

Leddy Mechanical
System
Evaluation

August 6, 2010

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Department of Public Works
645 Pine Street
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Re: Leddy Park Ice Rink – Simple Economic Analysis - Revised

Introduction

L.N. Consulting, Inc. was retained by the City of Burlington to complete a simple economic life cycle analysis for the Leddy Park Ice Rink located in Burlington, Vermont. We utilized previous ice rink modeling data provided to us by Second Law to develop probable operating costs for multiple refrigeration plants with and without heat recovery on the condenser water side of the system. We obtained the ice rink maintenance records to determine the existing average yearly maintenance costs from 2007 until 2009. We compared the existing conditions refrigeration plant in our economic model to compare with new refrigeration plants.

Options

L.N. Consulting completed a comparison of seven different options. These options are as follows:

1. Existing refrigeration plant operating with the current average yearly maintenance costs. This assumes continued maintenance for another 20 years before replacement.
2. New reciprocating, ammonia refrigeration plant.
3. New reciprocating, ammonia refrigeration plant with condenser heat recovery.
4. New heat pump style, R404a refrigeration plant.
5. New heat pump style, R404a refrigeration plant with condenser heat recovery.
6. New screw style, R404a refrigerant plant.
7. New screw style, R404a refrigerant plant with condenser heat recovery.

Option #1

We assumed that the existing refrigeration plant can operate for another 20 years under its current yearly maintenance costs before requiring a plant replacement. We assumed a yearly maintenance cost of \$12,850.00 which is based upon the average actual maintenance costs for years 2007 through 2009.



Option #2

We assumed direct replacement of the existing plant with a new reciprocating style ammonia refrigeration plant similar to what currently exists. The system model is based upon using condenser energy to provide heat for the under-floor defrost system. The yearly maintenance costs are based upon \$4800.00 per year with a system replacement in 40 years. The system replacement cost does not include electrical or controls costs assuming this work can be reused in 40 years.

Options #3A & B

Same as option #2 except it includes heat recovery on the condenser side of the refrigeration plant. The heat recovery in this option assumes a condenser water temperature of 95°F. We assumed that some of the heat recovered from the condensing of the refrigerant can be used to; preheat domestic hot water, preheat zamboni hot water, and preheat ventilation air for the ice rink. Option 3A is the preheat for the domestic hot water and zamboni water and Option 3B is the preheat for the ventilation air.

Option #4

We assumed direct replacement of the existing plant with a new heat pump style R404a modular refrigeration plant. This plant would utilize (5) five 20 ton rated Ice Kube style machines linked together to produce the 100 tons of cooling capacity. The system model is based upon using condenser energy to provide heat for the under-floor defrost system. The yearly maintenance costs are based upon \$900.00 per year with a system replacement in 25 years. The system replacement cost only includes replacement of (3) three of the five units as this is the typical plant loading, therefore back-up machines should not require replacement. We used a system replacement cost of \$90,000.00, current value, for this item. The replacement cost does not include electrical or controls costs assuming this work can be reused in 40 years.

Option #5A & B

Same as option #4 except it includes heat recovery on the condenser side of the refrigeration plant. The heat recovery in this option assumes a condenser water temperature of 105°F. We assumed that some of the heat recovered from the condensing of the refrigerant can be used to; preheat domestic hot water, preheat zamboni hot water, and preheat ventilation air for the ice rink. Option 5A is the preheat for the domestic hot water and zamboni water and Option 5B is the preheat for the ventilation air.

Option #6

We assumed direct replacement of the existing plant with a new screw style, R404a refrigeration plant. The system model is based upon using condenser energy to provide heat for the under-floor defrost system. The screw compressors use less energy as compared to the other refrigeration plant equipment, but have a higher installed cost and yearly maintenance cost. The yearly maintenance costs are based upon \$6600.00 per year with a system replacement in 40 years. The system replacement cost does not include electrical or controls costs assuming this work can be reused in 40 years.



Option #7A & B

Same as option #6 except it includes heat recovery on the condenser side of the refrigeration plant. The heat recovery in this option assumes a condenser water temperature of 95°F. We assumed that some of the heat recovered from the condensing of the refrigerant can be used to; preheat domestic hot water, preheat zamboni hot water, and preheat ventilation air for the ice rink. Option 7A is the preheat for the domestic hot water and zamboni water and Option 7B is the preheat for the ventilation air.

The energy model data interpolated for the Leddy Park Ice Arena is displayed below:

Second Law has reviewed results from other ice rink modeling efforts in order to provide probable economic yearly energy savings associated with the implementation of a heat pump style ice plant that can provide a portion of the building heat.

We are basing this analysis on a model created for an ice facility that contains locker rooms, a rental area and a snack bar. We understand that the Leddy Park ice arena includes two rinks, one is a standard-sized hockey rink, and the other, is a 1/3 size recreational rink. Therefore, we have adjusted results from the existing model to reflect a building 33% larger. Basic assumptions for building and ice rink loads are as follows:

Total Building Area: 44,300 sf
Total Ice Rink Area: 22,600 sf

Wall Insulation: R-18
Window to wall Ratio: 0.08
Roof – Barrel Shaped: R-31
Ice Rink Ceiling – Emissivity: 0.05

Lighting: 0.8 w/sf on principally from 8am to 10pm
Occupancy: 40-130 people on rink during occupied hours

Ice Rink Loads:

The ice rink has a number of associated loads. These include:

1. **Zamboni:** The zamboni uses about 130 gallons per resurfacing at 160°F. During weekdays, the ice is resurfaced 11 times per day and 13 times on week-ends. Heat for zamboni water is provided by the boiler.
2. **Subfloor Heat:** In order to keep the ground under the ice rink from freezing, subfloor heat is provided. This is a low-temperature load, so heat can be provided from ice rink heat recovery.
3. **Domestic Hot Water:** Hot water for showers is estimated at about 432 gallons per day. Heat for hot water is provided by the boiler.

Ventilation:



4,000 cfm of ventilation is provided to the facility during occupied hours.

Utility Rates:

Utility rates are approximated as follows:

Electricity:

\$0.14 / kwh

Natural Gas:

\$1.50/therm

Refrigeration Systems:

1. **Water Cooled Chiller:** A water cooled reciprocating chiller was modeled without any heat recovery. This is the baseline model. This system uses a single chiller with two compressor circuits, rated at 100 tons total. With 90°F condenser temperature, this system operates at a COP of approximately 2.2. This system can provide waste heat for snowmelt and under floor heat, with a maximum load of approximately 125,000 btu/hour.
2. **IKS:** A heat pump system utilizes four IKS 450 heat pumps. Equipment capacities and efficiencies were provided by Ice Kube Systems.
 - a. **Energy Recovery:** The IKS heat pumps can be used to provide hot and cold energy simultaneously. With 110°F condenser water temperature, we can get 110°F out of the heat pumps, this heat can be used for the following loads:
 - i. **Zamboni Water Pre-Heat:** The Facility uses 200 gallons of 140°F water each time the zamboni is used. Using 110°F waste water we can provide about 68% of the heat required for the zamboni water.
 - ii. **Domestic Water Pre-Heat:** 140°F water is needed for domestic hot water storage, and can be pre-heated by heat pump waste heat. Again, we can provide about 68% of the heat required for domestic hot water.
 - iii. **Ventilation Pre-Heat:** This facility uses about 4,000 cfm of ventilation air for the ice rink itself. Ventilation rates may vary depending on occupancy. For modeling purposes, 4,000 cfm was modeled consistently throughout the year. Preheating of ventilation air using waste heat reduces the load on the central system. This load varies depending on the outside air temperature.



3. **Screw Chiller:** This system uses two screw chillers. At operating conditions, the chillers have an EER of 3.5. They require a condenser water temperature of 95°F. For this reason, we can only recover heat to about 95°F.

a. **Energy Recovery:**

- i. **Zamboni Water Pre-Heat:** Due to the lower condenser water temperature, we can only recover about 48% of the heat required for zamboni water pre-heat
- ii. **Domestic Water Pre-Heat:** Due to the lower condenser water temperature, we can only recover about 48% of the heat required for domestic water pre-heat.
- iii. **Ventilation Pre-Heat:** There is no energy recovery available for Ventilation Pre-Heat.

Results:

Table 1:

	Probable Energy Use		
	Electricity		Natural Gas
	KWH	Peak(KW)	(MMBTU)
Hermetic Reciprocating Chiller	820,436	249	2,775
IKS	804,541	181	2,712
IKS and Heat Recovery	804,154	181	982
Screw Chiller	730,768	159	2,712
Screw Chiller and Heat Recovery	730,590	158	1,296

Table 2:

	Probable Utility Cost			
	Electricity	Natural Gas	Total	Savings
Hermetic Reciprocating Chiller	\$ 119,990	\$ 41,629	\$ 161,619	\$ -
IKS	\$ 112,522	\$ 40,683	\$ 153,205	\$ 8,414
IKS and Heat Recovery	\$ 112,522	\$ 14,734	\$ 127,256	\$ 34,363



Screw Chiller	\$ 102,331	\$ 40,683	\$ 143,014	\$ 18,605
Screw Chiller and Heat Recovery	\$ 102,331	\$ 19,438	\$ 121,769	\$ 39,850

Table 3:

	IKS Chiller		Screw Chiller	
	Heat Energy Recovered	\$\$ Saved	Heat Energy Recovered	\$\$ Saved
	(Mbtu)		(Mbtu)	
DHW	454.4	\$ 8,232.01	320.4	\$ 5,804.21
Zamboni	39.5	\$ 714.99	27.8	\$ 503.56
Ventilation	216.3	\$ 3,919.09	216.2	\$ 3,917.23
	\$ 710	\$ 12,866	\$ 564	\$ 10,225

Economic Life Cycle Cost Analysis

We completed life cycle cost analysis calculations for all ten (10) options to allow the City of Burlington the opportunity to make an educated selection. The installation, operations, and maintenance costs are included in the calculation sheets and may be referenced on the following Economic Life Cycle Cost calculation sheets. The results of the life cycle cost analysis is as follows:

Option #1	\$11,197,858
Option #2	\$11,735,663
Option #3A	\$11,605,812
Option #3B	\$11,623,145
Option #4	\$11,577,786
Option #5A	\$11,091,657
Option #5B	\$11,541,501
Option #6	\$10,516,151
Option #7A	\$10,168,226
Option #7B	\$10,403,760

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Capital Costs:

Option 7A - New Screw Chiller Ice Plant with DHW heat recovery	
Chiller material	\$325,000
Chiller mechanical labor	\$100,000
Chiller electrical labor	\$40,000
Chiller DDC controls	\$40,000
DHW Heat Recovery	\$20,000
Total	\$525,000

Option 7B - New Screw Chiller Ice Plant with vent. heat recovery	
Chiller material	\$325,000
Chiller mechanical labor	\$100,000
Chiller electrical labor	\$40,000
Chiller DDC controls	\$40,000
Ventilation Heat Recovery	\$55,000
Total	\$560,000

Annual Net Cash Flows:

A Year	Option 7A - New Screw Chiller Ice Plant with DHW heat recovery						Option 7B - New Screw Chiller Ice Plant with vent. heat recovery					
	B Capital Costs	C Maintenance Costs	D Energy Cost	E Net Cash Flow (B+C+D)	F Present Value Factor	G Present Value (Worth)	H Capital Costs	I Maintenance Costs	J Energy Cost	K Net Cash Flow (H+I+J)	L Present Value Factor	M Present Value (Worth)
0	\$525,000	\$0	\$0	\$525,000	1.0000	\$525,000	\$560,000	\$0	\$0	\$560,000	1.0000	\$560,000
1	\$0	\$4,800	\$136,706	\$141,506	0.9804	\$138,731	\$0	\$4,800	\$139,097	\$143,897	0.9804	\$141,075
2	\$0	\$4,944	\$140,807	\$145,751	0.9612	\$140,091	\$0	\$4,944	\$143,270	\$148,214	0.9612	\$142,459
3	\$0	\$5,092	\$145,031	\$150,124	0.9423	\$141,465	\$0	\$5,092	\$147,568	\$152,660	0.9423	\$143,855
4	\$0	\$5,245	\$149,382	\$154,627	0.9238	\$142,852	\$0	\$5,245	\$151,995	\$157,240	0.9238	\$145,266
5	\$0	\$5,402	\$153,864	\$159,266	0.9057	\$144,252	\$0	\$5,402	\$156,555	\$161,957	0.9057	\$146,690
6	\$0	\$5,565	\$158,480	\$164,044	0.8880	\$145,667	\$0	\$5,565	\$161,252	\$166,816	0.8880	\$148,128
7	\$0	\$5,731	\$163,234	\$168,966	0.8706	\$147,095	\$0	\$5,731	\$166,089	\$171,821	0.8706	\$149,580
8	\$0	\$5,903	\$168,131	\$174,035	0.8535	\$148,537	\$0	\$5,903	\$171,072	\$176,975	0.8535	\$151,047
9	\$0	\$6,080	\$173,175	\$179,256	0.8368	\$149,993	\$0	\$6,080	\$176,204	\$182,284	0.8368	\$152,527
10	\$0	\$6,263	\$178,370	\$184,633	0.8203	\$151,464	\$0	\$6,263	\$181,490	\$187,753	0.8203	\$154,023
11	\$0	\$6,451	\$183,721	\$190,172	0.8043	\$152,948	\$0	\$6,451	\$186,935	\$193,386	0.8043	\$155,533
12	\$0	\$6,644	\$189,233	\$195,877	0.7885	\$154,448	\$0	\$6,644	\$192,543	\$199,187	0.7885	\$157,058
13	\$0	\$6,844	\$194,910	\$201,754	0.7730	\$155,962	\$0	\$6,844	\$198,319	\$205,163	0.7730	\$158,597
14	\$0	\$7,049	\$200,757	\$207,806	0.7579	\$157,491	\$0	\$7,049	\$204,269	\$211,318	0.7579	\$160,152
15	\$0	\$7,260	\$206,780	\$214,041	0.7430	\$159,035	\$0	\$7,260	\$210,397	\$217,657	0.7430	\$161,722
16	\$0	\$7,478	\$212,983	\$220,462	0.7284	\$160,594	\$0	\$7,478	\$216,709	\$224,187	0.7284	\$163,308
17	\$0	\$7,703	\$219,373	\$227,076	0.7142	\$162,169	\$0	\$7,703	\$223,210	\$230,912	0.7142	\$164,909
18	\$0	\$7,934	\$225,954	\$233,888	0.7002	\$163,759	\$0	\$7,934	\$229,906	\$237,840	0.7002	\$166,526
19	\$0	\$8,172	\$232,733	\$240,904	0.6864	\$165,364	\$0	\$8,172	\$236,803	\$244,975	0.6864	\$168,158
20	\$0	\$8,417	\$239,715	\$248,132	0.6730	\$166,985	\$0	\$8,417	\$243,907	\$252,324	0.6730	\$169,807
21	\$0	\$8,669	\$246,906	\$255,576	0.6598	\$168,623	\$0	\$8,669	\$251,225	\$259,894	0.6598	\$171,472
22	\$0	\$8,929	\$254,313	\$263,243	0.6468	\$170,276	\$0	\$8,929	\$258,761	\$267,691	0.6468	\$173,153
23	\$0	\$9,197	\$261,943	\$271,140	0.6342	\$171,945	\$0	\$9,197	\$266,524	\$275,722	0.6342	\$174,850
24	\$0	\$9,473	\$269,801	\$279,274	0.6217	\$173,631	\$0	\$9,473	\$274,520	\$283,993	0.6217	\$176,565
25	\$0	\$9,757	\$277,895	\$287,653	0.6095	\$175,333	\$0	\$9,757	\$282,756	\$292,513	0.6095	\$178,296
26	\$0	\$10,050	\$286,232	\$296,282	0.5976	\$177,052	\$0	\$10,050	\$291,238	\$301,288	0.5976	\$180,044
27	\$0	\$10,352	\$294,819	\$305,171	0.5859	\$178,788	\$0	\$10,352	\$299,975	\$310,327	0.5859	\$181,809
28	\$0	\$10,662	\$303,664	\$314,326	0.5744	\$180,541	\$0	\$10,662	\$308,975	\$319,637	0.5744	\$183,591
29	\$0	\$10,982	\$312,773	\$323,755	0.5631	\$182,311	\$0	\$10,982	\$318,244	\$329,226	0.5631	\$185,391
30	\$0	\$11,312	\$322,157	\$333,468	0.5521	\$184,098	\$0	\$11,312	\$327,791	\$339,103	0.5521	\$187,209
31	\$0	\$11,651	\$331,821	\$343,472	0.5412	\$185,903	\$0	\$11,651	\$337,625	\$349,276	0.5412	\$189,047
32	\$0	\$12,000	\$341,776	\$353,776	0.5306	\$187,726	\$0	\$12,000	\$347,754	\$359,754	0.5306	\$190,897
33	\$0	\$12,360	\$352,029	\$364,390	0.5202	\$189,566	\$0	\$12,360	\$358,186	\$370,547	0.5202	\$192,769
34	\$0	\$12,731	\$362,590	\$375,321	0.5100	\$191,424	\$0	\$12,731	\$368,932	\$381,663	0.5100	\$194,659
35	\$0	\$13,113	\$373,468	\$386,581	0.5000	\$193,301	\$0	\$13,113	\$380,000	\$393,113	0.5000	\$196,567
36	\$0	\$13,507	\$384,672	\$398,178	0.4902	\$195,196	\$0	\$13,507	\$391,400	\$404,906	0.4902	\$198,494
37	\$0	\$13,912	\$396,212	\$410,124	0.4806	\$197,110	\$0	\$13,912	\$403,142	\$417,054	0.4806	\$200,440
38	\$0	\$14,329	\$408,098	\$422,427	0.4712	\$199,042	\$0	\$14,329	\$415,236	\$429,565	0.4712	\$202,406
39	\$0	\$14,759	\$420,341	\$435,100	0.4619	\$200,994	\$0	\$14,759	\$427,693	\$442,452	0.4619	\$204,390
40	\$1,662,689	\$0	\$432,952	\$2,095,641	0.4529	\$949,096	\$1,773,535	\$0	\$440,524	\$2,214,059	0.4529	\$1,002,726
41	\$0	\$15,658	\$445,940	\$461,598	0.4440	\$204,954	\$0	\$15,658	\$453,740	\$469,397	0.4440	\$208,417
42	\$0	\$16,128	\$459,318	\$475,446	0.4353	\$206,964	\$0	\$16,128	\$467,352	\$483,479	0.4353	\$210,461
43	\$0	\$16,611	\$473,098	\$489,709	0.4268	\$208,993	\$0	\$16,611	\$481,372	\$497,984	0.4268	\$212,524
44	\$0	\$17,110	\$487,291	\$504,401	0.4184	\$211,042	\$0	\$17,110	\$495,814	\$512,923	0.4184	\$214,607
45	\$0	\$17,623	\$501,910	\$519,533	0.4102	\$213,111	\$0	\$17,623	\$510,688	\$528,311	0.4102	\$216,711
46	\$0	\$18,152	\$516,967	\$535,119	0.4022	\$215,200	\$0	\$18,152	\$526,009	\$544,160	0.4022	\$218,836
47	\$0	\$18,696	\$532,476	\$551,172	0.3943	\$217,310	\$0	\$18,696	\$541,789	\$560,485	0.3943	\$220,982
48	\$0	\$19,257	\$548,450	\$567,707	0.3865	\$219,440	\$0	\$19,257	\$558,043	\$577,300	0.3865	\$223,148
49	\$0	\$19,835	\$564,904	\$584,738	0.3790	\$221,592	\$0	\$19,835	\$574,784	\$594,619	0.3790	\$225,336
50	\$0	\$20,430	\$581,851	\$602,281	0.3715	\$223,764	\$0	\$20,430	\$592,027	\$612,457	0.3715	\$227,545
TOTAL						\$10,168,226						\$10,403,760

Mathematically, the case with the lowest present value is the preferred alternative.

Assumptions:

- Energy cost escalation based upon 3.00% per year.
- Maintenance cost escalation based upon 3.00% per year.
- At the end of each system's life, assume salvage value is zero.
- Present value factors based upon interest rate of 2.00 percent per year.

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Capital Costs:

Option 5B - New IKS Chiller Ice Plant with vent. heat recovery	
Chiller material	\$315,000
Chiller mechanical labor	\$100,000
Chiller electrical labor	\$40,000
Chiller DDC controls	\$40,000
Ventilation Heat Recovery	\$55,000
Total	\$550,000

Option 6 - New Screw Chiller Ice Plant	
Chiller material (freon)	\$325,000
Chiller mechanical labor	\$100,000
Chiller electrical labor	\$40,000
Chiller DDC controls	\$40,000
Total	\$505,000

Annual Net Cash Flows:

A Year	Option 5B - New IKS Chiller Ice Plant with vent. heat recovery						Option 6 - New Screw Chiller Ice Plant					
	B Capital Costs	C Maintenance Costs	D Energy Cost	E Net Cash Flow (B+C+D)	F Present Value Factor	G Present Value (Worth)	H Capital Costs	I Maintenance Costs	J Energy Cost	K Net Cash Flow (H+I+J)	L Present Value Factor	M Present Value (Worth)
0	\$550,000	\$0	\$0	\$550,000	1.0000	\$550,000	\$505,000	\$0	\$0	\$505,000	1.0000	\$505,000
1	\$0	\$900	\$149,286	\$150,186	0.9804	\$147,241	\$0	\$4,800	\$143,014	\$147,814	0.9804	\$144,916
2	\$0	\$927	\$153,765	\$154,692	0.9612	\$148,685	\$0	\$4,944	\$147,304	\$152,248	0.9612	\$146,336
3	\$0	\$955	\$158,378	\$159,332	0.9423	\$150,142	\$0	\$5,092	\$151,724	\$156,816	0.9423	\$147,771
4	\$0	\$983	\$163,129	\$164,112	0.9238	\$151,614	\$0	\$5,245	\$156,275	\$161,520	0.9238	\$149,220
5	\$0	\$1,013	\$168,023	\$169,036	0.9057	\$153,101	\$0	\$5,402	\$160,964	\$166,366	0.9057	\$150,683
6	\$0	\$1,043	\$173,063	\$174,107	0.8880	\$154,602	\$0	\$5,565	\$165,792	\$171,357	0.8880	\$152,160
7	\$0	\$1,075	\$178,255	\$179,330	0.8706	\$156,118	\$0	\$5,731	\$170,766	\$176,498	0.8706	\$153,652
8	\$0	\$1,107	\$183,603	\$184,710	0.8535	\$157,648	\$0	\$5,903	\$175,889	\$181,793	0.8535	\$155,158
9	\$0	\$1,140	\$189,111	\$190,251	0.8368	\$159,194	\$0	\$6,080	\$181,166	\$187,246	0.8368	\$156,679
10	\$0	\$1,174	\$194,784	\$195,959	0.8203	\$160,754	\$0	\$6,263	\$186,601	\$192,864	0.8203	\$158,215
11	\$0	\$1,210	\$200,628	\$201,837	0.8043	\$162,330	\$0	\$6,451	\$192,199	\$198,650	0.8043	\$159,767
12	\$0	\$1,246	\$206,647	\$207,893	0.7885	\$163,922	\$0	\$6,644	\$197,965	\$204,609	0.7885	\$161,333
13	\$0	\$1,283	\$212,846	\$214,129	0.7730	\$165,529	\$0	\$6,844	\$203,904	\$210,747	0.7730	\$162,915
14	\$0	\$1,322	\$219,232	\$220,553	0.7579	\$167,152	\$0	\$7,049	\$210,021	\$217,070	0.7579	\$164,512
15	\$0	\$1,361	\$225,808	\$227,170	0.7430	\$168,791	\$0	\$7,260	\$216,322	\$223,582	0.7430	\$166,125
16	\$0	\$1,402	\$232,583	\$233,985	0.7284	\$170,445	\$0	\$7,478	\$222,811	\$230,289	0.7284	\$167,753
17	\$0	\$1,444	\$239,560	\$241,004	0.7142	\$172,116	\$0	\$7,703	\$229,495	\$237,198	0.7142	\$169,398
18	\$0	\$1,488	\$246,747	\$248,235	0.7002	\$173,804	\$0	\$7,934	\$236,380	\$244,314	0.7002	\$171,059
19	\$0	\$1,532	\$254,149	\$255,682	0.6864	\$175,508	\$0	\$8,172	\$243,472	\$251,643	0.6864	\$172,736
20	\$0	\$1,578	\$261,774	\$263,352	0.6730	\$177,228	\$0	\$8,417	\$250,776	\$259,193	0.6730	\$174,429
21	\$0	\$1,626	\$269,627	\$271,253	0.6598	\$178,966	\$0	\$8,669	\$258,299	\$266,969	0.6598	\$176,139
22	\$0	\$1,674	\$277,716	\$279,390	0.6468	\$180,720	\$0	\$8,929	\$266,048	\$274,978	0.6468	\$177,866
23	\$0	\$1,724	\$286,047	\$287,772	0.6342	\$182,492	\$0	\$9,197	\$274,030	\$283,227	0.6342	\$179,610
24	\$0	\$1,776	\$294,629	\$296,405	0.6217	\$184,281	\$0	\$9,473	\$282,251	\$291,724	0.6217	\$181,371
25	\$1,118,037	\$0	\$303,468	\$1,421,504	0.6095	\$866,451	\$0	\$9,757	\$290,718	\$300,475	0.6095	\$183,149
26	\$0	\$1,884	\$312,572	\$314,456	0.5976	\$187,912	\$0	\$10,050	\$299,440	\$309,490	0.5976	\$184,945
27	\$0	\$1,941	\$321,949	\$323,890	0.5859	\$189,755	\$0	\$10,352	\$308,423	\$318,774	0.5859	\$186,758
28	\$0	\$1,999	\$331,607	\$333,607	0.5744	\$191,615	\$0	\$10,662	\$317,675	\$328,338	0.5744	\$188,589
29	\$0	\$2,059	\$341,556	\$343,615	0.5631	\$193,494	\$0	\$10,982	\$327,206	\$338,188	0.5631	\$190,438
30	\$0	\$2,121	\$351,802	\$353,923	0.5521	\$195,391	\$0	\$11,312	\$337,022	\$348,333	0.5521	\$192,305
31	\$0	\$2,185	\$362,356	\$364,541	0.5412	\$197,306	\$0	\$11,651	\$347,133	\$358,783	0.5412	\$194,190
32	\$0	\$2,250	\$373,227	\$375,477	0.5306	\$199,241	\$0	\$12,000	\$357,546	\$369,547	0.5306	\$196,094
33	\$0	\$2,318	\$384,424	\$386,741	0.5202	\$201,194	\$0	\$12,360	\$368,273	\$380,633	0.5202	\$198,016
34	\$0	\$2,387	\$395,957	\$398,344	0.5100	\$203,166	\$0	\$12,731	\$379,321	\$392,052	0.5100	\$199,958
35	\$0	\$2,459	\$407,835	\$410,294	0.5000	\$205,158	\$0	\$13,113	\$390,701	\$403,814	0.5000	\$201,918
36	\$0	\$2,532	\$420,070	\$422,603	0.4902	\$207,170	\$0	\$13,507	\$402,422	\$415,928	0.4902	\$203,898
37	\$0	\$2,608	\$432,672	\$435,281	0.4806	\$209,201	\$0	\$13,912	\$414,494	\$428,406	0.4806	\$205,897
38	\$0	\$2,687	\$445,653	\$448,339	0.4712	\$211,252	\$0	\$14,329	\$426,929	\$441,258	0.4712	\$207,915
39	\$0	\$2,767	\$459,022	\$461,789	0.4619	\$213,323	\$0	\$14,759	\$439,737	\$454,496	0.4619	\$209,954
40	\$0	\$2,850	\$472,793	\$475,643	0.4529	\$215,414	\$1,599,349	\$0	\$452,929	\$2,052,278	0.4529	\$929,457
41	\$0	\$2,936	\$486,977	\$489,912	0.4440	\$217,526	\$0	\$15,658	\$466,517	\$482,175	0.4440	\$214,091
42	\$0	\$3,024	\$501,586	\$504,610	0.4353	\$219,659	\$0	\$16,128	\$480,513	\$496,640	0.4353	\$216,189
43	\$0	\$3,115	\$516,633	\$519,748	0.4268	\$221,812	\$0	\$16,611	\$494,928	\$511,539	0.4268	\$218,309
44	\$0	\$3,208	\$532,132	\$535,341	0.4184	\$223,987	\$0	\$17,110	\$509,776	\$526,885	0.4184	\$220,449
45	\$0	\$3,304	\$548,096	\$551,401	0.4102	\$226,183	\$0	\$17,623	\$525,069	\$542,692	0.4102	\$222,611
46	\$0	\$3,403	\$564,539	\$567,943	0.4022	\$228,400	\$0	\$18,152	\$540,821	\$558,973	0.4022	\$224,793
47	\$0	\$3,506	\$581,475	\$584,981	0.3943	\$230,640	\$0	\$18,696	\$557,046	\$575,742	0.3943	\$226,997
48	\$0	\$3,611	\$598,920	\$602,530	0.3865	\$232,901	\$0	\$19,257	\$573,757	\$593,014	0.3865	\$229,222
49	\$0	\$3,719	\$616,887	\$620,606	0.3790	\$235,184	\$0	\$19,835	\$590,970	\$610,805	0.3790	\$231,470
50	\$2,340,921	\$0	\$635,394	\$2,976,315	0.3715	\$1,105,784	\$0	\$20,430	\$608,699	\$629,129	0.3715	\$233,739
TOTAL						\$11,541,501						\$10,516,151

Mathematically, the case with the lowest present value is the preferred alternative.

