ENERGY IMPROVEMENTS IN PUBLIC ICE ARENAS

FINAL REPORT

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Executive Summary

There are approximately 270 indoor ice arenas in the state of Minnesota which spend a total of $13.5 million annually on energy costs. This project's technology assessment and on-site engineering analyses have demonstrated the potential to cost-effectively reduce ice arena energy costs by an average of 30 percent. After completing a technology assessment and survey of publicly owned arenas, the Center for Energy and Environment (CEE) then worked aggressively with 28 publicly owned ice arenas in Minnesota with the resulting implementation of $575,000 worth of energy efficiency and air quality improvements in 16 arenas. The improvements provide an energy cost savings of $106,500 annually. Educational promotion of energy efficiency and air quality improvements was also carried out.

Both site-specific engineering analyses and matching grants proved to be critical components of the project's efforts to encourage the installation of cost-effective improvements. The site specific engineering analyses proved to be invaluable for the following reasons:

1. the appropriate combination of technologies and their cost-effectiveness varied significantly from arena to arena
2. the audit reports provided clear recommendations along with supporting information that could be used by arena managers as tools both for decision making and to get buy in from key administrators and city council members
3. very detailed engineering specifications were necessary for proper implementation of a number of the measures

The low priority typically given to energy saving improvements was one of the barriers to the success of this project and it made the one-for-one matching grants a key component. A total of $222,900 worth of grants were provided and this amount was matched by local funding sources on a one for one basis. An additional 20 percent of the work was funded by local sources without a match. In addition to the state's matching grants, utility sponsored no-interest loans provided financing for about half of the improvements.[1] With this financial support and follow-up engineering services, one-third of the recommended, cost-effective improvements were installed. The number of completed improvements was partly limited by the ability of the municipalities to devote the necessary budget and administrative time necessary to complete the improvements within the project timeline. Because of competing funding and city staff priorities, a majority of the improvement work was completed in only the last two months that the matching grant funds were available, and three planned retrofit projects were not started.

The amount of post-retrofit verification of energy savings has been limited by the late completion of most of the energy saving improvements. However, on-site monitoring of a number of facilities has provided verification and valuable performance insights for a limited number of the energy and air quality improvements.

[1] These utility sponsored no-interest loan programs are being phased out in 1998.

Ice Arena Survey Results

Ice arena managers were surveyed in the fall of 1995 to gather information that would be useful for project phases that followed. The main objectives for conducting the survey were to:

1. Determine the typical characteristics of Minnesota arena energy systems and operation.
2. Identify the present degree of saturation and arena manager's level of interest in energy efficient technologies to aide in the prioritization of measures.
3. Compile information on arenas interested in participating in the program in order to select the most appropriate arenas for energy audits.

A 47-question survey and program information were mailed to the 151 publicly owned arenas in Minnesota. Follow-up phone calls were made to those arenas that did not respond within the specified time period. Over half of the arenas responded to the survey and 71 of those qualified for the program. Some key results of the survey are described below, while the survey instrument and a summary of the responses to each question can be found in Appendix 1.

While there has recently been increased interest in building more ice arenas in Minnesota, only 8% of the qualified arenas responding to the survey were built in the previous five years. Another quarter were 6 to 20 years old, and two-thirds were more than 20 years old. It is possible that this distribution is not representative of all arenas in Minnesota since managers of newer arenas may have been less likely to believe that energy improvements would provide significant benefits in their facilities and they were less interested in participating. However, the Minnesota Ice Arena Managers Association (MIAMA) 1995 annual survey of 96 single and multiple sheet arenas[2] found an average opening year of 1977, which is fairly consistent with the results from this survey. The high percentage of older arenas indicates that a significant number of arenas are likely to have older equipment that is in need of replacement or upgrades.

Figure 1 shows the percentage of arenas with various operating season lengths. This distribution is consistent with the results from the 1995 MIAMA survey which found the arenas to be open for ice activities an average of 7.8 months per year. Thus, only a little over a third of the arenas are presently operating in the summer months when arena air dehumidification is required. A cross-correlation of responses verified that dehumidification is used in all arenas that operate for at least 9 months and that very few of the arenas which operate for only half of the year have dehumidification equipment. These arenas will need to install dehumidification equipment if they choose to extend their operating seasons significantly. There is, however, a strong trend for newer arenas to have a longer operating season and dehumidification equipment. Figure 2 demonstrates the trend towards using dehumidification equipment in newer arenas. It also shows that although energy efficient gas-fired desiccant equipment has become common in new arenas, it has only been installed in a fraction of the existing arenas with longer operating seasons.

[2] The large majority of MIAMA members are located in Minnesota.

less than $2,500 within three months. For improvements costing more than $10,000, only half of the arenas would be able to fund the work in six months or less while three-fourths would be able to fund the work in one year or less.

This survey was not intended to provide a comprehensive market assessment of energy improvement technologies. However, a number of valuable insights were made about potential energy improvement technologies:

1. A significant number of arenas could be improved by using a multiple pump or multi-speed coolant pumping system.
2. A high percentage of arenas could save energy by varying the ice temperature setpoint according to arena use.
3. There may be a large potential for energy savings and reduced compressor wear from reducing head pressure settings.
4. Snow pit melting, and other uses of heat reclaim, are promising opportunities for reducing energy use in older arenas.
5. Since 95 % of arenas use hot or warm water for flooding the ice sheet, there is a large potential for saving energy through the use of flood water demineralization or other means to lower the flood water temperature.
6. Automated ventilation controls are being used in only a limited number of arenas and may be better able to balance the need for acceptable indoor air contaminant levels and minimized energy costs.
7. In 87% of the arenas individual banks of light fixtures can be switched on or off to vary light levels over the ice sheet. Better light quality and energy savings may be achieved in many arenas using multi-level output fixtures.

Additional relevant information that was used to characterize the refrigeration equipment and the opportunities to reduce its energy use are listed below:

1. Indirect and direct cooling of the ice sheet are used to about the same degree and half of the systems with a mechanical pumping system have a single coolant pump that runs continuously.
2. Three-fourths of the compressors are open-reciprocating (industrial grade), 20% are semi-hermetic reciprocating (commercial grade), and 4% are rotary screw (industrial grade).
3. About one-half of the arenas use coolant temperature for compressor control and most of the rest use a temperature sensor under or in the ice sheet.
4. Most of the arenas use either a water-cooled condenser with cooling tower or evaporative condenser and the remaining one-quarter use air-cooled condensers.
5. About two-thirds of the arenas are using heat reclaim from the chiller for either snow pit melting (30%), subfloor heating (27%), space heating (26%), and/or water heating (14%).
6. R-22 is used as a refrigerant in all of the arenas built in the past ten years and 81% of all surveyed arenas.

These results were used to focus efforts on technologies that are widely applicable to the most common equipment variations.

Assessment and Promotion of Energy Saving Technologies

A thorough assessment of energy saving retrofit technologies that were potentially appropriate for existing ice arenas was conducted early in the project. CEE's engineers contacted a wide variety of local, national, and international industry professionals that included arena designers, refrigeration system designers, and equipment manufacturers. Relevant published information from sources such as trade associations and engineering journals was also reviewed as part of the technology assessment. After objectively reviewing the available information on each technology's expected cost-effectiveness for the variety of ice arenas in Minnesota, CEE's engineers then pared down the list to include those technologies that are worthy of promotion and arena-specific evaluation as part of the energy audits.

Preliminary technology fact sheets were then prepared for technologies that would be cost-effective for a number of arenas in Minnesota. The preliminary technology fact sheets were then distributed to arenas that would be receiving an audit to help familiarize them with the options that would be evaluated. The preliminary fact sheets also served as a starting point for technology specific information that was included in each arena's audit report.

After the completion of the audits and subsequent retrofits, the technology fact sheets were updated and a summary report entitled *Cost-Effective Energy Efficient Improvements for Minnesota's Public Ice Arenas: Overview of 20 Options* was mailed to all the managers of public ice arenas in Minnesota. This report appears in Appendix 2 and it will be sent to interested parties upon request. Other efforts to promote the benefits of energy efficiency and indoor air quality retrofits included leading a roundtable discussion at a meeting of the Minnesota Ice Arena Managers Association and a presentation at an engineering conference.

Arena specific energy savings analysis procedures were also developed for the most viable technologies. For each arena, a site-specific, detailed arena model was developed to perform energy cost savings analyses for most of the promising technologies for each arena.

Utility bill analysis of a number of arenas was also carried out as part of this task to better characterize the typical variation in energy costs among arenas in Minnesota. This helped with preliminary evaluations of the potential energy cost savings for a number of technologies. Insights gained through this analysis also helped guide the development of the energy savings calculation procedures.

Energy Audits

Based on the written survey results (described previously) and follow-up contacts, 28 ice arenas were selected for energy audits.[3] The criteria used in selecting these arenas included considerations of the following factors:

1. Technical potential energy savings based on operation
2. Likelihood that funding and implementation could be realized within the timeline
3. Level of interest in the project and energy saving technologies
4. Even distribution throughout the state

The audited arenas are listed in Table 1 along with a summary of the key audit results. More information about specific arena audits can be found in the individual audit executive summaries that appear in Appendix 4.

Table 1. Summary of Arena Audits

Arena Name	Location	Ice Sheets	Annual Energy Cost	Annual Savings		Retrofit Cost
				Potential	% of Total	
Babbit Arena	Babbitt	1	$20,822*	$4,230	20%	$28,286
Bloomington Ice Gardens	Bloomington	3	$195,176	$49,343	25%	$212,186
Bud King Arena	Winona	1	$34,157	$8,021	23%	$72,233
Chaska Community Center	Chaska	1	$45,539*	$11,799	11%	$64,584
Columbia Arena	Fridley	2	$126,932	$70,170	55%	$346,452
Cottage Grove Ice Arena	Cottage Grove	2	$60,930	$28,252	46%	$167,322
Dave Skenzich Memorial Arena	Gilbert	1	-	$596	-	$3,210
Eagan Civic Arena	Eagan	1	$77,970	$23,205	30%	$95,530
Farmington Civic Arena	Farmington	1	$41,077	$15,114	37%	$85,722
Hodgins Berardo Arena	Coleraine	1	$39,710	$11,148	28%	$66,899
Hoyt Lakes Arena	Hoyt Lakes	1	$44,712	$11,726	26%	$92,164
Hutchinson Civic Arena	Hutchinson	1	$36,283	$8,538	24%	$47,634
Lee Community Center	Morris	1	$16,567	$1,218	7%	$10,854
Lily Lake Arena	Stillwater	1	$30,002	$2,972	10%	$20,373
Litchfield Civic Arena	Litchfield	1	$21,025	$2,815	13%	$23,668
Mankato Civic Arena	Mankato	1	$83,255	$7,397	9%	$51,000
Multipurpose Sports Building	Duluth (UMD)	1	$63,466*	$11,020	17%	$65,649
Parade Ice Garden	Minneapolis	3	$199,190	$58,639	29%	$238,879
Riverside Arena	Moose Lake	1	$30,002*	$651	2%	$6,841
VFW Memorial Ice Arena	E Grand Forks	1	$45,539	$2,142	5%	$13,858
Victory Memorial Ice Arena	Minneapolis	1	$50,671	$27,115	54%	$82,185
West St. Paul Arena	West St. Paul	1	$31,879	$2,116	7%	$18,796
Total	22	28	$1,294,904	$358,227	28%	$1,814,325
Per Ice Sheet	-	-	$46,247	$12,794	-	$64,797

*Because of limited utility data, these values are estimates based on the energy costs of similar arenas.

[3] Each of these arenas was required to verify compliance with Minnesota's prime ice time and gender preference requirements by submitting the Ice Arena Compliance Form that is found in Appendix 3.

Annual arena energy costs for the audited arenas average about $46,000 with significant site to site variances. Although a number of factors affect energy use, the two most dominant factors were operating season and indoor space temperature.

The energy audits identified a total of $358,000 worth of annual energy savings that could be realized by implementing all energy saving retrofits with a payback of 10 years or less. The average payback for the measures identified in the audits is 5 years. This amounts to a 28% potential reduction in energy costs or about $13,000 annually for a typical ice arena with the project group's average energy cost of $46,000. In addition, the energy audits found that over $30,000 in annual energy cost savings could be realized through simple adjustments to equipment controls without any substantial up-front costs. Although a variety of factors, such as operating season and degree to which an arena is heated, affected the amount of cost-effective energy savings that could be achieved for the various arenas, it was interesting that age of the arena was generally not a key factor.

Therefore, when the audit reports were delivered to the last 15 arenas, they were only guaranteed grants of at least $5,000 each for eligible improvement projects. Deadlines for turning in Energy Grant Applications were then established, and those arenas that applied for a grant of more than $5,000 were subsequently guaranteed larger grant amounts after other arenas decided not to apply. Some arenas then completed less work than was originally committed to, and three arenas did not complete any of the work committed to within the timeframe of the project. The matching grant funds that were freed up by these unmet commitments were distributed to the arenas that were completing the improvements within the project timeline. Since there was then enough grant money to provide a full one-for-one match to each participating arena that applied for and completed eligible improvement projects, some exceptions to the three previously listed requirements were granted. Table 3 shows how the original commitments to complete improvement projects translated into actual project completions and how the individual energy grants were effected. The "Original" grant amount reflects the minimum grant that was guaranteed after all applications were received, while the "Limited" grant amount reflects the arenas' energy grants according to a strict application of the three limitations that were temporarily established to make sure that the energy grant funds were not exhausted by the first participating arenas.

Table 3. Arena Follow-Through on Improvement Commitments

Arena	Location	Ice Sheets	Improvement Cost		Energy Grant Amount		
			Committed	Completed	Original	Limited	Final
Bloomington Ice Garden	Bloomington	3	$207,407	$195,774	$75,000	$75,000*	$93,273
Chaska Ice Arena	Chaska	1	$16,500	$0	$7,560	$0	$0
Cottage Grove Ice Arena	Cottage Grove	2	$144,322	$135,291	$50,000	$50,000*	$67,646
Eagan Civic Arena	Eagan	1	$9,530	$0	$4,765	$0	$0
Farmington Civic Arena	Farmington	1	$68,422	$55,308	$20,000	$15,906*,**	$25,937
Hutchinson Civic Arena	Hutchinson	1	$47,634	$28,675	$20,000	$14,338	$14,338
Lily Lake Arena	Stillwater	1	$10,345	$10,345	$5,000	$0**	$5,173
Litchfield Civic Arena	Litchfield	1	$15,500	$15,500	$7,750	$7,750	$7,750
Parade Ice Garden	Minneapolis	3	$59,174	$59,174†	$29,587	$0†	$0†
Riverside Arena	Moose Lake	1	$6,841	$6,841	$3,421	$3,421	$3,421
VFW Memorial Ice Arena	E Grand Forks	1	$7,400	$5,587	$3,700	$2,794	$2,794
Victory Memorial Arena	Minneapolis	1	$43,600	$57,021†	$0†	$0†	$0†
West St. Paul Arena	West St. Paul	1	$12,600	$5,138	$5,000	$338***	$2,569
Total	13	16	$649,275	$574,654	$231,783	$169,547	$222,901

†Ineligible for grants because improvements completed outside of the project timeline or with other state funding.
*Grants limited by $25,000 per ice sheet.
**Grants limited by higher actual costs leading to a payback > 10 years.
***Grant limited by payback of < 2 years.

Although some individual projects were delayed or dropped, the overall expenditures were 89 percent of the original commitments. Competing priorities for administrative and financial municipal resources was the biggest barrier to completion. Improvements at one site were postponed because the allotted budget was used for an emergency refrigeration equipment replacement, while two other improvement projects were delayed because key arena administrators could not take time away from the oversight of building addition projects. Some specific parts of other improvement projects were dropped when CEE's follow-up engineering services provided for project specification and construction oversight led to a change in the recommendations for those arenas. Variations between original cost estimates and actual installed costs also affected the ratio of project completions to commitments. Although various factors led to improvement project delays and cancellations, the fact that energy savings for actual improvements is 84 percent of what was projected for all improvement commitments indicates that these were not a major hindrance to the project's success once an arena actually made a commitment.

While follow-through on commitments was high, there were significant barriers to securing commitments to install cost-effective energy efficiency and air quality improvement measures. Only about 30 percent of potential cost-effective energy savings identified by the audits was actually implemented. The most important barrier preventing arenas from installing these improvements was the inability and low priority of municipalities to set aside funds for these improvements. This was exacerbated by the number of arenas that only had a window of from 4 to 9 months between receipt of the audit and the end of the project. One key to overcoming these barriers was by promoting the multiple benefits of many of the improvements beyond the primary energy efficiency or air quality improvement. Some examples of how other benefits helped to encourage energy saving improvements are listed below:

1. The installation of flood water demineralization equipment improves both the clarity and durability of the ice sheet, besides saving energy.
2. Lighting upgrades often lead to improved lighting levels while saving energy.
3. Lighting, motor, and refrigeration control upgrades allow arenas to install new equipment that will have reduced maintenance needs.
4. Low-emissivity ceiling installations improvedthe distribution of light and reduced ceiling moisture condensation while saving energy.
5. One of the condenser fan adjustable speed drive installations is expected to solve significant refrigeration equipment problems.

Because of these multiple benefits, many arenas made significant investments in improvements with energy savings paybacks on total costs of up to 10 years—even beyond 10 years in some cases. Because of grants and rebates, the actual payback periods for the municipal investments is less than or equal to half of the payback on total costs. Figure 6 shows the number of arenas that invested in each type improvement while Figure 7 energy savings payback time.

Another factor that helped many arenas overcome the funding priority barrier was the offer of zero interest financing by Northern States Power Company (NSP) and rebates from various utilities. This project leveraged more than $60,000 in energy improvement rebates from utilities, which helped reduced the arenas' net installation cost. A total of $252,000 worth of improvement work was also financed through NSP's no-interest loans that are paid back over the length of the energy savings payback period. In this way, the municipalities do not have to allocate any funds for improvements—they simply pay back the loan with the money that is saved on utility bills. While many arenas have benefited from NSP's Local Government Program, NSP has phased it out as of July 1998.

Appendix 1.
Survey Result Summary

Energy Improvements In Minnesota Public Ice Arenas
Arena Manager Survey

Arena Owner: ______________________________

Arena Name: ______________________________

Contact Person: ____________________ Phone Number: ____________________

Title: ____________________

This survey should be completed by the ice arena manager or the person that is most familiar with the arena refrigeration and other mechanical systems. Please fill-out a survey for each ice sheet at your facility. If you have any questions about the survey, contact Mark Hancock at (612) 348-8821.

General Arena Information

1. Is this arena publicly owned? **(N = 77)**

   (a) Yes 93 %
   (b) No 7 %
   (If no, you will not qualify for this program. You may stop here and return the survey to CEE.)

2. Approximately when was this arena built? **(N = 75)**

   (a) 1991 - 95 8 %
   (b) 1986 - 90 13 %
   (c) 1976 - 85 15 %
   (d) before 1976 64 %

3. Please estimate the spectator seating capacity. **(N = 74)**

   (a) 0 - 300 16 %
   (b) 300 - 750 32 %
   (c) over 750 52 %

4. Which one of these options best describes the arena structure? **(N = 75)**

   (a) steel beam, flat roof 35 %
   (b) steel beam, arched roof 37 %
   (c) wood beam, flat roof 0 %
   (d) wood beam, arched roof 24 %
   (e) other 4 %

5. How many <u>months</u> per year does your arena operate with an ice sheet in place? **(N = 75)**

   (a) less than 7 39 %
   (b) 7 - 8 25 %
   (c) 9 - 10 15 %
   (d) 11 - 12 21 %

6. About how many hours per day is the arena open for ice sheet activities during each season (check one in each row)?

	none	1 - 15 hrs	16 - 19 hrs	20 - 24 hrs	
Winter	**0 %**	**59 %**	**37 %**	**4 %**	**(N = 75)**
Spring/Fall	**9 %**	**72 %**	**16 %**	**3 %**	**(N = 65)**
Summer	**42 %**	**32 %**	**23 %**	**3 %**	**(N = 65)**

7. What is the hardness of your ice sheet flood water (grains)? **(N = 72)**

(a) 0 - 5 **23 %**
(b) 5 - 10 **35 %**
(c) 10 -20 **32 %**
(d) > 20 **10 %**
(e) don't know **(N = 41)**

8. What is the temperature of the flood water used for resurfacing? **(N = 75)**

(a) hot (e.g. only heating water or above 120 degrees) **64 %**
(b) warm (e.g. a mixture of hot and cold or 80 to 120 degrees) **31 %**
(c) cold (e.g. only use cold tap water or less than 80 degrees) **5 %**

9. What electric utility serves this facility? **(N = 74)**

(a) Interstate Power Company **3 %**
(b) Minnesota Power & Light **12 %**
(c) Northern States Power **48 %**
(d) Otter Tail Power **7 %**
(e) Other **30 %**

10. What natural gas utility serves this facility? **(N = 75)**

(a) Great Plains Natural Gas **3 %**
(b) Midwest Gas **1 %**
(c) Minnegasco **37 %**
(d) Northern States Power **23 %**
(e) Peoples Natural Gas **8 %**
(f) None **5 %**
(g) Other **23 %**

Arena Energy Improvements

11. Has an energy audit of this arena been completed within the past 10 years? **(N = 75)**

(a) No **75 %**
(b) Yes **25 %**

If yes, is the audit available for review? **(N = 17)**

(a) No **12 %**
(b) Yes **88 %**

12. Is this arena presently being served by a shared energy savings program that would prohibit you from participating in this State funded program? **(N = 65)**

(a) No **97 %**
(b) Yes **3 %**

13. Have there been any major renovations or changes to the arena in the past two years that would have significantly affected the energy use? **(N = 75)**

(a) No 63 %
(b) Yes 37 %

14. Are there approved plans for any major arena renovations or changes for the next two years that would significantly affect the arena energy use? **(N = 70)**

(a) No 76 %
(b) Yes 24 %

15. Please specify your level of interest in each of the energy improvement technologies listed below (check one box in each row).

