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LEVEL II ENERGY SURVEY AND ENGINEERING ANALYSIS
NOVI ICE ARENA
42400 ARENA DRIVE
NOVI, MICHIGAN 48375

for

CITY OF NOVI
45175 WEST TEN MILE ROAD
NOVI, MICHIGAN 48375

AKT PEERLESS PROJECT NO. 6341E
MONDAY, DECEMBER 14, 2009

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1.0 INTRODUCTION

The city of Novi retained AKT Peerless Environmental and Energy Services (AKT Peerless) to conduct a Level II Energy Survey and Engineering Analysis in order to prepare a Level II Energy Survey and Engineering Analysis Report of the building and associated property located at 42100 Arena Drive in Novi, Michigan. AKT Peerless' scope of work and methodology is based on its proposal PF-10031, dated Aug 6, 2009, and the terms and conditions of the agreement.

AKT Peerless' scope of work for this Level II Energy Survey and Engineering Analysis is based on American Society of Heating, Refrigeration and Air-Conditioning Engineers' (ASHRAE's) *Procedures for Commercial Building Energy Audits* and Sections 5, 6, and 7 of ASHRAE's *Standard 105, Standard Methods of Measuring, Expressing and Comparing Building Energy Performance.* Though water use is not considered in the ASHRAE methods, a summary of water use is included in this report.

AKT Peerless' Level II Energy Survey and Engineering Analysis was performed for the benefit of the city of Novi, which may rely on the contents and conclusions presented in this report.

1.1 PURPOSE AND SCOPE

The purpose of this report is to assist the Client in evaluating the property's current energy and cost efficiency relative to other, similar properties, and to identify and provide in depth analysis of the costs and savings potential of both low-cost/no-cost energy conservation measures as well as energy conservation capital improvements.

For this Level II Energy Survey and Engineering Analysis, property characteristics data was obtained from both the owner/operator of the subject property and from on-site observations and measurements. All energy analysis was conducted in accordance with ASHRAE Procedures for Commercial Building Energy Audits and ASHRAE Standard 105.

Utility bills for a one year period were summarized and reviewed for opportunities to obtain a better price through taking advantage of different utility rate classes. Monthly patterns were reviewed for irregularities. Irregularities are discussed and possible causes are proposed. Missing bills have been noted. It has also been noted if a bill reflects estimated energy consumption as opposed to actual energy consumption.

Energy and cost indices for each fuel or demand type, and their combined total, have been developed using methods specified in Sections 5, 6, and 7 of ASHRAE Standard 105. The Energy Utilization Index (EUI) and cost index are compared with the EUI of buildings having similar characteristics as reported by the Energy Information Administration (EIA) of the United States Department of Energy.

Target energy, demand, and cost indices have been derived for the subject building from either the review of data gathered by the EIA or from the experience and judgment of the Energy Analyst. The method used for generating the target EUI is discussed in the relevant narrative sections of the report. Energy and energy cost savings have been calculated for each fuel type if the subject property were to reach the target energy indices.

A walk-through survey of the subject building has been conducted by the energy analyst in order to become familiar with its construction, equipment, operation, and maintenance. Mechanical and electrical system design, installed condition, maintenance practices, and operating methods have been reviewed. Key operating parameters have been measured and compared to design levels. Where the energy analyst considers discrepancies between design conditions and actual operating conditions to be noteworthy, they have been discussed in the relevant narrative section of the report.

Energy conservation opportunities and preliminary costs and savings were identified, and those that were most likely to be of interest were reviewed with the subject property owner/operator. Energy conservation opportunities were then selected for further analysis and prioritized in anticipated order of implementation. The criteria used for prioritizing energy conservation opportunities are discussed in the relevant narrative sections of this report. Potential costs and savings were evaluated for each energy conservation opportunity. In order to account for interactions between energy conservation opportunities the energy analyst has assumed that modifications with the highest operational priority and/or the best return on investment will be implemented first.

The description of each selected energy conservation opportunity also includes a discussion of the existing conditions in the subject building and why they are causing excessive energy use, an outline of each proposed measure's impact on occupant health, comfort, and safety, and a discussion of each measures impact on occupant service capabilities, such as ventilation for late occupancy or year round cooling. Additionally, discussion of each energy conservation opportunity is accompanied by an estimation of each measures anticipated impact on building operations, maintenance costs, and non-energy operating costs, a description of any repairs that are required in order for a measure to be effective, an estimation of the expected life of the new equipment and the impact on the life of the existing equipment, and an outline of new skills that will be required for current and future operating staff.

For each practical measure, a financial evaluation of the energy conservation opportunity's investment potential has been prepared using the owner's/operator's chosen techniques and criteria. An economic evaluation has also been performed for the overall project. A discussion of any differences between the savings projected in this analysis and the estimated potential derived in the Level I analysis is also included, along with recommended measurement and verification methods that will be required in order to determine the actual effectiveness of the recommended measures.

Using this analysis energy conservation opportunities have been identified and it has been determined if further engineering analysis is recommended. All findings relating to this analysis are included in the relevant narrative sections of this Report.

1.2 USER PROVIDED INFORMATION AND DEVIATIONS FROM GUIDE

ASHRAE *Procedures for Commercial Building Energy Audits* recommends that the Energy Analyst apply a consistent definition of building square footage to both the subject building and to similar buildings used for energy performance comparisons. AKT Peerless cannot evaluate the accuracy or consistency of building square footage measurements of similar buildings included in the comparison database. However, in order to improve the consistency and accuracy of building measurements and comparisons within the client's own building portfolio, a procedure for measuring the subject building square footage has been incorporated into the Basic Buildings Characteristics form provided to the client and located in Appendix A.

For this Level II Energy Survey and Engineering Analysis report the Energy Analyst has not verified the accuracy of building floor area as reported by the building owner/operator and has not verified that the building owner/operator's definition of building usage is consistent with the definitions used in the CBECS. Also, the energy analyst has not verified that the property owner/operator has reported all sources and records of energy consumed at the subject property. Potentially unreported information may include, but is not limited to, bills, meters, and types of energy consumed. Inaccurate information provided to the energy analyst and information not reported to the energy analyst may influence the findings of this Level II Energy Survey and Engineering Analysis report. Information provided by the owner/operator of the subject building or other client representatives is summarized in the Basic Building Characteristics form located in Appendix A and the utility bills and other energy invoices are included in Appendix E.

1.3 ADDITIONAL SCOPE CONSIDERATIONS

Items required by ASHRAE *Standard 105* and recommended by ASHRAE *Procedures for Commercial Building Energy Audits* are included within the Level II Energy Survey and Engineering Analysis. Additional "non-scope" considerations were addressed as part of AKT Peerless' Level II Energy Survey and Engineering Analysis. These additional items are identified as follows:

1. A summary of greenhouse gas emissions related to building energy use has been included in this report (For calculation factors see ASHRAE *Standard 105, Additional Expressions of Energy Performance* included in Appendix C).

2.0 PERSONNEL INTERVIEWED

The following personnel from the facility were interviewed in the process of conducting the Level II Energy Survey and Engineering Analysis.

Table 1
Personnel Interviewed

Name and Title	Organization	Phone Number	Years Associated With Property
Kris Barnes General Manager	City of Novi	(248) 347-1010	3

The Level II Energy Survey and Engineering Analysis was performed with the assistance and cooperation of the above referenced property contact. The Basic Building Characteristics request form, included in Appendix A, was completed with information provided during interviews with the property contact.

3.0 PROPERTY DESCRIPTION

This section summarizes physical characteristics and general use of the subject property.

3.1 LOCATION

The subject property is located at 42400 Arena Drive in Novi, Michigan. Novi, Michigan is located in ASHRAE Climate Zone 5A.

3.2 PROPERTY CHARACTERISTICS

The subject property Primary Building Type is public assembly. General information pertaining to the subject building is summarized in the following table.

Table 2
Property Characteristics

Primary Building Type/ Occupancy	Region	Approximate Total Square Footage	Date of Construction
Public Assembly	East North Central	62,399	1998

The original date of construction is 1998. The gross floor area is 62,399 square feet. The total conditioned area is 62,399 square feet. The conditioned area with heating only is 0 square feet and the conditioned area with cooling only is 0 square feet. The conditioned area that is both heated and cooled is 62,399 square feet. There are 2 conditioned floors above grade and no conditioned floors below grade.

The subject building has also been assigned a Building ID, 66, which will be used to reference the subject building during energy performance comparison to buildings within the same portfolio. Property characteristics have been entered into the Basic Building Characteristics form included in Appendix A.

3.3 BUILDING ENVELOPE

This section describes basic characterisitics of the subject building envelope and construction.

3.3.1 WALLS AND WALL INSULATION

The above-grade building walls are constructed from concrete masonry units. The exterior wall height is approximately 20 feet and the wall perimeter is approximately 1,010 feet. The wall insulation could not be directly observed. However, the walls are assumed to be insulated with 2 inches of extruded polystyrene, with an insualtion value of R-14.

3.3.2 ROOF AND ROOF INSULATION

The roof type is standing-seam steel. The roof insulation could not be directly observed. However, the roof is assumed to be insulated with 2 inches of extruded polystyrene, with an insualtion value of R-14. The roof also has a reflective radiant barrier on the interior. The roof exterior is light green.

3.3.3 FENESTRATION AND DOORS

Information regarding fenestration and doors was obtained from the client and on-site observations. The building is equipped with dual-pane windows and doors. The window and door frames are metal. The surface area of the vertical windows and door openings is approximately 5% of the gross wall area.

