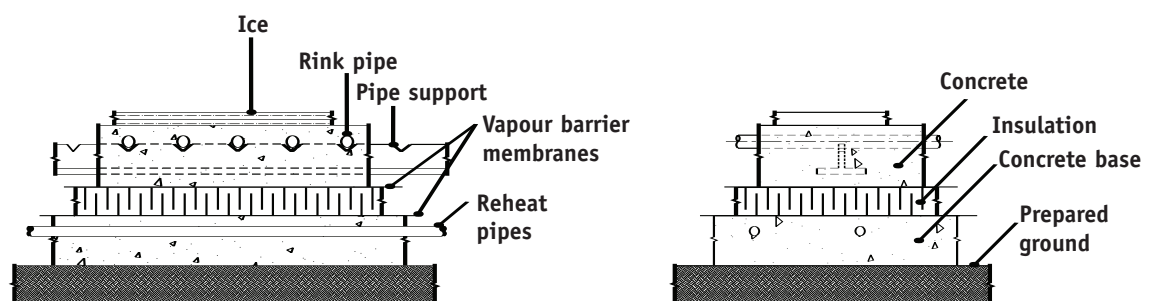
If compressor super heat is available from a Freon refrigeration plant, there may be ways to produce 160°F (71 C) hot water to supplement boiler water heat. Relatively few facilities have hot water heating systems, so applications are limited except in new construction or major heating system renovations.

Under slab heating

Extended use facilities install heating pipes below the insulated rink floor slab, as shown in Figure 6.8. Water circulated in the loop should be kept at 35°F to 40°F (2 C to 5 C) 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. (Note: One MBH is equivalent to 1,000 Btu per hour). 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.

Figure 6.8 - Typical hot deck piping configuration



Ice melting

Melting shaved ice and snow from rink maintenance 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.

Installing condenser heat coils or loops in a large drain sump provides a relatively constant temperature heat sink. Since water and ice can only co-exist at 32°F (0 C), the sump will be close to that temperature any time snow is in the pit. The system should be designed to melt snow at a rate equal to the maximum snow load expected.

Similarly, sensors in the pit should stop flow through the condenser heat loop if there is no snow to be melted. It is counter-productive to heat melt water and add humidity to the rink.

If the rink has a way to recapture waste heat from the condenser or the compressor, that heat could be used to melt snow. The new arena complex in the community of Aberdeen, SK uses waste heat recaptured from their heat pump (as shown in Figure 6.9).

Past practices often resulted in removing snow from the building and letting Mother Nature melt it in the spring. However, with ever-increasing environmental regulations, it may soon be required to melt the snow in a controlled area to avoid any contamination concerns from paint being removed with the snow scrapings.

Figure 6.9 - Snow melt pit



Electrical

In most ice rinks and arenas, refrigeration system motors consume the largest amount of electricity. The motors, which vary from one to 100 horsepower (hp), provide high quality ice in your rink.

Power factor correction

Power factor is the name given to the ratio of the usable power measured in kilowatts (kW) to the total power delivered measured in kilovolt-amperes (kVA).

Electrical systems with large electric motors can suffer from low power factors. Your demand charges will be higher than necessary for the actual work that is provided by your equipment.

In most rinks and arenas, all major motor loads are in a relatively small area. It is best to install power factor correction capacitors at the motor terminals. This reduces the load on the distribution wires to that point. Over-current protection must also be adjusted downward accordingly to prevent motor burnouts.

Large electric motors over 25 hp (19 kW) should have power factor correcting capacitors. The capacitor bank must be sized to suit the specific motor power, speed, and frame size to avoid over voltages and torques. A detailed technical discussion of power factor correction is included in the appendices (see Appendix iv).

Increasing your power factor correction helps you get more out of your electricity.

Example 6.1 - Power factor correction savings

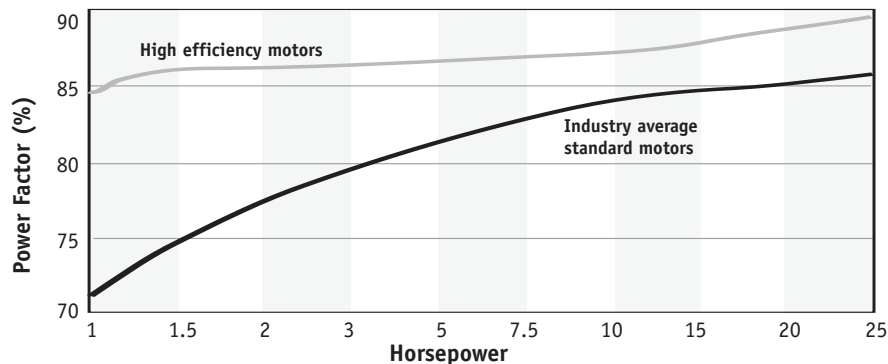
- » Power delivered: 100 kVA
- » Power factor improved from 80 to 95 per cent
- » Reduction in power delivered is: $100 - (100 \times 0.80/0.95) = 16 \text{ kVA}$
- » Savings: 16 kVA at \$10.71/kVA saves \$171/month or \$1,370 (plus applicable tax) in an eight month season.

To achieve the improvement in power factor in this example requires 34 kVAR. (Note: kVAR is kilo volt-amperes reactive). The cost of 34 kVAR of capacitors at the electrical service entrance, including automatic switching, is an estimated \$3,400. As a result, the simple payback is: $(\$3,400)/(\$1,370 \text{ per season}) = 2.5 \text{ seasons}$.

Check your own conditions to determine your requirement and your payback before proceeding. Rinks with shorter seasons have longer paybacks.

Figure 6.10 - Power factor efficiencies

Properly-sized energy efficient and premium efficiency motors help keep your power factor high and reduce demand charges.



Motor selection

Standard efficient motors have efficiencies ranging from 75 to 90 per cent, in sizes from 1 to 25 horsepower. However, these are no longer commercially available under Canada's Energy Efficiency Regulations – 2002. For the same horsepower sizes of one to 25, Energy Efficient (EE) motors have efficiencies from 82.5 to 92.4 per cent and Premium Efficiency (PE) motors have efficiencies from 85 to 93.6 per cent.

What seems like small efficiency increases for the better motors turns into large energy savings. If you have to replace a worn out or failed standard efficient 25 hp motor, choosing a PE motor over an EE motor is about a \$250 premium, but payback times are only a few years and are cost-effective.

Example 6.2 - Premium Efficient motors are cost-effective

If your old standard efficient 25 hp motor fails, upgrading to a Premium Efficient motor instead of an Energy Efficient motor is cost-effective with a payback period of less than three years. Assuming the motor operates the same 3,000 hours annually at an electrical rate of \$0.01539/kWh, the savings and payback period for upgrading to the PE motor are:

- » Demand savings (kW) = $(25\text{hp} \times 0.746) \times (0.88 \text{ load factor}) \times (1/0.90 - 1/0.936) = 0.70 \text{ kW}$
- » Consumption savings (kWh) = $(0.70 \text{ kW}) \times (3,000 \text{ hours}) = 2,100 \text{ kWh}$
- » Cost savings (\$) = $(2,100 \text{ kWh}) \times (\$0.05139/\text{kWh}) = \$107.92$
- » Payback period for upgrading = $(\$250 / \$107.92) = 2.3 \text{ years}$

The economics of replacing a **WORKING** standard efficient motor with an EE or PE version are poor. This is because a rink or arena's annual operating hours for the motor is small and the cost of the EE or PE motor makes payback periods long. Consider replacing working standard efficient motors when operating hours are greater than 3,500 hours annually or when a standard efficient motor fails.

Demand limiting

Consider demand limiting if your facility has large non-refrigeration electric loads, such as electric cooking equipment, electric heating systems, or large air conditioning units (in year-round facilities). When demand is peaking, control equipment shuts off or turns on these electric loads to reduce the peak demand for power.

Demand limiting equipment requires installation of meters and other devices to sense when new peak demand is approaching. Systems can simply warn operators, or they can use computers to automatically switch loads on and off to maintain set demand limits.

From the viewpoint of demand limiting, it is a good idea to install two smaller independent refrigeration plants in new or replacement construction. One is sized to handle average loads and the other is sized 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.

The cost of energy management systems can vary from a few hundred dollars for time clocks, to several thousand dollars for more sophisticated computerized systems. Contact your electrical contractor, electrical engineering consultant, controls contractor, or electric equipment supplier for more detailed information about demand limiting costs and opportunities for your specific application.

Low emissivity ceilings

Twenty eight per cent of the total refrigeration load on a refrigeration system in heated rinks is radiated heat from the arena ceiling. Savings of up to 80 per cent of this load are possible with the installation of low emissivity ceiling systems. Natural radiation of heat from the ceiling is controlled by placing a highly reflective paint or curtain at the ceiling. The cold surface of the ice no longer sees the relatively warm roof, but instead sees its own reflection.

Reflective paints can be applied to the underside of the roof deck. The paint is an aluminum based, silver coloured paint. The cost of applying the paint is highly variable, depending upon the type of surfaces you have, the heights at which painters will be working and whether local volunteer labour is being used. You will need to determine the life of the paint job, total costs, and the actual savings available.

The foil backing of insulation in metal building construction is a relatively good low emissivity ceiling material. In such installations, only the structural supports would require additional treatment. Even that may prove impractical when the cost/benefit analysis is examined, as discussed in Section 3.

An alternative is to install low emissivity ceiling curtains suspended on wires, an approach developed for rinks and arenas. Their characteristics, installation costs, and performance are documented. Ceiling curtains also improve illumination and reduce ceiling condensation.

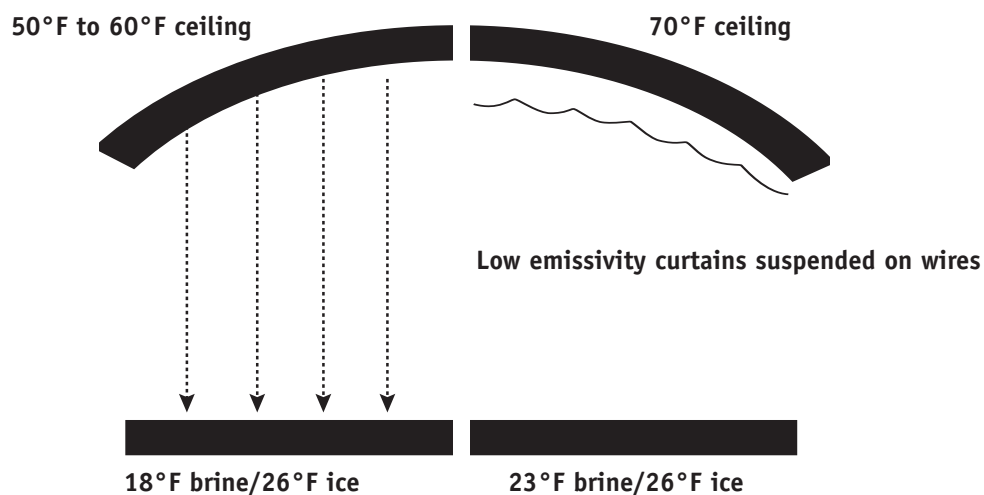


Figure 6.11 - Effect of installing a ceiling curtain

Section summary

This section looked at refrigeration and several ways of saving energy in rinks and arenas. Your budget and your expenses will dictate what you can or cannot afford. Categorize the saving measures by initial cost according to operating cost, low-cost and high-cost measures.

Example 6.3 - Cumulative energy savings

Note that energy savings are not additive but are multiples of each other. For example, a measure that yields 15 per cent savings combined with a measure that yields 10 per cent savings does not produce 25 per cent savings, but 23.5 per cent savings ($0.85 \times 0.90 = 0.765$ or 23.5 per cent of the original).

In short, certain low-cost energy efficiency measures produce big savings that pay back quickly. Subsequent high-cost energy efficiency measures usually apply to a system that has lower operating costs, making it harder to realize big payoffs.

Operational guidelines

- » Keep the ice thin, ideally 1 in. (25 mm) thick
- » Reduce flood water temperatures to 130°F (54 C) minimum
- » Set back spectator area heating when unoccupied
- » Dump snow outside of the building, if allowed
- » Allow ice temperatures to rise overnight to 28°F (-2 C) maximum
- » Match lighting levels to facility use
- » Paint ice with reflective, thermally conductive paints
- » Maintain brine at a specific gravity of between 1.20 to 1.22
- » Review your ventilation practices
- » Clean the rink floor slab thoroughly before installing ice

Section summary (con't)**Low cost measures**

- » Caulk and weather strip the building shell
- » Perform basic maintenance on all systems
- » Install timers on ventilation equipment
- » Install timers on lighting
- » Install locking thermostat covers to prevent tampering
- » Install low flow shower heads to reduce domestic hot water consumption
- » Modify ventilation equipment to minimize waste and maximize savings
- » Insulate hot and cold water piping, especially in cold areas
- » Alternate water supply
- » Install power factor correction capacitors

High cost measures - install the following:

- » Brine pump cycling or 2-speed pumping systems
- » Variable brine temperature controller
- » Variable speed pump controller
- » Dehumidification system
- » Computerized total management systems
- » Flood water heat recovery equipment
- » Domestic hot water heat recovery equipment
- » Heating system heat recovery equipment
- » High efficiency motors
- » Demand limiting systems
- » Low emissivity ceiling system (if you heat your rink for a long season)
- » Reverse osmosis flood water purification system

Optimum lighting sources

Good quality and effective lighting systems are necessary to create a pleasant functional indoor and outdoor environment. This section outlines some of the design concepts for achieving the most effective use of electricity for lighting in rinks and arenas.

Lighting must be considered as a system: an efficient lamp (bulb) must also be used with an efficient luminaire (light fixture). It is also important that the luminaire perform effectively for the intended environment. Lighting must be reasonably uniform for specific applications, with low glare properties. Good colour rendering may be necessary, so lamp selection is critical.

Lamp output is measured in lumens. For example, a 23 watt compact fluorescent lamp (CFL) delivers about 1,450 lumens of light. For efficiency comparison, lighting system efficiencies, in terms of lumens per input wattage (including ballast losses) are outlined in the following table. In general, as lamp wattage increases, so does lamp and system efficiency. Please note that reducing lighting energy consumption in locations where heat from the lighting helps warm an area will increase your annual heating costs.

Table 7.1 – Optimum lighting sources for indoor recreational facilities

Source	Lamp wattage (nominal)	System wattage	Initial lamp lumens	Rated lamp life (hours)	System efficiency (initial lumens/watt)
Self-ballasted compact fluorescent lamps					
Spiral screw base CFL	14	14	800	6,000	57.1
Spiral screw base CFL	20	20	1,200	6,000	60
Spiral screw base CFL	23	23	1,450	6,000	63
Spiral screw base CFL	42	42	3,200	6,000	76.1
Pin-based compact fluorescent lamps					
Compact Fluorescent	13	17	900	10,000	69
Compact Fluorescent	26	32	1,800	10,000	69
Compact Fluorescent	36	48	3,000	10,000	83
Tubular Fluorescent Lamps					
T-8 Fluorescent (48")	32	59	2,950	24,000	92.1
T-8 Fluorescent (48")	28	42	2,725	24,000	97.3
T-8 Super Saver (48")	25	39	2,475	24,000	99
T-8 Fluorescent (96")	59	115	5,800	15,000	90

Table 7.1 – Optimum lighting sources for indoor recreational facilities (con't)

Source	Lamp wattage (nominal)	System wattage	Initial lamp lumens	Rated lamp life (hours)	System efficiency (initial lumens/watt)
High Intensity Discharge Lamps					
Metal Halide (standard)	175	220	13,000	7,000	59
Metal Halide (standard)	250	300	20,000	10,000	67
Metal Halide (standard)	400	470	36,000	15,000-20,000	76
Metal Halide (Pulse start)	175	208	17,000	15,000	81
Metal Halide (Pulse start)	250	288	23,000	15,000	80
Metal Halide (Pulse start)	320	365	34,000	20,000	93
Metal Halide (Pulse start)	400	456	44,000	20,000	96
Incandescent Lamps (for comparison only)					
Incandescent	60	60	855	1,000	14.3
Incandescent	100	100	1,650	1,000	16.5
Incandescent	150	150	2,780	1,000	18.5
Incandescent	200	200	3,400	1,000	17.0
Incandescent	300	300	5,720	1,000	19.1
Incandescent	500	500	10,750	1,000	21.5
Parabolic Aluminum Reflector Lamps (for comparison only)					
PAR 38	65	65	765	2,000	11.8
PAR 38	75	75	1,040	2,000	13.9
PAR 38	150	150	1,740	2,000	11.6
PAR 38 (Halogen)	90	90	1,740	2,000	19.3

Notes to table 7.1:

- » PAR 38 are parabolic aluminized lamps used in spotlight and floodlight reflectors. Halogen PAR lamps provide 40 per cent energy savings over standard PAR 38 lamps which outweigh the lamp price difference in less than a year.
- » Fluorescent systems are based on electronic instant start (IS) 2-lamp ballasts suitable for cool environments 14°F to 0°F (-10 C to -18 C).
- » T5 and T5 HO (high output) fluorescent lamps are nominal length lamps, which means that they cannot be retrofit into fixtures using standard T-12 or T-8 lamps. Therefore, they are generally used for re-design or new construction projects.
- » Compact fluorescent systems are of two general types of lamps. One is the self-ballasted or screw based lamps, for direct replacement of incandescent lamp; the other is the pin-based lamps for compact fluorescent lamp and ballast systems. Look for the Energy Star® label when purchasing CFLs and also check the minimum cold starting temperature on the label.

Cold temperature CFLs can be successfully operated below their minimum temperature; however, the operating life may be reduced.

- » Metal halide lamp life is based on 10 hours per start. If operating 24 hours per day, the lamp should be turned off for at least 15 minutes once a week to prevent rupturing of the arc tube and damage to the luminaire unit.
- » New Pulse start metal halide systems are about 20 per cent more efficient than the older, probe start or standard metal halide systems.
- » Although listed for comparison purposes, incandescent lamps and PAR 38 lamps are not generally recommended and should be used in non-critical areas where lights are controlled by standard magnetic occupancy sensors or dimmers.

Common lighting sources

Inefficient lighting sources that are common in recreational facilities include some of the following:

T-12 Fluorescent

Under the recent *Energy Efficiency Act*, only low wattage versions of the T-12 lamp are readily available. For example, only the 4-foot 34 watt version T-12 is available to replace the old and very popular T-12, 40 watt lamp.

The lower wattage T-12 lamp has a 12 per cent reduction in light output with an additional 4 to 8 per cent light reduction because of the low ballast factor. Also, the 34 watt T-12 is temperature sensitive below 60°F (15 C).

Conversion to T-8 lamps is recommended, with the 32 watt lamp typically 15 to 20 per cent more efficient than the 40 watt T-12s, along with better colour rendition. High colour rendering index (CRI), 40 watt T-12 lamps were available, but at a higher cost.

Some high output (HO) and slimline lamps (mainly 8-foot length) were popular because of good low-temperature performance. However, the reduced wattage HO and slimline lamps, such as the 8-foot 90 watt (HO) and 60 watt slimline lamps replacing the old 105 watt HO and 75 watt slimline lamps, have traditionally been harder to start at cooler temperatures and therefore did not perform as well as their full wattage counterparts.

Standard 8-foot slimline and 4-foot standard lamps were also used with heat-retention jackets. Switching to T-8 fluorescent is recommended, but allowance must be made for light output reduction at cooler temperatures. The use of suitable lamp jackets is very effective. It may be more practical to simply use totally enclosed luminaires, which provide much better protection for lamps.

Mercury Vapour (MV)

Use of MV lamps should be discouraged. They are no longer specified for new construction or retrofits due to poor efficacy (lumens per watt). They are no more efficient than fluorescent lamps for indoor applications. In outdoor applications, MV lamps should be replaced with one of the other gas discharge lamps, such as metal halide, high pressure sodium or low pressure sodium lamps.

