

# CITY OF DOVER, NH



## YEAR 4 MEASUREMENT & VERIFICATION (M&V) REPORT

### Annual Contract Savings

(November 1, 2014 – October 31, 2015)

January 7, 2016



# CITY OF DOVER, NH

## PERFORMANCE CONTRACT

### Year 4

### Annual M&V Report

Performance Period Dates Covered: November 1, 2014 to October 31, 2015

Contract #: 9236-0143

Contract Year #: 4

Annual Year 4 Guaranteed Savings:

Energy:	\$297,376
Operations & Maintenance (O&M):	\$15,388
Capital Cost Avoidance:	\$33,840
Total Guarantee:	\$346,603

Contract Term: 10-Years

Term Guaranteed Savings: \$3,623,746

Utility Cost Avoidance Escalation Rate: 3.0%

O&M Cost Avoidance Escalation Rate: 4.0%

Guarantee Start Date: 11/1/2011

Guarantee End Date: 10/31/2021



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## EXECUTIVE SUMMARY

### Cost Avoidance Summary

The City of Dover, NH and Johnson Controls, Inc. entered into an energy savings performance contract (ESPC) in September in 2009. The goal of this contract was to make a wide range of Facility Improvement Measures (FIMs) to 14 city buildings and facilities that would be paid for by guaranteed reductions in the City's energy and energy related costs achieved through those measures. The 10 year guaranteed savings term of the contract began on November 1, 2011 and ends on October 31, 2021. This report covers the fourth full contract (guarantee) year which runs from November 2014 through October 2015. It is designed to enable the City of Dover to understand the performance of this project over time, including the guaranteed and actually achieved (verified) savings for all Facility Improvement Measures (FIMs) through four full years.

The 1<sup>st</sup> year annual savings guarantee of \$319,463 included \$271,943 in energy cost avoidance (after a Change Order (#9236-0142-CO2) to add a lighting retrofit project at the McConnell Center), \$13,680 in operations and maintenance (O&M) cost avoidance, and a future capital cost avoidance of \$33,840. The annual guaranteed energy savings amount escalates by 3% and the O&M savings escalate by 4% each year to account for inflation. Total term benefits are \$3,623,746.

**Year 4 savings of \$354,849 exceeded the guaranteed amount by \$8,246, or 2.4%.** Along with a \$3,799 (1.1%) savings surplus in Year 3, this was more than enough to overcome the total of small savings shortfalls experienced in Years 1 and 2 of the contract, for which the City of Dover was compensated. The following table summarizes the total guaranteed savings by year vs. the actual achieved or verified project savings:

City of Dover Annual Cost Savings Summary						
Guarantee Period	Guaranteed Energy Cost Avoidance	Guaranteed O&M Cost Avoidance	Guaranteed Future Capital Cost Avoidance	Total Guaranteed Cost Avoidance	Verified Annual Cost Avoidance	Variance
Year 1	\$271,943	\$13,680	\$33,840	\$319,463	\$317,642	(\$1,821) <sup>(1)</sup>
Year 2	\$280,169	\$14,227	\$33,840	\$328,236	\$321,420	(\$6,817) <sup>(2)</sup>
Year 3	\$288,644	\$14,796	\$33,840	\$337,280	\$341,079	\$3,799
<b>Year 4</b>	<b>\$297,375</b>	<b>\$15,388</b>	<b>\$33,840</b>	<b>\$346,603</b>	<b>\$354,849</b>	<b>\$8,246</b>
Year 5	\$306,371	\$16,004	\$33,840	\$356,214		
Year 6	\$315,638	\$16,644	\$33,840	\$366,122		
Year 7	\$325,186	\$17,310	\$33,840	\$376,336		
Year 8	\$335,023	\$18,002	\$33,840	\$386,865		
Year 9	\$345,157	\$18,722	\$33,840	\$397,719		
Year 10	\$355,598	\$19,471	\$33,840	\$408,909		
<b>Total</b>	<b>\$3,121,103</b>	<b>\$164,244</b>	<b>\$338,400</b>	<b>\$3,623,746</b>	<b>\$1,335,061</b>	<b>N/A</b>