Assumptions:

1. Energy cost escalation based upon 3.00% per year.
2. Maintenance cost escalation based upon 3.00% per year.
3. At the end of each system's life, assume salvage value is zero.
4. Present value factors based upon interest rate of 2.00 percent per year.

Leddy Park Ice Rink
 Simple Economic Analysis for Ice Plant
 LN Consulting, Inc.
 8/6/10, Revision 1

Capital Costs:

Option 3A - New Reciprocating Chiller Ice Plant with DHW heat recovery	
Chiller material	\$300,000
Chiller mechanical labor	\$100,000
Chiller electrical labor	\$40,000
Chiller DDC controls	\$40,000
DHW Heat Recovery	\$20,000
Total	\$500,000

Option 3B - New Reciprocating Chiller Ice Plant with vent. heat recovery	
Chiller material	\$300,000
Chiller mechanical labor	\$100,000
Chiller electrical labor	\$40,000
Chiller DDC controls	\$40,000
Ventilation Heat Recovery	\$55,000
Total	\$535,000

Annual Net Cash Flows:

A Year	Option 3A - New Reciprocating Chiller Ice Plant with DHW heat recovery						Option 3B - New Reciprocating Chiller Ice Plant with vent. heat recovery					
	B Capital Costs	C Maintenance Costs	D Energy Cost	E Net Cash Flow (B+C+D)	F Present Value Factor	G Present Value (Worth)	H Capital Costs	I Maintenance Costs	J Energy Cost	K Net Cash Flow (H+I+J)	L Present Value Factor	M Present Value (Worth)
0	\$500,000	\$0	\$0	\$500,000	1.0000	\$500,000	\$535,000	\$0	\$0	\$535,000	1.0000	\$535,000
1	\$0	\$12,850	\$152,672	\$165,522	0.9804	\$162,276	\$0	\$6,600	\$157,700	\$164,300	0.9804	\$161,078
2	\$0	\$13,236	\$157,252	\$170,488	0.9612	\$163,867	\$0	\$6,798	\$162,431	\$169,229	0.9612	\$162,658
3	\$0	\$13,633	\$161,970	\$175,602	0.9423	\$165,474	\$0	\$7,002	\$167,304	\$174,306	0.9423	\$164,252
4	\$0	\$14,042	\$166,829	\$180,870	0.9238	\$167,096	\$0	\$7,212	\$172,323	\$179,535	0.9238	\$165,863
5	\$0	\$14,463	\$171,834	\$186,296	0.9057	\$168,734	\$0	\$7,428	\$177,493	\$184,921	0.9057	\$167,489
6	\$0	\$14,897	\$176,989	\$191,885	0.8880	\$170,389	\$0	\$7,651	\$182,818	\$190,469	0.8880	\$169,131
7	\$0	\$15,344	\$182,298	\$197,642	0.8706	\$172,059	\$0	\$7,881	\$188,302	\$196,183	0.8706	\$170,789
8	\$0	\$15,804	\$187,767	\$203,571	0.8535	\$173,746	\$0	\$8,117	\$193,951	\$202,068	0.8535	\$172,463
9	\$0	\$16,278	\$193,400	\$209,678	0.8368	\$175,449	\$0	\$8,361	\$199,770	\$208,130	0.8368	\$174,154
10	\$0	\$16,766	\$199,202	\$215,969	0.8203	\$177,170	\$0	\$8,612	\$205,763	\$214,374	0.8203	\$175,862
11	\$0	\$17,269	\$205,178	\$222,448	0.8043	\$178,906	\$0	\$8,870	\$211,936	\$220,805	0.8043	\$177,586
12	\$0	\$17,787	\$211,334	\$229,121	0.7885	\$180,660	\$0	\$9,136	\$218,294	\$227,430	0.7885	\$179,327
13	\$0	\$18,321	\$217,674	\$235,995	0.7730	\$182,432	\$0	\$9,410	\$224,842	\$234,253	0.7730	\$181,085
14	\$0	\$18,871	\$224,204	\$243,075	0.7579	\$184,220	\$0	\$9,692	\$231,588	\$241,280	0.7579	\$182,860
15	\$0	\$19,437	\$230,930	\$250,367	0.7430	\$186,026	\$0	\$9,983	\$238,535	\$248,518	0.7430	\$184,653
16	\$0	\$20,020	\$237,858	\$257,878	0.7284	\$187,850	\$0	\$10,283	\$245,691	\$255,974	0.7284	\$186,463
17	\$0	\$20,620	\$244,994	\$265,614	0.7142	\$189,692	\$0	\$10,591	\$253,062	\$263,653	0.7142	\$188,291
18	\$0	\$21,239	\$252,344	\$273,583	0.7002	\$191,551	\$0	\$10,909	\$260,654	\$271,563	0.7002	\$190,137
19	\$0	\$21,876	\$259,914	\$281,790	0.6864	\$193,429	\$0	\$11,236	\$268,474	\$279,710	0.6864	\$192,001
20	\$0	\$22,533	\$267,711	\$290,244	0.6730	\$195,326	\$0	\$11,573	\$276,528	\$288,101	0.6730	\$193,884
21	\$0	\$23,209	\$275,743	\$298,951	0.6598	\$197,241	\$0	\$11,920	\$284,824	\$296,744	0.6598	\$195,785
22	\$0	\$23,905	\$284,015	\$307,920	0.6468	\$199,174	\$0	\$12,278	\$293,368	\$305,646	0.6468	\$197,704
23	\$0	\$24,622	\$292,535	\$317,157	0.6342	\$201,127	\$0	\$12,646	\$302,170	\$314,816	0.6342	\$199,642
24	\$0	\$25,361	\$301,311	\$326,672	0.6217	\$203,099	\$0	\$13,026	\$311,235	\$324,260	0.6217	\$201,600
25	\$0	\$26,121	\$310,351	\$336,472	0.6095	\$205,090	\$0	\$13,416	\$320,572	\$333,988	0.6095	\$203,576
26	\$0	\$26,905	\$319,661	\$346,566	0.5976	\$207,101	\$0	\$13,819	\$330,189	\$344,008	0.5976	\$205,572
27	\$0	\$27,712	\$329,251	\$356,963	0.5859	\$209,131	\$0	\$14,234	\$340,094	\$354,328	0.5859	\$207,587
28	\$0	\$28,544	\$339,129	\$367,672	0.5744	\$211,182	\$0	\$14,661	\$350,297	\$364,958	0.5744	\$209,622
29	\$0	\$29,400	\$349,302	\$378,702	0.5631	\$213,252	\$0	\$15,100	\$360,806	\$375,907	0.5631	\$211,678
30	\$0	\$30,282	\$359,782	\$390,063	0.5521	\$215,343	\$0	\$15,553	\$371,630	\$387,184	0.5521	\$213,753
31	\$0	\$31,190	\$370,575	\$401,765	0.5412	\$217,454	\$0	\$16,020	\$382,779	\$398,799	0.5412	\$215,848
32	\$0	\$32,126	\$381,692	\$413,818	0.5306	\$219,586	\$0	\$16,501	\$394,263	\$410,763	0.5306	\$217,965
33	\$0	\$33,090	\$393,143	\$426,233	0.5202	\$221,739	\$0	\$16,996	\$406,091	\$423,086	0.5202	\$220,102
34	\$0	\$34,083	\$404,937	\$439,020	0.5100	\$223,912	\$0	\$17,505	\$418,273	\$435,779	0.5100	\$222,259
35	\$0	\$35,105	\$417,085	\$452,190	0.5000	\$226,108	\$0	\$18,031	\$430,821	\$448,852	0.5000	\$224,438
36	\$0	\$36,158	\$429,598	\$465,756	0.4902	\$228,324	\$0	\$18,571	\$443,746	\$462,318	0.4902	\$226,639
37	\$0	\$37,243	\$442,486	\$479,729	0.4806	\$230,563	\$0	\$19,129	\$457,058	\$476,187	0.4806	\$228,861
38	\$0	\$38,360	\$455,761	\$494,121	0.4712	\$232,823	\$0	\$19,702	\$470,770	\$490,473	0.4712	\$231,104
39	\$0	\$39,511	\$469,433	\$508,944	0.4619	\$235,106	\$0	\$20,294	\$484,893	\$505,187	0.4619	\$233,370
40	\$1,583,513	\$0	\$483,516	\$2,067,030	0.4529	\$936,138	\$1,694,359	\$0	\$499,440	\$2,193,800	0.4529	\$993,551
41	\$0	\$41,917	\$498,022	\$539,939	0.4440	\$239,738	\$0	\$21,529	\$514,423	\$535,953	0.4440	\$237,969
42	\$0	\$43,175	\$512,962	\$556,137	0.4353	\$242,089	\$0	\$22,175	\$529,856	\$552,031	0.4353	\$240,302
43	\$0	\$44,470	\$528,351	\$572,821	0.4268	\$244,462	\$0	\$22,841	\$545,752	\$568,592	0.4268	\$242,657
44	\$0	\$45,804	\$544,202	\$590,006	0.4184	\$246,859	\$0	\$23,526	\$562,124	\$585,650	0.4184	\$245,036
45	\$0	\$47,178	\$560,528	\$607,706	0.4102	\$249,279	\$0	\$24,232	\$578,988	\$603,220	0.4102	\$247,439
46	\$0	\$48,594	\$577,344	\$625,937	0.4022	\$251,723	\$0	\$24,959	\$596,358	\$621,316	0.4022	\$249,865
47	\$0	\$50,051	\$594,664	\$644,715	0.3943	\$254,191	\$0	\$25,707	\$614,248	\$639,956	0.3943	\$252,314
48	\$0	\$51,553	\$612,504	\$664,057	0.3865	\$256,683	\$0	\$26,479	\$632,676	\$659,154	0.3865	\$254,788
49	\$0	\$53,099	\$630,879	\$683,979	0.3790	\$259,199	\$0	\$27,273	\$651,656	\$678,929	0.3790	\$257,286
50	\$0	\$54,692	\$649,806	\$704,498	0.3715	\$261,741	\$0	\$28,091	\$671,206	\$699,297	0.3715	\$259,808
TOTAL						\$11,605,812						\$11,623,145

Mathematically, the case with the lowest present value is the preferred alternative.

Assumptions:

1. Energy cost escalation based upon 3.00% per year.
2. Maintenance cost escalation based upon 3.00% per year.
3. At the end of each system's life, assume salvage value is zero.
4. Present value factors based upon interest rate of 2.00 percent per year.