The MV lamps are the least efficient of all the high intensity discharge (HID) lamps with efficacy ranging from 10 to 63 lumens per watt. Efficiency is low and is typically lower than T-12 fluorescents. Metal halide lamps are 40 to 50 per cent more efficient than MV lamps.

The disposals of MV lamps require special methods because of the mercury inside the lamp. Local disposal authorities should be contacted for approved disposal methods.

Lighting levels

Light level, or more correctly, Illuminance Level, is typically measured by a light meter (photometer) in either foot-candles (fc) or lux (lx) units. Illuminance is the light energy striking a surface. By definition, a foot-candle is the intensity of one lumen falling on one square foot of surface. The metric equivalent lux is the intensity of one lumen falling on one square meter. Light levels are normally measured on a horizontal plane, 2.5 to 3 feet above floor level or right at ice surfaces. The photometer responds only to the visual component of the light energy radiated by the luminaire.

The conversion factors are:

- » 1 fc = 10.76 lux
- » 1 lux = 0.093 fc

However, a common conversion is 10 lux to 1 foot-candle.

Table 7.2 - Typical lighting levels

Location	Foot-Candles	Lux
Auditorium, Public Spaces	10-20	100-200
Bathrooms	10-20	100-200
Curling (Bonspiel)		
Tees	50	500
Rink	30	300
Curling (Recreation)		
Tees	20	200
Rink	10	100
Hockey (Professional, Television)	150	1,500
Hockey (Pros, University, Competitive)	100	1,000
Hockey (Amateur)	50	500
Hockey (Recreational)	25-30	250-300
Offices	50-75	500-750
Cafeteria	5-10	50-100
Kitchens	50-100	500-1,000
Meeting Rooms, Administrative	30-50	300-500
Stairs	10	100
Main Entry (Exterior)	5	50
Parking Areas (Open)	0.2	2

Since lighting can easily account for about one-third of the total electricity consumed, it is important that all systems be efficient. For example, lighting of ice surfaces can be accomplished using efficient wide-beam luminaires, but it is very important that wall and ceiling reflectance be fairly high – at least 50 per cent reflectance. Light will diffuse well with good uniformity over the target area. The loss of one lamp should not result in a harsh dark spot and harsh shadows should not result from the players or participants.

A typical hockey rink of 15,000 square feet can be easily lit using metal halide lamps with good grade luminaires to 25 to 30 fc for recreational hockey, at a power density of one watt per square foot. Reflectance should be relatively large for low glare and efficiency. For safety, use totally enclosed luminaires.

Table 7.3 - Lighting options MH vs. HPS (Rink 85' x 155')

Option	Metal Halide (Pulse Start)	High Pressure Sodium
Minimum mounting height	20 ft. 0 in. (6.1m)	20 ft. 0 in. (6.1m)
No. of 400 watt lamps required for a skating rink	32	24
System wattage per lamp	456W	465W
Light level required in foot candles (and lux)	45 (485)	45 (485)
Lumens per lamp	30,000	44,000
Lumens per watt	75	96
Lamp life (hours)	20,000	24,000
Light loss over life of lamp	30%	15%
Warm-up time (minutes)	1-4	3-4
Re-start time (minutes)	2-8	0-1
Colour of light	clear white	golden
Consumption of power by above in kilowatts	14.59	11.16
Power density	1.11W/sq. ft.	0.85W/sq. ft.
Hours per month	480	480
Cost/month at 5.139¢ /kWh on (runoff rate) hours/month	\$359.88	\$275.24
Cost/month at \$10.71/kVA on installed kW	<u>\$149.94</u>	<u>\$117.81</u>
Total cost per month plus applicable taxes	\$509.82	\$393.05

Lighting systems

Incandescent

Because of its relatively poor efficiency, this source is quickly being displaced by other lighting sources. It is still used in areas where lights are to be switched often, dimmed for variable output or in very cold temperature applications; however lighting manufacturers are continuously improving CFL technology as replacements for these incandescent applications.

The life of an incandescent lamp is generally about 1,000 hours, with extended service versions of about 2,500 hours. Another category, called long life, can reach operating hours of 5,000 to 10,000 hours. Colour rendition is very good.

A close relative of this source is the quartz tungsten halogen lamp, which is basically an incandescent filament in an envelope containing special gases. Efficiencies of about 18 to 23 lumens per watt with life ratings of 2,000 hours can be achieved.

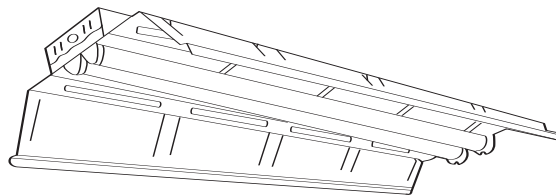
Loss of lumen output at the end of life is normally less than 10 per cent of the initial values. Loss of lumen output in cold weather is less than 5 per cent.

T-8 Fluorescent

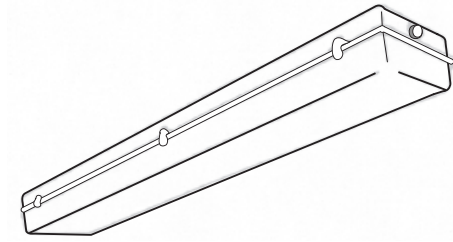
This source is extremely popular because of its efficiency, relatively good colour rendition and very good life (20,000 - 30,000 hours) and because it can replace a T-12 without changing the fixture. The F32 T-8 lamp (nominal 32 watts) is becoming the industry standard.

The lamp requires a ballast for operation because it is an arc discharge lamp. Standard ballasts are designed for reliable operation down to 50°F (10 C), with low temperature versions available down to 0°F (-18 C). Depending on actual luminaire construction, fluorescent lighting still remains a very economical lighting source. Sometimes lamp jackets or sleeves are used over the lamps to maximize light output at cool temperatures.

Figure 7.1 – Open style fluorescent luminaire



A typical open style fluorescent luminaire. Four foot tubes, usually T-12 which are 1.5 inches in diameter, are normally installed. They can be replaced with T-8s. T-5s require luminaire modifications.

Figure 7.2 – Enclosed fluorescent luminaire

This enclosed luminaire is dust and moisture-tight and made of non-corrosive material for long life in rinks and arenas.

There is no problem with fluorescent lights during momentary power dips (such as during the starting of large motors) as arc re-strike is virtually instantaneous. Lamp output is highly dependent on temperature. Output is maximum (100 per cent) at the optimal temperature of 77°F (25 C) and decreases to about 70 per cent at 30°F (-1 C). Loss of lumen output at end of life is normally about 20 per cent of the initial values.

Metal halide (standard technology or probe-start)

This source is effectively the same lamp type as mercury vapour, except that metallic salts (scandium and sodium) have been added for extra efficiencies. It requires a somewhat different ballast from a mercury vapour lamp because of higher starting voltages; however as an energy conservation retrofit, some MH lamps are designed as direct replacements for MV lamps and use the existing MV luminaires and ballasts.

Figure 7.3 – Metal halide lights in a rink

Note the low emissivity ceiling and the colour rendering of the metal halide lights in this rink.



A mercury lamp operates well on a metal halide ballast, but a metal halide lamp does not operate on a mercury ballast. Warm-up and re-strike times for metal halide lamps are slightly less than mercury. Because of its good efficiency as well as very good colour rendition, metal halide is a very popular source.

A lumen loss of about 30 per cent can be expected at the end of life. Some metal halide lamps have tended to explode at the end of their life, particularly if they were used continuously and never shut off. Rated life is about 10,000 to 20,000 hours. There is very little lumen loss at lower temperatures [30°F (-1 C)] compared to fluorescent lamps.

Metal halide lamps perform best in the Base-Up or Base-Down operating position. There is roughly a 15 per cent light loss in the horizontal (up to plus or minus 30°) position. Always select a luminaire with Base-Up burning for efficiency and ease of maintenance.

For ice rink applications, always specify -22°F (-30 C) operation, as ballasts with slightly higher open circuit voltage can be provided for starting reliability.

Metal halide (pulse-start)

The new technology of pulse-start metal halide (MH) lamps should be considered primarily due to increased lamp efficiency of about 20 per cent over standard metal halide. In some cases lamp life is also longer.

Pulse start is now available in a broader range of wattages – between 40 and 1,500 watts – however most arena or rink applications would use lamps in the 175 watt to 400 watt range. The pulse start MH lamp uses a starter to ignite the lamp, rather than relying on the ballast open circuit voltage. As a result, pulse start has better cold temperature starting reliabilities than the standard (probe-start) MH lamps. With the pulse start technology, warm-up and restart-time is faster, at one to four minutes and two to eight minutes respectfully.

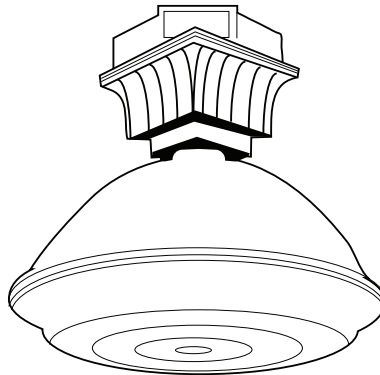
Due to the popularity of pulse start systems, both luminaire and lamp pricing is being reduced. As a good rule, the total luminaire cost of a standard versus a pulse-start MH system is about equal, even though about 20 per cent fewer pulse-start luminaires are required. Installation costs are lower and more important, less energy is required for the future life of the system.

Metal halide lamp safety

Luminaires with MH lamps should be fully enclosed and made of suitable material, such as tempered glass. Because the lamps operate under high pressure and very high temperatures, there is a possibility that the arc tube may rupture. When this happens, the outer bulb surrounding the arc tube may break, and particles of extremely hot quartz (from the arc tube) and glass fragments (from the outer bulb) create a risk of personal injury or fire.

For all MH lamp types, it is very important that failed lamps be changed out quickly to avoid progressive damage to the ballast. If you require a MH lamp to operate continuously, turn off the lamp for a minimum of 15 minutes per week to avoid rupturing of the arc tube.

Figure 7.4 – Enclosed metal halide luminaire



High Pressure Sodium (HPS)

The HPS lamp has gained popularity in both indoor and outdoor applications because of its efficiency, low cost and excellent lumen maintenance.

Figure 7.5 – Outdoor HPS luminaire – good vs. bad



Full cut-off HPS luminaire cuts off light below the horizontal, eliminates glare, light trespass and reduces light pollution. Full cut-off luminaires like this wall pack are dark-sky compliant.



This unshielded HPS wall pack luminaire is a very poor design by producing unsightly glare, increased light trespass and sky-glow light pollution

The average rated life of HPS lamps is about 24,000 hours. A loss of about 20 per cent of initial lumen output can be expected at the end of its life. The colour of light is golden-white or light amber and is accepted in all applications where colour rendition is not critical. Newer varieties of HPS lamps have better colour rendering properties but at the expense of lamp life and luminous efficiency.

A good variety of lamp wattages are available (35, 70, 100, 150, 250, 400, and 1,000 watt) as well as luminaire types by many manufacturers. Common applications for clear lamps are roadway lighting, floodlighting and area lighting. Coated HPS lamps are also used in area and floodlighting, as well as commercial indoor lighting and parking lots.

Ballasting for HPS sources is more critical than for mercury or metal halide lamps, as the ballast must have greater regulating properties as well as an electronic starting circuit to start the lamp. Ballasts must be integrally mounted with the lamp because of the high lamp ignition voltages required. The ballast provides a high-voltage pulse (2,500V) for one microsecond for lamp start. This high-voltage spike establishes the xenon arc between the main electrodes. The amalgam mercury and sodium in the tube then vaporize rapidly and maintain the arc.

Warm-up time is three to four minutes while re-strike time is about one minute – the shortest re-strike time of all high intensity discharge (HID) sources. Because HPS lamp output is relatively position insensitive, lamps can be operated in any position. HPS has excellent cold temperature operation and quicker warm-up and re-strike times, compared with mercury and metal halide.

HPS does not exhibit arc tube rupturing at end of life. A totally enclosed luminaire is still recommended, particularly for hockey rinks. Although lamp life is normally 24,000 hours, a dual-arc HPS is also available, with the advantage of instantaneous re-strike during a power dip or very short term outage, as the second arc re-strikes immediately while the first arc cools down. As a result, lamp life over these twin arcs is in the range of 30,000-40,000 hours.

As with metal halide, a burned-out lamp should be changed quickly as the ballast will gradually suffer damage. It is very advantageous (if possible) to match exterior as well as interior lamp wattages. Two very popular lamps are the 250 watt and the 400 watt.

Low Pressure Sodium

Low pressure sodium (LPS) lamps are closely related to the fluorescent lamp, since they have a low-pressure, low intensity discharge source and a linear lamp shape. The lamp consists of an arc tube enclosed in a clear tubular outer bulb. The arc tube is enclosed in a vacuum created inside the outer bulb.

The colour of the light is a monochromatic yellow. It can be used in applications where colour rendition is not critical; other colours may look either yellow or muddy brown. The CRI value does not apply to the LPS lamp, as the colour is equivalent to an index value of zero. A large variety of wattages are available, from 18 to 180 watts.

This source has the highest efficiency of all sources, ranging from 100 – 180+ lumens

per watt. Ballasts are required to operate this source. Typical start-up times are about 12 minutes; re-striking of the lamp occurs in less than a minute after interruption.

This lamp type starts and performs well at temperatures below 30°F (-1 C). Rated life is 18,000 hours. Wattage increases 7 per cent, and lumen output 5 per cent, by the end of lamp life.

The LPS lamp is generally not used in new construction, but it may be found in existing sites. This source is very good for exterior applications but has suffered market loss to HPS and MH lamps, primarily due to system cost. Some applications include roadway lighting, security and warehouse lighting.

Lighting ballasts

A ballast is a device used with a gas discharge lamp, such as a fluorescent or HID, to provide the necessary starting and operating electrical conditions. The ballast supplies the right voltage to start and operate the lamp.

Fluorescent Lamp Ballasts. The basic types of ballasts, based on ballast construction and efficiency, are the energy efficient ballasts, electronic ballasts, and the standard electro-magnetic ballast. Ballasts are also classified by the type and function of their electric circuit. Note that electro-magnetic fluorescent ballasts are gradually being removed from the market place by energy regulations.

Each ballast is designed to be used with a specific type and size (wattage) of lamp. The lamp type and size compatible with the ballast are listed on the ballast label.

A ballast, as an electric circuit, has electric energy losses. Ballast losses are obtained from catalogues of ballast manufacturers. Energy efficient ballasts have lower energy losses.

The average rated life of ballasts for most ballasted light sources is 15 years, and up to 20 years for premium quality ballasts. Most ballasts are designed for about 50,000 hours under standard conditions. The life of a ballast can be dramatically shortened if it is subjected to high temperatures for extended periods. If the ballast and lamp heat is not dissipated properly, ballast life is reduced. A 15-18°F (8-10 C) increase over rated temperature on the case will cut ballast life in half. Similarly, an 18°F (10 C) decrease will approximately double ballast life.

Types of fluorescent lamp ballasts

- » A rapid start ballast starts one or more gas discharge lamps by first heating the electrodes of the lamps to the proper electron emission temperature before initiating the arc.
- » An instant start ballast does not preheat the electrodes but initiates the arc by a higher starting voltage.
- » A modified start ballast starts the lamp in the same way as the rapid start ballast. It then reduces or cuts off the electrode heating voltage after the lamp arc has stabilized.
- » Older technology (i.e., electro-magnetic) ballasts are made of laminated cores wound with copper or aluminum wires; some have capacitors to control voltage and/or to correct power factor. Electromagnetic ballasts operate the lamps at line frequency, 60 Hz.

Electronic ballasts for fluorescent lamps have electronic or solid-state components and operate the lamps at a high current frequency, typically from 25-50 kHz.

Operation of rapid start lamps by instant start or modified start ballasts can potentially shorten lamp life if combined with other control technologies such as occupancy sensors.

In comparison with the electromagnetic ballast, the electronic ballast weighs less, operates at lower temperatures and noise levels, and is more energy efficient – but costs more.

It is essential to match the electrical characteristics of both lamps and ballasts.

Fluorescent luminaires should always be tightly surface mounted to ceilings to improve heat transfer. Suspending luminaires from ceilings results in low ballast temperatures. However, T-8 electronic ballasts have very low losses and are not as temperature critical as the old electro-magnetic versions.

HID Lamp Ballasts. Like fluorescent lamps, HID lamps are electric discharge lamps. A ballast is required to provide proper starting and operating voltage and current in order to initiate and sustain the arc. For HID ballasts, it is advisable to leave a minimum 6 in. (150 mm) space between the top of the ballast housing and the ceiling.

Probe Start Ballasts. The standard core and coil HID ballast or probe start ballast consists of a series of electrical coils on a core of steel laminations. The coils are impregnated with a varnish to provide electrical insulation, reduce noise and dissipate heat. Some ballasts for interior use are housed in metal cans and potted with insulating materials.

Pulse Start Ballasts. Pulse start HID Ballasts incorporate a different starting technique which reduces ballast losses and increases lamp performance. Pulse start ballast retrofits can be a good measure for existing metal halide installations. A 320 watt metal halide pulse start system can replace a 400 watt probe start system. The pulse start lamp gives less lamp lumen depreciation, better colour consistency over lamp life, and faster hot restrike.

Electronic HID Ballasts. Designed primarily for the low wattage Ceramic Metal Halide lamps, the electronic HID ballasts are gradually expanding to higher lamp wattages.

Electronic HID Ballast Advantages:

- » Significantly smaller size and lower weight than core and coil systems
- » More efficient, up to 20 per cent savings over conventional ballasts
- » Square wave output increases lamp life
- » Automatic end-of-life detection; shuts lamp down instead of trying to restart

Light emitting diode (LED) lighting

An LED is an electro-chemical light source. When the diode is forward-biased, light is generated. The light is monochromatic; the colour is dependent on the materials used. White light can be produced by using phosphors similar to those used in fluorescent and coated HID lamps.

Light emitting diodes are becoming more common in commercial and residential lighting. You may notice them at traffic intersection control lights, where they appear brighter, with a bullet type lighting pattern, versus the older incandescent lamp and colored reflector. They are common on large trucks and trailers and emergency vehicles because they are extremely durable and produce a much more intense light. Holiday season decorative lighting is another popular application.

Application for arenas and rinks would include the score board, door exit signs, exterior and interior signs and floodlighting. LED systems last up to 100,000 hours, based on the fact that when the light output has depreciated to less than 50 per cent of initial output, then the light source has effectively expired. Life of LED systems is dependent on a number of factors including the colour; red and green LEDs last significantly longer than blue and white LEDs. The efficacy of LED sources is improving continuously, currently about 30 lumens/watt is typical compared to incandescent lighting with a life of 1,000 hours and 20 lumens/watt.

LED Advantages:

- » Low power consumption and low heat generation
- » Extremely long life
- » Negligible early failures
- » High colour efficiency, because they are monochromatic
- » Very small
- » Resistant to damage from shock and vibration
- » No infrared or ultra-violet energy is emitted

Architects and lighting designers are using LED lighting indoors and outdoors to highlight specific objects and create appealing light effects. The use and applications of this light source will continue to increase now and into the future.

Lighting applications

Converting your fixtures

Converting old incandescent fixtures to either MH or HPS is not recommended because the insulation on socket wiring at the fixture is very likely brittle and poor. Other reasons include the following:

- » HPS requires a new pulse rated socket
- » Adapting the incandescent reflector to ballast housing can be difficult
- » Positioning the new lamp in an incandescent reflector requires extensive trial and error
- » The overall conversion requires the scrutiny of approving authorities before use

In contrast, converting T-12 fluorescent luminaires to T-8 technology is much easier. In the case of bi-pin lamp sockets, only a ballast and lamp change are required.