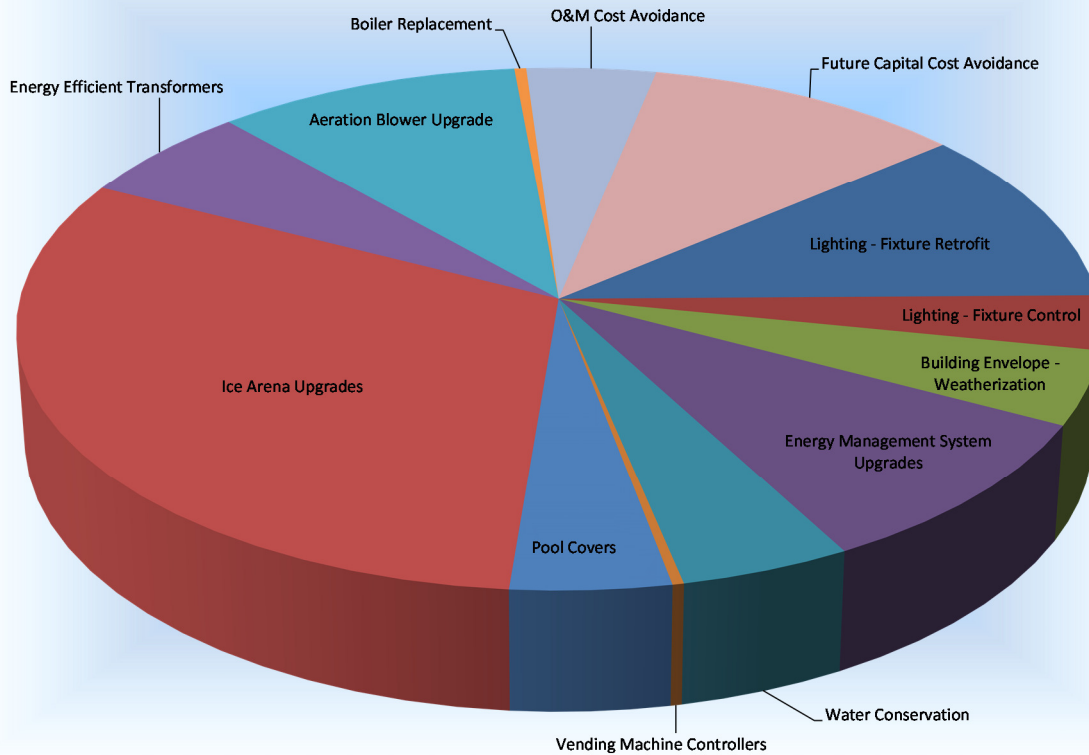
<sup>(1)</sup> Year 1 variance was due to non-installation of FIM 12- Power Factor Correction during Year 1 as explained in previous reports. The equipment was installed in the first quarter of Year 2 (January of 2013). The City of Dover has been compensated for the variance from guaranteed savings.

<sup>(2)</sup> Year 2 variance was due to Ice Arena controls & equipment overrides. Items have been corrected and the city has received compensation in the amount of the variance.

## EXECUTIVE SUMMARY

### Savings by Facility Improvement Measure (FIM)

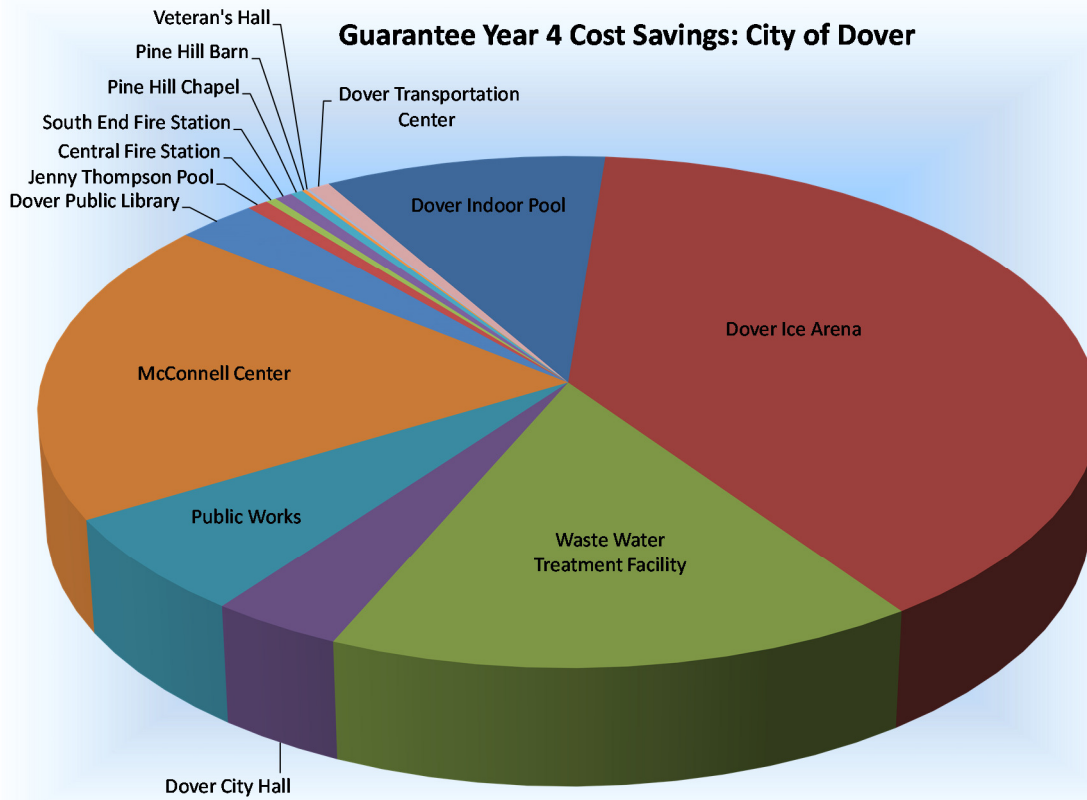
#### Guarantee Year 4 Cost Savings: City of Dover