		Already Present	Future Installation Planned	Interested in Installation	Would not Consider Installation	Not Familar With Technology
Multi-level ice sheet lighting	(N = 65)	18 %	5 %	34 %	29 %	14 %
High efficiency motor replacement	(N = 63)	17 %	3 %	56 %	10 %	14 %
Reflective ceiling	(N = 63)	6 %	11 %	46 %	24 %	13 %
CO controlled exhaust ventilation	(N = 67)	19 %	2 %	42 %	22 %	15 %
Resurfacer door ventilation control	(N = 67)	9 %	3 %	43 %	27 %	18 %
Desiccant dehumidification	(N = 66)	12 %	6 %	50 %	18 %	14 %
Electric dehumidification	(N = 65)	19 %	5 %	35 %	32 %	9 %
Electric ice resurfacer	(N = 68)	12 %	10 %	56 %	22 %	0 %
Demineralized flood water	(N = 66)	8 %	9 %	42 %	21 %	20 %
Multi-speed brine pump control	(N = 64)	6 %	6 %	39 %	27 %	22 %
Evaporative chiller condenser	(N = 64)	38 %	0 %	31 %	9 %	22 %
Upgrade chiller controls	(N = 65)	21 %	5 %	54 %	9 %	11 %
Chiller waste heat recovery	(N = 68)	34 %	0 %	52 %	7 %	7 %

16. Please specify any technologies not listed that you believe should be considered for this program.

Insulation (6)
variable-speed drive (2)
ECMS (1)
infrared heating (1)
infrared ice temperature control (1)
set-back thermostat (1)
refrigeration pump (1)
demand limit control (1)

17. Which of the following problems do you presently have in your arena?

(a) Poor arena light quality or control (N = 23)
(b) Fogging or structural moisture condensation (N = 40)
(c) High energy costs (N = 33)
(d) Unsatisfactory ice quality (N = 6)
(e) Difficulty maintaining arena air temperature (N = 23)
(f) Poor arena ventilation level or control (N = 16)
(g) Refrig. system requires freq. manual adjustment (N = 10)
(h) None (N = 6)
(i) Other (N = 7)
water purity (2)

18. The arena owner will be required to pay some of the cost of the energy improvements installed as part of this program, but you will be able to use any source of funds except State money. About how many months would it take to get approval to fund an energy improvement that would pay for itself in five years or less if the cost of the improvement is (please circle one value for each row):

	0 - 3	4 - 6	7 - 12	> 12	funds not available	don't know	
Less than $2,500	71 %	11 %	8 %	6 %	4 %	(N = 16)	(N = 64)
$2,500 to $10,000	44 %	21 %	19 %	11 %	5 %	(N = 20)	(N = 63)
more than $10,000	22 %	24 %	32 %	17 %	5 %	(N = 29)	(N = 70)

note: percentages do not include "don't know" responses

Arena Lighting Information

19. What is the main type of lighting used above the arena ice sheet? (N = 75)

(a) **Incandescent** (conventional bulbs) 0 %
(b) **Fluorescent** (tubes or compact bulbs) 5 %
(c) **High intensity discharge** 92 %
(includes metal halide, high pressure sodium, and mercury vapor)
(d) **Other** 3 %
a and b, b and c

20. What type of control is used to vary the light level in the arena? (N = 75)

(a) **On/off switching of all fixtures together** 5 %
(b) **Bi-level or multi-level output fixtures** 4 %
(c) **On/off switching of separate banks of fixtures** 87 %
(d) **Other** 4 %

21. About what fraction of the arena area other than above the ice sheet is supplied by these types of lighting (please circle one answer for each type - fractions should add to 1).

	0	1/4	1/2	3/4	1	
Incandescent (conventional bulbs)	3	7	10	0	5	(N = 25)
Fluorescent (tubes or compact bulbs)	2	3	13	6	40	(N = 64)
Other	3	2	4	1	2	(N = 12)

HVAC and Related Mechanical Systems

22. What type of ventilation system is used in the arena (check all that apply)? (N = 75)

(a) **Central air handling system with outside air intake** (N = 24)
(b) **Individual roof-top units with outside air intakes** (N = 17)
(c) **Exhaust fans** (N = 62)
(d) **No mechanical ventilation; natural ventilation only** (skip to question 24) (N = 1)
(e) **Other** (N = 1)
wall louvers

23. How is the ventilation system controlled? (N = 73)

(a) **Manually activated** 78 %
(b) **Switch activated by resurfacing** 4 %
(c) **Carbon monoxide or nitrogen dioxide sensor** 3 %
(d) **Time clock** 10 %
(e) **Other** 5 %
temperature-regulated switch (1), ECMS (2)

24. What type(s) of dehumidification are used in the arena (check all that apply)?

(a) **Air conditioner system**	**(N = 18)**
(b) **Electric dehumidifier**	**(N = 15)**
(c) **Desiccant dehumidifier**	**(N = 9)**
(d) **No dehumidification**	**(N = 32)**
(e) **Other**	**(N = 0)**

25. Does your arena use a snow melt pit? **(N = 75)**

(a) **No** **40 %**
(b) **Yes** **60 %**

If yes, how is it heated? **(N = 42)**

(a) **Chiller waste heat**	**67 %**
(b) **Water heater**	**14 %**
(c) **Boiler**	**5 %**
(d) **Other**	**14 %**
hot water (4)	

If yes, how is it controlled? **(N = 38)**

(a) **Manually**	**40 %**
(b) **Snow pit temperature**	**50 %**
(c) **Other**	**10 %**
brine/glycol temperature (2)	

26. What type of fuel does your primary ice resurfacer use? **(N = 75)**

(a) **LP**	**84 %**
(b) **Natural gas**	**0 %**
(c) **Electric** (battery)	**11 %**
(d) **Electric** (tether)	**1 %**
(e) **Gasoline**	**4 %**
(f) **Other**	**0 %**

Refrigeration System Information

27. Which refrigerant is used in the refrigeration system? **(N = 74)**

(a) **R-22**	**81 %**
(b) **Ammonia**	**14 %**
(c) **Don't know**	**0 %**
(d) **Other**	**5 %**
R502 (3)	

28. What type of rink chilling system is used? **(N = 73)**

(a) **Direct** (the refrigerant passes through piping under the ice rink itself)	**45 %**
(b) **Indirect** (a chiller cools a brine or glycol solution that is circulated under the rink - skip to question 30)	**55 %**
(c) **Don't know** (skip to question 30) **(N = 0)**	**0 %**

29. If direct, are you considering converting it to an indirect system (check all that apply)?

(a) **In the near future--plans are already under way**	**(N = 1)**
(b) **After the next refrigerant leak or major refrigeration system problem**	**(N = 2)**
(c) **Within the next five years--no firm plans are yet being made**	**(N = 1)**
(d) **Not within the next five years**	**(N = 19)**
(e) **Don't know**	**(N = 16)**

30. Are the refrigeration system setpoints (i.e. ice temperature) varied for any of the following (check all that apply)? (N = 73)

(a) **Non-operating versus operating hours** (N = 12), 16%
(b) **Based on activity** (i.e. different for hockey, figure skating, and/or open skating) (N = 25), 34%
(c) **Never** (N = 40), 55%

31. Who was the contractor that installed your refrigeration system?

Firm name: ____________________
Contact name and city (or phone): ____________________
(a) **Don't know**

32. How were the refrigeration system components purchased by the contractor or arena? **(N = 72)**

(a) **Most of the main components were purchased from a third party that packaged the refrigeration system47 %**
(b) **The main components were purchased from various vendors and put together by the installing contractor29 %**
(c) **The main components were purchased from the compressor manufacturer 15 %**
(d) **Don't know (N = 27)**
(e) **Other 9 %**
If (a) or (c), list the vendor name and city below.

____

33. Who provides regular service and maintenance for the refrigeration system? **(N = 74)**

(a) **Done in-house 41 %**
(b) **Contractor 59 %**
Firm name, contact name, and city (or phone): ____________________

34. Which refrigeration contractor(s) would you be likely to employ for major renovation or replacement of the refrigeration system (*this answer will be kept confidential and the results, if released at all, will only be released as a summary of all survey respondents*)?

Firm name: ____________________ ____________________
Contact name and city: ____________________ ____________________

The following questions may require a fairly detailed knowledge of the arena refrigeration system. If you do not know the answer to these questions, please skip to question 47 to request an arena audit and return the survey to our office.

35. What is the type of refrigerant feed to the evaporator (or chiller bundle)? **(N = 63)**

(a) **Direct expansion (with thermostatic expansion valve control) 47 %**
(b) **Flooded (refrigerant liquid level control) 18 %**
(c) **Liquid overfeed pumped by compressor discharge gas pressure 31 %**
(d) **Liquid overfeed pumped by mechanical pumps 4 %**
(e) **Other 0 %**
(f) **Don't know (N = 14)**

36. How many pumps are used to circulate brine, glycol, or refrigerant under the ice and how is the pump(s) controlled? **(N = 67)**

(a) **None (e.g. gas pumped liquid overfeed) 28 %**
(b) **One single-speed pump that is run continuously 37 %**
(c) **One pump that is cycled or operated at multiple speeds 5 %**
(d) **Multiple pumps that are operated continuously 12 %**
(e) **Multiple pumps that are cycled or have multiple speed control 18 %**
(f) **Don't know (N = 2)**

37. What is the total refrigeration system size (answer both if known)?

(a) ___181*___ **hp of compressor motors** **(N = 59)**
(b) ___134*___ **tons of cooling capacity** **(N = 40)**
(c) Don't know **(N = 8)**
* indicates average value of responses

38. How many compressors does the ice rink refrigeration system have?

___2.4 *___ **(N = 72)**
(a) Don't know **(N = 0)**
* indicates average value of responses

39. What type of compressor(s) does the refrigeration system have (check all that apply)? **(N = 70)**

(a) Semi-hermetic reciprocating (the motor is encased within the compressor) **(N = 14)**
(b) Open reciprocating (motor is separate and uses a belt or shaft to drive the unit) **(N = 54)**
(c) Rotary screw **(N = 3)**
(d) Other **(N = 0)**

40. Which of the following is used to provide <u>part-load operation</u> of at least one of the compressors? **(N = 68)**

(a) Cylinder unloading **(N = 46)**
(i.e. blocked suction, by-pass gas, open suction valve, incr. re-expan. volume)
(b) Slide valve control for a screw compressor **(N = 3)**
(c) The suction pressure floats up to reduce capacity **(N = 2)**
(d) No part-load compressor control is implemented **(N = 9)**
(e) Don't know **(N = 9)**

41. Is <u>heat reclaimed</u> from the <u>refrigeration system</u> for any of the following purposes (check <u>all that apply</u>)? **(N = 70)**

(a) Space heating or reheat of dehumidified air **(N = 18)**
(b) Snow pit melting **(N = 21)**
(c) Subfloor heating **(N = 19)**
(d) Hot water heating or preheating **(N = 10)**
(e) None of the above **(N = 26)**
(f) Don't know **(N = 0)**

42. What type of <u>refrigerant condensing</u> system is used? **(N = 70)**

(a) Air-cooled condenser **23 %**
(b) Water cooled condenser with a cooling tower **48 %**
(c) Evaporatively cooled condenser **29 %**
(d) Don't know **0 %**

43. What is the minimum head pressure setting?

___161*___ **psig** (pounds per square inch) **(N = 36)**
(a) Don't know **(N = 26)**
* indicates average value of responses

44. How is the head pressure controlled (check <u>all that apply</u>)" **(N = 66)**

(a) Liquid floodback valve and/or condenser bypass **(N = 1)**
(b) Cycling off condenser fans based on head pressure **(N = 50)**
(c) Cycling off condenser fans based on outside temperature **(N = 2)**
(d) Other **(N = 6)**
(e) Don't know **(N = 11)**

45. How are the compressors controlled? **(N = 70)**

(a) Suction pressure control (e.g. one cycles off at 35 psig pressure) **4 %**
(b) Brine or refrigerant temperature **49 %**
(c) Ice temperature control (embedded in the ice itself) **44 %**
(d) Other **3 %**
(e) Don't know **0 %**

46. Are there other special features of the refrigeration system that we should be aware of? **(N = 57)**

(a) No **86 %**
(b) Yes **14 %**

47. Are you interested in having CEE conduct an energy and indoor air quality audit of this arena (*this is a required first step necessary to obtain a grant to install energy improvements*)? **(N = 70)**

(a) No **6 %**
(b) Yes **94 %**

If yes, when in 1996 would you prefer to have the audit performed?

(a) January - March **68 %**
(b) April - June **17 %**
(c) July - September **3 %**
(d) October - December **3 %**
(e) no preference **9 %**

Thank you for your cooperation. Please return this survey in the postage-paid envelope provided. Someone from our office will contact you in January 1996 to give you more information about the program.

Appendix 2.
Summary Report on Arena Energy and IAQ Improvement Opportunities

available upon request

Appendix 2.
Summary Report on Arena Energy and IAQ Improvement Opportunities

COST-EFFECTIVE ENERGY EFFICIENT IMPROVEMENTS FOR MINNESOTA'S PUBLIC ICE ARENAS: OVERVIEW OF 20 OPTIONS

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Energy Improvements
in Minnesota Public Ice Arenas Project

June 1998

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*** Possible low-cost/no-cost improvements**

OPERATION AND MAINTENANCE IMPROVEMENTS

*Increase Ice Temperature

Many arenas can substantially reduce energy costs by increasing the average ice temperature. The ice sheet constantly absorbs heat from the warmer air and building around it and the rate of heat absorption naturally decreases as the temperature of the ice sheet goes up. Because the refrigeration system must work to remove the heat that the ice sheet absorbs, its energy use also decreases whenever the ice sheet temperature can be raised even slightly. The reduced heat absorption also reduces the amount of energy needed to heat the arena and the higher average ice sheet temperature causes the refrigeration system to operate more efficiently.

Because the overriding concern of arena operators must be to maintain the ice sheet integrity, temperature controls are often set at a conservatively low value that will maintain ice sheet quality under the most adverse conditions. Because the ice sheet might be subjected to such adverse conditions for only a few hours, days, or weeks, a conservatively low temperature setpoint will keep the ice sheet colder than it really needs to be the majority of the time. Depending on an arena's schedule and refrigeration system, it may also be practical to substantially increase the ice temperature during long unoccupied periods (e.g. overnight and throughout the morning). Unless an automatic set-back control is used, adjusting ice temperatures may require daily, manual adjustments Annual energy cost savings from increasing the average ice temperature only 1°F range from $200 to $800 for a six-month arena and from $800 to $1,600 for a year-round facility.

*Reduce Ice Sheet Thickness

Control and reduction of ice sheet thickness can reduce energy costs while also providing more consistent ice quality. While the minimum acceptable ice sheet thickness varies somewhat from arena to arena, a typical optimal thickness is one inch or less for arenas with an even concrete base; arenas with a sand base may need ice at least two to three inches thick to provide adequate support for the resurfacer. Reducing the ice sheet thickness by one-quarter inch will allow the ice surface temperature to be kept the same while the coolant or slab temperature setting is increased by two-thirds of a degree. Increasing the coolant and slab temperatures saves energy by increasing the efficiency of the refrigeration system. Typical annual energy cost savings from increasing the ice temperature one degree (one-half inch reduction in ice thickness) are approximately $145 for a six-month arena and $300 for facility that operates more than 9 months. In addition to energy savings, closely controlling ice thickness also makes the quality of ice more consistent because the ice surface temperature is closer to the rink floor and coolant temperature.

*Reduce Refrigeration System Head Pressure Controls

Energy consumption in many ice arenas can be reduced by adjusting the refrigeration system's head pressure controls. The refrigeration system keeps the ice sheet cold by recirculating refrigerant. The refrigerant absorbs heat from under the ice sheet and then dumps that heat to the

* Possible low-cost/no-cost improvement

outside air through a condenser. In order for heat to flow from the refrigerant in the condenser to the outside air, the refrigerant must be at a high temperature and pressure (referred to as the head pressure). This high temperature and pressure is generated by the compressors that pump the refrigerant through the various parts of the refrigeration system. Since the compressors are the primary energy users in the refrigeration system, reducing the head pressure will save significant amounts of energy and reduce wear on the compressors. Many direct refrigeration systems will operate properly with head pressures as low as 150 psi, while many indirect systems (those with thermostatic expansion valves) may need higher pressures of 175 psi. Typical annual energy cost savings that can be realized with only a 20 to 25 psi reduction are $400 to $1,000 for a six-month arena and $900 to $1,800 for facilities that operate 9 months or more.

The head pressure can be reduced in two ways: (1) by manual adjustment or (2) by replacing standard condenser controls with more efficient automated condenser control systems (see refrigeration system section). The refrigeration industry has traditionally encouraged maintaining a higher than necessary head pressure by turning off fans that blow outside air through the condenser and/or by using a pump that sprays water over the condenser. These approaches are very conservative in terms of ensuring adequate cooling of the ice under the most taxing conditions; however, these practices unnecessarily increase energy costs and wear on the compressors during periods of normal arena operation. This energy conservation method has already been successfully implemented in several Minnesota ice arenas.

LIGHTING IMPROVEMENTS

Efficient Lighting Fixtures for Public Spaces

A number of existing technologies can make interior and exterior lighting significantly more energy efficient. The impact any particular lighting improvement has on operating costs depends heavily on the hours of operation. Obviously, fixtures which are operated 24 hours a day will provide more savings from high efficiency improvements than similar fixtures that only operate for a fraction of each day. Maintenance costs for replacing spent fixtures must also be considered when calculating the paybacks of lighting improvements.

There are six main types of lighting improvements which are feasible in most ice arenas. Ice sheet lighting recommendations are dealt with in the next section.

1. Replacing standard incandescent lamps or "light bulbs" with more efficient fluorescent lamps will use 30 to 80 percent less electricity per lamp while producing the same light levels. In addition, maintenance costs will be reduced since fluorescent lamps last 5 to 12 times longer than standard incandescents.

2. Replacing existing four or eight foot fluorescent fixtures with high efficiency fluorescent T-8 lamps and improved electronic ballasts can provided significant cost savings.

3. Public areas such as halls, corridors, and lobbies often have more fixtures than are needed for desired light levels. Wasted light can easily be eliminated by either using lower wattage ballasts (dewatting) or disconnecting unnecessary ballasts (delamping).

4. Replacing incandescent or compact fluorescent exit signs with low power LED lamps can save from 14 to 39 watts per fixture. Since LED lamps have a life expectancy of over 20 years, maintenance costs can also be significantly reduced.

5. Exterior incandescent or quartz flood lights can be cost effectively upgraded to energy efficient high intensity discharge lamps, such as metal halide or high pressure sodium fixtures.

6. Timed switches and occupancy sensors are automatic controls which turn off lights in unoccupied areas and turn them on only when needed. Storage areas, public restrooms, hallways, offices, meeting rooms, and outdoor entrances are often cost-effective applications for these automatic controls.

All of the previous lighting recommendations have been implemented successfully in hundreds of commercial buildings in Minnesota. The payback of any lighting improvement must be calculated on an area by area basis since operating hours and other conditions may vary significantly. Many electric utilities offer lighting efficiency rebates. A few arenas that have recently upgraded public space lighting are listed below.