3.4 HEATING, VENTILATING, AND AIR CONDITIONING

The subject building is equipped with multiple mechanical systems for heating, ventilating, and air conditioning. There are three chillers, one of which is used for air conditioning in the summer. There are two rooftop furnaces, one rooftop makeup air handler, and a rooftop dehumidifier.

3.5 LIGHTING

The lighting system is primarily 250 watt metal halide fixtures, in the process of being replaced with T-8 flourescent fixtures. All lighting throughout the building is being retrofitted.

4.0 UTILITIES

This section provides information on energy delivery to the subject property.

4.1 ELECTRICITY

The electricity provider is DTE Energy. There is 1 electric meter. Electricity consumption is measured in kilowatt hours (kWh) and demand is measured in kilowatts (kW).

4.2 NATURAL GAS

The natural gas provider is Consumers Energy. There is 1 gas meter. Natural gas consumption is measured in therms.

4.3 OIL/FUEL OIL/DIESEL/COAL/PROPANE

Equipment requiring these fuel types is not used on the subject property.

4.4 PURCHASED STEAM/HOT WATER/CHILLED WATER

These sources of energy are not purchased for use on the subject property.

4.5 ON-SITE RENEWABLE ENERGY GENERATION

No renewable energy systems are present on the subject property.

5.0 CALCULATION OF ENERGY USE INDICES AND COST INDICES

The data measurement period for all energy analysis extends from December 2008 through November 2009.

Target energy consumption indices for each energy source have been developed by averaging energy performance of similar buildings evaluated by the CBECS. Explanations of data filters applied to CBECS data are included in the Comparison of Energy Performance form located in Appendix D.

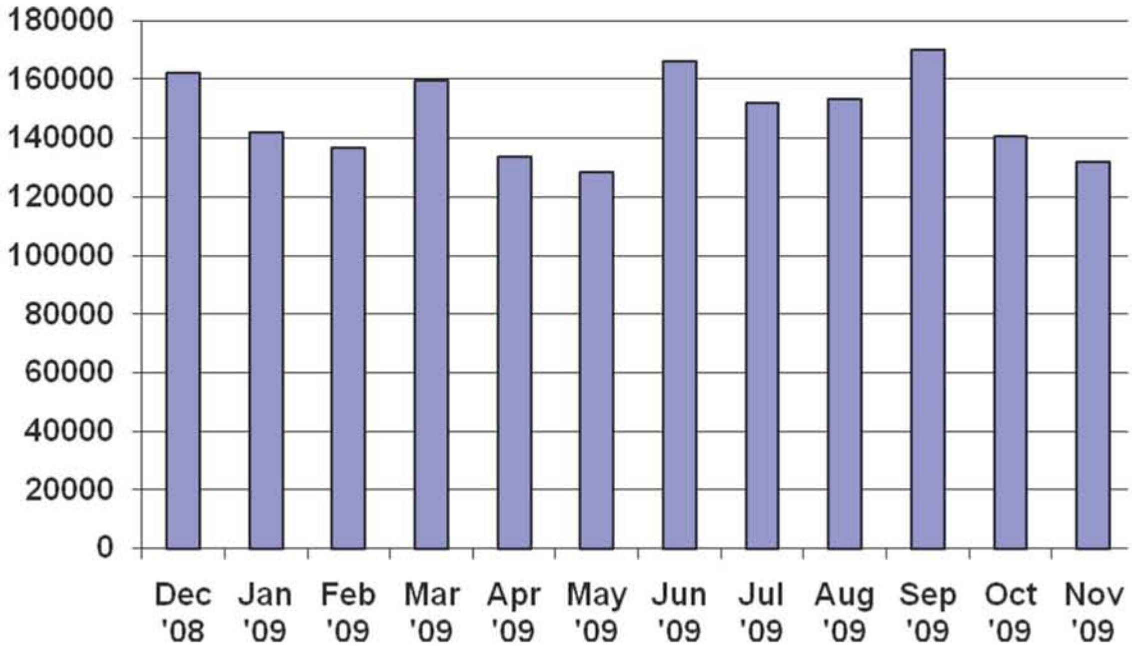
5.1 ELECTRICITY

For the time period covered by records provided, historic electricity use is summarized in the table included below.

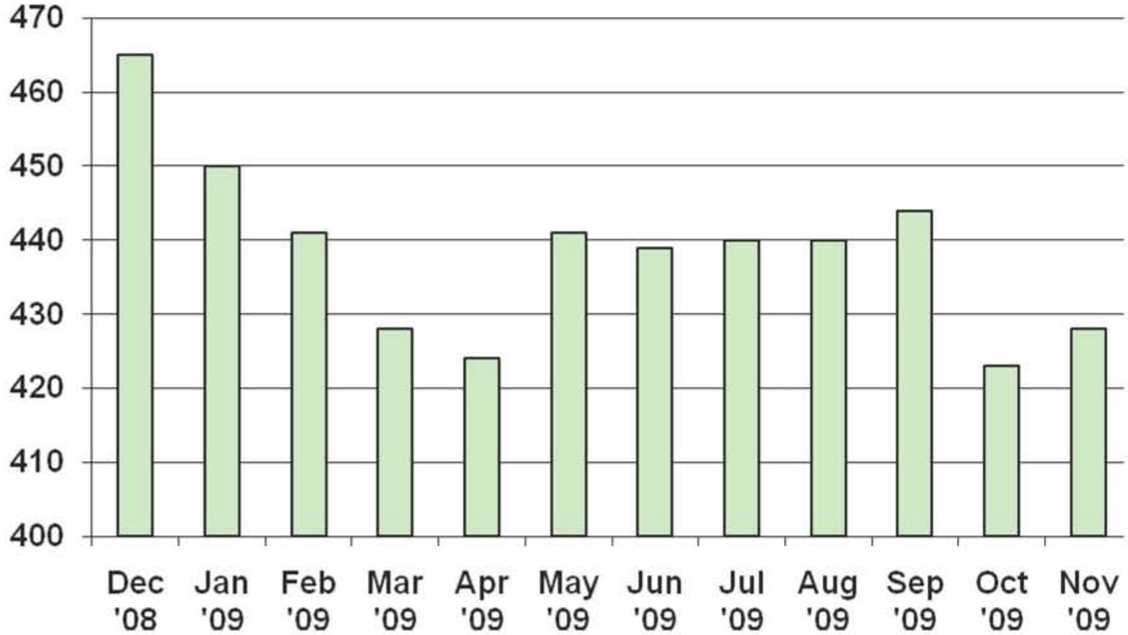
Table 3
Electricity Consumption Records

Account Number:	Date Start	Date End	Consumption	Estimate	Measured Demand	Consumption $	Demand $	Total $
0001-1471-0	12/1/2008	1/1/2009	162,190	☐	465	$9,127.21	$6,393.75	$15,520.96
0001-1471-0	1/1/2009	2/1/2009	141,960	☐	450	$7,988.77	$6,187.50	$14,176.27
0001-1471-0	2/1/2009	3/1/2009	136,710	☐	441	$7,693.33	$6,063.75	$13,757.08
0001-1471-0	3/1/2009	4/1/2009	159,530	☐	428	$8,977.52	$5,885.00	$14,862.52
0001-1471-0	4/1/2009	5/1/2009	133,630	☐	424	$7,520.00	$5,830.00	$13,350.00
0001-1471-0	5/1/2009	6/1/2009	128,240	☐	441	$7,216.68	$6,063.75	$13,280.43
0001-1471-0	6/1/2009	7/1/2009	166,110	☐	439	$9,347.80	$6,036.25	$15,384.05
0001-1471-0	11/1/2009	12/1/2009	131,950	☐	428	$7,425.46	$5,885.00	$13,310.46
0001-1471-0	7/1/2009	8/1/2009	152,040	☐	440	$8,556.02	$6,050.00	$14,606.02
0001-1471-0	8/1/2009	9/1/2009	153,440	☐	440	$8,634.80	$6,050.00	$14,684.80
0001-1471-0	9/1/2009	10/1/2009	170,170	☐	444	$9,576.28	$6,105.00	$15,681.28
0001-1471-0	10/1/2009	11/1/2009	140,840	☐	423	$7,925.74	$5,816.25	$13,741.99

Monthly Electricity Consumption (kWh), December 2008 - November 2009, Building ID 66



Monthly Electricity Demand (kW), December 2008 - November 2009, Building ID 66



No bills are missing. Electricity usage follows anticipated patterns. There are abnormalities in monthly electricity usage patterns. Electricity usage does not follow anticipated seasonal trends. Further engineering analysis is required to perform a proper diagnosis of irregular building electrical consumption. Additional information regarding annual electricity cost, consumption, and demand is summarized in the following table.

Table 4
Electricity Consumption Indices and Cost

Annual Electrical Consumption (kWh)	Average Monthly Demand (kW)	Average Cost/kWh ($)	Average Cost/kW ($)	Total Annual Electricity Cost ($)	kWh/Square Foot
1,935,927	438.58	$0.06	$13.75	$187,791	31.02

Total annual electrical consumption is 1,935,927 kWh. Average monthly demand is 438.58 kW. The average demand cost per kW on an annual basis is 13.75. Average cost per kWh on an annual basis is $0.06. Total annual electricity cost is $187,790.

The subject building consumes 31.02 kWh per square foot per year (square footage measurement excludes parking lot and other illuminated exterior spaces). The target use index, based on expected average performance as indicated by the CBECS, is 10.23 kWh per square foot per year.