City of Dover, NH - Guarantee Year 4 Savings									
FIM #	FIM Description	Electricity Savings			Thermal Savings		Water Savings		Total Y4 \$ Savings
		kW	kWh	\$	MMBtu	\$	kgal	\$	
1	Lighting - Fixture Retrofit	1,426	265,428	\$40,924	(253)	(\$3,691)	0	\$0	\$37,233
2	Lighting - Fixture Control	310	93,119	\$11,775	0	\$0	0	\$0	\$11,775
3	Bldg. Envelope - Weatherization	0	5,155	\$626	1,171	\$17,638	0	\$0	\$18,263
4	EMS -Upgrades	0	86,709	\$10,296	1,115	\$17,769	0	\$0	\$28,065
6	Water Conservation	0	0	\$0	164	\$2,472	1,117	\$13,486	\$15,958
9	Vending Machine Controllers	0	8,425	\$1,059	0	\$0	0	\$0	\$1,059
10	Pool Cover	0	46,656	\$5,331	560	\$8,799	64	\$777	\$14,907
11	Ice Arena - Upgrades	(741)	(146,573)	(\$22,281)	10,005	\$138,261	0	\$0	\$115,981
12	Power Factor Correction	50	11,666	\$1,739	0	\$0	0	\$0	\$1,739
13	Energy Efficient Transformers	318	150,628	\$21,230	0	\$0	0	\$0	\$21,230
14	Aeration Blower Upgrade	724	248,010	\$37,837	0	\$0	0	\$0	\$37,837
15	Boiler Replacement	0	0	\$0	102	\$1,574	0	\$0	\$1,574
<b>Energy Totals</b>		<b>2,088</b>	<b>769,223</b>	<b>\$108,538</b>	<b>12,863</b>	<b>\$182,821</b>	<b>1,181</b>	<b>\$14,262</b>	<b>\$305,621</b>
O&M Cost Avoidance		-	-	-	-	-	-	-	\$15,388
Future Capital Cost Avoidance		-	-	-	-	-	-	-	\$33,840
<b>Totals</b>		<b>2,088</b>	<b>769,223</b>	<b>\$108,538</b>	<b>12,863</b>	<b>\$182,821</b>	<b>1,181</b>	<b>\$14,262</b>	<b>\$354,849</b>

## EXECUTIVE SUMMARY

### Savings by Facility



City of Dover, NH – Guarantee Year 4 Savings									
Facility Location	Electricity Savings			Thermal Savings		Water Savings		O&M / Cap Cost Savings	Total \$ Savings
	kW	kWh	\$	MMBtu	\$	kgal	\$		
Central Fire Station	0	227	\$31	60	\$993	21	\$250		\$1,274
Dover City Hall	150	36,169	\$4,926	208	\$3,761	302	\$3,649	\$540	\$12,876
Dover Ice Arena	(432)	(39,134)	(\$7,885)	10,332	\$142,790	239	\$2,882	\$12,688	\$150,475
Dover Public Library	102	34,354	\$5,053	205	\$3,163	127	\$1,537	\$540	\$10,293
Dover Transportation Ctr.	0	19,905	\$2,657	0	\$0	0	\$0		\$2,657
Indoor Pool	37	123,686	\$14,484	1,027	\$16,109	280	\$3,378	\$34,380	\$68,351
Jenny Thompson Pool	0	0	\$0	25	\$372	141	\$1,700		\$2,072
McConnell Center	821	169,916	\$26,310	508	\$7,810	0	\$0	\$540	\$34,660
Pine Hill Barn	0	0	\$0	28	\$511	0	\$0		\$511
Pine Hill Chapel	0	27	\$5	50	\$899	7	\$79		\$983
Public Works	571	136,427	\$19,087	215	\$2,606	56	\$680	\$540	\$22,913
South End Fire Station	0	111	\$16	105	\$1,998	9	\$108		\$2,122
Veterans Hall	0	0	\$0	20	\$391	0	\$0		\$391
Waste Water Treatment Facility	838	287,536	\$43,854	79	\$1,419	0	\$0		\$45,272
<b>Totals</b>	<b>2,088</b>	<b>769,223</b>	<b>\$108,538</b>	<b>12,863</b>	<b>\$182,821</b>	<b>1,181</b>	<b>\$14,262</b>	<b>\$49,228</b>	<b>\$354,849</b>

EXECUTIVE SUMMARY

Savings (\$) by FIM and Facility:

City of Dover, NH Building Location	FIM 1	FIM 2	FIM 3	FIM 4	FIM 6	FIM 9	FIM 10	FIM 11	FIM 12	FIM 13	FIM 14	FIM 15	O&M Savings / Capital Cost Avoidance	Totals / Building
	Lighting Fixtures	Lighting Controls	Building Envelope (Weatherization)	Energy Management System - Upgrades	Water Conservation	Vending Machine Controllers	Pool Cover	Ice Arena Upgrades	Power Factor Correction	Energy Efficient Transformers	Aeration Blower Upgrade	Boiler Replacement		
Central Fire Station			\$968		\$306									\$1,274
Dover City Hall	\$3,172	\$1,052	\$1,259	\$2,470	\$4,025	\$357							\$540	\$12,876
Dover Ice Arena	\$6,156	\$1,507	\$5,353		\$3,611	\$347		\$115,981	\$1,739	\$3,092			\$12,688	\$150,475
Dover Public Library	\$3,732	\$1,042	\$476	\$1,230	\$1,699							\$1,574	\$540	\$10,293
Dover Transportation Ctr.				\$2,657										\$2,657
Indoor Pool	\$1,293	\$30	\$1,513	\$12,879	\$3,178	\$171	\$14,907						\$34,380	\$68,351
Jenny Thompson Pool					\$2,072									\$2,072
McConnell Center	\$11,608	\$4,970	\$1,371	\$7,897						\$8,274			\$540	\$34,660
Pine Hill Barn				\$511										\$511
Pine Hill Chapel			\$626	\$270	\$86									\$983
Public Works	\$11,272	\$3,173	\$2,879	\$150	\$833	\$183				\$3,882			\$540	\$22,913
South End Fire Station			\$1,975		\$147									\$2,122
Veterans Hall			\$391											\$391
Waste Water Treatment Facility			\$1,454							\$5,981	\$37,837			\$45,272
<b>Totals / FIM</b>	<b>\$37,233</b>	<b>\$11,775</b>	<b>\$18,263</b>	<b>\$28,065</b>	<b>\$15,958</b>	<b>\$1,059</b>	<b>\$14,907</b>	<b>\$115,981</b>	<b>\$1,739</b>	<b>\$21,230</b>	<b>\$37,837</b>	<b>\$1,574</b>	<b>\$49,228</b>	<b>\$354,849</b>

EXECUTIVE SUMMARY

Savings (\$) by FIM, by Month

Cost savings are provided on a monthly basis for Contract Year 4 in the table below. The annual guaranteed savings per FIM comprise the amounts that add up to the total annual guarantee. FIM savings are not guaranteed individually; the savings guarantee applies to the project as a whole. Therefore a savings shortfall from one FIM can be overcome by another FIM in an accounting of overall project savings.

City of Dover, NH															
FIM #	FIM Description	Fiscal Year 2015								Fiscal Year 2016				Total Contract Year 4 Savings	Annual Guaranteed Savings
		NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT		
1	Lighting - Fixture Retrofit	\$1,949	\$1,957	\$1,821	\$1,599	\$1,921	\$2,026	\$2,335	\$2,298	\$2,597	\$2,622	\$2,374	\$2,129	\$25,625	\$24,497
	Lighting Fixtures (McConnell Ctr)	\$865	\$853	\$784	\$722	\$835	\$904	\$1,061	\$1,060	\$1,229	\$1,246	\$1,110	\$939	\$11,608	\$11,684
2	Lighting - Fixture Control	\$559	\$578	\$578	\$522	\$578	\$559	\$578	\$559	\$578	\$578	\$559	\$578	\$6,805	\$6,537
	Lighting Controls (McConnell Ctr)	\$409	\$422	\$422	\$381	\$422	\$409	\$422	\$409	\$422	\$422	\$409	\$422	\$4,970	\$4,667
3	Building Envelope - Weatherization	\$1,921	\$2,260	\$2,963	\$2,972	\$2,445	\$1,524	\$825	\$208	\$565	\$560	\$653	\$1,369	\$18,263	\$15,814
4.1	EMS - Building Controls	\$1,146	\$1,403	\$1,962	\$2,007	\$1,549	\$830	\$267	\$170	\$68	\$65	\$145	\$694	\$10,308	\$9,184
4.2	EMS - Building Controls / Optimal Start	\$280	\$343	\$480	\$491	\$379	\$203	\$60	\$36	\$2	\$0	\$27	\$170	\$2,470	\$2,212
4.3	AHU Upgrade - VFD on Fan <sup>(3)</sup>	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$7,234
4.4	Pool Dehumidification - EMS & VFD's	\$1,038	\$1,073	\$1,073	\$969	\$1,073	\$1,038	\$1,073	\$1,038	\$1,073	\$1,073	\$1,038	\$1,073	\$12,630	\$12,251
4.5	Repair Snow Melt Sensor	\$293	\$606	\$606	\$547	\$606	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$2,657	\$2,578
6	Water Conservation	\$1,312	\$1,355	\$1,355	\$1,224	\$1,355	\$1,312	\$1,355	\$1,312	\$1,355	\$1,355	\$1,312	\$1,355	\$15,958	\$15,444
9	Vending Machine Controllers	\$87	\$90	\$90	\$81	\$90	\$87	\$90	\$87	\$90	\$90	\$87	\$90	\$1,059	\$1,023
10	Pool Covers	\$1,225	\$1,266	\$1,266	\$1,144	\$1,266	\$1,225	\$1,266	\$1,225	\$1,266	\$1,266	\$1,225	\$1,266	\$14,907	\$14,460
11	Ice Arena Upgrades <sup>(4)</sup>	\$7,746	\$3,636	\$8,435	\$7,167	\$5,133	\$4,130	\$10,285	\$18,609	\$16,336	\$17,529	\$11,247	\$5,728	\$115,981	\$103,901
12	Power Factor Correction	\$138	\$141	\$141	\$130	\$141	\$138	\$141	\$192	\$157	\$141	\$138	\$141	\$1,739	\$7,860
13	Energy Efficient Transformers	\$1,493	\$1,537	\$1,537	\$1,406	\$1,537	\$1,493	\$1,537	\$1,493	\$1,537	\$1,537	\$1,493	\$1,537	\$18,139	\$16,873
	E.E. Transformers (Ice Arena)	\$255	\$262	\$262	\$239	\$262	\$255	\$262	\$255	\$262	\$262	\$255	\$262	\$3,091	\$3,231
14	Aeration Blower Upgrade	\$3,116	\$3,205	\$3,205	\$2,939	\$3,205	\$3,116	\$3,205	\$3,116	\$3,205	\$3,205	\$3,116	\$3,205	\$37,837	\$36,559
15	Boiler Replacement	\$195	\$239	\$334	\$342	\$264	\$71	\$0	\$0	\$0	\$0	\$9	\$118	\$1,574	\$1,368
<b>ENERGY COST SAVINGS</b>		<b>\$24,027</b>	<b>\$21,225</b>	<b>\$27,315</b>	<b>\$24,883</b>	<b>\$23,060</b>	<b>\$19,318</b>	<b>\$24,762</b>	<b>\$32,067</b>	<b>\$30,741</b>	<b>\$31,951</b>	<b>\$25,197</b>	<b>\$21,076</b>	<b>\$305,621</b>	<b>\$297,376</b>
O&M Cost Avoidance		\$1,261	\$1,303	\$1,303	\$1,219	\$1,303	\$1,261	\$1,303	\$1,261	\$1,303	\$1,303	\$1,261	\$1,303	\$15,388	\$15,388
Future Capital Cost Avoidance		\$2,774	\$2,866	\$2,866	\$2,681	\$2,866	\$2,774	\$2,866	\$2,774	\$2,866	\$2,866	\$2,774	\$2,866	\$33,840	\$33,840
<b>TOTAL COST SAVINGS</b>		<b>\$28,062</b>	<b>\$25,395</b>	<b>\$31,484</b>	<b>\$28,783</b>	<b>\$27,230</b>	<b>\$23,354</b>	<b>\$28,931</b>	<b>\$36,102</b>	<b>\$34,911</b>	<b>\$36,121</b>	<b>\$29,232</b>	<b>\$25,245</b>	<b>\$354,849</b>	<b>\$346,603</b>