Simple open-lamp fluorescent luminaires should not be used in the rink area without a solid (non-slotted) reflector. This type of reflector greatly increases performance and forms a thermal cavity for the fluorescent lamp to increase lamp ambient temperature over ice surfaces. The reflector also protects the lamps from overhead moisture dripping on the fixture.

There is still the additional option of adding sleeves or jackets on fluorescent lamps for operating temperatures well below freezing 14°F to -4°F (-10 C to -18 C). Keep temperature stratification in mind. If the ice surface is kept at about 23°F (-5 C), the temperature about 15 feet above surface at the luminaire could sit at the freezing point.

For curling rinks, use either reflected units or wrap-around (lens) fluorescent units. For hockey rinks, MH and HPS (or a combination) are more practical because polycarbonate lens luminaires can be used, with the additional option of wire guards. The addition of wire guards is a significant add-on for fluorescents because of the relatively large luminaire area.

Indoor low wattage incandescent lamps (40, 60 and 100 watt) are easily changed out with low temperature operating CFLs. They can also be converted to a pin-based compact fluorescents using new surface-mounted or recessed luminaires. Where possible, it is more economical to use the linear 4-foot lamp (T-8), even if a single lamp luminaire must be used. A single lamp 4-foot T-8 unit can easily displace a 100 watt incandescent lamp.

Converting from incandescent to HID sources should utilize a luminaire with metal reflectors, which are integrally ballasted for economic reasons. The economics of 250 watt and 400 watt versions should be considered. Using an efficient low bay style luminaire, it is possible to displace 400 watt mercury with 250 watt standard MH with a very small reduction in light. But pulse start 250 watt MH would easily match a 400 watt mercury vapour. Depending on luminaire type, 400 watt MH (standard or pulse) is a very economical option. Colour rendering properties of MH are very good.

The use of high-pressure sodium lamps should be given serious consideration because of the strong market trend to this source. However, colour rendering may not be adequate for television cameras and a strobe effect could be created. It is very important that an

entire area, either curling and/or arena, be converted to this source; otherwise there may be a very strong colour contrast with the remaining sources. Depending on the details, it may be possible to mix in some metal halide or possibly fluorescents.

Historically, many curling rinks and arenas were designed with a majority of mercury lighting luminaires. Some incandescent lighting was mixed in to provide critical lighting in the event of momentary power dips which would cause mercury lighting to extinguish for about 15-20 minutes. The removal of such incandescent lighting (if not used for normal lighting) and the installation of emergency battery packs would yield substantial savings. The additional feature of having emergency lighting in the event of a short power outage is a very important benefit, particularly in skating or hockey arenas.

Where lighting is being converted to another source, it is very important to avoid a significant reduction in the number of lighting luminaires. Glare and lighting system uniformity must be carefully considered. In general, lamp efficiency increases with lamp wattage, but there are some very practical limits. For metal halide, the limit is about 400 watts; 1,000 watt MH could be used at about 24-foot mounting heights. However, attempting to achieve a lighting level of about 30 foot candles with 1,000 watt MH will result in very wide luminaire spacings, and therefore harsh shadows, particularly if one lamp is burned out.

Daylighting

If used properly, daylight can provide the bulk of the illumination required. Desks or work areas should be situated such that light comes from the side. This minimizes glare, veils reflections on the task and eliminates the problem of people working in their own shadow. The benefits of natural daylight should be balanced against security concerns and the cost of cooling heat generated by the sunlight.

Visibility

The problem of visibility in arena lighting is complex. The playing surface must be well lit for the players, spectators, and television cameras (if applicable). The problem is that these three functions conflict with one another.

Overhead lighting provides good illumination for the players but it is a harsh light and obscures facial and body detail for spectators and television cameras. Low angle lighting improves spectator viewing but can produce shadows and glare for the players. Limited ceiling height can add extra problems or limitations.

To avoid problems with lighting and glare, we suggest that you ask a professional lighting designer to review your ideas and make recommendations. Lighting consultants, electrical contractors, and lighting suppliers can help.

Painting the ice a reflective white helps to diffuse lighting on the playing surface and increase the lighting effect in the arena. Painting of walls and ceilings is equally important.

Lighting energy efficiency

There are two basics for energy efficiency in lighting: increase efficiency where possible, and if you don't need it, shut it off.

Achieving lighting energy savings is considered one of the fundamental energy efficiency measures with numerous opportunities and supporting benefits. Choices include:

- » replacing incandescent with compact fluorescent, linear fluorescent or HID lamp types
- » redesigning older linear fluorescent lamp configurations to meet present applications, such as upgrading lamps and luminaires with better lighting technology

Lighting projects executed properly and comprehensively can be easily justified for a number of reasons including:

- » energy savings; often a 25 per cent internal rate of return or better
- » emission reductions, direct correlation between energy and emission reduction
- » maintenance cost savings from replacing inefficient systems
- » increasing light levels for tenant comfort or improved safety considerations
- » improved Colour Rendering Index (CRI) to enhance comfort

Improving the efficiency of your lamps must be followed by selecting efficient luminaires as well. It is pointless to put an efficient lamp in an inefficient luminaire or poorly selected luminaire. Also remember that the efficiency of a lamp increases with power rating of the lamp.

Lighting control

Uncontrolled lighting wastes energy and money. The first step in controlling lighting is manual switching by someone responsible for turning lights on or off as required by the schedule for the facility. In typical public facilities, a schedule of events is established and areas to be used are defined.

Be careful not to switch lights off too frequently, otherwise you might reduce lamp life significantly. However, switching a lamp off lessens the operating time. The calendar lamp life is increased and replacement and electricity costs are reduced. Here are some additional considerations:

Switching Incandescent Lamps. Frequent switching only mildly affects incandescent lamp life.

Switching CFLs. The life of a CFL due to frequent switching is very dependent on the quality of the product and its components. Always choose an Energy Star® labeled CFL when installing new lamps or replacing old incandescent lamps.

Switching Linear Fluorescent Lamps. Lamp manufactures use a 3 hour on, 20 minutes off switching cycle to determine the life of a linear fluorescent lamp. The nominal hours of operation listed by the manufacture is based on 50 per cent of a large sample of lamps burning out before the nominal operating hours. For example, consider the calendar life and burning cycle for a single, F32 T-8 rapid start fluorescent tube with a nominal life of

20,000 hours. This lamp operating for an average of 12 hours per day will last about 6 1/2 years, with 28,860 hours of actual burn time. If that same lamp is switched off to operate only six hours per day, it will last just over 11 years, with 24,420 hours of actual burn time.

Switching HID Lamps. Lamp manufactures use a 10 hour burn cycle for rating lamp life of HIDs, much greater than the testing used for linear fluorescents. Frequent switching of HID lamps such as Metal Halide, High Pressure Sodium and Mercury vapour is not recommended and not practical due to the re-strike times for the lamps to come back to their full light output. A better solution may be the use of dimming technology controls for these types of lights.

The re-strike time for MH with pulse start have decreased to two to eight minutes from previous probe start at 8-15 minutes. The pulse start MH lamps are 20 per cent more efficient than the probe start or standard MH systems. However, the pulse start MH should be turned off for a minimum of 15 minutes per week to avoid the potential of the lamp's arc tube rupturing.

A good rule for fluorescent lights at room temperature is to turn the light out if the room will be unoccupied for more than 15 minutes. For MH, HPS, and fluorescents over ice surfaces, consult with manufacturers.

Consider installing motion sensors in rooms to automatically control the switching of lights. Here's an example of their benefits: during figure skating practice only one dressing room may be used and the arena lighting levels can be lower than for hockey. There may be a few spectators but the kitchen areas won't likely be needed. So you can keep lighting levels low in most areas, and off in the unused change rooms and kitchen.

Continuous operating low wattage night lights should be used in stairwells, washroom entrances, and other key locations for safety and security.

The use of time clocks to switch lighting is a very economical way to provide control and conserve energy.

It is difficult to reduce lighting levels without major renovations, including rewiring or adding special equipment to existing facilities. Evaluate your options when new construction or replacement is under consideration.

Planning an automatic lighting control system

Automatic lighting systems must be planned according to area or work performed, time of day, time of week, lighting level requirements, availability of daylighting, manual override needs and safety. Automatic lighting control should be considered for all fluorescent and HID lighting installations. Electrical engineering consultants and lighting designers will be able to help you in the selection and application of automatic lighting control.

Three lighting levels can be designated for different ice surface uses. The lowest level of light is used for figure skating, the next for ice cleaning, and the highest level for hockey. A variable manual setting can also be used to control the light levels between the lower and highest settings.

The control unit is wall mounted and is simple to operate. A photocell sensor is located in the middle of the ceiling. It keeps light levels constant in each setting, compensating for lamp aging, lens and dirt depreciation, and natural daylight. The system requires dimming ballasts.

Additional savings are possible by supplementing an automatic energy control system with timing controls to dim lighting during low-use periods.

About 30 per cent of the arena's electrical consumption for lighting can be saved by using this dimmer system. Savings of this amount could be expected in most lighting applications. The payback on the system, however, depends on the size of the lighting load and operating hours. It would range from 5-10 years.

The other significant factor to consider in reducing lighting levels is that the ice surface absorbs a portion of the energy transmitted in the form of light and heat from lamps and ballasts.

Eventually, all the energy supplied to the lights must be removed by the ice plant. A reduction in energy provided for lighting therefore creates a similar reduction in the run time of your ice-making equipment, nearly doubling the effective savings by reducing lighting levels.

An incandescent lamp has losses in the form of heat conducted away from the filament by the gas, direct radiation absorbed by the bulb and base, and heat which is conducted through the support and leading wires.

Table 7.4 – Heat distribution of incandescent lamps

Percentage of Radiation Beyond Bulb				Percentage of Energy Losses			
Watts	Light	Infrared	Total	Support & Wires	Gas Loss	Bulb & Base Loss	Total
25	8.7	85.3	94.0	1.5	–	4.5	6.0
40	7.4	63.9	71.3	1.6	20.0	7.1	28.7
60	7.5	73.3	80.8	1.2	13.5	4.5	19.2
75	8.4	72.8	81.2	1.2	12.8	4.8	18.8
100	10.0	72.0	82.0	1.3	11.5	5.2	18.0
200	10.2	67.2	77.4	1.7	13.7	7.2	22.6
300	11.1	68.7	79.8	1.8	11.6	6.8	20.2
500	12.0	70.3	82.3	1.8	8.8	7.1	17.7

A typical energy distribution of a 100 watt incandescent lamp is as follows:

» Light	10 per cent
» Radiated heat	72 per cent
» Conducted heat	6.5 per cent
» Convected heat	11.5 per cent

A typical energy distribution of a T-12 40 watt fluorescent lamp is as follows:

» Light	22 per cent (2 per cent directly from 253.7 nm UV which is 60 per cent of input)
» Radiated heat	36 per cent (infrared)
» Conducted heat	13 per cent
» Convected heat	29 per cent

Source: General Electric Co., "Incandescent Lamps", Bulletin TP-110R1, 1980

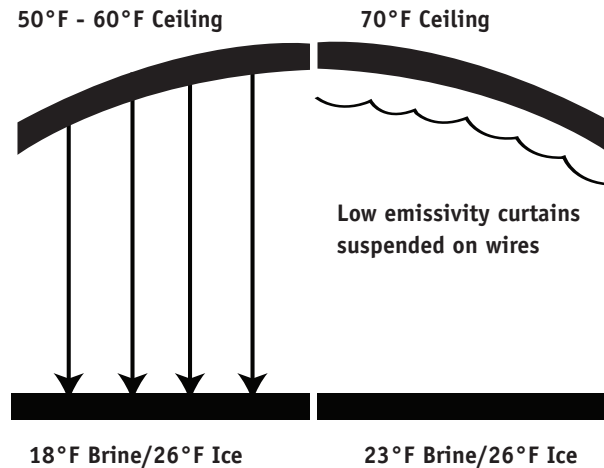
Refer also to Section 6 and Section 8 for discussions on the effects of lighting levels on refrigeration systems, energy consumption, and efficiency.

Another interesting opportunity available to rink owners and operators is to install reflective material on the ceiling. Light from ceiling luminaires is first reflected off the white ice surface, then off the reflective ceiling. It continues to bounce around until it is eventually absorbed. This re-use of light can greatly reduce the number of luminaires required, or reduce the wattage required to provide adequate lighting levels in the rink.

As well as lighting benefits, some low emissivity ceilings can significantly reduce refrigeration energy, eliminate ceiling condensation, and improve arena acoustics.

The use of light coloured paint inside the arena, especially on wood surfaces, provides a similar result. A coat of white enamel paint will provide a highly reflective surface for lighting and can act as a vapour retarder. This may be a more economical solution in some instances.

The foil backing on fiberglass roof insulation is similar in effect to a low emissivity ceiling. It also reflects a high percentage of the light to provide a higher lighting level in prefabricated metal structures. Care must be taken to protect the exposed foil back insulation from pucks that could puncture it.

Figure 7.6 – Improve the arena with a reflective ceiling

Reflective ceilings can reduce the number of luminaires and wattage required, glare, refrigeration energy, and ceiling condensation while improving the arena acoustics.

Light pollution

Light pollution is light that shines where it is not needed or wanted. It is easily recognized as light that: is poorly aimed and too bright for its surroundings; shines off or onto your property; and shines up into the night sky.

What causes light pollution is the use of artificial over-lighting with poorly designed and/or aimed outdoor lighting fixtures. This results in the effects of annoying glare, light trespass onto neighbouring properties and sky glow - the unsightly yellowish-orange uplight glow seen around communities, and rural commercial and industrial sites at night.

Lighting only what is actually needed, when it is needed and to the required minimum lighting levels will help to reduce your electrical costs and help reduce the expanding problem of light pollution.

Consider installing full cut-off (flat lens) luminaires for lighting your outdoor and parking lot areas. Depending on the application, a full cut-off luminaire or shielded fixture may allow you to reduce the lamp wattage resulting in better illumination and lower costs. Shields for existing lights causing light pollution can be easily made or purchased.

Sky glow

Sky glow is the illumination of the night sky caused by natural and artificial factors. The natural components are well quantified such as sunlight reflected off the moon, earth and interplanetary dust, glow in the upper atmosphere from the permanent low-grade aurora and northern lights, and the light from the stars themselves.

Electric lighting is the artificial and human-made source that increases night sky brightness. This is a result of uplight emitted from the sides of a non cut-off luminaires and the reflected light off of building surfaces, pavement, and snow. Uplight is wasted light that goes directly up into the night sky and serves no useful purpose and costs you money on your electric bill.

“Our natural heritage of a view of the starry night sky has become so eroded that an informal survey of schoolchildren in Toronto recently revealed that two-thirds of them have never seen the Milky Way.”

Bob King - July/August
2001 issue of SkyNews,
Reducing Light
Pollution

Figure 7.7 – Satellite image of Canada and U.S.A. at night

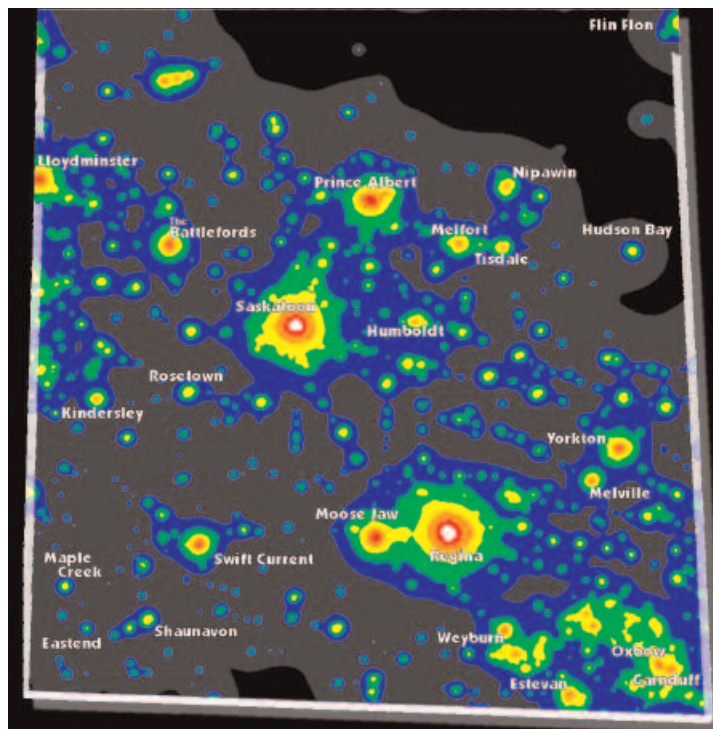
The composite photo depicts the lights from cities and gas flares at night. Source data collected October 1994 - March 1995 from the U.S. Defence Meteorological Satellite Program (DMSP)



Figure 7.8 – Artificial night sky brightness of Saskatchewan

The large urban cities in Saskatchewan are easily identifiable in this satellite image of artificial night sky brightness.

Can you find your community?



Skyglow Map background courtesy of: P. Cinzano, F. Falchi (University of Padova, Italy), C. D. Elvidge (NOAA – National Oceanic and Atmospheric Administration - National Geophysical Data Center, Boulder, CO, USA). Copyright Royal Astronomical Society. Reproduced from the Monthly Notices of the RAS by permission of Blackwell Science. Edited by the Saskatchewan Light Pollution Abatement (SLPA) committee. (www.lightpollution.it/dmsp)

Light trespass

Light trespass is the unwanted and unneeded light being cast from floodlights, parking lot lights, yard lights or streetlights that illuminate a neighbour's property, home or business. Parking lot lighting, for example, should light the parking lot and sidewalks but not shine into second floor bedroom windows or illuminate rooftops.

Also known as spill light, light trespass can be significantly reduced by the use of proper full cut-off luminaires, correct aiming of fixtures (at night) keeping the flat lens parallel with the ground or horizon and shielding of existing fixtures.

Glare

Glare is the disabling or discomforting brightness a person experiences when having to look in the direction of a light source. Most people are familiar with light glare from on-coming traffic at night. However, disability and discomfort glare is also caused by fixed lighting from sources such as parking lot lights, yard lights, streetlights, floodlights, signs, sports field lighting, and decorative and landscape lights.

Disability glare is caused by an intense light source in your field of view resulting in a reduction in visibility. Discomfort glare, caused by an overly bright light source, can cause the sensation of annoyance or pain. Just as a mechanic uses a shielded trouble light to illuminate what he is fixing and protect the light from shining into his eyes, reducing the glare from a light source is an effective way to improve the area lighting and help improve security.

A good outdoor lighting design will minimize glare. Take note of your outdoor lighting, if the light source itself is more apparent than what it is illuminating, then you have bad lighting.

Heat in the building

Electrical equipment and appliances, from lighting systems and office equipment to motors and water heaters, produce useful services. But the electrical energy they use also appears as heat within the building, which can either be useful or detrimental to the building's heating, ventilating and air conditioning systems, depending on the season.

In cold weather, heat produced by the electrical equipment can help reduce the load on the building's heating system. In contrast, during warm weather, this heat adds to the building's air conditioning load.

Energy efficient equipment and appliances consume less energy to produce the same useful work, but they also produce less heat. As a result, efficient equipment increases the load on your heating systems in winter and reduces the load on your air conditioning systems in summer.

The impacts of energy efficient electrical equipment and appliances on the energy use for building heating and air conditioning systems are commonly called interactive effects or cross effects.

When considering the overall net savings of an energy efficient product it is very important to consider the interactive effects of the product on building heating, cooling and refrigeration systems. Weighing the interactive effects will result in better informed decisions and realistic expectations of savings.

The percentage of heat that is useful in your specific 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 or room
- » Whether the room is an interior space (no outside walls or ceiling) or an exterior space (perimeter of the building)
- » The seasons when the building is used
- » Type of heating, ventilation and air conditioning system used in each room

Please note that interactive effects are often quite complex and may require assessment by an experienced mechanical engineer or technologist.

