Detailed Energy Audit

City of Dover
Dover, New Hampshire

February 27, 2009

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SECTION 1 Executive Summary

Johnson Controls, Inc. (hereinafter "JC") is assisting the City of Dover, NH (hereinafter "City") to reduce energy costs by implementing an energy performance contract. The goals of the project are to cut energy costs, provide capital upgrades, increase the energy efficiency and the reliability of City's mechanical and electrical systems, and to maintain or increase occupant comfort and well-being. This report provides the results of the Detailed Energy Audit.

JC wishes to thank the staff at the City specifically; Sharon Lucey, Gary Bannon, Pat McNulty, Barry Riordan and Ray Vermette for their invaluable assistance and generous time spent with the JC team during this study effort. Without their help and guidance, data collection and system understanding the audit process would have been significantly more difficult. The fact that there are staff who have been with the City for a large number of years, and who know the systems quite intimately is a huge asset both to City as well as a contractor such as JC.

Table 1 below provides an overall economic summary of the recommended measures. A detailed list of the measures is shown in Table 2. Note that the project cost does not include any utility incentives.

Table 1: Project Summary

Project Cost	**$2,423,485**
Estimated Rebates /Incentives	**$225,445**
Project Cost after Rebates/Incentives......	**$2,198,040**
Estimated Annual Savings.....................	**$256,990**
Estimated Capital Cost Avoidance	**$33,840**
Estimated Operational Savings	**$13,680**
Simple Payback, Years..........................	**7.21**

Several Facility Improvement Measures ("FIMs") were identified as a result of the detailed energy audit conducted at the City. The table on the following page summarizes the various measures and their associated energy savings.

Findings

The major findings of this study are as follows:

- There are many opportunities to reduce operating costs at the City buildings. By implementing the recommendations outlined in this study, the City could reduce energy costs **by 22.7%** from calendar year 2007-2008 levels.

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- The City's mechanical and electrical systems are in good condition, and are operated well, given system age, funding and staffing level constraints.
- The staff has been proactive identifying and implementing cost reduction and energy efficiency initiatives. However, several opportunities still exist for additional savings, mostly due to the availability of new technologies, or improvements to systems that may have been considered efficient at the time they were designed, but are no longer. Operational changes can also be made.
- The recommended measures will maintain or improve occupant comfort.
- By implementing the measures, the City will benefit from capital upgrades for equipment that is beyond its useful life, or in need of repair.

Recommendations

- **Lighting – Fixture Retrofit & Controls:** Retrofit old high energy consuming fixtures with appropriate less energy consuming fixtures without compromising quality and install new occupancy sensor to ensure that lights are not on during unoccupied hours of the day.
- **Building Envelope Improvements**: Improve the overall building weatherization through the installation of insulation, weather-stripping and air-sealing
- **Energy Management System - Upgrades:** Retrofit building controls, install ductless split system and equipment to enable more efficient operation through the application of building temperature setbacks and enhanced building control.
- **Water Conservation:** Retrofit existing plumbing fixtures with newer more efficient models.
- **Vending Machine Controls:** Install controls on the cold drink vending machines to improve the overall efficiency of the units.
- **Pool Cover:** Retrofit existing indoor pool with a new fully automatic pool cover to eliminate unnecessary evaporation and heat loss.
- **Ice Arena - Upgrades:** Retrofit several of the ice arenas mechanical systems to improve operational efficiency of the building systems. The scope of the retrofit includes the installation of a new high efficiency chiller, low-E ceiling, ice temperature controls and new dehumidification system at the Foster rink.
- **Power Factor Correction:** Install new capacitors that will enable the efficient use of energy at the facilities were proposed.
- **Transformers - Retrofit**: Retrofit existing transformers with new high efficiency models.
- **WWTP Aeration Blower – Retrofit:** Install new high efficiency aeration blowers at the WWTP.
- **Heating System Upgrade – Boiler Replacement *:** Install new high efficiency hot water fired boiler at the City of Dover Public Library.
  * *The Heating System Upgrade has already been commissioned.*

The table below provides a summary, by measure, of the energy and cost savings achievable by implementing the recommended measures.

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Table 2: Project Savings Detail

Project Summary	
Facility Improvement Measures	**Estimated Savings, $/yr**
Lighting – Fixture Retrofit & Controls	$28,379
Building Envelope Improvements	$14,461
Energy Management System – Upgrades	$30,597
Water Conservation	$14,123
Vending Machine Controls	$936
Pool Cover	$13,223
Ice Arena - Upgrades	$95,015
Power Factor Correction	$7,188
Transformers – Retrofit	$18,385
WWTP Aeration Blower – Retrofit	33,432
Heating System Upgrade – Boiler Replacement	$1,251
Total Savings	**$256,990**

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Environmental Impact

The table below provides a summary of the environmental impact of the recommended project and the reduction in green house gas (Carbon Dioxide, Sulfur Dioxide and Nitrogen Dioxide) emissions as a result of reduced electric, oil and gas usage at the facilities.

Table 3: Project Environmental Impact

Energy Project GHG Calculator *for the US*

Please provide data on expected energy consumption savings based on the project's characteristics for each different source.		Total Reduced GHGs	963.5	*tons CO_2-e*
Electricity				
		eGRID Subregion	NEWE	NPCC New England
Enter location's Zip Code:	03820	Emission Factor	0.00037943	*tons CO_2-e/kWh*
kWh	875,990	Reduced GHGs	332.4	*tons CO_2-e*
Natural Gas				
		Emission Factor	0.0053	*tons CO_2-e/therms*
Therms	118,819	Reduced GHGs	631.1	*tons CO_2-e*

The project's reduced emissions would be equivalent to:

CO_2 sequestered by	24,704	tree seedlings grown for 10 years in an urban scenario	
CO_2 sequestered by	219	acres of pine or fir forests	
CO_2 emissions from	176	passenger vehicles	
CO_2 emissions from	2,241	barrels of oil consumed	
CO_2 emissions from the *energy* use of	85	homes for one year	
CO_2 emissions from burning	5	coal railcars	

Source:
All carbon equivalencies extracted directly from the EPA website.
"Greenhouse Gas Equivalencies Calculator." Clean Energy. U.S. Environmental Protection Agency. <www.epa.gov/cleanenergy/energy-resources/calculator.html> (Aug. 6, 2008).

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The remainder of the report is organized as follows:

- Section 2 describes the facility profile, including the energy consumption profile, energy and water costs tables and a summary of buildings.
- Section 3 briefly describes the development of the energy usage baseline and basis for the energy unit costs used in the savings calculations.
- Section 4 contains detailed descriptions of the measures, including existing and proposed conditions, scope of work and a summary of the savings calculation. Where applicable, the existing conditions section contains charts that were developed from data recorded by the energy management system or portable loggers. The charts help to illustrate the problem or condition the particular measure will address.
- Section 5 provides a draft of the proposed Assured Performance Guarantee and the methodology JC will use to calculate the energy savings.
- Section 6 provides the commissioning plan for the proposed facility improvement measures
- Section 7 The appendices contain all the relevant charts derived from the energy management system and portable logger data, copies of the savings calculations, proposed system flow diagrams and new equipment catalog information. Additionally, this section includes the lighting audit, supplemental utility data and the useful life of the proposed equipment.

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SECTION 2 - Facility Profile

Energy Consumption Profile

Energy Intensity

The energy use within the City of Dover buildings is diverse. During the detailed energy study the Johnson Controls engineering team evaluated the utility usage across all buildings for the purposes of identifying energy savings opportunities. Each of the buildings utility usage was aggregated and then divided by the conditioned square footage to determine the buildings energy intensity in MBtu/ft^2. The chart below illustrates the energy intensities for each of the buildings within the City of Dover; however it is important to note that for the Wastewater Treatment Facility, Indoor Pool and the Jenny Thompson Pool the energy intensity method of comparison does not provide a reasonable means for comparison due to their unique facility type.

Energy intensities for the Cities buildings ranged from a low of 23 MBtu/ft^2 for Veterans Hall to a high of roughly 600 Mbtu/ft^2 for the Indoor Pool. With an average intensity of 80 MBtu/ft^2 (excluding the pool(s), wastewater treatment facility and the ice arena) there were significant amount energy efficiency opportunities at each of the Cities buildings. Typically, efficient municipal facilities will have energy intensities of 50-60 MBtu/ft^2 and below depending on their occupancy and usage class.

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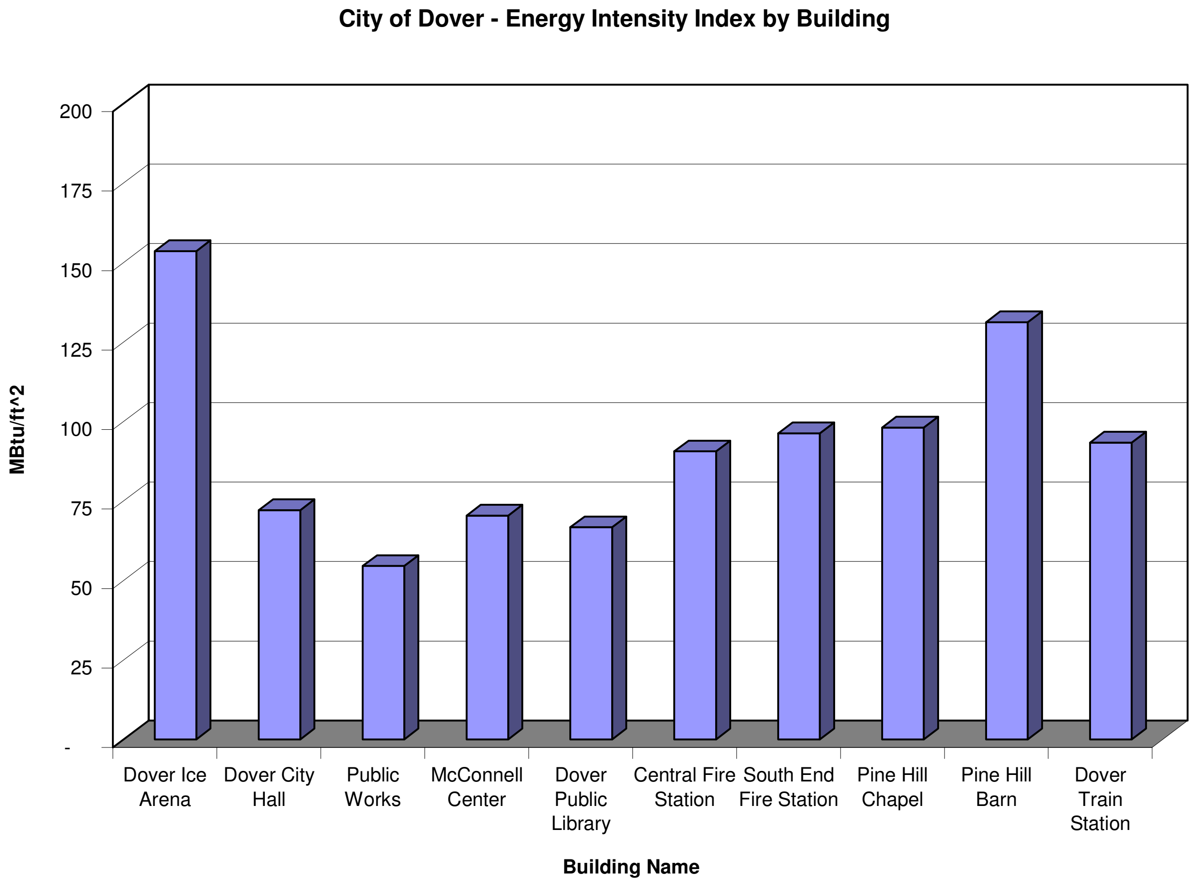

Utility Expenditures

The City utilizes electricity, natural gas, propane and oil to provide for heating, cooling, lighting and other building related processes. Electricity is supplied from Public Service of New Hampshire. Natural Gas was supplied from Northern Utilities (2006) and Metromedia (2007) and is now supplied from Santa Buckley. Propane at the South End Fire Station was supplied by DF Richard (2006) and Proulx Oil (2007) and is now supplied from Ferrell Gas. Heating Oil for several of the buildings was supplied from Hanscom (2006) and Down East Energy (2007) and is now supplied from Irving Oil.

The following chart depicts the City's utility expenditures from August 2007 through July 2008. During this period the City spent $1,131,579 for electricity, natural gas and oil. In terms of percentages, electricity comprises roughly 62% of the total utility expenditures, natural gas/propane makes up 33% and oil makes up the remaining 5%.

Additionally, Johnson Controls has completed a building by building summary and analysis of utility histories for each of the buildings evaluated as part of this study. Further building summary detail is

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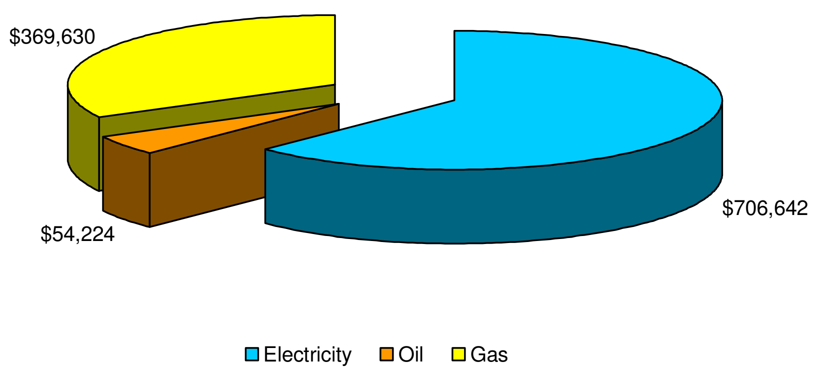
provided on the following pages and a copy of each utility summary with it’s energy profile is included in Appendix 2 as reference.

City of Dover Energy Costs



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Energy and Water Costs Table

The following tables represent the utility usage for each of the Cities buildings evaluated as part of this study. A three year history is provided.

FY 2008 Utility Summary (August 2007 - July 2008)										
	Electricity			Natural Gas		Oil		Propane		Total
Building	kW	kWh	Cost ($)	Therms	Cost ($)	Therms	Cost ($)	Therms	Cost ($)	Cost ($)
Indoor Pool	55.0	423,000	$50,025	48,170	$69,230	-	$0	-	$0	$119,255
Dover Ice Arena	266.4	1,473,600	$177,702	143,267	$181,032	-	$0	-	$0	$358,734
Wate Water Treatment Facility	303.6	1,662,000	$197,687	-	$0	12,344	$20,573	-	$0	$218,260
Dover City Hall	86.5	437,890	$54,539	-	$0	17,316	$28,860	-	$0	$83,399
Public Works	74.8	340,200	$43,525	18,273	$20,618	-	$0	-	$0	$64,143
McConnell Center	187.8	959,000	$118,882	39,726	$56,083	-	$0	-	$0	$174,965
Dover Public Library	35.9	127,440	$17,143	8,985	$12,706	-	$0	-	$0	$29,849
Jenny Thompson Pool	15.3	86,730	$10,906	10,425	$14,062	-	$0	-	$0	$24,968
Central Fire Station	15.4	80,470	$10,068	3,596	$5,496	-	$0	-	$0	$15,564
South End Fire Station	13.2	70,101	$9,000	-	$0	-	$0	5,303	$9,374	$18,374
Pine Hill Chapel	-	10,262	$1,736	-	$0	1,117	$1,862	-	$0	$3,599
Pine Hill Barn	-	6,055	$1,212	-	$0	1,757	$2,928	-	$0	$4,140
Veterans Hall	-	*	*	675	$1,217	-	$0	-	$0	1,217
Dover Train Station	23.8	115,560	$14,108	526	$1,006	-	$0	-	$0	$15,114
Total	**1,077.8**	**5,792,308**	**$706,531**	**273,643**	**$361,450**	**32,534**	**$54,224**	**5,303**	**$9,374**	**$1,131,579**

* **Data not available**

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FY 2007 Utility Summary (August 2006 - July 2007)										
	Electricity			Natural Gas		Oil		Propane		Total
Building	kW	kWh	Cost ($)	Therms	Cost ($)	Therms	Cost ($)	Therms	Cost ($)	Cost ($)
Indoor Pool	56.5	287,000	$35,280	63,845	$90,527	-	$0	-	$0	$125,806
Dover Ice Arena	294.3	1,527,800	$183,902	161,778	$203,587	-	$0	-	$0	$387,489
Wate Water Treatment Facility	319.8	1,871,400	$220,130		$0	8,129	$13,783	-	$0	$233,913
Dover City Hall	71.2	364,720	$44,307		$0	14,630	$24,805	-	$0	$69,112
Public Works	82.0	350,800	$43,773	18,877	$28,237	-	$0	-	$0	$72,010
McConnell Center	135.5	685,136	$83,639	44,166	$67,093	-	$0	-	$0	$150,732
Dover Public Library	36.1	128,880	$16,744	8,706	$13,802	-	$0	-	$0	$30,546
Jenny Thompson Pool	13.2	67,450	$8,403	10,100	$11,793	-	$0	-	$0	$20,197
Central Fire Station	15.2	79,470	$9,794	3,540	$5,780	-	$0	-	$0	$15,574
South End Fire Station	13.6	73,799	$9,179		$0	-	$0	6,008	$10,831	$20,011
Pine Hill Chapel	-	10,474	$1,757		$0	1,238	$2,099	-	$0	$3,855
Pine Hill Barn	-	7,459	$1,278		$0	1,937	$3,284	-	$0	$4,562
Veterans Hall	-	*	*	877	$1,643	-	$0	-	$0	$1,643
Dover Train Station	20.5	98,010	$12,312	389	$865	-	$0	-	$0	$13,177
Total	**1,057.9**	**5,552,398**	**$670,499**	**312,278**	**$423,327**	**25,933**	**$43,971**	**6,008**	**$10,831**	**$1,148,627**

* **Data not available**

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FY 2006 Utility Summary (August 2005 - July 2006)

	Electricity			Natural Gas		Oil		Propane		Total
Building	kW	kWh	Cost ($)	Therms	Cost ($)	Therms	Cost ($)	Therms	Cost ($)	Cost ($)
Indoor Pool	59.4	220,040	$31,518	68,133	$72,354	-	$0	-	$0	$103,873
Dover Ice Arena	281.3	1,460,000	$193,184	172,387	$181,068	-	$0	-	$0	$374,252
Wate Water Treatment Facility	324.1	1,953,600	$254,684		$0	8,956	$12,212	-	$0	$266,896
Dover City Hall	68.8	364,200	$81,602		$0	19,452	$26,495	-	$0	$108,098
Public Works	90.0	351,400	$49,227	19,377	$29,456	-	$0	-	$0	$78,683
McConnell Center	46.4	207,040	$28,247	-	$0	-	$0	-	$0	$28,247
Dover Public Library	37.7	133,440	$19,031	8,562	$10,068	-	$0	-	$0	$29,099
Jenny Thompson Pool	13.9	73,740	$9,656	8,489	$9,714	-	$0	-	$0	$19,370
Central Fire Station	15.5	81,250	$10,943	3,811	$6,127	-	$0	-	$0	$17,070
South End Fire Station	13.3	69,653	$9,529		$0	-	$0	6,336	$8,226	$17,756
Pine Hill Chapel	-	10,510	$1,832		$0	1,397	$1,905	-	$0	$3,737
Pine Hill Barn	-	8,309	$1,465		$0	1,785	$2,434	-	$0	$3,899
Veterans Hall	-	*	*	668	$1,333	-	$0	-	$0	$1,333
Dover Train Station	21.7	107,840	$14,640	389	$865	-	$0	-	$0	$15,505
Total	**972.0**	**5,041,022**	**$705,558**	**281,816**	**$310,985**	**31,590**	**$43,047**	**6,336**	**$8,226**	**$1,067,817**

* Data not available

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Site Map

Since the buildings are not co-located a site map is not available for the buildings audited as part of this project.

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Summary of Buildings

Consolidated Building Data							
Buildings Audited	Conditioned Square Footage	Occupancy Schedule	Building Use	Original Construction Date	Type of Heating System	Type of Cooling System	Metering Data
Indoor Pool	10,279	M-F 15.5 Hrs/Day Sat 16 Hrs Sun 14 Hrs	Pool	1968	HW Boiler	AHU	
Dover Ice Arena	126,084	16 Hrs/Day	Arena	1974/2001	AHU	AHU/Chiller	
Waste Water Treatment Facility		16 Hrs/Day		1991	HW Boiler	AHU	
Dover City Hall	44,844	13 Hrs/Day	Offices	1935	HW Boiler	Mixed	
Public Works	54,800	10 Hrs/Day	Offices/Vehicle Storage	2001	AHU/Boiler	AHU	
McConnell Center	103,000	17 Hrs/Day	Office	1904	Heat Pump	Heat Pump	
Dover Public Library	20,000	10 Hrs/Day	Library	1905/1988	HW Boiler	AHU	
Jenny Thompson Pool		12 Hrs/Day	Pool	1977	HW Boiler	None	
Central Fire Station	7,000	24/7	Public Svc	1899	HW Boiler	Split/Window AC	
South End Fire Station	8,000	24/7	Public Svc	1967	HW Boiler	Split/Window AC	
Pine Hill Chapel	1,500	8 Hrs/Day	Office	1911	Furnace	Split AC	
Pine Hill Barn	1,500	24/7 *	Office	1900	Furnace	None	
Veterans Hall	2,952	500 Hrs/Yr	Assembly	1920		None	
Dover Train Station	4,791	8 Hrs/Day	Public Svc	2001	AHU	AHU	

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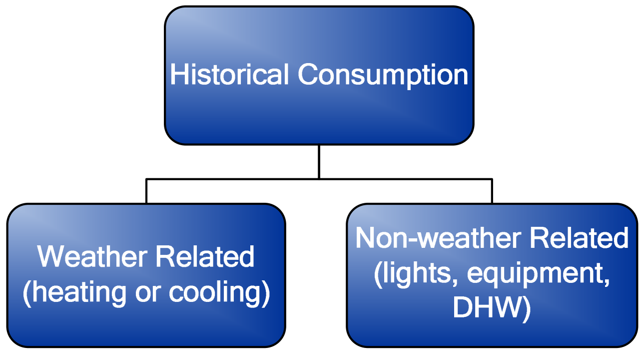
SECTION 3 - Utility Information

This section presents the utility rates that were used to determine existing and post-retrofit estimated utility costs. These utility rates will also be used to determine actual energy savings following installation of the measures in accordance with the measurement and verification methods described for each measure.