<sup>(3)</sup> The VFD as part of FIM 4.3 at the Public Works building was removed in September 2012 from the AHU due to continued system compatibility issues encountered over the life of the project.

<sup>(4)</sup> The City of Dover Ice Arena discontinued using IceMax in January 2013



## EXECUTIVE SUMMARY

### Savings by Source

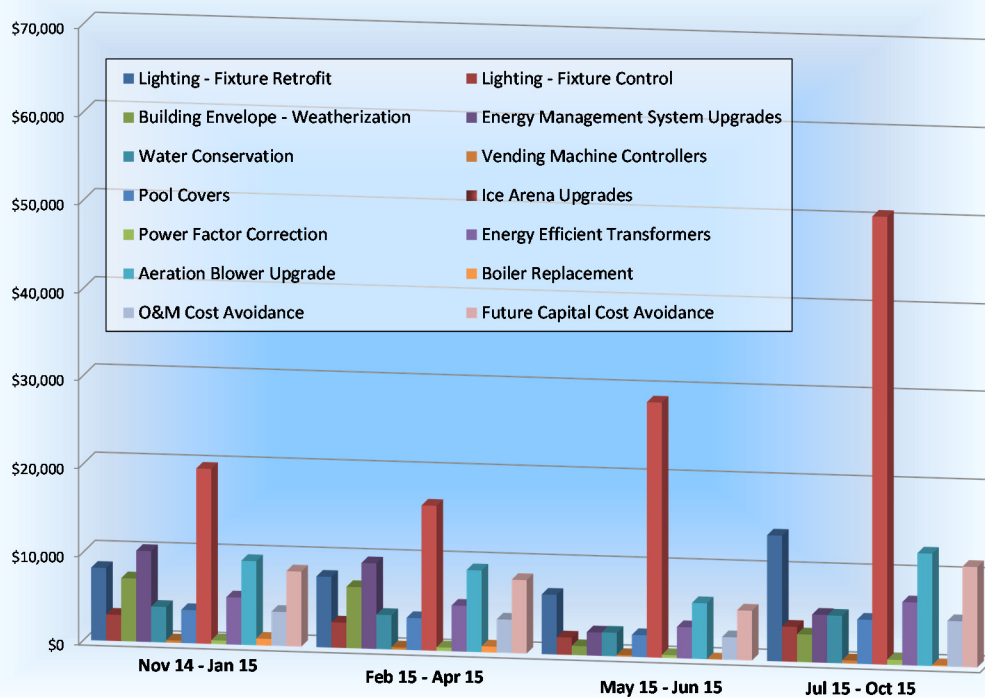
Savings under the project can also be understood as coming from the following sources:

- 1) Electricity (energy and demand)
- 2) Thermal savings (heating fuel)
- 3) Water/sewer savings (gallons)
- 4) Operations and Maintenance savings and capital cost avoidance (dollars)

The table below shows the units and amounts of these sources of savings:

Type of Savings	Units Saved	Dollars Saved
Electricity Consumption	769,223 kWh	\$108,538
Electricity Demand	2,088 kW	
Thermal (Oil/Gas/Propane)	12,848 MMBtu	\$182,821
O&M / Capital Cost Avoidance	-	\$49,228

**Guarantee Year 4 Cost Savings: City of Dover**



Thermal Savings consist of savings from Natural Gas (therms), Oil (gallons), and Propane (gallons). In order to provide a basis for comparison, these have all been reported in MMBtu. Conversion factors used in assembling this report are listed below:

- Natural Gas: 1 therm = 0.1 MMBtu
- Oil: 1 gallon = 0.139 MMBtu
- Propane: 1 gallon = 0.0916 MMBtu

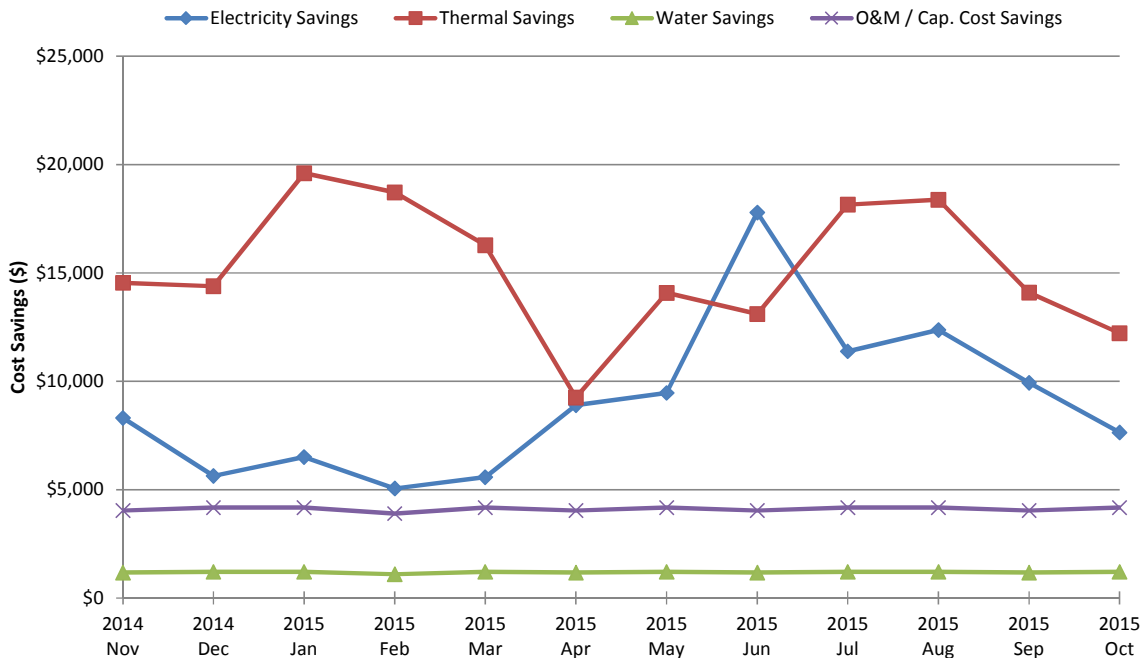
## EXECUTIVE SUMMARY

### Aggregate Savings, by Source, by Month

Included below are the total monthly energy unit savings and associated dollar cost savings for all FIMs.

City of Dover- Performance Contract Savings										
Contract Year 4 Energy Cost Avoidance										
Month	Year	Electric Savings			Thermal Savings		Water Savings		O&M / Cap. Cost Savings	Total Cost \$ Savings
		kW	kWh	Cost \$	MMBtu	Cost \$	kGal	Cost \$		
November	2014	210	55,459	\$8,313	1,013	\$14,542	97	\$1,172	\$4,035	\$28,062
December	2014	111	38,332	\$5,626	995	\$14,388	100	\$1,211	\$4,170	\$25,395
January	2015	147	43,444	\$6,498	1,360	\$19,606	100	\$1,211	\$4,170	\$31,484
February	2015	131	32,887	\$5,067	1,296	\$18,721	91	\$1,094	\$3,901	\$28,783
March	2015	141	35,839	\$5,570	1,129	\$16,279	100	\$1,211	\$4,170	\$27,230
April	2015	140	65,548	\$8,901	638	\$9,245	97	\$1,172	\$4,035	\$23,354
May	2015	203	65,905	\$9,465	1,002	\$14,085	100	\$1,211	\$4,170	\$28,931
June	2015	265	133,767	\$17,788	934	\$13,106	97	\$1,172	\$4,035	\$36,102
July	2015	161	85,018	\$11,376	1,302	\$18,154	100	\$1,211	\$4,170	\$34,911
August	2015	205	90,557	\$12,361	1,318	\$18,379	100	\$1,211	\$4,170	\$36,121
September	2015	182	71,507	\$9,935	1,006	\$14,090	97	\$1,172	\$4,035	\$29,232
October	2015	192	50,961	\$7,638	856	\$12,226	100	\$1,211	\$4,170	\$25,245
<b>Contract Yr 4</b>		<b>2,088</b>	<b>769,223</b>	<b>\$108,538</b>	<b>12,848</b>	<b>\$182,821</b>	<b>1,181</b>	<b>\$14,262</b>	<b>\$49,228</b>	<b>\$354,849</b>