Arena	Contact Person	Phone
Bloomington Ice Gardens	Andy Baltgalvis	(612) 948-8842
Farmington Civic Arena	Jim Bell	(612) 463-1851
Cottage Grove Arena	Dean Mulso	(612) 458-2846
Lily Lake (Stillwater)	Diane Deblon	(612) 430-8811
West St. Paul Arena	Dave Malay	(612) 552-4155

Ice Sheet Lighting Recommendations

Ice sheet lighting costs can be reduced by replacing or upgrading inefficient light fixtures and by varying ice sheet light levels based on activity. Common lighting fixture upgrades that are often cost-effective include changing from standard fluorescent or mercury vapor fixtures to metal halide or high pressure sodium fixtures. A relatively new option that can provide even greater energy savings is to upgrade to compact fluorescent fixtures designed specifically for athletic facilities. In addition to providing energy cost savings, the lighting fixture upgrades mentioned above also tend to result in lower maintenance costs, better quality lighting, and increased control options. Three arenas in Minnesota that are using the newer compact fluorescent fixtures over the ice sheet are listed below.

Arena	Contact Person	Phone
Cottage Grove Arena	Dean Mulso	(612) 458-2846
Vogel Arena (New Ulm)	Jim Krapf	(507) 354-8321
St. Louis Park Arena	Craig Panning	(612) 924-2545

The level of illumination required for any sports lighting installation depends upon many factors, including the general nature of the task, the speed of the action, the skill of the players, the number of spectators and their distance from the field of play. Recommended illumination levels for various ice activities from the Illuminating Engineering Society are listed below.

Recommended Ice Rink Illumination Levels

Activity	Foot-candles
Pro Hockey	100
Amateur Hockey	50
Recreational Hockey	20
Figure Skating	15
Curling	10-20
Recreational Skating	10

Because ice sheet lighting requirements vary significantly for different types of on-ice activities a lighting system which can respond to changing light level requirements will be most energy efficient. In addition to using more electricity, ice rink lighting systems which over-illuminate also cause the refrigeration system to work harder than necessary. Multi-level lighting systems provide energy savings by more closely matching the light output and energy usage to the activity on the ice. Multi-level systems are usually more cost-effective than dimming systems. Some rinks have tried to bank their lighting system to achieve similar results, but this approach tends to produce shadows and non-uniformity that can make it difficult for players and spectators to follow the puck. Many electric utilities offer lighting efficiency rebates.

RESURFACING IMPROVEMENTS

Demineralized Flood Water Treatment

Water purity has a direct effect on the quality of ice and the amount of energy used to produce and maintain the ice surface. Ice arenas are extremely large users of water. A moderately busy ice arena with an average of 6 resurfacings a day will use approximately 1,000 gallons of water per day. The majority of this water is use to recondition the ice surface. As a general rule, heated city water is used to fill the resurfacer tank which in turn are used to flood the ice sheet. The water is heated to provide a better bond to the existing ice and to melt and fill in cracks in the ice caused by skate blades. With the use of demineralized flood water the need for heating is eliminated because pure water bonds very easily to the existing ice sheet. A reduction in the water temperature also reduces the amount of energy needed to freeze the flood water thereby reducing the work of the refrigeration system. Pure water also provides a harder ice surface that is more resistant to cuts.

Demineralized water can be achieved by two different methods. The first is an ion-exchange method that uses chemicals to remove the minerals. The second is a reverse osmosis filter that allows only pure water to pass through a filtering membrane. Both methods are extremely effective in removing the impurities in common water supplies. Installation costs for the ion-exchange demineralization and the reverse osmosis filtration systems are approximately $18,000. Operational costs for the two systems are different. The ion-exchange requires chemicals that cause the operational costs to be around $15 per 1000 gallons of processed water. Instead of requiring chemicals, the reverse osmosis systems require additional pumping power to force the water through the filtering membrane. Operational costs for the reverse osmosis systems average $3 to $5 per 1000 gallons. The paybacks on both systems typically span 6 to 10 years. The paybacks can be reduced by a change in the temperature of the ice sheet. With the use of demineralized water the temperature of the ice sheet can be raised slightly to accommodate the reduction of energy needed to freeze pure water as compared to water with dissolved solids. Several arenas that use either temporary ion-exchange tanks or a reverse osmosis flood water demineralization system are listed below.

Demineralization Type	Arena	Contact Person	Phone
Reverse Osmosis, Tanks	Bloomington Ice Gardens	Andy Baltgalvis	(612) 948-8842
Reverse Osmosis	Hutchinson Civic Arena	Marv Haugen	(320) 234-4227
Reverse Osmosis	Cottage Grove Arena	Dean Mulso	(612) 458-2846
Reverse Osmosis	Victory (Minneapolis)	Virgil Oldre	(612) 627-2953

Electric Ice Resurfacer

Ventilation with outside air is extremely important in ice arenas where resurfacers driven by internal combustion engines are used. The airborne pollutants emitted during the combustion process must be removed from the space or diluted to a concentration level that will not harm arena occupants. A fine balance must be found to ensure that sufficient outdoor air is provided to dilute combustion contaminants, while minimizing excessive levels to reduce dehumidification and heating loads. Using electric resurfacers eliminates the need for extra outdoor air ventilation to dilute combustion products. The only remaining need for ventilation is to assure adequate occupant comfort.

Electric resurfacers have been improved with technology from the forklift industry. Electric powered forklifts have been in use for many years and have performed indoors without problems. The power requirements of an ice resurfacer are somewhat higher than a forklift, but this is easily overcome with the addition of a larger battery pack. The alternative to the battery operated machine is to plug the resurfacer into an electrical supply grid. This is accomplished with the use of a tether that is supported in the ceiling of the arena. Costs for electric resurfacers range from $72,000 for tethered machines to $75,000 for battery models. Simple paybacks for electric resurfacers can be somewhat high when only considering the incremental cost over a new propane resurfacer. A new propane powered resurfacer has a cost of $55,000 which results in an incremental cost of $20,000. The resulting payback is typically over 10 years. Paybacks are reduced when operational costs are considered. The typical propane resurfacer will use approximately $1,620/yr in propane where as an electric resurfacers performing the same number of resurfacings will use only $420/yr, resulting in a $1,200/yr savings in operational costs alone. Replacing a propane powered resurfacer will provide the immediate benefit of improved indoor air quality even though the economic payback is longer than for many other improvements.

Resurfacer	Arena	Contact Person	Phone
Battery	Victory Memorial Arena	Virgil Oldre	(612) 627-2953
Battery	Bloomington Ice Gardens	Andy Baltgalvis	(612) 948-8842
Battery	Parade Ice Garden	Tom Herbst	(612) 370-4846
Tethered	Fogerty Arena	Mark Clasen	(612) 780-3323
Tethered	Edison Youth Hockey	John Myers	(612) 782-2123

*Automatic Flood Water Fill Shut-off Nozzle

Overfilling resurfacer flood water tanks wastes water and energy. After every resurfacing, the flood water tank is refilled so it is ready for its next use, usually every hour. When fully opened, most water hoses will fill the flood water tank in 20 - 30 minutes, but an employee must turn off the valve to avoid overflowing. In some arenas the flow rate is reduce so the flood water tank is filled in approximately an hour, or the time allotted between resurfacing. Overflowing is common in either method and results in wasting water which is expensive. It is even more costly in terms of energy consumption in arenas which use heated water for resurfacing because overflowing a tank is like pouring hot water down the drain.

Arenas can conserve water and energy by installing a simple, inexpensive device used on all gasoline pumps. An automatic shut-off nozzle can be attached to the end of the fill water hose and when the tanks are full the nozzle will automatically turn off the water. The cost for an automatic shut-off nozzle is around $30 dollars and if only one gallon of water is eliminated from spilling at every resurfacing, the payback is estimated at 6 years based on water charges alone. If the cost for heating the water is factored in, the payback decreases to only 3 years. Automatic shut-off nozzles also decrease staff time required to monitor the tank levels between resurfacing periods. Automatic shut-off nozzles are used in many Minnesota ice arenas.

REFRIGERATION SYSTEM IMPROVEMENTS

Condenser Fan Variable Speed Drive

A condenser fan variable speed drive will not only reduce the condenser energy use, but also save on compressor energy use by lowering the average head pressure. The lower and much steadier head pressure will also reduce wear on the compressors.

Energy consumption in many ice arenas can often be reduced by lowering the head pressure that is maintained by the condenser fan and/or pump controls. The refrigerant that is circulated through the refrigeration system first absorbs heat from underneath the ice sheet and then dumps that heat to the outside air through a condenser. In order for heat to flow from the refrigerant in the condenser to the outside air, the refrigerant must be at a high temperature and pressure (referred to as the head pressure). This high temperature and pressure is generated by the compressors that pump the refrigerant through the various parts of the refrigeration system. The compressors are the primary energy users in the refrigeration system, and reducing the head pressure that they must generate will dramatically reduce the arena's energy use and equipment maintenance needs. Therefore, the condenser controls should be set to provide the minimum

* Possible low-cost/no-cost improvement

head pressure needed for proper system operation whenever it is possible. Most ice rink refrigeration equipment can operate with lower head pressures during mild and cool weather because the condensers can more easily dump heat to the outside air. However, typical condenser fan and pump controls are not capable of tight, consistent head pressure control so they are set to operate the equipment well above the lower head pressure limits. Retrofitting existing equipment with a variable speed drive on the condenser fan motor is often the best way to continually keep the head pressure near its minimum operating limit.

Maximizing the cost-effectiveness of a condenser fan variable speed drive retrofit usually requires some changes to the condenser control strategy. Therefore, a new control unit for both the condenser fan and pump (for evaporative condensers) is often needed. The new control strategies used with variable speed drives virtually eliminate the short-term on and off cycling of condenser fan and pump motors and the associated head pressure fluctuations.

Although installed costs for recently completed retrofits have averaged $7,000, there has been a wide variation in cost from project to project. Typical energy cost savings are $1,200 annually. Contact information for a number of arenas that have installed a condenser fan variable speed drive control is listed in the table below.

Arena	Contact Person	Phone
West St. Paul Arena	Dave Malay	(612) 552-4155
Litchfield Civic Arena	Steve Olson	(320) 693-2679
Farmington Civic Arena	Jim Bell	(612) 463-1851
Hutchinson Civic Arena	Marv Haugen	(320) 234-4227
Cottage Grove Arena	Dean Mulso	(612) 458-2846
Victory (Minneapolis)	Virgil Oldre	(612) 627-2953

Reclaiming Waste Heat from the Refrigeration System

Waste heat generated by the ice sheet refrigeration system can often be cost-effectively captured and used to supplement an arena's heating needs, thereby reducing heating fuel use. The ice sheet refrigeration system normally takes all of the heat that the ice sheet absorbs (plus some extra heat added by the refrigeration system itself) and then dumps that heat to the outside air through an outdoor condenser. However, much of the heat that the refrigeration systems normally rejects to the outside air can instead be reclaimed to provide useful heat. The reclaimed heat can be used to heat air or water up to a temperature of 90°F or more. Typical uses of reclaimed heat include: heating the air in the arena, heating service hot water, and/or melting the snow scraped off by the resurfacer. More than half of the ice arenas in Minnesota use well-established heat reclaim technology to provide heat for one or more of these uses. Adding heat reclaim equipment costs at least several thousand dollars, but in some cases the investment will pay for itself in just a few years.

Cooling System Pump Control

More closely matching the ice sheet coolant pumping rate to the exact amount of cooling that is needed saves energy. The pump that circulates coolant under the ice sheet is chosen so that it can provide the highest coolant pumping rate that will ever be needed to maintain the ice; however, a much lower coolant pumping rate will provide adequate cooling 75 to 95 percent of the time. Controls that provide multiple levels of pumping capacity greatly reduce the energy penalty from continuously operating large, high capacity coolant pumps at their maximum capacity.

The cooling system pump control options available include:

1. using a variable speed drive to adjust the speed of the pump's motor
2. cycling single or multiple pumps on and off
3. using a two-speed motor to power the pump

The first two control options have been used successfully in Minnesota ice arenas. The third control option is commonly used in industrial applications and is also appropriate for ice arenas. Two-speed motors provide a lower cost alternative that is particularly cost-effective when a pump motor needs to be replaced. The approximate costs for these options range from $1,500 to $12,000 and the payback on investment is often attractive--even for short season ice arenas. The implementation of cooling system pump control should be considered in conjunction with improving ice temperature control and implementing automatic capacity control for compressors. In Minnesota, a number of newer packaged refrigeration systems have two different sized pumps that are automatically controlled. Contact information for two arenas that have variable speed drive control of the pump motor is listed below.

Arena	Contact Person	Phone
Litchfield Civic Arena	Steve Olson	(320) 693-2679
Lily Lake (Stillwater)	Kevin Shields	(612) 430-1234

Improve Ice Temperature Control

Improvements to ice temperature controls can often provide better ice quality and reduce energy costs by consistently maintaining the ice surface at the highest acceptable temperature level. The ice sheet absorbs heat from the warmer air and building which surround it. As the temperature of the ice sheet increases, less heat is absorbed thus reducing the amount of energy needed for the refrigeration system. The reduced heat absorption into the ice sheet not only reduces the refrigeration system energy use, but also reduces the amount of energy needed to heat the arena.

The ice surface temperature can often be increased by using two control technologies:

1. infrared ice temperature sensors
2. overnight setback of ice temperature

Infrared sensors can be mounted above the ice sheet to measure the ice temperature by sensing the amount of infrared light radiated by the ice sheet. Although this promising technology has not yet been applied in Minnesota, it has been successfully used in a number of arenas in the United States and Canada. Overnight setback of ice temperature (e.g. from a normal setpoint of 20°F to 24°F) provides another opportunity to reduce refrigeration system energy use. This technology allows the ice sheet to warm during non-use and then automatically cools the ice sheet before skaters return to the ice arena (without affecting ice quality).

Making energy saving improvements to an ice temperature control system can sometimes cost as little as $1,000, but significant upgrades usually cost at least $9,000, with a resulting energy savings payback period that is typically several years long or longer. The implementation of improved ice temperature control should be considered in conjunction with implementing automatic capacity control for compressors and installing cooling system pump controls. Arenas that have infrared ice temperature control and/or ice temperature setback are listed below.

Arena	Contact Person	Phone
Litchfield Civic Arena	Steve Olson	(320) 693-2679
Farmington Civic Arena	Jim Bell	(612) 463-1851
Cottage Grove Arena	Dean Mulso	(612) 458-2846
Bloomington Ice Gardens	Andy Baltgalvis	(612) 948-8842

Automatic Capacity Control of Compressors

The compressors in ice arena refrigeration systems are sized large enough to be able to handle the initial freezing of the ice sheet. During lower cooling load periods, such as overnight and in winter, the compressors are oversized and waste energy. Many control systems simply cycle an arena's compressors on and off—even when the potential to vary compressor capacity is built into the system. Automatic capacity control of the compressors can provide more efficient operation of the compressors by supplying a more consistent feed of refrigerant at a slightly higher average temperature. The higher temperature allows the refrigeration system to operate more efficiently and use less energy.

Additional savings can also be realized by a reduction in an arena's monthly electric demand charge. The electric utility bases an arena's demand charge on the highest power draw over a fifteen minute interval during a given month. The power draw for compressors with a simple on-off cycling control is high because the compressors operate near their maximum capacity whenever they are on. In contrast, automatic capacity control allows the compressors to operate at significantly reduced power draws most of the time. The reduction in monthly demand charges (kilowatt or kW) can be significant, amounting to more than the savings associated with total monthly electric use charges (kilowatt hours or kWh).

Automatic capacity control of compressors has long been used by a number of ice arenas in Minnesota. The cost to upgrade an existing refrigeration system with a new control system using automatic capacity control is usually several thousand dollars or more, which typically leads to a long energy cost savings payback time period. However, the most important benefit of automatic capacity control is often the reduction in the personnel time and expertise necessary for day-to-day operation of the refrigeration system. This is because the simple on-off control systems used in many ice arenas often demand significant arena staff time to frequently check on the system and make manual adjustments. The implementation of automatic capacity control of compressors should be considered in conjunction with the decisions to implement improved ice temperature control and/or cooling system pump control. Two arenas that have recently added automatic capacity control are listed below.

Arena	Contact Person	Phone
Bloomington Ice Gardens	Andy Baltgalvis	(612) 948-8842
Cottage Grove Arena	Dean Mulso	(612) 458-2846

HEATING, DEHUMIDIFICATION AND VENTILATION IMPROVEMENTS

Low Emissivity Reflective Ceiling

Reducing the amount of heat that the ice sheet absorbs will result in lower energy bills and improved ice quality. One of the main sources for heat in an ice arena is infrared radiation. Infrared radiation can account for more than 35 percent of the total cooling load of an ice sheet. Although it can not be seen or felt, heat from the ceiling and lights radiates down on the ice sheet and increases the load on the refrigeration system. The amount the refrigeration system has to work varies from day-to-day depending on the outside temperature, arena air temperature, ice temperature, and direct sunlight on the roof. The infrared radiation load also varies from site to site due to the amount of roof insulation, the ceiling height, and the ceiling's ability to transmit energy.

Installation of a barrier between the ceiling and ice sheet can effectively stop the infrared radiation. There are typically two types of barriers used in ice arenas: low emissivity paint applied directly to the ceiling, and low emissivity fabric suspended just below the ceiling. Both products reduce the amount of heat that is radiated down to the ice sheet. The installation cost of the low emissivity paint ranges from $20,000 to $100,000 depending on the roof structure and amount of prep work needed. Paybacks for low emissivity paints are typically from 2.5 to 12 years with a functional life span of four to five years. The low emissivity fabric ceilings can be installed for $23,000 to $28,000 and generate a payback of approximately 2 years in arenas which operate 11 months a year. The useful life of low emissivity fabric is over 20 years. Both low emissivity paints and fabrics have been used in Minnesota arenas with proven success. A number of sites with low emissivity fabric are listed below.

Arena	Contact Person	Phone
Bloomington Ice Gardens	Andy Baltgalvis	(612) 948-8842
Hutchinson Civic Arena	Marv Haugen	(320) 234-4227
Farmington Civic Arena	Jim Bell	(612) 463-1851
Cottage Grove Arena	Dean Mulso	(612) 458-2846
Victory (Minneapolis)	Virgil Oldre	(612) 627-2953

CO_2 and CO Ventilation Control

Typically ice arenas are over-ventilated to assure that occupants are not harmed from the exhaust gases from ice resurfacers. The gases carbon dioxide (CO_2) and carbon monoxide (CO) are by-products of the internal combustion engines that power some types of resurfacers. CO_2 is also released when skaters and spectators exhale. Ventilating the arena removes the potential harmful gases by replacing polluted air with fresh air. Ventilation also assures that the arena will pass the required weekly air quality check that is required by the Minnesota Department of Health. If the rate of outside air introduced into an arena is not controlled properly the arena will be either under- or over-ventilated. If it is under-ventilated the arena will fail its air quality checks and possibly cause health problems for the occupants. Over ventilation increases energy consumption in two ways. First, during winter heated air is vented outside and make-up air taken from outside is brought into the building. The heating system works harder because the fresh air must be heated to the desired indoor temperature. Second, the introduction of warm moisture air during the summer into the cool arena causes moisture problems in the form of fog and condensation on the building which significantly increases the refrigeration system's energy consumption.

The installation of sensors that measure CO_2 and CO along with an exhaust fan control system provide active and accurate control of the amount of fresh air brought into an arena. A minimum air flow will typically be called for during periods of limited use (i.e. ice skating lessons) or non-occupancy. The level of outdoor air is automatically increased during higher occupancy and reduced during low occupancy periods. The system is programmed to ventilate at its maximum capacity during the time the resurfacer is in operation and then to monitor for CO and adjust the ventilation rates as the concentration of CO decreases. Thus, ventilation levels are optimized for sufficient indoor air quality while energy costs are minimized. Installation costs vary depending on the number of exhaust fans and the type of control system that is currently in use. Typically these costs will be between $2,000 and $5,000 with a payback ranging from 1 to 5 years. This type of ventilation control has been implemented in several arenas around Minnesota.