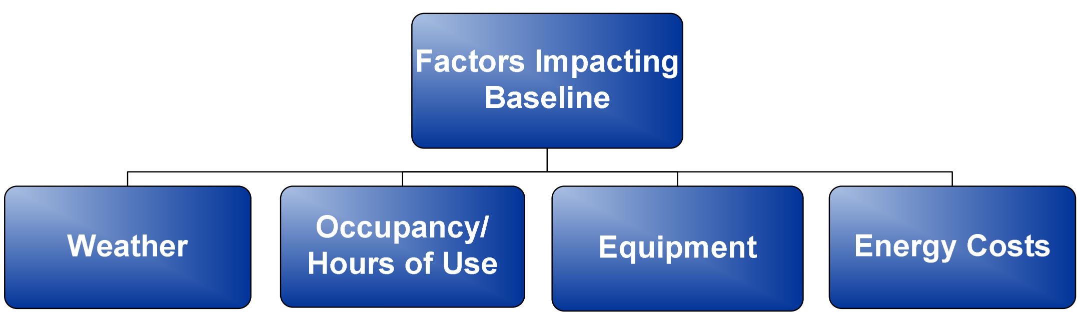
Two key elements comprise baseline data – weather-related usage and non-weather-related usage.



Baseline energy usage is compiled using historical utility data regarding the prior energy usage and conditions that affect that usage, such as weather, occupancy patterns, and building use and equipment.

As conditions, equipment, and usage change, the baseline may need to be adjusted periodically to account for those variables. The guaranteed energy cost savings are based on a reduction in energy units consumed from the current baseline, under the existing conditions. Changes in price or the existing conditions can result in either reductions or increases on the baseline energy use.

The projected energy savings are cost avoidance savings, and should not be viewed as an absolute reduction in the operating costs. The potential adjustments to the baseline are illustrated below.



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The baseline has been structured in the following manner:

Financial baseline	The actual energy usage for the most recent complete fiscal year will be assumed to be the minimum budget and all savings are calculated from those figures.
Weather baseline	The weather data corresponding to the same fiscal year shall be the minimum heating degree days and cooling degree days.
Consumption baseline	The energy consumption during the same fiscal year shall be the figures from which savings are calculated.
Occupancy baseline	The occupancy schedules (run hours, ventilation rates, personnel levels, existing equipment, etc.) shall be the minimum values for projecting savings.

As such, Johnson Controls takes a snapshot of the facility as it operated during the most recent fiscal year. Because the City had a budget that met these conditions, this budget is the Baseline Budget or Financial Baseline to be used.

If, during the period of the energy performance contract, the weather is more severe than during this "study" period, the savings will actually be more than anticipated, but the City will need to budget funds for severity, as the increases in efficiency may not totally offset the severity index.

If the weather is less severe, resulting in an overall reduction in consumption, the savings will be adjusted to determine the level of savings that would have been achieved under normal weather conditions. The overall energy expense to the City in this scenario should actually be less than projections for an average winter.

In non-weather sensitive cases, such as lighting, savings will be based on the current occupancy hours and rate, even if the actual hours of operation change.

This approach allows the flexibility to operate the facilities as the City sees fit without jeopardizing the guarantee.

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Rate Summary Table

The following charts and graphs identify the Base Year electrical and gas usage for the City of Dover. This utility data will be the basis from which Johnson Controls shall arrive at the baseline to determine the guaranteed savings.

City of Dover, New Hampshire

Utility Rate Summary (Based on FY 2008)

Rate Summary Table							
	Electricity		Natural Gas	Oil	Propane	Water**	Sewer**
Building	$/kW	$/kWh	$/Therm	$/Therm	$/Therm	$/HCF	$/HCF
Indoor Pool	$8.82	$0.104	$1.437	-	-	$3.75	$4.51
Dover Ice Arena	$7.09	$0.105	$1.264	-	-		
Waste Water Treatment Facility	$7.03	$0.119	-	$1.667	-		
Dover City Hall	-	$0.125	-	$1.667	-		
Public Works	-	$0.128	$1.128	-	-		
McConnell Center	$7.10	$0.107	$1.412	-	-		
Dover Public Library	-	$0.135	$1.414	-	-		
Jenny Thompson Pool	-	$0.126	$1.349	-	-		
Central Fire Station	-	$0.125	$1.528	-	-		
South End Fire Station	-	$0.128	-	-	$1.768		
Pine Hill Chapel	-	$0.169	-	$1.667	-		
Pine Hill Barn	-	$0.200	-	$1.667	-		
Veterans Hall[1]	-	$1.650	$1.803	-	-		
Dover Train Station	-	$0.122	$1.913	-	-		

*unblended cost if demand charges are available, if not blended cost

[1] Since veterans Hall does not consume the minimum amount of electricity they are charged a fixed monthly amount which is reflected in the $/kWh price of electricity.

** Since water/sewer consumption data was not available for all the buildings, current rates were used for all the calculations.

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Rebate and/or Subsidy Opportunities

Rebates are available through the local utilities for the retrofits proposed herein.

Estimated PSNH Incentives

Lighting

Estimated Utility Incentive (Estimated by ESCO)

Building	Fixtures	Controls
Indoor Pool	$1,360	$25
Ice Arena	$5,050	$1,325
City Hall	$1,735	$1,140
Public Works	$8,790	$2,720
Public Library	$3,060	$1,335
Totals	**$19,995**	**$6,545**

Total Estimated Lighting Incentive:	$26,540

VFD Installation

Motor Application / Name	Motor Size hp	Est. Incentive
Ice Arena – Floor Pump	25	$2,050
Ice Arena – Brine Pump	50	$3,100
Pool – New AHU	10	$1,350
Totals		**$6,500**

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Incentive Summary

FIM	Incentive	% Expected	Total
Lighting	$26,540	100%	$26,540
VFD Installation	$6,500	100%	$6,500
Total	**$33,040**		**$33,040**

Custom Incentive
Dependent upon Energy (kWh &kW) and Cost Savings, Payback and Project Cost
Utility Representative decides amount, could be up to 35% of installed cost

Estimated Installed Cost: $900,000

Installed cost of equipment directly related to electrical savings

CUSTOM INCENTIVE	Incentive	% Expected	Total
Potential Custom Incentive:	$54,810	50%	**$27,405**

Custom incentives are estimated using utility guidelines; all measures must be submitted and pre-approved by utility before any rebates are granted. Above amount is estimated.

Estimated Grant Funds
Federal and State Energy grant funds are available via EPA, NHDES and NHPUC. RGGI programs to provide incentive and offset project cost for energy efficiency measures.

ESTIMATED GRANT FUNDS	Incentive	% Expected	Total
Federal and State Grants	$165,000	100%	**$165,000**

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Estimated Northern Utilities Incentives

Large Business Customers

Includes all municipal buildings

Annual Gas Usage exceeds 40,000 therms

Must be on a firm Commercial Rate

Northern Utilities will pay 50% of the qualified installed cost, up to a maximum of $50,000 per master meter

Areas evaluated

Boiler/Burner
Improvements
Heating system improvements
Water heating system improvements
Gas-Fired process equipment
Control Improvements
Heat Recovery
Potential
Ceiling / Wall
Insulation
Gas Fired Steam Absorption Chillers

Estimated Installed Cost:	$300,000

Installed equipment directly related to Natural Gas Savings

Northern Utilities (N.G.)		**% Expected**	**Total**
Potential Incentive:	$150,000	50%	**$75,000**

* *Customer gets the entire rebate.*

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Developing the Baseline

In order to accurately assess performance of a FIM, it is necessary to be able to make comparisons of pre-retrofit and post-retrofit conditions of the facility under similar terms. The pre-retrofit baseline has been established by documenting conditions (in terms of unit energy consumption, energy efficiency, or other performance parameters) over a defined time period. The baseline will thus provide a yardstick for the pre-retrofit operation of the facility in terms of hours of use on a daily/monthly/yearly basis and the corresponding energy consumption performance for those hours of use. When possible, a baseline may be created from already-established energy consumption information as well. A facility may have historically recorded annual utility data by end use and utility type, which may be adequate to establish a baseline. Alternatively, a baseline may be established by using utility billing data for a utility type and knowledge of the various end uses, if the agreed-upon data are representative of pre-retrofit physical and operational conditions.

In order to develop a baseline for a facility, we must gain an understanding of the various utility types (electricity, natural gas, oil, central steam, etc.) used at the facility; whether the various utilities are metered on more than one utility (billing) meter per utility type; and whether the facility in question is a single- or a multi-building facility. Typically, a baseline is established for each utility type. For example, in an existing facility that has a constant volume HVAC system and is being considered for an energy saving retrofit, if the HVAC system is heated and cooled by electricity, then a single baseline is used to define its pre-retrofit operation and performance. If the HVAC system uses electric cooling and gas heating, then two baselines are required to define its pre-retrofit operation and performance: one for its electricity use and one for its gas use. If the project being considered addresses building(s) with multiple electric meters, multiple baselines would be necessary. An “all electricity use” facility with one utility meter and multiple buildings requires multiple baselines to identify the individual energy use pattern of each building. When we establish the baselines, the given conditions of a particular project may be simulated to lessen the complexity of baseline determination.

A baseline is the set of agreed-upon operating conditions, including hours, load(s), and other related values. The performance measurement is the measured value(s) of the (post-retrofit) operating condition(s) affected by the retrofit implementation. Energy savings are the result of the agreed-upon energy savings calculation, which is based on the difference between the performance measurement(s) and its associated baseline value(s). Energy cost savings is determined by applying the appropriate unit cost to the calculated energy savings. Total Dollar Savings is the sum of the energy cost savings from each retrofit and any other savings as identified herein.

The schematic sequence of calculations, for each day of each month, is as follows:

1. Sensible hourly loads for all zones are calculated component by component:
    - (a) envelope loads are calculated using the Transfer Function Method
    - (b) the radiant portion of instantaneous heat gains from lighting, equipment, process, and occupant loads are converted to hourly cooling loads using Room Transfer Function

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(c) the convective portion of sensible instantaneous heat gains are calculated from instantaneous hourly values
(d) the sensible loads from air infiltration are calculated from daily average values
(e) duct losses are computed from duct specifications and hot and cold supply temperatures and ambient temperatures.

2. Latent hourly loads for all zones are obtained directly from (a) the latent portion of convective heat gains from equipment, occupants, indoor swimming pools, and process, and from (b) the latent load from air infiltration calculated on a daily average basis only; and from (c) latent duct losses computed from duct leakage and supply and ambient humidity ratios.
3. Where indoor temperature is not held constant, actual hourly Heat Extraction Rates are calculated from the sensible cooling loads in each zone, taking into account room air circulation and thermal mass of each zone. If indoor temperature is held constant, Heat Extraction Rates and Cooling Loads are assumed identical.
4. Hourly energy use for water heating is calculated by taking into account the actual usage schedules and storage effects during times of high demand. The energy requirements to meet water-heating loads can be modeled either through stand-alone water heaters or as part of a boiler plant that also meets space-heating loads.
5. System supply air requirements and cooling coil and heating coil loads are modeled next, as a function of occupancy ventilation needs; ventilation controls; hot and cold supply air controls, and thermostat or humidistat controls.
6. Heating and cooling energy to meet heating and cooling coil loads are simulated by using performance models of boilers, furnaces, chillers, DX-air equipment, air-air heat pumps and water-air heat pumps. Sensible and latent full-load capacities (total capacity only for heating equipment) are dependent on temperature and humidity ratio of ambient air and of the supply air stream at the coil. Wherever possible, manufacturer's data are used to characterize the capacity dependence on the applicable temperature and humidity conditions. Part-load performance of heating and cooling equipment is modeled using polynomial fits to part-load ratio. Wherever practical, functional forms and coefficient values are taken from DOE-2.1.
7. All energy requirements by auxiliary equipment (lighting, equipment, process, swimming pools) are separately calculated on an hourly basis and tabulated by fuel type.
8. After all hourly energy requirements are calculated, monthly consumption totals and demand are calculated and, if required, by the energy rates specified, broken down into appropriate time-of-use periods using the hourly profiles.
9. Energy rate calculations are performed on monthly data of consumption and demand (broken down by TOU for rates that so require). Virtually all types of commercial and industrial rates encountered in the U.S. and Canada can be modeled by Market Manager through a hierarchical rate classification scheme.
10. Measure calculations are done, if measures were used to specify scenarios, to separate the individual contribution of each measure to the overall savings of the measure package that contains the measure.

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Adjustments to the Baseline

The following is a summary of how a baseline can be developed using utility data and regression analysis techniques. In all cases, modifications will be documented and mutually agreed upon with the customer.

Select a Tuning Period. First, Johnson Controls will identify a pre-retrofit time period that is representative of physical and operational conditions within the premises.

Identify Relationships of Consumption to Independent Variables. We will then apply a regression analysis calculation to each individual utility item during the selected tuning period against one or more independent variables. The resultant relationship of utility consumption as a function of time, weather, and other independent variable is represented by the regression analysis calculation.

Make Modifications to the Baseline. A modification will be made up of a number of units to be applied, a time period to apply the units, and a description of why the modification is being applied.

Use Annual Periodic Modifications. Johnson Controls uses annual periodic modifications to adjust the baseline consumption for anomalies that may have occurred during the tuning period due to operational procedures or abnormal conditions. Such “out-of-line” consumption periods may cause the regression equation to over- or under-predict consumption. Modifications help to fit the equation’s predicted value to the actual value that occurred during the tuning period. We can then predict future consumption with a high degree of confidence once the predicted and actual tuning period consumption is matched properly.

Make Additional Modifications. Johnson Controls may also make modifications to the baseline to account for physical or operational changes within the premises that are beyond the scope of the approved conditions.

Calculate Utility Consumption Savings. Johnson Controls calculates an adjusted baseline by performing the regression analysis and applying to it any necessary modifications for each time period being evaluated. This adjusted baseline represents the utility consumption that would have occurred if the retrofits had not been implemented. Utility consumption savings are derived from the difference between the adjusted baseline consumption and the actual post-retrofit consumption for the same period.

Calculate Utility Cost Savings. Utility cost savings will be determined by applying the appropriate utility unit costs to the consumption units. Total dollar savings is calculated from the sum of the utility cost savings from each utility type and any other savings as identified.

Miscellaneous Adjustments. Johnson Controls understands that during the life of the contract, changes may occur in the use, operation and/or maintenance of facilities, systems and equipment,

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in ways that impact the baseline or affect the calculation of savings. We also understand that utility rates and billing methods may be modified by utilities during the course of the contract. In such cases, Johnson Controls will work with the customer to achieve mutually agreeable adjustments, refunds, and rebates.

Individual Facility Improvement Measures (FIM) Evaluation

A baseline will be developed for each building utilizing the data collected. This baseline must be within 2 percent of the actual utility data. This establishes the “as built” energy performance of the building. Modifications are implemented, one FIM at a time, with a resultant new energy profile. The model calculates the difference in usage should that FIM be implemented. In addition, the cost to install that FIM is determined using industry-standard estimating methods.

At this level, each FIM will be considered independently, as if only that FIM were implemented. This will provide a fair evaluation of the economic impact of each FIM. Cost savings will be calculated using the unit costs provided by the customer. The following factors will determine whether or not to include a particular FIM in the final model:

- Energy cost impact and simple payback
- Useful life
- Effect on building maintenance and operation cost
- Implementation time
- The customer’s priority list of improvements
- Positive effects on tenant comfort and system reliability

When selecting FIMs, evaluating each FIM independently does not reveal the bottom line energy savings that will occur if more than one FIM is implemented. Interaction between FIMs that will ultimately increase savings associated with each FIM. A final evaluation is performed, which includes all FIMs actually implemented so interactive energy savings can be calculated.

The interactions between FIMs can affect the actual energy savings, implementation costs and payback periods. For example, if a lighting retrofit and cooling system improvements are implemented in the same area, the lighting retrofit will reduce heat loads in the area and, therefore, increases the cooling savings. Our analysis will allow for the “cascading” of FIMs, namely recalculating the savings from the previous FIM results.

The final step in the detailed study is the preparation of a comprehensive report. All FIMs evaluated will be presented to the customer for consideration. The choosing of the project FIMs will be a joint effort between Johnson Controls and the customer. Different scenarios can be prepared to determine the most desirable and cost-effective solution. The final project installation will include those FIMs selected.

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Factors that Necessitate Adjustment to the Baseline

During the initial energy baseline creation and during the ongoing performance management of the project, it may become necessary to adjust the energy baseline for factors or unique changes in the building's use, utility or for non-controllable variables. Common adjustments are for items such as:

- Additions or deletions of conditioned square footage.
- Major increases or decreases in building occupancy.
- Major changes in the weather.
- Major additions or deletions to the non-temperature sensitive loads in the facility such as computers, copiers, printers, etc.
- Changes resulting from the addition or replacement of equipment with more energy efficient equipment.
- Changes in production variables.
- Major changes in building operations outside of the energy baseline parameters.

Approach Johnson Controls' approach to energy baseline adjustments is to ONLY apply adjustments where it is both fair and equitable for both Johnson Controls and our customer. Our approach is not to claim savings for consumption or demand reduction that did not result from Johnson Controls or the energy conservation measures. Nor do we believe that we should be financially harmed by changes outside of our control that negatively impact the savings generated. Furthermore, our assured performance guarantee is designed for modifications versus cancellation. Rest assured that our assured performance guarantee will never be canceled due to changes but rather modified to reflect the adjustments to which our customers and Johnson Controls agree.

Methodology Johnson Controls' methodology to adjust our energy baseline for one or all of the above variables is accomplished as follows:

- Calculate the Impact: Johnson Controls models the change(s) to calculate the impact on the energy baseline.
- If a Utility Bill Comparison Savings Calculation Method was utilized on the project, then Johnson Controls takes advantage of the advanced features of the Metrix software to simulate the energy baseline change as a result of the interplay of the occupancy +/-, weather +/- and usage +/- changes.
- If a Measure Specific Comparison Savings Method was utilized on the project, then Johnson Controls computes the energy baseline calculation utilizing the changed variables and compares this with the actual measured calculation to determine the impact of the change(s).
- If a Stipulated Performance Measure was utilized, no change to the energy baseline is computed, as stipulated energy savings are agreed, upon contract signing, to have been considered achieved.

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Customer Approval Once Johnson Controls has computed the impact of all adjustments to the energy baseline, this information is then provided to and reviewed with our customers. Our customers then either accept or reject our proposed adjustments. If our customer accepts the proposed adjustments, the energy baseline is adjusted accordingly and savings are computed and reported based upon the adjusted baseline. If our customer rejects the proposed adjustments, then Johnson Controls and our customer agree to a proposed course of action to resolve the adjustment issue. This might include utilizing an expert disinterested third party, agreeable to both Johnson Controls and our customer, to provide binding direction for adjustments. Upon such direction, Johnson Controls then computes the energy baseline utilizing the agreed upon adjustments and report savings accordingly.

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SECTION 4 - Savings Opportunities Summary

On the following pages, we have described several Facility Improvement Measures ("FIM") deemed as viable energy conservation opportunities for the City of Dover. The recommended FIMs were selected from a long list of possible improvements, and were based on gaining the greatest benefit for the money spent. Please refer Page 87 for Facility Improvement Measures (FIMs) that were studied in detail and based on payback were not included in the final scope. Based on the information gathered during the Detailed Energy Audit and Johnson Controls' extensive experience with local government buildings throughout New England, the measures identified represent a significant reduction to base year utility expenditures for the City. We estimate that the successful implementation of these measures will result in a 23% reduction of the base year utility spend.

Listed below are assumptions that are common to all FIMs:

- Savings for all measures are interacted with each other. The proposed conditions from one measure may be the existing condition for another. In general, boiler replacement savings are considered and calculated first, then, other equipment modification and load reduction savings are taken next, with boiler savings as MMBtu.
- All savings are calculated using the present electricity rates in effect at each of the facilities.
- Unit operating conditions (air flow, kW, temperatures) were determined with field measurements whenever possible, and for a portion of the population. In some cases, particularly with air flows, if direct measurements were not possible either with hand-held anemometers or through the energy management system, baseline values were taken from original design drawing schedules. If those were not available, the filter bank size was observed and air flow was estimated based on a typical, 500 fpm design value.
- The retrofits will occur in the existing facility areas only. Any future building additions or renovations are not included at this point.
- All new systems will be designed and constructed according to applicable codes and standards.
- Asbestos abatement costs are not included in the project estimates. Any asbestos removal work that is required will become the responsibility of the City.
- Cost estimates are based on contractor quotes for the work concepts outlined herein. Cost estimates include an allowance for working within the City Buildings and the inherent difficulties associated with occupied buildings, plus disposal of removed equipment. No sales taxes are included. Detailed estimates include everything necessary for a complete, working installation, plus system check-out and start-up.
- Project costs are estimated based on standard, facility working conditions and normal, daytime work hours, with an allowance for some second and third shift work that may be required for work that occurs within spaces (or above the ceilings of spaces) that are normally occupied during the day.
- Prevailing wages are assumed.