### Monthly Project Savings



## FIM DESCRIPTION

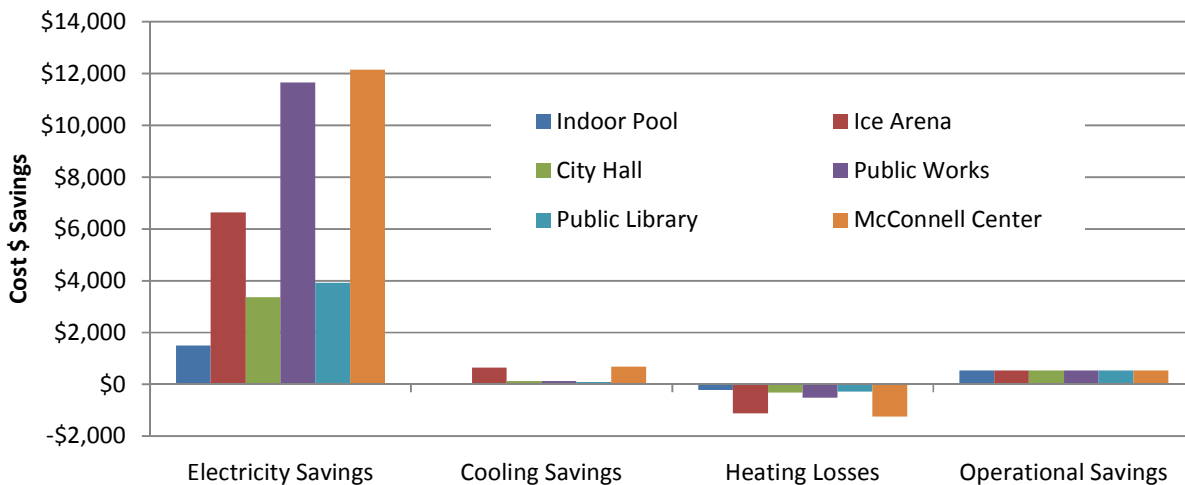
### FIM 1: Lighting – Fixture Retrofit

Lighting can be broken down into four savings parts: Electricity Savings from the replacement of higher power fixtures with more efficient ones, Cooling Savings from less fixture heat being introduced into a cooled space, Heating Losses from less fixture heat being introduced in a heated space, and Operational Savings from decreased lighting changes and uniform lighting stock. Annual guaranteed electric savings associated with FIM 1 are 262,508 kWh with a monthly reduction in demand of 118.8 kW. Annual guaranteed heating losses are calculated to be 250 MMBtu resulting in a total guaranteed energy cost savings for FIM 1 of \$36,181 in Contract Year 4. Operational Savings are stipulated at \$3,240 for Year 4 for this measure.

FIM 1: Lighting – Fixture Retrofit									
Contract Year 4 Energy Cost Avoidance									
Building	Electricity Savings			Cooling Savings		Heating Losses		O&M	Total Cost
	kW	kWh	Cost \$	kWh	Cost \$	MMBtu	Cost \$	\$ Savings	\$ Savings
Indoor Pool	36	10,084	\$1,503	98	\$11	(14)	(\$221)	\$540	\$1,833
Ice Arena	142	47,806	\$6,641	5,507	\$638	(81)	(\$1,123)	\$540	\$6,696
City Hall	88	24,717	\$3,366	948	\$129	(18)	(\$324)	\$540	\$3,712
Public Works	382	83,305	\$11,655	949	\$133	(42)	(\$516)	\$540	\$11,812
Public Library	102	26,608	\$3,914	621	\$91	(18)	(\$273)	\$540	\$4,272
McConnell Center <sup>(5)</sup>	675	58,936	\$12,156	5,849	\$686	(80)	(\$1,235)	\$540	\$12,148
<b>Totals</b>	<b>1,426</b>	<b>251,455</b>	<b>\$39,235</b>	<b>13,973</b>	<b>\$1,689</b>	<b>(253)</b>	<b>(\$3,691)</b>	<b>\$3,240</b>	<b>\$40,473</b>

<sup>(5)</sup> McConnell Center included into scope with FIM 1 due to CO # 9236-0142-CO2

### FIM 1: Contract Year 4 Savings



Verified savings are obtained from calculations and verified by measurements of circuit kW on a sample of lighting circuits before and after the retrofit was implemented. Calculation equations have been provided in Appendix C for reference. Hours of operation are stipulated for the contract term as per the contract.