Leddy Park Ice Rink
Simple Economic Analysis for Ice Plant
LN Consulting, Inc.
8/6/10, Revision 1

Capital Costs:

Option 4 - New IKS Chiller Ice Plant

Chiller material	\$315,000
Chiller mechanical labor	\$100,000
Chiller electrical labor	\$40,000
Chiller DDC controls	\$40,000
Total	\$495,000

Option 5A - New IKS Chiller Ice Plant with DHW heat recovery

Chiller material	\$315,000
Chiller mechanical labor	\$100,000
Chiller electrical labor	\$40,000
Chiller DDC controls	\$40,000
DHW Heat Recovery	\$20,000
Total	\$515,000

Annual Net Cash Flows:

A Year	Option 4 - New IKS Chiller Ice Plant						Option 5A - New IKS Chiller Ice Plant with DHW heat recovery					
	B Capital Costs	C Maintenance Costs	D Energy Cost	E Net Cash Flow (B+C+D)	F Present Value Factor	G Present Value (Worth)	H Capital Costs	I Maintenance Costs	J Energy Cost	K Net Cash Flow (H+I+J)	L Present Value Factor	M Present Value (Worth)
0	\$495,000	\$0	\$0	\$495,000	1.0000	\$495,000	\$515,000	\$0	\$0	\$515,000	1.0000	\$515,000
1	\$0	\$900	\$153,205	\$154,105	0.9804	\$151,083	\$0	\$900	\$144,258	\$145,158	0.9804	\$142,312
2	\$0	\$927	\$157,801	\$158,728	0.9612	\$152,565	\$0	\$927	\$148,586	\$149,513	0.9612	\$143,707
3	\$0	\$955	\$162,535	\$163,490	0.9423	\$154,060	\$0	\$955	\$153,043	\$153,998	0.9423	\$145,116
4	\$0	\$983	\$167,411	\$168,395	0.9238	\$155,571	\$0	\$983	\$157,635	\$158,618	0.9238	\$146,539
5	\$0	\$1,013	\$172,434	\$173,447	0.9057	\$157,096	\$0	\$1,013	\$162,364	\$163,377	0.9057	\$147,975
6	\$0	\$1,043	\$177,607	\$178,650	0.8880	\$158,636	\$0	\$1,043	\$167,235	\$168,278	0.8880	\$149,426
7	\$0	\$1,075	\$182,935	\$184,009	0.8706	\$160,191	\$0	\$1,075	\$172,252	\$173,326	0.8706	\$150,891
8	\$0	\$1,107	\$188,423	\$189,530	0.8535	\$161,762	\$0	\$1,107	\$177,419	\$178,526	0.8535	\$152,370
9	\$0	\$1,140	\$194,076	\$195,216	0.8368	\$163,348	\$0	\$1,140	\$182,742	\$183,882	0.8368	\$153,864
10	\$0	\$1,174	\$199,898	\$201,072	0.8203	\$164,949	\$0	\$1,174	\$188,224	\$189,398	0.8203	\$155,373
11	\$0	\$1,210	\$205,895	\$207,104	0.8043	\$166,566	\$0	\$1,210	\$193,871	\$195,080	0.8043	\$156,896
12	\$0	\$1,246	\$212,072	\$213,317	0.7885	\$168,199	\$0	\$1,246	\$199,687	\$200,933	0.7885	\$158,434
13	\$0	\$1,283	\$218,434	\$219,717	0.7730	\$169,848	\$0	\$1,283	\$205,677	\$206,961	0.7730	\$159,987
14	\$0	\$1,322	\$224,987	\$226,308	0.7579	\$171,513	\$0	\$1,322	\$211,848	\$213,169	0.7579	\$161,556
15	\$0	\$1,361	\$231,736	\$233,098	0.7430	\$173,195	\$0	\$1,361	\$218,203	\$219,564	0.7430	\$163,140
16	\$0	\$1,402	\$238,688	\$240,091	0.7284	\$174,893	\$0	\$1,402	\$224,749	\$226,151	0.7284	\$164,739
17	\$0	\$1,444	\$245,849	\$247,293	0.7142	\$176,608	\$0	\$1,444	\$231,492	\$232,936	0.7142	\$166,354
18	\$0	\$1,488	\$253,225	\$254,712	0.7002	\$178,339	\$0	\$1,488	\$238,436	\$239,924	0.7002	\$167,985
19	\$0	\$1,532	\$260,821	\$262,353	0.6864	\$180,087	\$0	\$1,532	\$245,590	\$247,122	0.6864	\$169,632
20	\$0	\$1,578	\$268,646	\$270,224	0.6730	\$181,853	\$0	\$1,578	\$252,957	\$254,535	0.6730	\$171,295
21	\$0	\$1,626	\$276,705	\$278,331	0.6598	\$183,636	\$0	\$1,626	\$260,546	\$262,171	0.6598	\$172,974
22	\$0	\$1,674	\$285,006	\$286,681	0.6468	\$185,436	\$0	\$1,674	\$268,362	\$270,037	0.6468	\$174,670
23	\$0	\$1,724	\$293,557	\$295,281	0.6342	\$187,254	\$0	\$1,724	\$276,413	\$278,138	0.6342	\$176,383
24	\$0	\$1,776	\$302,363	\$304,140	0.6217	\$189,090	\$0	\$1,776	\$284,706	\$286,482	0.6217	\$178,112
25	\$1,006,233	\$0	\$311,434	\$1,317,667	0.6095	\$803,159	\$1,046,889	\$0	\$293,247	\$1,340,136	0.6095	\$816,854
26	\$0	\$1,884	\$320,777	\$322,662	0.5976	\$192,816	\$0	\$1,884	\$302,044	\$303,929	0.5976	\$181,621
27	\$0	\$1,941	\$330,401	\$332,341	0.5859	\$194,706	\$0	\$1,941	\$311,106	\$313,046	0.5859	\$183,402
28	\$0	\$1,999	\$340,313	\$342,312	0.5744	\$196,615	\$0	\$1,999	\$320,439	\$322,438	0.5744	\$185,200
29	\$0	\$2,059	\$350,522	\$352,581	0.5631	\$198,543	\$0	\$2,059	\$330,052	\$332,111	0.5631	\$187,016
30	\$0	\$2,121	\$361,038	\$363,159	0.5521	\$200,489	\$0	\$2,121	\$339,953	\$342,074	0.5521	\$188,849
31	\$0	\$2,185	\$371,869	\$374,053	0.5412	\$202,455	\$0	\$2,185	\$350,152	\$352,337	0.5412	\$190,701
32	\$0	\$2,250	\$383,025	\$385,275	0.5306	\$204,440	\$0	\$2,250	\$360,657	\$362,907	0.5306	\$192,570
33	\$0	\$2,318	\$394,516	\$396,833	0.5202	\$206,444	\$0	\$2,318	\$371,476	\$373,794	0.5202	\$194,458
34	\$0	\$2,387	\$406,351	\$408,738	0.5100	\$208,468	\$0	\$2,387	\$382,621	\$385,008	0.5100	\$196,365
35	\$0	\$2,459	\$418,542	\$421,000	0.5000	\$210,512	\$0	\$2,459	\$394,099	\$396,558	0.5000	\$198,290
36	\$0	\$2,532	\$431,098	\$433,630	0.4902	\$212,576	\$0	\$2,532	\$405,922	\$408,455	0.4902	\$200,234
37	\$0	\$2,608	\$444,031	\$446,639	0.4806	\$214,660	\$0	\$2,608	\$418,100	\$420,708	0.4806	\$202,197
38	\$0	\$2,687	\$457,352	\$460,038	0.4712	\$216,764	\$0	\$2,687	\$430,643	\$433,330	0.4712	\$204,179
39	\$0	\$2,767	\$471,072	\$473,840	0.4619	\$218,889	\$0	\$2,767	\$443,562	\$446,329	0.4619	\$206,181
40	\$0	\$2,850	\$485,204	\$488,055	0.4529	\$221,035	\$0	\$2,850	\$456,869	\$459,719	0.4529	\$208,202
41	\$0	\$2,936	\$499,760	\$502,696	0.4440	\$223,202	\$0	\$2,936	\$470,575	\$473,511	0.4440	\$210,244
42	\$0	\$3,024	\$514,753	\$517,777	0.4353	\$225,391	\$0	\$3,024	\$484,692	\$487,716	0.4353	\$212,305
43	\$0	\$3,115	\$530,196	\$533,311	0.4268	\$227,600	\$0	\$3,115	\$499,233	\$502,348	0.4268	\$214,386
44	\$0	\$3,208	\$546,102	\$549,310	0.4184	\$229,832	\$0	\$3,208	\$514,210	\$517,418	0.4184	\$216,488
45	\$0	\$3,304	\$562,485	\$565,789	0.4102	\$232,085	\$0	\$3,304	\$529,636	\$532,941	0.4102	\$218,611
46	\$0	\$3,403	\$579,359	\$582,763	0.4022	\$234,360	\$0	\$3,403	\$545,525	\$548,929	0.4022	\$220,754
47	\$0	\$3,506	\$596,740	\$600,246	0.3943	\$236,658	\$0	\$3,506	\$561,891	\$565,397	0.3943	\$222,918
48	\$0	\$3,611	\$614,642	\$618,253	0.3865	\$238,978	\$0	\$3,611	\$578,748	\$582,359	0.3865	\$225,104
49	\$0	\$3,719	\$633,082	\$636,801	0.3790	\$241,321	\$0	\$3,719	\$596,110	\$599,829	0.3790	\$227,310
50	\$2,106,829	\$0	\$652,074	\$2,758,903	0.3715	\$1,025,009	\$2,191,953	\$0	\$613,994	\$2,805,947	0.3715	\$1,042,487
TOTAL						\$11,577,786						\$11,091,657

Mathematically, the case with the lowest present value is the preferred alternative.

Assumptions:

- Energy cost escalation based upon 3.00% per year.
- Maintenance cost escalation based upon 3.00% per year.
- At the end of each system's life, assume salvage value is zero.
- Present value factors based upon interest rate of 2.00 percent per year.

August 6, 2010

Anna Thelemarck
Department of Public Works
645 Pine Street
Burlington, Vermont 05401

Clark Sweeney
- carbon monoxide
detectors
- bathroom

Re: Leddy Park Ice Rink – Simple Economic Analysis - Revised

Introduction

L.N. Consulting, Inc. was retained by the City of Burlington to complete a simple economic life cycle analysis for the Leddy Park Ice Rink located in Burlington, Vermont. We utilized previous ice rink modeling data provided to us by Second Law to develop probable operating costs for multiple refrigeration plants with and without heat recovery on the condenser water side of the system. We obtained the ice rink maintenance records to determine the existing average yearly maintenance costs from 2007 until 2009. We compared the existing conditions refrigeration plant in our economic model to compare with new refrigeration plants.

Options

L.N. Consulting completed a comparison of seven different options. These options are as follows:

1. Existing refrigeration plant operating with the current average yearly maintenance costs. This assumes continued maintenance for another 20 years before replacement.
2. New reciprocating, ammonia refrigeration plant.
3. New reciprocating, ammonia refrigeration plant with condenser heat recovery.
4. New heat pump style, R404a refrigeration plant.
5. New heat pump style, R404a refrigeration plant with condenser heat recovery.
6. New screw style, R404a refrigerant plant.
7. New screw style, R404a refrigerant plant with condenser heat recovery.

Option #1

We assumed that the existing refrigeration plant can operate for another 20 years under its current yearly maintenance costs before requiring a plant replacement. We assumed a yearly maintenance cost of \$12,850.00 which is based upon the average actual maintenance costs for years 2007 through 2009.



Option #2

We assumed direct replacement of the existing plant with a new reciprocating style ammonia refrigeration plant similar to what currently exists. The system model is based upon using condenser energy to provide heat for the under-floor defrost system. The yearly maintenance costs are based upon \$4800.00 per year with a system replacement in 40 years. The system replacement cost does not include electrical or controls costs assuming this work can be reused in 40 years.

Options #3A & B

Same as option #2 except it includes heat recovery on the condenser side of the refrigeration plant. The heat recovery in this option assumes a condenser water temperature of 95°F. We assumed that some of the heat recovered from the condensing of the refrigerant can be used to; preheat domestic hot water, preheat zamboni hot water, and preheat ventilation air for the ice rink. Option 3A is the preheat for the domestic hot water and zamboni water and Option 3B is the preheat for the ventilation air.

Option #4

We assumed direct replacement of the existing plant with a new heat pump style R404a modular refrigeration plant. This plant would utilize (5) five 20 ton rated Ice Kube style machines linked together to produce the 100 tons of cooling capacity. The system model is based upon using condenser energy to provide heat for the under-floor defrost system. The yearly maintenance costs are based upon \$900.00 per year with a system replacement in 25 years. The system replacement cost only includes replacement of (3) three of the five units as this is the typical plant loading, therefore back-up machines should not require replacement. We used a system replacement cost of \$90,000.00, current value, for this item. The replacement cost does not include electrical or controls costs assuming this work can be reused in 40 years.

Option #5A & B

Same as option #4 except it includes heat recovery on the condenser side of the refrigeration plant. The heat recovery in this option assumes a condenser water temperature of 105°F. We assumed that some of the heat recovered from the condensing of the refrigerant can be used to; preheat domestic hot water, preheat zamboni hot water, and preheat ventilation air for the ice rink. Option 5A is the preheat for the domestic hot water and zamboni water and Option 5B is the preheat for the ventilation air.

Option #6

We assumed direct replacement of the existing plant with a new screw style, R404a refrigeration plant. The system model is based upon using condenser energy to provide heat for the under-floor defrost system. The screw compressors use less energy as compared to the other refrigeration plant equipment, but have a higher installed cost and yearly maintenance cost. The yearly maintenance costs are based upon \$6600.00 per year with a system replacement in 40 years. The system replacement cost does not include electrical or controls costs assuming this work can be reused in 40 years.



Option #7A & B

Same as option #6 except it includes heat recovery on the condenser side of the refrigeration plant. The heat recovery in this option assumes a condenser water temperature of 95°F. We assumed that some of the heat recovered from the condensing of the refrigerant can be used to; preheat domestic hot water, preheat zamboni hot water, and preheat ventilation air for the ice rink. Option 7A is the preheat for the domestic hot water and zamboni water and Option 7B is the preheat for the ventilation air.

The energy model data interpolated for the Leddy Park Ice Arena is displayed below:

Second Law has reviewed results from other ice rink modeling efforts in order to provide probable economic yearly energy savings associated with the implementation of a heat pump style ice plant that can provide a portion of the building heat.

We are basing this analysis on a model created for an ice facility that contains locker rooms, a rental area and a snack bar. We understand that the Leddy Park ice arena includes two rinks, one is a standard-sized hockey rink, and the other, is a 1/3 size recreational rink. Therefore, we have adjusted results from the existing model to reflect a building 33% larger. Basic assumptions for building and ice rink loads are as follows:

Total Building Area: 44,300 sf
Total Ice Rink Area: 22,600 sf

Wall Insulation: R-18
Window to wall Ratio: 0.08
Roof – Barrel Shaped: R-31
Ice Rink Ceiling – Emissivity: 0.05

Lighting: 0.8 w/sf on principally from 8am to 10pm
Occupancy: 40-130 people on rink during occupied hours

Ice Rink Loads:

The ice rink has a number of associated loads. These include:

1. **Zamboni:** The zamboni uses about 130 gallons per resurfacing at 160°F. During weekdays, the ice is resurfaced 11 times per day and 13 times on week-ends. Heat for zamboni water is provided by the boiler.
2. **Subfloor Heat:** In order to keep the ground under the ice rink from freezing, subfloor heat is provided. This is a low-temperature load, so heat can be provided from ice rink heat recovery.
3. **Domestic Hot Water:** Hot water for showers is estimated at about 432 gallons per day. Heat for hot water is provided by the boiler.