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FIM 1 & 2 Lighting – Fixture Retrofit & Controls

Detailed Description of Facility Improvement Measure

Johnson Controls has performed a survey of the interior lighting system at several City of Dover buildings and has found opportunities to capture energy savings, improve lighting quality and reduce maintenance costs.

As a result of the survey and analysis, Johnson Controls has developed a high efficiency lighting upgrade project that will provide the City of Dover with a retrofit of over 2,250 existing lighting fixtures resulting in an annual savings of 239,036 kWh and a reduction in electrical demand of 85 kW. For a detailed reference, a room-by-room lighting survey is included in the Appendix.

Existing Conditions

Lighting – Fixture Retrofit

The existing lighting system data utilized for this project was collected during site visits conducted by Johnson Controls in October, 2008. The hours of operation have been determined from schedules provided and/or verified by the City of Dover at the time of audit. The lighting demand (kW) per fixture, fixture quantities and recommended Facility Improvement Measures as listed, are based on the physical inspection of, and subsequent analysis by Johnson Controls.

In identifying the lighting improvement measure opportunities Johnson Controls has attempted to establish an accurate accounting of the various fixture styles, lamp and ballast types being used in the facility; the operating characteristics and various illumination requirements of the lighting system; long term energy and maintenance savings opportunities within the operating constraints of the existing system and immediate energy savings opportunities based on the impact of the Energy Policy Act of 1992 (EPACT).

The results of Johnson Controls' technical analysis indicate that the majority of energy savings opportunities result from conversion of existing T8 fixtures to more efficient lamps and ballasts. During the survey, opportunities were identified for the installation of occupancy sensors

Lighting – Fixture Controls

In the City of Dover's buildings, lighting loads in the offices, corridors, mechanical rooms, administrative offices, stairwells and other areas are currently controlled utilizing standard one way or two-way wall switches. Opportunity exists to improve the overall operation of the facilities lighting systems through the installation of occupancy sensors.

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Proposed Conditions

Lighting – Fixture Retrofit

Johnson Controls, Inc. proposes to retrofit the lighting systems with new high efficiency fixtures. The proposed lighting retrofits have been identified and are included with this Detailed Energy Audit as an Appendix. In general, JC will retrofit all fixtures that are candidates for retrofit/replacement with new fixtures or new lamps and ballast combinations.

The proposed lighting system shall:

1. Provide the most energy efficient lighting available on a retrofit or replacement basis, using state-of-the-art components and technology.
2. Exceed all Federal Energy Policy Act of 1992 (EPACT) lamp and luminaire efficiency standards.
3. Provide maintained light levels, which meet or exceed current Illuminating Engineering Society (IES) recommendations, while addressing particular illumination requirements for specific area and task functions.
4. Provide a quality of light conducive to a productive, safe and aesthetically pleasing environment. Specifically, issues of color rendition and uniformity of illumination shall be addressed.
5. Provide a reduction in future maintenance requirements through the standardization, extended life cycle and reduction in quantity of system components.

Lighting – Fixture Controls

In order to implement appropriate fluorescent lighting control throughout the included buildings, Johnson Controls recommends the installation of the following occupancy sensor:

> Type W- This is a dual technology sensor utilizing ultrasonic and passive infrared wall or ceiling switch sensor to be installed in small offices and various use areas. It will control 2-16 lighting fixtures, with loads ranging from 62 watts to 1000 watts.

In addition to the energy savings derived from the reduced operating hours, we assume that these occupancy sensors will reduce the fluorescent lighting kW demand. This presumes that there is a coincident factor of 20-30 percent of the controlled lights off at any time during on-peak hours. This is based on extensive practical experience in similar lighting control installations. Johnson Controls has not taken any credit for this demand reduction.

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Savings Estimate

Savings Calculations

Savings calculations for lighting retrofits are generally calculated using the following methodology:

Baseline Energy Usage (kWh/yr)	=	Existing Fixture Watts x Operating Hours/yr x 1 kW/1000 Watts
Estimated Energy Usage (kWh/yr)	=	Proposed Fixture Watts x Op. Hours/yr x 1 kW/1000 Watts
Energy Savings (kWh/yr)	=	Baseline Energy Usage – Estimated Energy Usage

The following savings calculations represent the energy savings from the implementation of lighting controls on fixtures identified in the lighting tables in the Appendix. For lighting controls, the baseline fixture watts for determining savings have been based on the post-retrofit fixture wattage.

Baseline Energy Usage (kWh/yr)	=	Controlled Fixture Watts x Operating Hours/yr x 1 kW/1000 Watts
Estimated Energy Usage (kWh/yr)	=	Controlled Fixture Watts x Operating Hours/yr x 1 kW/1000 Watts x % hours "off"
Energy Savings (kWh/yr)	=	Baseline Energy Usage – Estimated Energy Usage

Table 1-1: Energy Savings Summary

Savings Summary	
Water (kgal/yr)	-
Water and Sewer ($/yr)	-
Electricity (kWh/yr)	239,036
Electricity (kW)	85.0
Electricity ($/yr)	$30,369
Thermal Energy (MMBtu/yr)	(-1,539)
Thermal Energy ($/yr)	($1,990)
Total Savings ($/yr)	$28,379

Assumptions

The following specific assumptions were made:

- See calculations in Appendix 3 and line-by-line in Appendix 5

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Operating Hours

In order to calculate the energy savings illustrated above, Johnson Controls relied on the kilowatt reduction achieved through its design and the facility's representation of the operating hours within the facility. Based on information gathered during interviews with the facility staff, an operating profile was determined to represent the majority of the lighting within the space considered for different areas as follows: (The following list provides a sample of operating hours used to determine energy savings. For area specific operating hours please refer to the room-by-room survey located in the Appendix hereto.)

Table 1-2

Representative Location(s)	Hours of Operation	
	Weekly	Annual
Admin, Offices	43	2,250
Conference	30	1,600
File Storage	19	1,000
General Storage	9.6	500
Offices – Other	30	1,600

Scope of Work

A detailed listing of the fixtures proposed and room-by-room retrofits is included in the Appendix 5.

The lighting retrofit proposed for the City of Dover includes:

- Retrofit existing T8 fixtures with Super T8 electronic fixtures; provide tandem wiring double fixtures and reflectors according to the room-by-room table in the Appendix. A summary of each proposed retrofit is given in the Appendix.

  As a standard for installing T8 lamps, Johnson Controls will provide a high-grade "super saver" lamp that carries a higher color rendering index (CRI of 75 or greater) and higher lumen output per watt than the current T12 lamp type in use. Johnson Controls has specified a 4' F32 (28watt) 4,100K lamp that will pass the Federal guidelines relating to hazardous waste, specifically minimal mercury content, as the standard. It is due in part to the higher lumen per watt rating and the use of new lamps and ballasts that the light output from newly retrofitted fixtures will produce a higher foot-candle average than the existing system. In addition, due to the longer rated life and the ability of the T8 tri-phosphor lamp to maintain its lumen levels longer, there are ongoing maintenance savings attributable to the project.

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- Installation of switch mounted, wall and ceiling mounted “dual technology” occupancy sensors as outlined in the Appendix
- Retrofit of incandescent fixtures with compact fluorescent lamps as outlined in the Appendix
- Retrofit of mercury vapor fixtures with metal halide fixtures as outlined in the Appendix.
- Removal of fixtures and de-lamping as outlined in Appendix.
- Replace metal halide fixtures with new pulse start fixtures as outlined in Appendix.

Exclusions

- None noted

Hazardous Waste Disposal

All necessary and appropriate barrels and containers for proper packaging of all PCB-containing ballasts and mercury-containing lamps removed are included as part of this project. Johnson Controls and its subcontractors will assume no liability in the generation, ownership or responsibility for hazardous waste material, except to assist in the coordination of the packaging of material removed. As part of this program, Johnson Controls has included the cost for handling, recycling and disposal of ballast and lamp waste.

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FIM 3 Building Envelope Improvements

Detailed Description of Facility Improvement Measure

Existing Conditions

Heat is lost from various locations throughout the buildings in the City due to infiltration. The heat losses and heat gains occur due to gaps and openings that allow the building's conditioned (heated or cooled) air to mix with the outside ambient air.

Throughout the buildings, many leaks were found that would allow heat to be lost during the winter and gained during the summer. These openings range from gaps around doors, exhaust pipes, rooftop ventilators and windows. Also, unsealed roof-wall joints and rooftop ventilator dampers stuck in the open position contribute to leakage in some buildings. Outside wind conditions also provide increased pressure gradients across the leakage surfaces, which allow for correspondingly increased leakage rates. Temperature gradients also create the "source to sink" flow, therefore, the greater the difference between the outside air and the indoor air temperature, the greater the rate of infiltration.

Proposed Conditions

Johnson Controls Inc. proposes that doors be weatherproofed, sweeps installed/ replaced and caulking be applied around structural leakage. During the door weatherproofing process, the hinges may need to be replaced to ensure proper mechanical functioning. Windows will be re-caulked around the rough-in perimeter, and locations along the soffit and fascia will be sealed. Roof penetrations, wall joints and any other envelope penetrations will be properly sealed.

Savings Estimate

The size of the cracks/openings is estimated based on visual inspection. The area of the opening is calculated based on the information obtained during the inspection process. The volume of air moving through the openings is then calculated using an ASHRAE developed equation. Local weather data including average temperature difference and wind speed are also used to calculate the air volume in CFM. The energy required to condition this volume is then calculated using the following equation.

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Table 3-1: Energy Savings Summary

Savings Summary	
Water (kgal/yr)	-
Water and Sewer ($/yr)	-
Electricity (kWh/yr)	4,486
Electricity (kW)	-
Electricity ($/yr)	$488
Thermal Energy (MMBtu/yr)	1,019
Thermal Energy ($/yr)	$13,973
Total Savings ($/yr)	$14,461

Assumptions

For assumptions please see detailed calculations in Appendix 3.

Scope of Work

The scope of work for this measure will include the following services. (The locations and length/area are shown separately.)

Door weather-stripping

Carrier Installation

- Carrier cut to length of jam
- Compression seal cut to length of carrier
- Snap compression seal into carrier
- Attach carrier to jamb
- Measure header length
- Cut carrier to length
- Assemble and install
- Caulk perimeter

Sweep Installation

- Measure door bottom
- Cut sweep to length
- Install sweep

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- Caulk sweep

Adjust and check each operating unit of hardware and each door to ensure proper operation or function of every unit. Replace units that cannot be adjusted to operate freely and smoothly or as intended for the application made.

Roof Wall Joint Sealing

- Lift T-Bar drop ceiling tile from wall, and place aside
- Apply to roof/wall joint in as even a bead as possible.
- Replace T bar ceiling tile and clean area below ceiling of any dust or dirt.

Roof Top Ventilators

- Remove screws holding unit down.
- Tilt unit to gain access to damper.
- Damper blades to be lubricated and inspected for function.
- Adjust blades where necessary.
- Seal perimeter of damper with appropriate material depending on gap size.
- Replace screws where necessary with at least #10 x 2".

Locations and Quantity/Length

Indoor Pool

- Two (2) Single Commercial Doors to be weather-stripped
- One (1) Double Commercial Door to be weather-stripped
- Two (2) Overhead Doors to be weather-stripped

Dover Ice Arena

- Ten (10) Single Commercial Doors to be weather-stripped (exterior)
- Five (5) Double Commercial Doors to be weather-stripped (exterior)
- Seventeen (17) Single Commercial Doors to be weather-stripped (interior)
- Ten (10) Double Commercial Doors to be weather-stripped (interior)
- 192' Roof Level change to be sealed
- 3,120 Square feet of 4" Foam to be installed on underside of 2 x 6 Roof Deck and Interior 2 x 4 Wall of Attic Space (attic space above locker room addition)
- 120' Soffit to be sealed (attic space above locker room addition) *will be sealed when insulating roof deck
  * Fiberglass must be removed from attic space before installation of foam can commence.

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Waste Water Treatment

- Five (5) Single Commercial Doors to be weather-stripped
- Three (3) Double Commercial Doors to be weather-stripped
- Three (3) Overhead Doors to be weather-stripped

Dover City Hall

- One (1) Single Commercial Door to be weather-stripped
- Five (5) Double Commercial Doors to be weather-stripped

Dover Public Works Facility

- Fourteen (14) Single Commercial Doors to be weather-stripped (exterior)
- One (1) Double Commercial Door to be weather-stripped (exterior)
- Four (4) Single Commercial Doors to be weather-stripped (interior)
- One (1) Double Commercial Door to be weather-stripped (interior)
- Twelve (12) Overhead Doors to be weather-stripped

McConnell Center

- Six (6) Single Commercial Doors to be weather-stripped
- Six (6) Double Commercial Doors to be weather-stripped
- Twelve (12) Roof Top Ventilators to be opened, perimeter sealed, dampers lubricated, 68 linear feet

Dover Public Library

- Four (4) Single Commercial Doors to be weather-stripped
- Three (3) Roof Top Ventilators to be opened, perimeter sealed, dampers lubricated, 16 linear feet

Central Fire Station

- Three (3) Single Commercial Doors to be weather-stripped
- Three (3) Overhead Doors to be weather-stripped

South Fire Station

- Three (3) Single Commercial Doors to be weather-stripped
- Three (3) Overhead Doors to be weather-stripped

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Pine Hill Chapel

- One (1) Single Commercial Door to be weather-stripped
- Two (2) Double Commercial Doors to be weather-stripped
- Fourteen (14) Windows to be Caulked (inside)

Pine Hill Barn

- No improvements recommended

Veterans Hall

- Four (4) Single Commercial Doors to be weather-stripped

Dover Train Station

- No improvements recommended

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FIM 4 Energy Management System - Upgrades

Detailed Description of Facility Improvement Measure

A total of six (of fourteen) City buildings are under the control of the building automation system; however there are some buildings with control systems that are operated manually. Although the operators are attentive to their duties, the installation of automated controls will ensure that the building is secured consistently in the unoccupied mode at night.

The objective of this measure is to retrofit non-functioning direct digital controls (DDC) and to install ductless split system to augment existing systems as further described herein, which will provide reliable occupancy and comfort control. Generally, overall occupied/unoccupied control will be overseen by the existing DDC system, but those controls in smaller spaces, such as offices will remain with pneumatic control if already equipped. Replacing complete controls on a room-by-room level is not cost-effective from an energy savings standpoint, but should be done whenever spaces are renovated. The benefits of replacing the controls and installing a ductless split system include improved occupant comfort, reducing maintenance staff time for trouble-shooting complaints, and significant energy savings.

Existing Conditions

During the detailed audit, the buildings located in the City of Dover were evaluated for the purposes of identifying energy savings opportunities. Many of the buildings are presently under the control of the Siemens building automation system (“BAS”); however upon inspection many of the systems and equipment were not functioning as designed and thus wasting energy. The following provides a brief summary of the existing conditions identified during the detailed audit which were verified through facility staff surveys, physical inspection and/or data logging.

> **Pine Hill Barn** – Audit shows that temperature is being maintained at 66-67°F, therefore opportunity to install additional temperature controls to enable night/unoccupied setback exists. The chart on the following page shows wide temperature swings across the logging period and also shows that the heating system is not being setback during unoccupied periods. Installation of new temperature controls would help alleviate this issue.

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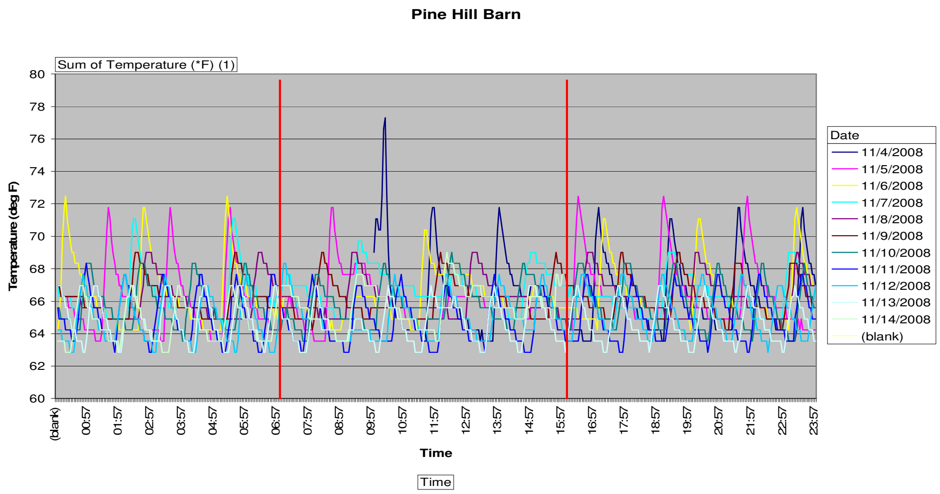
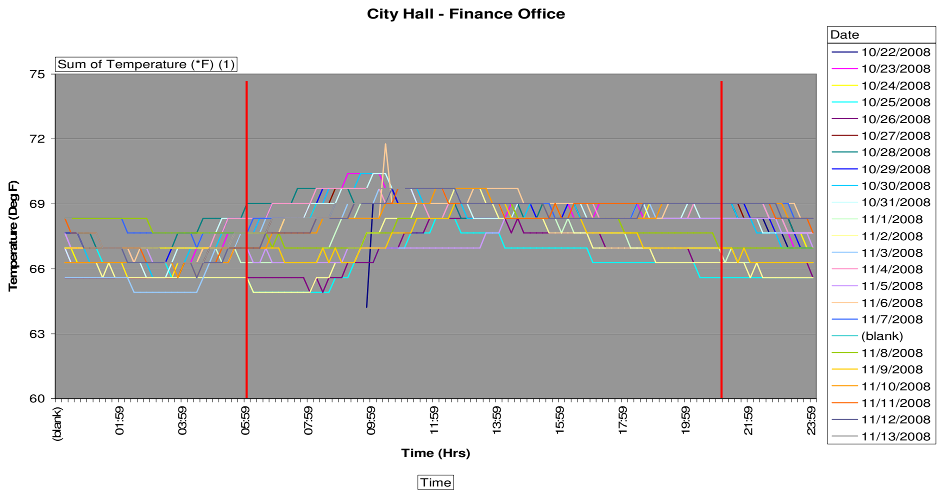


City Hall Controls – The Police Department is open 24/7 therefore opportunity to set back temperature in that space is limited. The building also has 1 AHU located in the Finance Office which is presently under the control of the Siemens system and is presently being setback from occupied temp of 70° to 65° during unoccupied hours. However, the occupancy schedule for this unit is less than optimal. The AHU is presently configured to cycle on at 3:00am and then turn off at 9:00pm. The chart below provides evidence that the AHU is being setback during unoccupied periods; however the control of the temperature setback is not optimal. Other areas, such as the auditorium, are not being set back; however temperature in the auditorium during the observation period did not drop below 65°F, which would indicate that the heating set point is not being adjusted based on occupancy schedules. Additionally, the building has 7 zones (steam radiation) in total that are under BAS control.