The electric cost index per square foot per year is $3.01. The target cost index is $0.58 per square foot per year. $73,017 in annual savings is possible from meeting the target use index. Additional analysis would be required to determine the feasibility of this facility achieving target energy performance.

An additional survey (with monitoring) would be necessary to obtain sufficient information to evaluate the feasibility of achieving a more favorable rate class.

Note on Electrical Demand and Pricing

The two major components of an electric utility bill for most commercial buildings (on a demand based rate) are an electricity consumption charge and an electricity demand charge. Electricity consumption is measured in kilowatt-hours (kWh) and electricity demand is measured in kilowatts (kW). Consumption and demand refer to distinct aspects of a building's energy profile, but both represent a substantial portion of a building's electric utility charges.

Electricity consumption, measured in kWh, is a measurement of the actual amount of energy a facility consumes over the course of an entire billing period. A kilowatt-hour equals one thousand watt-hours. A watt-hour is the total energy consumed by using energy at the rate of one watt for a period of one hour. If energy is consumed at a rate of one thousand watts for one hour, total consumption is one kWh. If energy is consumed at a rate of one thousand watts for two hours, total consumption is two kWh. kWh consumption is increased by inefficient equipment, which consumes energy at a faster rate than efficient equipment, and it is also increased by operating equipment for longer periods of time than is necessary.

Electricity demand, measured in kW, is a measurement of a facility's maximum rate of electricity consumption. Demand measurements are used by the utility company in order to properly size the equipment associated with a facility's connection to the electric grid. For example, a facility with higher electric demand will require a larger transformer. A facility's demand is primarily influenced by equipment inefficiencies and operating practices that allow large amounts of equipment to run simultaneously. If multiple pieces of inefficient equipment are running simultaneously, demand is increased. Demand can be decreased by either increasing equipment efficiency, or by scheduling equipment operation to minimize simultaneous operation.

Demand charges can be based on the previous month's usage or the previous year's peak fifteen minutes of consumption. For example, the Novi ice arena bill of August 28, 2009 through September 28, 2009 shows a demand charge of $7,067.55 out of a total bill of $15,682.28. In this case, the demand charge accounts for 45% of the bill. In general, all of the energy conservation measures that lower energy consumption also help to reduce peak demand. More specifically, the proposed measures for the automated ice plant management system and for a dedicated smaller chiller for summertime air conditioning of the building aim to reduce the demand charge by reducing the peak demand price set point.

Based on a review of recent electric utility bills, the City of Novi is paying a demand charge of $13.75 per kW. Total monthly demand charges are as high as $6,393.75. Substantial savings opportunities are most likely available from implementing improved demand management strategies.

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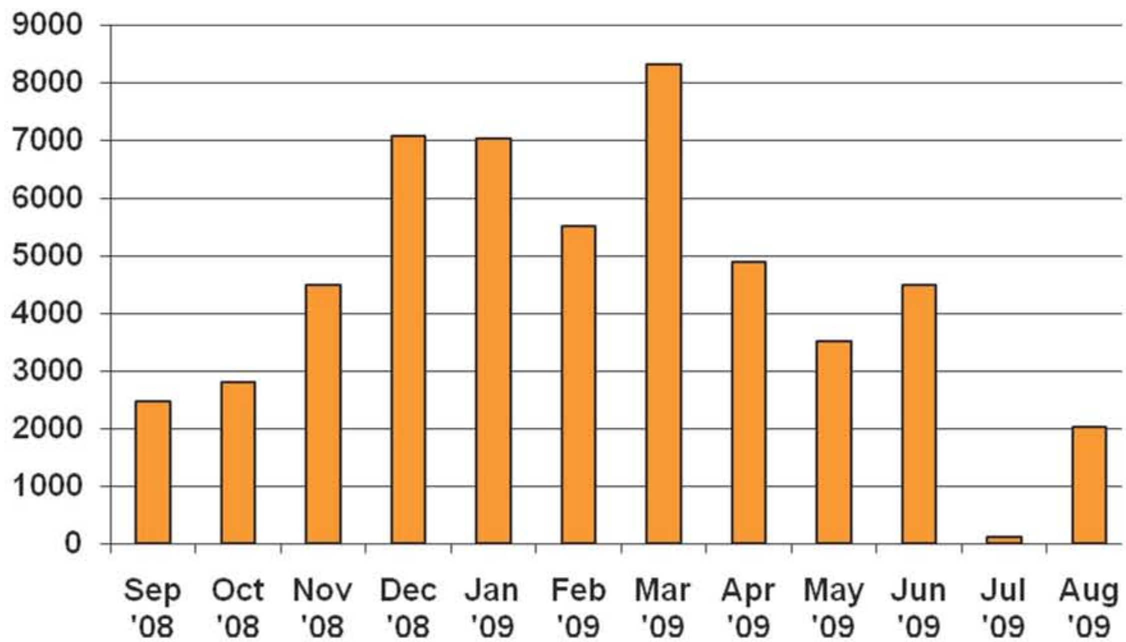
5.2 NATURAL GAS

For the time period covered by records provided, historic natural gas use is summarized in the table included below.

Table 5
Natural Gas Consumption Records

Account Number:	Date Start	Date End	Consumption	Estimate	Consumption $	Demand $	Total $
100000199479	8/1/2009	9/1/2009	2,027	☐	$2,051.13	$0.00	$2,051.13
100000199479	7/1/2009	8/1/2009	116	☐	$117.38	$0.00	$117.38
100000199479	6/1/2009	7/1/2009	4,504	☐	$4,557.62	$0.00	$4,557.62
100000199479	5/1/2009	6/1/2009	3,513	☐	$3,554.82	$0.00	$3,554.82
100000199479	4/1/2009	5/1/2009	4,889	☐	$4,947.20	$0.00	$4,947.20
100000199479	3/1/2009	4/1/2009	8,326	☐	$8,425.12	$0.00	$8,425.12
100000199479	2/1/2009	3/1/2009	5,511	☐	$5,576.60	$0.00	$5,576.60
100000199479	1/1/2009	2/1/2009	7,022	☐	$7,105.59	$0.00	$7,105.59
100000199479	12/1/2008	1/1/2009	7,075	☐	$7,159.22	$0.00	$7,159.22
100000199479	11/1/2008	12/1/2008	4,496	☐	$4,549.52	$0.00	$4,549.52
100000199479	10/1/2008	11/1/2008	2,813	☐	$2,846.49	$0.00	$2,846.49
100000199479	9/1/2008	10/1/2008	2,471	☐	$2,500.42	$0.00	$2,500.42

Monthly Natural Gas Consumption (Therms), September 2008 - August 2009, Building ID 66



No bills are missing. Therm usage follows anticipated monthly patterns and no abnormalities were observed. Additional information regarding annual natural gas cost and consumption is summarized in the following table.

Table 6
Natural Gas Consumption Indices and Cost

Annual Natural Gas Consumption (Therms)	Average Cost/Therm ($)	Total Annual Natural Gas Cost ($)	Therms/Square Foot
57,660	$1.012	$58,347	0.92

Total natural gas consumption is 57,660 therms. Average cost per therm on an annual basis is $1.01. Total annual natural gas cost is $58,346.

The subject building consumes 0.92 therms per square foot per year (square footage measurement excludes parking lot and other illuminated exterior spaces). The target use index, based on expected average performance as indicated by the CBECS, is 0.90 therms per square foot per year.

The natural gas cost index per square foot per year is $0.94. The target cost index is $0.91 per square foot per year. $1,439 in annual savings is possible from meeting the target use index. Additional analysis would be required to determine the feasibility of this facility achieving target energy performance.

AKT Peerless was not provided sufficient information to evaluate the feasibility of achieving a more favorable rate class.

5.3 OIL/FUEL OIL/DIESEL/COAL/PROPANE

Equipment requiring these fuel types is not used on the subject property.

5.4 PURCHASED STEAM/HOT WATER/CHILLED WATER

These sources of energy are not purchased for use on the subject property.

6.0 CALCULATION OF CARBON EMISSION EQUIVALENCIES FROM BUILDING ENERGY USE

Based on data gathered from the United States Environmental Protection Agency (USEPA) eGRID database, the subject building is located in eGRID electric utility subregion RFCM. This grid's conversion factor is 0.74. The annual electric use is 1,935,927 kWh. The subject property's electrical consumption has resulted in greenhouse gas emissions equivalent to 1,441.38 metric tonnes of carbon dioxide. Greenhouse gas emissions from electrical consumption are based on emissions data measured at the electrical generating facilities serving consumers located in the specified eGRID utility subregion, and therefore greenhouse gas emissions reflect the mix of fuel sources used by the regional electrical utilities serving the subject property.

Natural gas consumption by the subject building has resulted in greenhouse gas emissions equivalent to 306.18 metric tonnes of carbon dioxide. Emissions factors for natural gas consumption are based on data gathered from the 2009 United States Greenhouse Gas Inventory, Annex 2.

Total greenhouse house gas emissions from building energy use are equivalent to 1,747.56 metric tonnes of carbon dioxide.

7.0 ENERGY PERFORMANCE BENCHMARK

The subject property's EUI (expressed in units of kBtu/ft^2/yr) is compared to the Energy Performance Benchmarks of other buildings of similar characteristics. Benchmarks may be expressed as therms/ft^2/yr, kWh/ft^2/yr or kBtu/ft^2/yr (also called EUI). AKT Peerless obtains comparison EUIs (benchmarks) from the following sources:

- "Table C5. Consumption and Gross Energy Intensity by Census Region for Sum of Major Fuels for Non-Mall Buildings, 2003" prepared by the Energy Information Administration of the United States Department of Energy.
- A statistical analysis of the Commercial Building Energy Consumption Survey (CBECS) prepared by the Energy Information Administration of the United States Department of Energy.