Changing to energy efficient metal halide lighting fixtures in this curling rink saved electricity and reduced the amount of heat generated by the lighting. As a result, the saving gained from installing energy efficient lighting was (in part) offset by the additional heat required for the building.

Figure 8.1 - Curling rink using energy efficient lighting



Indoor lighting

Energy efficient lighting reduces system operating and maintenance costs. In addition, it improves lighting quality and increases lighting levels.

However, lighting systems also contribute to the space heating requirements of recreational facilities, which often operate almost entirely during winter.

Electrical energy is transformed initially by a light fixture into visual and infrared light and two types of heating energy (conducted and convective), which ultimately all becomes heat.

For example, 10 kilowatts of T-12 fluorescent luminaires (light fixtures) operating for 10 hours will transform 100 kWh of energy into:

- » 42 kWh of heat transferred directly from the ballasts and lamps by convection to the surrounding air
- » 36 kWh of infrared radiant energy which is absorbed by objects within view of the light fixtures, to be absorbed as heat, which is then transferred to the air by convection
- » 22 kWh of visible lighting energy which is also absorbed by objects within view of the fixture and then transferred to the air by convection
- » Ultimately all 100 kWh of electrical energy consumed by these light fixtures will appear as heat in the building

If the same amount of light can be produced by retrofitting to T-8 fluorescent luminaires that draw only 6.5 kW, then in 10 hours of operation, the new lighting fixtures will produce only 65 kWh of heat. If the building is heated, then the heaters may have to produce a large portion of the 35 kWh of lost heat to maintain the same level of heating in the building. On a winter's day, when heating is required, the net energy saving will be the cost of the heating source (likely natural gas) needed to replace the heat from the lights.

In this way, the energy you have saved by installing more efficient lighting will be offset by the additional heating required. Currently, natural gas heating for commercial facilities is one-quarter to one-third cheaper than electricity when using the balance rate of \$0.05139/kWh.

The amount of electrical energy that is transformed directly into heat, infrared radiation, and visible light will be different for the various light sources commonly used. However, the result is the same: 100 per cent of the electricity used by the lighting system ultimately becomes heat. If you install energy efficient lighting that reduces the amount of heat during the heating season, much of the loss will have to be made up by the heating system in the building.

If the source of heating energy is less expensive than electrical radiant heating (typically geothermal heat pump or natural gas are cheaper, depending on utility rates and furnace efficiency) the incremental cost difference of the two heat sources will be saved. If it is more expensive (typically oil or propane cost more) the incremental cost difference of the two heat sources will be lost. If it is the same (electricity) you will break even.

When the lighting system operates in the spring and fall and neither heating nor air conditioning is needed, the net energy savings will be the same as the lighting system savings. When the lighting system operates in summer while air conditioning is required, an additional 33 to 40 per cent for air conditioning savings can be added to the lighting energy savings.

Figure 8.2 - Heat from arena luminaires

In a hockey arena, because the lighting is generally mounted above and away from the heaters and their thermostats, it is difficult to predict how much heat from the light is useful in space heating.



In a hockey arena, most of the luminaires are usually mounted high over the rink surface, while the heaters and their thermostats are at a lower level over the spectator stands, (Figure 8.2). With this configuration, the heat transferred by convection directly off the luminaires is so high up that it is not of direct use to the area where the heaters are in the stands. However, some of the air heated by the luminaires will mix within the building air and be of some use. The exact portion of heat that will be useful as space heating is difficult, if not impossible, to predict.

In a curling rink, luminaires are usually mounted in close proximity to the heaters and thermostats, with a much lower ceiling height and within the heated space of the curlers. Under this configuration, very close to 100 per cent of the lighting heat will be useful. Any loss of this heat will have to be made up by the heating system.

Outdoor or indoor lighting in unheated areas

Lighting outdoors or in unheated indoor areas such as hockey rinks is not affected by interactive heating effects. Net overall savings will be the same as the energy savings calculated for retrofitting to energy efficient lighting.

In unheated rinks where several kilowatts of incandescent lamps have been converted to much more efficient metal halide fixtures, the switch will yield significant energy and demand savings. However, the loss of waste heat from the inefficient incandescent lamps has also resulted in slightly cooler air temperatures in the rinks.

Ice plants

You can take advantage of interactive effects to lower the cost of operating your ice plant.

For example, a 20 hp brine pump draws about 15 kW. About 10 per cent (1.5 kW) comes off the motor as heat in the motor room. The remaining 90 per cent (13.5 kW) appears as heat in the circulating brine solution. Reducing the run time of the brine pump saves energy and money in two ways:

- » It lowers the cost of operating the brine pump
- » It cuts back on the operation of the ice plant which needs to cool less brine, resulting in 33 to 40 per cent in additional savings

Skills and commitment

The key to successful operation of rinks and arenas depends upon the skills and commitment of the staff. Having a good building and related systems helps; having a good building that is easy to maintain is better; but having a good, well-trained, knowledgeable maintenance staff is best.

This section discusses methods and procedures for operating and maintaining facilities that enhance energy efficiency in rinks and arenas, with a particular emphasis on facilities with artificial ice.

Maintenance is critical to the energy efficiency program in any type of facility or process. This is because maintaining operating efficiencies is often as difficult as it is to increase efficiencies. Maintenance of buildings and equipment is the most important function in energy management.

In new construction, it is recommended that operating and maintenance (O&M) manuals are prepared. If you have one for your facility, consider it a bonus. Often these manuals are lost or forgotten. The following material was written with the operator of an old facility in mind, someone who may not have the benefit of an O&M manual at their disposal.

You can compile your own O&M manual by contacting the suppliers and manufacturers of the equipment in your facility and requesting copies of their maintenance procedures. Major Canadian cities will have representatives for most equipment and would be able to assist you.

Maintaining the building envelope

Maintaining the building envelope or building shell is related to the same four systems listed in Section 4: air barrier system, insulation, cladding (for roofs and waterproofing), and a vapour retarder.

If maintenance of these four items is neglected, it is possible for the building structure – the studs, columns and beams – to deteriorate.

The first three items are the most important systems to maintain, although it is easy to maintain a Vapor retarder. It is particularly important to maintain the air barrier system and the cladding or exterior shell of the building. The air barrier protects the building from moisture and condensation, and the cladding protects the building from rain and the natural elements.

A well maintained building envelope saves energy in two primary ways. It prevents the uncontrolled flow of outside air through the building, and it improves the thermal integrity of the building. This reduces heat losses and lowers heating and refrigeration bills. Excessive humidity in rinks and arenas puts additional loads on the refrigeration equipment, so limiting moisture penetration either directly or as airborne humidity conserves energy.

Symptoms to look for

Section 4 listed several problems related to moisture accumulation. On masonry buildings, efflorescence is caused by moisture moving through the bricks and carrying with it the dissolved minerals and salts that make up part of the bricks. When the solution reaches the brick surface, the salts and minerals are deposited there as the moisture evaporates. Surface staining by other minerals or materials is similarly caused when moisture carries these dissolved minerals and particles through to the surface of the building.

Such staining is a sign of other potential problems related to the accumulation of moisture within the building envelope. Cracking of the exterior cladding can occur when normally dry materials, such as brick or stucco, absorb moisture and swell. Spalling of masonry and concrete block is caused primarily by moisture accumulating in the bricks or blocks. It occurs when the saturated materials go through a number of freezing and thawing cycles.

When the moisture freezes, it expands and displaces the surrounding material, and gradually leads to a breakdown of the brick or block. This occurs most easily on the surface, since the resistance of the material is weakest there and the surface goes through more freeze and thaw cycles. In severe cases, a number of bricks or blocks may disintegrate sufficiently to place the entire structure in jeopardy.

Other problems discussed in Section 4 include corrosion and rusting of metal components, icicles, displacement of materials, and melt water running out of the building when it warms up. All of these indicate the presence of water in the building envelope, either as frost, ice or liquid. Maintenance is required to stop the accumulation of the water, although it is important to allow any entrapped water to drain.

Maintaining the air barrier system

Reseal cracks and joints on the interior of the building every year, during summer or early fall. If a membrane system was used inside the walls and ceiling, it may be impossible to seal any leaks detected during operation or air tightness tests. However, sealing of the interior and retesting will eventually transform the interior surface into the air barrier system.

Air leakage should be tested during commissioning of a new building and periodically throughout its life. This provides both engineering and practical knowledge of the amount, location, and type of air leakage.

Insulation

Maintaining the insulation is seldom necessary if other maintenance items are satisfactorily handled. Maintenance is required only if the insulation is displaced, creating a cold spot on the interior, or if the insulation becomes wet. This is more common in the roof than in the wall, although in locations where the air barrier system or cladding fails, the wall insulation can become wet. Insulation, such as fiberglass batts, will drain most moisture in a vertical installation, such as a wall cavity. Most other situations will require that the insulation be replaced with dry material. The cause of wetness must be fixed as well.

Cladding - rain penetration

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. Such holes allow the moisture to drain out of the building envelope and you must ensure that this remains possible. Rain or moisture penetration is caused by four different forces:

- » Momentum of the rain drops can drive them past the exterior cladding elements into the assemblies
- » Water draining from the surface of the building may flow by gravity into the assemblies through cracks or openings
- » Water from the wetted surface may be absorbed into the cladding and interior components of the assemblies
- » Air infiltration – air leaking from the exterior to the interior – will carry moisture with it during periods of rain

Sealing the air barrier system on the inside of the building to stop wind-driven rain is necessary to block the wind from coming through the building. If the wind cannot come through the wall, it will not get into the wall in the first place and bring rain along with it. This is often called the Rain Screen Principle.

It is important to maintain flashings so that water does not drain into the wall or get blown past the flashing.

Vapour retarder

Where polyethylene is used in the interior of the wall and ceiling, little maintenance is required for it to function as a vapour retarder. A vapour retarder can be something as simple as three coats of a good oil-based paint. Maintenance of the vapour retarder should ensure that it is not becoming worn.

The vapour retarder may or may not be installed as part of the air barrier system. If it acts as the air barrier as well as the vapour retarder, it must be maintained as both.

Heating equipment

A well maintained heating and ventilation system is like a well-tuned car. It runs better and quieter, uses less fuel, lasts longer and has a higher resale value when you're ready to trade it in. An investment in maintenance pays dividends in the long term.

Follow the procedures listed below to identify problems so they can be corrected before energy is wasted through inefficient or ineffective equipment.

Gas-fired

Make sure that your heating equipment works at maximum efficiency. Gas-fired heating equipment including furnaces, boilers, unit heaters, water heaters, and radiant heaters should be checked monthly and thoroughly inspected yearly.

Your monthly inspections should include:

- » Gas valve
- » Thermostatic controls and limits
- » Pilot light or electronic ignition
- » Flue connection
- » Chimney
- » Gas piping and valves

Your annual inspection should include:

- » Remove and clean all burners
- » Check flame and adjust gas feed and combustion air baffles, if necessary
- » Replace any combustion air filters on radiant heating equipment
- » Clean flue passages on heat exchangers
- » Remove the chimney base tee inspection plate
- » Perform a water test for boiler water

Electric

All equipment should be inspected monthly and thoroughly checked annually. Complete annual inspection before the heating season starts.

Your monthly inspections should include:

- » Thermostat controls and limits
- » Power cables and control wiring

Your annual inspections should include:

- » clean and vacuuming the heating elements

Water heaters

Water heaters must be maintained in a manner similar to any other appliance. In addition, flush and drain the hot water storage tanks once a year to remove scale deposits. Flush more often in areas with very hard water.

You can extend the life of your water heater, and avoid the cost of a new tank and cleanup, by periodically replacing the anode rod in the tank. The average life of a water heater is between nine and 13 years. In theory, water tanks can last indefinitely if you regularly replace their anodes.

The anode, a solid rod of magnesium or aluminum, is suspended from the top of the tank. It is there to corrode away, little by little, and in doing so prevents any rusting of the steel water tank.

Check your anodes every three to four years, or one or two years if you have very hard, acidic, or softened water (common in Saskatchewan). Anode rods are often about 44 inches long and 3/4 inches in diameter, with a 1-1/16 hex plug at the top. With luck, the hex head will be accessible when doing maintenance.

If you are planning on changing the anode, find out what type of rod your water heater has, what you will replace it with, and where you can get the replacement. Anodes are available from plumbing supply houses.

Figure 9.1 - Typical water heater



Boiler water systems

A well-maintained hot water heating system saves pump energy by ensuring that pipes and equipment are clean. It also keeps water system piping pressure drops to an absolute minimum.

Boiler water contains a number of inhibitors to control scale, rust, and biological growth. It may also contain antifreeze solutions to prevent freezing of pipes. All these additives need to be monitored to ensure that they are present in sufficient quantities to work properly for your system. The concentrations should be monitored monthly and more often after a significant leak or drain down.

Strainers and filters on water systems should be examined regularly and cleaned out annually. This saves pump energy by reducing pump heads.

All valves should be opened and closed annually to ensure that all parts are lubricated and are operating correctly. If a valve is stuck or does not seal tightly, it will not be of any use to you when you need it.

Check expansion tanks monthly to ensure that they are not water logged. Excess pressure will build up in the boiler water if this happens. Check air vents to ensure that they are free of obstructions. During your check, vent any excess air in the system.

Ventilation equipment

The ventilation system can be the greatest waster of energy if it is poorly maintained. Clogged filters waste fan energy. Excess fresh air costs a lot to heat. Slipping fan belts cause unnecessary wear. An out-of-control cooling system makes life uncomfortable.

Properly operated and maintained, the ventilation system provides healthy and comfortable conditions at a very reasonable cost. There are four basic components that require maintenance in the ventilation and air handling systems: fans, filters, controls and cooling.

Fans

Fans and their associated motors should be checked annually and lubricated as directed by the equipment manufacturer. Belts should be checked for wear and deterioration. If belts are questionable, they should be replaced rather than risking a break down of the heat distribution or exhaust systems. It is a good idea to keep spare replacement belts on hand.

The standard v-belt drive deteriorates in efficiency by as much as 5 per cent over time to only 93 per cent. The reduction in efficiency is due to belt slippage and lack of re-tensioning maintenance. Cogged v-belts have lower flexing losses, run cooler, last longer and are better than 95 per cent efficient. Synchronous belts are the most efficient with only 1 to 2 per cent losses in energy. In addition, they maintain that efficiency over time, as this belt has no slip. However, synchronous belts are noisy and may not be suitable for all applications.

Example 9.1 - Savings by upgrading belts

If a 25 hp motor operating in the rink consumes 50,000 kWh annually at \$0.05139/kWh, the dollar savings by upgrading from a standard v-belt to a cogged belt would be:

$$\text{Annual cost savings} = 50,000\text{kWh} \times [1 - (0.93/0.95)] \times \$0.05139/\text{kWh} = \$54$$

Filters

Dirty filters waste energy and reduce air flow in buildings. Air filters should be cleaned regularly. If you have permanent filters they should be cleaned and replaced. Throw-away filters should be replaced with new filters of the same type and style.

The schedule for replacement depends on the type of air that the unit must filter. A heating only unit in a non-smoking area may need replacement once every two or three months.

Controls

The controls for ventilation systems are generally very simple (or should be). Room thermostats require little maintenance but should be checked annually to ensure that they are properly calibrated.

Rooftop HVAC units have more complex systems to control ventilation and cooling equipment. Ventilation dampers should be examined annually to ensure that the dampers are moving freely and through the entire range of operation. Check that the mixed air settings are correct.

Air conditioners

Cooling systems should be checked annually by an authorized refrigeration mechanic to help ensure long trouble-free operations.

Most refrigeration mechanics will tell you that 90 per cent of the troubles people have with air-conditioning systems are electrical. If you have any trouble with yours, first check the thermostat and the electrical breaker. You may save yourself the cost of a service visit.

Dehumidifiers should be disconnected. Occasionally dehumidifiers were installed in rinks to eliminate condensation during mild weather outside. Sections 4, 5, and 6 discuss reasons for reducing humidity in rinks and ways of doing so. A dehumidifier is basically an air conditioning (cooling) unit that removes humidity by cooling air below the desired dew point temperature required for the desired rink humidity level.

Because dehumidifiers are very expensive to operate relative to other methods discussed, they should be shut down.

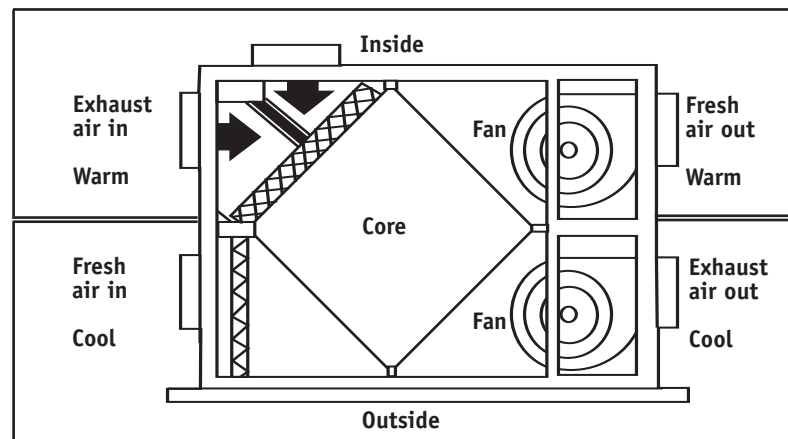
Heat recovery

Air-to-air heat exchangers conserve energy by transferring heat from exhaust air to replacement fresh air. They consist of fans, ducts, controls and the heat recovery coil. Some units include filters similar to those discussed earlier in this section (see Figure 9.2).

Special care must be taken to ensure that the controls are operating correctly so that the heat recovery core defrosts when required. A coil that does not defrost will plug up solid with ice on the exhaust air side. In that case, there will be no exhaust air flow and no fresh air warming.

Care of the heat recovery core will differ, depending on the manufacturer and the design. Heat recovery cores can be constructed of plastic, paper, steel, copper or aluminum. It is best to obtain the manufacturer's recommended maintenance procedures to determine exactly what maintenance is required. Failure to do so may damage the core beyond repair.

Figure 9.2 - Air-to-air heat exchanger



Planned maintenance

Maintain your building and heating systems in the summer when your rink is not too busy and outside work is feasible. Schedule the maintenance in advance and have all replacement belts, filters, and other parts on hand before you start. Arrange to have a refrigeration mechanic inspect your air conditioning in April or early May. If you need to bring in a mechanic from some distance, arrange the work early so that the service agency can schedule other work in your area and reduce your cost by sharing travel costs with other clients.

Scheduling monthly inspections will prevent you from forgetting them. Pick a convenient date and be sure that you have any necessary replacement parts or filters. If this work requires that you spend any time outdoors or on the roof, you will not want to spend any more time than you need to finish your work. Murphy's Law suggests that the day you need to go onto the roof and replace a filter will be the coldest, windiest, most miserable day of the month! Try not to delay too long.

Make a detailed list of the functions that need to be performed for each piece of equipment in your facility. Work with the list and expand it as necessary. The list will help you in your job and will be invaluable for the next facility operator.

Operation of mechanical systems

The operation of mechanical systems and equipment is ultimately what uses energy. The following are energy-saving suggestions on the operation of heating and ventilation systems. Many of these are also covered, in some detail, in previous sections.

- » Shut off exhaust systems during unoccupied times
- » Shut off ventilation systems during unoccupied times
- » Shut off spectator area heaters when there are no spectators; turn them on for games and off during practices or other times of low occupancy
- » Set back heating thermostats during unoccupied times
- » Set cooling thermostats as high as possible during unoccupied hours
- » Install low flow shower heads to save domestic hot water and heating costs
- » Insulate hot and cold water lines, as well as domestic hot water tanks, to prevent heat loss
- » Insulate water lines running in unheated areas
- » Provide timed shut-off shower heads to eliminate the possibility of leaving showers running, which wastes water and heat energy; infrared sensors for starting and stopping showers are also gaining popularity
- » Keep room temperatures at a reasonable level; excessive room temperatures add to heat loss and energy consumption
- » Set back boiler water temperatures in mild weather. Excess heat loss from pipes can cause ventilation rates to increase unnecessarily. Boilers may short cycle and wear out prematurely

For detailed information on ice making and maintenance contact the Saskatchewan Parks and Recreation Association at 1-800-563-2555, to inquire about the Arena Operator Level 1 course.