Arena	Contact Person	Phone
Mankato Civic Center	Marshal Madsen	(507) 389-3000

*Time-of-Day Heating and Ventilation System Control

Implementation of time-of-day controls for heating and ventilation systems can significantly reduce the operating expense of ice arenas. Manual operation of heating and ventilation systems is only efficient if ice arena employees adjust controls whenever heating or ventilation needs change. For example, when an internal combustion engine-driven resurfacer is operating, employees must manually activate exhaust fans to provide adequate ventilation for the arena. If these fans are left on too long after resurfacing the arena will be over-ventilated which can cause moisture problems, added heating and cooling costs, and added refrigeration loads. The efficiency of manual controls is dependent on how well the arena staff understands the heating and ventilation systems and how often energy conserving practices are followed. Automatic operation of the heating and ventilation systems based on time-of-day and occupancy can result in optimum control of an arena's indoor conditions and minimal energy use. Some of the measures that can be installed to provide energy savings include:

1. Night setback of heating setpoints to allow arena temperature to drop at times of non-use.

* Possible low-cost/no-cost improvement

2. Automatically cutting back on the amount of ventilation during unoccupied periods.
3. Automatically controlling exhaust fans during and after resurfacing.

Each of these measures has the benefit of being automatically activated at prescribed times of the day. Once a time of use schedule is developed for each piece of equipment, there is no need to worry about making manual adjustments to operate that system. Installation costs for each of the above measures are typically $1,000 to $2,000 a piece. Paybacks are typically less than 12 months but also depend on the current operation of the arena. Regardless of energy savings, properly programmed time-of-day controls provide optimal space heating and ventilation under a variety of conditions. Night setback thermostats, automatic ventilation systems, and automatic exhaust fans have all been used successfully in Minnesota arenas. Some examples are listed below.

Application	Arena	Contact Person	Phone
Setback thermostat	Cottage Grove Arena	Dean Mulso	(612) 458-2846
Ventilation while resurfacing	VFW (E. Grand Forks)	Dale Skyberg	(218) 773-1181
Ventilation while resurfacing	Bloomington Ice Gardens	Andy Baltgalvis	(612) 948-8842

Spectator Radiant Heating

Ice arenas have unique heating requirements because only certain areas of the building such as spectator seating and players benches need to be heated. Heating ice arenas with traditional forced air furnaces can result in high energy costs and overheating of areas that do not require heat. Forced air furnaces draw air from a central location and pass it through a heater exchanger were the air is heated. The air is then distributed throughout the arena to maintain a desired temperature. The air movement around the arena causes a disturbance in the stratification of air over the ice sheet. Air currents over the ice increase the convective heat loss on the ice sheet and force the refrigeration system to work harder to maintain the ice sheet's temperature. The warm air supplied by the forced air furnace also tends to accumulate at the ceiling were it will add to the infrared heat gain to the ice surface by maintaining the ceiling at a higher temperature than what is needed.

Heating with low intensity infrared heaters solves this problem by only heating surfaces such as walls, floors, and people. These surfaces, in turn, act as heat reservoirs and release heat to the surrounding air. Infrared heaters are positioned over spectator areas and players boxes were the heat is needed. The heaters are also directed away from the ice sheet so that they will not emit any heat towards the ice. The air over the ice is not disturbed so the refrigeration system doesn't have to work as hard as it would with a forced air system. Infrared heating has the added benefit of being a negative pressure system so that the noxious combustion gases are expelled outside and do not cause indoor air quality problems. Low-intensity infrared heating has been used in a wide variety of Minnesota arenas with great success. Installation of infrared heating systems cost approximately $15,000 to $20,000. Paybacks have to be analyzed on an arena by arena basis. Some of the arenas in Minnesota that use infrared heaters are listed below.

Arena	Contact Person	Phone
Hoyt Lakes	Tom Ferris	(218) 225-2226
Hodgins Berardo (Coleraine)	Pat Guyer	(218) 245-3525
West St. Paul	Dave Malay	(612) 552-4155
Farmington Civic Arena	Jim Bell	(612) 463-1851
Bud King (Winona)	Bob Monstrose	(507) 454-7775
Cottage Grove Arena	Dean Mulso	(612) 458-2846

Desiccant Dehumidification

Elevated relative humidity in ice arenas negatively affects skaters, spectators, and building components. High humidity is typically uncomfortable for skaters and spectators and can result in the formation of fog over the ice which restricts visibility. The humid air also condenses on the cooler building structural components which can cause deterioration of the building and dripping onto the ice surface. Condensation causes steel components to prematurely rust and results in high building maintenance costs through added repairs and repainting. Wet building components also provide growth sites for mold and bacteria. High relative humidity also wastes energy by causing increased condensation on the ice sheet. Extra condensation forces the refrigeration system to work harder to maintain the ice sheet temperature. Without proper ice maintenance, the thickness of the ice sheet will also increase which also increases the refrigeration system's workload.

Controlling moisture is essential for arenas which operate for 10 to 11 months a year. The use of conventional direct expansion air conditioning equipment can handle the moisture load for the majority of summer months but at an extremely high energy cost. The use of desiccant dehumidification equipment is ideally suited for high moisture load applications. Desiccant dehumidification systems work by absorbing moisture. These systems primarily use natural gas which can be purchased at a reduced cost in off-peak summer months when they are needed. Installation costs for desiccant dehumidification systems can be high ($150,000 to $300,000) but the addition of the dehumidification systems can result in an extension of the operating season from 7 months to year round operation. Paybacks on dehumidification systems are difficult to determine due to the change in the operating season and must be calculated on an arena by arena basis. Desiccant dehumidification systems are only appropriate for arenas which operate during the summer months. Several arenas in Minnesota that have added desiccant dehumidification systems to extend their operating season are listed below.

Arena	Contact Person	Phone
Bloomington Ice Gardens	Andy Baltgalvis	(612) 948-8842
Cottage Grove Arena	Dean Mulso	(612) 458-2846
Blake	Tom Donahue	(612) 988-3825
West St. Paul	Dave Malay	(612) 552-4155
Hutchinson Civic Arena	Marv Haugen	(320) 234-4227

MISCELLANEOUS IMPROVEMENTS

Power Factor Correction

By eliminating a power factor correction penalty, electric bills in many ice arenas can be reduced without changing the amount of electric used by the arena. Often when older electric motors are used to operate equipment they have low power factors. The power factor is the ratio of actual power being used in a circuit (in kilowatts) to the power which is apparently being drawn from the line (in kilovolt-ampere). The actual power is the "real" power that performs useful work such as causing a motor to rotate or creating heat in a resistive element. Apparent power is the power required to establish an electrical field for the motor. The apparent power is used by the motor and returned back into the electrical system to establish a circuit. The apparent power level is used by the utility to size all system components from generation capacity and distribution lines to transformers at the building site. Electric utilities penalize customers for low power factors because they have to have generate more electric than what is required by their customers.

Low power factors can usually be corrected by installing capacitor banks at the point where the supply of electricity enters the building. Capacitor banks act as storage devices that store current needed by the electric motor and release the current to the motor at the correct time thereby improving the overall power factor of the building. Power factor correction is typically performed if utility bills indicate that the overall power factor for the site is below 90 - 95 percent, depending on the utility. Not all utilities charge power factor penalties. Power factor correction equipment can be installed by most electricians and ranges in price based on the voltage supplied to the building, amount of capacity needed to correct the problem, and the total electrical load of the building. Typical paybacks are less than 5 years for a building with a power factor of 80 percent or lower.

High Efficiency Motor Replacement

About half of the world's electricity is used by motors. The electric bill for America's motor driven systems is about $90 billion per year. Given the significant amount of energy and money devoted to motor-driven systems, even modest improvements in their efficiency hold the promise of huge savings.

The electric motors currently being used in arenas for refrigeration systems, pumps, and exhaust fans have a large impact on total arena electrical consumption. Electric motors are relatively cheap to purchase and extremely expensive to operate. The cost of electricity to run a typical commercial or industrial sector motor with a duty factor of at least 4,000 hours per year is equivalent to ten times its capital cost. The replacement of an older standard efficiency motor with a new high efficiency motor may result in double savings. First, savings will occur by significantly reducing energy consumption. High efficiency motors will use less energy than an older motor with the same horsepower rating and load. Second, if an arena is charged a power factor correction penalty by their electric utility, this penalty will likely be eliminated by replacing older motors. Older motors have power factors in the range of 70 to 80%. New high efficiency motors have power factors of better than 95%, which do not incur power factor penalties.

Motor replacement is not always recommended in every situation. The hours of operation, motor load, and the ability to downsize the new motor all have to be considered during the evaluation of a potential motor replacement. In many applications replacing a relatively new standard efficiency motor with a high efficiency motor will produce a payback within a year. Capital costs for high efficiency motors are based on the size and type of motor but are typically 30% to 50% higher than standard motor replacements. Over the life of a typical industrial motor, a one-percentage-point efficiency gain will pay for the incremental cost of the more efficient motor several times over, and may even save as much as the entire capital cost of the motor. Many electric utilities offer rebate programs for replacing inefficient motors. Three arenas that have carried out high efficiency motor replacements are listed below.

Arena	Contact Person	Phone
Farmington Civic Arena	Jim Bell	(612) 463-1851
Bloomington Ice Gardens	Andy Baltgalvis	(612) 948-8842
Cottage Grove Arena	Dean Mulso	(612) 458-2846

Appendix 3.
Prime Ice Time and Gender Preference Compliance Form

ICE ARENA COMPLIANCE FORM

I verify that the specified ice arena is in compliance with the prime ice time and gender preference requirements in 1994 Minnesota Laws, Ch. 632, Art. 3, Sec. 23[15.98].

____

Arena Name

____ ____________

Signature Date

1994 Minnesota Laws, Ch. 632, Art. 3, Sec. 23[15.98]

This section applies to an indoor ice arena operated by a political subdivision, a state agency, the University of Minnesota, a state higher education institution, or any other organization that makes an arena available to the public. If the arena provides more prime ice time to groups of one gender than to groups of the other gender, the arena may not deny a request for prime ice time from the group of the underrepresented gender, provided that the group of the underrepresented gender pays the same price charged to groups of the other gender. An underrepresented gender group must be allowed up to 15 percent of prime ice time for the 1994-1995 season, up to 30 percent by the 1995-1996 season, and up to 50 percent by the 1996-1997 season. This section does not: (1) require an arena to allocate more time to any one group than is generally allocated to other groups; or (2) affect a political subdivision's ability to grant preference to groups based on the political subdivision, provided this preference is not based on gender. For purposes of this section, prime ice time means the hours of 4:00 p.m. to 10:00 p.m. Monday to Friday and 9:00 a.m. to 8:00 p.m. on Saturdays and Sundays. Any group that generates revenue as a result of tickets sold to persons in attendance at arena events must be excluded in determining if the arena provides more prime ice time to groups of one gender than the other.

Appendix 4.
Audit Executive Summaries

available upon request

(These are ordered alphabetically by arena name. An ordered list appears on page 7.)

Appendix 4.
Audit Executive Summaries

(These are ordered alphabetically by arena name. An ordered list appears on page 7.)

Babbitt Ice Arena (January 1998): Executive Summary

This energy audit identifies energy improvement measures for Babbitt Ice Arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program. The audit includes an analysis of the facility's recent electric and gas energy use, on-site inspection of the building envelope, mechanical and lighting systems examination, operation discussions with maintenance personnel regarding, maintenance and arena occupancy, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arenas and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of cost-effective energy improvements for this facility that will reduce the annual energy costs by as much as $4,230.

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for Babbitt Arena. The total estimated cost for these improvements is $625,320 after available utility rebates have been applied[4]. A minimum Energy Grant of $5,000 has been applied to the improvement costs to yield an arena cost of $20,320. The sum of the anticipated first year savings for all of the individual measures is $4,230 which corresponds to a combined simple payback of 4.8 years on the net installation cost. Because of interactive effects between some of the improvements, the total savings would be somewhat less than $4,230 if all the measures were implemented. The more significant interactive effects have been discussed in the audit, and a final determination of total savings will be computed when a complete package of improvements is selected.

Estimated Cost of Proposed Improvements:	$28,286
Estimated Minnesota Power Rebate	-2,966
Energy Grant:	- $5,000
Arena's Cost for Improvement Package:	$20,320
Anticipated Annual Energy Savings:	$4,230
Simple Payback:	4.8 years

A complete list of the recommended energy improvements is shown in the table below, along with pertinent savings and payback information. Two of the three recommended energy improvement measures have a simple payback of less than 7 years, with the other recommendation less than ten years. In addition to energy cost savings, a number of the measures provide benefits such as improved ice quality, improved arena lighting, and reduced maintenance costs. A number of no cost and low cost energy saving actions are also identified in the report, but not included in the summary tables.

[4] Additional utility rebates may be available. Final rebate amounts will be computed based on improvements to be installed at the arena.

List of Recommended Improvements

Energy Improvement Measures	Total Cost	Utility Rebate	Arena Cost	Annual Savings	Payback with Rebate
Glycol Pump ASD & Improved Ice Temperature Controller	$15,000	$1,377	$13,623	$2,529	5.4 years
Lighting Improvements	$12,002	$1,509	$10,493	$1,572	6.7 years
Motor Replacement	$1,284	$80	$1,204	$129	9.3 years
Total	$28,286	$2,966	$25,320	$4,230	6.0 years
Energy Grant			$5,000		
Total, Including Energy Grant & Utility Incentives	**$28,286**	**$2,966**	**$20,320**	**$4,230**	

Payback, Including Energy Grant and Utility Incentives*:	4.8 years
Required Arena Owner Funding:	$20,320

A number of other energy saving improvements were considered, but not recommended because the energy cost savings would not provide a simple payback of ten years or less. These included: reclaiming heat from the refrigeration system; automatic unloading control of the compressors; air-cooled condensers for the refrigeration system; ice sheet lighting replacement; low emissivity ceiling, flood water demineralization, and occupancy sensors for lighting control. If significant changes are made to the arena operations or the operating season, some of these items should be reevaluated.

For all improvements considered in this audit, it was assumed that a Minnesota Power rebate of $100 per kilowatt of demand savings would be available to reduce the installation cost of the measure. Once a preliminary decision has been made regarding which measures will be implemented, CEE can assist with utility grant applications. The guaranteed $5,000 minimum energy grant from the Minnesota Ice Arena Energy Improvement Program was included in the above analysis. Applications for an energy grant must be submitted by February 20, 1998 and CEE will provide a final determination of the energy grant amount by February 27.

All energy cost calculations were performed using an electric use rate of $0.04612 per kilowatt hour (kWh) and demand rate of $4.30 per kilowatt (kW) according to current rate structure information provided by Minnesota Power. All energy costs calculations related to gas consumption used a cost of $0.49/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet.

Bloomington Ice Garden (10/95; update 11/96): Executive Summary

This energy audit identifies energy improvement measures for the three ice arenas at the Bloomington Ice Gardens. It was performed as part of the Northern States Power (NSP) Local Government Program that provides special financing, bounty incentives and engineering fee reimbursement to county or municipal customers. The audit includes an analysis of the facility's recent electric and gas energy use, on-site inspection of the building envelope, examination of mechanical and lighting systems, discussions with maintenance personnel regarding operation, maintenance and arena occupancy, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of current conditions in the arenas and todetermine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of energy improvements for this facility that will reduce the annual energy costs by $35,000, which is equivalent to 19% of the present energy costs.

This audit is a second step toward a comprehensive energy audit of the entire facility. Most of the cost effective improvements for the arenas have been evaluated as part of this report. There are a limited number of improvements requiring more extensive analysis that may be evaluated at a later date. The analyses of some of the improvements may be conducted after CEE has completed the technology assessment phase of the state-funded project for Energy Improvements in Minnesota Ice Arenas.

The present facility consists of three arenas built at different time periods. Rink 3, completed in November 1993, is an Olympic sized rink cooled by a 100 ton indirect refrigeration system. The refrigeration plant uses four semi-hermetic compressors controlled by a temperature sensor on the glycol return line and has a staged, air-cooled condenser with two variable speed drives. Chiller waste heat is used to heat the snow melt pit and for sub-floor heating. Dehumidification, ventilation, and mild weather heating is supplied by a desiccant dehumidification system. A separate furnace provides space heat during winter months. An energy management and control system (ECMS) controls the operation of these systems with ventilation of resurfacer exhaust automatically activated by a resurfacer door switch. Bi-level HID fixtures are used to light the ice sheet. The arena is typically operated with an ice sheet in place for the entire year. However, the concrete floor and dehumidification system does allow for summer dry floor activities.

The ice rink in the second arena is a standard size and has no spectator seating. A single refrigeration plant cools the ice in both rinks 1 and 2. This 150 ton direct system has an evaporative condenser and two open, reciprocating compressors controlled by temperature sensors placed under the ice sheets. The two compressors had manual unloading capabilities at the time of the initial arena walk-through, but automatic unloading controls have been added since then. Even though there is a single refrigeration system for rinks 1 and 2, two independent discharge-gas-powered pumping systems provide a separate supply of cold liquid refrigerant to each of the rinks. Four rooftop units with standard furnaces and refrigerant-based air conditioners provide space heating, cooling, and ventilation. Waste heat from the refrigeration system also supplements the gas-fired heating equipment. Single-level HID fixtures are used over the ice sheet and conventional fluorescent fixtures are used in the public areas. The concrete floored arena is typically operated with an ice sheet in place for 9 to 10 months of the year. Other activities are often scheduled during the summer months when the ice sheet is not in place.

The ice rink in the first arena is a standard size and has seating for approximately 1200 spectators. Two rooftop units with standard furnaces and refrigerant-based air conditioners provide space heating, cooling, and ventilation. Waste heat from the refrigeration system is also used to supplement the gas-fired heating equipment. Single-level HID fixtures are used over the ice sheet along with fluorescent fixtures that operate during high school hockey games and other special events. This arena has a sand-based floor and operates with an ice sheet in place for the entire year. Neither rink 1 or 2 has a snow melt pit. Rink 1 has a new battery powered ice resurfacer that has eliminated the need for exhaust ventilation during resurfacing.

The weather normalized annual energy consumption for the three rinks of the Bloomington Ice Gardens is approximately 2,426,000 kWh and 146,000 therm. The total annual electric costs are $114,000 and the gas costs are $69,000 for a combined annual energy cost of $183,000. The variation in gas use is strongly related to outside temperature with higher use in colder months. About 83% of gas use is for space heating and that is split into 49% for rinks 1 and 2 and 35% for rink 3. Desiccant dehumidification of rink 3 accounts for approximately 12% of gas use and the remaining 5% is for miscellaneous end uses. Electric costs show little seasonal variation with a slight increase in warmer summer months. The largest portion of the electric costs (57%) are due to the two refrigeration systems followed by 19% for lighting, 13% for HVAC air handlers and pumps, 5% for rinks 1 and 2 dehumidification, and 5% for miscellaneous uses. It is interesting to note that the refrigeration system serving rink 3 is estimated to use 11% more electricity than the system serving both rinks 1 and 2. This is due to the higher ventilation, larger ice sheet area, warmer arena air temperature, and year round operation of rink 3. The low-e ceiling in rink 1 also reduces the radiation load for that ice sheet. A quick analysis of electric data from before rink 3 was added indicates that electric costs in this facility have increased by much more than 50% since the third rink was built. This energy audit presents a number of recommendations to reduce the energy consumption of rink 3 to levels that are more typical of those seen in the first two rinks.

Bloomington Ice Gardens has implemented a number of innovative energy saving measures including: a low-e ceiling in rink 1, an evaporative condenser for rinks 1 and 2 chiller, desiccant dehumidification of rink 3, electric resurfacer for rink 1, utilization of refrigeration waste heat for rinks 1 and 2 space heating, and bi-level lighting and snow pit and subfloor heating for rink 3. However, a number of additional measures were identified that will significantly reduce energy costs for this facility. The package of recommended improvements includes thirteen measures with a total cost of $112,506. Utility incentives of $29,372 will reduce the installation cost to $83,134. The individual savings on each measure total $35,506, which corresponds to a simple payback of 2.3 years. Almost half of the total cost would go to the installation of low-e ceilings for rinks 2 and 3. The low-e ceilings are expected to achieve paybacks of 3.4 and 1.7 years respectively for rinks 2 and 3. Lighting improvements and de-mineralized flood water treatment for rink 3 combine for another 37% of the improvement costs and the remainder will go to high efficiency motor replacements and improved ventilation and refrigeration system controls. Suggestions with no costs, such as reduced outdoor air ventilation in rink 3 and a 2 °F lower arena temperature, would provide immediate paybacks.

This audit was completed in part through funding from the State of Minnesota. The State has appropriated $470,000 to develop and implement a program to install energy improvements in Minnesota's publicly-owned ice arenas. Funding was approved by the Minnesota Legislature, 1995 Minnesota Laws, Ch. 220, Sec. 19, Subd. 11(e) as recommended by the Legislative Commission on Minnesota Resources from Oil Overcharge Money. State funds were used to develop some of the technical information and energy use computational procedures for some of the improvement measures included in this audit report.