Table C5 is a simple lookup table that is presented in Appendix F. The statistical analysis of the CBECS filters the database based on region, building use, size, and year of construction (refer to Appendix D). This filtered data set is used to calculate the benchmarks for each energy source, as well as an overall benchmark EUI. The benchmarks shown in the portfolio summary are derived from the statistical analysis described in this section.

Table 7
Energy Performance Benchmark

	Actual Building	Statistical Benchmarks	Table C5
kWh/ft^2/yr	31.02	10.23	
Therms/ft^2/yr	0.92	0.90	
EUI	189.92	125.03	101.7

8.0 ENERGY STAR RATING

Based on statistical models employed by the Energy Star program of the United States Department of Energy the subject building is estimated to receive an Energy Star score of 3. Only a limited number of building use types is available in Energy Star. The building use type used for this analysis is Refrigerated Warehouse. A building qualifying for Energy Star certification must have a minimum score of 75. Therefore, the subject property is not a candidate for Energy Star certification.

9.0 ENERGY MODELING

Hour-by-hour energy use in the subject building has been simulated with eQUEST energy modeling software. The eQUEST simulation engine is DOE-2, which is a set of energy simulation programs developed for the United States Department of Energy by the Lawrence Berkeley National Laboratory's Simulation Group.

DOE-2 calculates the hourly energy use and energy cost of a commercial or residential building given information about the building's climate, construction, operation, utility rate schedule, and HVAC equipment. Using the program, designers can determine the choice of building parameters that improve energy efficiency while maintaining thermal comfort and cost-effectiveness.

10.0 ENERGY CONSERVATION OPPORTUNITIES

AKT Peerless has identified 6 potential energy conservation measures (ECMs). ECMs have been prioritized according to return on investment, and it is assumed that ECMs with the greatest investment returns will be implemented first. Savings may be different if a different implementation sequence is followed.

10.1 ECM 1 – HVAC – COMPRESSOR HEAD REBUILD

Over time all compressors lose efficiency with normal wear. Like a car engine, these compressors greatly benefit from replacement of worn parts. This is a very cost effective way of lowering energy usage without having to replace an older compressor.

Implementation of this ECM is expected to reduce annual electrical consumption by 49,500 kWh. It is expected to cost $6,600 and provide an annual savings of $2,772. This ECM is recommended for implementation.

10.2 ECM 2 - HVAC – SUB-SLAB HEATING ENERGY RECOVERY

Maintaining ice sheets for extended periods of time can cause freezing of the sub-soil which can in turn cause damage to or destroy the concrete slab of the rink. A technique that pumps warm water through plastic tubing to heat the soil beneath the rink just enough to keep it from freezing has been developed. Of course, it is necessary to have an adequate layer of insulation between the heated sub-soil and the chilled concrete slab. Otherwise the ice plants, (chillers) assigned to freeze the ice sheet and the boilers, assigned to keep the ground from freezing would end up fighting each other. Traditionally this heat is created through the purchase of natural gas to fire boilers. However, the entire sub-slab heating requirement can be met by use of heat that is currently being rejected from the chillers. Recovering this “waste” heat off of the compressor can result in a typical energy savings of 35,000 Kwh per year.

Implementation of this ECM is expected to reduce annual electrical consumption by 35,000 kWh. It is expected to cost $14,200 and provide an annual savings of $1,960. This ECM is recommended for implementation.

10.3 ECM 3 – HOT WATER SYSTEMS OFF COMPRESSOR WASTE RECOVERY

Domestic hot water for showers and hand-washing and water used by the ice resurfacers requires a higher temperature. The super-heated refrigeration gas at the outlet of the chiller's compressor offers an excellent source of heat for domestic hot water needs. Since there is a wide variation of daily demand, this energy recovery measure requires storage tanks to hold the hot water until needed.

Implementation of this ECM is expected to reduce annual electrical consumption by 26,000 kWh. It is expected to cost $17,500 and provide an annual savings of $1,456. This ECM is recommended for implementation.

10.4 ECM 4 – INSTALL SMALL CHILLER DEDICATED TO AC INSTEAD OF USING ICE PLANT CHILLERS

In order to operate at peak efficiency, equipment must always be properly sized for the load. At the Ice Arena, one compressor is typically in service at any time for each ice sheet. The third compressor, which is redundant, is used most often for air conditioning in the summer. When this happens, the third compressor is used to supply chilled water to the air conditioning system. Because this compressor is sized for cooling ice rinks, it is unnecessarily large to meet the demands of the buildings air conditioning load. Each compressor draws approximately 0.75 kilowatts of power. A properly sized compressor for air conditioning needs would be between 40-50 horsepower. Therefore, installing an additional compressor designated for air conditioning would save 450 kWh over the course of 12 operating hours.

Implementation of this ECM is expected to reduce annual electrical consumption by 64,824 kWh. It is expected to cost $43,600 and provide an annual savings of $3,630. This ECM is recommended for implementation.

10.5 ECM 5 – CORRECT UNDERSIZED HEAT EXCHANGE PIPE IN ICE MELTING PIT

These compressors are equipped with a Hench Control which allows the head pressure to float in response to varying loads. Lowering the head pressure adds capacity and reduces the compressor's power draw. The small pipe diameter and the unnecessary back pressure regulating valve in the current system nullifies this capability.

In addition, the current piping is carbon steel. The replacement piping should be stainless steel.

Implementation of this ECM is expected to reduce annual electrical consumption by 100,000 kWh. It is expected to cost $8,720 and provide an annual savings of $5,600. This ECM is recommended for implementation.

10.6 ECM 6 – HVAC- ICE PLANT AUTOMATED MANAGEMENT SYSTEM

This is a computerized energy management system that optimizes the run time of the compressors, therefore dramatically reducing chiller power consumption. Among the functions that this system can perform are compressor sequencing and peak power draw management. These systems monitor the ice conditions, allowing the compressors to run the minimal amount necessary to keep the ice at ideal conditions, drastically lowering energy use.

Implementation of this ECM is expected to reduce annual electrical consumption by 98,000 kWh. It is expected to cost $37,450 and provide an annual savings of $5,488. This ECM is recommended for implementation.

10.7 ECM SUMMARY

The following table summarizes expected savings from all proposed energy conservation opportunities. Savings are based on the implementation order presented above. Savings may be different if a different implementation sequence is followed:

ECM Description	ECM	Additional First Cost ($)	KWH Annual Savings (KWh)	KWH Annual Savings ($)	Therm Annual Savings (Therms)	Therm Annual Savings ($)	Total Annual Savings ($)	GHG Reduction (Metric Tonnes)
HVAC - Compressor Head Rebuild (x2)	ECM1	$6,600	49,500	$2,772	0	$0	$2,772	36.6
HVAC - Sub Slab Heating Energy Recovery (x2)	ECM2	$14,200	35,000	$1,960	0	$0	$1,960	25.9
HVAC - Hot Water Systems off Compressor Waste Heat (x2)	ECM3	$17,500	26,000	$1,456	0	$0	$1,456	19.2
Install a small chiller dedicated for air conditioning instead of using larget ice plant chillers	ECM4	$43,600	64,824	$3,630	0	$0	$3,630	48.0
Correct undersized heat exchange pipe in ice melting pit	ECM5	$8,720	100,000	$5,600	0	$0	$5,600	74.0
HVAC - Ice Plant Automated Management System	ECM6	$37,450	98,000	$5,488	0	$0	$5,488	72.5
Totals		**$128,070**	**373324**	**$20,906**	**0**	**$0**	**$20,906**	**276.3**

10.8 ECM FINANCIAL EVALUATION

The following table summarizes the anticipated investment performance of the selected ECMs:

Energy Cost Reduction Measure (ECM)	ID	Study Period	Additional First Cost	Annual Savings	Monthly Savings	Simple Payback (yrs)
HVAC - Compressor Head Rebuild (x2)	ECM1	10	$6,600	$2,772	$231	2.4
HVAC - Sub Slab Heating Energy Recovery (x2)	ECM2	10	$14,200	$1,960	$163	7.2
HVAC - Hot Water Systems off Compressor Waste Heat (x2)	ECM3	10	$17,500	$1,456	$121	12.0
Install a small chiller dedicated for air conditioning instead of using larget ice plant chillers	ECM4	10	$43,600	$3,630	$303	12.0
Correct undersized heat exchange pipe in ice melting pit	ECM5	10	$8,720	$5,600	$467	1.6
HVAC - Ice Plant Automated Management System	ECM6	10	$37,450	$5,488	$457	6.8
Totals		$60	$128,070	$20,906	$1,742	

11.0 DOCUMENTATION REVIEW

Prior to the Level II Energy Survey and Engineering Analysis, relevant documentation was requested that could aid in the knowledge of the subject property's historic energy use. The review of submitted documents does not include comment on the accuracy of such documents or their preparation, methodology, or protocol. The following documents were available for review while performing the Level II Energy Survey and Engineering Analysis:

- Electric Utility Bills
- Natural Gas Utility Bills
- USEPA eGRID Database
- 2009 United States Greenhouse Gas Inventory, Annex 2
- USEPA Climate Leaders Calculator for Low Emitters
- 2003 Commercial Building Energy Consumption Survey

No other documents were provided for review. Annual energy consumption is also summarized in the Energy Performance Summary form, included in Appendix B. All utility bills and invoices are included in Appendix D.