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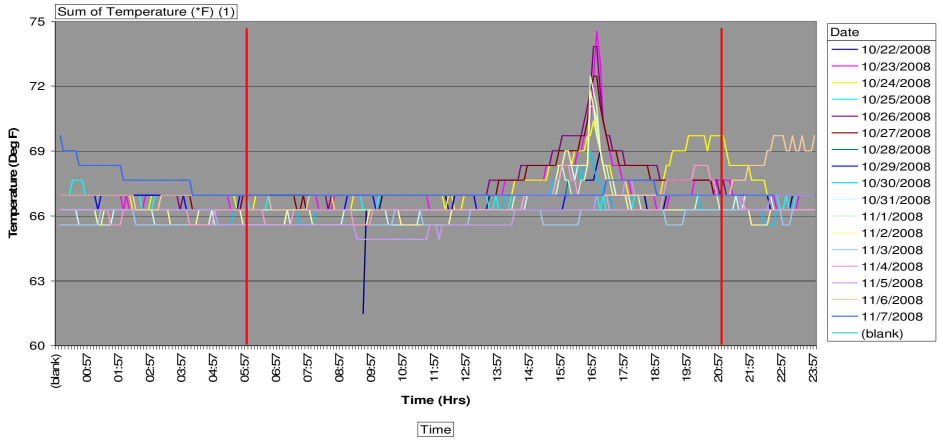
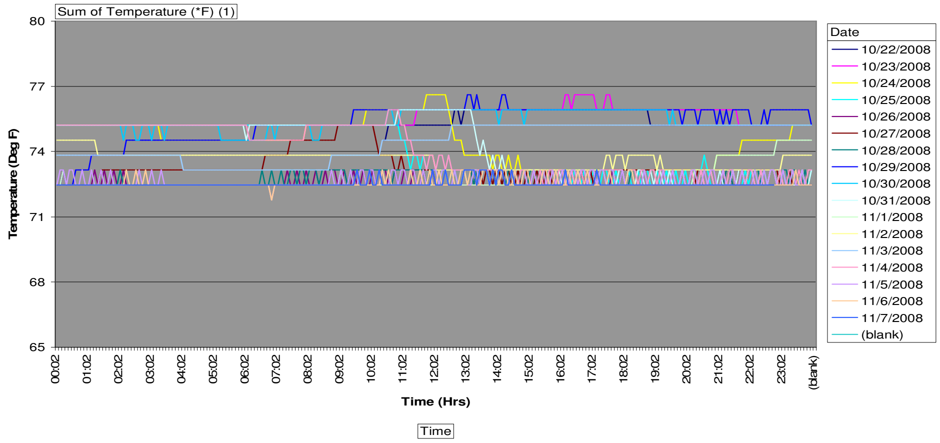
City Hall - Auditorium



City Hall - Police Department



Public Library – The AHU which serves the new section at the public library is presently under the Siemens control system. According to the Siemens BAS, this AHU is being setback from 74℉ to 65℉. During the audit data loggers were deployed within the new section of the library to determine the effectiveness of the setback program. The chart below provides data obtained for the new section of the library throughout the logging period. As evidenced below, the temperature is not being setback according to the programming in the BAS and therefore opportunity exists to control the space temperatures with the use of programmable thermostats. During the observation period, the boiler malfunctioned and was inoperable for a period of time. As such, we have relied on the data gathered during the initial day and observations of equipment. (Manual thermostat)

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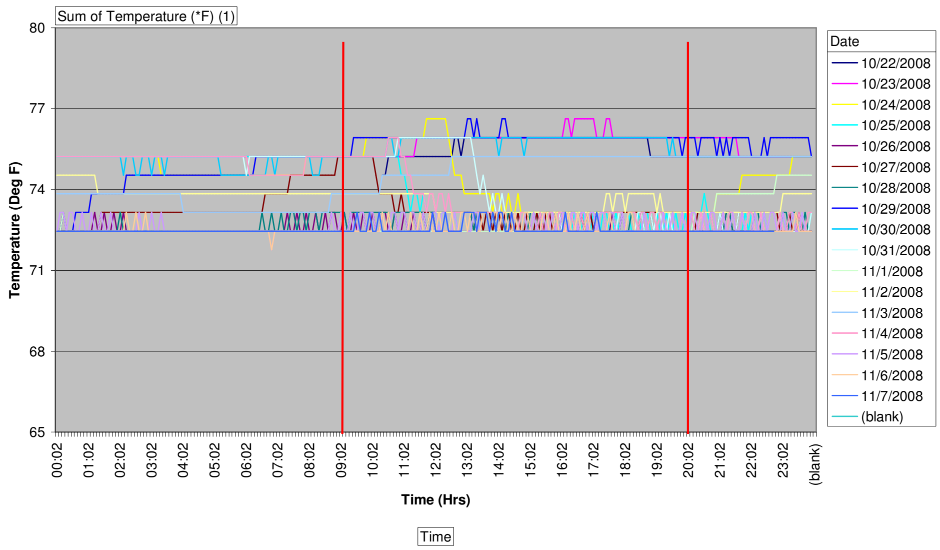
Public Library - 1st Floor (New section)



McConnell Center – The McConnell Center recently underwent a major renovation to enable more efficient space utilization and offer office spaces for several public programs. When renovated the heating and cooling systems within the building were upgraded to a water source heat pump system with a boiler and cooling tower to provide supplemental heat and heat rejection to the loop. Additionally, the building was configured with a large amount of fin-tube radiation to address heat losses around the perimeter of the building, specifically in areas with large amount of window spaces. During the audit it was observed that there are consistent temperature control issues within the McConnell Building that need to be addressed. A common compliant is that over heating within the spaces and simultaneous heating and cooling is occurring during the shoulder months.

This condition is caused primarily because the controls for the radiation and the heat pump systems are not configured with the right deadband settings. As a result, both systems are continually fighting each other to provide the right amount of cooling or heating depending on the spaces load and occupant requirements.

Additionally, data logging shows that the temperature in the spaces is not being set back during unoccupied periods (see chart below). Opportunity exists to improve the operation of the heating and cooling systems at the McConnell center through the implementation of proper deadband controls on the heat pumps and implementation of a night setback routine.

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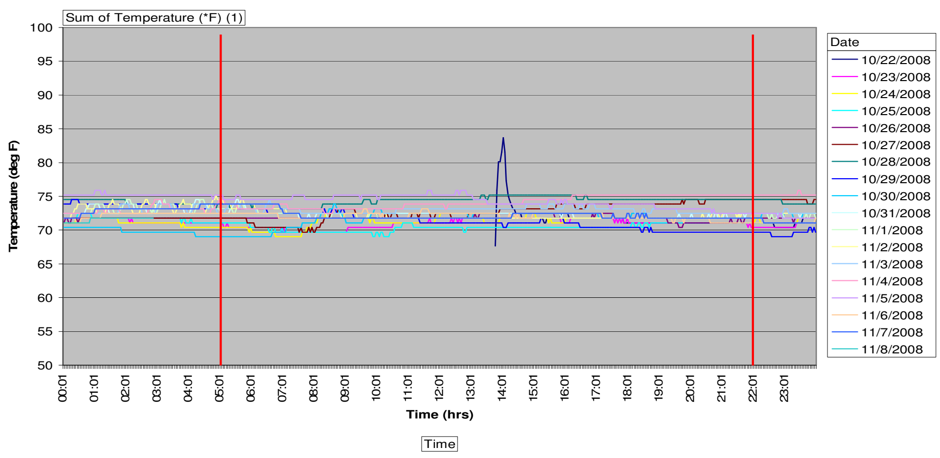
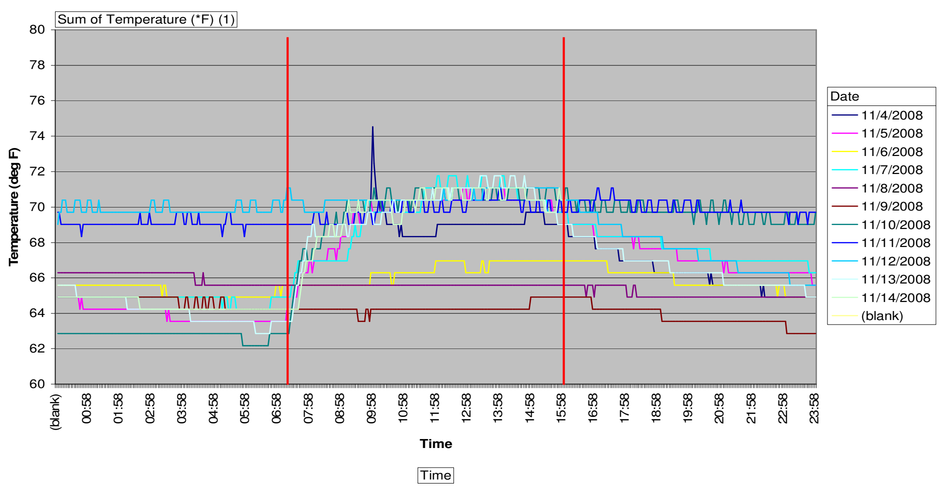
McConnell Center - 3rd Floor Office



Pine Hill Chapel – The building has manual thermostats which are presently being turned down at the end of the day by the building occupants. Data logging shows that this is consistently being performed by the facility staff. (see chart below) Opportunity exists to install a programmable thermostat to ensure consistent implementation of the setback schedule. Presently, setback is occurring 80% of the time based on data logging.

Pine Hill Chapel



South End Fire Station – This location is occupied 24/7 and has programmable thermostats with multiple zones to control the heating system. Therefore, opportunity for the installation of building controls is limited and not recommended. Additionally, during the detailed audit it was noted that when the fire trucks leave for a call the heating system remains operational and

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continues to provide heating when the overhead truck doors are opened, thus wasting heating energy. Opportunity exists to eliminate this condition by interlocking the heating system with the operation of the overhead doors.

Veterans Hall – Building is not under EMS controls, and occupancy for building is less than 500 hrs per yr. When building is not in use the heating systems are turned to the minimum set point.

Central Fire Station – This location is occupied 24/7 and has programmable thermostats with multiple zones to control the heating system. Therefore, opportunity for the installation of extensive building controls is limited and not recommended. Additionally, during the detailed audit it was noted that when the fire trucks leave for a call the heating system remains operational and continues to provide heating when the overhead truck doors are opened, thus wasting heating energy. Opportunity exists to eliminate this condition by interlocking the heating system with the operation of the overhead doors.

Jenny Thompson Pool – Building is not under EMS controls and does not have a heating system. There is no opportunity for implementation of control strategies.

Dover Indoor Pool – The Dover Indoor Pool is under control of the EMS system. At present the system maintains temperature and RH continuously without any setback in temperature. During the detailed audit, the temperature and RH were logged continuously for a period of 2 weeks to determine the actual operating conditions at the pool (see charts below). Based on this data logging it has become apparent that the EMS system is controlling the temperature well within the space, however there is presently no setback schedule enabled. Space temperature is maintained at 82-83°F and RH is enabled at 48-50%.

Air Handling System – Replacement/Temperature Setback

Conditioned air to the natatorium is supplied by a Dussault heating and ventilation unit with a heat recovery unit. This unit is original to the building and nearing the end of its useful life. Further, the manufacturer of this equipment is no longer in business and the availability of replacement parts is very limited. Based on information furnished by facility staff, this unit is in need of replacement. In its present configuration, the air handling unit does not provide adequate air changes per hour (ACH) as per building code. Current building code dictates that natatoriums operate with a minimum of 0.5 CFM of outside air per square foot of building area and a minimum of 5 ACH. Based on the present unit specifications and existing duct sizes it is estimated that the AHU is capable of meeting 4 ACH.

Opportunity exists to improve the operation of the air handling equipment and update old infrastructure. During periods of no occupancy, based on the temperature data it looks like the existing system is not controlling the air handling equipment to do setback (see chart below) and therefore it is recommended that the air handler be slowed down and the temperature of the space is setback.

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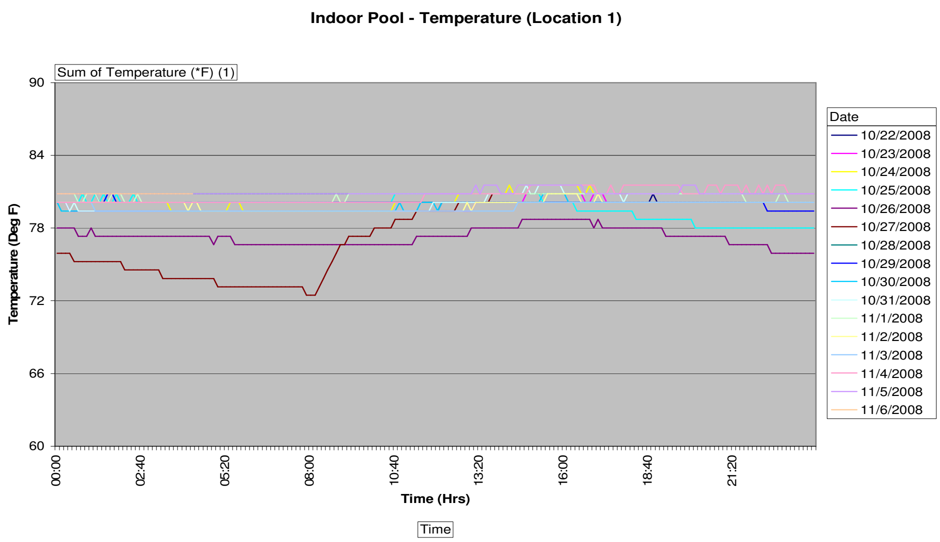

Pool Office – Eliminate Simultaneous Heating and Cooling

During the detailed audit all spaces within the pool building were evaluated for the purposes of identifying energy conservation opportunities. One area that presents opportunity is the pool office. At present, conditioned air (heated/cooled) is supplied via an air handler located in the closet mechanical room. In addition, fin-tube radiation is installed along the perimeter of the office to provide supplemental heating during the winter months. A thermostat located in the space provides temperature control for the AHU, however a separate thermostat provides temperature control for the fin-tube radiation. Based on JC walk-through, the fin-tube radiation is operational and provides supplemental heating when the air-conditioning is operational and providing cooling. Opportunity exists to eliminate this simultaneous heating and cooling by retrofitting the controls to enable proper operation of the system.

Dover Public Works – Building controls are installed at this location and based on field observations and data logging the existing system is not programmed properly to setback during unoccupied times. The EMS schedule for AHU-1 and AHU-2 is 5:00am to 4:00pm for occupied periods. Based on logging this setback is not taking place. The charts below provide data which further substantiates the fact that the air handling equipment is not being setback.

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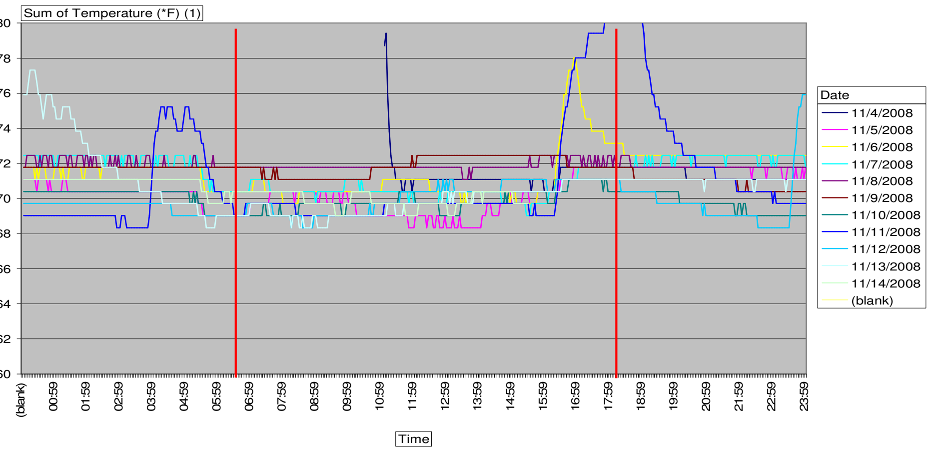
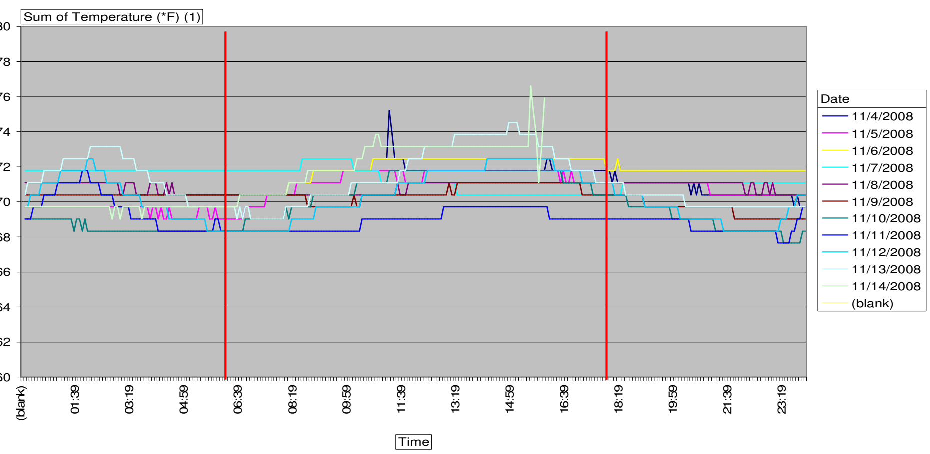
Public Works - Cafeteria



Public Works - Office Space



Ice Arena – A description of existing conditions for this location have been included within the Ice Arena FIM.

Dover Train Station – Presently, the mechanical systems located at the train station are not under the control of the Siemens BAS. Conditioned air is provided by an air handling unit located in the train station and according to facility staff, this air handler is operated via a programmable thermostat. During the detailed audit, the temperature setback programming of this thermostat was verified and at the time of the audit was operational.

In addition to the basic mechanical systems located at the train station, the platform is equipped with an electric resistance snow melt system. This system is located beneath approximately 200 sq ft of yellow safety markings at the edge of the platform. Operation of this system is controlled via a snow sensor mounted on a pole adjacent to the platform. At the time of the detailed audit,

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JC was informed that the snow melt sensor is not operational and the snow melt sensor had failed. Upon review of the three years utility data the electrical usage at the train station doubles during the winter months. It is estimated that approximately 30% of this additional usage is attributable to the winter/holiday lighting that is installed at the train station; however the remaining electrical usage is for the electric snow melt system. To eliminate this condition and reduce the amount of electrical usage at the train station it is recommended that the snow melt sensor be replaced as part of this project and a maintenance program be established to test and replace the sensor on a bi-annual basis.

Proposed Conditions

While comfort conditions in most spaces are kept within acceptable ranges (given the limitations of the existing controls systems), it appears that more energy-saving functions could be implemented in most mechanical systems, without loss of occupant comfort or jeopardizing any City programs. Rather than repair the existing, conventional controls, JCI will install direct digital control systems on the major HVAC systems in the buildings. Some areas may require minor programming, while others will require system upgrades to accommodate the proposed retrofit. Since the vast majority of the system is on the existing BAS most of the retrofits will be rudimentary. A description of the proposed retrofit follows.

Pine Hill Barn – Install a programmable thermostat to ensure consistent implementation of the setback schedule. The new temperature controls will be installed in place of the existing manually operated thermostats and programmed to setback the space temperature from 65°F to 60°F during unoccupied periods.

City Hall Controls – Since temperature controls are functioning as designed no retrofits are being considered for this building. However, it is recommended that the current BAS be evaluated and a basic controls optimization be performed at the building. This would include checking building set points, calibration of thermostats and verification of occupancy schedules for the 7 existing heating zones within the space. Installation of ductless split system to replace inefficient and labor intensive window air conditioners in approximately 10,000 square feet of City Hall building.

Public Library – Opportunity exists to control the space temperatures in the old areas of the library through the installation of 7 day programmable thermostats. These new temperature controls will be installed in place of the existing manually operated thermostats and programmed to setback the space temperature from 68°F to 60°F during unoccupied periods.

McConnell Center – it is recommended that the current BAS be evaluated and a basic controls optimization be performed at the building. This would include checking building set points, calibration of thermostats and verification of occupancy schedules for the existing heating zones within the space. Additionally, JC proposes to modify the programming of the Siemens BAS

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system to enable the proper deadband to prevent any unnecessary simultaneous heating and cooling in the spaces.

Pine Hill Chapel – Install a programmable thermostat to ensure consistent implementation of the setback schedule. Presently, setback is occurring 80% of the time based on data logging. These new temperature controls will be installed in place of the existing manually operated thermostats and programmed to setback the space temperature from 65°F to 60°F during unoccupied periods.

South End Fire Station – This location is occupied 24/7 and has programmable thermostats with multiple zones to control the heating system. Therefore, opportunity for the installation of building controls is limited and not recommended. However, during the detailed audit it was noted that when the fire trucks leave for a call the heating system remains operational and continues to provide heating when the overhead truck doors are opened, thus wasting heating energy. As part of this retrofit, JC will install controls necessary to eliminate this condition by interlocking the heating system with the operation of the overhead doors.

Veterans Hall – Building is not under EMS controls, and occupancy for building is less than 500 hrs per yr. When building is not in use the heating systems are turned to the minimum set point therefore modifications are not recommended.

Central Fire Station – This location is occupied 24/7 and has programmable thermostats with multiple zones to control the heating system. Therefore, opportunity for the installation of building controls is limited and not recommended. However, during the detailed audit it was noted that when the fire trucks leave for a call the heating system remains operational and continues to provide heating when the overhead truck doors are opened, thus wasting heating energy. As part of this retrofit, JC will install controls necessary to eliminate this condition by interlocking the heating system with the operation of the overhead doors.

Jenny Thompson Pool – Building is not under EMS controls and does not have a heating system, there is no opportunity for control.

Dover Indoor Pool – Several opportunities exist at the Dover Indoor pool which will garner energy savings through their implementation. A brief discussion of each follows.

Air Handling System – Replacement/Temperature Setback

As part of the recommended retrofit, JC will replace the Dussault air handler with a new high efficiency unit. The existing AHU will be removed and a new on will be installed in its place. To enable efficient operation the new air handler will be configured as follows.

New operation – during unoccupied hours

- Fan speed slowed to 50% during unoccupied hours (adjustable)

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- Outside air damper will be closed, thus allowing recirculation air to condition the space
- Temperature in the space will be setback by 5°F during unoccupied periods (adjustable)

Pool Office – Eliminate Simultaneous Heating and Cooling

To eliminate the simultaneous heating and cooling present in the office, JC will retrofit the air handler and fin-tube radiation controls to prevent simultaneous operation during the cooling mode. This will be accomplished through the installation of a new sensor and control valve as required to prevent the fin tube radiation from becoming operable during cooling season.

Dover Public Works – The BAS system will be modified to enable the setback sequences to occur at the Public Works building. It is recommended that the current BAS be evaluated and a basic controls optimization be performed at the building. This would include checking building set points, calibration of thermostats and verification of occupancy schedules for the existing heating zones within the space. Additionally, a VFD will be installed on the air handling unit that serves the repair shop. Once installed, this VFD will enable the unit to be slowed down based on occupancy and thus garner energy savings.

Ice Arena – Improvements recommended for implementation at the Ice Arena are considered under another FIM.

Dover Train Station – Since the building is not under EMS controls, and occupancy for building is limited to the duration when trains are operating, limited opportunity exists for implementation of HVAC related energy conservation measures. When the building is not in use the heating systems are turned to the minimum set point through the use of a programmable thermostat.

To improve the operation of the electric snow melt system at the Train Station it is recommended that a new snow sensor be installed. The new sensor will be installed in place of the existing failed snow melt sensor which will enable proper operation of the system.