If there are questions with regard to this report, please call David Bohac (348-4830).

Summary of Recommendations

Table 1 is an overall summary of anticipated costs and savings for the recommended energy improvements for the Bloomington Ice Gardens. The total estimated cost for these improvements is $112,506. Utility incentives totaling $29,372 will be available to reduce the cost of installing these improvements. The sum of the anticipated first year savings for all of the measures is $35,506, corresponding to a combined simple payback of 2.3 years on the net installation costs. Because of interactive effects between some of the improvements, the total savings would be somewhat less than $35,506 if all the measures were implemented. The more significant interactive effects have been discussed in the audit and a final determination of total savings will be computed when a complete package of improvements is selected.

Should the City of Bloomington decide to implement some or all of the suggested improvements, the State of Minnesota will provide partial funding for selected improvements though its Energy Improvements for Minnesota Ice Arena program. The amount of funding available and set of measures that the funds can be applied to will be determined in consultation with the arena manager. Final funding decisions will be partially based on the ability to evaluate savings of the improvements and on the ability to relate these savings to other arenas.

Table 1

Estimated Cost of Proposed Improvements	**$112,506**
Utility Incentives:	**$29,372**
Improvement Package Net Cost:	**$83,134**
Anticipated Annual Energy Savings:	**$35,506**
Simple Payback	**2.3 years**

A complete list of the individual recommended energy improvement measures is shown in Table 2, along with pertinent savings and payback information. All recommended improvements have a simple payback of less than 10 years and many have a payback of less than 2 years. Almost half of the total cost ($52,750) would go to install low-e ceilings in rinks 2 and 3. Another 22% of the total expenses ($24,969) would cover lighting improvements and $17,000 would be spent on a de-mineralized water treatment system for rink 3 flood water. A small portion ($3,587) would be used for high efficiency motor replacements and the remainder ($14,200) on various ventilation and refrigeration system control measures.

Later sections of this report provide a description of the recommended measures along with a summary of the cost, savings, and payback of each improvement measure. The sections are divided by type of end-use. Appendices at the end of the report include more detailed descriptions and energy savings computations of the improvement measures.

For all improvements considered in this audit it was assumed that an NSP incentive of 0.10 $/kWh of the first year's annual savings or 50% of the equipment cost, which ever is less, would be available to reduce the installation cost of the measure. All energy cost calculations were performed using an electric use rate of 0.031 $/kWh and demand rates of 9.26 $/kW for June to September and 6.61 $/kW for October to May. Bloomington Ice Gardens is on a peak controlled rate with a predetermined demand level (PDL) of 400 kW. For all measures analyzed that were expected to generate demand savings, it was expected that any demand savings would occur at the higher non-controlled demand rate. All energy cost calculations that affected gas consumption used a cost of 0.50 $/therm.

Table 2. List of Recommended Improvements

Recommendations	Total Cost	Utility Incentive	Program Grant*	Net Cost	Annual Savings	Payback In Years
Ice Temperature Change Control: Rink 3	$9,000	$3,500		$5,500	$1,058	5.2
Lower Refrigeration Head Press: Rink 3	unknown	unknown		unknown	$3,131	unknown
Rinks 1 & 2 Compressor Unloader	$1,200	$300		$900	$1,419	0.6
Rink 3 Reduced Outside Air	$0	$0		$0	$3,753	---
Rink 3 CO_2 Ventilation Control	$2,000	$500		$1,500	$1,790	0.8
Rink 3 HVAC Night Shut Down	$2,000	$0		$2,000	$1,951	1.0
Rink 3 Reflective Ceiling	$27,925	$7,805		$20,120	$11,880	1.7
Rink 2 Reflective Ceiling	$24,825	$6,909		$17,916	$5,150	3.4
Lighting Fixture Retrofits (402)	$20,190	$2,761		$17,429	$2,700	6.5
Lighting fixture Replacements (50)	$4,779	$554		$4,225	$443	9.5
Motor Replacements (7)	$3,587	$1,043		$2,544	$553	4.6
Flood Water De-mineralization for Rink 3	$17,000	$6,000		$11,000	$2,006	5.5
Reduce Arena Temperature in Rink 3	$0	$0		$0	$2,803	---
Total⁺	**$112,506**	**$29,372**		**$83,134**	**$35,506**	**2.3**

*** - State of Minnesota program grants will be determined in consultation with the arena manager and other appropriate city staff.**
⁺ - totals do not include lower head pressure for rink 3.

Addendum 3: Updated List of Recommended Improvements

Date: November 22, 1996

This table has been updated to take into account the reduction in NSP's bounty amounts and the updates noted in Addendums 2 and 3, the interactive effects of HVAC measures that were selected by the arena, and to show the paybacks without the bounty.

Update to Table 2 (page 4). List of Recommended Improvements (Bloomington Ice Garden)

Recommendations	Total Cost	Utility Incentive	Program Grant	Net Cost	Annual Savings	Payback in Years+
Rinks 1 & 2 Compressor Unloader	$1,200	$0		$1,200	$1,419	0.8
Rink 2 and 3 Flooded Chiller Upgrade	$90,000	$11,601		$78,399	$13,462	6.7
Rink 3 Reduced Outside Air	$0	$0		$0	$3,753	---
Rink 3 CO_2 Ventilation Control	$2,000	$500		$1,500	$1,790	1.1
Rink 3 HVAC Night Shut Down	$2,000	$0		$2,000	$551	3.6
Rink 3 Reflective Ceiling	$27,925	$7,805		$20,120	$11,880	2.4
Rink 2 Reflective Ceiling	$24,825	$6,909		$17916	$5,150	4.8
Lighting Fixture Retrofits (402)	$20,190	$1,902		$18,288	$2,700	7.5
Lighting fixture Replacements (50)	$4,779	$0		$4,779	$443	10.8
Motor Replacements (5)*	$2,267	$369		$1,898	$345	6.6
Flood Water De-mineralization for Rink 3	$17,000	$3,748		$13,252	$2,006	8.5
Reduce Arena Temperature in Rink 3	$0	$0		$0	$2,803	---
Electric Resurfacer for Rink 3	$20,000	$2,000		$18,000	$3,041	6.6
Total+	**$212,186.00**	**$34,834.00**	**$75,000**	**$177,352**	**$49,343.00**	**2.1**

* - The two brine pump motors for the rink 3 refrigeration system were omitted because the system will be replaced.

+ - Paybacks for individual measures were calculated without the utility incentives, while the Total payback was calculated with the utility incentives and the state program grant.

Bud King Arena (December 1997): Executive Summary

This energy audit identifies energy improvement measures for Bud King Arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program[5] and NSP's Local Government Program, which provides special financing, bounty incentives and engineering fee reimbursement to county and municipal customers. The audit includes an analysis of the facility's recent electric and gas energy use, an on-site inspection of the building, discussions with arena staff regarding operations and schedules, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arena and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of cost-effective energy improvements for this facility that will reduce the annual energy costs by as much as $8,021

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for Bud King Arena. The total estimated cost for these improvements is $62,198 after available utility rebates have been applied[6]. A minimum Energy Grant of $5,000 has been applied to the improvement costs to yield an arena cost of $57,198. The sum of the anticipated first year savings for all of the individual measures is $8,021 which corresponds to a combined simple payback of 7.1 years on the net installation cost. Because of interactive effects between some of the improvements, the total savings would be somewhat less than $8,021 if all the measures were implemented. The more significant interactive effects have been discussed in the audit, and a final determination of total savings will be computed when a complete package of improvements is selected.

Estimated Cost of Proposed Improvements:	$72,233
Utility Incentives:	- $10,035
Energy Grant:	- $5,000
Arena's Cost for Improvement Package:	$57,198
Anticipated Annual Energy Savings:	$8,021
Simple Payback:	7.1 years

A complete list of the recommended energy improvements is shown in the table below, along with pertinent savings and payback information. Three of the six recommended energy improvement measures have a simple payback of less than 6 years, with the other three recommendations less than ten years. In addition to energy cost savings, a number of the measures provide benefits such as improved ice quality, improved arena lighting, and reduced

[5]The State of Minnesota has appropriated $470,000 to develop and implement this program. Funding for this project approved by the Minnesota Legislature, 1995 Minnesota Laws, Ch. 220, Sec. 19, Subd.11(e) as recommended by the Legislative Commission on Minnesota Resources from the Oil Overcharge Money.

[6] Additional utility rebates may be available. Final rebate amounts will be computed based on improvements to be installed at the arena.

maintenance costs. A number of no cost and low cost energy saving actions are also identified in the report, but not included in the summary tables.

List of Recommended Improvements

Energy Improvement Measures	Total Cost	Utility Rebate	Arena Cost	Annual Savings	Payback (years)
Lighting Improvements	$1,334	$299	$1,035	$467	2.2
Motors	$899	$201	$698	$167	4.2
Ice Control & Glycol Pump ASD	$17,000	$3,628	$13,372	$2,523	5.3
Condenser Fan ASD	$6,000	$752	$5,248	$551	9.5
Flood Water Demineralization	$18,000	$1,587	$16,413	$1,723	9.5
Low-E Ceiling	$29,000	$3,568	$25,432	$2,590	9.8
Total	$72,233	$10,035	$62,198	$8,021	9.0
Energy Grant			$5,000		
Total, Including Energy Grant & Utility Incentives	**$72,233**	**$10,035**	**$57,198**	**$8,021**	

Payback, Including Energy Grant and Utility Incentives*:	7.1 years
Required Arena Owner Funding:	$57,198

A number of other energy saving improvements were considered, but not recommended because the energy cost savings would not provide a simple payback of ten years or less. These included: reclaiming additional heat from the refrigeration system; liquid line pumps to reduce refrigeration system head pressures; ice sheet lighting replacement; and occupancy sensors for lighting control.

For all improvements considered in this audit, it was assumed that an NSP Local Government Program incentive of 0.05 $/kWh of the first year's annual savings or 50% of the equipment cost, which ever is less, would be available to reduce the installation cost of the measure. Measures must be installed and verified by June 30, 1998 in order to be eligible for NSP's Local Government Program. Rebates are available from NSP Gas for measures that reduce gas use. The gas rebate amount will be computed for each measure that is of interest to be included in the final improvement package. Measures that are to be installed and verified by June of 1998 will also qualify for a matching energy grant of at least $5,000 through the Minnesota Ice Arena Energy Improvement Program. Once a preliminary decision has been made regarding which measures will be implemented, CEE can assist with utility grant applications and a determination of eligibility for an energy grant.

All energy cost calculations were performed using an electric use rate of $0.031/kWh and demand rates of $9.25/kW for June to September and $6.61/kW for October to May. All energy costs calculations related to gas consumption used a cost of $0.43/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet. Savings calculation documentation is presented in the appendices.

Chaska Community Center (December 1997): Executive Summary

This energy audit identifies energy improvement measures for Chaska Civic Ice Arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program.[7] The audit includes an analysis of the facility's recent electric and gas energy use, on-site inspection of the building envelope, mechanical and lighting systems examination, operation discussions with maintenance personnel regarding maintenance and arena occupancy, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arena and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of cost-effective energy improvements for this facility that will reduce the annual energy costs by as much as $11,799.

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for Chaska Civic Arena. The total estimated cost for these improvements is $64,584.[8] A minimum Energy Grant of $5,000 has been applied to the improvement costs to yield an arena cost of $59,584. The sum of the anticipated first year savings for all of the individual measures is $11,799 which corresponds to a combined simple payback of 5.0 years on the net installation cost. Because of interactive effects between some of the improvements, the total savings would be somewhat less than $11,799 if all the measures were implemented. The more significant interactive effects have been discussed in the audit, and a final determination of total savings will be computed when a complete package of improvements is selected.

Estimated Cost of Proposed Improvements:	$64,584
Energy Grant:	- $5,000
Arena's Cost for Improvement Package:	$59,584
Anticipated Annual Energy Savings:	$11,799
Simple Payback:	5.0 years

A complete list of the recommended energy improvements is shown in the table below, along with pertinent savings and payback information. The operational schedule for the existing arena has been set to six months a year to reflect the anticipated heavier use of a new ice sheet that is currently under construction. Two of the seven recommended energy improvement measures have a simple payback of less than 6 years, with the other five recommendations less than ten years. In addition to energy cost savings, a number of the measures provide benefits such as improved ice quality, improved arena lighting, and reduced maintenance costs. A number of no cost and low cost energy saving actions are also identified in the report, but not included in the summary tables.

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[7] The State of Minnesota has appropriated $470,000 to develop and implement this program. Funding for this project approved by the Minnesota Legislature, 1995 Minnesota Laws, Ch. 220, Sec. 19, Subd.11(e) as recommended by the Legislative Commission on Minnesota Resources from the Oil Overcharge Money.

[8] Additional utility rebates may be available. Final rebate amounts will be computed based on improvements to be installed at the arena.

List of Recommended Improvements

Energy Improvement Measures	Total Cost	Utility Rebate	Arena Cost	Annual Savings	Payback w/o rebate
Condenser Fan Adjustable Speed Drive	$8,000	$0	$8,000	$2,142	3.7
Low-E Ceiling	$28,000	$0	$28,000	$5,970	4.7
Automatic Capacity Control of Compressors	$4,500	$0	$4,500	$702	6.4
Reclaim More Waste Heat from Refrigeration System	$8,500	$0	$8,500	$1,214	7.0
Motor Replacements	$1,158	$0	$1,158	$152	7.6
Liquid Line Pump to Reduce Head Pressure	$12,000	$0	$12,000	$1,344	8.9
Lighting Improvements	$2,426	$0	$2,426	$275	8.8
Total	$64,584	$0	$64,584	$11,799	5.5
Energy Grant			$5,000		
Total, Including Energy Grant & Utility Incentives	**$64,584**	**$0**	**$59,584**	**$11,799**	

Payback, Including Energy Grant and Utility Incentives*:	5.0 years
Required Arena Owner Funding:	$59,584

nay be reduced by implementing "no cost" operation and maintenance measures

A number of other energy saving improvements were considered, but not recommended because the energy cost savings would not provide a simple payback of ten years or less. These included: infrared ice temperature control with setback; ice sheet lighting replacement; and occupancy sensors for lighting control.

Measures that are to be installed and verified by June of 1998 will also qualify for a matching energy grant of at least $5,000 through the Minnesota Ice Arena Energy Improvement Program. However, an application must be submitted by January 16th for Chaska Civic Arena to be eligible for a grant. Once a preliminary decision has been made regarding which measures will be implemented, CEE can assist with utility grant applications and a determination of eligibility for an energy grant through the Minnesota Ice Arena Energy Improvement Program.

All energy cost calculations were performed using an electric use rate of $0.0285/kWh and demand rate of $8.30/kW. All energy costs calculations related to gas consumption used a cost of $0.45/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet.

Columbia Arena (September 1997): Executive Summary

This energy audit identifies energy improvement measures for Columbia Ice Arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program. The audit includes an analysis of the facility's recent electric and gas energy use, an on-site inspection of the building, discussions with arena staff regarding operations and schedules, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arenas and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of cost-effective energy improvements for this facility that will reduce the annual energy costs by as much as $70,170

The Columbia Ice Arena consists of two sheets of ice. The Main Rink was constructed in 1968 and operates for approximately eight months a year. Rink 2 was added in 1975 And operates for nine months a year. Two separate refrigeration systems supply cooling for the two ice sheets. In a typical weather year, the ice arena electricity costs total $87,861. Approximately 56% of the costs are due to the two refrigeration systems with the remainder due to: 15% for lighting, 9% for motors, and 20% for other loads. Gas consumption for a typical year is $39,079 with 78% going to space heating, 8% to resurfacer water heating, and 14% to other uses.

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for Columbia Ice Arena. The total estimated cost for these improvements is $339,807 after available utility rebates have been applied[9]. The sum of the anticipated first year savings for all of the individual measures is $70,170 which corresponds to a combined simple payback of 4.8 years on the net installation cost. Because of interactive effects between some of the improvements, the total savings would be somewhat less than $70,170 if all the measures were implemented. The more significant interactive effects have been discussed in the audit, and a final determination of total savings will be computed when a complete package of improvements is selected.

Estimated Cost of Proposed Improvements:	$346,452
Utility Incentives:	$6,645*
Arena's Cost for Improvement Package:	$339,807
Anticipated Annual Energy Savings:	$70,170
Simple Payback:	4.8 years

* Additional utility rebates maybe available

[9] Additional utility rebates maybe available. Final rebate amounts will be computed based on improvements to be installed at the arena.

A complete list of the recommended energy improvements is shown in the table below, along with pertinent savings and payback information. Except for lighting improvements, all recommended energy improvement measures have a simple payback of fewer than 10 years, and many have a payback of fewer than 5 years. In addition to energy cost savings, a number of the measures provide benefits such as improved ice quality, improved arena lighting, and reduced maintenance costs.

List of Recommended Improvements

Energy Improvement Measures	Total Cost	Utility Rebate	Arena Cost	Annual Savings	Payback (before rebate)
Condenser Fan Variable Speed Drive: Rink 2	$5,000	$240	$4,760	$3,087	1.6
Automatic Compressor Capacity Control: Both Rinks	$9,000	$0	$9,000	$3,856	2.3
Low-E Ceiling: Both Rinks	$64,000	$0	$64,000	$23,385	2.7
Improved Ice Temperature Controller: Both Rinks	$19,500	$0	$19,500	$5,249	3.7
Liquid Line Pump to Reduce Head Pressure: Rink 2	$12,000	$0	$12,000	$3,008	4.0
Reclaim Waste Heat From Regrigeration: Both Rinks	$25,000	$0	$25,000	$6,075	4.1
Electric Resurfacer: Both Rinks	$20,000	$2,000	$18,000	$4,048	4.9
Flood Water De-mineralization	$23,000	$0	$23,000	$4,637	5.0
Motor Replacements	$16,969	$3,301	$13,668	$2,239	7.6
Brine Pump Variable Speed Drive: Main Rink	$8,000	$0	$8,000	$1,017	7.9
Air Cooled Condenser: Main Rink	$60,000	$0	$60,000	$7,058	8.5
Water Heater for Non-Heating Season Use	$5,000	$0	$5,000	$552	9.1
Lighting Improvements	$78,983	$1,344	$77,639	$5,959	13.3
Total	$346,452	$6,885	$339,567	$70,170	4.9
Including Energy Grant & Utility Incentives	**$346,452**	**$6,885**	**$339,567**	**$70,170**	

Payback, Including Energy Grant and Utility Incentives*:	4.8 years
Required Arena Owner Funding:	$339,567

Rebates were only computed for motor recommendations and the non-ice sheet lighting improvements because NSP has set rebate amounts for these retrofits. No rebates have been computed for other measures with electric or gas savings. The rebate amount will be computed for each measure that is of interest to be included in the final improvement package. Rebates will be available through NSP's commercial custom rebate program and Minnegasco's custom rebate program. All energy cost calculations were performed using an electric use rate of $0.031/kWh and demand rates of $9.25/kW for June to September and $6.61/kW for October to May. All energy costs calculations related to gas consumption used a cost of $0.50/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet. Savings calculation documentation is presented in the appendices.

Cottage Grove Ice Arena (July 1997): Executive Summary

This energy audit identifies energy improvement measures for the two ice arenas at the Cottage Grove Arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program and NSP's Local Government Program that provide special financing, bounty incentives and engineering fee reimbursement to county and municipal customers. The audit includes an analysis of the facility's recent electric and gas energy use, on-site inspection of the building envelope, mechanical and lighting systems examination, operation discussions with maintenance personnel regarding, maintenance and arena occupancy, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arenas and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of cost-effective energy improvements for this facility that will reduce the annual energy costs by $27,756, which is equivalent to 45% of the present energy costs.

Cottage Grove Arena consists of two arenas. The building was constructed in 1974 and operates for approximately 8 months a year. A single refrigeration system supplies cooling for the Main and Studio rinks. In a typical weather year, the ice arena electricity costs will total $39,646. Approximately 48% of the costs are due to the refrigeration system with the remainder due to: 26% for lighting, 9% for motors, and 17% for other loads. Gas consumption for a typical year is $21,263 with 82% going to space heating, 12% to resurfacer water heating, and 6% to other uses.