12.0 CONCLUSIONS AND RECOMMENDATIONS

The purpose of AKT Peerless' Level II Energy Survey and Engineering Analysis is to assist the Client in evaluating the property's current energy and energy cost efficiency relative to other, similar properties, and to determine if further engineering study and analysis are likely to produce significant energy savings.

AKT Peerless' scope of work is based on ASHRAE's "*Procedures for Commercial Building Energy Audits" and ASHRAE* Standard 105 *"Standard Methods of Measuring, Expressing and Comparing Building Energy Performance*."

The combined annual EUI for the subject building is 189.92 kBtu per square foot per year. The annual energy cost index is $3.94 per square foot per year. Reduction of all fuel (non-electrical), and electrical energy consumption to target levels indicated in Section 5 could result in an EUI of 125.04 kBtu per square foot per year and a possible annual cost index of $1.49 per square foot per year. If all recommended ECMs are implemented, anticipated total savings are $20,906.

13.0 LIMITATIONS

Analysis of potential energy cost savings are based on the assumption that future average energy costs will remain the same as the average energy costs calculated from energy bills and energy invoices provided for the purpose of conducting this Level II Energy Survey and Engineering Analysis.

AKT Peerless accepts responsibility for the competent performance of its duties in executing this assignment and preparing this report in accordance with the normal standards of the profession, but disclaims any responsibility for consequential damages. Although AKT Peerless believes the results contained in herein are reliable, AKT Peerless cannot warrant or guarantee that the information provided is exhaustive, or that the information provided by the Client, third parties, or the secondary information sources cited in this report is complete or accurate.

Should additional information become available to the Client that differs significantly from our understanding of conditions presented in this report, AKT Peerless requests that such information be forwarded immediately to our attention so that we may reassess the conclusions provided herein and amend this project's scope of services as necessary and appropriate.

Nothing in this report constitutes a legal opinion or legal advice. For information regarding individual or organizational liability, AKT Peerless recommends consultation with independent legal counsel.

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14.0 SIGNATURES

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Cappy Kidd

APPENDICES

Appendix A

ASHRAE STANDARD 105, BASIC BUILDING CHARACTERISTICS

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BASIC BUILDING CHARACTERISTICS

Building ID	66			
Address	42400 Arena Drive			
City, State, ZIP Code	Novi , Michigan , 48375			
Gross Floor Area[1]	62,399			
Number of Conditioned Floors:	Above Grade:	2	Below Grade:	0
Primary year of construction[2]	1998			

BUILDING TYPE 3 (PERCENT OF GROSS FLOOR AREA)

Office
____ Owner Occupied
____ Leased—1–5 Tenants
____ Leased—5+ Tenants
____ Bank/Financial
____ Courthouse
____ Other—Define __________

Hotel/Motel
____ Motel (No Food)
____ Hotel
____ Hotel/Convention
____ Other—Define __________

Apartment
____ General Occupancy
____ Seniors Only
____ Dorm/Fraternity/Sorority
____ Other—Define __________

Education
____ Primary
____ Pre-School/Daycare
____ Secondary
____ College/University
____ Other—Define __________

Food Services
____ Restaurant—Full Service
____ Fast Food
____ Take Out
____ Lounge
____ Other—Define __________

Auto Services
____ Service/Repair
____ Sales
____ Other—Define __________

Public Order
____ Jail/Penitentiary
____ Fire/Police Station

Health Care
____ Nursing Home/Assisted Living
____ Psychiatric
____ Clinic/Outpatient
____ Active Treatment Hospital
____ Other—Define _____________

Retail
____ Dry-Cleaning/Laundromat
____ Supermarket/Food Market
____ General Merchandise
____ Shopping Mall without Tenant Loads
____ Shopping Mall without Tenant Lighting Loads
____ Shopping Mall
____ Specialty Shop
____ Bakery
____ Other—Define _____________

Assembly
____ Theatre
____ Library
____ Convention Center
____ Museum/Gallery
____ Church/Synagogue
____ Arena/Gym
__x_ Arena/Rink
____ Nightclub
____ Other—Define _____________

Other
____ Laboratory
____ Warehouse
____ Warehouse—Refrigerated
____ Recreation/Athletic Facility
____ Post Office/Center
____ Transport Terminal
____ Multi-Use Complex

1. GROSS FLOOR AREA is all floor area contained within the outside finished surface of permanent outer building walls including basements, mechanical equipment floors, and penthouses.

Appendix B

ASHRAE STANDARD 105, ENERGY PERFORMANCE SUMMARY

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ENERGY PERFORMANCE SUMMARY

Energy Type	Source of Energy Data	Energy Use Numerical Value	Units	Conversion Multiplier to kBtu (kWh)	Energy, kBtu/yr (kWh/yr)	Energy Cost, $
1. Electricity—Purchased	Bills	1,935,927	kWh	3.143	6,084,620	$187,791
2. Natural gas	Bills	57,660	Therm	100	5,766,016	$58,347
3. Steam						
4. Hot water						
5. Chilled water						
6. Oil # _______						
7. Propane						
8. Coal						
9. Thermal—On-Site Renewable						
10. Other						
11. Electricity—On-Site Generated						
12. Thermal or Electricity—Exported						
Total Energy [1] sum of 1 to 11 minus 12					**A: 11,850,636**	
Net Energy [2] Sum of 1 to 11 minus 9 and solar PV-generated kWh in 11					**B: 11,850,636**	**C: $246,137.27**

[1]The Total Energy is the sum of all energy used in the building, plus on-site generated electricity from renewable sources or from sources other than fuels covered in items 2–8, minus exported energy. Under a net metering agreement, the electric utility meter may record the purchased energy minus the exported energy.

[2]The Net Energy is the sum of the purchased energy minus sold or exported energy (thus accounting for both on-site generated energy used in the building and energy exported from the site).

ENERGY AND COST INDICES

Total Energy Index (A ÷ Gross Floor Area)	189.92	kBtu/ft^2/yr·yr (kWh/m^2·yr)
Net Energy Index (B ÷ Gross Floor Area)	189.92	kBtu/ft^2/yr·yr (kWh/m^2·yr)
Energy Cost Index (C ÷ Gross Floor Area)	$3.94	$/ft^2·yr ($/m^2·yr)

Appendix C

ASHRAE STANDARD 105, ADDITIONAL EXPRESSIONS OF ENERGY PERFORMANCE

Additional Expressions of Energy Performance

Specification of Comparison of Normalizing Factors

Name of Additional Factor or Characteristic for Normalization (for performance comparison, all factors shown must be specified)	**Type of Factor: Occupancy, Building, Weather, Energy, User-Specified**	**Value of Factor: Numeric or Logical** (for performance comparison, factors not applicable must be shown as "N/A.")	**Unit of Factor, if needed, or notes**
Number of full-time equivalent workers	Occupancy		
Number of full-time equivalent students	Occupancy		
Number of licensed hospital beds	Occupancy		
Food service seating capacity	Occupancy		Seats
Number of personal computers	Occupancy		
Weekly hours of operation	Occupancy		Hours/ Week
Annual months of operation	Occupancy		Months/ Year
Computer center/network/comm. area	Building		Percent of Floor Area
Annual average W/sq ft (W/sq mtr) for computer center and comm. Area	Building		W/sq ft (W/sq mtr)
Percent of gross floor area heated	Building		Percent of Floor Area
Percent of gross floor area cooled	Building		Percent of Floor Area
Heating degree-days (base 65F/18C)	Weather		Degree-Days
Cooling degree-days (base 65F/18C)	Weather		Degree-Days
Parking garages	Building		Sq Ft (Sq Mtr)
Natatorium space	Building		Sq Ft (Sq Mtr)
Natatorium present or not	Building		Yes or No, 1 or 0
Annual peak electric demand	Energy		kW
Electricity generation capacity	Energy		kW
Annual electricity generation	Energy		kWh/yr

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Additional Numerical Expressions of Energy Use Performance

TOTAL ENERGY: kBtu (kWh) Total from Form 2 (provide note if other energy total is used)	Factor or Characteristic for Normalization	Expression of Energy Performance (numerical value)	Units of Performance
Examples:	Factors	Might include factors such as licensed beds for hospitals, number of annual transactions for retail stores, number of students for schools.	
	Corresponding Units of Performance	Could be kBtu/yr (kWh/yr) per bed for hospitals, per each transaction for retail stores, per student for schools.	

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Appendix D

ASHRAE STANDARD 105, COMPARISON OF BUILDING ENERGY PERFORMANCE

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COMPARISON OF ENERGY PERFORMANCE

Building Identification

Building ID	66	Comparison Start Date	
Address	42400 Arena Drive	Comparison End Date	
City, State, Country, ZIP Code	Novi, Michigan 48375		
Gross Floor Area from Form 1	62,399	ft^2 (m^2)	
Total Energy Index from Form 2	189.92	kBtu/ft^2/yr·yr (kWh/m^2·yr)	
Net Energy Index from Form 2	189.92	kBtu/ft^2/yr·yr (kWh/m^2·yr)	
Cost Index from Form 2	$3.94	\$/ft^2·yr (\$/m^2·yr)	

Documented Comparison	Access point of report describing analytical methods	URL or other: See section 8
Access Information	Access point of comparison data base used for analytical method	URL or other: http://www.eia.doe.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/detailed_tables_2003.html

Comparison Data Basic Statistics—Provide for ALL METHODS

Comparison Factor Name/Description	Units	Mean	Maximum	Minimum
Gross Floor Area	Sq Ft	24812.5	40500	19750
Year of Construction	Years	1,974	1998	1952

For additional factors, attach additional sheet(s).