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Savings Estimate

Table 4-1: Energy Savings Summary

Savings Summary	Pine Hill Barn & Chapel	City Hall	Public Library	McConnell Center	S. End Fire Station	Veterans Hall
Water & Sewer (kgal/yr)	-	-	-	-	-	-
Water and Sewer ($/yr)	-	-	-	-	-	-
Electricity (kWh/yr)	-	-	-	1,908	-	-
Electricity (kW)	-	-	-	-	-	-
Electricity ($/yr)	-	-	-	$118	-	-
Thermal Energy (MMBtu/yr)	38	121	71	447	-	-
Thermal Energy ($/yr)	$640	$2,023	$1,008	$6,308	-	-
Total Savings ($/yr)	$640	$2,023	$1,008	$6,426	-	-

Table 4-1: Energy Savings Summary

Savings Summary	Dover Train Station	Central Fire Station	Jenny Thompson Pool	Indoor Pool	Dover Public Works	Total
Water (kgal/yr)	-	-	-	-	-	
Water and Sewer ($/yr)	-	-	-	-	-	
Electricity (kWh/yr)	19,308	-	-	63,143	41,564	
Electricity (kW)	-	-	-	-	-	
Electricity ($/yr)	$2,357	-	-	$6,598	$5,318	
Thermal Energy (MMBtu/yr)	-	-	-	334	125	
Thermal Energy ($/yr)	-	-	-	$4,809	$1,418	
Total Savings ($/yr)	$2,357	-	-	$11,407	$6,736	$30,597

Assumptions

For specific assumptions please see the calculations in Appendix 3

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Scope of Work

The City Buildings where JCI will install/retrofit controls include:

- **Pine Hill Barn**
  - Install 7 day programmable thermostat. If sufficient power (24VDC) is not available to thermostat a battery powered stat will be provided. New thermostat shall be equipped with tamper resistant locking enclosure.
  - Program new thermostat to maintain the following conditions
    - Occupied Periods: 6:30am to 4:00pm, temperature setting of 70°F
    - Unoccupied Periods: 4:00pm to 6:30am, temperature setting of 60°F
- **Pine Hill Chapel**
  - Install 7 day programmable thermostat. If sufficient power (24VDC) is not available to thermostat a battery powered stat will be provided. New thermostat shall be equipped with tamper resistant locking enclosure.
  - Program new thermostat to maintain the following conditions
    - Occupied Periods: 6:30am to 4:00pm, temperature setting of 70°F
    - Unoccupied Periods: 4:00pm to 6:30am, temperature setting of 60°F
- **City Hall**
  - Optimization of Siemens DDC building automation system to include
    - Verification of building set points
    - Calibration of DDC sensors
    - Verification of occupancy schedules and reprogramming as required
  - Replacement of faulty end devices, such as control valves and damper actuators is not included.
  - Installation of ductless split system to replace inefficient and labor intensive window air conditioners in approximately 10,000 square feet of City Hall building.
- **Public Library**
  - Install 7 day programmable thermostat in old library building. If sufficient power (24VDC) is not available to thermostat a battery powered stat will be provided. New thermostat shall be equipped with tamper resistant locking enclosure.
  - Program new thermostat to maintain the following conditions
    - M-W Occupied Periods: 8:30 am to 8:30 pm, temperature setting of 70°F
    - T/F Occupied Periods: 8:30 am to 5:30 pm, temperature setting of 70°F
    - Sat Occupied Periods: 8:30 am to 5:30 pm, temperature setting of 70°F
    - Sun Occupied Periods: 12:30 am to 5:00 pm, temperature setting of 70°F
    - All unoccupied periods the temperature will be set back to 60°F
- **McConnell Center**
  - Programming of Siemens BAS to prevent simultaneous heating and cooling
  - Programming of Siemens BAS to enable night setback capability.
    - M-F Occupied Periods: 5:30 am to 11:00 pm, temperature setting of 70°F
    - Sat Unoccupied
    - Sun Unoccupied

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        - All unoccupied periods the temperature will be set back to 60°F
    - Optimization of Siemens DDC building automation system to include
        - Verification of building set points
        - Calibration of DDC sensors
        - Verification of occupancy schedules and reprogramming as required
    - Replacement of faulty end devices, such as control valves and damper actuators is not included.
- **Veterans Hall**
    - No controls scope at Veterans Hall
- **Dover Train Station**
    - Furnish and install new snow sensor.
    - Provide 4 spare sensors for replacement by City staff at a 2-yr interval.
    - Provide commissioning as necessary to ensure proper operation.
    - Implementation of this FIM is for replacement of the snow melt sensor only. At the time of installation JC will check the wiring and connections to validate proper operation. If wiring to the sensor is faulty JC will provide the City with an estimated cost prior to replacement of the sensor.
- **Jenny Thompson Pool**
    - No controls scope at the Jenny Thompson Pool
- **Dover Indoor Pool**
    - Provide and Install new PoolPac™ Air Handling unit for the Dover indoor pool
        - Disconnect old dehumidifier prepare for removal.
        - Remove and dispose of old humidifier and associated duct work.
        - Modify unit mounting pad to accommodated new dehumidifier.
        - Supply new dehumidifier sized to deliver 13,500 CFM of air with heat pipe heat recovery system. Unit to have internal economizer controls with minimum ventilation set point of 4,000 CFM to meet current ventilation code.
        - Supply and install new air distribution duct work similar to existing system sized for larger air flow.
        - Provide new reheat coil in supply air duct work and reconnect hot water piping.
        - Supply new hot water control valve for reheat coil and reuse existing Siemens control system.
        - Provide necessary power wiring to accommodate larger dehumidifier.
        - Air balance new air distribution system.
        - Provide documentation as required to secure building permits.
        - Start up system and provide operational training.
    - New operation – during unoccupied hours
        - Fan speed slowed to 50% during unoccupied hours (adjustable)
        - Outside air damper will be closed, thus allowing recirculation air to condition the space
        - Temperature in the space will be setback by 5°F during unoccupied periods (adjustable)
    - Pool Manager Office – eliminate simultaneous heating and cooling

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        - To eliminate the simultaneous heating and cooling present in the office, JC will retrofit the air handler and fin-tube radiation controls to prevent simultaneous operation during the cooling mode. This will be accomplished through the installation of a new temperature sensor and control valve as required to prevent the fin tube radiation from becoming operable during cooling season.
- **Dover Public Works**
    - Program building automation system to enable setback sequences to properly occur at the DPW facility.
        - M-F Occupied Periods: 6:00 am to 5:00 pm, temperature setting of 68°F
        - Sat Unoccupied
        - Sun Unoccupied
        - All unoccupied periods the temperature will be set back to 60°F
    - Optimization of Siemens DDC building automation system to include
        - Verification of building set points
        - Calibration of DDC sensors
        - Verification of occupancy schedules and reprogramming as required
    - Replacement of faulty end devices, such as control valves and damper actuators is not included.
    - Maintenance Garage
        - Furnish and install new 10 HP VFD on HV-3 at the DPW facility (maintenance garage).
        - Programming to enable AHU to cycle to 50% speed during unoccupied periods. (see above occupancy schedule)
        - Install new programmable thermostat to enable occupied/unoccupied VFD operation.
- **Ice Arena**
    - Controls scope for this portion of the scope is included in the Ice Arena FIM

Exclusions

Where pneumatic devices are installed, JC has assumed that existing pneumatic line sets and end devices (e.g. sensors, actuators) are functional. Upon further inspection, should these items prove to be non functional and prohibit the implementation of the proposed retrofit JC will provide owner with a cost estimate to complete the repair.
Pursuant to discussions with the owner's representative, JCI has agreed to set an allowance for certain repairs as required per the retrofits contained herein. Should the amount of the repairs exceed the agreed to allowance JCI will immediately inform the customer in writing and provide an cost estimate for each repair. Upon review of additional work, customer will notify JCI in writing as to the appropriate course of action. (i.e. repair vs. no repair)

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FIM 6 Water Conservation

Detailed Description of Facility Improvement Measure

Bathroom fixtures offer good water saving opportunities because any of these fixtures can be replaced or retrofitted with new low flow models to reduce the amount of water consumed per flush (toilets and urinals) or per minute (sinks). Reducing sink water usage also saves energy that would otherwise be used to make hot water.

Existing Conditions

An engineering survey of the staff and public restroom identified a total of 77 toilets, 22 urinals, 65 bathroom sinks, and 58 showers. 42 of the identified toilets are Ultra Low Flush (ULF) types that use 1.6 gallons per flush (gpf). The remaining 35 toilets use an average of 3.5 gpf. The 22 urinals are located in public and staff restrooms, 16 of which are high flow and 6 of which are low flow. All of the 64 sinks were found to be high-flow, using and average of 2.1 gpm. However, of 65 sinks, 18 were found to be non retrofittable. All of the 58 showers we found to be high-flow, using an average of 2.5 gpm. Below is a summary of the bathroom fixtures surveyed at each site.

Table 6 -1

Domestic Fixture Summary – Existing Conditions

Location	Public/Staff Toilets		Public/Staff Urinals		Public/Staff Sinks		Public/Staff Showers
	High Flow	Low Flow	High Flow	Low Flow	High Flow	Non Retro	Retrofit
Ice Arena	2	30	6	3	20	0	24
Jenny Thompson Pool	6	0	2	0	0	4	8
Indoor Pool	5	0	1	0	6	0	18
Public Works	0	5	0	2	6	0	2
City Hall	16	1	5	0	3	13	3
Public Library	4	2	2	0	6	0	0
Central Fire Dept.	1	1	0	1	3	0	1
South End Fire Dept.	0	3	0	0	3	0	2
Pine Hill Chapel	1	0	0	0	0	1	0
Totals	**35**	**42**	**16**	**6**	**47**	**18**	**58**

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Proposed Conditions

The High Flow sink faucets, High Flow toilets, and High Flow urinals are good candidates for water-saving retrofits. JCI proposes to change out these high flow components with their low flow counterparts. The table below shows the measured baseline flow and proposed low flow for the various fixture types.

Table 6-2				
Fixture Rate of Utilization				
	Baseline		Proposed	
Toilets	3.5	gpf	1.6	gpf
Urinals	1.5	gpf	1.0	gpf
Sinks	2.1	gpm	0.5	gpm
Showers	2.5	gpm	1.5	gpm

Savings Estimate

Table 6-3: Energy Savings Summary

Savings Summary	
Water (kgal/yr)	1,083
Water and Sewer ($/yr)	$12,098
Electricity (kWh/yr)	-
Electricity (kW)	-
Electricity ($/yr)	-
Thermal Energy (MMBtu/yr)	147
Thermal Energy ($/yr)	$ 2,025
Total Savings ($/yr)	$14,123

Assumptions

Domestic water savings depend on the amount of water used per toilet/urinal flush or sink use, the number of people using the bathrooms, and the frequency of use. Existing and proposed domestic water consumption was calculated based on the demographics information supplied by facility personnel and an example of the assumptions are listed in the table below.

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Table 6-4 (Example from City Hall)		
Domestic Water Conservation, List of Assumptions		
	User Classification	
	Staff	**Visitor**
Number of Users	62	175
% Year Round Occupancy	66%	100%
Toilet (Flushes/Day/Person)	3.50	1.00
Total Flushes Per Day	142	175
Total Flushes Per Day (Less Urinal Flushes)	140	172
% Men	35%	40%
Total Men	14	70
% Men Flushes to Urinals	5%	5%
% of Total Flushes to Urinals	2%	2%
Total Flushes per Day to Urinals	2.5	3.5
Sink (Minutes/Day/Person)	1.50	0.40
Total Sink Usage (Minutes/Day)	61	70
%Taking Showers	70%	0
Shower (Minutes/Day/Person)	8.00	0.00
Total Shower Usage (Minutes/Day)	228	0
Total Number of Toilets	6	11
Total Number of Urinals	0	5
Total Number of Sinks	6	10
Total Number of Showers	2	0
Total Number of Toilets to be Retrofitted	5	11
Total Number of Urinals to be Retrofitted	0	5
Total Number of Sinks to be Retrofitted	1	2
Total Number of Showers to be Retrofitted	2	0
% Toilets Being Retrofitted	94%	
% Urinals Being Retrofitted	0%	100%
% Sinks Being Retrofitted	17%	20%
% Showers Being Retrofitted	100%	0%

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Calculation Methodology:

Frequency of Use = number of users x % year-round occupancy x fixture uses/day/person

The following calculation for Program Savings can be applied to all Bathroom Fixtures:

Program Savings = Frequency of Use x (Baseline - Estimated Flow Rate) (gpm or gpf per fixture) x 365 days/year x % toilets/urinals/sinks/showers being retrofitted

Sink/Shower
Energy Savings = Water Savings (gal/yr) x 1/3 (hot water to sinks/showers) x 8.34 lb/gal x(120℉ - 65℉) domestic hot water temp - city water temp x 1Btu/lb x l/ Boiler Efficiency (82%)* x 1Mlb/1,000,000 Btu

**Boiler Efficiency Varies Per Building*

Scope of Work

All non-ULF flushometer toilets identified for replacement will be replaced with new 1.6 gpf toilets and new flushometer valve retrofit kits, or valves if needed. All non-ULF tank toilets identified for replacement will be replaced with new 1.6 gpf toilets. The 16 urinals will have the flushometer valves retrofitted with new 1.0 gpf retrofit kits. All sink faucet aerators will be replaced with 0.5 gpm laminar faucet flow restrictors.

A typical toilet and flush valve retrofit includes the following major components:

- 1.6 gpf in kind china replacement with new retrofit kits or Sloan Regal flushometer valves if needed.
- New outlet seals
- New toilet seats with stainless steel hardware
- Installation of new sanitary floor flanges, or repair to such flanges other than installation of spanner flanges, and repair of wall carriers are not included in the scope of work.
- No architectural patching or painting is included in the scope of work.
- Structural damage caused by JCI's subcontractors will be corrected.

    NOTE: Control stops will be replaced as needed. In the event the control stop needs to be replaced, The City of Dover will be responsible for identifying and operating water system isolation valves. JCI will replace the stop once the water has been turned off. In such case, time is of the essence in shutting down risers and repairing stops. Stop repairs must be completed in a timeframe that allows JCI to complete the flushometer retrofits without a disruption in schedule.

A typical urinal flush valve retrofit or replacement includes the following components:

- Installation of new 1.0 gpf retrofit kit
- Installation of new Sloan Regal 1.0 gpf flushometer valve.

* *Dual flush toilets and urinals maybe available as an option at additional cost as the typical retrofit.*

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A typical bathroom sink retrofit consists of removing existing aerator and installing a new pressure-compensating, laminar flow 0.5 gpm restrictor.

A typical showerhead replacement consists or removing existing showerhead and installing a new 1.5 gpm showerhead.

Below is a site by site breakdown of the proposed toilet, urinal, sink, and showerhead retrofit/replacement.

Ice Arena

- 2 Floor Mount Flushometer Toilets to be converted from 3.5 to 1.6 gpf
- 6 Urinals to be converted from 1.5 to 1.0 gpf
- 20 Sinks to be converted from 2.2 to 0.5 gpm
- 24 Showers to be converted from 2.5 to 1.5 gpm

Jenny Thompson Pool

- 6 Wall Mount Flushometer Toilets to be converted from 3.5 to 1.6 gpf
- 2 Urinals to be converted from 1.5 to 1.0 gpf
- 8 Showers to be converted from 2.5 to 1.5 gpm

Indoor Pool

- 5 Floor Mount Flushometer Toilets to be converted from 3.5 to 1.6 gpf
- 1 Urinals to be converted from 1.5 to 1.0 gpf
- 6 Sinks to be converted from 2.2 to 0.5 gpm
- 18 Showers to be converted from 2.5 to 1.5 gpm

Public Works

- 6 Sinks to be converted from 2.2 to 0.5 gpm
- 2 Showers to be converted from 2.5 to 1.5 gpm

City Hall

- 16 Floor Mount Flushometer Toilets to be converted from 3.5 to 1.6 gpf
- 5 Urinals to be converted from 1.5 to 1.0 gpf
- 3 Sinks to be converted from 1.73 to 0.5 gpm
- 3 Showers to be converted from 2.5 to 1.5 gpm

Public Library

- 3 Floor Mount Flushometer Toilets to be converted from 3.5 to 1.6 gpf
- 1 Floor Mount Tank Toilet to be converted from 3.5 to 1.6 gpf
- 2 Urinals to be converted from 1.5 to 1.0 gpf
- 6 Sinks to be converted from 2.2 to 0.5 gpm

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Central Fire Department
- 1 Floor Mount Tank Toilet to be converted from 3.5 to 1.6 gpf
- 3 Sinks to be converted from 2.2 to 0.5 gpm
- 1 Shower to be converted from 2.5 to 1.5 gpm

South End Fire Department
- 3 Sinks to be converted from 2.2 to 0.5 gpm
- 2 Showers to be converted from 2.5 to 1.5 gpm

Pine Hill Chapel
- 1 Floor Mount Flushometer Toilet to be converted from 3.5 to 1.6 gpf

Exclusions

None Noted

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FIM 9 Vending Machine Controls

Detailed Description of Facility Improvement Measure

The buildings throughout the City are equipped with refrigerated beverage vending machines. This measure addresses the inefficient control system that is standard on all units.

Existing Conditions

Johnson Controls has performed a detailed walk-through of the City buildings and has inventoried the applicable refrigerated vending machines that are located in these buildings. The following table denotes the quantities of refrigerated vending machines that are installed.

Table 9-1: Existing Conditions

Building Name	Vending Machine Quantity
Dover Pool	1
City Hall	2
DPW	1
Jenny Thompson Pool	1
Ice Arena	2
McConnell Building	2
South End Fire Station	1
Total	10

At present, all of these units run 24 hours a day throughout the year with the refrigeration compressors running 33 percent of the time irrespective of the facility or the equipment being occupied.

Proposed Conditions

Johnson Controls proposes to install vending machine controls (Vending Miser^{TM}) on all vending machines. The proposed system utilizes a custom passive infrared sensor, the controller powers down a vending machine when the area surrounding it is unoccupied and automatically re-powers the vending machine when the area is reoccupied. The intelligent controller develops optimal start-stop based upon the building occupancy, and modifies the time-out period accordingly.

Additionally, the unit monitors the ambient temperature while the vending machine is powered down. Using this information, the Vending Miser automatically powers up the vending machine refrigeration compressor at appropriate intervals, independent of occupancy, to ensure that the vended product stays cold. The controller also monitors electrical current used by the vending machine ensuring that it will never power down a vending machine while the compressor is running, so a high head pressure start never occurs. In addition, the current sensor also ensures that every time the vending machine is

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powered up, the cooling cycle is run to completion before again powering down the vending machine. This unique process also ensures a cold vended product. Vending Miser's unique approach to power management makes it the most advanced energy saver available:

- Equipment is powered up when anyone approaches the machine, and is powered down when the area is vacant.
- Product Integrity is Maintained; the controller measures ambient temperature and compressor current, re-powering the vending machine as needed to ensure that cold product temperature is maintained.
- Product is Always Available for Vending The customer never sees a powered down vending machine.

Savings Estimate

Table 9-2: Energy Savings Summary

Savings Summary	
Water (kgal/yr)	-
Water and Sewer ($/yr)	-
Electricity (kWh/yr)	8,146
Electricity (kW)	-
Electricity ($/yr)	$936
Thermal Energy (MMBtu/yr)	-
Thermal Energy ($/yr)	-
Total Savings ($/yr)	$936

Scope of Work

The following work will be accomplished as part of this facility improvement measure.

- Provide and install Refrigerated Vending Machine Control
- Install 6 vending machine at the following locations

Table 9-3: Scope of Work

Building Name	Vending Machine Quantity
Dover Pool	1
City Hall	2
DPW	1
Ice Arena	2

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- Electrical wiring necessary for a complete integration with building electrical system and vending machine
- Testing and Commissioning to ensure proper operation
- Operator training as required

Exclusions

None noted

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FIM 10 Pool Cover

Detailed Description of Facility Improvement Measure

The indoor pool can be covered during off-hours, which will reduce evaporation to save water and energy. A cover will also reduce moisture and condensation in the building.

Existing Conditions

The main swimming pool is located on the main level of the Indoor Pool in the City of Dover, there is a secondary pool located in the same space which is primarily used for therapeutic purposes. The main pool, which is 43 feet by 76 feet, and the secondary pool which is 30 feet x 36 feet, lose a substantial amount of water and energy through evaporation. Four Peerless gas boilers rated at 520,000 Btu/hr each maintain the pool water temperature at 83°F. To heat the pool, water is fed from the boilers to an Everhot™ shell and tube heat exchanger located in the basement mechanical room.

The operating hours for the pool were determined through staff interviews during the walkthrough audit. For the vast majority of the year, the pool is open approximately 15-1/2 hours per day (5:30a – 9p), Monday through Friday, and 16 hours (7a-11p) on Saturday and 14 hrs (9a-11p) on Sunday. Based on this data the pool is operating for a total of 5,590 operating hours/year.

During non-operational hours, the pool is not covered. Water losses due to evaporation and people using the pool, result in the addition of city water on a fairly regular basis. As determined through the calculations, 64,345 gal/yr are lost to evaporation, while the pool is not in use. Once the pool is covered during the non-use periods, overall evaporation and latent heat gain will be significantly reduced.

Proposed Conditions

The evaporative losses can be significantly decreased by simply placing a barrier, in our case a pool cover, between the water and the indoor airspace, when the pool is not in use. A fully automatic pool cover was chosen for its ease of use. The unit will be wall mounted, 12 to 16 feet above the deck, with two operator controlled fully automatic pulley systems moving a single blanket (please see appendices for design sketches). The unit will take approximately one and a half minutes to completely deploy/retract. A control panel will be mounted on the wall approximately 20' from the pool storage reels so that the operator is clear from the operating cover.