Ice maintenance

A well-maintained ice surface is smooth, clearly marked, level and available when required by the users. It will be inherently safe (i.e. free from holes or areas where ice will shear off, and free of ridges or bumps that could cause instability while skating). Ice maintenance is one of the most important aspects of arena operation. Maintaining ice at high quality and uniform thickness takes education, practice and skill.

Energy saving practices

Slab Preparation. Start with a clean floor slab. Ice must bond to the slab to ensure good heat transfer. Any impurities, such as oil and dirt, will affect the bonding of the ice to the slab. Other impurities will affect the freezing point of the water, making it difficult to freeze the affected zones.

The refrigeration system must be capable of freezing the most difficult area of the ice surface, so if you are keeping the rest of the rink colder than necessary, you are wasting energy.

Water Purity. The purity of water used for flooding is critical to the quality of the ice produced. Any impurity in the water adversely affects the making of ice. The normal ions found in water disrupt the hydrogen bonding that normally occurs when water freezes. This creates ice that breaks up more easily.

Salts in the floodwater lower the natural freezing point. Lower refrigerant brine temperatures are required to freeze the ice and this uses more energy.

Air in the water acts like insulation. This makes it harder for the brine in the slab to freeze the top layer of ice. Air can be removed from the water by heating it above 140°F (60 C). This produces water that is warm enough to bond with the base ice but is not so hot that it imposes a huge load on the refrigeration system. Heating floodwater above 140°F (60 C) produces a potential double penalty; first, energy is used to heat the water; second, energy must be also used to freeze it.

If your current water source is hard or alkali, has large deposits of salt, carbonates, chlorine or iron, you will have problems making ice. A good source of pure water is rainwater. Rainwater sources such as roof run-off or dugouts can be examined if practical. Many curling rinks collect water off the roof and store it in a cistern to use for ice making throughout the winter. It is recommended to have your water tested before pursuing this option.

Choose ice surface paints that are designed to be thermally conductive. Paints for line and ice colouring, like all other impurities, reduce the heat transfer through the ice.

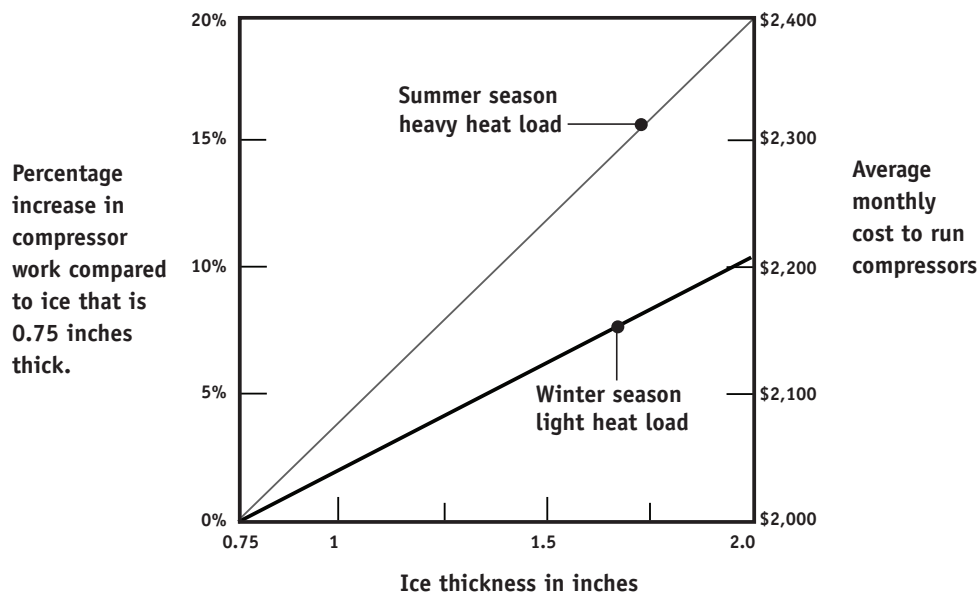
If your water supply is bad, it may pay to clean it up. Water high in iron will produce a coloured ice that will absorb radiant light energy and put an extra heat load on the ice plant. Reverse osmosis water purification systems will produce pure, demineralized water that is free from organic material, colour, bacteria and silica. Because pure water has a higher freezing temperature than softened water, brine temperature can be raised. The ice produced is harder so less snow is produced and less ice surface maintenance is required. Pure water can be applied at a lower floodwater temperature, which saves on heating and refrigeration energy. Less water is required for each flood, which means ice shaving is not required as often. This saves on equipment wear for the ice surfacing machine.

Generally, hockey players, figure skaters and curlers agree that the ice quality is better for their sport when pure water is used. Reverse osmosis machines are available from many water-conditioning companies. These units cost approximately \$18,000 for a 5-gpm unit. Check with these companies for current pricing.

For detailed information on Refrigeration, contact the Saskatchewan Parks and Recreation Association at 1-800-563-2555 to inquire about the Arena Operator Level 2 course.

Ice Thickness. Keep ice thickness between 3/4" to 1" (19 to 25 mm). Because the ice acts as an insulator, excessive ice thickness will increase compressor load and energy cost. Figure 9.3 shows the relationship between compressor work and ice thickness for a hockey rink.

Figure 9.3 - Thickness in ice versus monthly cost of ice production



The 2" (50 mm) ice thickness causes the compressor to run an extra 10 - 20 per cent and costs an estimated \$200/month extra.

Proper maintenance and operation of the refrigeration equipment result in energy conservation and reduced maintenance costs. Equipment that lasts a long time will not need to be replaced, so costs are delayed. Properly operating equipment is efficient, uses less energy while operating and does not need to run as many hours. If equipment is not operating as long, it lasts longer. All these initiatives save dollars now and in the future.

Introduction

This section looks at the steps that should be undertaken when planning a building or maintenance project for a typical rink or arena. With minor adaptations, the procedure should work for nearly any major investment. It was written primarily with the needs of the management committee in mind.

This section considers the renovation of existing facilities, addition of new areas to existing facilities, and the construction of an entirely new facility. Typical construction costs and practical examples are included.

Treat your facilities and projects as rental properties, using a business model to generate a profit. If your committee sets your profit goal at zero or less, provide an appropriate place for that option.

The energy efficiency and energy management ideas presented throughout this manual should form part of the planning process in your facility, now and in the future.

Project concept

Start with the assumption that somebody out there has a good idea for a project – anything from a whole new building, to an addition, to a renovation or maintenance-type job.

In many instances management and building committees will be established to nurture or kill ideas that are brought forward. In the absence of these groups, the idea person(s) must develop the concept. Either way, think of the following factors that should be considered for the idea.

Demand forces

Define the forces that are creating a demand for your project.

- » Who will use the project?
- » What will they pay to use it?
- » What features will they want?
- » How soon do they need it?
- » Can you do it profitably?
- » How will it affect other programs?

To answer these basic questions and many more, you must do your homework and learn more about your facility and your market.

Economic base analysis

You need to determine the economic and demographic forces that will shape your decisions. An overall analysis of your community is an excellent point of departure for your study. If the community is weak and exhibiting a decline in economic vitality, financing will be difficult to secure. If your community is strong, with economic growth and a solid base of employment, financing should be attainable.

Demographics. To understand the basic principles of demographics for your community, the issue of a person's life stage needs must be considered.

Look at your community, the surrounding towns and your district to determine if the population is increasing or decreasing. What age brackets are increasing and which are decreasing? If you are considering a hockey rink and the residents of the community age 6 - 39 are on the decrease, your analysis should project a future demand that is less than current levels.

On the other hand, if you are looking at a curling rink and the group ages 30 - 69 are steadily increasing, then your projection should suggest an increase in future demand from current levels. Sounds simple, right? Remember that those 20 - 29 year olds will be 30 - 39 year olds in 10 years.

Population statistics and economic development for most communities are available from:

- » Statistics Canada – www.statcan.ca
- » Saskatchewan Regional Economic Development Authorities (REDAs) – www.ir.gov.sk.ca
- » SaskTrends Monitor – www.sasktrends.ca

Employment. Who will pay? If you expect people to pay for the benefits that they receive from using your facility, then they will need a stable income.

On a community basis you must look at employment levels, historical employment levels and expected changes in total jobs. Unemployment statistics can be misleading, so try to obtain data that lets you know how many people are working in your community and your district.

Your knowledge of the community will be necessary to analyze any unique factors influencing the employment prospects of your town. Look at local employers; is your community dependent on one or a few industries? How would a work stoppage affect things?

Consider a simple example. In 1988 the Town of Hudson Bay, SK replaced a fire damaged ice rink facility with a new \$1.2 million expanded facility. In 1990 the town's largest employers pulled out, the population dropped, and income in the community fell. If this could have been forecasted, some decisions may have been made differently.

Income. The average income level of the people in your district is available from Statistics Canada. This data will help you to make decisions on the public's ability to support your facility – both in terms of user pay benefits and for general fund raising (if applicable).

Even though your population statistics indicate a strong demand for services, if the people in your town can't pay for these services, then chances are you won't be in a position to provide them.

Examine the case where a community has a large number of people with a very low average income. Those individuals will only be able to afford modestly-priced services. Don't plan on much beyond recreational hockey, public skating or recreational curling.

Competition. To evaluate your competition you must consider all factors involved in the average person's decision to support your facility. Only then will you know who your competition is.

If your town doesn't have a rink or an arena, that doesn't mean you don't have any competition. What you are really selling is leisure, recreation, sports and entertainment, and maybe even more. Let's look at both direct and indirect competitors.

Direct competitors consist of facilities that provide the same services you propose to provide. Consider other rinks and arenas in your district, within 50 km and within 100 km.

Indirect competitors consist of alternate sources of leisure activities in your marketplace. They may include:

- » Bowling alleys
- » Malls
- » Movie theatres
- » Pool halls
- » Swimming pools
- » Restaurants
- » Community halls
- » Tennis clubs
- » Bars and taverns
- » Dance clubs
- » Television

Your customer has a finite supply of time and money. You must convince yourself, your banker, and the public that some of the people's time and money will be spent at your facility. Each of these indirect competitors takes people's time and money and holds a certain number of people away from your facility.

Unique Circumstances. Does your community have some other unique factors that will enhance the viability of your project? Are there unique opportunities that could be pursued to enhance a project's worth?

Seek out special circumstances. If a new or improved recreational facility could be built, would people be attracted to relocate into your area? Would it sway a large employer to locate in your town instead of somewhere else? Would it keep the town vibrant, attracting new families to shop in the local stores?

Look at the availability of land and the availability of services for your project on an easily accessible site. There may be good land 10 km from town but 5 km from natural gas or power lines. Servicing costs would probably make the project impractical.

Look at reducing costs by sharing facilities or expanding your services to incorporate other needs. If a rink was located near the local school and the students used it during the day as part of their physical education, your utilization and revenue would increase. If you can provide a meeting room for a local senior citizen's group, thus renting out more than just ice time, your idea may come closer to reality.

Examine the other groups, organizations, service clubs, and institutions in your community. Look for joint opportunities; you'll find some. An existing facility has basic overhead costs that must be covered by the basic operation of the facility. Increasing the use of the building for meetings, shows, concerts, weddings, and clubs increases revenue, increases utilization, but only marginally increases total operating cost.

Political Developments. For lack of a better name, politics occasionally create situations that influence the viability of certain projects. Grants, loans and subsidies are made available at certain times for a variety of reasons and purposes. Watch for them and use them if practical – once you know all the facts and implications.

Don't count on using grants alone to pay for new projects. As many communities can attest, grants can be withdrawn or modified, creating severe difficulties for unprepared organizations.

Market needs

Your project must fulfill a need of the society you plan to serve. To be successful you must provide that service better than your competition at a price that people are willing to pay, and that meets your cash flow requirements.

Once you have determined the need you will fill and the people who will benefit, figured out your competition and tied down a good location, it is time to talk about money.

Planning process

In the beginning, there is nothing except an idea. At this point there are no constraints and no limitations. Anything is possible. Then reality sets in. Budgets are limited, costs are prohibitive, your site is only so big and retractable roofs don't work well at -40°F (-40 C). The planning process shapes those good ideas into practical solutions.

Organization. It is important to establish early on in the planning who and how decisions are to be made. This often consists of a building committee with an appointed chairperson. Occasionally there is a parallel committee responsible for financing and fund raising. Together, you have one committee raising money while the other committee spends it.

This approach has been particularly successful in hospitals, nursing homes, universities, and similar public service institutions. A review of how these organizations raise money is

certain to help you raise money, but will not be covered in these guidelines. It is very important to establish the procedures to be followed by the building committee:

- » Who do they report to?
- » Who has the final say in decisions?
- » What records must be kept?
- » What is the schedule?

If your project is small, the whole job may be delegated to one person. For example, you might ask Joe, a person you trust, to get the public address system replaced. You'll want him to look at P.A. systems in buildings in the vicinity, talk to system suppliers and electricians, get prices from two or three contractors and report to the Board of Management in one month. Joe knows what to do, what information to collect, and he has a timetable in which to do it.

Elements of Planning. To take the idea and make it a reality requires a few basic steps:

- » Analyzing need
- » Collecting solutions
- » Reviewing alternatives
- » Establishing budgets
- » Establishing costs
- » Prioritizing options
- » Planning options

These basic elements of the planning process apply to any size and type of project. As the project grows in size and complexity, the process of producing a final solution will grow in size and complexity.

At some time every owner needs the help of professional planners. These include architects and engineers who specialize in the design of rinks, arenas and recreation buildings. Their training and experience will assist in the planning process. In most projects funded by public money or over a certain dollar value, the use of professional engineers and/or architects is a legal requirement to satisfy funding rules and provincial bylaws. The Saskatchewan Association of Architects and the Consulting Engineers of Saskatchewan will be pleased to forward the names of qualified firms.

Additional sources of basic information are contractors, wholesalers, distributors, manufacturers, and other sales organizations. Talk with other facility owners to learn about their experiences. You can benefit from their successes and avoid their mistakes.

Planning Options. When you are considering a project, you must review some options such as: to build new, to replace, to repair, to renovate, or to add-on. Virtually every need will be fulfilled by one or more of these options.

Planning for energy efficiency

When considering energy efficiency projects, you are dealing with a different type of need. First consider a need to save money – financial need. Second, consider a need to save energy – an environmental need. The analysis of these needs requires a full understanding of some financial concepts.

Cost avoidance

If the current monthly electricity bill in your facility is \$2,000/month and you are planning an energy efficiency project that will save \$500/month, you are looking at avoiding future electrical costs of \$500/month. This is referred to as cost avoidance.

The trouble with cost avoidance is that it never shows up anywhere. You will never get a cheque, nor a credit; nothing to tell you that you just saved \$500. But the savings are real. Without your energy efficiency improvement project, the \$500 would be in the utility's bank account, not yours.

Inflation

In energy efficiency projects, you can assume that energy prices escalate at a rate from zero to 5 per cent per annum. Assume that a budget is established to pay the utility bills at that steadily increasing level. When you do your analysis of an energy efficiency project, the savings show up as the difference between the budgeted utility costs and the projected utility costs. The savings must be large enough to justify the cost of your energy project.

Using the previous example of \$2,000 a month current costs and a cost avoidance of \$500/month, and assuming inflation at 5 per cent, the inflated values are shown in the following table:

Table 10.1 - Effects of inflation on cost avoidance

Year	Electrical bill (Before)	Electrical bill (After)	Cost avoidance
1	\$2,000	\$1,500	\$500
2	\$2,100	\$1,575	\$525
3	\$2,205	\$1,654	\$551
4	\$2,315	\$1,736	\$579
5	\$2,431	\$1,823	\$608

The effects of inflation result in cost avoidance being inflated. Because future costs will be inflated, the dollar savings increase at the same rate as inflation.

Financial analysis

When examining the finances of your project, remember that inflation has an effect on the future value of the money that you are using to pay your financing cost or energy costs. This is referred to as the net present value of money. To help you get a feel for the relative cost of different construction and repair options, consult the following table of work and related costs. See more on financial analysis in Section 3.

Typical repair and replacement costs

This manual uses figures adjusted for inflation using the Consumer Price Index (CPI in 1999 was 110.5; CPI in 2006 is 129.5) and added for material cost to generate the following numbers. They should only be used as a very rough guideline. An architect, consulting engineer, or contractor will be able to help you with current pricing.

Table 10.2 - Typical repair and replacement costs

Replace existing hockey rink concrete floor with new concrete floor including hot deck		\$400,000
Replace refrigeration compressor (ammonia)	50 ton	\$26,000
	60 ton	\$31,000
	75 ton	\$35,000
	100 ton	\$45,000
Replace brine pump	10 hp	\$ 6,000
	15 hp	\$ 7,000
	20 hp	\$ 7,500
Replace evaporative condenser (ammonia)	50 ton	\$29,000
	60 ton	\$34,000
	75 ton	\$39,000
	100 ton	\$54,000
Renovate public areas	\$110/ft ² (\$1200/m ²) of floor area	
Renovate wash/change rooms	\$140/ft ² (\$1,500/m ²) of floor area	
Add R 15 to exterior wall	Stud wall	\$7.00/ft ² (\$70/m ²) of wall
	Masonry wall	\$30.00/ft ² (\$300/m ²) of wall
Add R 20 to roof	Attic (blown insulation)	\$1.00/ft ² (\$10/m ²) of roof
	Inverted roof	\$20.00/ft ² (\$210/m ²) of roof
	Flat	\$60/ft ² (\$650/m ²) of roof
	Sloped metal	\$85/ft ² (\$900/m ²) of roof
Install Low E ceiling		\$35,000
Demineralized Water		\$25,000
Brine Pump with VSD		\$19,000 - \$22,000
Liquid pressure amplifier		\$ 5,000 each

Table 10.3 - Typical costs of new construction

New hockey rink 24,000 ft ²		
-new rink with ice plant		\$950,000
-new rink without ice plant		\$850,000
Ice plant for new rink including 5" concrete floor slab		
-50 ton winter-only operation		\$110,000
-75 ton year-round operation		\$135,000
New curling rink with washrooms and lounge plus viewing areas:		
	Building	Refrigeration
	2 sheet	\$225,000
	3 sheet	\$350,000
	4 sheet	\$450,000
	6 sheet	\$700,000
Extra public area	\$100/ft ² (\$1100/m ³)	
Extra rink/warehouse area	\$30/ft ² (\$320/m ³)	
Mezzanine space	\$75/ft ² (\$800/m ³)	
Architects and engineers	8 per cent of construction value	

Planning check list

Phase I - Needs analysis

Establish need for service:

- » Address unmet needs
- » Meet competition with better service
- » Location

Consider competition:

- » Who is your direct competition?
- » Where are they located?
- » What other services are competing for your customers' time and money?