Data Filters Used for Analysis—Provide for ALL METHODS

Comparison Factor Name/Description*	Units	Filter Criteria
Census Region		"East North Central"
Building Use		"Public assembly"
Gross Floor Area	Sq Ft	22399 < Gross Floor Area < 102399
Year of Construction	Years	1948 < Year of Construction < 2048

For additional factors, attach additional sheet(s).

*Initial data filters are a square foot range of 10,000 square feet above and below the subject building's actual square footage and a year of construction 20 years before and after the subject building's actual year of construction. If the initial data filters do not return a minimum of 12 data points, the data filters are widened until they return at least 12 data points.

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Appendix E

Utility Bills / Consumption Records

Electric Consumption

AccountNumber:	Date Start	Date End	Consumption	Estimate	Measured Demand	Consumption $	Demand $	Total $
0001-1471-0	11/1/2009	12/1/2009	131,950	☐	428	$7,425.46	$5,885.00	$13,310.46
0001-1471-0	10/1/2009	11/1/2009	140,840	☐	423	$7,925.74	$5,816.25	$13,741.99
0001-1471-0	9/1/2009	10/1/2009	170,170	☐	444	$9,576.28	$6,105.00	$15,681.28
0001-1471-0	8/1/2009	9/1/2009	153,440	☐	440	$8,634.80	$6,050.00	$14,684.80
0001-1471-0	7/1/2009	8/1/2009	152,040	☐	440	$8,556.02	$6,050.00	$14,606.02
0001-1471-0	6/1/2009	7/1/2009	166,110	☐	439	$9,347.80	$6,036.25	$15,384.05
0001-1471-0	5/1/2009	6/1/2009	128,240	☐	441	$7,216.68	$6,063.75	$13,280.43
0001-1471-0	4/1/2009	5/1/2009	133,630	☐	424	$7,520.00	$5,830.00	$13,350.00
0001-1471-0	3/1/2009	4/1/2009	159,530	☐	428	$8,977.52	$5,885.00	$14,862.52
0001-1471-0	2/1/2009	3/1/2009	136,710	☐	441	$7,693.33	$6,063.75	$13,757.08
0001-1471-0	1/1/2009	2/1/2009	141,960	☐	450	$7,988.77	$6,187.50	$14,176.27
0001-1471-0	12/1/2008	1/1/2009	162,190	☐	465	$9,127.21	$6,393.75	$15,520.96

Natural Gas Consumption

AccountNumber:	Date Start	Date End	Consumption	Estimate	Consumption $	Total $
100000199479	8/1/2009	9/1/2009	2,027	☐	$2,051.13	$2,051.13
100000199479	7/1/2009	8/1/2009	116	☐	$117.38	$117.38
100000199479	6/1/2009	7/1/2009	4,504	☐	$4,557.62	$4,557.62
100000199479	5/1/2009	6/1/2009	3,513	☐	$3,554.82	$3,554.82
100000199479	4/1/2009	5/1/2009	4,889	☐	$4,947.20	$4,947.20
100000199479	3/1/2009	4/1/2009	8,326	☐	$8,425.12	$8,425.12
100000199479	2/1/2009	3/1/2009	5,511	☐	$5,576.60	$5,576.60
100000199479	1/1/2009	2/1/2009	7,022	☐	$7,105.59	$7,105.59
100000199479	12/1/2008	1/1/2009	7,075	☐	$7,159.22	$7,159.22
100000199479	11/1/2008	12/1/2008	4,496	☐	$4,549.52	$4,549.52
100000199479	10/1/2008	11/1/2008	2,813	☐	$2,846.49	$2,846.49
100000199479	9/1/2008	10/1/2008	2,471	☐	$2,500.42	$2,500.42

Appendix F

Table C5. Consumption and Gross Energy Intensity by Census Region for Sum of Major Fuels for Non-Mall Buildings, 2003

Table C5. Consumption and Gross Energy Intensity by Census Region for Sum of Major Fuels for Non-Mall Buildings, 2003

	Energy Intensity for Sum of Major Fuels (thousand Btu/ square foot)			
Principal Building Activity	North-east	Mid-west	South	West
Education	101.6	86.3	75.5	77.6
Food Sales	Q	219.1	187.7	Q
Food Service	Q	218.8	283.4	243.8
Health Care	212.2	205.6	169.8	179.6
Inpatient	Q	272.2	226.7	246.8
Outpatient	Q	124.4	60.9	115.3
Lodging	Q	109.0	96.9	103.7
Retail (Other Than Mall)	65.0	102.7	68.7	63.2
Office	101.2	108.8	87.0	72.1
Public Assembly	Q	101.7	93.2	91.2
Public Order and Safety	Q	Q	Q	Q
Religious Worship	52.1	52.8	38.3	27.6
Service	79.8	85.0	66.3	80.0
Warehouse and Storage	41.6	74.7	26.7	39.0
Other	Q	Q	Q	Q
Vacant	Q	Q	Q	Q

Appendix G

CBECS Data Set Buildings

Building ID	Census Division	Building Use	Sq Footage	Date Constr.	Ann kWh	Ann Nat Gas	Adj Weight	EUI
207	East North Central	Service	22,000	1997	106584	6187	776.54	34674.7914861964
492	East North Central	Service	20,000	1968	176792	30019	2724.37	491083.262819424
800	East North Central	Service	19,750	1985	478762	25319	122.17	25766.6485710623
1099	East North Central	Service	25,000	1980	285392	5000	864.37	50954.8709492992
2591	East North Central	Service	25,000	1955	129861	20495	780.38	77806.5621415264
3866	East North Central	Service	23,500	1962	115557	11730	780.38	52045.7167703796
4070	East North Central	Service	22,000	1952	124179	518	173.32	3746.06559106182
4894	East North Central	Service	28,000	1990	469566	33524	80.08	14170.03928912
4943	East North Central	Service	22,000	1972	279796	16211	864.37	101200.594872284
5413	East North Central	Service	30,000	1971	987378	13274	404.15	63267.4426468133
5447	East North Central	Service	40,500	1998	137957	13578	199.06	8987.23600180346
5944	East North Central	Service	20,000	1955	384271	35508	404.15	98247.50406529

Appendix H

Glossary

Barrel: A volumetric unit of measure for crude oil and petroleum products equivalent to 42 U.S. gallons.

Bottled Gas, LPG, or Propane: Any fuel gas supplied in liquid form, such as liquefied petroleum gas, propane or butane. It is usually delivered by tank truck and stored near the building in a tank or cylinder until used.

Btu (British Thermal Unit): A unit of energy consumed by or delivered to a building. A Btu is defined as the amount of energy required to increase the temperature of 1 pound of water by 1 degree Fahrenheit, at normal atmospheric pressure. Energy consumption is expressed in Btu to allow for consumption comparisons among fuels that are measured in different units. (See Btu Conversion Factors and Metric Conversion Factors.)

Btu Conversion Factors: The Btu conversion factors used for the CBECS are shown in the following table. Only the Natural gas factor differed between the 199 and 2003 surveys.

Energy Source	Btu Equivalent	Unit
Electricity	3,413	kilowatt hour
Natural Gas (1999)	1,027	cubic foot
Natural Gas (2003)	1,031	cubic Foot
Distillate Fuel Oils (Nos. 1, 2, and 4)	138,690	Gallon
Residual Fuel Oils (Nos. 5 and 6)	149,690	Gallon

Sources: Energy Information Administration, *Annual Energy Review 2004*.

Note: A Btu of district hot water has been converted into equivalent pounds of steam with the conversion of 1,000 Btu hot water approximately =1 pound steam.

Source: *Methodological Issues in the Nonresidential Buildings Energy Consumption Survey* (September 1983), p. 173-175

CDD: See Cooling Degree-Days (CDD).

Census Region and Division: A geographic area consisting of several states defined by the U.S. Department of Commerce, Bureau of the Census. See following table:

Region	Division	States
Northeast	New England	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont
	Middle Atlantic	New Jersey, New York, and Pennsylvania
Midwest	East North Central	Illinois, Indiana, Michigan, Ohio, and Wisconsin
	West North Central	Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota
South	South Atlantic	Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, and West Virginia

	East South Central	Alabama, Kentucky, Mississippi, and Tennessee
	West South Central	Arkansas, Louisiana, Oklahoma, and Texas
West	Mountain	Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, and Wyoming
	Pacific	Alaska, California, Hawaii, Oregon, and Washington

Cogeneration: The simultaneous production of electric and thermal energy in on-site, distributed energy systems; typically, waste heat from the electricity generation process is recovered and used to heat, cool, or dehumidify building space. Neither generation of electricity without use of the byproduct heat, nor waste-heat recovery from processes other than electricity generation is included in the definition of cogeneration. (See Electricity Generation.)

Commercial: In the CBECS, commercial refers to any building that is neither residential (used as a dwelling for one or more households), manufacturing/industrial (used for processing or procurement of goods, merchandise raw materials or food), nor agricultural (used for the production, processing, sale, storage, or housing of agricultural products, including livestock). At least 50 percent of the floor space must be used for purposes other than these for a building to be considered "commercial."

Commercial Building: A building with more than 50 percent of its floor space used for commercial activities. Commercial buildings include, but are not limited to, the following: stores, offices, schools, churches, gymnasiums, libraries, museums, hospitals, clinics, warehouses, and jails. Government buildings were included except for buildings on sites with restricted access, such as some military bases. Agricultural buildings, residences, and manufacturing/industrial buildings are excluded. Since 1995, parking garages and commercial buildings on manufacturing sites have also been excluded. For a list of building types, see "Description of types of buildings." (See Building , Commercial, and Principal Building Activity.)