The rate of evaporation was calculated from an industry-accepted formula published by the U.S. Department of Energy's, Reduce Swimming Pool Costs! (REPEC!) Department.

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Savings Estimate

Table 10-1: Energy Savings Summary

Savings Summary	
Water (kgal/yr)	62.4
Water and Sewer ($/yr)	$ 689
Electricity (kWh/yr)	45,256
Electricity (kW)	-
Electricity ($/yr)	$4,729
Thermal Energy (MMBtu/yr)	543
Thermal Energy ($/yr)	$7,805
Total Savings ($/yr)	$13,223

Scope of Work

The pool cover installation will consist of the following:

- Installation of a two fully automatic custom sized pool covers
  - 1 for main pool, mounted on the wall adjacent to the pool
  - 1 for ancillary pool
- Each pool cover will included the following
  - Pool blanket 2#/CFT closed cell polyethylene foam with laminated core
  - Deployer and 1/16" stainless steel deployer cables
  - Storage reel with wall mount brackets
  - Main control box with control panel, supplied with 120VAC, 20 A (control box to be mounted 20' from storage reel motors) All power systems will be complete with NEMA 6P enclosures.

<u>Exclusions</u>

- Tile work not related to the installation of the pool covers and pre-existing tile damage.

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FIM 11 Ice Arena

Detailed Description of Facility Improvement Measure

Existing Conditions

The Dover Ice Arena, located on Portland Ave in Dover NH, is comprised of two ice rink floors, locker rooms, stands and various mechanical spaces. The new ice surface - Charles E. Holt Rink is in use year round, while the other ice surface - Robert H. Foster is shut down during the summer months until peak ice season begins in the fall. Both the ice rinks are served by a set of chillers - one Tecogen - Tecochill natural gas unit and one backup Acme reciprocating electric chiller. Both are piped to a common chilled brine storage tank which provides chilled brine to one or both of the ice rink floors.

Each chiller has a dedicated brine pump to circulate chilled brine to the storage tank and back to the respective chiller and operates only when it respective chiller is operating. Based on information furnished by facility staff, although old, the brine storage tank has an internal baffle installed between the cold and warm side of the tank to prevent stratification in the tank. Insulating values of this tank are poor and it is recommended that the tank be insulated to prevent unnecessary heat gain. Because of the poor insulation levels, the minor heat gain through the tank contributes to poor overall system efficiency and thus causes the chiller and ancillaries to operate longer than necessary.

In order for the Tecochill to be most effective (in terms of energy savings and payback), it is imperative that the excess heat from the gas engine be recovered and sent back to the building in the form of fluid to air and/or water for space heating, Zamboni flood water heating preheating and regeneration air to the Munters dehumidifier. In its present configuration, the heat recovery loop provides a maximum of 480,000 Btu/hr of supplemental heat to the areas directly adjacent to the Zamboni garage and provides pre-heating to the hot water tanks that serve the Zamboni in the old ice rink. During the detailed survey, it was noticed that little heat, if any, was being reclaimed. Inlet and outlet temperatures of the heat recovery loop were spot checked with an infrared temperature gun and substantiated that the amount of heat being recovered was marginal.

According to facility staff, the chiller is operated on a year round basis and during periods of low load the compressor is “unloaded”, however the chiller continually operates. Operating logs were analyzed for a three year period and indicated that the Tecochill chillers operate an average of 6,400 hrs per

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year. Operating data for the existing electric chillers was not available. This increases chiller and engine wear significantly as well as wasting a large amount of natural gas and electricity. Additionally, the overall maintenance budget for the Tecochill system is approximately $30,000 per year. Installation of new electric chiller would help to eliminate a portion of that annual maintenance expense.

The rink staff indicated that ice temperatures are adjusted by changing brine temperatures manually. As such, the Dover rink is about 25 years behind in control technology. For optimal operation, the ice floor temperatures should be controlled by ice temperature. Installation of infrared temperature controls and a variable speed drive on the floor pumps would be required to enable this mode of control.

Dehumidification for the old rink is served by electric refrigerated dehumidifiers in the 5 to 7.5 hp range. Refrigerated dehumidifiers work marginally in a close temperature range down to perhaps 45°F. Most refrigerated dehumidifiers will shut off on low temperature "safety" return air thermostats @ 40°F. As entering air temperatures decrease, refrigeration system suction pressures decrease and the compressors become increasingly less efficient increasing run times and power consumption. The new ice rink is served by a 10,000 cfm, Munters A30 model desiccant dehumidifier and is regenerated by natural gas.

The ceilings in both of the ice rinks are original to the building and do not provide any significant means of insulating value. Each ceiling is provided with fiberglass batts underneath a steel deck roof. During the summer months as the outside temperature rises, the roof deck heats up and thus energy transfer from the roof deck to the ceiling is increased. In its present state the ceiling acts as a warm plane radiating heat from the ceiling to the ice and thus causes the cooling load on the refrigeration equipment to rise unnecessarily. Opportunity exists to eliminate this heat gain and therefore improve the efficiency of the building. Installation of a Low-E ceiling would greatly reduce the heat gain on the ice surface.

In the older of the two rinks, the floor surface and dasher board system is flawed as installed, with the dasher board system mounted to the perimeter warm concrete, butting up to the flexible expansion joint. This flexible expansion joint remains in the field of play, presenting a non refrigerated area around the perimeter of the rink. The rink staff advised that steel plates are placed on the refrigerated floor to cover the expansion joint up to the dasher boards to provide a cold "bridge" from the cold floor to the dashers. The "bridge" requires additional labor to install/remove at the beginning and end of the season. A "bridge" such as this presents perimeter ice freeze/thaw issues as well as potential safety issues for skaters and rink staff. Further, to successfully make ice on a surface that is not refrigerated the ice floor needs to be set lower in temperature, thus driving the chiller to run longer. Each 1°F that we lower the brine or floor temperature results in a 4 to 8 % increase in chiller run time. Significant chiller energy savings would be realized if the floor/dasher issue described was resolved.

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Proposed Conditions

A walkthrough survey was conducted and as a result of this survey the following facility improvement measures (FIM) have been identified for implementation at the Ice Arena.

FIM 11-1: Low E-ceiling

Both ice rinks would benefit greatly from low emissivity ceilings below the roof, above the sprinklers. Low emissivity ceilings are recognized (ASHRAE Refrigeration Handbook 2006 chapter 35) as a significant measure to reduce radiant heat (load) to the ice rink ice sheet. Ceiling radiant heat accounts for 28% of the load to the floor. A low emissivity ceiling can block up to approximately 90% of the radiant heat thus reducing the load on the refrigeration plant. These ceilings can be installed with or without ice "on". As part of this retrofit, Johnson Controls will install a Low-E ceiling in both of the ice rinks. The new ceiling will be installed below the existing ceiling and above the existing lighting system and thus provide an extra level of protection from the added heat gain throughout the year.

FIM 11-2: Ice temperature controls optimization

A more accurate method to measure and control the ice surface temperature would be the addition of non contact infrared sensors suspended above the ice rink floors, sending signals back to a DDC system which would then control the following; Chiller on/off operation, system circulating pumps and floor supply pumps. Ice temperatures would be selected based on time of day, rink occupancy, activity (hockey, figure or public skating). To enable this configuration, a new VFD will be installed on the floor pumps and their speed will be cycled based on actual ice floor temperature.

FIM 11-3: Dehumidification controls

JC proposes to install new desiccant based dehumidifiers for the Foster Rink. One of the key contributing factors to have a great ice surface is proper humidity control in the building envelope. Excess humidity also increases the refrigeration load on the ice plant. The most reliable and economical way of dealing with the humidity is through the use of a desiccant dehumidifier. This will provide an excellent ice surface during all weather conditions at a fraction of the operating cost of the old style mechanical dehumidifiers.

As part if this retrofit, a new desiccant based dehumidification system will be installed in the Foster Rink. The existing dehumidifier located on the North side of the rink closest to the Zamboni storage garage will be removed and replaced with the new unit.

FIM 11-4: Ice Max System

To improve the operations of the Dover Ice Arena and improve energy efficiency, Johnson Controls proposes the use of the Johnson Controls Icemax product. Icemax is a protein that is derived from a biotech fermentation process much like making beer, wine, yogurt or cheese. The active protein in

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Icemax has been in use globally for 20 years and has been used in a wide array of applications, including snowmaking, cloud seeding, wastewater concentration, ice harvesting and thermal storage process cooling plants.

Icemax changes the molecular adhesion properties of water and will influence ice crystal size by producing finer and more tightly packed crystalline lattices. It increases the bond cohesion between ice crystals at higher temperatures and reduces the amount of heat required to be removed to reach the nucleation or freezing point of water. As a parts per million (ppm) additive to ice rink water, Icemax provides a cost effective way to generate a superior ice surface, reduce energy costs, and improve customer satisfaction. Some of the benefits of using Icemax follow.

Superior Ice Surface

- Icemax will produce a tighter grained ice crystal that will behave much like de-ionized ice rink water, without the capital and maintenance costs of a DI plant.
- Icemax will help to remove impurities from the rink's source water, giving the ice a cleaner, smoother surface.
- Icemax will increase the bond cohesion between ice layers to give a better, stronger and more durable ice surface without the risk of ice layer delamination.

Energy Cost-Savings

- Reduces the heat load on the ice Icemax can produce a stronger ice layer bond even when cold water is used in the resurfacing equipment, allowing substantial energy cost-savings of 10%-20%.
- With Icemax, rink operators can run their base ice temperature 2 to 4 degrees higher to save energy, while still maintaining a quality ice surface.
- Use warm, rather than hot, water in the resurfacer ("Zamboni")
    - Reduces the heat load on the ice and the de-humidifiers

Icemax is shipped in sufficient quantity for 30 days of ice resurfacing. Since the product is biological it is required to be stored in the freezer to help protect the efficacy of the product. To properly use Icemax, a pouch of ice max is placed into the ice resurfacer during filling each time.

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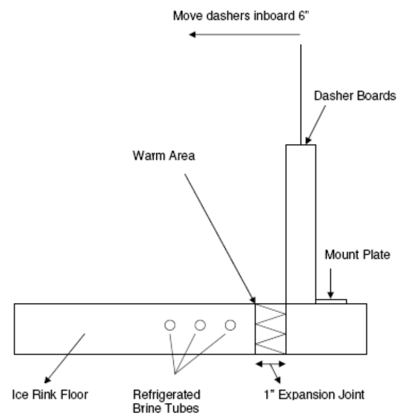
FIM 11-5: Move the dashers inboard



A drawing of the existing ice rink floor and dasher board system showing the relationship of the dashers, floor and expansion joint is shown below. It is standard in the industry for the dashers to either be mounted completely on the cold refrigerated floor or have the dashers straddle the expansion joint. From a safety standpoint having the expansion joint in the ice surface is not recommended.

As part of this retrofit the dashers will be moved inward by 6” and eliminate the need to install metal plates over the 1” expansion joint along the perimeter of the rink.

FIM 11-6: Installation of New Chiller

The existing Tecochill system provides low temperature brine for the ice making process at the Dover Ice Arena. As designed, the system provides cooling to most of the rink for the majority of the year with the existing electric chiller providing backup cooling during periods of high ice load or extreme summer temperatures. Presently, the Tecochill is operating with a 1.03 COP (with heat recovery) vs a 3.2 COP for a new electric chiller. As such, Johnson Controls proposes the replacement of the 30 year old Acme electric chiller with a new high efficiency unit. The existing Tecochill would remain installed as a backup in the event that both chillers are required for ice making (typically at startup when ice load is greatest). Further, many measures will be implemented to reduce the overall load on the ice sheet and as such the run time of the chiller system will be greatly reduced.

Proposed is a 120 ton high efficiency Carrier chiller with 3 compressors offering greater operational flexibility and part loading ability. The new chiller is 12’ L x 3’ w x 6’ h and will be installed in the location of the existing Acme electric chiller. To accommodate the installation, the housekeeping pad will be modified and all piping will be removed and re-installed to accommodate the header arrangement of the new Carrier chiller. When installed, the new electric chiller will be interconnected with the existing building automation system and enabled for automatic operation. Chiller staging will be controlled by ice temperature and actual load vs the present “always on” operating conditions. Additionally, Johnson Controls will provide local operator control of the refrigeration plant to enable minor operational changes.

The Tecochill provides supplemental heating for the Zamboni resurfacing water and several fan coil units in the team areas adjacent to the rink. As part of this retrofit, the Tecochill will go from operating as the lead chiller to the backup. With that, the capability of providing heating to the Zamboni and other fan coils connected to the heat recovery loop is lost. As such, Johnson Controls proposes the installation of a new wall mounted condensing boiler to provide backup heating to the equipment connected to the heat recovery loop. The new boiler will be rated at 399,000 Btu/hr and will be installed on the wall in the Tecochill mechanical room. Gas piping will be run from a nearby gas line to the new boiler and venting will be via a 4” CPVC vent pipe which will be run through the sidewall.

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From an operational perspective it is envisioned that the new chiller will provide a large majority of the cooling capacity for the ice rinks, especially given that other load reduction measures are being implemented at the rink.

Additionally, according to information furnished by facility staff, maintenance on the Tecochill is $30,000/yr and often requires frequent visits from a certified Tecochill maintenance technician. Since 2005, Tecochill has visited the site an average of 30 times per year. With the new electric chillers, it is expected that the overall maintenance costs will be reduced by approximately $10,000 per year.

Existing Maintenance Cost: $30,000

Proposed Maintenance Cost: $15,000 (Electric) (estimated)
Proposed Maintenance Cost: $ 5,000 (Tecochill) (estimated)
Total Proposed Maintenance Cost: $20,000

Net Operational Savings: $10,000

FIM 11-7: Pumping System – VFD on Pump

Savings Estimate

Table 11-1: Energy Savings Summary

Savings Summary	
Water (kgal/yr)	-
Water and Sewer ($/yr)	-
Electricity (kWh/yr)	(31,670)
Electricity (kW)	(62)
Electricity ($/yr)	($8,614)
Thermal Energy (MMBtu/yr)	9,088
Thermal Energy ($/yr)	$112,131
Additional Spending ($/yr)	($8,765)
Operational Savings ($/yr)[1]	$10,776
Total Savings ($/yr)	$105,528

[1] Includes operational savings from moving Dashers ($776) and Chiller Replacement ($10,000)

Assumptions

Detailed calculations for each of the Facility Improvement Measures at the Ice Arena at included in the Appendix.

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- Operating hours for the chiller system were obtained from data logs supplied by the Ice Arena facility staff. These hours were available from inspection of maintenance logs kept in accordance with the Tecochill service contract.
- Base on operating logs, operating hours for the Tecochill were determined to be
  - Average of 6,400 hours per year. (total hours over the 3.5 yr period)
- Average RH in the rinks is 50-70% (See charts in Appendix 3)
- Average temp in the rinks 45°F as determined through data logging (See charts in Appendix 3)

Scope of Work

FIM 11-1: Low E-ceiling

Johnson Controls, Inc. will furnish and install a new Low-E ceiling for both the Holt and Foster rinks. As part of this installation Johnson Controls will supply the following;

- Removal and re-installation of existing light fixtures
- Furnish and install new Low-E ceiling for the Charles E. Holt and Robert H. Foster Rinks
  - Aluma-zorb Low-E ceiling to be LAMTEC or equal
- Installation of ceiling support structure as per manufactures guidelines
- Electrical work as required for removal and re-installation of existing lighting

FIM 11-2: Ice Temperature Controls

Johnson Controls, Inc. will furnish and install a new ice temperature monitoring and control system for both the Holt and Foster rinks. As part of this installation Johnson Controls will supply the following;

- Furnish and install 2 infrared temperature sensors, 1 ea for the Holt and Foster Rinks respectively.
- Electrical and controls wiring to enable proper operation of the Infrared sensors
- Furnish and install 50 HP VFD for existing floor pump
- Electrical and controls wiring for proper operation of VFD
- Programming of VFD to enable motor speed control based on floor temperature.

FIM 11-3: Dehumidification System Controls

Johnson Controls, Inc. will furnish and install new desiccant based Dehumidification system for the Foster Ice Rink. As part of this installation Johnson Controls will supply the following;

- Removal and disposal of existing dehumidifier
- Provide new Arid Ice MS-2600 Desiccant Dehumidifier
- Furnish and install new desiccant based dehumidification system in the Charles E. Holt Ice rink.
  - New dehumidification system will be installed on the structural steel support structure located adjacent to the Zamboni storage room.

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- Gas piping for regeneration of Desiccant
- Electrical and controls wiring to enable proper operation of the dehumidifiers
- Integration of new dehumidification system with existing building controls

FIM 11-4: Ice Max System

Johnson Controls, Inc. will provide Icemax for the Dover Ice Arena. As part of this installation Johnson Controls will supply the following;

- Provide 1-year supply of Johnson Controls Ice Max system which will enable ice temperature set point to be raised from 22°F to 26°F.
- Adjust set point of ice resurfacing water from 120°F to 80°F
- Icemax will be delivered monthly to the Dover Ice Arena staff for use in the ice resurfacer.

FIM 11-5: Move the dashers inboard

Johnson Controls, Inc. will retrofit the existing dasher boards at the Dover Ice Arena. As part of this installation Johnson Controls will supply the following;

- Furnish labor and materials necessary to remove the dashers in the Charles E. Holt rink and re-install them 6" inward.
- Coordination of installation will need to be accomplished with rink staff during the summer when the ice surface not active.

FIM 11-6: Installation of New Chiller

Johnson Controls, Inc. will furnish and install a new chiller for use at the Dover Ice Arena. The proposed system will is designed to provide higher efficiency production of ice for the rinks. As part of this installation Johnson Controls will supply the following;

- Chiller Installation
  - Removal and disposal of Carrier based (Acme) chiller
    - Including rigging out old chiller, rigging in new chiller
  - Removal and disposal of compressor oils and refrigerant
  - Removal and storage of system secondary refrigerant (ethylene glycol) from existing chiller
  - Provide and install new Carrier 120 ton Chiller model 30HXC206RA-6-TA or equal
    - Modify housekeeping pad to accommodate new chiller
  - Power and control hookup to existing systems
  - Piping new chiller to existing system glycol and water systems
  - Cold glycol piping insulation
  - Pipe labeling
  - Site supervision

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- Refill new chiller with stored glycol fluids
- Piping and electrical materials
- Provide electrical upgrades in mechanical room to accommodate single point power connection at new chiller. Upgrades to include new disconnect, power wiring and circuit breakers.
- Provide new ventilation system upgrade to comply with ASHRAE 15 standards. Upgrade to include Power exhaust fan and duct, dampers with intake control and Leak detection sensors for room and vent line.
- Boiler Installation - Install new Triangle Tube Prestige Solo 399 wall mounted gas fired condensing boiler (or equal) rated at 399,000 Btu/hr (input) to supply heating to existing fan coil units served by the Tecochill heat recovery loop.
    - Mounting of boiler in Tecochill mechanical room
    - 1” gas piping
    - 4” CPVC venting will be through the wall.
    - Electrical and Controls for operation of boiler
    - Installation of piping, isolation valves and insulation required for interconnection to the existing heat recovery loop.

- Energy Management System
    - Install Siemens AEM controller to enable basic (w/o graphics based UIE) local operator control
    - Replace CO2 Sensor in Foster Rink
    - Optimization of Siemens DDC building automation system to include
        - Verification of building set points
        - Calibration of DDC sensors
        - Verification of occupancy schedules and reprogramming as required
- Startup and commissioning of new chiller and boiler systems.

Exclusions

None noted

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FIM 12 Power Factor Correction

Detailed Description of Facility Improvement Measure

Existing Conditions

The electrical system at the City of Dover, Ice Arena typically incurs a power factor penalty charge imposed by the local utility, Public Service of New Hampshire. This penalty is levied upon customers with power factors below 100%. A low power factor also reduces the amperage capacity of any facility's distribution system. High power factor has the following advantages: (1) eliminates utility power factor penalties; (2) reduces the heating losses of transformers and distribution equipment, prolonging life of the equipment; (3) stabilizes voltage levels; and (4) results in increased system capacity. It should be noted that the power factor is the ratio of actual power being used in a circuit, expressed in watts or kilowatts (kW), to the power which is apparently being drawn from the line, expressed in volt-amperes or kilovolt-amperes. The higher the power factor, the more effectively electrical power is being used.

During the field engineering survey, JC performed a review of the Ice Arenas electric utility bills. While reviewing PSNH account, it was found that the City of Dover incurred a monthly demand charge from PSNH due to a power factor less than 90%. This demand charge can be viewed as a penalty incurred by City of Dover Ice Arena for lagging (inductive) loads such as lighting or motors. The Ice Arena's monthly power factor during peak periods (as shown on the electric utility bills) is approximately 81-87%, and approximately 78-86% during off-peak periods. Raising the power factor to 90% or above would reduce the kVA demand charges imposed when the power factor is less than 90%.

Proposed Conditions

JCs experience has shown that the installation of capacitor banks will correct the system power factor. The installation of capacitor banks will correct the power factor to an average of 0.99 at all times, assuring that the penalty is significantly reduced and that the distribution system operating parameters are improved.

JC proposes to use existing billing data to determine complete load cycle in order to properly determine the operation of the switched bank of capacitors. New metering will be installed to closely monitor kW, kX, kVA, and true RMS power factor. From this data, the magnitude of avoided penalties can be determined. Utility meters and site-specific meters will be installed to determine the portion of system loss reduction associated with transformer and line losses.