Ventilation:



4,000 cfm of ventilation is provided to the facility during occupied hours.

Utility Rates:

Utility rates are approximated as follows:

Electricity:

\$0.14 / kwh

Natural Gas:

\$1.50/therm

Refrigeration Systems:

1. **Water Cooled Chiller:** A water cooled reciprocating chiller was modeled without any heat recovery. This is the baseline model. This system uses a single chiller with two compressor circuits, rated at 100 tons total. With 90°F condenser temperature, this system operates at a COP of approximately 2.2. This system can provide waste heat for snowmelt and under floor heat, with a maximum load of approximately 125,000 btu/hour.
2. **IKS:** A heat pump system utilizes four IKS 450 heat pumps. Equipment capacities and efficiencies were provided by Ice Kube Systems.
 - a. **Energy Recovery:** The IKS heat pumps can be used to provide hot and cold energy simultaneously. With 110°F condenser water temperature, we can get 110°F out of the heat pumps, this heat can be used for the following loads:
 - i. **Zamboni Water Pre-Heat:** The Facility uses 200 gallons of 140°F water each time the zamboni is used. Using 110°F waste water we can provide about 68% of the heat required for the zamboni water.
 - ii. **Domestic Water Pre-Heat:** 140°F water is needed for domestic hot water storage, and can be pre-heated by heat pump waste heat. Again, we can provide about 68% of the heat required for domestic hot water.
 - iii. **Ventilation Pre-Heat:** This facility uses about 4,000 cfm of ventilation air for the ice rink itself. Ventilation rates may vary depending on occupancy. For modeling purposes, 4,000 cfm was modeled consistently throughout the year. Preheating of ventilation air using waste heat reduces the load on the central system. This load varies depending on the outside air temperature.



3. **Screw Chiller:** This system uses two screw chillers. At operating conditions, the chillers have an EER of 3.5. They require a condenser water temperature of 95°F. For this reason, we can only recover heat to about 95°F.

a. **Energy Recovery:**

- i. **Zamboni Water Pre-Heat:** Due to the lower condenser water temperature, we can only recover about 48% of the heat required for zamboni water pre-heat
- ii. **Domestic Water Pre-Heat:** Due to the lower condenser water temperature, we can only recover about 48% of the heat required for domestic water pre-heat.
- iii. **Ventilation Pre-Heat:** There is no energy recovery available for Ventilation Pre-Heat.

Results:

Table 1:

	Probable Energy Use		
	Electricity		Natural Gas
	KWH	Peak(KW)	(MMBTU)
Hermetic Reciprocating Chiller	820,436	249	2,775
IKS	804,541	181	2,712
IKS and Heat Recovery	804,154	181	982
Screw Chiller	730,768	159	2,712
Screw Chiller and Heat Recovery	730,590	158	1,296

Table 2:

	Probable Utility Cost			
	Electricity	Natural Gas	Total	Savings
Hermetic Reciprocating Chiller	\$ 119,990	\$ 41,629	\$ 161,619	\$ -
IKS	\$ 112,522	\$ 40,683	\$ 153,205	\$ 8,414
IKS and Heat Recovery	\$ 112,522	\$ 14,734	\$ 127,256	\$ 34,363



Screw Chiller	\$ 102,331	\$ 40,683	\$ 143,014	\$ 18,605
Screw Chiller and Heat Recovery	\$ 102,331	\$ 19,438	\$ 121,769	\$ 39,850

Table 3:

	IKS Chiller		Screw Chiller	
	Heat Energy Recovered	\$\$ Saved	Heat Energy Recovered	\$\$ Saved
	(Mbtu)		(Mbtu)	
DHW	454.4	\$ 8,232.01	320.4	\$ 5,804.21
Zamboni	39.5	\$ 714.99	27.8	\$ 503.56
Ventilation	216.3	\$ 3,919.09	216.2	\$ 3,917.23
	\$ 710	\$ 12,866	\$ 564	\$ 10,225

Economic Life Cycle Cost Analysis

We completed life cycle cost analysis calculations for all ten (10) options to allow the City of Burlington the opportunity to make an educated selection. The installation, operations, and maintenance costs are included in the calculation sheets and may be referenced on the following Economic Life Cycle Cost calculation sheets. The results of the life cycle cost analysis is as follows:

Option #1	\$11,197,858
Option #2	\$11,735,663
Option #3A	\$11,605,812
Option #3B	\$11,623,145
Option #4	\$11,577,786
Option #5A	\$11,091,657
Option #5B	\$11,541,501
Option #6	\$10,516,151
Option #7A	\$10,168,226
Option #7B	\$10,403,760



Based upon the results of the economic life cycle cost analysis, we recommend that the City of Burlington replace the existing ice rink refrigeration plant with a screw style refrigeration plant fitted with heat recovery for the domestic and zamboni water as it produces the lowest 50 year cost to the City. The heat recovery for the ventilation air could be reviewed by the Vermont Gas to determine if incentives could support the implementation of this system.

Thank you for the opportunity to develop this report, please contact our office with any questions you may have.

Sincerely,

L.N. Consulting, Inc.

Wayne Nelson, President

Encl: Economic Life Cycle Cost Calculation Sheets

Leddy Park Ice Rink
 Simple Economic Analysis for Ice Plant
 LN Consulting, Inc.
 8/6/10, Revision 1
 Capital Costs:

Option 1 - Existing Reciprocating Chiller Ice Plant

\$35,000 to re-tube existing chiller in Year 0 (now).
 Capital cost anticipated to be \$90,000 (today's dollars) in years 10 and 40.
 Year 10 and 40 capital costs determined using the maintenance cost escalation below.

Option 2 - New Reciprocating Chiller Ice Plant

Chiller material	\$300,000
Chiller mechanical labor	\$100,000
Chiller electrical labor	\$40,000
Chiller DDC controls	\$40,000
Total	\$480,000

Annual Net Cash Flows:

A Year	Option 1 - Existing Reciprocating Chiller Ice Plant						Option 2 - New Reciprocating Chiller Ice Plant					
	B Capital Costs	C Maintenance Costs	D Energy Cost	E Net Cash Flow (B+C+D)	F Present Value Factor	G Present Value (Worth)	H Capital Costs	I Maintenance Costs	J Energy Cost	K Net Cash Flow (H+I+J)	L Present Value Factor	M Present Value (Worth)
0	\$35,000	\$0	\$0	\$35,000	1.0000	\$35,000	\$480,000	\$0	\$0	\$480,000	1.0000	\$480,000
1	\$0	\$12,850	\$161,619	\$174,469	0.9804	\$171,048	\$0	\$6,600	\$161,619	\$168,219	0.9804	\$164,921
2	\$0	\$13,236	\$166,468	\$179,703	0.9612	\$172,725	\$0	\$6,798	\$166,468	\$173,266	0.9612	\$166,537
3	\$0	\$13,633	\$171,462	\$185,094	0.9423	\$174,418	\$0	\$7,002	\$171,462	\$178,464	0.9423	\$168,170
4	\$0	\$14,042	\$176,605	\$190,647	0.9238	\$176,128	\$0	\$7,212	\$176,605	\$183,817	0.9238	\$169,819
5	\$0	\$14,463	\$181,904	\$196,366	0.9057	\$177,855	\$0	\$7,428	\$181,904	\$189,332	0.9057	\$171,484
6	\$0	\$14,897	\$187,361	\$202,257	0.8880	\$179,599	\$0	\$7,651	\$187,361	\$195,012	0.8880	\$173,165
7	\$0	\$15,344	\$192,982	\$208,325	0.8706	\$181,360	\$0	\$7,881	\$192,982	\$200,862	0.8706	\$174,863
8	\$0	\$15,804	\$198,771	\$214,575	0.8535	\$183,138	\$0	\$8,117	\$198,771	\$206,888	0.8535	\$176,577
9	\$0	\$16,278	\$204,734	\$221,012	0.8368	\$184,933	\$0	\$8,361	\$204,734	\$213,095	0.8368	\$178,308
10	\$117,430	\$0	\$210,876	\$328,306	0.8203	\$269,325	\$0	\$8,612	\$210,876	\$219,488	0.8203	\$180,056
11	\$0	\$17,269	\$217,202	\$234,472	0.8043	\$188,577	\$0	\$8,870	\$217,202	\$226,072	0.8043	\$181,822
12	\$0	\$17,787	\$223,718	\$241,506	0.7885	\$190,426	\$0	\$9,136	\$223,718	\$232,854	0.7885	\$183,604
13	\$0	\$18,321	\$230,430	\$248,751	0.7730	\$192,293	\$0	\$9,410	\$230,430	\$239,840	0.7730	\$185,404
14	\$0	\$18,871	\$237,343	\$256,214	0.7579	\$194,178	\$0	\$9,692	\$237,343	\$247,035	0.7579	\$187,222
15	\$0	\$19,437	\$244,463	\$263,900	0.7430	\$196,082	\$0	\$9,983	\$244,463	\$254,446	0.7430	\$189,057
16	\$0	\$20,020	\$251,797	\$271,817	0.7284	\$198,004	\$0	\$10,283	\$251,797	\$262,080	0.7284	\$190,911
17	\$0	\$20,620	\$259,351	\$279,972	0.7142	\$199,945	\$0	\$10,591	\$259,351	\$269,942	0.7142	\$192,783
18	\$0	\$21,239	\$267,132	\$288,371	0.7002	\$201,905	\$0	\$10,909	\$267,132	\$278,040	0.7002	\$194,673
19	\$0	\$21,876	\$275,146	\$297,022	0.6864	\$203,885	\$0	\$11,236	\$275,146	\$286,382	0.6864	\$196,581
20	\$0	\$22,533	\$283,400	\$305,932	0.6730	\$205,884	\$0	\$11,573	\$283,400	\$294,973	0.6730	\$198,508
21	\$0	\$23,209	\$291,902	\$315,110	0.6598	\$207,902	\$0	\$11,920	\$291,902	\$303,822	0.6598	\$200,455
22	\$0	\$23,905	\$300,659	\$324,564	0.6468	\$209,940	\$0	\$12,278	\$300,659	\$312,937	0.6468	\$202,420
23	\$0	\$24,622	\$309,679	\$334,301	0.6342	\$211,999	\$0	\$12,646	\$309,679	\$322,325	0.6342	\$204,404
24	\$0	\$25,361	\$318,969	\$344,330	0.6217	\$214,077	\$0	\$13,026	\$318,969	\$331,995	0.6217	\$206,408
25	\$0	\$26,121	\$328,538	\$354,660	0.6095	\$216,176	\$0	\$13,416	\$328,538	\$341,955	0.6095	\$208,432
26	\$0	\$26,905	\$338,394	\$365,299	0.5976	\$218,295	\$0	\$13,819	\$338,394	\$352,213	0.5976	\$210,475
27	\$0	\$27,712	\$348,546	\$376,258	0.5859	\$220,435	\$0	\$14,234	\$348,546	\$362,780	0.5859	\$212,539
28	\$0	\$28,544	\$359,003	\$387,546	0.5744	\$222,597	\$0	\$14,661	\$359,003	\$373,663	0.5744	\$214,623
29	\$0	\$29,400	\$369,773	\$399,172	0.5631	\$224,779	\$0	\$15,100	\$369,773	\$384,873	0.5631	\$216,727
30	\$0	\$30,282	\$380,866	\$411,148	0.5521	\$226,983	\$0	\$15,553	\$380,866	\$396,419	0.5521	\$218,851
31	\$0	\$31,190	\$392,292	\$423,482	0.5412	\$229,208	\$0	\$16,020	\$392,292	\$408,312	0.5412	\$220,997
32	\$0	\$32,126	\$404,060	\$436,187	0.5306	\$231,455	\$0	\$16,501	\$404,060	\$420,561	0.5306	\$223,164
33	\$0	\$33,090	\$416,182	\$449,272	0.5202	\$233,724	\$0	\$16,996	\$416,182	\$433,178	0.5202	\$225,352
34	\$0	\$34,083	\$428,668	\$462,750	0.5100	\$236,016	\$0	\$17,505	\$428,668	\$446,173	0.5100	\$227,561
35	\$0	\$35,105	\$441,528	\$476,633	0.5000	\$238,330	\$0	\$18,031	\$441,528	\$459,558	0.5000	\$229,792
36	\$0	\$36,158	\$454,774	\$490,932	0.4902	\$240,666	\$0	\$18,571	\$454,774	\$473,345	0.4902	\$232,045
37	\$0	\$37,243	\$468,417	\$505,660	0.4806	\$243,026	\$0	\$19,129	\$468,417	\$487,545	0.4806	\$234,320
38	\$0	\$38,360	\$482,469	\$520,830	0.4712	\$245,408	\$0	\$19,702	\$482,469	\$502,172	0.4712	\$236,617
39	\$0	\$39,511	\$496,943	\$536,454	0.4619	\$247,814	\$0	\$20,294	\$496,943	\$517,237	0.4619	\$238,937
40	\$285,032	\$0	\$511,852	\$796,884	0.4529	\$360,901	\$1,520,173	\$0	\$511,852	\$2,032,025	0.4529	\$920,285
41	\$0	\$41,917	\$527,207	\$569,124	0.4440	\$252,697	\$0	\$21,529	\$527,207	\$548,737	0.4440	\$243,645
42	\$0	\$43,175	\$543,024	\$586,198	0.4353	\$255,174	\$0	\$22,175	\$543,024	\$565,199	0.4353	\$246,033
43	\$0	\$44,470	\$559,314	\$603,784	0.4268	\$257,676	\$0	\$22,841	\$559,314	\$582,155	0.4268	\$248,445
44	\$0	\$45,804	\$576,094	\$621,898	0.4184	\$260,202	\$0	\$23,526	\$576,094	\$599,619	0.4184	\$250,881
45	\$0	\$47,178	\$593,376	\$640,555	0.4102	\$262,753	\$0	\$24,232	\$593,376	\$617,608	0.4102	\$253,341
46	\$0	\$48,594	\$611,178	\$659,771	0.4022	\$265,329	\$0	\$24,959	\$611,178	\$636,136	0.4022	\$255,825
47	\$0	\$50,051	\$629,513	\$679,564	0.3943	\$267,931	\$0	\$25,707	\$629,513	\$655,220	0.3943	\$258,333
48	\$0	\$51,553	\$648,398	\$699,951	0.3865	\$270,558	\$0	\$26,479	\$648,398	\$674,877	0.3865	\$260,865
49	\$0	\$53,099	\$667,850	\$720,950	0.3790	\$273,210	\$0	\$27,273	\$667,850	\$695,123	0.3790	\$263,423
50	\$0	\$54,692	\$687,886	\$742,578	0.3715	\$275,889	\$0	\$28,091	\$687,886	\$715,977	0.3715	\$266,005
TOTAL						\$11,197,858						\$11,735,663

Mathematically, the case with the lowest present value is the preferred alternative.