Demand forces:

- » Population (growing, steady, declining)
- » Employment (stable workforce, transient)
- » Income level (high, average, low)
- » Unique factors

Finances & Grants:

- » Budgeted expense
- » Loans and mortgages
- » Grants
- » Cost of service
- » Operating and maintenance
- » Price for service
- » Local fund raising
- » Local operating grants

Phase II - Plans and specifications

Scope of work:

- » Define size of project
- » Define budget constraint
- » Establish time table

Consultation:

- » Building committee
- » Hire consultants as required
- » Talk to other owners
- » Talk to contractors

Planning:

- » Prepare preliminary floor plans
- » Re-examine project and financial plans
- » Prepare final plans
- » Look at the details of the project
- » Confirm that all needs are addressed
- » Check budget again

Specifications:

- » Establish quality expected
- » Establish energy efficiency goals expected
- » Communicate expectations clearly

Tendering:

- Bidding
 - » Sole source, negotiated
 - » Invitational
 - » Public tender

- Pricing
 - » Cost plus (time and material)
 - » Fixed price

Phase III - Construction

Tender evaluation:

- » Select contractor
- » Bid bond - if required
- » Insurance during construction
- » Check references
- » Is it within the budget?
- » Is contractor qualified?
- » Construction schedule

Pre-construction meeting:

- » Prepare and sign contracts
- » Establish lines of communication
- » Establish limitations (if applicable)
- » Establish payment procedure
- » Establish grievance procedure

Construction:

- » Review progress
- » Ensure that you get what you paid for, review workmanship
- » Communicate changes promptly
- » Try to keep changes to a minimum
- » Pay promptly once claims approved

Post construction:

- » Obtain maintenance manuals
- » Receive operator training

Air barrier	A barrier usually consists of a membrane to prevent the uncontrolled flow of air through the building envelope.
Ambient temperature	Temperature (usually of the air) surrounding operating equipment.
Ammonia (NH₃)	One of the earliest compounds used as a refrigerant.
Ampere (A)	The unit of measurement of electric current.
Atmospheric Pressure	Pressure exerted because air has weight. Under normal conditions this pressure is 14.7 lb./sq. in. (101.2 kPa).
Basic monthly charge	A fixed monthly amount that covers the cost of billing, meter reading, account administration and the cost of supplying the customer with electricity or natural gas service.
Btu (British thermal unit)	Amount of heat energy required to raise the temperature of one pound of water one degree Fahrenheit. It is approximately the amount of heat generated by burning a common match.
Btu/h (British thermal unit per hour)	See definition for Btu. Air conditioners are rated in Btu/h capacity.
Building envelope	The building exterior—including walls, roof, windows, doors, foundation, floor, insulation, Vapor retarder, and air barrier— that acts as a unit to provide shelter and an indoor space.
Calorie	Amount of heat energy required to raise the temperature of one gram of water through a change of one degree Celsius. (8,604 kilo calories = 1 kWh).
Capacitor	Functions primarily to accumulate and store electrical charges. Used for power factor correction.
Capital cost	Initial cost of equipment and systems; purchase price, also known as first cost.
Coefficient of Performance	COP is the ratio of cooling or heating to energy consumption
Compressor	Takes a refrigerant Vapor at a low temperature and pressure and raises it to higher temperature and pressure.
Condensation	Process by which a Vapor is changed into a liquid without changing temperature.
Condenser (general)	That part of the refrigeration system in which the refrigerant condenses and in so doing gives off heat.
Conduction	A method by which heat energy is transferred by actual collision of the molecules.
Convection	A method of transferring heat by the actual movement of heated molecules.

Cubic meter (m³)	Unit of measurement for natural gas distribution and billing in Saskatchewan.
Dew point	The temperature at which the air (space) becomes saturated. When air is cooled to the dew point, water Vapor condenses into liquid form (provided its latent heat is removed).
Demand	Demand is the rate at which electric energy is delivered to a load. It is expressed in either kilowatts (kW) or kilovolt-amperes (kVA). Demand is the peak amount of power drawn through the meter during a specific billing period.
Efficacy	The ratio of total lumens produced by a lamp to the watts consumed by the lamp, expressed in lumens per watt.
Energy Efficiency Ratio (EER)	An indication of the efficiency of a unit such as an air conditioner. The higher the EER, the more energy efficient the unit.
Enthalpy	Total heat energy in a substance. The sum of sensible and latent heat.
Evaporation	The process by which a liquid changes into a Vapor as a result of absorbing heat.
Evaporator	Device in the low-pressure side of a refrigeration system through which the unwanted heat flows; absorbs the heat into the system in order that it may be moved or transferred to the condenser.
First cost	See Capital cost.
Foot candle	A unit of measurement of usable light (illumination) that reaches any given surface. It is defined as one lumen falling uniformly over an area of one square foot.
Gas main	The high pressure portion of an underground natural gas distribution system.
Gauge pressure	Pressure above or below atmospheric pressure.
Gigajoule (GJ)	Equals one billion joules. A joule is a unit of energy used to measure energy content. One gigajoule equals 948,200 Btu or 277.8 kilowatt-hours.
Heat of vaporization	The heat required to change a liquid into its Vapor or gaseous form without changing temperature.
Heat transfer	The movement of heat energy from one place to another.
Inverted roof	Roofing system with water-proofing membrane under exterior grade insulation and ballast (gravel or paving stones).

Kilovolt (kV)	The unit of electrical pressure, or force, equivalent to 1000 volts (V).
Kilowatt (kW)	The unit of electrical power equivalent to 1000 watts (W).
Kilowatt-hour (kWh)	The unit by which electrical energy is measured. For example, 10, 100 watt light bulbs switched on for one hour would use one kilowatt-hour (1000 watts for one hour).
Latent heat	That heat energy which causes a change of state without any change of temperature.
Latent heat of vaporization	Amount of heat to be added to (or subtracted from) one pound of the refrigerant to cause it to vaporize (or condense).
Lamp	An electric source of light consisting of a filament or arc tube, supporting hardware, enclosing envelope and base.
Liquid line	Runs from condenser to expansion valve, providing liquid refrigerant to the cooling process on the high pressure, high temperature side.
Lumen	A unit of measurement of light emitted by a lamp at the light source. A unit of luminous flux.
Luminaire	Complete lighting unit – lamp, reflectors, ballast, power supply and necessary parts.
LUX	A unit of measurement of usable light (illumination) that reaches any given surface. It is defined as one lumen falling uniformly upon an area of one square meter. (metric equivalent of foot candle).
MBH	1000 British thermal units per hour. A unit of power normally used for heating equipment.
Megawatt (MW)	The unit of electrical power equal to one million watts or 1000 kilowatts.
Mercaptan	The odourant added to natural gas to make it smell like rotten eggs.
Natural gas	A fossil fuel found deep in the earth. Its main component is methane (CH ₄). It is colourless, odourless, and lighter than air. When burned it produces carbon dioxide and water.
Ohm	The unit of measurement of electrical resistance against the flow of electric current.
Peak load	Record of maximum amount of electricity used in a given time period.
Power	The rate of using electrical energy, usually measured in watts, kilowatts, or megawatts.
Power factor	The ratio of real usable power measured in kilowatts to the total power (real and reactive power) measured in kilovolt-amperes.

Primary gas	Natural gas received from Western Canada. It can be purchased on an unregulated basis from a natural gas marketer, or from SaskEnergy.
Radiation	A method of transferring heat which uses energy waves that move freely through space; these energy waves may be reflected and/or absorbed.
Receiver	A container for storing liquid refrigerant.
Reflectance	The ratio of light emitted from a surface to the light falling on that surface.
Reflectivity	Ability of a material to reflect radiant heat energy.
Refrigerant	Substance which is circulated in a refrigeration system to transfer heat.
Regulator	An adjustable mechanical device that measures, restricts, and maintains a constant downstream pressure of a gas or liquid.
Relative humidity	A ratio, expressed as a percent, of the amount of water Vapor in an air space compared to the amount of water Vapor that the air space could hold at a given temperature.
Saturation	The condition that exists when the space occupied by a Vapor is holding as much of the Vapor as it can at a particular temperature.
Seasonal Energy Efficiency Ratio (SEER)	It is the ratio of the total cooling provided during the season in Btu divided by the total energy used by the system in watt-hours. The higher the SEER, the more energy efficient the unit. Also the EER of a unit averaged out over the heating or cooling season.
Sensible heat	The portion of heat energy used to warm or cool dry air from one temperature to another. Sensible heat plus latent heat equals the total heat energy required to change the temperature of air (excluding phase changes).
Sublimation	A change of state from solid to gas without going through the liquid state.
Subcooling	Drop in temperature resulting from the removal of sensible heat from a liquid.
Suction line	Runs from evaporator to compressor; returns the heat-laden gases from the evaporator to the compressor.
Superheating	A process resulting in a rise in temperature due to the addition of heat to the refrigerant Vapor, either in the evaporator or the suction line.

Supplemental gas	Natural gas that SaskEnergy purchases to ensure supply is available when demand is higher than normal. This usually represents about 5 per cent of a customer's annual natural gas use. Supplemental gas costs fluctuate during warmer or colder-than-normal years.
Thermostatic expansion valve	Control valve which maintains constant superheat in the evaporator; also used for temperature control. Operates on increased pressure resulting from a rise in temperature.
Ton of cooling	An old-fashioned term used to describe the cooling effect felt by melting one ton of ice in a 24-hour period. One ton of cooling equals 12,000 Btu/h.
Torque	Twisting force; usually expressed in foot-pounds or inch-pounds or Newton-meter; computed by multiplying a force over the distance it is exerted.
Transportation charge	Cost of transporting natural gas to SaskEnergy customers, including pipeline charges and the cost of storage facilities where SaskEnergy stores natural gas purchased in the summer for use in the winter.
Vapor retarder	Previously and commonly referred to as the Vapor barrier. Prevents the movement of water Vapor through the building envelope.
Volt (V)	The unit of measurement of electrical pressure, or force, which causes electric current to flow.
Volt-amp	Unit used to measure apparent power. 1000 Volt Amps = 1 kVA.
Volt-amp resistance	Unit used to measure reactive power. 1000 VAR = 1 kVAR
Watt	Unit used to measure real or useable power. 1000 watts = 1kW

The following is a list of a few publications that were reviewed during the preparation of this manual. These publications will provide additional information on the subjects listed. Most are available from the organization listed beside the title.

American Society of Heating, Refrigeration, and Air-Conditioning Engineers. ASHRAE.

- » 2002 Refrigeration Handbook

BC Hydro

- » Energy efficiency in recreation buildings - H651, May 1990
- » Energy savings at ice rinks - C202, February 1990
- » Case history - energy management in municipalities, December 1985

Canadian Electricity Association

- » Energy management control systems, reference guide
- » Heat pump reference guide
- » Lighting reference guide
- » Electric variable speed drive reference guide

Ontario Arena Association

- » Design guidelines for energy conservation in skating rinks and arenas
- » Refrigeration and ice making publication, March 1988

Ontario Energy Network

- » Volume 10, #2 - New refrigeration control saves energy and money, Winter 1990
- » Volume 9, #1 - Lease financing energy management projects, October 1988

Ontario Ministry of Energy

- » Purchasing energy management advice
- » Energy conservation in existing arenas (three case studies)

Saskatchewan Recreation Facility Association

- » Air alert - toxic gases in community arenas

TransAlta Energy Systems

- » Energy conservation and management - a proposal for rink operators and managers

U.S. Department of Energy

- » Energy conservation in ice skating arenas

This appendix presents a brief introduction to energy calculations for operators of rinks and arenas.

Energy calculations can be easily done for the heat loss that occurs in winter and the amount of heat input required in maintaining the temperature. Calculations to estimate the amount of cooling required for ice making, or to maintain a cold building during the summer, are more difficult and should only be attempted by a qualified consultant.

The rate at which heat flows through different materials is called that material's conductivity, which is determined by the make-up of the material.

A building board such as plywood or drywall sheathing has a certain thickness and conductivity, and will conduct heat at a fairly consistent rate. This is called the conductance of the building board. The higher the conductance value, the more heat will be transported (by conduction) through the board. As an example, three-quarter inch plywood has a conductance value of 1.07, where as one-half inch drywall has a conductance value of 2.25.

A common method of expressing conductance (U) is by taking its inverse (1/U), which is the familiar resistance (R-value in imperial units, RSI in metric units) to heat flow.

Calculating heat loss from conduction

To calculate heat loss due to conduction, use the following equation:

$$\text{Heat flow} = \frac{(\text{Area}) \times (\text{Temperature difference})}{(\text{Thermal resistance})}$$

OR

$$Q_k = (A \times \Delta T) / (R)$$

When using this equation to calculate heat flow in imperial units:

Q_k = heat flow in Btu/hour

A = area in square feet (ft²)

ΔT = temperature difference in degrees F

R = thermal resistance in R-value

When using metric units:

Q_k = heat flow in watts (W)

A = area in square meter (m²)

ΔT = temperature difference in degrees C

R = thermal resistance in RSI

The degree at which insulation is minimized is related to how much of the structure or framing goes through the insulation. The calculation that is required to determine the exact effect is somewhat complicated and should be carried out by a consultant, but there are counterbalancing factors as well. The resistance of the interior and exterior sheathing, and even the resistance of the still air on the interior and exterior surface of the building, add to the overall resistance. The result is that quite often the nominal resistance – the resistance of the insulation alone – is fairly close to the assembly resistance.

The resistance of the assembly is also affected by the quality of its construction and installation of the insulation. This often affects the overall result more than the difference between the nominal and assembly resistance.

The amount of heat carried by air currents brushing against the interior and exterior surfaces of the building is best calculated by estimating the equivalent conductive resistance. This is termed the surface film resistance and can be used in the calculation of the assembly conductive resistance, although the added effect will be small.

Radiant barriers on insulation do not add much resistance to a well-insulated building envelope. The reason is that a well-insulated building envelope in winter will have interior and exterior surface temperatures close to the ambient conditions on either side. There will be some benefit from radiant barriers that protect against heat gain.

Heat transfer through windows

The exception to radiant barriers is windows. Making the window opaque or reflective to heat radiation decreases the amount of heat transmission through the window and increases the comfort level next to the window.

The R-value of windows have improved over the years with common upgrades such as; low emissivity (low-E) coating on the glass, inert gas fill (i.e. argon or krypton) between glass layers, and insulating spacers between panes of glass. All of these are designed to reduce heat transfer from the warmest to the coldest parts of the window. This also helps reduce window condensation caused by increased humidity, allowing the space to be more comfortable. Other upgrade options include additional glass layers and improved frame design using fiberglass and PVC materials.

The Energy Rating (ER) label is a positive or minus rating system that makes it easy to compare performance among different quality windows by evaluating solar heat gain; heat loss through frames, spacer and glass; and heat loss due to air leakage. A few high-efficiency windows rate positive, which means they can actually contribute to heating the space through passive solar heat gain.

Look for the ENERGY STAR® label and climate zone rating on windows for the best in energy efficiency. Four climate zones have been determined in Canada (A-B-C-D), from warmest to coldest. Saskatchewan's climate zone is C. ENERGY STAR qualified windows will show the climate zone on the label or on its sales literature.

Generally speaking, windows that are fixed or non-opening are more energy efficient than operable windows.

Calculating heat flow caused by air leakage

To calculate the amount of heat flow due to air leakage, use the following equation:

$$\text{Heat flow} = (\text{Volume flow rate}) \times (\text{Air density}) \\ \times (\text{heat capacity of the air}) \times (\text{temp. difference})$$

OR

$$Q_a = (V) \times (d) \times (cp) \times (\Delta T)$$

Where:

Q_a = heat loss in watts (W)

V = flow rate volume in litres per second (L/s)

d = air density at standard conditions in kilograms per cubic metre (kg/m^3)

cp = specific heat capacity of air in kilojoule per kilogram degree Kelvin ($\text{kJ}/\text{kg } ^\circ\text{K}$)

ΔT = temperature difference in degrees C

The heat capacity of the air is the amount of heat that the air can hold per degree of temperature. It is expressed in pounds or kilograms of air per degree of temperature.

Using imperial units and average temperatures for the equation above yields:

$$Q_a = (V) \times (d) \times (cp) \times (\Delta T)$$

$$Q_a = (V) \times [(0.075) \times (0.24)] \times (\Delta T)$$

$$Q_a = (V) \times (0.018) \times (\Delta T)$$

Where:

Q_a = heat loss in Btu/h

V = flow rate volume in cubic feet per hour (cf/h)

d = air density at 70°F - 0.075 pounds per cubic foot (lb/cf)

cp = specific heat capacity of air - 0.24 btu per pound degree F (Btu/lb °F)

ΔT = temperature difference in degrees F

Calculating the amount of energy loss in ventilation is exactly the same as for air leakage. If heat recovery is used on the ventilation exhaust air, then you must multiply the total air volume by the fraction of unrecovered energy.

Heat recovery ventilators (HRV) are becoming common appliances in energy efficient homes, and similar units are available for larger municipal and institutional facilities. HRV's are rated according to their effectiveness in recovering exhaust heat. The higher the effectiveness, the higher the heat recovery. Check the main body and Appendix vi of the manual for details on HRV's and other mechanical equipment that can reduce energy consumption.

Heat flow methods

There are basically four methods of heat flow that have to be considered for buildings:

- » Conduction across all the building assemblies, such as walls, ceilings, floors, windows and doors
- » Air leakage (infiltration)
- » Ventilation heat losses
- » Radiation (solar)

The effect of radiation on the building envelope can be calculated using the SolAir temperature in the conduction calculations. This is explained in the 2001 ASHRAE Handbook of Fundamentals.

Calculations for energy transfer between interior surfaces by radiation should be done when the surface temperatures differ between assemblies, such as for the ceiling and ice surface. Detailed calculations, where required, should be done by a qualified consultant.

Energy software programs

Simplified energy programs can be run on most personal computers. These generally work best and most accurately for buildings that require heating only. This is because it is too difficult to estimate the exact effect of heat gains from people, who give off heat depending on their activities, and equipment, which may run only intermittently.

The simplest programs require information about the building envelope, such as the areas of the walls and various R-values. This type of information is required for all the different components that make up the building envelope; that is, all the walls, the ceiling or roof, the different areas of the floor, and such elements as the windows and doors.

One of the most popular software programs is used in the R-2000 housing series, called HOT2000™. The software is available on-line and free to download from Natural Resources Canada – Buildings Group. The HOT2000™ program is a computer simulation tool that is used as the reference calculation application for the R-2000 Program. The building simulation tool helps you build comfort, sustained energy performance and lower operating costs into all your new construction and major renovation projects.

The tool was designed to model houses, but can be used for buildings that have little or no ventilation systems and are less than 8,000 square feet.

Other simulation tools available from Natural Resources Canada – Buildings Group include software applications in areas such as lighting and daylighting, HVAC, Building Envelope and Windows, Whole House Design and Performance, and Whole Building Performance.

Power factor

Power factor can be described as the ratio of power actually used by a customer to the power supplied by SaskPower. Typically, power factor ranges from about 0.7 to more than 0.95 and is expressed as a percentage. The higher your power factor, the harder your electricity works for you and the lower your costs for power. You can often improve your power factor by adding relatively inexpensive components, such as industrial capacitors, to lower your electricity bills by as much as 20 per cent.

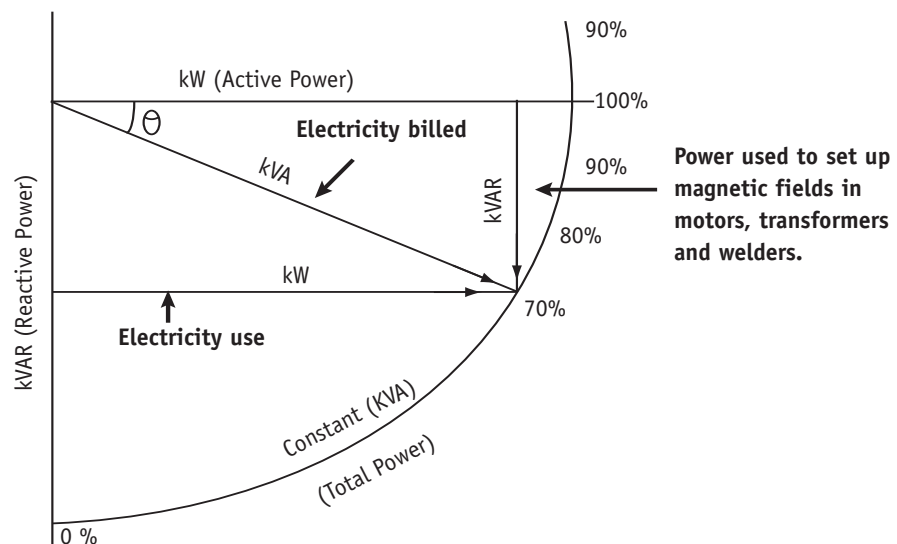
Power factor correction is of concern to commercial or industrial customers whose plant equipment includes large three-phase electric motors and is demand metered. If your plant's power factor is poor, SaskPower must supply more electrical capacity than your equipment actually requires. SaskPower recovers the cost of providing this extra capacity through demand charges that are a part of the electricity charges on your power bill. Power factor (PF) is the name given to the ratio of the real useable power measured in kilowatts (kW) to the total power (real power plus reactive or magnetizing power) measured in kilovolt-amperes (kVA).