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for Cottage Grove Ice Arena. The total estimated cost for these improvements is $162,336. Utility incentives totaling $15,761 will be available to reduce the cost of installing these improvements. A State of Minnesota Energy Grant of $50,000 is also available to reduce the net cost to $96,575. The sum of the anticipated first year savings for all of the individual measures is $27,756, which corresponds to a combined simple payback of 3.5 years on the net installation cost. Because of interactive effects between some of the improvements, the total savings would be somewhat less than $27,756 if all the measures were implemented. The more significant interactive effects have been discussed in the audit, and a final determination of total savings will be computed when a complete package of improvements is selected.

Estimated Cost of Proposed Improvements:	$162,336
Utility Incentives:	$15,761
Energy Grant:	$50,000
Improvement Package Arena Cost:	$96,575
Anticipated Annual Energy Savings:	$27,756
Simple Payback:	3.5 years

An Energy Grant of up to $50,00 is available to reduce the simple payback for the energy improvements to as few as 2 years. The Energy Grant amount is computed for the entire package of improvements. The Grant restrictions are as follows: (1) the Grant amount cannot exceed 50% of the installed cost, (2) the total Grant amount cannot exceed $25,000 per ice sheet in the facility, and (3) each energy improvement measure must have a simple payback of 10 years or fewer. Available utility rebates will be included in the 2 year minimum payback limit. Also, measures that provide substantial indoor air quality improvement are not subject to the 10 year simple payback requirement. A draft of the Energy Grant application form is included at the end of this section. Once the City of Cottage Grove has made a preliminary indication of which improvements will be implemented, CEE will calculate the revised Grant amount.

A complete list of the recommended energy improvements is shown in the table below, along with pertinent savings and payback information. Except for the resurfacer upgrades, all recommended improvements have a simple payback of fewer than 10 years, and many have a payback of fewer than 4 years.

List of Recommended Improvements

Energy Improvement Measures	Total Cost	Utility Rebate	Energy Grant	Arena Cost	Annual Savings	Payback (before rebate)
Reduced Space Temperture in Both Rinks	$1,500	$607		$893	$1,545	1.0
Reclaim Additional Refrigeration Waste Heat	$11,000	$0		$11,000	$4,244	2.6
Condenser Fan Variable Speed Drive	$3,600	$1,427		$2,173	$1,182	3.0
Motor Replacements	$917	$220		$697	$95	9.7
Liquid Line Pump to Reduce Head Pressure	$12,000	$3,065		$8,935	$2,258	5.3
Improved Ice Temperature Control	$9,500	$1,311		$8,189	$1,759	5.4
Flood Water De-mineralization	$23,000	$998		$22,002	$4,013	5.7
Low-E Ceiling: Both Rinks	$40,000	$3,200		$36,800	$6,593	6.1
Automatic Compressor Capacity Control	$4,500	$701		$3,799	$704	6.4
Reduced Space Temperture in Entryway	$200	$0		$200	$30	6.7
Lighting Improvements	$6,848	$793		$6,055	$659	10.4
Electric Resurfacer	$20,000	$2,000		$18,000	$1,444	13.9
Resurfacer upgrades	$1,200	$0		$1,200	$54	22.2
Total	$134,265	$14,322		$119,943	$24,580	5.5
Including Energy Grant & Utility Incentives	$134,265	$14,322	$50,000	$69,943	$24,580	

Payback, Including Energy Grant and Utility Incentives*:	2.8 years
Required Arena Owner Funding:	$69,943

For all improvements considered in this audit, it was assumed that an NSP incentive of 0.05 $/kWh of the first year's annual savings or 50% of the equipment cost, which ever is less, would be available to reduce the installation cost of the measure. No incentives were calculated for gas savings at the time of this audit. Rebates are available from NSP Gas for measures that reduce gas use. The rebate amount will be computed for each measure that is of interest to be included in the final improvement package. A zero interest loan is also available through the NSP Local Government Program for all electricity savings measures. This loan qualifies as matching funds towards the State Energy Grant. It appears that the required arena funding of $96,575 could be obtained from the NSP program. All energy cost calculations were performed using an electric use rate of 0.031 $/kWh and demand rates of 9.25 $/kW for June to September and 6.61 $/kW for October to May. All energy costs calculations that affected gas consumption used a cost of 0.50 $/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet. Savings calculation documentation is presented in the appendices.

Dave Skenzich Memorial Arena (February 1998): Executive Summary

This energy audit identifies energy improvement measures for Dave Skenzich Memorial Arena and the warming house that is adjacent to the arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program.[10] The audit includes an analysis of the facility's recent electric and gas energy use, an on-site inspection of the building, discussions with arena staff regarding operations and schedules, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arena and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended cost-effective lighting improvements for this facility that will reduce the annual energy costs by $596.

The table below is a summary of the anticipated costs and savings for the recommended lighting improvements for Dave Skenzich Memorial Arena. The total estimated cost for these improvements is $3,209. An expected Energy Grant of $1,605 has been applied to the improvement cost to yield an arena cost of $1,605. The anticipated first year savings $596 which corresponds to a simple payback of 2.7 years on the net installation cost.

Estimated Cost of Proposed Improvements:	$3,210
Energy Grant:	- $1,605
Arena's Cost for Improvement Package:	$1,605
Anticipated Annual Energy Savings:	$596
Simple Payback:	2.7 years

A number of no cost and low cost energy saving actions are also identified in the report, but not included in the summary tables. A number of other energy saving improvements were considered, but not recommended at this time because the energy cost savings would not provide a simple payback of ten years or less. The limited operating season, limited heating and lack of artificial ice limit the opportunities for cost-effectively reducing the already low energy costs. However, general descriptions of energy saving improvements that reduce the refrigeration load are included because they should be considered if the City of Gilbert does install an artificial ice plant. Load reducing items were included because they have the potential of not only reducing energy costs, but also extending the operating season that would be possible with a limited capacity refrigeration system

Measures that are to be installed and verified by June of 1998 will qualify for a matching energy grant of at least $5,000 through the Minnesota Ice Arena Energy Improvement Program. However, an application must be submitted by February 20th for Dave Skenzich Memorial Arena

[10]The State of Minnesota has appropriated $470,000 to develop and implement this program. Funding for this project approved by the Minnesota Legislature, 1995 Minnesota Laws, Ch. 220, Sec. 19, Subd.11(e) as recommended by the Legislative Commission on Minnesota Resources from the Oil Overcharge Money.

to be eligible for a grant. Once a preliminary decision has been made regarding whether or not the proposed lighting improvements will be implemented, CEE can assist with the development of bid specifications and a determination of the exact size of the energy grant that will be available through the Minnesota Ice Arena Energy Improvement Program.

Electric energy cost calculations were performed using an electric use rate of $0.071 per kilowatt hour (kWh). Energy cost savings calculations were performed using standard engineering principles and a variety of software.

Eagan Civic Arena (October 1997): Executive Summary

This energy audit identifies energy improvement measures for Eagan Civic Arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program. The audit includes an analysis of the facility's recent electric and gas energy use, an on-site inspection of the building, discussions with arena staff regarding operations and schedules, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arena and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of cost-effective energy improvements for this facility that will reduce the annual energy costs by as much as $23,205

Eagan Civic Arena is a single sheet facility constructed in 1995 and operates for approximately eight months a year. In a typical weather year, the ice arena electricity costs total $38,975. Approximately 40% of the costs are due to the refrigeration system with the remainder due to: 25% for lighting, 14% for motors, and 21% for other loads. Gas consumption for a typical year is $15,152 with 80% going to space heating, 10% to resurfacer water heating, and 10% to other uses.

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for Eagan Civic Arena. The total estimated cost for these improvements is $95,530 after available utility rebates have been applied[11]. The sum of the anticipated first year savings for all of the individual measures is $23,205 which corresponds to a combined simple payback of 4.1 years on the net installation cost. Because of interactive effects between some of the improvements, the total savings would be somewhat less than $23,205 if all the measures were implemented. The more significant interactive effects have been discussed in the audit, and a final determination of total savings will be computed when a complete package of improvements is selected.

Estimated Cost of Proposed Improvements:	$95,530
Utility Incentives:	$0
Arena's Cost for Improvement Package:	$95,530
Anticipated Annual Energy Savings:	$23,205
Simple Payback:	4.1 Years

[11] Additional utility rebates may be available. Final rebate amounts will be computed based on improvements to be installed at the arena.

A complete list of the recommended energy improvements is shown in the table below, along with pertinent savings and payback information. All recommended energy improvement measures have a simple payback of fewer than 10 years, and many have a payback of fewer than 5 years. In addition to energy cost savings, a number of the measures provide benefits such as improved ice quality and reduced maintenance costs. Although no major lighting work was recommended, the arena staff should use more efficient bulbs in the five incandescent fixtures when they are replaced through normal maintenance. In addition, the light quality and fixture lighting system efficiency over the ice sheet could be improved by replacing the existing fixtures with compact fluorescent fixtures, but this retrofit is not recommended because the energy savings payback is more than ten years.

List of Recommended Improvements

Energy Improvement Measures	Total Cost	Utility Rebate	Arena Cost	Annual Savings	Payback (before rebate)
Reduced Space Temperature: Arena	$2,000	$0	$2,000	$1,479	1.4
Reduce Head Pressure	$3,000	$0	$3,000	$1,607	1.9
Low-E Ceiling: Both Rinks	$29,000	$0	$29,000	$8,677	3.3
Reclaim More Waste Heat From Regrigeration	$25,000	$0	$25,000	$5,592	4.5
Condenser Fan Variable Speed Drive	$5,000	$0	$5,000	$1,064	4.7
Motor Replacements	$1,530	$0	$1,530	$284	5.4
Flood Water De-mineralization	$19,000	$0	$19,000	$2,982	6.4
Improved Ice Temperature Controller	$11,000	$0	$11,000	$1,520	7.2
Total	$95,530	$0	$95,530	$23,205	4.1
Including Energy Grant & Utility Incentives	**$95,530**	**$0**	**$95,530**	**$23,205**	

Payback, Including Energy Grant and Utility Incentives*:	4.1 years
Required Arena Owner Funding:	$95,530

*This payback may be reduced by implementing "no cost" operation and maintenance measures

Some of the measures may also be eligible for utility rebates. Dakota Electric Association's Energy Grant Program selects grant recipients quarterly from a number of project proposals. The next quarterly deadline for project proposals is November 20, 1997. People's Natural Gas also has a program to provide grants for energy saving projects. Once a preliminary decision has been made regarding which measures will be implemented, CEE can assist with utility grant applications.

All energy cost calculations were performed using an electric use rate of $0.0238/kWh and a demand rate of $6.45/kW for the entire year. All energy costs calculations related to gas consumption used a cost of $0.43/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet. Savings calculation documentation is presented in the appendices.

Farmington Civic Arena (October 1997): Executive Summary

This energy audit identifies energy improvement measures for Farmington Civic Arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program[12] and NSP's Local Government Program, which provides special financing, bounty incentives and engineering fee reimbursement to county and municipal customers.. The audit includes an analysis of the facility's recent electric and gas energy use, an on-site inspection of the building, discussions with arena staff regarding operations and schedules, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arenas and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of cost-effective energy improvements for this facility that will reduce the annual energy costs by as much as $15,114

Farmington Civic Arena is a single sheet facility constructed in 1976 and operates for approximately seven months a year. In a typical weather year, the ice arena electricity costs total $29,677. Approximately 41% of the costs are due to the refrigeration system with the remainder due to: 20% for lighting, 8% for motors, and 31% for other loads. Gas consumption for a typical year is $11,400 with 92% going to space heating, 7% to resurfacer water heating, and 1% to other uses.

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for Farmington Civic Arena. The total estimated cost for these improvements is $76,039 after available utility rebates have been applied[13]. The sum of the anticipated first year savings for all of the individual measures is $15,114 which corresponds to a combined simple payback of 5.0 years on the net installation cost. Because of interactive effects between some of the improvements, the total savings would be somewhat less than $15,114 if all the measures were implemented. The more significant interactive effects have been discussed in the audit, and a final determination of total savings will be computed when a complete package of improvements is selected.

Estimated Cost of Proposed Improvements:	$85,722
Utility Incentives:	$9,683
Arena's Cost for Improvement Package:	$76,039
Anticipated Annual Energy Savings:	$15,114
Simple Payback:	5.0 years

[12]The State of Minnesota has appropriated $470,000 to develop and implement this program. Funding for this project approved by the Minnesota Legislature, 1995 Minnesota Laws, Ch. 220, Sec. 19, Subd.11(e) as recommended by the Legislative Commission on Minnesota Resources from the Oil Overcharge Money.

[13] Additional utility rebates maybe available. Final rebate amounts will be computed based on improvements to be installed at the arena.

A complete list of the recommended energy improvements is shown in the table below, along with pertinent savings and payback information. Except for motor replacements, all recommended energy improvement measures have a simple payback of fewer than 7 years, and many have a payback of fewer than 5 years. In addition to energy cost savings, a number of the measures provide benefits such as improved ice quality, improved arena lighting, and reduced maintenance costs. A number of no cost and low cost energy saving actions are also identified in the report, but not included in the summary tables.

List of Recommended Improvements

Energy Improvement Measures	Total Cost	Utility Rebate	Arena Cost	Annual Savings	Payback (with rebate)
Hot Water Circulation Pump Control	$60	$0	$60	$35	1.7
Condenser Fan Variable Speed Drive	$6,000	$1,725	$4,275	$1,405	3.0
Pipe Insulation	$103	$0	$103	$27	3.8
Low-E Ceiling: Both Rinks	$28,000	$3,258	$24,742	$5,867	4.2
Reclaim More Waste Heat From Regrigeration	$17,300	$0	$17,300	$3,447	5.0
Improved Ice Temperature Controller	$9,500	$1,307	$8,193	$1,389	5.9
Liquid Line Pump to Reduce Head Pressure	$12,000	$2,127	$9,873	$1,568	6.3
Lighting Improvements	$2,943	$380	$2,563	$397	6.5
Motor Replacements	$9,816	$886	$8,930	$979	9.1
Total	$85,722	$9,683	$76,039	$15,114	5.0
Including Energy Grant & Utility Incentives	$85,722	$9,683	$76,039	$15,114	

Payback, Including Energy Grant and Utility Incentives*:	5.0 years
Required Arena Owner Funding:	$76,039

For all improvements considered in this audit, it was assumed that an NSP Local Government Program incentive of 0.05 $/kWh of the first year's annual savings or 50% of the equipment cost, which ever is less, would be available to reduce the installation cost of the measure. Measures must be installed and verified by June 30, 1998 in order to be eligible for NSP's Local Government Program. Although it was not considered in the economic analysis, People's Natural Gas also has a program to provide grants for energy saving projects. Measures that are installed and verified by June of 1998 might also be able to receive a matching energy grant of up $25,000 through the Minnesota Ice Arena Energy Improvement Program. Once a preliminary decision has been made regarding which measures will be implemented, CEE can assist with utility grant applications and a determination of eligibility for an energy grant.

All energy cost calculations were performed using an electric use rate of $0.031/kWh and demand rates of $9.25/kW for June to September and $6.61/kW for October to May. All energy costs calculations related to gas consumption used a cost of $0.43/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet. Savings calculation documentation is presented in the appendices.

Hodgins Berardo Arena (January 1998): Executive Summary

This energy audit identifies energy improvement measures for Hodgins Berardo Arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program[14] and Minnesota Power's Conservation Improvement Programs, which provide rebates and energy audit reimbursements. The audit includes an analysis of the facility's recent electric and gas energy use, on-site inspection of the building envelope, mechanical and lighting systems examination, operation discussions with maintenance personnel regarding, maintenance and arena occupancy, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arenas and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of cost-effective energy improvements for this facility that will reduce the annual energy costs by as much as $11,148.

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for Hodgins Berardo Arena. The total estimated cost for these improvements is $64,436 after available utility rebates have been applied. A minimum Energy Grant of $5,000 has been applied to the improvement costs to yield an arena cost of $59,436. The sum of the anticipated first year savings for all of the individual measures is $11,148 which corresponds to a combined simple payback of 5.3 years on the net installation cost. Because of interactive effects between some of the improvements, the total savings would be somewhat less than $11,148 if all the measures were implemented. The more significant interactive effects have been discussed in the audit, and a final determination of total savings will be computed when a complete package of improvements is selected.

Estimated Cost of Proposed Improvements:	$66,899
Estimated Minnesota Power Rebate:	- $2,463
Energy Grant:	- $5,000
Arena's Cost for Improvement Package:	$59,436
Anticipated Annual Energy Savings:	$11,148
Simple Payback:	5.3 years

A complete list of the recommended energy improvements is shown in the table below, along with pertinent savings and payback information. Four of the six recommended energy improvement measures have a simple payback of less than 7 years, with the other two recommendations less than ten years. In addition to energy cost savings, a number of the measures provide other benefits such as reduced maintenance costs. A number of no cost and low cost energy saving actions are also identified in the report, but not included in the summary tables.

[14]The State of Minnesota has appropriated $470,000 to develop and implement this program. Funding for this project approved by the Minnesota Legislature, 1995 Minnesota Laws, Ch. 220, Sec. 19, Subd.11(e) as recommended by the Legislative Commission on Minnesota Resources from the Oil Overcharge Money.

List of Recommended Improvements

Energy Improvement Measures	Total Cost	Utility Rebate	Arena Cost	Annual Savings	Payback with Rebate
Glycol Pump ASD & Improved Ice Temperature Controller	$16,000	$0	$16,000	$4,114	3.9 years
Motor Replacement	$7,307	$610	$6,697	$1,109	6.0 years
Low-e Ceiling	$28,000	$0	$28,000	$4,331	6.5 years
Lighting Improvements	$3,592	$359	$3,233	$485	6.7 years
Unloading Controls for Intermediate Capacity Steps	$5,000	$1,364	$3,636	$410	8.9 years
Condenser Fan Adjustable Speed Drive	$7,000	$130	$6,870	$699	9.8 years
Total	$66,899	$2,463	$64,436	$11,148	5.8 years
Energy Grant			$5,000		
Total, Including Energy Grant & Utility Incentives	**$66,899**	**$2,463**	**$59,436**	**$11,148**	

Payback, Including Energy Grant and Utility Incentives*:	5.3 years
Required Arena Owner Funding:	$59,436

A number of other energy saving improvements were considered, but not recommended because the energy cost savings would not provide a simple payback of ten years or less. These included: reclaiming additional heat from the refrigeration system; flood water demineralization; and occupancy sensors for lighting control.

For all improvements considered in this audit, it was assumed that a Minnesota Power rebate of $100 per kilowatt of demand savings would be available to reduce the installation cost of the measure. Once a preliminary decision has been made regarding which measures will be implemented, CEE can assist with utility grant applications. The guaranteed $5,000 minimum energy grant from the Minnesota Ice Arena Energy Improvement Program was included in the above analysis. Applications for an energy grant must be submitted by February 20, 1998 and CEE will provide a final determination of the energy grant amount by February 27.

All energy cost calculations were performed using an electric use rate of $0.04612 per kilowatt hour (kWh) and demand rate of $4.30 per kilowatt (kW) according to current rate structure information provided by Minnesota Power. All energy costs calculations related to gas consumption used a cost of $0.49/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet.

Hoyt Lakes (February 1998): Executive Summary

This energy audit identifies energy improvement measures for the Hoyt Lakes Sports Arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program[15] and Minnesota Power's Conservation Improvement Programs, which provide rebates and energy audit reimbursements. The audit includes an analysis of the facility's recent electric and gas energy use, an on-site inspection of the building, discussions with arena staff regarding operations and schedules, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arena and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of cost-effective energy improvements for this facility that will reduce the annual energy costs by as much as $11,726 and provide operational improvements such as higher quality ice and improved lighting quality.

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for Hoyt Lakes Sports Arena. The total estimated cost for these improvements is $88,051 after available utility rebates have been applied[16]. A minimum Energy Grant of $5,000 has been applied to the improvement costs to yield an arena cost of $83,051. The sum of the anticipated first year savings for all of the individual measures is $11,726 which corresponds to a combined simple payback of 7.1 years on the net installation cost. Because of interactive effects between some of the improvements, the total savings would be somewhat less than $11,726 if all the measures were implemented. The more significant interactive effects have been discussed in the audit, and a final determination of total savings will be computed when a complete package of improvements is selected.

Estimated Cost of Proposed Improvements:	$92,164
Estimated Minnesota Power Rebates:	- $4,113
Energy Grant:	- $5,000
Arena's Cost for Improvement Package:	$83,051
Anticipated Annual Energy Savings:	$11,726
Simple Payback:	7.1 years

A complete list of the recommended energy improvements is shown in the table below, along with pertinent savings and payback information. In addition to energy cost savings, a number of the measures provide benefits. For example, both the low emissivity ceiling and new light fixtures will improve the light quality in the arena while the flood water demineralization can

[15] The State of Minnesota has appropriated $470,000 to develop and implement this program. Funding for this project approved by the Minnesota Legislature, 1995 Minnesota Laws, Ch. 220, Sec. 19, Subd.11(e) as recommended by the Legislative Commission on Minnesota Resources from the Oil Overcharge Money.