Conditional Energy Intensity: Total consumption of a particular energy source(s) or fuel(s) divided by the total floorspace of buildings that use the energy source(s) or fuel(s), i.e., the ratio of consumption to energy source-specific floorspace. This measure is used in the fuel-specific detailed tables.

Consumption: The amount of energy used in, or delivered to, a building during a given period of time. Unless otherwise noted, all consumption statistics are site energy consumption, which includes electric utility sales to commercial buildings but excludes electrical system and district heat energy losses. Statistics are presented on an annual basis for the survey calendar year. Site consumption is the amount of energy delivered to the site (building); no adjustment is made for the fuels consumed to produce electricity or district sources. Site consumption is also referred to as net energy. Primary consumption is the amount of site consumption plus losses that occur in the electricity generation process.

Data on energy consumption were not collected by end uses separately. For example, although it might be known that electricity was used in some buildings for heating, the consumption of electricity reported for those buildings would typically include other uses of electricity as well (such as lighting and water heating). Total consumption is reported as well as “Consumption per Square Foot”—the aggregate ratio of total consumption for a particular set of buildings to the total floor space of those buildings; and “Consumption per Worker”—the aggregate ratio of total consumption to total number of workers (main shift). (See Btu, Conversion Losses, Energy Supplier, Expenditures, Floor space, and Workers (Main Shift).)

Cooling Degree-Days (CDD): A measure of how hot a location was over a period of time, relative to a base temperature. In this report, the base temperature is 65 degrees Fahrenheit, and the period of time is one year. The cooling degree-day is the difference between that day’s average temperature and 65 degrees if the daily average is greater than 65; it is zero if the daily average temperature is less than or equal to 65. Cooling degree-days for a year are the sum of the daily cooling degree-days for that year.

Cubic Foot (cf): As a natural gas measure, the volume of gas contained in a cube with an edge that is 1 foot long at standard temperature and pressure (60 degrees Fahrenheit and 14.73 pounds standard per square inch.) The thermal content varies by the composition of the gas. (See Natural Gas and Btu Conversion Factors.)

Degree-Days 45-Year Average: The average of the total annual heating and cooling degree-days (base, 65 Degrees Fahrenheit) in each NOAA Division, for the 45 years, 1931 through 1975. Computed from the Division’s daily temperature averages for each year in question and used to assign individual buildings to climate zones. (See NOAA Division and Climate Zone.)

Electricity: Electric energy supplied to a building by a central utility via power lines or from a central physical plant in a separate building that is part of the same multibuilding facility. Electric power generated within a building for exclusive use in that building is specifically excluded from the definition of electricity as an energy source.

Electricity Generation: As an energy end use, the onsite production of electricity by means of electricity generators on either a regular or emergency basis. (See **Energy End Use** and **Electricity**.)

Energy Intensity: The ratio of consumption to unit of measurement (floor space, number of workers, etc.) Energy intensity is usually given on an aggregate basis, as the ratio of the total consumption for a set of buildings to the total floor space in those buildings. Conditional energy intensity and gross energy intensity are presented. The energy intensity can also be computed for individual buildings. (See **Conditional Energy Intensity** and **Gross Energy Intensity**.)

Energy-Related Space Functions: The use of space in the building for one or more of three specific functions: commercial food preparation, activities requiring large amounts of hot water, and separate computer areas. (See **Commercial Food Preparation**, **Separate Computer Area**, and **Activities with Large Amounts of Hot Water**.)

Energy Source: A type of energy or fuel consumed in a building. In the CBECS, information about the use of electricity, natural gas, fuel oil, district heat, district chilled water, propane, wood, coal, and solar thermal panels in commercial buildings was obtained from the building respondent. In most tables, wood, coal, and solar thermal panels are included in the "Other" category under "Energy Sources." (See **Electricity**, **Natural Gas**, **Fuel Oil**, **District Heat**, **District Chilled Water**, **Liquefied Petroleum Gas [LPG]**, **Propane**, **Wood**, **Coal**, and **Solar Thermal Panels**.)

Energy Source-Specific Floorspace: Total floorspace of those buildings that use a particular fuel, for example, total floorspace in buildings that use natural gas. (See **Conditional Energy Intensity**.)

Floorspace: All the area enclosed by the exterior walls of a building, both finished and unfinished, including indoor parking facilities, basements, hallways, lobbies, stairways, and elevator shafts. For aggregate floorspace statistics, floorspace was summed or aggregated over all buildings in a category (such as all office buildings in the United States). (See **Square Footage**.)

Fuel Oil: A liquid petroleum product used as an energy source that is less volatile than gasoline. Fuel oil includes distillate fuel oil (Nos. 1, 2, and 4), residual fuel oil (Nos. 5 and 6), and kerosene.

Gallon: A volumetric measure equal to 4 quarts (231 cubic inches) used to measure fuel oil. One barrel equals 42 gallons.

Geothermal Heat Pump: See **Ground Source Heat Pump**.

Government Owned: A building owned by a Federal, State, or local government agency. The building may be occupied by agencies of more than one government and may also be shared with nongovernment establishments.

Gross Energy Intensity: Total consumption of a particular energy source(s) or fuel(s) by a group of buildings, divided by the total floorspace of those buildings, including buildings and floorspace where the energy source or fuel is not used, i.e., the ratio of consumption to gross floorspace. (See **Conditional Energy Intensity**.)

Gross Floorspace: Total floorspace of a group of buildings, regardless of which end uses are present or which energy sources or fuels are used within the buildings. (See **Energy Source-Specific Floorspace** and **Gross Energy Intensity**.)

Heating Degree-Days (HDD): A measure of how cold a location was over a period of time, relative to a base temperature. In CBECS, the base temperature used is 65 degrees Fahrenheit, and the period of time is one year. The heating degree-day is the difference between that day's average temperature and 65 degrees if the daily average is less than 65; it is zero if the daily average temperature is greater than or equal to 65. Heating degree-days for a year are the sum of the daily heating degree-days for days that year.

Imputation: A statistical method used to generate values for missing items, designed to minimize the bias of estimates based on the resulting data set. In this survey, missing responses were generated using a procedure known as a "hot-deck imputation" which uses random resampling from similar nonmissing cases to generate values for missing cases.

Intensity: The amount of a quantity per unit of measurement (floorspace, number of workers, etc.) This is a method of adjusting either the amount of energy consumed or expenditures spent, for the effects of various building characteristics, such as size of the building, number of workers, or number of operating hours, to facilitate comparisons of energy across time, fuels, and buildings. (See **Conditional Energy Intensity**, **Energy Intensity**, **Expenditures**, and **Gross Energy Intensity**)

Kilowatthour (kWh): A unit of work or energy, measured as 1 kilowatt (1,000 watts) of power expended for 1 hour. One kWh is equivalent to 3,413 Btu. (See **Btu**.)

Liquefied Petroleum Gas (LPG): Any fuel gas supplied to a building in liquid form. Propane is the usual LPG, but gases such as butane, propylene, butylene, and ethane are also LPG. For this report, any LPG reported was assumed to be propane. (See **Energy Source**, **Propane**, and **Natural Gas**.)

LPG: See **Liquefied Petroleum Gas (LPG)**.

Major Fuels: The energy sources or fuels for which consumption and expenditures data are collected. These fuels or energy sources are: electricity, fuel oil, natural gas, district steam, and district hot water. (See **Energy Source**.)

Manufacturing: As an energy end use, any of the energy-using operations required for manufacturing/industrial processes. (See **Energy End Use**.)

Metric Conversion Factors: Estimates are presented in customary U.S. units. Floorspace estimates may be converted to metric units by using the relationship: 1 square foot is approximately equal to 0.0929 square meters. Energy estimates may be converted to metric units by using the relationship: 1 Btu is approximately equal to 1,055 joules; one kilowatthour is exactly equal to 3,600,000 joules; and one gigajoule (10^9 joules) is approximately 278 kilowatthours (kWh).

Multibuilding Facility: A group of two or more buildings on the same site owned or operated by a single organization, business, or individual. Examples include university campuses and hospital complexes.

Multistage Area Probability Sample: A sample design executed in stages with geographic “clusters” of sampling units selected at each stage.

Natural Gas: Hydrocarbon gas (mostly methane) supplied as an energy source to individual buildings by pipelines from a central utility company. Natural gas does not refer to liquefied petroleum gas (LPG) or to privately owned gas wells operated by a building owner. (See **Energy Source**, **Liquefied Petroleum Gas (LPG)**, and **Propane**.)

NOAA Division: One of the 356 weather divisions designated by the National Oceanic and Atmospheric Administration (NOAA) that encompass the 50 contiguous United States and the District of Columbia. These divisions usually follow county borders to encompass counties with similar weather conditions. However, the NOAA division does not follow county borders when weather conditions vary considerably within a county, as is likely to be the case when a county borders the ocean or contains high mountains. A State contains an average of seven NOAA divisions; a NOAA division contains an average of nine counties. (See **Climate Zone**.)

Nongovernment Owned: Owned by an individual or a group, such as a private business, a nonprofit organization, a privately-owned utility company; or a church, synagogue, or other religious organization. The building may be occupied by more than one agency and may be owner occupied, nonowner occupied or unoccupied.

Nonowner Occupied: Refers to a building that actually "does not have the owner or the owners' business located at the site." (If both the owner and other tenants are in a building, the building would be classified as owner occupied. Just because someone else is there, in and of itself, does not mean the building is nonowner occupied.)