Transformers, induction motors, lighting that uses iron core ballasts, and other electromagnetic devices must be magnetized in order to function. The current through each of these devices consists of two components – real and reactive power. The real current does the useful work and develops the power required, while the reactive current establishes magnetic fields. Magnetic current contributes nothing to the work output and actually places hardship on the supply system. The total current is the vector sum of the real current and the reactive current.

The power factor of a system may be described as either lagging or leading, depending on whether the reactive power is inductive or capacitive. Most common motors, transformers, welding machines and inductive heating coils produce lagging power factor. Resistive loads, such as heaters, ranges and incandescent lights, have a perfect power factor of 1.0 or 100 per cent. Capacitors and some synchronous motors produce leading power factor.

Lagging power factor can be corrected by connecting capacitors to the system. The current which flows in a capacitor produces a leading power factor. This current flows in the opposite direction to that in an inductive device. When the two circuits are combined, the effect of capacitance tends to cancel the effect of inductance. The problem is to select the proper amount of capacitors to produce the optimum cost-effective saving. Too few will not correct to a sufficiently high power factor and too many will cause the power factor to deteriorate in the leading mode with the same undesirable effects.

Figure iv.1 - Power factor triangle



Measuring power factor from the meter

SaskPower will, on request, provide an accurate instantaneous measure of power factor. As a first step, you can determine a rough instantaneous value from your electro-mechanical demand meter. This value will indicate the advisability of further and more accurate measurement.

Use this formula to determine your power factor from an electro-mechanical demand meter:

$$\text{Power factor} = \frac{\text{kh} \times 3,600 \times 100 \text{ per cent}}{\text{multiplier} \times \text{demand} \times \text{time}}$$

Where:

Kh = constant from meter face

multiplier = the internal multiplier of your meter

demand = present demand reading in volt amperes (VA)

time = number of seconds for one disc revolution

Example iv.1 - Power factor calculation

Kh = 1.08

multiplier = 2

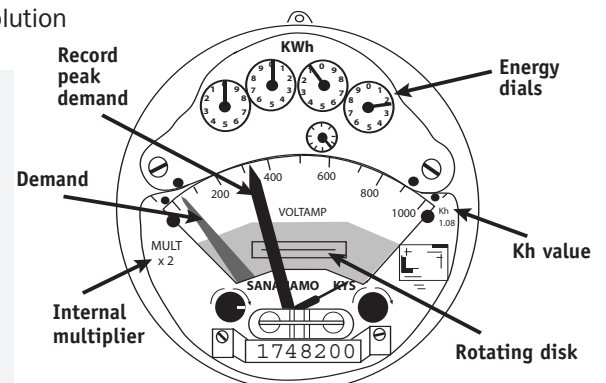
demand = 300 volt amperes (VA)

time = 80 sec. for 10 rev. (= 8 sec. per rev.)

$$\text{Power factor} = \frac{1.08 \times 3,600 \times 100 \text{ per cent}}{2 \times 300 \times 8}$$

$$\text{Power factor} = 0.81 \text{ (81\%)}$$

Demand meter showing the inherent multiplier (kh = 1.08) and the internal multiplier (2). Time the disc for 10 revolutions to get the average time for one.



Note that an installation with this power factor requires a closer look and more accurate measurement:

- » Power factor is instantaneous
- » It is a value for the whole installation
- » It is important that the readings be made during a time of peak demand. Readings must be taken at least 15 minutes after the last major load change.

Advantages of power factor correction

- » **Reduced demand charges.** The demand portion of all SaskPower customers is billed on measured kVA (real and reactive power) based on the highest registered demand recorded on the demand meter. Increasing the power factor will decrease the measured kVA, lowering the demand and therefore your monthly bill.
- » **Increased load carrying capability of circuits.** Loads that draw reactive power also demand reactive current. Installing capacitors on the ends of circuits near the inductive loads reduces the amperage on each circuit. In addition, the diminished current flow reduces resistive losses in the circuit.
- » **Improved voltage.** Low power factor results in a higher current flow for a given load. As line current increases, there is a greater voltage drop in the conductor, which may result in poor voltage at equipment.

Disadvantages of power factor correction

- » Capacitors consume energy at the rate of 0.5-1.0 watts per kVAR
- » Slight voltage increase can be expected
- » Blown fuses due to resonance occurring with rectifier circuits in the system
- » Harmonic(s) distortion produced by variable speed drives or other equipment which alters the normal A/C wave can be magnified when capacitors are used

Savings from power factor correction

The most popular method of improving power factor is to install capacitors at the main distribution point, bus, or motor control centre for small motors or at individual large motors. Every customer will experience a different level of cost reduction due to power factor correction, depending on the situation.

Example iv.2 - Power factor (PF) correction costs, savings and payback

Maximum demand = 100 kVA

Minimum power factor = 80 per cent

Assume power factor correction to 95 per cent

Calculate kW:

$$100 \text{ kVA} \times 0.80 = 80 \text{ kW}$$

With a desired PF of 95 per cent, the kW still equals 80, but

$$\text{kVA} = 80 \text{ kW} / 0.95 \text{ PF}$$

$$\text{kVA} = 84$$

The approximate capacitance (kVAR) required is:

$$\text{kVAR} = \sqrt{(\text{kVA}_{\text{old}})^2 - (\text{kW})^2} - \sqrt{(\text{kVA}_{\text{new}})^2 - (\text{kW})^2}$$

$$\text{kVAR} = \sqrt{(100)^2 - (80)^2} - \sqrt{(84)^2 - (80)^2}$$

$$\text{kVAR} = 60 - 25.6 = 34.4$$

Capacitors cost about \$100 per kVAR installed.

$$\text{Cost (\$)} = (34 \text{ kVAR}) \times (\$100)$$

$$\text{Cost (\$)} = \$3400$$

Demand Savings:

$$100 \text{ kVA} - 84 \text{ kVA} = 16 \text{ kVA}$$

Reduced demand charges are:

$$16 \text{ kVA} \times \$10.71/\text{kVA} = \$171.36/\text{month}$$

Payback period:

$$\text{Payback} = \frac{\text{total cost of installation}}{\text{annual savings}}$$

$$\text{Payback} = \frac{\$3,400}{(\$171.36/\text{month}) \times (8 \text{ months/season})}$$

$$\text{Payback} = 2.5 \text{ seasons}$$

Section summary

- » Power factor correction means lower demand charges
- » System power factor should be maintained at or greater than 90 per cent lagging
- » Where economically feasible, install capacitors to improve the power factor to the optimum 95 per cent
- » Size motors to closely match the load they will carry
- » Capacitors, when properly applied, are the main components used for power factor correction

A geo-exchange project review

by Doug Norman

Would a geo-exchange system for heating, cooling and refrigeration reduce the energy costs in your community's hockey or curling arena?

Would it be better to buy a conventional refrigeration plant or maintain your current refrigeration and heating system instead?

To help you answer these questions, here is a brief look at how geo-exchange (heat pump) systems work. In addition, we will provide an overview of the geo-exchange installation put into service at Aberdeen, Saskatchewan in 2005/06. It will also discuss the advantages and disadvantages of installing a geo-exchange system (also known as an earth energy system or ground-source heat pump system).

Understanding heat pump technology

A heat pump does not create heat by burning fossil fuels or circulating electricity through a heating element. It simply extracts low-temperature heat energy from one location, transfers it to another location, and by compressing it to a higher temperature, can make that energy more useful. One tremendous advantage of a heat pump system is that it is reversible and can be used for heating or cooling without duplicate equipment.

Heat pumps are a technology that is common in all refrigeration systems. In fact, a conventional refrigeration system used for making ice in arenas and curling rinks is a type of heat pump. It makes ice by moving heat from under the rink slab to an evaporative or air-cooled condenser. Outside air dissipates the heat to the atmosphere.

Using geo-exchange in arenas

Geo-exchange heat pump systems can be used to create ice for rinks or arenas and to warm viewing areas. They work efficiently by using the ground around the building to collect or dissipate heat. These geo-exchange systems are often known as ground source heat pumps (GSHP). They use a network of pipes, often carrying a mixture of water and methanol, buried in the ground to move heat or cooling. Geo-exchange systems may require several thousand feet of high density polyethylene pipe, depending on the amount of heat or cooling needed for the building.

Depending on the soil conditions and the amount of space available, the pipe may be buried in a horizontal network eight to 12 feet below the surface or in a series of vertical bored holes from 80 to 200+ feet deep.

When geo-exchange systems are making ice or providing air conditioning, they remove heat from the rink pipes or the interior of the building by circulating fluid contained in the pipes through a heat exchanger.

One of the greatest advantages of a heat pump system is that the heat extracted during the ice making process can be pumped to other locations where it is required.

It is common to have a second heat pump to heat the building when the ice plant heat pump is not running or when it is not producing enough waste heat to meet other building requirements.

The initial cost of installing the pipe is high, but as natural gas costs increase, the overall economics of heating with a heat pump improves. Since the coefficient of performance (COP) is 3 to 1 or better, heat pumps act to offset inflationary increases in energy costs.

Why are heat pumps so efficient?

With a standard 60 per cent efficient burning furnace (oil, propane or natural gas), approximately 40 per cent of the energy in the fuel is exhausted straight up the chimney during combustion. Mid-efficient and high-efficient furnaces are better, at about 80 and 92+ per cent efficiency, respectfully.

Ground source heat pumps are also far more efficient than electric radiant heating furnaces. Heat pumps move heat from one place to another, rather than create it through electric elements. For every unit of electricity consumed, a geo-exchange heat pump system delivers at least three units.

Simply reversing the flow of a geo-exchange system will provide cooling for the building. Thus, a geo-exchange system can eliminate the capital cost of a separate air-conditioning system. If a portion of the building is used during the summer cooling months, total annual energy operating costs will be further reduced with a geo-exchange system.

Aberdeen and District Recreation Complex

In 2002, the community of Aberdeen, located in central Saskatchewan, started the work needed to build a hockey arena and curling rink on a site beside the existing high school. The first season of partial operation for the complex was in 2005/06. In addition to the rinks, the facility houses a bowling alley, a senior citizen room, fitness centre, cultural dance area, public library and playschool. The community opted for a geo-exchange heat pump system for the facility's refrigeration requirements. The system also recaptures waste heat from the geo-exchange ice plant and uses it for preheating hot water, snow melting of the ice scrapings, and as space heating. There is a potential to extend the use of waste heat to serve other facilities nearby.

The community and all personnel involved in this project must be commended for their hard work.

Figure v.1 - Exterior view of Aberdeen complex

A view of the skating rink with the curling rink partially shown on the right end of the picture.



Figure v.2 - Interior view of Aberdeen complex

A view of the new arena looking towards the main entrance and second level viewing area.



The recreation committee looked at several facilities with geo-exchange heat pumps prior to making the final decision. Countless hours of community labour and fund raising went into making this community facility a reality.

CANMET – Canadian Energy Technology Centre (a branch arm of Natural Resources Canada) intends to monitor the installation once it is in complete operation. This will help those communities who may be starting from scratch determining the viability of these systems for their own facilities.

Figure v.3 - Main lobby and second floor viewing area**Design considerations**

Proceeding with a geo-exchange heat pump was not an easy decision. Comparative energy savings information from similar operations was considered. Representatives from Aberdeen also visited several facilities with heat pump installations to discuss the advantages and disadvantages.

Based on the committee's investigation, a decision was made to increase the insulation of the building envelope and install a geo-exchange system, rather than a conventional ice plant, to maximize energy savings. They felt the electrical demand charges from a geo-exchange system would be less than from conventional units and the waste heat could be recaptured and substantially reduce the facility's natural gas consumption. Air conditioning costs would be reduced for the areas of the facility used on a year-round basis.

Environmental considerations

By installing a geo-exchange system, Aberdeen demonstrated leadership in reducing their environmental footprint. Greenhouse gases are emitted during the generation of electricity and the burning of natural gas. Consequently, greenhouse gases are produced when energy is used to cool or heat a building. The reduction in the electricity and natural gas consumption results in a positive change in the environmental impact of operating a building.

Figure v.4 - Heat pump air distribution unit

Note the heat pump air distribution unit located above the ceiling tiles in the viewing area.

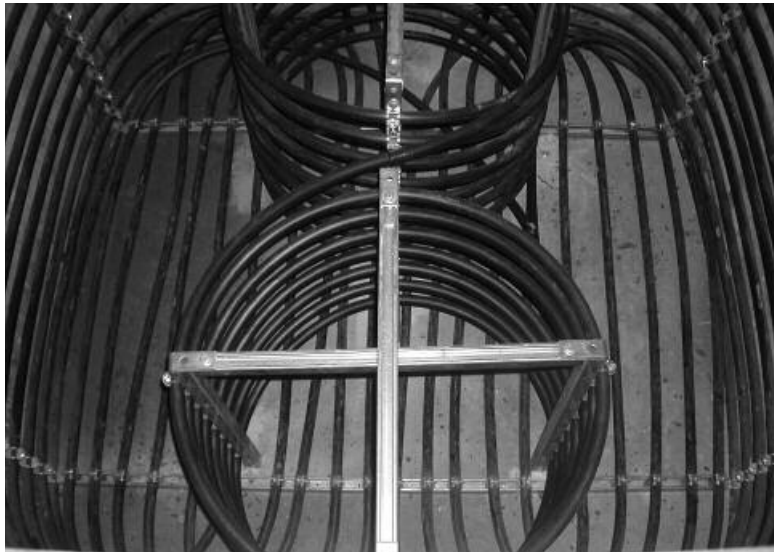


Recapturing waste heat from the refrigeration plant to melt snow scrapings is an environmentally friendly application for the use of waste heat. Snow scrapings normally contain waste paint (for lines and ice surface). Melting that snow rather than dumping it outside year after year allows a facility to more effectively manage the waste material.

Figure v.5 - Ice resurfacers and snow melt pit

Ice scrapings on the snow melt pit.



Figure v.6 - Piping system in snow melt pit

The curling rink in the Aberdeen facility does not use natural gas-fired hanging unit heaters to warm the facility. The curling rink is heated from in-floor pipes installed in the concrete walkways around the perimeter of the rink. The source of heat is waste heat from the geo-exchange units. Insulation between the concrete walkways and the ice surface must be uniform and relatively high (in this case, two inches of rigid styrofoam) to prevent heat transfer to the ice surface, thus providing more consistent ice.

Figure v.7 - Interior view of curling rink

Radiant floor heating in the concrete walkways around the rink supply space heating. The source of the radiant heat is waste heat from the geo-exchange ice plant.



The community of Aberdeen is prepared to share their experience with other communities considering a similar facility.

Questions to ask

Depending on the size and complexity of the total system design, there may be considerable operation and maintenance cost savings with a geo-exchange heat pump system. Answering these questions will assist you in determining the right system for your situation:

What is the cost and frequency of equipment replacement? With a heat pump system (much like your household refrigerator), the compressors are designed to operate with very little maintenance. Rebuilds are not required. The fluid used in an integrated system is typically an alcohol or glycol solution, inside a pressurized sealed system. There is little chance of air entering the system, and much less chance of corrosion inside the heat exchangers or pumps.

What are the shutdown and start-up procedures? Start-up and shutdown procedures for a heat pump system are relatively simple; not much more elaborate than plugging in a refrigerator or starting your home air conditioner. Oil levels do not require monitoring.

Are there hidden installation costs? Some of the installation costs may not be readily apparent. For example, the cost of installing equipment on the roof of a building must include the increased structural cost to support the equipment, the openings through the roof, the increased maintenance costs, and the decreased lifetime of equipment exposed to the harsh Saskatchewan climate.

These system costs may not be included directly in the cost of the mechanical system. They may be hidden in the structural section of the building budget.

What are the applicable codes and regulations? Because of the toxicity of ammonia, equipment using it as the refrigerant is subject to much more stringent code requirements than equipment using other refrigerants. An addition to the building may be needed to house equipment using ammonia refrigerant. Equipment using a safer refrigerant can often be installed in existing space within the building.

Will we need specially trained personnel? The cost of hiring a specially trained technician to start up the system in fall and shut the system down properly in springtime should not be overlooked. The size of the compressors and motors used in some systems may require a more highly trained and highly paid operator than a system with smaller modular units.

What are the costs of maintaining an evaporative condenser vs. ground loop? In a cold climate, the cost of maintaining an evaporative condenser may be significant in comparison to the cost of maintaining an earth loop buried in a field next to the rink or under a parking lot.

What is the annual maintenance schedule for the equipment? Large industrial or commercial refrigeration equipment, though very durable and long lasting if properly maintained, requires scheduled maintenance to maintain dependable performance. Heat pump systems also require annual maintenance, but in many cases it is less complicated and less expensive than conventional systems.

What happens if the system fails? Think about the implications of the failure of a key component of a system. If a pump fails, how long will it take before a replacement pump can be installed? Will expensive overtime service rates be incurred if the pump fails on a holiday?

Do we require additional insulation? Arenas and curling rinks benefit from increasing the insulation of the building envelope. Less heat is required in curling rinks, and comfort is improved in both. The most noticeable savings occur during the spring and fall (or in summer for hockey schools) when outdoor temperatures are much higher. The heat pump operating time (and subsequent consumption cost) will be significantly reduced by increasing the amount of insulation. As suggested earlier, a low emissivity ceiling will also reduce the load on the refrigeration unit, most noticeably during the shoulder seasons.

Figure v.8 - Partial view of low emissivity ceiling



Are there problems with humidity? Controlling humidity is often a problem in arenas and curling rinks. Adequate ventilation must be part of the construction of these facilities. Fan speed should be controlled by a multi-speed motor and vents must close properly when fans are not in operation.

Figure v.9 - Exterior and interior views of ventilation exhaust fan



What level of lighting is required? Proper lighting and lighting control is essential. Skating and curling rinks both use metal halide lighting, which is most often recommended for light efficiency and color rendering. The size and type of lighting should be taken into consideration when deciding on the type of refrigeration and heating system to install in a new facility, or if replacing an existing system.

Figure v.10 - 400 watt metal halide luminaire



If possible, visit facilities with similar systems to yours, and speak with the operators and owners about their experiences. Examine the track record of the supplier and installer of your system to be sure they have the skill, knowledge and staff to complete your work.

In summary, life-cycle construction, operation, and maintenance costs should be significantly lower with a heat pump system than with a conventional, refrigeration system.

Retrofitting possibilities. For existing facilities, installation and retrofit costs are the major drawback for replacing refrigeration units with a geo-exchange heat pump system. Unfortunately, in most retrofitting situations, the floor must be replaced and insulation installed under the floor. The costs to replace conventional refrigeration systems with a geo-exchange system may be much more costly and may not provide the effective use of waste heat.

It is anticipated that an integrated design, where heat recovery is maximized, is most likely to be cost-effective. Retrofits, where a heat pump simply replaces the existing refrigeration unit, will often have longer payback periods, particularly if the arena floor is replaced and heat recapture equipment is installed. If your community is looking at replacing an existing ice plant with a heat pump, you should consider visiting a community where they have undertaken a retrofit to determine the cost-effectiveness of such a system.