[16] Additional utility rebates may be available. Final rebate amounts will be computed based on improvements to be installed at the arena.

make the ice quality even better than it currently is. A number of no cost and low cost energy saving actions are also identified in the report, but not included in the summary tables.

List of Recommended Improvements

Energy Improvement Measures	Total Cost	Utility Rebate	Arena Cost	Annual Savings	Payback with Rebate
Motor replacements	$458	$30	$428	$89	4.8 years
Condenser Fan Adjustable Speed Drive	$9,000	$984	$8,016	$1,239	6.5 years
Low-e Ceiling	$26,000	$0	$26,000	$3,544	7.3 years
Lighting Improvements	$33,706	$1,907	$31,799	$4,282	7.4 years
Unloading Controls for Intermediate Capacity Steps	$5,000	$1,192	$3,808	$461	8.3 years
Flood Water Demineralization	$18,000	$0	$18,000	$2,111	8.5 years
Total	$92,164	$4,113	$88,051	$11,726	7.9 years
Energy Grant			$5,000		
Total, Including Energy Grant & Utility Incentives	**$92,164**	**$4,113**	**$83,051**	**$11,726**	

Payback, Including Energy Grant and Utility Incentives*:	7.1 years
Required Arena Owner Funding:	$83,051

A number of other energy saving improvements were considered, but not recommended because the energy cost savings would not provide a simple payback of ten years or less. These included: reclaiming additional heat from the refrigeration system; infrared ice temperature control with overnight setback; and occupancy sensors for lighting control.

For all improvements considered in this audit, it was assumed that a Minnesota Power rebate of $100 per kilowatt of demand savings would be available to reduce the installation cost of the measure. Once a preliminary decision has been made regarding which measures will be implemented, CEE can assist with utility grant applications. The guaranteed $5,000 minimum energy grant from the Minnesota Ice Arena Energy Improvement Program was included in the above analysis. Applications for an energy grant must be submitted by February 20, 1998 and CEE will provide a final determination of the energy grant amount by February 27.

All energy cost calculations were performed using an electric use rate of $0.04612 per kilowatt hour (kWh) and demand rate of $4.30 per kilowatt (kW) according to current rate structure information provided by Minnesota Power. All energy costs calculations related to gas consumption used a cost of $0.43/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet.

Hutchinson Civic Arena (November 1997): Executive Summary

This energy audit identifies energy improvement measures for Hutchinson Civic Arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program[17]. The audit includes an analysis of the facility's recent electric and gas energy use, an on-site inspection of the building, discussions with arena staff regarding operations and schedules, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arenas and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of cost-effective energy improvements for this facility that will reduce the annual energy costs by as much as $8,538

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for Hutchinson Civic Arena. The total estimated cost for these improvements is $47,634 after available utility rebates have been applied[18]. The sum of the anticipated first year savings for all of the individual measures is $8,538 which corresponds to a combined simple payback of 5.6 years on the net installation cost. Because of interactive effects between some of the improvements, the total savings would be somewhat less than $8,538 if all the measures were implemented. The more significant interactive effects have been discussed in the audit, and a final determination of total savings will be computed when a complete package of improvements is selected.

Estimated Cost of Proposed Improvements:	$47,634
Utility Incentives:	$0
Arena's Cost for Improvement Package:	$47,634
Anticipated Annual Energy Savings:	$8,538
Simple Payback:	5.6 years

[17]The State of Minnesota has appropriated $470,000 to develop and implement this program. Funding for this project approved by the Minnesota Legislature, 1995 Minnesota Laws, Ch. 220, Sec. 19, Subd.11(e) as recommended by the Legislative Commission on Minnesota Resources from the Oil Overcharge Money.
[18] Additional utility rebates maybe available. Final rebate amounts will be computed based on improvements to be installed at the arena.

A complete list of the recommended energy improvements is shown in the table below, along with pertinent savings and payback information. Except for motor replacements and flood water demineralization, all recommended energy improvement measures have a simple payback of fewer than 6 years, and a couple have a payback of fewer than 4.5 years. In addition to energy cost savings, a number of the measures provide benefits such as improved ice quality, improved arena lighting, and reduced maintenance costs. A number of no cost and low cost energy saving actions are also identified in the report, but not included in the summary tables.

List of Recommended Improvements

Energy Improvement Measures	Total Cost	Utility Rebate	Arena Cost	Annual Savings	Payback (with rebate)
Condenser Fan Variable Speed Drive	$12,958	$0	$12,958	$1,851	7.0
Improved Ice Temperature Control	$14,000	$0	$14,000	$3,197	4.4
Glycol Pump Variable Speed Drive	$7,000	$0	$7,000	$1,281	5.5
Lighting Improvements	$1,317	$0	$1,317	$229	5.8
Motor replacements	$317	$0	$317	$38	8.3
Flood Water Demineralization	$18,000	$0	$18,000	$1,942	9.3
Total	$53,592	$0	$53,592	$8,538	6.3
Including Energy Grant & Utility Incentives	**$53,592**	**$0**	**$53,592**	**$8,538**	

Payback, Including Energy Grant and Utility Incentives*:	6.3 years
Required Arena Owner Funding:	$53,592

Measures that are installed and verified by June of 1998 might also be able to receive a matching energy grant of up $25,000 through the Minnesota Ice Arena Energy Improvement Program. Once a preliminary decision has been made regarding which measures will be implemented, CEE can assist with a determination of eligibility for an energy grant.

A number of other energy saving improvements were considered, but not recommended because the energy cost savings would not provide a simple payback of ten years or less. These included: reclaiming additional heat from the refrigeration system for space heating; ice sheet lighting replacement; and occupancy sensors for lighting control.

All energy cost calculations were performed using an electric use rate of $0.0449/kWh and a monthly demand rate of $3.65/kW. All energy costs calculations related to gas consumption used a cost of $0.458/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet.

Lee Community Center (February 1998): Executive Summary

This energy audit identifies energy improvement measures for Lee Community Center. It was performed as part of the Minnesota Ice Arena Energy Improvement Program[19] and Otter Tail Power Company's energy conservation programs. The audit includes an analysis of the facility's recent electric and gas energy use, on-site inspection of the building envelope, mechanical and lighting systems examination, operation discussions with maintenance personnel regarding maintenance and arena occupancy, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arena and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended two significant energy improvements for this facility that will reduce the annual energy costs by $1,218.

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for Lee Community Center. The total estimated cost for these improvements is $10,854.[20] The minimum Energy Grant of $5,000 and estimated Otter Tail Power Rebate of $595 have been applied to the improvement costs to yield an arena cost of $5,259. This would provide a combined simple payback of 4.3years on the net installation cost.

Estimated Cost of Proposed Improvements:	$10,854
Estimated Otter Tail Power Rebate:	$595
Energy Grant:	- $5,000
Arena's Cost for Improvement Package:	$5,259
Anticipated Annual Energy Savings:	$1,218
Simple Payback:	4.3 years

A complete list of the recommended energy improvements is shown in the table below, along with pertinent savings and payback information. A number of no cost and low cost energy saving actions are also identified in the report, but not included in the summary tables.

[19] The State of Minnesota has appropriated $470,000 to develop and implement this program. Funding for this project approved by the Minnesota Legislature, 1995 Minnesota Laws, Ch. 220, Sec. 19, Subd.11(e) as recommended by the Legislative Commission on Minnesota Resources from the Oil Overcharge Money.

[20] Additional utility rebates may be available. Final rebate amounts will be computed based on improvements to be installed at the arena.

List of Recommended Improvements

Interested Improvement	Energy Improvement Measures	Total Cost	Utility Rebate	Arena Cost	Annual Savings	Payback w/ rebate
☐	Non Ice Sheet Lighting Improvements	$4,854	$595	$4,259	$598	7.1
☐	Glycol Pump Two Speed Motor	$6,000	$0	$6,000	$620	9.7
	Total	$10,854	$595	$10,259	$1,218	8.9
	Energy Grant			$5,000		
	Total, Including Energy Grant & Utility Incentives	**$10,854**	**$595**	**$5,259**	**$1,218**	

Payback, Including Energy Grant and Utility Incentives*:	4.3 years
Required Arena Owner Funding:	$5,259

* this payback may be reduced by implementing "no cost" operation and maintenance measures

A number of other energy saving improvements were considered, but not recommended because the energy cost savings would not provide a simple payback of ten years or less. These included: refrigeration system heat reclaim; infrared ice temperature control with setback; low emissivity ceiling; ice sheet lighting replacement; and occupancy sensors for lighting control.

Measures that are to be installed and verified by June of 1998 will qualify for a matching energy grant of at least $5,000 through the Minnesota Ice Arena Energy Improvement Program. However, an application must be submitted by February 20th for the Lee Community Center to be eligible for a grant. Otter Tail Power Company may also provide a rebate for one or more of the improvements, but the rebate amount can not be accurately estimated without submitting an application to Otter Tail Power Company for pre-approval. Once a preliminary decision has been made regarding which measures will be implemented, CEE can assist with utility grant applications and a determination of eligibility for an energy grant through the Minnesota Ice Arena Energy Improvement Program.

Energy cost savings calculations were based electric rates of $0.024 per kilowatt for the refrigeration system and $0.07134 per kilowatt hour for most other end-uses. All energy costs calculations related to gas consumption used a cost of $0.45/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software.

Lily Lake Arena (February 1998): Executive Summary

This energy audit identifies energy improvement measures for the Lily Lake Arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program[21] and NSP's Local Government Program that provide special financing, bounty incentives and engineering fee reimbursement to county and municipal customers. The audit includes an analysis of the facility's recent electric and gas energy use, on-site inspection of the building envelope, mechanical and lighting systems examination, operation discussions with maintenance personnel regarding maintenance and arena occupancy, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arena and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of cost-effective energy improvements for this facility that will reduce the annual energy costs by nearly $3,000.

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for the Lily Lake Arena. The total estimated cost for these improvements is $20,373. Utility incentives totaling $1,781 will be available to reduce the cost of installing these improvements. A State of Minnesota matching Energy Grant may also available to reduce the net cost. The sum of the anticipated first year savings for all of the individual measures is $2,972, which corresponds to a combined simple payback of 6.3 years on the net installed cost. Because of interactive effects between some of the improvements, the total savings would be somewhat less if all the measures were implemented. The more significant interactive effects have been discussed in the audit, and a determination of total savings will be computed when a preliminary package of improvements is selected.

Estimated Cost of Proposed Improvements:	$20,373
Utility Incentives:	$1,781
Energy Grant:	TBA
Improvement Package Arena Cost:	$18,591
Anticipated Annual Energy Savings:	$2,972
Simple Payback:	6.3 years

A summary of the recommended energy improvements is shown in the table on the next page, along with pertinent savings and payback information. A number of no and low cost energy cost savings opportunities are also identified in the audit report, but not included in the improvement summary tables presented here. Except for the resurfacer upgrades, all recommended improvements have a simple payback of 10 years or less.

[21]The State of Minnesota has appropriated $470,000 to develop and implement this program. Funding for this project approved by the Minnesota Legislature, 1995 Minnesota Laws, Ch. 220, Sec. 19, Subd.11(e) as recommended by the Legislative Commission on Minnesota Resources from the Oil Overcharge Money.

List of Recommended Improvements

Energy Improvement Measures	Total Cost	Utility Rebate	Arena Cost	Annual Savings	Payback w/ rebate
Glycol Pump Adjustable Speed Drive	$3,000	$0	$3,000	$1,370	2.2
Insulate Hot Water Storage Tank	$750	$0	$750	$91	8.2
Lighting Improvements	$6,848	$692	$6,156	$659	9.3
High Efficiency Motor Replacements: Glycol Pumps	$2,274	$440	$1,834	$190	9.7
Condenser Fan Adjustable Speed Drive	$7,500	$649	$6,851	$662	10.3
Total	$20,372	$1,781	$18,591	$2,972	6.3

For all improvements considered in this audit, it was assumed that an NSP incentive of 0.05 $/kWh of the first year's annual savings or 50% of the equipment cost, which ever is less, would be available to reduce the installation cost of the measure. No incentives were calculated for gas savings at the time of this audit. Rebates are available from NSP Gas for measures that reduce gas use. The rebate amount will be computed for each measure that is of interest to be included in the final improvement package. A zero interest loan is also available through the NSP Local Government Program. This loan qualifies as matching funds towards the State Energy Grant.

All energy cost calculations were performed using an electric use rate of 0.031 $/kWh and demand rates of 9.25 $/kW for June to September and 6.61 $/kW for October to May. All energy costs calculations that affected gas consumption used a cost of 0.45 $/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet.

Litchfield Civic Arena (November 1997): Executive Summary

This energy audit identifies energy improvement measures for Litchfield Civic Arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program.[22] The audit includes an analysis of the facility's recent electric and gas energy use, an on-site inspection of the building, discussions with arena staff regarding operations and schedules, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arenas and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of cost-effective energy improvements for this facility that will reduce the annual energy costs by as much as $2,815

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for Litchfield Civic Arena. The total estimated cost for these improvements is $23,668.[23] The sum of the anticipated first year savings for all of the individual measures is $2,815 which corresponds to a combined simple payback of 8.4 years on the net installation cost. Because of interactive effects between some of the improvements, the total savings would be somewhat less than $2,815 if all the measures were implemented. The more significant interactive effects have been discussed in the audit, and a final determination of total savings will be computed when a complete package of improvements is selected.

Estimated Cost of Proposed Improvements:	$23,668
Utility Incentives:	$0
Arena's Cost for Improvement Package:	$23,668
Anticipated Annual Energy Savings:	$2,815
Simple Payback:	8.4 years

A complete list of the recommended energy improvements is shown in the table below, along with pertinent savings and payback information. In addition to energy cost savings, a number of the measures provide benefits such as improved ice quality, improved arena lighting, and reduced maintenance costs. A number of no cost and low cost energy saving actions are also identified in the report, but not included in the summary tables.

[22]The State of Minnesota has appropriated $470,000 to develop and implement this program. Funding for this project approved by the Minnesota Legislature, 1995 Minnesota Laws, Ch. 220, Sec. 19, Subd.11(e) as recommended by the Legislative Commission on Minnesota Resources from the Oil Overcharge Money.

[23] Additional utility rebates maybe available. Final rebate amounts will be computed based on improvements to be installed at the arena.

List of Recommended Improvements

Energy Improvement Measures	Total Cost	Utility Rebate	Arena Cost	Annual Savings	Payback (with rebate)
Condenser Fan Variable Speed Drive	$7,000	$0	$7,000	$1,137	6.2
Removal of One Storage Tank and Insulate Other	$1,050	$0	$1,050	$124	8.5
Improved Ice Temperature Control	$1,200	$0	$1,200	$130	9.2
Direct Water Line from Locker room Water Heater	$1,500	$0	$1,500	$160	9.4
Glycol Pump Variable Speed Drive	$8,500	$0	$8,500	$862	9.9
Lighting Improvements	$4,418	$0	$4,418	$402	11.0
Total	$23,668	$0	$23,668	$2,815	8.4
Including Energy Grant & Utility Incentives	$23,668	$0	$23,668	$2,815	

Payback, Including Energy Grant and Utility Incentives*:	8.4 years
Required Arena Owner Funding:	$23,668

The costs for making a number of the recommended improvements might be reduced through grants provided by the Minnesota Ice Arena Energy Improvement Program and/or other sources. Although it was not considered in the economic analysis, Minnegasco has a program to proide rebates for energy saving projects. Once a preliminary decision has been made regarding which measures will be implemented, CEE can assist with utility rebate applications and a determination of eligibility for an energy grant.

A number of other energy saving improvements were considered, but not recommended because the energy cost savings would not provide a simple payback of ten years or less. These included: infrared ice temperature control; heat reclaim from the refrigeration system; refrigerant liquid line pump; insulating the floor above the two corners with a refrigerated floor (only saves $35 per year); flood water demineralization; high efficiency motor replacements; ice sheet lighting replacement; and occupancy sensors for lighting control. Although many of these improvements are viable options in some rinks, the low energy costs—achieved through the combination of relatively low arena air temperatures, a short operating season, and low electric rates—reduce the cost savings potential for Litchfield Civic Arena.

All energy cost calculations were performed using an electric use rate of $0.037/kWh and no demand charges. All energy costs calculations related to gas consumption used a cost of $0.50/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet.

Mankato Civic Arena (December 1997): Executive Summary

This energy audit identifies energy improvement measures for Mankato Civic Arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program[24] and NSP's Local Government Program, which provides special financing, bounty incentives and engineering fee reimbursement to county and municipal customers. The audit includes an analysis of the facility's recent electric and gas energy use, an on-site inspection of the building, discussions with arena staff regarding operations and schedules, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arena and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of cost-effective energy improvements for this facility that will reduce the annual energy costs by as much as $7,397

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for Mankato Civic Arena. The total estimated cost for these improvements is $46,035 after available utility rebates have been applied[25]. A minimum Energy Grant of $5,000 has been applied to the improvement costs to yield an arena cost of $41,035. The sum of the anticipated first year savings for all of the individual measures is $7,397 which corresponds to a combined simple payback of 5.5 years on the net installation cost. Because of interactive effects between some of the improvements, the total savings would be somewhat less than $7,397 if all the measures were implemented. The more significant interactive effects have been discussed in the audit, and a final determination of total savings will be computed when a complete package of improvements is selected.

Estimated Cost of Proposed Improvements:	$51,000
Utility Incentives:	- $4,965
Energy Grant:	- $5,000
Arena's Cost for Improvement Package:	$41,035
Anticipated Annual Energy Savings:	$7,397
Simple Payback:	5.5 years

A complete list of the recommended energy improvements is shown in the table below, along with pertinent savings and payback information. A number of no cost and low cost energy saving actions are also identified in the report, but not included in the summary tables.

[24]The State of Minnesota has appropriated $470,000 to develop and implement this program. Funding for this project approved by the Minnesota Legislature, 1995 Minnesota Laws, Ch. 220, Sec. 19, Subd.11(e) as recommended by the Legislative Commission on Minnesota Resources from the Oil Overcharge Money.

[25] Additional utility rebates may be available. Final rebate amounts will be computed based on improvements to be installed at the arena.

List of Recommended Improvements

Energy Improvement Measures	Total Cost	Utility Rebate	Arena Cost	Annual Savings	Payback w/o rebate
Condenser Fan Adjustable Speed Drive	$8,000	$0	$8,000	$2,142	3.7
Low-E Ceiling	$28,000	$0	$28,000	$5,970	4.7
Automatic Capacity Control of Compressors	$4,500	$0	$4,500	$702	6.4
Reclaim More Waste Heat from Refrigeration System	$8,500	$0	$8,500	$1,214	7.0
Motor Replacements	$1,158	$0	$1,158	$152	7.6
Liquid Line Pump to Reduce Head Pressure	$12,000	$0	$12,000	$1,344	8.9
Lighting Improvements	$2,426	$0	$2,426	$275	8.8
Total	$64,584	$0	$64,584	$11,799	5.5
Energy Grant			$5,000		

A number of other energy saving improvements were considered, but not recommended because the energy cost savings would not provide a simple payback of ten years or less. These included: reclaiming additional heat from the refrigeration system; infrared ice temperature control; flood water deminerialization; ice sheet lighting replacement; and occupancy sensors for lighting control.

For all improvements considered in this audit, it was assumed that an NSP Local Government Program incentive of 0.05 $/kWh of the first year's annual savings or 50% of the equipment cost, which ever is less, would be available to reduce the installation cost of the measure. Measures must be installed and verified by June 30, 1998 in order to be eligible for NSP's Local Government Program. Rebates may be available from Minnegasco for measures that reduce gas use. The gas rebate amount will be computed for each measure that is of interest to be included in the final improvement package. Measures that are to be installed and verified by June of 1998 will also qualify for a matching energy grant of at least $5,000 through the Minnesota Ice Arena Energy Improvement Program. However, an application must be submitted by January 16th for Mankato Civic Arena to be eligible for a grant. Once a preliminary decision has been made regarding which measures will be implemented, CEE can assist with utility grant applications and a determination of eligibility for an energy grant through the Minnesota Ice Arena Energy Improvement Program.

All energy cost calculations were performed using an electric use rate of $0.031/kWh and demand rates of $9.25/kW for June to September and $6.61/kW for October to May. All energy costs calculations related to gas consumption used a cost of $0.45/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet.