Assumptions:

1. Energy cost escalation based upon 3.00% per year.
2. Maintenance cost escalation based upon 3.00% per year.
3. At the end of each system's life, assume salvage value is zero.
4. Present value factors based upon interest rate of 2.00 percent per year.

Leddy Park Ice Rink
 Simple Economic Analysis for Ice Plant
 LN Consulting, Inc.
 8/6/10, Revision 1

Capital Costs:

Option 3A - New Reciprocating Chiller Ice Plant with DHW heat recovery	
Chiller material	\$300,000
Chiller mechanical labor	\$100,000
Chiller electrical labor	\$40,000
Chiller DDC controls	\$40,000
DHW Heat Recovery	\$20,000
Total	\$500,000

Option 3B - New Reciprocating Chiller Ice Plant with vent. heat recovery	
Chiller material	\$300,000
Chiller mechanical labor	\$100,000
Chiller electrical labor	\$40,000
Chiller DDC controls	\$40,000
Ventilation Heat Recovery	\$55,000
Total	\$535,000

Annual Net Cash Flows:

A Year	Option 3A - New Reciprocating Chiller Ice Plant with DHW heat recovery						Option 3B - New Reciprocating Chiller Ice Plant with vent. heat recovery					
	B Capital Costs	C Maintenance Costs	D Energy Cost	E Net Cash Flow (B+C+D)	F Present Value Factor	G Present Value (Worth)	H Capital Costs	I Maintenance Costs	J Energy Cost	K Net Cash Flow (H+I+J)	L Present Value Factor	M Present Value (Worth)
0	\$500,000	\$0	\$0	\$500,000	1.0000	\$500,000	\$535,000	\$0	\$0	\$535,000	1.0000	\$535,000
1	\$0	\$12,850	\$152,672	\$165,522	0.9804	\$162,276	\$0	\$6,600	\$157,700	\$164,300	0.9804	\$161,078
2	\$0	\$13,236	\$157,252	\$170,488	0.9612	\$163,867	\$0	\$6,798	\$162,431	\$169,229	0.9612	\$162,658
3	\$0	\$13,633	\$161,970	\$175,602	0.9423	\$165,474	\$0	\$7,002	\$167,304	\$174,306	0.9423	\$164,252
4	\$0	\$14,042	\$166,829	\$180,870	0.9238	\$167,096	\$0	\$7,212	\$172,323	\$179,535	0.9238	\$165,863
5	\$0	\$14,463	\$171,834	\$186,296	0.9057	\$168,734	\$0	\$7,428	\$177,493	\$184,921	0.9057	\$167,489
6	\$0	\$14,897	\$176,989	\$191,885	0.8880	\$170,389	\$0	\$7,651	\$182,818	\$190,469	0.8880	\$169,131
7	\$0	\$15,344	\$182,298	\$197,642	0.8706	\$172,059	\$0	\$7,881	\$188,302	\$196,183	0.8706	\$170,789
8	\$0	\$15,804	\$187,767	\$203,571	0.8535	\$173,746	\$0	\$8,117	\$193,951	\$202,068	0.8535	\$172,463
9	\$0	\$16,278	\$193,400	\$209,678	0.8368	\$175,449	\$0	\$8,361	\$199,770	\$208,130	0.8368	\$174,154
10	\$0	\$16,766	\$199,202	\$215,969	0.8203	\$177,170	\$0	\$8,612	\$205,763	\$214,374	0.8203	\$175,862
11	\$0	\$17,269	\$205,178	\$222,448	0.8043	\$178,906	\$0	\$8,870	\$211,936	\$220,805	0.8043	\$177,586
12	\$0	\$17,787	\$211,334	\$229,121	0.7885	\$180,660	\$0	\$9,136	\$218,294	\$227,430	0.7885	\$179,327
13	\$0	\$18,321	\$217,674	\$235,995	0.7730	\$182,432	\$0	\$9,410	\$224,842	\$234,253	0.7730	\$181,085
14	\$0	\$18,871	\$224,204	\$243,075	0.7579	\$184,220	\$0	\$9,692	\$231,588	\$241,280	0.7579	\$182,860
15	\$0	\$19,437	\$230,930	\$250,367	0.7430	\$186,026	\$0	\$9,983	\$238,535	\$248,518	0.7430	\$184,653
16	\$0	\$20,020	\$237,858	\$257,878	0.7284	\$187,850	\$0	\$10,283	\$245,691	\$255,974	0.7284	\$186,463
17	\$0	\$20,620	\$244,994	\$265,614	0.7142	\$189,692	\$0	\$10,591	\$253,062	\$263,653	0.7142	\$188,291
18	\$0	\$21,239	\$252,344	\$273,583	0.7002	\$191,551	\$0	\$10,909	\$260,654	\$271,563	0.7002	\$190,137
19	\$0	\$21,876	\$259,914	\$281,790	0.6864	\$193,429	\$0	\$11,236	\$268,474	\$279,710	0.6864	\$192,001
20	\$0	\$22,533	\$267,711	\$290,244	0.6730	\$195,326	\$0	\$11,573	\$276,528	\$288,101	0.6730	\$193,884
21	\$0	\$23,209	\$275,743	\$298,951	0.6598	\$197,241	\$0	\$11,920	\$284,824	\$296,744	0.6598	\$195,785
22	\$0	\$23,905	\$284,015	\$307,920	0.6468	\$199,174	\$0	\$12,278	\$293,368	\$305,646	0.6468	\$197,704
23	\$0	\$24,622	\$292,535	\$317,157	0.6342	\$201,127	\$0	\$12,646	\$302,170	\$314,816	0.6342	\$199,642
24	\$0	\$25,361	\$301,311	\$326,672	0.6217	\$203,099	\$0	\$13,026	\$311,235	\$324,260	0.6217	\$201,600
25	\$0	\$26,121	\$310,351	\$336,472	0.6095	\$205,090	\$0	\$13,416	\$320,572	\$333,988	0.6095	\$203,576
26	\$0	\$26,905	\$319,661	\$346,566	0.5976	\$207,101	\$0	\$13,819	\$330,189	\$344,008	0.5976	\$205,572
27	\$0	\$27,712	\$329,251	\$356,963	0.5859	\$209,131	\$0	\$14,234	\$340,094	\$354,328	0.5859	\$207,587
28	\$0	\$28,544	\$339,129	\$367,672	0.5744	\$211,182	\$0	\$14,661	\$350,297	\$364,958	0.5744	\$209,622
29	\$0	\$29,400	\$349,302	\$378,702	0.5631	\$213,252	\$0	\$15,100	\$360,806	\$375,907	0.5631	\$211,678
30	\$0	\$30,282	\$359,782	\$390,063	0.5521	\$215,343	\$0	\$15,553	\$371,630	\$387,184	0.5521	\$213,753
31	\$0	\$31,190	\$370,575	\$401,765	0.5412	\$217,454	\$0	\$16,020	\$382,779	\$398,799	0.5412	\$215,848
32	\$0	\$32,126	\$381,692	\$413,818	0.5306	\$219,586	\$0	\$16,501	\$394,263	\$410,763	0.5306	\$217,965
33	\$0	\$33,090	\$393,143	\$426,233	0.5202	\$221,739	\$0	\$16,996	\$406,091	\$423,086	0.5202	\$220,102
34	\$0	\$34,083	\$404,937	\$439,020	0.5100	\$223,912	\$0	\$17,505	\$418,273	\$435,779	0.5100	\$222,259
35	\$0	\$35,105	\$417,085	\$452,190	0.5000	\$226,108	\$0	\$18,031	\$430,821	\$448,852	0.5000	\$224,438
36	\$0	\$36,158	\$429,598	\$465,756	0.4902	\$228,324	\$0	\$18,571	\$443,746	\$462,318	0.4902	\$226,639
37	\$0	\$37,243	\$442,486	\$479,729	0.4806	\$230,563	\$0	\$19,129	\$457,058	\$476,187	0.4806	\$228,861
38	\$0	\$38,360	\$455,761	\$494,121	0.4712	\$232,823	\$0	\$19,702	\$470,770	\$490,473	0.4712	\$231,104
39	\$0	\$39,511	\$469,433	\$508,944	0.4619	\$235,106	\$0	\$20,294	\$484,893	\$505,187	0.4619	\$233,370
40	\$1,583,513	\$0	\$483,516	\$2,067,030	0.4529	\$936,138	\$1,694,359	\$0	\$499,440	\$2,193,800	0.4529	\$993,551
41	\$0	\$41,917	\$498,022	\$539,939	0.4440	\$239,738	\$0	\$21,529	\$514,423	\$535,953	0.4440	\$237,969
42	\$0	\$43,175	\$512,962	\$556,137	0.4353	\$242,089	\$0	\$22,175	\$529,856	\$552,031	0.4353	\$240,302
43	\$0	\$44,470	\$528,351	\$572,821	0.4268	\$244,462	\$0	\$22,841	\$545,752	\$568,592	0.4268	\$242,657
44	\$0	\$45,804	\$544,202	\$590,006	0.4184	\$246,859	\$0	\$23,526	\$562,124	\$585,650	0.4184	\$245,036
45	\$0	\$47,178	\$560,528	\$607,706	0.4102	\$249,279	\$0	\$24,232	\$578,988	\$603,220	0.4102	\$247,439
46	\$0	\$48,594	\$577,344	\$625,937	0.4022	\$251,723	\$0	\$24,959	\$596,358	\$621,316	0.4022	\$249,865
47	\$0	\$50,051	\$594,664	\$644,715	0.3943	\$254,191	\$0	\$25,707	\$614,248	\$639,956	0.3943	\$252,314
48	\$0	\$51,553	\$612,504	\$664,057	0.3865	\$256,683	\$0	\$26,479	\$632,676	\$659,154	0.3865	\$254,788
49	\$0	\$53,099	\$630,879	\$683,979	0.3790	\$259,199	\$0	\$27,273	\$651,656	\$678,929	0.3790	\$257,286
50	\$0	\$54,692	\$649,806	\$704,498	0.3715	\$261,741	\$0	\$28,091	\$671,206	\$699,297	0.3715	\$259,808
TOTAL						\$11,605,812						\$11,623,145

Mathematically, the case with the lowest present value is the preferred alternative.

Assumptions:

1. Energy cost escalation based upon 3.00% per year.
2. Maintenance cost escalation based upon 3.00% per year.
3. At the end of each system's life, assume salvage value is zero.
4. Present value factors based upon interest rate of 2.00 percent per year.

Leddy Park Ice Rink
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Capital Costs:

Option 4 - New IKS Chiller Ice Plant

Chiller material	\$315,000
Chiller mechanical labor	\$100,000
Chiller electrical labor	\$40,000
Chiller DDC controls	\$40,000
Total	\$495,000

Option 5A - New IKS Chiller Ice Plant with DHW heat recovery

Chiller material	\$315,000
Chiller mechanical labor	\$100,000
Chiller electrical labor	\$40,000
Chiller DDC controls	\$40,000
DHW Heat Recovery	\$20,000
Total	\$515,000

Annual Net Cash Flows:

A Year	Option 4 - New IKS Chiller Ice Plant						Option 5A - New IKS Chiller Ice Plant with DHW heat recovery					
	B Capital Costs	C Maintenance Costs	D Energy Cost	E Net Cash Flow (B+C+D)	F Present Value Factor	G Present Value (Worth)	H Capital Costs	I Maintenance Costs	J Energy Cost	K Net Cash Flow (H+I+J)	L Present Value Factor	M Present Value (Worth)
0	\$495,000	\$0	\$0	\$495,000	1.0000	\$495,000	\$515,000	\$0	\$0	\$515,000	1.0000	\$515,000
1	\$0	\$900	\$153,205	\$154,105	0.9804	\$151,083	\$0	\$900	\$144,258	\$145,158	0.9804	\$142,312
2	\$0	\$927	\$157,801	\$158,728	0.9612	\$152,565	\$0	\$927	\$148,586	\$149,513	0.9612	\$143,707
3	\$0	\$955	\$162,535	\$163,490	0.9423	\$154,060	\$0	\$955	\$153,043	\$153,998	0.9423	\$145,116
4	\$0	\$983	\$167,411	\$168,395	0.9238	\$155,571	\$0	\$983	\$157,635	\$158,618	0.9238	\$146,539
5	\$0	\$1,013	\$172,434	\$173,447	0.9057	\$157,096	\$0	\$1,013	\$162,364	\$163,377	0.9057	\$147,975
6	\$0	\$1,043	\$177,607	\$178,650	0.8880	\$158,636	\$0	\$1,043	\$167,235	\$168,278	0.8880	\$149,426
7	\$0	\$1,075	\$182,935	\$184,009	0.8706	\$160,191	\$0	\$1,075	\$172,252	\$173,326	0.8706	\$150,891
8	\$0	\$1,107	\$188,423	\$189,530	0.8535	\$161,762	\$0	\$1,107	\$177,419	\$178,526	0.8535	\$152,370
9	\$0	\$1,140	\$194,076	\$195,216	0.8368	\$163,348	\$0	\$1,140	\$182,742	\$183,882	0.8368	\$153,864
10	\$0	\$1,174	\$199,898	\$201,072	0.8203	\$164,949	\$0	\$1,174	\$188,224	\$189,398	0.8203	\$155,373
11	\$0	\$1,210	\$205,895	\$207,104	0.8043	\$166,566	\$0	\$1,210	\$193,871	\$195,080	0.8043	\$156,896
12	\$0	\$1,246	\$212,072	\$213,317	0.7885	\$168,199	\$0	\$1,246	\$199,687	\$200,933	0.7885	\$158,434
13	\$0	\$1,283	\$218,434	\$219,717	0.7730	\$169,848	\$0	\$1,283	\$205,677	\$206,961	0.7730	\$159,987
14	\$0	\$1,322	\$224,987	\$226,308	0.7579	\$171,513	\$0	\$1,322	\$211,848	\$213,169	0.7579	\$161,556
15	\$0	\$1,361	\$231,736	\$233,098	0.7430	\$173,195	\$0	\$1,361	\$218,203	\$219,564	0.7430	\$163,140
16	\$0	\$1,402	\$238,688	\$240,091	0.7284	\$174,893	\$0	\$1,402	\$224,749	\$226,151	0.7284	\$164,739
17	\$0	\$1,444	\$245,849	\$247,293	0.7142	\$176,608	\$0	\$1,444	\$231,492	\$232,936	0.7142	\$166,354
18	\$0	\$1,488	\$253,225	\$254,712	0.7002	\$178,339	\$0	\$1,488	\$238,436	\$239,924	0.7002	\$167,985
19	\$0	\$1,532	\$260,821	\$262,353	0.6864	\$180,087	\$0	\$1,532	\$245,590	\$247,122	0.6864	\$169,632
20	\$0	\$1,578	\$268,646	\$270,224	0.6730	\$181,853	\$0	\$1,578	\$252,957	\$254,535	0.6730	\$171,295
21	\$0	\$1,626	\$276,705	\$278,331	0.6598	\$183,636	\$0	\$1,626	\$260,546	\$262,171	0.6598	\$172,974
22	\$0	\$1,674	\$285,006	\$286,681	0.6468	\$185,436	\$0	\$1,674	\$268,362	\$270,037	0.6468	\$174,670
23	\$0	\$1,724	\$293,557	\$295,281	0.6342	\$187,254	\$0	\$1,724	\$276,413	\$278,138	0.6342	\$176,383
24	\$0	\$1,776	\$302,363	\$304,140	0.6217	\$189,090	\$0	\$1,776	\$284,706	\$286,482	0.6217	\$178,112
25	\$1,006,233	\$0	\$311,434	\$1,311,667	0.6095	\$803,159	\$1,046,889	\$0	\$293,247	\$1,340,136	0.6095	\$816,854
26	\$0	\$1,884	\$320,777	\$322,662	0.5976	\$192,816	\$0	\$1,884	\$302,044	\$303,929	0.5976	\$181,621
27	\$0	\$1,941	\$330,401	\$332,341	0.5859	\$194,706	\$0	\$1,941	\$311,106	\$313,046	0.5859	\$183,402
28	\$0	\$1,999	\$340,313	\$342,312	0.5744	\$196,615	\$0	\$1,999	\$320,439	\$322,438	0.5744	\$185,200
29	\$0	\$2,059	\$350,522	\$352,581	0.5631	\$198,543	\$0	\$2,059	\$330,052	\$332,111	0.5631	\$187,016
30	\$0	\$2,121	\$361,038	\$363,159	0.5521	\$200,489	\$0	\$2,121	\$339,953	\$342,074	0.5521	\$188,849
31	\$0	\$2,185	\$371,869	\$374,053	0.5412	\$202,455	\$0	\$2,185	\$350,152	\$352,337	0.5412	\$190,701
32	\$0	\$2,250	\$383,025	\$385,275	0.5306	\$204,440	\$0	\$2,250	\$360,657	\$362,907	0.5306	\$192,570
33	\$0	\$2,318	\$394,516	\$396,833	0.5202	\$206,444	\$0	\$2,318	\$371,476	\$373,794	0.5202	\$194,458
34	\$0	\$2,387	\$406,351	\$408,738	0.5100	\$208,468	\$0	\$2,387	\$382,621	\$385,008	0.5100	\$196,365
35	\$0	\$2,459	\$418,542	\$421,000	0.5000	\$210,512	\$0	\$2,459	\$394,099	\$396,558	0.5000	\$198,290
36	\$0	\$2,532	\$431,098	\$433,630	0.4902	\$212,576	\$0	\$2,532	\$405,922	\$408,455	0.4902	\$200,234
37	\$0	\$2,608	\$444,031	\$446,639	0.4806	\$214,660	\$0	\$2,608	\$418,100	\$420,708	0.4806	\$202,197
38	\$0	\$2,687	\$457,352	\$460,038	0.4712	\$216,764	\$0	\$2,687	\$430,643	\$433,330	0.4712	\$204,179
39	\$0	\$2,767	\$471,072	\$473,840	0.4619	\$218,889	\$0	\$2,767	\$443,562	\$446,329	0.4619	\$206,181
40	\$0	\$2,850	\$485,204	\$488,055	0.4529	\$221,035	\$0	\$2,850	\$456,869	\$459,719	0.4529	\$208,202
41	\$0	\$2,936	\$499,760	\$502,696	0.4440	\$223,202	\$0	\$2,936	\$470,575	\$473,511	0.4440	\$210,244
42	\$0	\$3,024	\$514,753	\$517,777	0.4353	\$225,391	\$0	\$3,024	\$484,692	\$487,716	0.4353	\$212,305
43	\$0	\$3,115	\$530,196	\$533,311	0.4268	\$227,600	\$0	\$3,115	\$499,233	\$502,348	0.4268	\$214,386
44	\$0	\$3,208	\$546,102	\$549,310	0.4184	\$229,832	\$0	\$3,208	\$514,210	\$517,418	0.4184	\$216,488
45	\$0	\$3,304	\$562,485	\$565,789	0.4102	\$232,085	\$0	\$3,304	\$529,636	\$532,941	0.4102	\$218,611
46	\$0	\$3,403	\$579,359	\$582,763	0.4022	\$234,360	\$0	\$3,403	\$545,525	\$548,929	0.4022	\$220,754
47	\$0	\$3,506	\$596,740	\$600,246	0.3943	\$236,658	\$0	\$3,506	\$561,891	\$565,397	0.3943	\$222,918
48	\$0	\$3,611	\$614,642	\$618,253	0.3865	\$238,978	\$0	\$3,611	\$578,748	\$582,359	0.3865	\$225,104
49	\$0	\$3,719	\$633,082	\$636,801	0.3790	\$241,321	\$0	\$3,719	\$596,110	\$599,829	0.3790	\$227,310
50	\$2,106,829	\$0	\$652,074	\$2,758,903	0.3715	\$1,025,009	\$2,191,953	\$0	\$613,994	\$2,805,947	0.3715	\$1,042,487
TOTAL						\$11,577,786						\$11,091,657

Mathematically, the case with the lowest present value is the preferred alternative.

Assumptions:

1. Energy cost escalation based upon 3.00% per year.
2. Maintenance cost escalation based upon 3.00% per year.
3. At the end of each system's life, assume salvage value is zero.
4. Present value factors based upon interest rate of 2.00 percent per year.

Leddy Park Ice Rink
 Simple Economic Analysis for Ice Plant
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Capital Costs:

Option 5B - New IKS Chiller Ice Plant with vent. heat recovery	
Chiller material	\$315,000
Chiller mechanical labor	\$100,000
Chiller electrical labor	\$40,000
Chiller DDC controls	\$40,000
Ventilation Heat Recovery	\$55,000
Total	\$550,000

Option 6 - New Screw Chiller Ice Plant	
Chiller material (freon)	\$325,000
Chiller mechanical labor	\$100,000
Chiller electrical labor	\$40,000
Chiller DDC controls	\$40,000
Total	\$505,000

Annual Net Cash Flows:

A Year	Option 5B - New IKS Chiller Ice Plant with vent. heat recovery						Option 6 - New Screw Chiller Ice Plant					
	B Capital Costs	C Maintenance Costs	D Energy Cost	E Net Cash Flow (B+C+D)	F Present Value Factor	G Present Value (Worth)	H Capital Costs	I Maintenance Costs	J Energy Cost	K Net Cash Flow (H+I+J)	L Present Value Factor	M Present Value (Worth)
0	\$550,000	\$0	\$0	\$550,000	1.0000	\$550,000	\$505,000	\$0	\$0	\$505,000	1.0000	\$505,000
1	\$0	\$900	\$149,286	\$150,186	0.9804	\$147,241	\$0	\$4,800	\$143,014	\$147,814	0.9804	\$144,916
2	\$0	\$927	\$153,765	\$154,692	0.9612	\$148,685	\$0	\$4,944	\$147,304	\$152,248	0.9612	\$146,336
3	\$0	\$955	\$158,378	\$159,332	0.9423	\$150,142	\$0	\$5,092	\$151,724	\$156,816	0.9423	\$147,771
4	\$0	\$983	\$163,129	\$164,112	0.9238	\$151,614	\$0	\$5,245	\$156,275	\$161,520	0.9238	\$149,220
5	\$0	\$1,013	\$168,023	\$169,036	0.9057	\$153,101	\$0	\$5,402	\$160,964	\$166,366	0.9057	\$150,683
6	\$0	\$1,043	\$173,063	\$174,107	0.8880	\$154,602	\$0	\$5,565	\$165,792	\$171,357	0.8880	\$152,160
7	\$0	\$1,075	\$178,255	\$179,330	0.8706	\$156,118	\$0	\$5,731	\$170,766	\$176,498	0.8706	\$153,652
8	\$0	\$1,107	\$183,603	\$184,710	0.8535	\$157,648	\$0	\$5,903	\$175,889	\$181,793	0.8535	\$155,158
9	\$0	\$1,140	\$189,111	\$190,251	0.8368	\$159,194	\$0	\$6,080	\$181,166	\$187,246	0.8368	\$156,679
10	\$0	\$1,174	\$194,784	\$195,959	0.8203	\$160,754	\$0	\$6,263	\$186,601	\$192,864	0.8203	\$158,215
11	\$0	\$1,210	\$200,628	\$201,837	0.8043	\$162,330	\$0	\$6,451	\$192,199	\$198,650	0.8043	\$159,767
12	\$0	\$1,246	\$206,647	\$207,893	0.7885	\$163,922	\$0	\$6,644	\$197,965	\$204,609	0.7885	\$161,333
13	\$0	\$1,283	\$212,846	\$214,129	0.7730	\$165,529	\$0	\$6,844	\$203,904	\$210,747	0.7730	\$162,915
14	\$0	\$1,322	\$219,232	\$220,553	0.7579	\$167,152	\$0	\$7,049	\$210,021	\$217,070	0.7579	\$164,512
15	\$0	\$1,361	\$225,808	\$227,170	0.7430	\$168,791	\$0	\$7,260	\$216,322	\$223,582	0.7430	\$166,125
16	\$0	\$1,402	\$232,583	\$233,985	0.7284	\$170,445	\$0	\$7,478	\$222,811	\$230,289	0.7284	\$167,753
17	\$0	\$1,444	\$239,560	\$241,004	0.7142	\$172,116	\$0	\$7,703	\$229,495	\$237,198	0.7142	\$169,398
18	\$0	\$1,488	\$246,747	\$248,235	0.7002	\$173,804	\$0	\$7,934	\$236,380	\$244,314	0.7002	\$171,059
19	\$0	\$1,532	\$254,149	\$255,682	0.6864	\$175,508	\$0	\$8,172	\$243,472	\$251,643	0.6864	\$172,736
20	\$0	\$1,578	\$261,774	\$263,352	0.6730	\$177,228	\$0	\$8,417	\$250,776	\$259,193	0.6730	\$174,429
21	\$0	\$1,626	\$269,627	\$271,253	0.6598	\$178,966	\$0	\$8,669	\$258,299	\$266,969	0.6598	\$176,139
22	\$0	\$1,674	\$277,716	\$279,390	0.6468	\$180,720	\$0	\$8,929	\$266,048	\$274,978	0.6468	\$177,866
23	\$0	\$1,724	\$286,047	\$287,772	0.6342	\$182,492	\$0	\$9,197	\$274,030	\$283,227	0.6342	\$179,610
24	\$0	\$1,776	\$294,629	\$296,405	0.6217	\$184,281	\$0	\$9,473	\$282,251	\$291,724	0.6217	\$181,371
25	\$1,118,037	\$0	\$303,468	\$1,421,504	0.6095	\$866,451	\$0	\$9,757	\$290,718	\$300,475	0.6095	\$183,149
26	\$0	\$1,884	\$312,572	\$314,456	0.5976	\$187,912	\$0	\$10,050	\$299,440	\$309,490	0.5976	\$184,945
27	\$0	\$1,941	\$321,949	\$323,890	0.5859	\$189,755	\$0	\$10,352	\$308,423	\$318,774	0.5859	\$186,758
28	\$0	\$1,999	\$331,607	\$333,607	0.5744	\$191,615	\$0	\$10,662	\$317,675	\$328,338	0.5744	\$188,589
29	\$0	\$2,059	\$341,556	\$343,615	0.5631	\$193,494	\$0	\$10,982	\$327,206	\$338,188	0.5631	\$190,438
30	\$0	\$2,121	\$351,802	\$353,923	0.5521	\$195,391	\$0	\$11,312	\$337,022	\$348,333	0.5521	\$192,305
31	\$0	\$2,185	\$362,356	\$364,541	0.5412	\$197,306	\$0	\$11,651	\$347,133	\$358,783	0.5412	\$194,190
32	\$0	\$2,250	\$373,227	\$375,477	0.5306	\$199,241	\$0	\$12,000	\$357,546	\$369,547	0.5306	\$196,094
33	\$0	\$2,318	\$384,424	\$386,741	0.5202	\$201,194	\$0	\$12,360	\$368,273	\$380,633	0.5202	\$198,016
34	\$0	\$2,387	\$395,957	\$398,344	0.5100	\$203,166	\$0	\$12,731	\$379,321	\$392,052	0.5100	\$199,958
35	\$0	\$2,459	\$407,835	\$410,294	0.5000	\$205,158	\$0	\$13,113	\$390,701	\$403,814	0.5000	\$201,918
36	\$0	\$2,532	\$420,070	\$422,603	0.4902	\$207,170	\$0	\$13,507	\$402,422	\$415,928	0.4902	\$203,898
37	\$0	\$2,608	\$432,672	\$435,281	0.4806	\$209,201	\$0	\$13,912	\$414,494	\$428,406	0.4806	\$205,897
38	\$0	\$2,687	\$445,653	\$448,339	0.4712	\$211,252	\$0	\$14,329	\$426,929	\$441,258	0.4712	\$207,915
39	\$0	\$2,767	\$459,022	\$461,789	0.4619	\$213,323	\$0	\$14,759	\$439,737	\$454,496	0.4619	\$209,954
40	\$0	\$2,850	\$472,793	\$475,643	0.4529	\$215,414	\$1,599,349	\$0	\$452,929	\$2,052,278	0.4529	\$929,457
41	\$0	\$2,936	\$486,977	\$489,912	0.4440	\$217,526	\$0	\$15,658	\$466,517	\$482,175	0.4440	\$214,091
42	\$0	\$3,024	\$501,586	\$504,610	0.4353	\$219,659	\$0	\$16,128	\$480,513	\$496,640	0.4353	\$216,189
43	\$0	\$3,115	\$516,633	\$519,748	0.4268	\$221,812	\$0	\$16,611	\$494,928	\$511,539	0.4268	\$218,309
44	\$0	\$3,208	\$532,132	\$535,341	0.4184	\$223,987	\$0	\$17,110	\$509,776	\$526,885	0.4184	\$220,449
45	\$0	\$3,304	\$548,096	\$551,401	0.4102	\$226,183	\$0	\$17,623	\$525,069	\$542,692	0.4102	\$222,611
46	\$0	\$3,403	\$564,539	\$567,943	0.4022	\$228,400	\$0	\$18,152	\$540,821	\$558,973	0.4022	\$224,793
47	\$0	\$3,506	\$581,475	\$584,981	0.3943	\$230,640	\$0	\$18,696	\$557,046	\$575,742	0.3943	\$226,997
48	\$0	\$3,611	\$598,920	\$602,530	0.3865	\$232,901	\$0	\$19,257	\$573,757	\$593,014	0.3865	\$229,222
49	\$0	\$3,719	\$616,887	\$620,606	0.3790	\$235,184	\$0	\$19,835	\$590,970	\$610,805	0.3790	\$231,470
50	\$2,340,921	\$0	\$635,394	\$2,976,315	0.3715	\$1,105,784	\$0	\$20,430	\$608,699	\$629,129	0.3715	\$233,739
TOTAL						\$11,541,501						\$10,516,151