Figure v.11 - Refrigeration units in Aberdeen complex

In the Aberdeen complex there are six individual units which provide refrigeration for the curling and skating rinks.



Figure v.12 - Four lane bowling alley in Aberdeen complex



If your community is considering building a new facility, you may find it beneficial to correspond with Aberdeen to find out what worked and what didn't work. You are encouraged to contact the Aberdeen town office at 306-253-4311 for more information.

Building a new facility. The design stage is the right time to integrate heat recovery from either a geo-exchange system or standard refrigeration system. Energy saving measures, such as a thermal storage buffer, a radiant floor heating system, and a snow melt pit are most easily added during the original design stage with very little additional costs during building construction.

The most cost-effective building design will include input from not only the owner and the community, but also from the design engineer or architect, the general contractor, as well as sub contractors and equipment suppliers. The goal is to build a cost-effective, energy efficient, user-friendly, functional and comfortable facility with the lowest possible life cycle cost.

Considering that waste heat from conventional and geo-exchange ice plants can exceed the amount required for heating the arena, the location of a new facility should consider other uses for the excess heat, such as supplementing heat to nearby buildings and facilities.

Rink floors with thermal storage buffer

A rink floor design, with a thick layer of dense material and a second layer of pipe (between the pipe at the rink surface and the insulation), can provide thermal storage that can be a significant benefit to the operation of the rink.

In recent years, most rinks were built to include a 3-4 in. (75-100 mm) thickness of high-density foam insulation placed a couple of inches below the surface to help slow the transfer of heat from the warm ground to the ice sheet. In a facility used during the off-season for other uses, such as inline hockey or lacrosse, a 4-6 in. (100-150 mm) concrete surface is used.

In many older arenas and curling rinks constructed without a permanent concrete floor, the ice sheet is made by laying polyethylene pipe on a sand bed.

Figure v.13 - Conventional rink floor

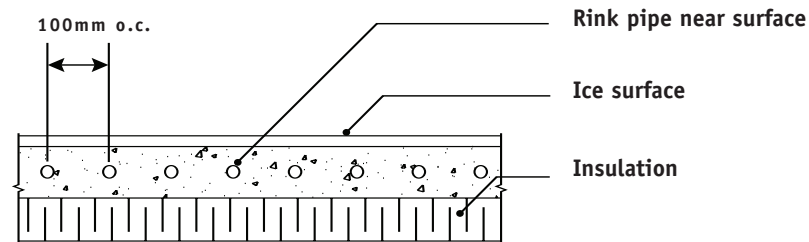
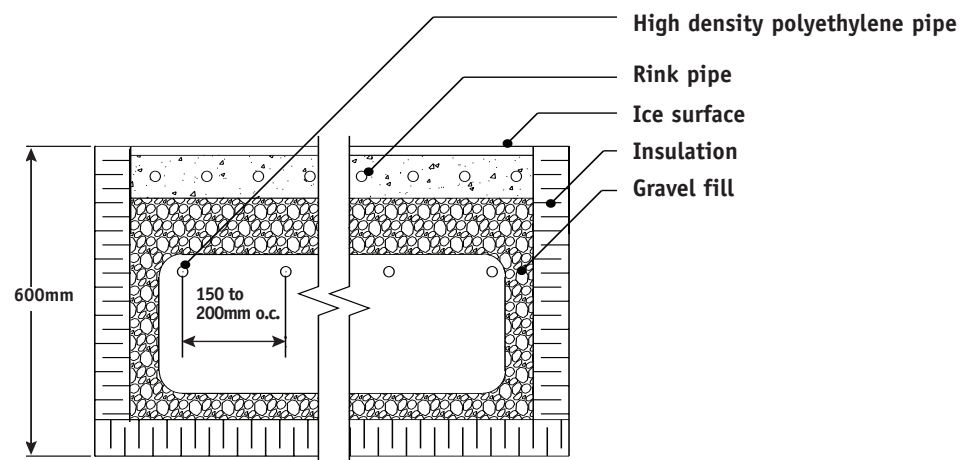


Figure v.14 - Rink floor with thermal storage buffer



Ability to shift peak demand

The large mass of the thickened floor can be cooled several degrees cooler than the ice surface at night, when the ice is not used. The heat taken from the floor can be used to warm the building. The chilled floor absorbs a large portion of the heat from the ice the following day. Basically, the building is heated tonight with tomorrow's refrigeration.

Greater capacity to hold ice

If the power supply to the facility is interrupted, the large mass of the thick concrete floor will absorb enough heat to maintain the ice for several days, eliminating the need to rebuild the ice surface. If a pump or a compressor fails, the stored cold in the floor will help maintain the ice until repairs are made.

More even ice temperature

The ice on a conventional rink floor is maintained only by the chilled fluid circulating through the pipes just under the ice. When a second layer of pipe is buried in a thick layer of dense material directly under the ice surface, the whole floor system chills the ice. The ice temperature is more consistent because the space between the pipes is as cold as the fluid circulating through the pipes at the surface.

The temperature of the large mass of the thick floor system is more difficult to change than the temperature of a conventional floor. This is similar to using a heavy cast iron frying pan rather than an inexpensive, light aluminum pan. The large mass creates more consistent, more uniform ice temperatures.

Smaller brine pump/smaller ice plant

A rink floor is usually designed to remove heat from the ice under the heaviest use. A conventional rink floor relies strictly on the fluid circulated through the pipe immediately under the rink surface to take away all of the heat. Enough fluid must be circulated to remove all of the heat. This requires a sufficiently large circulation pump. Typically, a three-sheet curling rink with a conventional floor will require a 7 1/2 or 10 hp brine pump. A full size hockey rink with a thin floor usually requires a 15-25 hp brine pump.

The mass of the thick floor changes the pumping requirements. A large portion of the heat load on the ice is absorbed directly by the frozen buffer. By reducing the amount of heat that has to be removed by the fluid circulating through the rink pipe, the size of the pump can be reduced. A 2 or 3 hp pump working with the thermal storage buffer absorbs the heat on a three-sheet curling rink. Depending on the use of the hockey rink, one, two or three 3-hp pumps combined with a thick floor will provide the refrigeration needed during heavy use.

When an aging facility needs the concrete floor replaced, a thermal buffer can then be installed. Thermal storage buffers can be installed without a concrete floor. Due to budget constraints, several rinks in Saskatchewan and Manitoba have been built with only the pipe in the thermal storage buffer. After a few years, when the financial resources come available, the concrete floor can be added.

Demand savings: A geo-exchange advantage

Charges for electricity at facilities such as arenas and community halls are generally based on the greatest amount of electricity used during any 30-minute period throughout the month, also known as peak demand. By lowering peak demand, users can substantially lower their electricity bills.

One way to keep peak demand down is to shed unnecessary loads during times of the day when demand for electricity is highest. Unnecessary loads may include domestic hot water heating, parking lot receptacles, large motors and lighting.

The integration of the refrigeration system, the heating system, the energy storage capacity of the earth, and the thermal storage buffer provide significant electricity demand reductions. During the night when the electricity demand in the arena is low, heat pumps – which have lower electricity demand compared with conventional refrigeration systems – work long hours to withdraw heat from the cold storage buffer.

After overnight cooling, the storage buffer can hold the ice during the day, making it possible to turn off the ice-making heat pumps during peak times when the building is heavily used. The result can be a significant saving on electricity bills.

Conclusion

Geo-exchange heat pump systems are now becoming an effective design option for ice rinks throughout Saskatchewan. As the community of Aberdeen demonstrates, when an integrated design is included, a facility can be constructed and operated at lower costs than conventional designs. Any community considering a new facility should seriously consider all possibilities for reducing its ongoing operational costs. It is apparent throughout the province, that increasing costs of operations are challenging the viability of many facilities. The future of many recreational facilities requires forward thinking community leaders who will consider all innovative possibilities.

Table v.1 - Costs to determine when considering a heat pump system

	Ground Source Heat Pump	Conventional System
Low temperature heat pump to make ice	_____	_____
Ground source heat pump for HVAC ducting	_____	_____
Circulation pumps for the ice and earth loops	_____	_____
Vertical earth loop	_____	_____
Controls	_____	_____
Rink floor insulation	_____	_____
Excavation for the rink floor	_____	_____
Insulation under the rink floor	_____	_____
Labour	_____	_____
Conventional ice plant cost	_____	_____
Addition to house the ice plant	_____	_____
Upgrade to the electrical service	_____	_____
Potential incentives	_____	_____
Total Project Cost	_____	_____

Table v.2 - Annual operating and maintenance (O&M) costs

	Ground Source Heat Pump	Conventional System
Energy costs for the rink	_____	_____
Annual service including start-up and shut-down	_____	_____
Daily maintenance (1.5 hours/day)	_____	_____
Ice maker operating staff (6 months/year)	_____	_____
6,000 hour check (cost/year)	_____	_____
12,000 hour check (cost/year)	_____	_____
Replace heat pump (once in 20 years)	_____	_____
Replace circulation pump (once in 20 years)	_____	_____
Replace chiller, header and condenser (20 years)	_____	_____
Replace HVAC system (once in 20 years)	_____	_____
Total annual O&M costs	_____	_____

The information contained in this appendix referring to heat recovery from refrigeration systems has copyright protection. The copyrights are with the Canadian Energy Technology Centre (CETC), Varennes, Quebec, Natural Resources Canada. We thank them for allowing their information to be published in this manual.

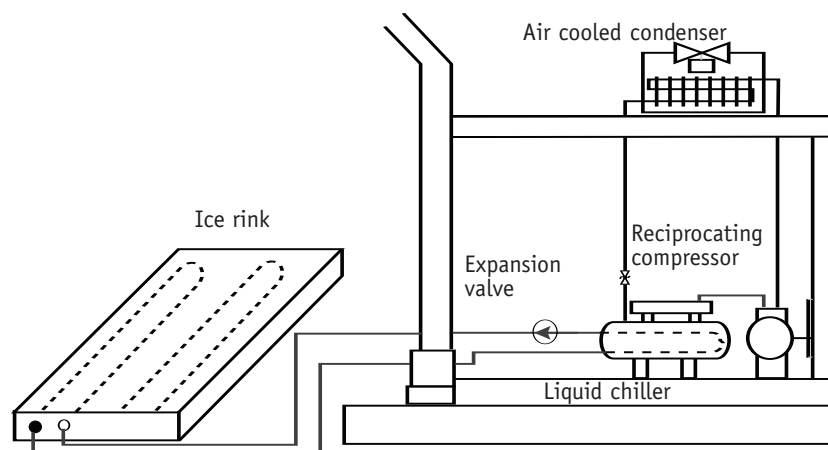
Heat recovery from refrigeration systems - CETC

The amount of heat wasted from refrigeration units is substantial. Much of that heat can be recovered and used to replace other heating requirements in your arena or curling rink.

SaskPower strongly advises each community planning to capture waste heat from your refrigeration system to work closely with your refrigeration plant installer and maintenance provider during the planning and installation stages of heat recovery equipment.

The following information on heat recovery from ice plants was taken from a presentation given by representatives of the Canadian Energy Technology Centre in the fall of 2005.

Figure vi.1 - Traditional refrigeration unit

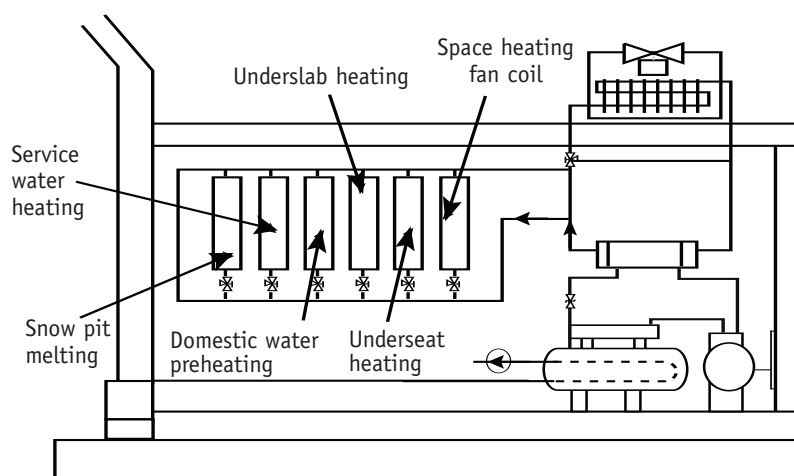


The traditional refrigeration unit expels heat from the condenser unit that is approximately equal to three times the energy consumed by the compressor. This waste heat could have several different uses in your facility.

Applications for recovered heat

Waste heat can be captured by installing a heat recovery unit on the line to the condenser unit. Note the uses for waste heat as shown in Figure vi.2 below. In order to achieve an acceptable payback for installing the retrofits, the arena or rink should operate for at least six months each year. Most of the calculations CETC has used are based on an eight month operating year.

Figure vi.2 - Applications for recovered waste heat

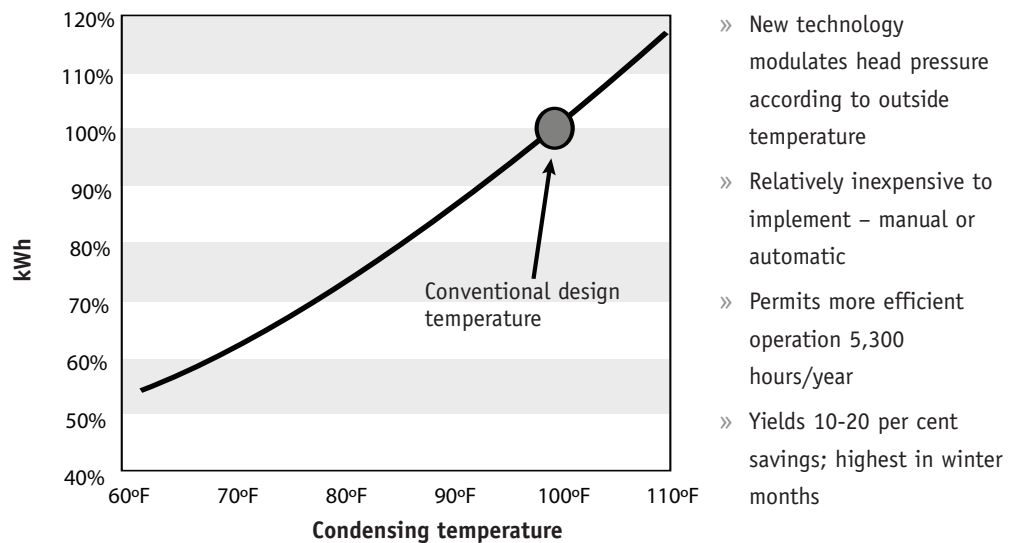


Head pressure control

Another option to save energy is to reduce the head pressure on the compressor.

A traditional refrigeration system uses a fixed and pre-set head pressure. High head pressure causes high condensing temperatures, resulting in high power consumption. Traditional head pressure settings are adjusted for outside design conditions of 86°F (30 C). For year-round rink operation in Canada, design conditions may occur for less than 100 hours per year.

If you modulate the head pressure according to outside air temperature, up to 25 per cent of the energy normally required could be saved and the life expectancy of the compressor would be increased. This should only be attempted with the approval and assistance of the refrigeration unit supplier and maintenance representative.

Figure vi.3 - Condensing temperature savings

A more efficient approach is to have the head pressure correspond with the cooling needed according to the outside temperature. As the outside temperature falls, the compressor does not work as hard to provide cooling. The supplier of your refrigeration equipment should be aware of new technology which will integrate head pressure and the outside temperature.

Financial assistance for commercial, institutional and municipal buildings

Your community project may qualify for financial incentives from different levels of government and supporting organizations. This section has been added to help direct you to proper locations to obtain further information on what assistance is available.

Federation of Canadian Municipalities - Green Municipal Fund

<http://www.fcm.ca/english/gmf/gmf.html>

Municipal governments and their partners can apply for funding for sustainable community planning and infrastructure projects from the Federation of Canadian Municipalities (FCM).

Office of Energy Conservation – Saskatchewan

<http://www.oec.ca/html/funding/Commercial/index.cfm>

The Office of Energy Conservation is a resource for information on cost-effective energy conservation initiatives and practices for Saskatchewan. For more ideas on saving money through energy efficiency, visit the OEC web site at www.oec.ca or call the OEC Hotline at 1-800-668-4636.

Natural Resources Canada

Incentives and Rebates: <http://www.oee.nrcan.gc.ca/corporate/incentives.cfm>

Existing Buildings:

<http://www.oee.nrcan.gc.ca/commercial/financial-assistance/existing/retrofits/index.cfm>

Natural Resources Canada's Office of Energy Efficiency (OEE) wants to help improve energy efficiency in municipal, institutional and commercial buildings. EnerGuide for Existing Buildings (EEB), formerly known as the Energy Innovators Initiative, works with a network of partners and service providers across Canada to provide financial assistance, publications, training and tools for commercial business, public institutions and other eligible organizations. After joining EEB, members can access EEB retrofit incentives, including the new Communities and Institutional Buildings Program.

Eligible organizations:

Commercial Sector (Examples)

- » Retail
- » Hotels
- » Restaurants
- » Office buildings
- » Multi-unit residential buildings
- » Warehouses without manufacturing

Institutional Sector (Examples)

- » School boards
- » Colleges and universities
- » Health care
- » Non-profit
- » Provincial and municipal governments

New Buildings

<http://www.oeenrcan.gc.ca/commercial/financial-assistance/new-buildings/index.cfm>

Energy-efficient designs of new facilities may qualify for the Commercial Building Incentive Program (CBIP).

Regional Incentives

<http://www.oeenrcan.gc.ca/commercial/financial-assistance/existing/retrofits/complementary.cfm>

Some utilities and provincial governments offer incentives and rebates that can be combined with Natural Resources Canada funding.

Renewable Energy

<http://www2.nrcan.gc.ca/es/erb/reed/redi/index.asp>

Visit the Renewable Energy Deployment Initiative (REDI) web site for information on funding for solar heating or biomass systems.

Other Financial Information

<http://www.oeenrcan.gc.ca/commercial/financial-assistance/other-information.cfm>

Understand payback, arrange financing and track your savings.

Cross-Canada Database

http://www.oeenrcan.gc.ca/corporate/statistics/neud/dpa/policy_e/programs.cfm

Search for financial and other initiatives from governments and utilities with the Directory of Energy Efficiency and Alternative Energy Programs.

Buildings, Industry and Equipment

<http://www.oeenrcan.gc.ca/commercial/buildings.cfm>

Quick links to initiatives and incentives.

Tax Incentives

<http://www2.nrcan.gc.ca/es/erb/erb/english/View.asp?x=68>

Visit the Renewable and Electrical Energy Web site for information on tax benefits for large-scale investments in energy efficiency.

Environment Canada

Community Programs, Prairie and Northern Region

EcoAction

The EcoAction Community Funding Program is an Environment Canada program that provides financial support to community groups for projects that have measurable, positive impacts on the environment. EcoAction encourages projects that protect, rehabilitate or enhance the natural environment and build the capacity of communities to sustain these activities into the future.

Saskatchewan Contact(s):

EcoAction

Environment Canada

<http://www.ec.gc.ca/envhome.html>

Room 150

123 Main Street

Winnipeg, Manitoba R3C 4W2

Telephone: (204) 984-5952

Fax: (204) 983-0964

Toll-free (information): 1-800-567-1570

E-mail: ecoaction.pnr@ec.gc.ca

Inquiry Centre

http://www.ec.gc.ca/inqry_e.html

For general information on the programs, services and publications of Environment Canada:

Inquiry Centre

70 Crémazie St.

Gatineau, Quebec K1A 0H3

Telephone: 819-997-2800 or 1-800-668-6767

Fax: 819-994-1412

TTY: 819-994-0736 (Teletype for the hearing impaired)

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