Multipurpose Sport Building (January 1998): Executive Summary

This energy audit identifies energy improvement measures for Duluth Multipurpose Facility. It was performed as part of the Minnesota Ice Arena Energy Improvement Program[26] and Minnesota Power's Conservation Improvement Programs, which provide rebates and energy audit reimbursements. The audit includes an on-site inspection of the building, discussions with arena staff regarding operations and schedules, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arena and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of cost-effective energy improvements for this facility that will reduce the annual energy costs by as much as $11,020

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for Duluth Multipurpose Facility. The total estimated cost for these improvements is $63,189 after available utility rebates have been applied[27]. The sum of the anticipated first year savings for all of the individual measures is $11,020 which corresponds to a combined simple payback of 6.0 years on the net installation cost. Because of interactive effects between some of the improvements, the total savings would be somewhat less than $11,020 if all the measures were implemented. The more significant interactive effects have been discussed in the audit, and a final determination of total savings will be computed when a complete package of improvements is selected.

Estimated Cost of Proposed Improvements:	$65,649
Utility Incentives:	- $2,460
Arena's Cost for Improvement Package:	$63,189
Anticipated Annual Energy Savings:	$11,020
Simple Payback:	6.0 years

A complete list of the recommended energy improvements is shown in the table below, along with pertinent savings and payback information. Three of the five recommended energy improvement measures have a simple payback of less than 6 years, with the other two recommendations less than ten years. In addition to energy cost savings, a number of the measures provide benefits such as improved ice quality, improved arena lighting, and reduced maintenance costs. A number of no cost and low cost energy saving actions are also identified in the report, but not included in the summary tables.

[26] The State of Minnesota has appropriated $470,000 to develop and implement this program. Funding for this project approved by the Minnesota Legislature, 1995 Minnesota Laws, Ch. 220, Sec. 19, Subd.11(e) as recommended by the Legislative Commission on Minnesota Resources from the Oil Overcharge Money.
[27] Additional utility rebates may be available. Final rebate amounts will be computed based on improvements to be installed at the arena.

List of Recommended Improvements

Energy Improvement Measures	Total Cost	Utility Rebate	Arena Cost	Annual Savings	Payback w/ rebate
Lighting Improvements	$2,967	$75	$2,892	$1,341	2.2
Motor Replacements	$4,182	$360	$3,822	$1,106	3.5
Ice Temperature Controller	$12,500	$2,025	$10,475	$2,373	4.4
Low-E Ceiling	$28,000	$0	$28,000	$4,119	6.8
Flood Water Demineralization	$18,000	$0	$18,000	$2,081	8.6
Total	$65,649	$2,460	$63,189	$11,020	6.0

Payback, Including Energy Grant and Utility Incentives*:	6.0 years
Required Arena Owner Funding:	$63,189

A number of other energy saving improvements were considered, but not recommended because the energy cost savings would not provide a simple payback of ten years or less. These included: reclaiming additional heat from the refrigeration system; adjustable speed drive to control condenser fans; ice sheet lighting replacement; and occupancy sensors for lighting control.

For all improvements considered in this audit, it was assumed that a Minnesota Power rebate of $100 per kilowatt of demand savings would be available to reduce the installation cost of the measure. Once a preliminary decision has been made regarding which measures will be implemented, CEE can assist with utility grant applications.

All energy cost calculations were performed using an electric use rate of $0.03081 per kilowatt-hour and demand rates of $7.25 per kilowatt. All energy costs calculations related to gas consumption used a cost of $0.243 per 100 cubic feet. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet.

Parade Ice Garden (June 1997): Executive Summary

This energy audit identifies energy improvement measures for the three ice arenas at the Parade Ice Gardens. It was performed as part of the Minnesota Ice Arena Energy Improvement Program and NSP's Local Government Program that provide special financing, bounty incentives and engineering fee reimbursement to county and municipal customers. The audit includes an analysis of the facility's recent electric and gas energy use, on-site inspection of the building envelope, mechanical and lighting systems examination, operation discussions with maintenance personnel regarding, maintenance and arena occupancy, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arenas and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of cost-effective energy improvements for this facility that will reduce the annual energy costs by $58,639, which is equivalent to 25% of the present energy costs.

Parade Ice Gardens consists of three arenas. The South and Studio Rinks were constructed in 1976, they operate for approximately 8 months a year. The North rink was added in 1988 and it operates 11 months a year. A single refrigeration system supplies cooling for the South and Studio rinks, and a separate system cooling the North rink. In a typical weather year, the ice arena electricity costs will total $144,850. Approximately 41% of the costs are due to the two refrigeration systems with the remainder due to: 19% for lighting, 6% for motors, and 34% for other loads. Gas consumption for a typical year is $53,305 with 82% going to space heating, 11% to resurfacer water heating, and 7% to other uses.

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for the Parade Ice Gardens. The total estimated cost for these improvements is $238,879. Utility incentives totaling $38,213 will be available to reduce the cost of installing these improvements. A State of Minnesota Energy Grant of $75,000 is also available to reduce the net cost to $125,666. The sum of the anticipated first year savings for all of the individual measures is $58,639, which corresponds to a combined simple payback of 2.1 years on the net installation cost. Because of interactive effects between some of the improvements, the total savings would be somewhat less than $58,639 if all the measures were implemented. The more significant interactive effects have been discussed in the audit, and a final determination of total savings will be computed when a complete package of improvements is selected.

Estimated Cost of Proposed Improvements:	$238,879
Utility Incentives:	$38,213
Energy Grant:	$75,000
Improvement Package Arena Cost:	$125,666
Anticipated Annual Energy Savings:	$58,639
Simple Payback:	2.1 years

An Energy Grant of up to $75,000 is available to reduce the simple payback for the energy improvements to as few as 2 years. The Energy Grant amount is computed for the entire package of improvements. The Grant restrictions are as follows: (1) the Grant amount cannot exceed 50% of the installed cost, (2) the total Grant amount cannot exceed $25,000 per ice sheet in the facility, and (3) each energy improvement measure must have a simple payback of 10 years or fewer. Available utility rebates will be included in the 2 year minimum payback limit. Also, measures that provide substantial indoor air quality improvement are not subject to the 10 year simple payback requirement. A draft of the Energy Grant application form is included at the end of this section. Once the City of Minneapolis has made a preliminary indication of which improvements will be implemented, CEE will calculate the revised Grant amount.

A complete list of the recommended energy improvements is shown in the table below, along with pertinent savings and payback information. Except for the resurfacer upgrades, all recommended improvements have a simple payback of fewer than 10 years, and many have a payback of fewer than 4 years.

List of Recommended Improvements

Energy Improvement Measures	Total Cost	Utility Rebate	Energy Grant	Arena Cost	Annual Savings	Payback (before rebate)
Reduced Space Temperture: North	$1,500	$750		$750	$3,770	0.4
Flood Water De-mineralization	$23,000	$5,440		$17,560	$10,431	2.2
Automated Controls: South and Studio	$10,000	$1,711		$8,289	$3,415	2.9
Reclaim Refrigeration Waste Heat: South	$11,000	$0		$11,000	$3,233	3.4
Improved Ice Temperature Control: Both	$17,500	$4,302		$13,198	$5,008	3.5
Automatic Compressor Capacity Control: Both	$8,500	$714		$7,786	$2,236	3.8
Condenser Fan Variable Speed Drive: Both	$8,100	$2,573		$5,527	$2,125	3.8
Liquid Line Pump to Reduce Head Pressure: North	$12,000	$4,589		$7,411	$3,131	3.8
Low-E Ceiling: North	$28,000	$3,448		$24,552	$7,017	4.0
Low-E Ceiling: South and Studio rink	$38,000	$3,884		$34,116	$6,980	5.4
Motor Replacements	$20,905	$4,007		$16,898	$3,693	5.7
Lighting Improvements	$59,174	$6,795		$52,379	$7,570	7.8
Resurfacer upgrades	$1,200	$0		$1,200	$30	40.0
Total	$238,879	$38,213		$200,666	$58,639	4.1
Total, Including Energy Grant & Utility Incentives	**$238,879**	**$38,213**	**$75,000**	**$125,666**	**$58,639**	

Payback, Including Energy Grant and Utility Incentives*:	2.1 years
Required Arena Owner Funding:	$125,666

For all improvements considered in this audit, it was assumed that an NSP incentive of 0.05 $/kWh of the first year's annual savings or 50% of the equipment cost, which ever is less, would be available to reduce the installation cost of the measure. A zero interest loan is also available through the NSP Local Government Program for all electricity savings measures. This loan qualifies as matching funds towards the State Energy Grant. It appears that the required arena funding of $125,666 could be obtained from the NSP program. All energy cost calculations were performed using an electric use rate of 0.031 $/kWh and demand rates of 9.25 $/kW for June to September and 6.61 $/kW for October to May. All energy costs calculations that affected gas consumption used a cost of 0.50 $/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet. Savings calculation documentation is presented in the appendices.

Riverside Arena (final 3/98; preliminary 5/96): Executive Summary

This energy audit provides information on energy improvement measures for Riverside Arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program.[28] The audit results are based on an on-site inspection of the building envelope, mechanical and lighting systems, discussions regarding maintenance and arena occupancy, and consultations with contractors. Because the facility has been constantly changing with a major building expansion and the addition of a new refrigeration system, the audit report includes very detailed analyses for only those improvements that arena decision-makers indicated a specific interest in. A preliminary audit report (see the Appendix) provided information on a wider variety of technologies; and the responses to that report guided the preparation of this final audit report. The variable occupancy associated with the expansion also did not allow for the reliable use of historic utility bills in the projection of energy savings, so total building energy use is not detailed in this audit.

Four energy improvements proved to be both economically viable and feasible within the constraints of the larger building improvement project, and were therefore implemented. These improvements are listed below. Refrigeration system heat reclaim was implemented only after CEE provided follow-up information subsequent to the preliminary audit report and an Energy Grant of $3,420.50 was provided to offset the total installed cost of $6,841. This will provide the arena with an energy cost savings payback of 5 years. The three other improvements listed below were implemented without detailed information (beyond what was provided in the preliminary audit report), so it is unclear exactly what impact the Minnesota Ice Arena Energy Improvement Program had on the selection of these items.

Energy Efficient Features of Facility Expansion

- Refrigeration System Heat Reclaim
- High Efficiency Electric Motors
- Brine Pump Controls
- High Efficiency Public Space Lighting

[28]The State of Minnesota has appropriated $470,000 to develop and implement this program. Funding for this project approved by the Minnesota Legislature, 1995 Minnesota Laws, Ch. 220, Sec. 19, Subd.11(e) as recommended by the Legislative Commission on Minnesota Resources from the Oil Overcharge Money.

VFW Memorial Ice Arena (February 1998): Executive Summary

This energy audit identifies energy improvement measures for VFW Memorial Arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program.[29] The audit includes an analysis of the facility's recent electric and gas energy use, on-site inspection of the building envelope, mechanical and lighting systems examination, operation discussions with maintenance personnel regarding maintenance and arena occupancy, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arena and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended two specific cost-effective energy improvements for this facility that will reduce the annual energy costs. In addition, many other energy savings technologies have been explored and presented for the review of the arena manager. Accurate payback information could not be obtained for many of the technologies. If any of the technologies are of interest to the manager, further analysis, and more accurate cost estimates will be explored to perform an accurate economic analysis of the improvement measures.

A number of other energy saving improvements were considered, but not recommended because the energy cost savings would not provide a simple payback of ten years or less. These included: infrared ice temperature control with setback; adjustable speed drive control of evaporative condenser; ice sheet lighting replacement; public space lighting; occupancy sensors for lighting control, low emissivity ceiling, and flood water demineralization.

Measures that are to be installed and verified by June of 1998 will qualify for a matching energy grant of at least $5,000 through the Minnesota Ice Arena Energy Improvement Program. However, an application must be submitted by February 20th for VFW Memorial Arena to be eligible for a grant. Once a preliminary decision has been made regarding which measures will be implemented, CEE can assist with a determination of eligibility for an energy grant through the Minnesota Ice Arena Energy Improvement Program.

All energy cost calculations were performed using an electric use rate of $0.04932kWh. All energy costs calculations related to gas consumption used a cost of $0.45/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet.

[29] The State of Minnesota has appropriated $470,000 to develop and implement this program. Funding for this project approved by the Minnesota Legislature, 1995 Minnesota Laws, Ch. 220, Sec. 19, Subd.11(e) as recommended by the Legislative Commission on Minnesota Resources from the Oil Overcharge Money.

Victory Memorial Ice Arena (August 1997): Executive Summary

This energy audit identifies energy improvement measures for Victory Memorial Ice Arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program. The audit includes an analysis of the facility's recent electric and gas energy use, on-site inspection of the building envelope, mechanical and lighting systems examination, operation discussions with maintenance personnel regarding, maintenance and arena occupancy, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arenas and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of cost-effective energy improvements for this facility that will reduce the annual energy costs by as much as $27,115[30].

Victory Memorial Ice Arena has a single ice sheet. The building was constructed in 1974 and operates for approximately 10 months a year. A single refrigeration system supplies cooling for a standard 85 x 200ft rink. In a typical weather year, the ice arena electricity costs will total $37,046. Approximately 44% of the costs are due to the refrigeration system with the remainder due to: 21% for lighting, 5% for motors, and 30% for other loads. Gas consumption for a typical year is $16,989 with 88% going to space heating, 7% to resurfacer water heating, and 5% to other uses.

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for Victory Memorial Ice Arena. The total estimated cost for these improvements is $82,185. A State of Minnesota Energy Grant of $25,000 is also available to reduce the net cost to $54,586. The sum of the anticipated first year savings for all of the individual measures is $27,115 which corresponds to a combined simple payback of 2.0 years on the net installation cost. Because of interactive effects between some of the improvements, the total savings would be somewhat less than $27,115 if all the measures were implemented. The more significant interactive effects have been discussed in the audit, and a final determination of total savings will be computed when a complete package of improvements is selected.

Estimated Cost of Proposed Improvements:	$82,185
Utility Incentives:	$2,599
Energy Grant:	$25,000
Improvement Package Arena Cost:	$54,586
Anticipated Annual Energy Savings:	$27,115
Simple Payback:	2.0 years

[30] Savings of $31,359 are based on the energy consumption of the building with an unfinished wood roof that will be installed in April of 1998.

A complete list of the recommended energy improvements is shown in the table below, along with pertinent savings and payback information. Except for the resurfacer upgrades, all recommended improvements have a simple payback of fewer than 10 years, and many have a payback of fewer than 4 years.

List of Recommended Improvements

Energy Improvement Measures	Total Cost	Utility Rebate	Energy Grant	Arena Cost	Annual Savings	Payback (before rebate)
Low-E Ceiling*	$25,000	$0		$25,000	$16,153	1.5
Condenser Fan Variable Speed Drive	$3,600	$0		$3,600	$1,839	2.0
Automatic Compressor Capacity Control	$4,000	$0		$4,000	$1,192	3.4
Improved Ice Temperature Control	$8,000	$0		$8,000	$1,759	4.5
Flood Water De-mineralization	$15,000	$0		$15,000	$2,427	6.2
Liquid Line Pump to Reduce Head Pressure	$12,000	$0		$12,000	$1,835	6.5
Lighting Improvements	$5,650	$839		$4,811	$780	7.2
Motor Replacements	$8,935	$1,760		$7,175	$1,130	7.9
Total	$82,185	$2,599		$79,586	$27,115	3.0
Including Energy Grant & Utility Incentives	**$82,185**	**$2,599**	**$25,000**	**$54,586**	**$27,115**	

* Savings for low-e are based on improvement over unfinished wood ceiling

Payback, Including Energy Grant and Utility Incentives*:	2.0 years
Required Arena Owner Funding:	$54,586

* this payback may be reduced by implementing "no cost" operation and maintenance measures

An Energy Grant of up to $25,000 is available to reduce the simple payback for the energy improvements to as few as 2 years. The Energy Grant amount is computed for the entire package of improvements. The Grant restrictions are as follows: (1) the Grant amount cannot exceed 50% of the installed cost, (2) the total Grant amount cannot exceed $25,000 per ice sheet in the facility, and (3) each energy improvement measure must have a simple payback of 10 years or fewer. Available utility rebates will be included in the 2 year minimum payback limit. Also, measures that provide substantial indoor air quality improvement are not subject to the 10 year simple payback requirement. A draft of the Energy Grant application form is included at the end of this section. Once the School District has made a preliminary indication of which improvements will be implemented, CEE will calculate the revised Grant amount.

Rebates were only computed for motors recommendations and lighting improvements because NSP has set rebate amounts for these retrofits. No rebates have been computed for other measures with electric or gas savings. The rebate amount will be computed for each measure that is of interest to be included in the final improvement package. Rebates will be available through NSP's commercial custom rebate program and Minnegasco's custom rebate program. All energy cost calculations were performed using an electric use rate of 0.031 $/kWh and demand rates of 9.25 $/kW for June to September and 6.61 $/kW for October to May. All energy costs calculations that affected gas consumption used a cost of 0.50 $/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet. Savings calculation documentation is presented in the appendices.

West St. Paul Arena (February 1998): Executive Summary

This energy audit identifies energy improvement measures for the two ice arenas at the West St. Paul Arena. It was performed as part of the Minnesota Ice Arena Energy Improvement Program[31] and NSP's Local Government Program that provides special financing, bounty incentives and engineering fee reimbursement to county and municipal customers. The audit includes an analysis of the facility's recent electric and gas energy use, on-site inspection of the building envelope, mechanical and lighting systems examination, operation discussions with maintenance personnel regarding maintenance and arena occupancy, and consultations with contractors to determine costs. The purpose was to obtain an accurate assessment of the current conditions in the arenas and to determine the potential for various energy efficiency improvements. The Center for Energy and Environment (CEE) has recommended a list of cost-effective energy improvements for this facility that will reduce the annual energy costs by $2,116.

The table below is an overall summary of the anticipated costs and savings for the recommended energy improvements for the West St. Paul Arena. The total estimated cost for these improvements is $18,796. Utility incentives will be available to reduce the cost of installing these improvements. A State of Minnesota Energy Grant may also be available to reduce the net cost. The sum of the anticipated first year savings for all of the individual measures is $2,116, which corresponds to a combined simple payback of eight years on the net installed cost. Because of interactive effects between two of the improvements, the total savings would be somewhat less than $2,116 if all the measures were implemented. A final determination of total savings will be computed once a preliminary package of improvements is selected.

Estimated Cost of Proposed Improvements:	$18,796
Utility Incentives:	$1,798
Energy Grant:	TBA
Improvement Package Arena Cost:	$16,998
Anticipated Annual Energy Savings:	$2,116
Simple Payback:	8.0 years

A complete list of the recommended energy improvements is shown in the table below, along with pertinent savings and payback information. A number of no and low cost energy cost savings opportunities are also identified in the audit report, but not included in the improvement summary tables presented here.

[31] The State of Minnesota has appropriated $470,000 to develop and implement this program. Funding for this project approved by the Minnesota Legislature, 1995 Minnesota Laws, Ch. 220, Sec. 19, Subd.11(e) as recommended by the Legislative Commission on Minnesota Resources from the Oil Overcharge Money.

List of Recommended Improvements

Interested Improvement	Energy Improvement Measures	Total Cost	Utility Rebate	Arena Cost	Annual Savings	Payback w/ rebate
☐	High Efficiency Motor Replacements	$796	$110	$686	$80	8.6
☐	Condenser Fan Adjustable Speed Drive	$10,000	$1,688	$8,312	$1,232	6.7
☐	Reclaim Waste Heat from Refrigeration System	$8,000	$0	$8,000	$804	10.0
	Total	$18,796	$1,798	$16,998	$2,116	8.0

For all improvements considered in this audit, it was assumed that an NSP incentive of 0.05 $/kWh of the first year's annual savings or 50% of the equipment cost, which ever is less, would be available to reduce the installation cost of the measure. No incentives were calculated for gas savings at the time of this audit. Rebates are available from NSP Gas for measures that reduce gas use. The rebate amount will be computed for each measure that is of interest to be included in the final improvement package. A zero interest loan is also available through the NSP Local Government Program. This loan qualifies as matching funds towards the State Energy Grant. All energy cost calculations were performed using an electric use rate of 0.031 $/kWh and demand rates of 9.25 $/kW for June to September and 6.61 $/kW for October to May. All energy costs calculations that affected gas consumption used a cost of 0.45 $/therm. Energy cost savings calculations were performed using standard engineering principles and a variety of software, including a detailed ice arena simulation spreadsheet.