Mathematically, the case with the lowest present value is the preferred alternative.

Assumptions:

1. Energy cost escalation based upon 3.00% per year.
2. Maintenance cost escalation based upon 3.00% per year.
3. At the end of each system's life, assume salvage value is zero.
4. Present value factors based upon interest rate of 2.00 percent per year.

Leddy Park Ice Rink
 Simple Economic Analysis for Ice Plant
 LN Consulting, Inc.
 8/6/10, Revision 1

Capital Costs:

Option 7A - New Screw Chiller Ice Plant with DHW heat recovery	
Chiller material	\$325,000
Chiller mechanical labor	\$100,000
Chiller electrical labor	\$40,000
Chiller DDC controls	\$40,000
DHW Heat Recovery	\$20,000
Total	\$525,000

Option 7B - New Screw Chiller Ice Plant with vent. heat recovery	
Chiller material	\$325,000
Chiller mechanical labor	\$100,000
Chiller electrical labor	\$40,000
Chiller DDC controls	\$40,000
Ventilation Heat Recovery	\$55,000
Total	\$660,000

Annual Net Cash Flows:

A Year	Option 7A - New Screw Chiller Ice Plant with DHW heat recovery						Option 7B - New Screw Chiller Ice Plant with vent. heat recovery					
	B Capital Costs	C Maintenance Costs	D Energy Cost	E Net Cash Flow (B+C+D)	F Present Value Factor	G Present Value (Worth)	H Capital Costs	I Maintenance Costs	J Energy Cost	K Net Cash Flow (H+I+J)	L Present Value Factor	M Present Value (Worth)
0	\$525,000	\$0	\$0	\$525,000	1.0000	\$525,000	\$660,000	\$0	\$0	\$660,000	1.0000	\$660,000
1	\$0	\$4,800	\$136,706	\$141,506	0.9804	\$138,731	\$0	\$4,800	\$139,097	\$143,897	0.9804	\$141,075
2	\$0	\$4,944	\$140,807	\$145,751	0.9612	\$140,091	\$0	\$4,944	\$143,270	\$148,214	0.9612	\$142,459
3	\$0	\$5,092	\$145,031	\$150,124	0.9423	\$141,465	\$0	\$5,092	\$147,568	\$152,660	0.9423	\$143,855
4	\$0	\$5,245	\$149,382	\$154,627	0.9238	\$142,852	\$0	\$5,245	\$151,995	\$157,240	0.9238	\$145,266
5	\$0	\$5,402	\$153,864	\$159,266	0.9057	\$144,252	\$0	\$5,402	\$156,555	\$161,957	0.9057	\$146,690
6	\$0	\$5,565	\$158,480	\$164,044	0.8880	\$145,667	\$0	\$5,565	\$161,252	\$166,816	0.8880	\$148,128
7	\$0	\$5,731	\$163,234	\$168,966	0.8706	\$147,095	\$0	\$5,731	\$166,089	\$171,821	0.8706	\$149,580
8	\$0	\$5,903	\$168,131	\$174,035	0.8535	\$148,537	\$0	\$5,903	\$171,072	\$176,975	0.8535	\$151,047
9	\$0	\$6,080	\$173,175	\$179,256	0.8368	\$149,993	\$0	\$6,080	\$176,204	\$182,284	0.8368	\$152,527
10	\$0	\$6,263	\$178,370	\$184,633	0.8203	\$151,464	\$0	\$6,263	\$181,490	\$187,753	0.8203	\$154,023
11	\$0	\$6,451	\$183,721	\$190,172	0.8043	\$152,948	\$0	\$6,451	\$186,935	\$193,386	0.8043	\$155,533
12	\$0	\$6,644	\$189,233	\$195,877	0.7885	\$154,448	\$0	\$6,644	\$192,543	\$199,187	0.7885	\$157,058
13	\$0	\$6,844	\$194,910	\$201,754	0.7730	\$155,962	\$0	\$6,844	\$198,319	\$205,163	0.7730	\$158,597
14	\$0	\$7,049	\$200,757	\$207,806	0.7579	\$157,491	\$0	\$7,049	\$204,269	\$211,318	0.7579	\$160,152
15	\$0	\$7,260	\$206,780	\$214,041	0.7430	\$159,035	\$0	\$7,260	\$210,397	\$217,657	0.7430	\$161,722
16	\$0	\$7,478	\$212,983	\$220,462	0.7284	\$160,594	\$0	\$7,478	\$216,709	\$224,187	0.7284	\$163,308
17	\$0	\$7,703	\$219,373	\$227,076	0.7142	\$162,169	\$0	\$7,703	\$223,210	\$230,912	0.7142	\$164,909
18	\$0	\$7,934	\$225,954	\$233,888	0.7002	\$163,759	\$0	\$7,934	\$229,906	\$237,840	0.7002	\$166,526
19	\$0	\$8,172	\$232,733	\$240,904	0.6864	\$165,364	\$0	\$8,172	\$236,803	\$244,975	0.6864	\$168,158
20	\$0	\$8,417	\$239,715	\$248,132	0.6730	\$166,985	\$0	\$8,417	\$243,907	\$252,324	0.6730	\$169,807
21	\$0	\$8,669	\$246,906	\$255,576	0.6598	\$168,623	\$0	\$8,669	\$251,225	\$259,894	0.6598	\$171,472
22	\$0	\$8,929	\$254,313	\$263,243	0.6468	\$170,276	\$0	\$8,929	\$258,761	\$267,691	0.6468	\$173,153
23	\$0	\$9,197	\$261,943	\$271,140	0.6342	\$171,945	\$0	\$9,197	\$266,524	\$275,722	0.6342	\$174,850
24	\$0	\$9,473	\$269,801	\$279,274	0.6217	\$173,631	\$0	\$9,473	\$274,520	\$283,993	0.6217	\$176,565
25	\$0	\$9,757	\$277,895	\$287,653	0.6095	\$175,333	\$0	\$9,757	\$282,756	\$292,513	0.6095	\$178,296
26	\$0	\$10,050	\$286,232	\$296,282	0.5976	\$177,052	\$0	\$10,050	\$291,238	\$301,288	0.5976	\$180,044
27	\$0	\$10,352	\$294,819	\$305,171	0.5859	\$178,788	\$0	\$10,352	\$299,975	\$310,327	0.5859	\$181,809
28	\$0	\$10,662	\$303,664	\$314,326	0.5744	\$180,541	\$0	\$10,662	\$308,975	\$319,637	0.5744	\$183,591
29	\$0	\$10,982	\$312,773	\$323,755	0.5631	\$182,311	\$0	\$10,982	\$318,244	\$329,226	0.5631	\$185,391
30	\$0	\$11,312	\$322,157	\$333,468	0.5521	\$184,098	\$0	\$11,312	\$327,791	\$339,103	0.5521	\$187,209
31	\$0	\$11,651	\$331,821	\$343,472	0.5412	\$185,903	\$0	\$11,651	\$337,625	\$349,276	0.5412	\$189,044
32	\$0	\$12,000	\$341,776	\$353,776	0.5306	\$187,726	\$0	\$12,000	\$347,754	\$359,754	0.5306	\$190,897
33	\$0	\$12,360	\$352,029	\$364,390	0.5202	\$189,566	\$0	\$12,360	\$358,186	\$370,547	0.5202	\$192,769
34	\$0	\$12,731	\$362,590	\$375,321	0.5100	\$191,424	\$0	\$12,731	\$368,932	\$381,663	0.5100	\$194,659
35	\$0	\$13,113	\$373,468	\$386,581	0.5000	\$193,301	\$0	\$13,113	\$380,000	\$393,113	0.5000	\$196,567
36	\$0	\$13,507	\$384,672	\$398,178	0.4902	\$195,196	\$0	\$13,507	\$391,400	\$404,906	0.4902	\$198,494
37	\$0	\$13,912	\$396,212	\$410,124	0.4806	\$197,110	\$0	\$13,912	\$403,142	\$417,054	0.4806	\$200,440
38	\$0	\$14,329	\$408,098	\$422,427	0.4712	\$199,042	\$0	\$14,329	\$415,236	\$429,565	0.4712	\$202,406
39	\$0	\$14,759	\$420,341	\$435,100	0.4619	\$200,994	\$0	\$14,759	\$427,693	\$442,452	0.4619	\$204,390
40	\$1,662,689	\$0	\$432,952	\$2,095,641	0.4529	\$949,096	\$1,773,535	\$0	\$440,524	\$2,214,059	0.4529	\$1,002,726
41	\$0	\$15,658	\$445,940	\$461,598	0.4440	\$204,954	\$0	\$15,658	\$453,740	\$469,397	0.4440	\$208,417
42	\$0	\$16,128	\$459,318	\$475,446	0.4353	\$206,964	\$0	\$16,128	\$467,352	\$483,479	0.4353	\$210,461
43	\$0	\$16,611	\$473,098	\$489,709	0.4268	\$208,993	\$0	\$16,611	\$481,372	\$497,984	0.4268	\$212,524
44	\$0	\$17,110	\$487,291	\$504,401	0.4184	\$211,042	\$0	\$17,110	\$495,814	\$512,923	0.4184	\$214,607
45	\$0	\$17,623	\$501,910	\$519,533	0.4102	\$213,111	\$0	\$17,623	\$510,688	\$528,311	0.4102	\$216,711
46	\$0	\$18,152	\$516,967	\$535,119	0.4022	\$215,200	\$0	\$18,152	\$526,009	\$544,160	0.4022	\$218,836
47	\$0	\$18,696	\$532,476	\$551,172	0.3943	\$217,310	\$0	\$18,696	\$541,789	\$560,485	0.3943	\$220,982
48	\$0	\$19,257	\$548,450	\$567,707	0.3865	\$219,440	\$0	\$19,257	\$558,043	\$577,300	0.3865	\$223,148
49	\$0	\$19,835	\$564,904	\$584,738	0.3790	\$221,592	\$0	\$19,835	\$574,784	\$594,619	0.3790	\$225,336
50	\$0	\$20,430	\$581,851	\$602,281	0.3715	\$223,764	\$0	\$20,430	\$592,027	\$612,457	0.3715	\$227,545
TOTAL						\$10,168,226						\$10,403,760

Mathematically, the case with the lowest present value is the preferred alternative.

Assumptions:

1. Energy cost escalation based upon 3.00% per year.
2. Maintenance cost escalation based upon 3.00% per year.
3. At the end of each system's life, assume salvage value is zero.
4. Present value factors based upon interest rate of 2.00 percent per year.