Implementation of this FIM through the installation of fixed and switched capacitor banks will assure that the electrical system power factor will always average 98-99%, and the user will therefore avoid significant penalties. Additionally, the installation of these capacitor banks will reduce electrical system loss and improve ampacity and voltage levels throughout the complex. Power factor correction

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capacitors work, as reactive current generators "providing" needed reactive power (KVAR) to the power supply. By supplying their own source of reactive power, the facility frees the utility from having to supply it; therefore, the total amount of apparent power (KVA) supplied by the utility will be less.

Savings Estimate

The following is based on a review of PSNH Account during the period of August 2007 through July 2008. During that time, the Ice Arena operated with an average power factor of 81-87% on peak. Installation of new capacitors will increase the average power factor to above 90%. During summer months, when inductive loads are highest (creating lower power factors), the power factor will remain above 90%. Cost reduction is achieved by eliminating the penalty for operating below a 90% power factor.

Table 12-1: Energy Savings Summary

Savings Summary	
Water (kgal/yr)	-
Water and Sewer ($/yr)	-
Electricity (kWh/yr)	67,810
Electricity (kW)	-
Electricity ($/yr)	$7,188
Thermal Energy (MMBtu/yr)	-
Thermal Energy ($/yr)	-
Total Savings ($/yr)	$7,188

Assumptions

See savings calculations in Appendix 3 for specific assumptions.

Scope of Work

The scope will include the following work:

- Furnish and install KVAR fixed capacitor power factor correction system in the main electrical room in accordance with the National and State Electrical Code.
- Startup, testing and commissioning

Exclusions

None Noted

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FIM 13 Transformers – Retrofit

Detailed Description of Facility Improvement Measure

Energy savings can be obtained by replacing the standard efficiency transformers located at several City of Dover Buildings with new high efficiency transformers.

Existing Conditions

During the Detailed Energy Audit, JCI surveyed the City of Dover buildings for the purposes of identifying energy savings opportunities. While conducting the survey, JCI evaluated the electrical systems at each facility and determined that several of the existing transformers were of standard efficiency. These transformers are not designed to handle harmonic loads of today's modern facilities and suffer significant losses as a result. The most common efficiency for commercial and industrial transformers supplying linear loads (nameplate efficiency) in the 30-150kVA range is 95%. Further, conventional transformer losses, which are non-linear, increase by 2.7 times when feeding computer loads.

The nonlinear load loss multiplier reflects this increase in heat loss, which decreases the net transformer efficiency. Also, unlike most substation transformers that are vented to the exterior, building transformers are ventilated within the building they are located and their heat losses therefore add to the buildings cooling load. JCI performed on site loading tests on the transformers. The following table lists the transformers that were identified as prime candidates for replacement.

Table 13-1: Existing Conditions

Building	Location	Type	kVA
McConnell Center	Boiler Room	MLV	75
McConnell Center	Main Elec Room	KPLV1	75
McConnell Center	Main Elec Room	LV1S	45
McConnell Center	Room 251	LV2W	75
McConnell Center	Room 230A	LV2S	45
McConnell Center	Room 320A	LV3S	45
McConnell Center	Room 345A	LV3W	75
McConnell Center	Room Storage	LV4E	45
McConnell Center	Room Storage	HV3E	45
Waste Water	Primary Sediment	L4	30
Waste Water	Compost	T-5 / L-6	30
Waste Water	UV Building	#1	75

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Waste Water	UV Building	#2	75
Waste Water	Blower Building	PP1	45
Waste Water	Garage Process Bldg	L5	30
Waste Water	Main Elec. Process Bldg	L1	30
Waste Water	Admin Bldg	T-3	37.5
Waste Water	Admin Bldg	T-2	30
Public Works	Main Elec Room	LP-A	30
Public Works	Welding Shop	LP-B	45
Public Works	Pole Barn	PB-1	75
Public Works	Mezzanine	LP-P	75
Public Works	Mezzanine	LP-C	30
Public Works	Mezzanine	LP-C	30
Ice Rink	New Elec. Room	NP2	75
Ice Rink	Old Elec. Room	-	75
Ice Rink	Old Elec. Room	PL1	45
Museum / Pool	Main Elec. Room	PP1	112.5
Museum / Pool	Main Elec. Room	RP1	112.5

Proposed Conditions

Opportunity exists to improve the energy efficiency of the electrical distribution systems in several of the buildings through the replacement of the transformers with new high efficiency units. The proposed transformers will be Powersmiths, High Efficiency K-Star Harmonic Mitigating units. They are Energy-Star rated and meet the new TP1 Law requiring replacement of transformers of 600 volts or under.

The IEEE Emerald book notes that a conventional transformer reaches its full load losses at half its nameplate load when feeding computer-type loads. Research carried out by Tom Key and Jih-Sheng Lai (IEEE Trans. On Industry App., NO. 5, Sept./Oct. 1996) points out that core losses double and eddy currents increase by a factor of 17 times, resulting in an almost tripling of losses when feeding 120V electronic equipment such as personal computers.

The Powersmiths approach starts with a higher efficiency (98%) and in addition treats the harmonic currents instead of simply surviving them. The energy savings resulting from the reduction in harmonic distortion and inherent reduction in losses are substantial enough to justify the Powersmiths approach. Using Powersmiths harmonic cancellation and K-Star transformers peak power consumption will be reduced by at least 10%, operating costs will be lowered, more capacity will be regained for pending projects and achieve a short ROI. Existing and projected harmonic power quality issues will be resolved with the installation of the proposed transformers.

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For the retrofit, the existing transformers will be de-energized, removed and disposed of properly. New transformers will be installed in their place.

Savings Estimate

Table 13-2: Energy Savings Summary

Savings Summary	
Water (kgal/yr)	-
Water and Sewer ($/yr)	-
Electricity (kWh/yr)	145,544
Electricity (kW)	26
Electricity ($/yr)	$18,385
Thermal Energy (MMBtu/yr)	-
Thermal Energy ($/yr)	-
Total Savings ($/yr)	$18,385

Note: For a summary by location see appendix

Assumptions

Savings were based on the difference of transformer losses measured on the field for existing units and losses quoted by the manufacturer for the replacement equipment. For additional assumptions see Appendix 3.

Scope of Work

The following will be accomplished Per Transformer Unit:

- Coordination with local facilities staff for shutdown of electrical service
- Shut off the main electric power to the transformer to be replaced.
- Disconnect the existing transformer and install replacement unit.
- Turn power back on.
- Inspect unit operation by performing electrical and harmonics testing.
- Removal and disposal of old transformers in accordance with local regulations.

Exclusions

Removal of any City of Dover property for access to transformer (e.g. material stored on or around transformer)

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The following transformers will be replaced with Powersmiths high efficiency transformers as part of this facility improvement measure:

Table 13-3: Transformer Replacements

Building	Location	Type	kVA
McConnell Center	Boiler Room	MLV	75
McConnell Center	Main Elec Room	KPLV1	75
McConnell Center	Main Elec Room	LV1S	45
McConnell Center	Room 251	LV2W	75
McConnell Center	Room 230A	LV2S	45
McConnell Center	Room 320A	LV3S	45
McConnell Center	Room 345A	LV3W	75
McConnell Center	Room Storage	LV4E	45
McConnell Center	Room Storage	HV3E	45
Waste Water	Primary Sediment	L4	30
Waste Water	Compost	T-5 / L-6	30
Waste Water	UV Building	#1	75
Waste Water	UV Building	#2	75
Waste Water	Blower Building	PP1	45
Waste Water	Garage Process Bldg	L5	30
Waste Water	Main Elec. Process Bldg	L1	30
Waste Water	Admin Bldg	T-3	37.5
Waste Water	Admin Bldg	T-2	30
Public Works	Main Elec Room	LP-A	30
Public Works	Welding Shop	LP-B	45
Public Works	Pole Barn	PB-1	75
Public Works	Mezzanine	LP-P	75
Public Works	Mezzanine	LP-C	30
Public Works	Mezzanine	LP-C	30
Ice Rink	New Elec. Room	NP2	75
Ice Rink	Old Elec. Room	-	75
Ice Rink	Old Elec. Room	PL1	45

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FIM 14 WWTP Aeration Blowers - Retrofit

Detailed Description of Facility Improvement Measure

Existing Conditions

On September 30, October 1, and October 16, 2008 JC visited and performed an extensive review of the Dover New Hampshire Wastewater Treatment Facility located on 484 Middle Road in Dover New Hampshire. Originally designed and constructed in 1988 through 1991 the treatment facility is a conventional activated sludge plant consisting of primary clarifiers, aeration tanks, and secondary clarification, with ultraviolet disinfection. The plant's liquid process and organic design capacity is as shown in the following Table 14-1:

Table 14-1

Unit Process Criteria – Design Year 2005	
Design Flows	
Average Daily Flow	4.7 MGD
Maximum Day Flow	13.8 MGD
Peak Hour Flow	16.8 MGD
Organic and Suspended Solids Loading	
Average Day BOD_5	7,170 pounds per day
Maximum Day BOD_5	10,930 pounds per day
Average Day TSS	6,680 pounds per day
Maximum Day TSS	14,480 pounds per day

The plant's NPDES Permit (No. NH0101311) provides the limits and conditions for discharging treated effluent into the Piscataqua River. Table 14-2 shows the limits established that the Dover facility must meet.

Table 14-2

NPDES Effluent Quality Limits	
Average Daily Flow	4.7 MGD
Monthly Average BOD_5	30 mg/L
Weekly Average BOD_5	45 mg/L
Daily Maximum BOD_5	50 mg/L
Monthly Average TSS	30 mg/L
Weekly Average TSS	45 mg/L
Daily Maximum TSS	50 mg/L
pH	6.0 to 8.0 SU
Fecal Coliform	14 fecal coliform per 100 milliliters

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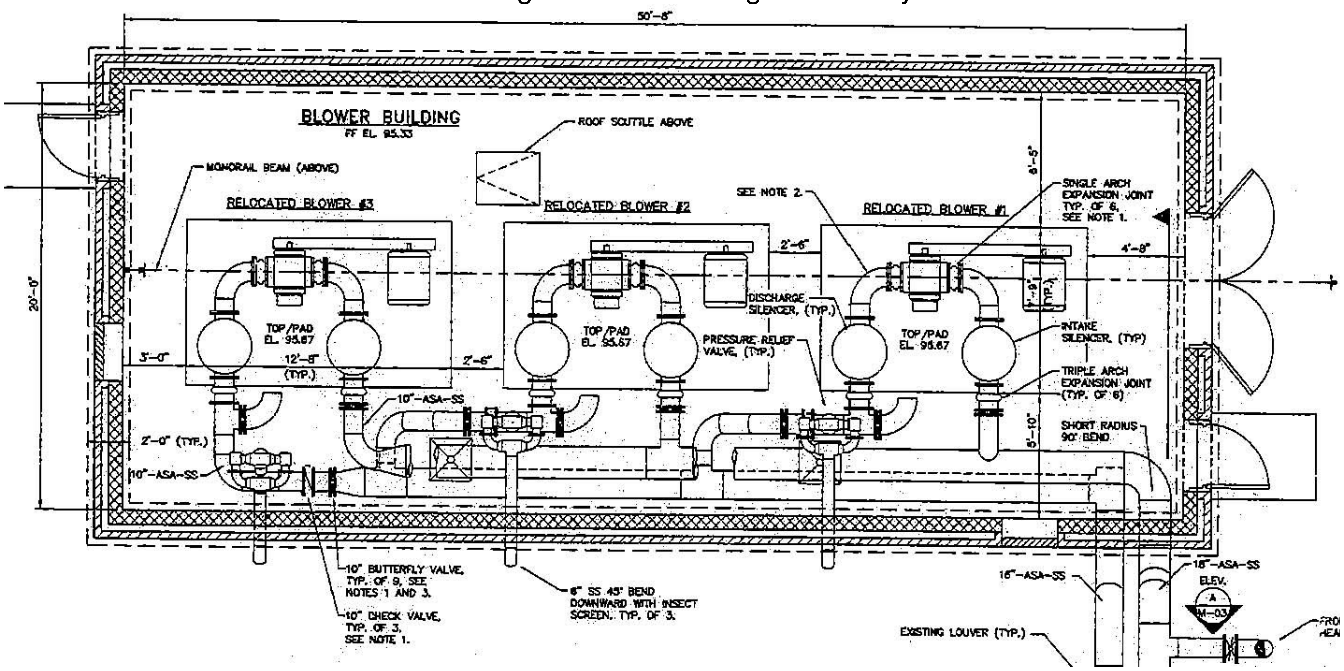
The purpose of the evaluation was to perform onsite investigations at the Dover, NH WWTF to gather adequate physical, process control, as built and compliance testing information to assess where replacement of process equipment can effect a sufficient reduction in energy usage. In addition JC would identify all process systems evaluated which do not meet the general intent of the audit and explain.

<u>Activated Sludge Reactor (Aeration System):</u> The primary energy users at the WWTF are the three (3) 125 HP positive displacement blowers providing dissolved oxygen to the reactor. The existing blowers are Dresser Roots Model 817 RCS-J positive displacement blowers powered by 125 HP 460 volt 3 phase motors. At the October 10, 2008 onsite visit only one of the three existing blowers was operational. This system was closely evaluated and a recommendation for blower replacement was made. Figure 14-1 below shows the existing layout of the blowers.

Figure 14-1: Existing Blower Layout



<u>Other Systems Evaluated</u>

<u>Grit Removal:</u> Grit removal at this facility is performed hydraulically by differential sedimentation, which allows the heavier solid particles to settle and permits the lighter putrescible solids to pass on to the Primary Clarifiers. This system is not an energy intensive process and was therefore eliminated as a candidate for further evaluation.

<u>Primary Sedimentation:</u> Primary Sedimentation is a process which uses detention time and surface area as a means to reduce the velocity of the incoming flow to permit gravity to settle

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putrescible solids and fine inorganic particles and allowing soluble BOD and buoyant organics to pass on to the Secondary Aeration Tanks. Although this system has primary sludge pumps and motors powering the clarifier mechanism it was determined that the pump motors, which were generally 5 HP and less are too small for a retrofit or replacement that could provide a reasonable return on investment. Therefore, this system was eliminated as a candidate for further evaluation.

Secondary Clarification: Secondary Clarification is a process, which uses detention time and surface area to permit flocculation of activated sludge from the aeration tanks to settle forming a blanket of active organisms to be returned and reused at the beginning of the secondary treatment process. Secondary Clarification is performed through deferential settlement that permits active organisms to settle and be returned and the floatable scum and surface debris to be skimmed and removed from the plant. Although this system has scum pumps, waste sludge pumps and return sludge pumps none were found to be obsolete or inefficient. Each pump except for the scum pumps had variable frequency controls and none were found to be oversized. It was determined that pump replacement would not provide improvements in process control or effect a reduction in energy use, therefore, this system was eliminated as a candidate for further evaluation.

Disinfection: Disinfection is accomplished through high intensity Ultra Violet light which disrupts and lyses the cell membrane of both entercocci and fecal coliform bacteria and deactivates viruses. Although, an intense energy user this system is the most effective technology for deactivating bacteria, cysts, and viruses. There is at this time no replacement technology available to perform this task using less energy or without creating the chloramines associated with a hypochlorite system.

Sludge Management: Sludge management is currently performed using a blend of primary and secondary sludge that is pumped to gravity belt thickeners and belt filter presses. The final dewatered sludge is then moved to a compost facility on site where it is mixed with saw dust and/or wood chips and biologically stabilized to generate a Class A Biosolid suitable for soil enhancement. There are several issues with the system such as odor, the sludge has a relatively low percent solid content in the cake after pressing, its relatively labor intense, it is energy intensive and there is a low marketability of the product produced. The system could be overhauled with new technologically superior equipment that would save energy, increase solids content in the final cake, reduce the total energy required to operate, reduce odor and reduce labor intensity. This process system has significant potential for improvement and the potential for beneficial use of methane gas production for power generation however, the level of evaluation required to determine the form it would take to make the system financially viable far exceeds the scope of this audit. A further detailed evaluation should be performed under a separate agreement to determine the viability of a new design.

Odor Control: A separate odor control system for the secondary treatment aeration system was retrofitted to the WWTF in the late 1990's. This system utilizes a biological media system to filter the air retrieved from the head space of the aeration system. Because the system is

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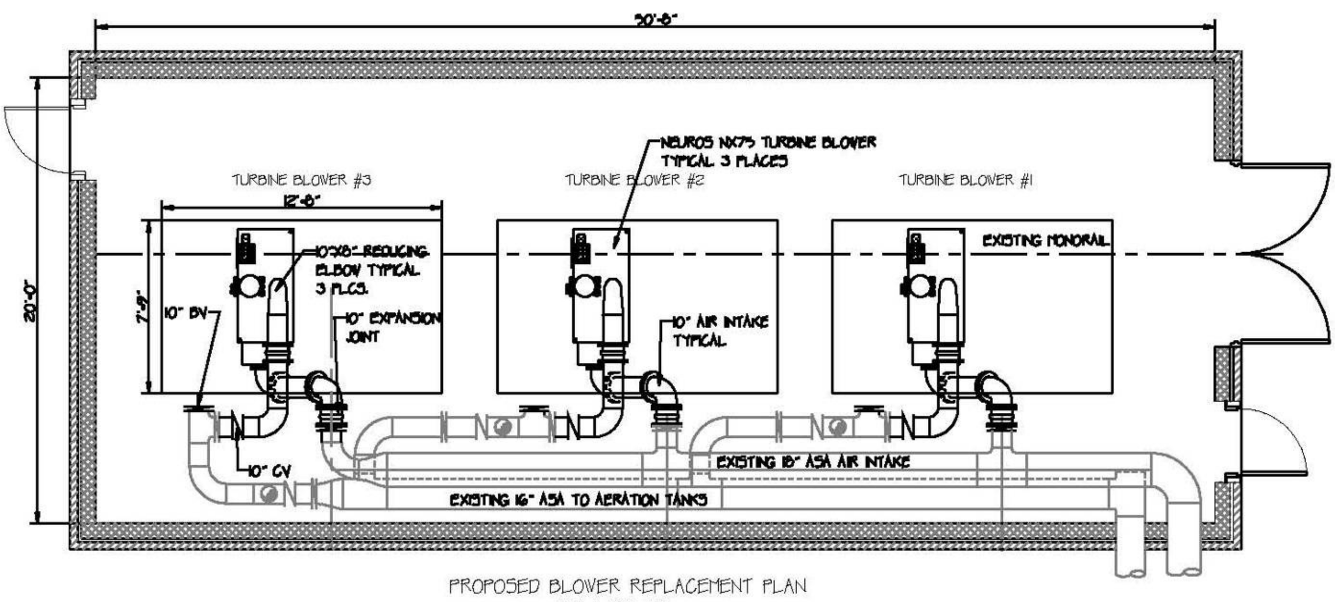
biological it is temperature sensitive and requires a 300,000 BTU/Hour propane fired heat source to maintain a minimum temperature in order to keep the biology that removes sulfurous compounds viable. This system uses significant quantities of LP gas during the winter months to maintain the viability of the biology in the media. The intense use of an unregulated petroleum based fuel source exposes the WWTF to significant economic pressures due to the current unsettled oil markets. Retrofitting this system with a different technology could significantly reduce the financial liability of this system. Further discussion of this retrofit is provided in this report.

Proposed Conditions

As discussed herein, the greatest energy users at the WWTF are the three (3) 125 HP positive displacement blowers providing dissolved oxygen to the reactor. The existing blowers are Dresser Roots Model 817 RCS-J positive displacement blowers powered by 125 HP 460 volt 3 phase motors. Although, positive displacement blowers have been used successfully as the primary means of producing low pressure air for aeration system for many years, new technology has become available that performs the same service but with much less energy.

Figure 14-2 below shows the proposed conditions for Dover's Blower System.



Due to past advances in jet turbine propulsion technology new methods of aeration are now available that can replace older positive displacement blowers with high efficiency turbine blowers. Such is the

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case at the Dover WWTF. JC performed a detailed evaluation on replacing the three existing 125 HP Dresser Roots blowers with two 75 HP Neuros, HIS Turbine Blowers or equal.

Table 14-3 below provides the summary of the evaluation:

Table 14-3

Power Consumption Comparison between Existing and Proposed Blowers			
Blower	kWh/Day Used	Days/Yr.	kWh/Yr Used
Existing RCS-J Roots	2,250	365	821,192
Proposed NX75-C050	1,504	365	548,928
Estimated Annual kWh Saving =			272,264
Estimated annual savings in electricity @ $0.1228 kWh =			$33,432

As can be readily seen replacing the existing positive displacement blowers with Turbine Blowers can reduce electricity consumption by about 1/3rd making this a viable economic investment. This analysis does not include any government or utility grants or incentives that may be available for this type of project.

Blower Inlet Air

The existing inlet aeration header for the blowers takes a small portion of its air requirement from the odor control duct off the abandon Headworks odor scrubber system. This method of recycling air to the aeration system is customary in many applications. However, as recently discovered [through a meeting with the manufacturer's representative on Wednesday December 17, 2008] air that has even small to moderate concentrations of H_2S maybe deleterious to the sensitive mechanical and electronic parts of the High Speed Turbine Blowers presently proposed to replace the existing positive displacement blowers.

Due to the viable characteristics of headworks odor it was determined that the existing abandon chemical odor control scrubber be replaced with a canister of activated carbon designed to treat the odor and H_2S from the headworks. This canister would replace the existing abandon chemical scrubber and its ancillary supporting equipment still located in the Headworks Odor Control Room.

Replacing the abandon scrubber equipment will permit "Valving Off" the 8-inch line presently in service which takes and recycles the headworks air to the aeration system, there by allowing only fresh air to be taken in by the proposed high speed turbine blowers.