Owner Occupied: Refers to a building that has the owner or the owner's business represented at the site.

Ownership and Occupancy: Ownership refers to the individual, agency, or organization that owns the building. Building ownership is grouped into Government ownership (Federal, State, or local) and Nongovernment ownership (a private business or nonprofit organization owned by a group or an individual). Occupancy refers to the individual, agency, or organization that leases or holds the space on a full-time basis. (See **Owner Occupied** and **Nonowner Occupied**.)

Percent of Floorspace Cooled: The percentage of a building's square footage that is cooled to meet the comfort requirements of the occupants.

Percent of Floorspace Heated: The percentage of a building's square footage designed to be heated to at least 50 degrees Fahrenheit.

Primary Sampling Unit (PSU): A sampling unit selected at the first stage in a multistage area probability sample. A PSU typically consists of one to several contiguous counties—for example, an MSA with surrounding suburban counties.

Principal Building Activity: The activity or function occupying the most floorspace in a building. The categories were designed to group buildings that have similar patterns of energy consumption. Examples of various types of principal activity include office, health care, lodging, and mercantile and service. (See Description of CBECS Building Types for a complete list and definitions of each.)

RSE or Relative Standard Error: A measure of the reliability or precision of a survey statistic. Variability occurs in survey statistics because the different samples that could be drawn would each produce different values for the survey statistics. The RSE is defined as the standard error (the square root of the variance) of a survey estimate, divided by the survey estimate and multiplied by 100. For example, an RSE of 10 percent means that the standard error is one-tenth as large as the survey estimate. Tables of RSEs are provided for each of the CBECS Detailed Tables.

Square Footage: Floorspace, in units of square feet. One square foot is approximately equal to 0.0929 square meters. (See **Floorspace**.)

Standard Error: A measure of the precision of an estimate, equal to the square root of the variance. (See **Variance** and **RSE or Relative Standard Error**.)

Vacant: A building was considered vacant if 50 percent or more of the floorspace was not occupied by any tenant or establishment at the time of the interview. A vacant building may contain occupants who are using up to 50 percent of the floorspace. For all buildings, data were collected on whether the building had any floorspace that was vacant for three or more consecutive months and on the number of months the building was in use. (See **Principal Building Activity**.)

Variance: A measure of the variability of a set of observations that are subject to some chance variation, equal to the expected squared difference between a single observation and the average of all possible observations obtained in the same manner. The variance is the square of the standard error of estimates. The variance indicates the likely difference between the value computed from the CBECS sample and the average of the values that could have been computed from all possible samples that might have been obtained by the same sample selection process. (See **Standard Error**.)

Weight: The number of buildings in the United States that a particular building in the sample represents. To estimate the total value of an attribute (such as square footage) in the U.S. commercial buildings population as a whole, each sample building's value is multiplied by the building's weight. Summing (aggregating) the weighted sample values provides an estimate of the national total.

Year Constructed: The year in which the major part or the largest portion of a building was constructed.

APPENDIX I

SOFTWARE INPUT AND OUTPUT DATA/MANUAL CALCULATIONS

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Discussion of Energy Recovery in Ice Arenas

Maintaining ice sheets for extended periods of time can cause freezing of the sub-soil which can in turn cause damage to or destroy the concrete slab of the rink. A technique that pumps warm water through plastic tubing to heat the soil beneath the rink just enough to keep it from freezing has been developed. Of course, it is necessary to have an adequate layer of insulation between the heated sub-soil and the chilled concrete slab. Otherwise the ice plants, (chillers) assigned to freeze the ice sheet and the boilers, assigned to keep the ground from freezing would end up fighting each other. Traditionally this heat is created through the purchase of natural gas to fire boilers. However, the entire subslab heating requirement can be met by use of heat that is currently being rejected from the chillers. Recovering this “waste” heat off of the compressor can result in a typical energy savings of 35,000 Kwh per year.

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APPENDIX J

VARIABLE FREQUENCY DRIVES

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Variable frequency drives (VFD)— what they are and how they work

Variable frequency drives are devices that can modulate the speed of electric motors. Heating, ventilation and air-conditioning systems are typically designed to meet a building's loads at peak conditions. However, most buildings operate at full load conditions for only short periods of time. This means that the building is operating with oversized equipment throughout the rest of the year. The fans and pumps that drive the HVAC systems are some of the largest consumers of electric power in the building. These include chilled water and hot water distribution pumps, cooling tower fans, air handling unit fans and ventilation fans.

Substantial energy savings can be achieved if the speed of these electric motors can be reduced in response to changing load conditions. Since the power draw of electric motors is proportional to the cube of its rotational speed, very large reductions in power consumption can be achieved through relatively small reductions in speed. For example, if the rotational speed of an electric motor is reduced by one half, the corresponding electricity use will be only one eighth of the initial power draw.

How variable frequency drives work

Variable frequency drives can change the frequency of the input alternating current and therefore change the rotational speed of the electric motor.

Alternating current travels in sine waves. The number of sine wave cycles per second is called frequency, expressed in hertz (Hz). In the United States, alternating current is delivered at 60 Hz. In most of the rest of the world, alternating current is delivered at 50 Hz. The stationary component of electric motors consists of a number of windings called poles. Poles always come in pairs. Typical induction motors are constructed with 2, 4, 6, 8, 10 and 12 pole configurations. If you change either the frequency of the current or the number of poles, you will change the rotational speed of the motor.

The synchronous speed of an induction motor is based on the supply frequency of the electric currents and the number of poles in the motor winding. This is expressed in the formula

$W = 2\ (60)\ (f)/N$
where W = pump shaft rotational speed
f = frequency
N = number of poles

Examples:

A 2 pole induction motor at 60 Hz will rotate at a theoretical speed of 3,600 rpm
A 2 pole induction motor at 50 Hz will rotate at a theoretical speed of 3,000 rpm

A 4 pole induction motor at 60 Hz will rotate at a theoretical speed of 1,800 rpm

A 4 pole induction motor at 50 Hz will rotate at a theoretical speed of 1500 rpm

Variable frequency drives convert alternating current into direct current and then back into alternating current at a variety of different frequencies. There are no moving parts in a variable frequency drive. The main components of VFD consist of

1. Rectifier converts alternating current into direct current
2. Intermediate Circuit stabilizes the direct current
3. Inverter converts the direct current back into alternating current with a wide and variable range of frequencies
4. Control Circuit controls and coordinates the functions of the previously listed components and provides protective functions for the VFD as a whole

Savings Potential… First the system must lend itself to the application. Once that has been established then the larger the motor the greater the savings potential of VFDs. Originally, VFDs were available for only the largest triple phase induction motors. However, in recent years, the technology has advanced to the point that there are VFDs for triple phase and single phase motors all the way down to fractional horsepower applications.

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APPENDIX K
UNDERSTANDING DEMAND CHARGES

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Understanding Demand Charges

Demand charges are an unrecognized component of commercial energy bills that can have the largest single impact on a facility's operating cost. It is extremely important to be aware of demand charges because they set the baseline for what a facility will pay for their electrical service every month before they use even a single kilowatt hour of electricity.

Demand charges can be based on the previous month's usage or the previous year's peak fifteen minutes of consumption. For example, the Novi ice arena bill of August 28, 2009 through September 28, 2009 shows a demand charge of $7,067.55 out of a total bill of $15,682.28. In this case, the demand charge accounts for 45% of the bill. In general, all of the energy conservation measures that lower energy consumption also help to reduce peak demand. More specifically, the proposed measures for the automated ice plant management system and for a dedicated smaller chiller for summertime air conditioning of the building aim to reduce the demand charge.

The two major components of an electric utility bill for most commercial buildings are an electricity consumption charge and an electricity demand charge. Electricity consumption is measured in kilowatt-hours (kWh) and electricity demand is measured in kilowatts (kW). Consumption and demand refer to distinct aspects of a building's energy profile, but both represent a substantial portion of a building's electric utility charges.

Electricity consumption, measured in kWh, is a measurement of the actual amount of energy a facility consumes over the course of an entire billing period. A kilowatt-hour equals one thousand watt-hours. A watt-hour is the total energy consumed by using energy at the rate of one watt for a period of one hour. If energy is consumed at a rate of one thousand watts for one hour, total consumption is one kWh. If energy is consumed at a rate of one thousand watts for two hours, total consumption is two kWh. kWh consumption is increased by inefficient equipment, which consumes energy at a faster rate than efficient equipment, and it is also increased by operating equipment for longer periods of time than is necessary.

Electricity demand, measured in kW, is a measurement of a facility's maximum rate of electricity consumption. Demand measurements are used by the utility company in order to properly size the equipment associated with a facility's connection to the electric grid. For example, a facility with higher electric demand will require a larger transformer. A facility's demand is primarily influenced by equipment inefficiencies and operating practices that allow large amounts of equipment to run simultaneously. If multiple pieces of inefficient equipment are running simultaneously, demand is increased. Demand can be decreased by either increasing equipment efficiency, or by scheduling equipment operation to minimize simultaneous operation.

Based on a review of recent electric utility bills, the City of Novi is paying a demand charge of $13.75 per kW for the ice arena. Total monthly demand charges for the ice arena are as high as $7,067.55. Substantial savings opportunities are most likely available from implementing improved demand management strategies.

The load watcher program offered by DTE has an initial cost of $1,000 and a month charge of $40. It offers facilities an easy way to monitor their demand charge and to be alerted if a facility is approaching an electricity consumption peak.