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Savings Estimate

Table 14-4: Energy Savings Summary

Savings Summary	
Water (kgal/yr)	-
Water and Sewer ($/yr)	-
Electricity (kWh/yr)	272,264
Electricity (kW)	62.2
Electricity ($/yr)	$33,432
Thermal Energy (MMBtu/yr)	-
Thermal Energy ($/yr)	-
Total Savings ($/yr)	$33,432

Assumptions

- Hours of operation for the existing and proposed case were determined through review of plant operational data
- Electrical loading of the blowers was determined through metering
- For detailed calculations see Appendix 3

Scope of Work

- Remove and Salvage existing Dresser Roots 125 HP Blowers
- Remove and Dispose of one Blower w/ VFDs and the second Blower with two speed control.
- Remove and Salvage 10-inch Butterfly Valves for reuse on new blowers
- Remove and Salvage existing 10-inch Wafer Check Valves for reuse on new blowers.
- Remove and dispose of existing 10-inch stainless steel inlet and discharge piping at existing blowers to the limits shown on Figure 2.
- Furnish and install 2 new turbine blowers as shown on Figure 2.
- Furnish and install new starters in the Blower MCC Panel
- Furnish and install new power connection between Blower MCC and Turbine's VDF located on the packaged skid.
- Furnish and install 4 new D.O. probes at the aeration tanks and connect into existing control wiring to the blower system and plant SCADA system.
    - New DO probes for each aeration train will be polled to determine average DO level through out the aeration system. This average level will control the operation of the new VFD controlled Turbine Blowers.

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  - New DO probes will permit operators to balance DO through out the system by controlling air flow via the butterfly valve on each of the 3-zones in each train.
  - The recommended DO level to maintain through out the aeration tanks will be 1.5 to 2.5 mg/L.
- Carbon Filter – Calgon, Model HF 2000 with Centaur Carbon
  Installation of carbon filter will enable new blowers to utilize 100% fresh inlet air for aeration.
  - Location of new carbon filter to be determined and mutually agreed to
  - Carbon canister
  - Liquid tight flow control/regeneration valve
  - Carbon sample port
  - Flanged outlet
  - Polypropylene rain-tee with bird screen.
- Connect new turbine blowers to existing SCADA system.
- Manufacturer to provide minimum three days of onsite test and start up assistance
- Manufacturer to provide Operation and Maintenance Manual
- Manufacture to provide three year non prorated warranty for equipment defects and workmanship.

Exclusions

Installation of Carbon Filter has been budgeted at $52,000 subcontractor cost and is included in cash flow analysis. Prior to implementation of performance contract JCI will provide pricing for the installation. Should the work associated with installation of the carbon filter work required be greater than this amount JC will provide the customer with a detailed cost estimate prior to proceeding.

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FIM 15 Heating System Upgrade – Boiler Replacement

** The heating system upgrade has already been commissioned.*

Detailed Description of Energy Conservation Measure

The Dover Public Library utilizes hot water for heating that is supplied by a single cast iron sectional hot water boiler. The boiler was installed in over 20 years ago and has recently failed. Under this FIM, the existing boiler would be removed and replaced with a new high-efficiency gas-fired boiler. The intent of this FIM is to provide a higher level of energy efficiency for heating the building which at the same time would represent a capital upgrade that would defer maintenance and repair costs.

Existing Conditions

The existing boiler in the Dover Public Library is a HB Smith 450 Mills cast-iron sectional boiler with 17 sections. The boiler has an oil burner rated at 46.65 GPH at the maximum firing rate. The boiler nameplate indicates an output of 4,371 MBH, so the efficiency is estimated to be in the range of 70% (original design). The actual operating efficiency is likely to be lower than this due to the boilers' age.

Proposed Conditions

For the Dover Public Library boiler room, JCI will remove the existing older boiler. A new high-efficiency gas-fired boiler will be installed and will be properly sized (based on a heat loss calculation). Existing supply and return systems and gas supply piping will be reused with the new boiler.

Savings Estimate

Table 15-1: Energy Savings Summary

Savings Summary	
Water (kgal/yr)	-
Water and Sewer ($/yr)	-
Electricity (kWh/yr)	-
Electricity (kW)	-
Electricity ($/yr)	-
Thermal Energy (MMBtu/yr)	88
Thermal Energy ($/yr)	$1,251
Total Savings ($/yr)	$1,251

Assumptions

JCI used available capacity data for the existing boiler, along with the natural gas delivery history to estimate the average annual boiler loading.

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Savings Calculations

JCI performed spreadsheet-based calculations to model the annual fuel usage and the savings for the boiler replacement based on long-term weather data for Concord, NH. The savings calculation spreadsheet for the boiler replacement is included in Appendix 3.

Scope of Work

JCI proposes to install a new properly sized hot water heating boiler in the existing boiler room, including all necessary specifications, contractor selection, construction management, checkout, startup, commissioning and training:

- The existing boiler will be demolished.
- Disconnect all gas piping, supply/return piping, electrical connections and breaching
- A new properly sized gas-fired hot water boiler will be installed and will be connected to existing distribution piping.
- Re-install all gas piping, supply/return piping, electrical connections and breaching
- Leak test new boiler
- Reconnect EMS control and monitoring points will be installed for the boiler system.
- Startup, commissioning and operator training

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Energy Conservation Measures considered but not recommended

Description of Measure	Savings	Cost	Payback
Solar Photovoltaic Generation	$658	$91,454	139.0
Solar Thermal System	$5,521	$114,498	20.7
Micro - Hydro Turbine	$11,478	$657,158	120.0
Interlock Truck Bay Doors	$919	$20,410	22.2
Pipe Insulation	$213	$7,201	33.8
Totals	**$18,789**	**$1,890,721**	**100.6**

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SECTION 5 – Measurement & Verification Plan

The following M&V plan will be implemented for the City of Dover, NH. The plan for each FIM will be reviewed and approved by the city, or a representative of the city. A proper M&V plan should be developed to obtain a balance between M&V costs and savings certainty. Our M&V plan will accurately identify and verify savings associated with each improvement, while balancing the M&V costs with savings expectations.

Our goal is to ensure that our customers are comfortable and in full agreement with the savings calculations and the methodology used to verify the savings.

The three widely accepted M&V references are:

- FEMP (Federal Energy Management Protocol)
- IPMVP (International Performance Measurement & Verification Protocol)
- ASHRAE Guideline 14

FIM 1: Lighting – Fixture Retrofit

IPMVP Option A

Pre-Installation Baseline:

Measure kW levels on a representative sample of circuits. Identify circuits/fixtures measured. Read actual lumen levels in areas affected by the retrofit; provide a table of pre-installation lumen readings for each. Hours of operation will be provided by facility representatives and will remain stipulated throughout the term of the contract. Facility representatives will notify JCI when long term changes in operation occur.

Post-Installation:

Measure kW levels on the same sample of circuits/fixtures as the "Pre-Installation Baseline". Measure post installation lumen levels and provide the "Pre-Installation Baseline" table with the actual post- installation values added.

Duration of Measurement:

One Time Pre & Post Installation

Stipulated Variables:

Hours of operation for areas not affected by lighting controls. Hours of operation will be provided by facility representatives and agreed upon.

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FIM 2: Lighting – Fixture Controls

IPMVP Option A

Pre-Installation Baseline:

Utilize occupancy sensor data loggers to log 5% of each area type by building to determine existing hours that lights are left on while areas are unoccupied. Identify lighting fixtures/circuits affected by the new lighting controls.

Post-Installation:

Use data collected during “Pre-Installation Baseline” to verify lighting control savings.

Duration of Measurement:

Four weeks before installation

Stipulated Variables:

Fixture wattages under control of each new occupancy sensor, based on detailed lighting audit.

FIM 3: Building Envelope Improvements

Non-Measured – Engineering Calculations

Pre-Installation Baseline:

Identify and record all building envelope issues to be repaired / improved.

Post-Installation:

Verify that approved “Scope of Work” for FIM 3 has been completed. Record any changes to the scope and adjust potential savings if necessary.

Duration of Measurement:

Not Required

Stipulated Variables:

None Required

FIM 4-1,2: Energy Management System - Upgrades

IPMVP Option A

Pre-Installation Baseline:

Record existing equipment (motor hp, heating / cooling capability), control strategies (occ. control, outside air delivery, humidity control capability), and areas associated with FIM 4.

Post-Installation:

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Trending and totalization with FMS

Duration of Measurement:

One time before and after implementation, Annual review and optimization of FIM 4 control system

Stipulated Variables:

Hours of operation, pre-installation control strategies, equipment energy consumption pre & post retrofit

FIM 4-3: VFD on Fans

IPMVP Option A

Pre-Installation Baseline:

Identify existing operational schedules, strategies and control capacity for each fan associated with FIM 4-3. Record existing fan type, CFM and Load Profile for each fan associated with FIM 4-3. Measure fan kW, supply air and space temperatures.

Post-Installation:

Inspect all installed equipment for proper operation and control. Verify varied speed operation. Measure fan kW, supply air and space temperatures.

Minimum Duration of Measurement:

Annual inspection of all VFDs installed, confirm variable speed operation

Stipulated Variables:

Hours of Operation, motor power

FIM 4-4: Pool Dehumidification Control

IPMVP Option A

Pre-Installation Baseline:

Record existing equipment (motor hp, heating / cooling capability) and control strategies (occ. control, outside air delivery system, humidity control capability). Record humidity levels throughout facility.

Post-Installation:

Verify new equipment operation (motor hp, heating / cooling capability) approved control strategies (occ. control, outside air delivery, humidity control capability). Annual review of FIM operation and functionality, also identify overrides to approved control strategies. Track and trend humidity throughout facility through the building automation system.

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Duration of Measurement:

Continual tracking and trending of humidity levels

Stipulated Variables:

Hours of operation, equipment energy consumption pre & post retrofit, pool operational temperatures

FIM 4-5: Repair Snowmelt Sensor

IPMVP Option A

Pre-Installation Baseline:

Measure power draw of snow melt system. Determine time-of-use for the system operated manually, which will then be stipulated for the remainder of the term.

Post-Installation:

Install data logger on snow melt system to determine post installation hours of operation

Minimum Duration of Measurement:

Annual testing of snow melt sensor system, replacement bi-annually of sensor

Stipulated Variables:

Pre-Installation hours of operation

Minimum Performance Period:

Annual inspection of solar hot water system

Considerations:

Savings are a function of severity of winter weather

FIM 6: Water Conservation

IPMVP Option A

Pre-Installation Baseline:

Flow measurement of sampling of fixtures associated with FIM 6. Record existing conditions of equipment

Post-Installation:

Flow measurement of same sampling of fixtures associated with FIM 6 as "Pre-Installation Baseline". Record existing conditions of equipment

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Minimum Duration of Measurement:
One-Time Pre and Post Installation

Stipulated Variables:
Pre-installation Operation, Occupancy

FIM 9: Vending Machine Controls

Non-Measured – Engineering Calculations

Pre-Installation Baseline:
None Required

Post-Installation:
Review installation of vending machine controllers to ensure FIM9 scope has been fully implemented

Minimum Duration of Measurement:
One-Time Pre and Post Installation

Stipulated Variables:
None Required

FIM 10: Pool Cover

Non-Measured – Engineering Calculations

Pre-Installation Baseline:
None

Post-Installation:
Inspection of installation

Minimum Duration of Measurement:
None Required, annual inspection of pool cover

Stipulated Variables:
Operational hours

FIM 11-1: Low Emissivity Ceiling ("Low-E ceiling")

Non-Measured – Engineering Calculations

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Pre-Installation Baseline:

None Required

Post-Installation:

Verify that the new ceiling has been installed correctly

Duration of Measurement:

None Required

Stipulated Variables:

Pre-installation heat transfer variables for existing ceiling, Ice Emissivity values

FIM 11-2: Infrared Ice Surface Temperature Monitoring and Controls

IPMVP Option A

Pre-Installation Baseline:

Record existing ice temperature readings for a two – four week period

Post-Installation:

Record post-installation ice temperatures for a two – four week period.

Duration of Measurement:

One time before and after implementation, annual review of ice temperature sample

Stipulated Variables:

None Required

FIM 11-3: Dehumidification Controls

IPMVP Option A

Pre-Installation Baseline:

Record existing equipment (motor hp, heating / cooling capability) and control strategies (occ. control, outside air delivery system, humidity control capability). Record existing humidity levels

Post-Installation:

Verify new equipment operation (motor hp, heating / cooling capability) approved control strategies (occ. control, outside air delivery, humidity control capability). Annual review of FIM operation and functionality, also identify overrides to approved control strategies. Track and trend humidity levels through building automation system.

Duration of Measurement:

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Annual tracking of humidity levels

Stipulated Variables:
Hours of operation, equipment energy consumption pre & post retrofit, operational temperatures

FIM 11-4: Icemax to Maintain Consistent Ice Surface

IPMVP Option A

Pre-Installation Baseline:
Record existing brine supply and return temperatures

Post-Installation:
Record post implementation brine supply and return temperatures.

Duration of Measurement:
Four weeks pre-installation and four weeks post installation

Stipulated Variables:
Chiller efficiency

Considerations:
Icemax is a chemical that is applied to the ice manually through the ice resurfacing machine. The ice resurfacing machine operator is responsible for adding the icemax to the hot water tank on the resurfacing machine. There is the possibility that the chemical will not be added to the resurfacing machine by accident, or the fill tank on the resurfacing machine may overflow during fill-up, diluting the chemical to a point where it has lost its potency and is no longer effective. The effectiveness of icemax will be acknowledged during the post-installation period and savings will be based on proper application of the chemical.

FIM 11-5: Move the dashers inboard

Non-Measured – Engineering Calculations

Pre-Installation Baseline:
Document the pre-existing condition of the dasher boards (scale drawings). Document the pre-installation brine supply temperature.

Post-Installation:
Verify proper retrofit of dasher boards; document the post-installation brine supply temperature

Minimum Duration of Measurement:
One-time pre & post installation (four weeks pre-installation & four weeks post-installation)

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Stipulated Variables:

Pre-Installation supply temperature once measured

FIM 11-6: Cooling System Upgrade - Chiller Replacement

IPMVP Option C

Pre-Installation Baseline:

Unit energy input (MMbtu) will be calculated based on manufactures specifications. Measure chilled water flow, and temperature differential. Determine existing efficiency (COP based on manufactures specifications) and tons in weather bins, both occupied and unoccupied. Set natural gas baseline.

Post-Installation:

Measure unit energy input (kW, therm, MMbtu, etc…) chilled water flow, and temperature differential; record outside air temperature during all measurements. Monitor natural gas and electricity consumption for the facility.

Minimum Duration of Measurement:

Measurements will be taken at least two weeks before and four weeks after implementation when cooling is required. Ongoing kW/ton readings and annual inspection of equipment

Stipulated Variables:

COP of existing chiller based on manufacturers specifications, Load profile weather bins not measured, Operational hours

FIM 11-7: VFD on Pumps

IPMVP Option A

Pre-Installation Baseline:

Identify existing operational schedules, strategies and control capacity for each pump associated with FIM 11-7. Record existing pump type, operational flow and load profile for each pump associated with FIM 11-7. Measure pump motor kW.

Post-Installation:

Inspect all installed equipment for proper operation and control. Verify varied speed operation (varied flow). Measure Pump Motor kW.

Minimum Duration of Measurement:

Annual inspection of all VFDs installed, confirm variable speed operation

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Stipulated Variables:

Hours of Operation, motor power

FIM 12: Power Factor Correction

IPMVP Option A

Pre-Installation Baseline:

Measurement and documentation of exiting power factor values for a representative amount of the equipment affected by FIM 12

Post-Installation:

Measurement and documentation of power factor values for the same representative amount of the equipment post-installation

Minimum Duration of Measurement:

One-time pre & post installation

Stipulated Variables:

Pre-Installation Power Factor once measured

FIM 13: Transformers - Retrofit

IPMVP Option A

Pre-Installation Baseline:

Measurement of pre-retrofit power, harmonics, PF and efficiency

Post-Installation:

Measurement of post- retrofit power, harmonics, PF and efficiency

Minimum Duration of Measurement:

At least two weeks pre and installation and post installation

Stipulated Variables:

Operational Hours, Input Power

Minimum Duration of Measurement:

One-time pre and post installation. Annual inspection of aeration blower system and O&M records

Stipulated Variables:

Pre-Installation loading, hours-of-operation

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Considerations:

Operation and maintenance will be performed by The City of Dover in accordance with manufacture's specifications and recommendations.

FIM 14: Aeration Blower Update (WWTP)

IPMVP Option A

Pre-Installation Baseline:

Measure and record power draw and loading of existing system.

Post-Installation:

Measure and record power draw of new system.

Minimum Duration of Measurement:

One-time pre and post installation. Annual inspection of aeration blower system and O&M records

Stipulated Variables:

Pre-Installation loading, hours-of-operation

Considerations:

Operation and maintenance will be performed by The City of Dover in accordance with manufacture's specifications and recommendations.

FIM 15: Boiler Replacement

IPMVP Option A

Pre-Installation Baseline:

Past 24 months fuel use correlated to weather data with combustion efficiency stipulated at 78% (Boiler replaced during detailed audit, November 2008 as part of emergency repair).

Post-Installation:

Perform combustion efficiency test over a range of firing rates to ensure greater efficiency over old boiler

Minimum Duration of Measurement:

One week of variable load post-installation, annual combustion efficiency testing

Stipulated Variables:

Pre-installation boiler efficiency

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SECTION 6 – Commissioning Plan

Purpose

The purpose of the commissioning plan is to provide direction for the commissioning process during construction. In particular, it provides details on issues such as scheduling, participation of various parties in this particular project, actual lines of reporting and approvals, coordination, etc. This plan will facilitate the commissioning, cleaning, and testing of the motors, VFDs, boilers, building controls and HVAC units, prior to and during start-up. For Johnson Controls, commissioning plan and guidelines please see Appendix 6.

The instructions contained herein are not intended to override any of the specific recommendations presented in the individual equipment manuals. In fact, by reference, the equipment manuals are made an active part of these instructions. Consequently, this document, together with the individual equipment manuals, must be followed as each system is brought into active service. The individual equipment manuals will contain detailed information that describes installation, checkout and start-up, safe operation, maintenance, and repairs.

The interaction of each item or system within the entire facility must be considered as each is activated. Due to interactions, certain compromises must be made as they arise. In some cases, the operating conditions are temporarily exceeded in order to ensure proper performance at the design level. In addition, there are periods when some of the safety devices are bypassed or temporarily rendered inoperative. This condition requires that a careful system of tags, checking, and follow-up documentation be imposed to restore all elements to their proper condition prior to start-up. It also requires rigorous monitoring of the systems during such testing.

Scheduling of these preparatory activities will be carefully coordinated with the construction phase to ensure an expeditious and well-organized start-up. No attempt is made here to establish the order in which these tasks are to be performed. This sequence is best established in the field, with due consideration being given to the status of construction, the availability of the required utilities, and responsible personnel.

The roles of the manufacturer's representative, system test conductor, contractor personnel, and operating staff must be clearly defined at each step. Precise lines of authority and communication at each level must be enforced to ensure the safety of all personnel and to limit chances for damaging expensive equipment and property. This plan does not provide a detailed explanation of required testing procedures. The detailed testing procedures, forms, checklists, etc. will be developed during the design phase and will be available on site during the construction and testing phase.

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Commissioning Scope

Commissioning is a systematic process of ensuring that all FIMs perform interactively according to the design intent and the owner's operational needs. This is achieved by: 1) clearly documenting the design intent during the design phase, 2) verifying the design intent throughout construction, start-up, commissioning, and acceptance, and 3) verifying ongoing performance during the warranty and performance periods.
Initial commissioning begins prior to and during the design phase of the project. At this time, the project objectives are clearly defined and a review process is established to ensure that: 1) the design documents fully incorporate each FIMs operating and performance objectives and that the designs and specifications comply with all applicable codes, and 2) the project specifications fully define the testing and quality control requirements needed to ensure that the design intent has been achieved. In addition, JC develops an "initial" commissioning plan to outline the commissioning requirements of each FIM as well as the key performance factor that must be met in order to achieve measure acceptance. JC will also provide all pre-functional acceptance test and functional acceptance test forms for customer review and approval.

Commissioning during the construction phase of the project is intended to achieve the following specific objectives:

- Verify the proper operation of all system and equipment safety devices.
- Ensure that all applicable equipment and systems are installed in accordance with engineering drawings, manufacturer installation manuals, and applicable codes.
- Ensure that all equipment and systems receive adequate operational checkout by the installing contractors.
- Verify and document proper performance of equipment and systems.
- Ensure that a complete package of commissioning, as-built, and operating and maintenance documentation is left on site.
- Ensure that the operating and maintenance personnel are adequately trained.

After the design phase is complete, JC develops a final start-up and commissioning plan to detail the steps required to achieve the above objectives.

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SECTION 7 – Project Schedule

Once final selection of facility improvement measures is completed Johnson Controls will prepare a detailed project schedule using Microsoft Project. This schedule will contain a FIM by FIM implementation matrix and outline specific project milestones such as; mobilization, construction meetings, material delivery, implementation and project commissioning, measurement and verification and closeout. At this time, Johnson Controls has contemplated a 9-12 month project delivery schedule depending on the mix of facility improvement measures.

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SECTION 8 Appendix – Supporting Documentation

Appendix 1 – Sources of Information

Appendix 2 – Basic Data for Calculations

Appendix 3 – Calculations

Appendix 4 – Outline Specifications for All Equipment

Appendix 5 – Lighting Schedules

Appendix 6 – Commissioning Plan

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