## FIM DESCRIPTION

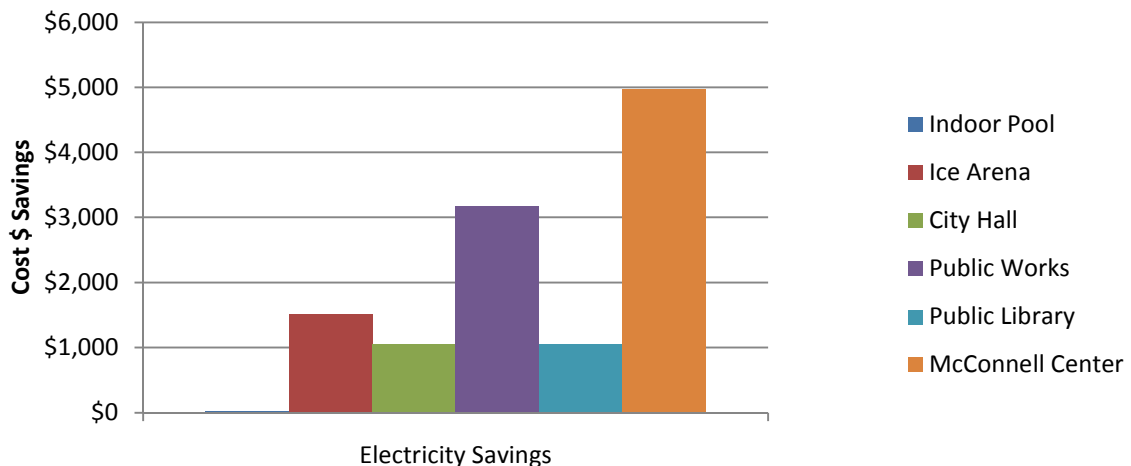
### FIM 2: Lighting – Fixture Controls

By using occupancy sensors and shutting off lights in unoccupied areas, Dover is guaranteed to save 88,559 kWh per year, with a reduction in demand of 24.8 kW. As per the Detailed Energy Audit (DEA) page 28, FIM 2 annual cost savings are not taken using demand savings. Cost savings are calculated from consumption savings only and are guaranteed to be \$11,204 for Year 4.

FIM 2: Lighting – Fixture Controls				
Contract Year 4 Energy Cost Avoidance				
Building	Electricity Savings			Total Cost \$ Savings
	kW	kWh	Cost \$	
Indoor Pool	1	260	\$30	\$30
Ice Arena	59	13,002	\$1,507	\$1,507
City Hall	61	7,726	\$1,052	\$1,052
Public Works	189	22,683	\$3,173	\$3,173
Public Library	0	7,084	\$1,042	\$1,042
McConnell Center <sup>(6)</sup>	0	42,364	\$4,970	\$4,970
<b>Totals</b>	<b>310</b>	<b>93,119</b>	<b>\$11,775</b>	<b>\$11,775</b>

<sup>(6)</sup> McConnell Center included with FIM 2 from CO # 9236-0142-CO2

### FIM 2: Contract Year 4 Savings



Verified savings are obtained from calculations which use collected data that tracked occupancy and lighting schedule in areas where equipment is installed. This data is used to verify lighting control savings. Calculation equations used have been provided in the appendix for reference. Fixture wattages under control of the sensors are stipulated as per the contract.

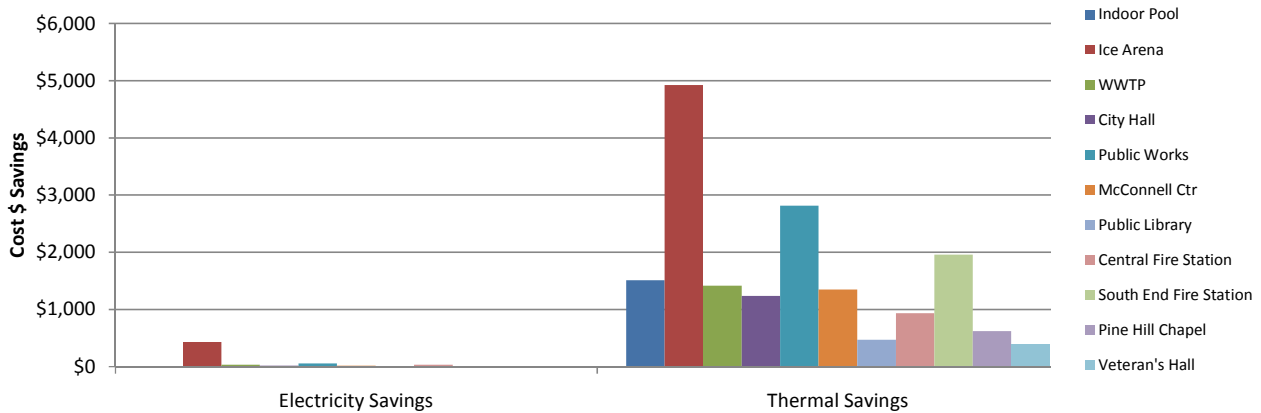
## FIM DESCRIPTION

### FIM 3: Building Envelope- Weatherization

Weatherization savings are determined by the losses of less conditioned air due to seals of gaps and openings in the building. The weatherization portion of the project is guaranteed to save 4,486 kWh of electrical energy and 1,019 MMBtu's in thermal energy, resulting in Year 4 guarantee of \$15,814.

FIM 3: Building Envelope- Weatherization						
Contract Year 4 Energy Cost Avoidance						
Building	Electricity Savings			Thermal Savings		Total Cost \$ Savings
	kW	kWh	Cost \$	MMBtu	Cost \$	
Indoor Pool	0	4	\$0	98	\$1,512	\$1,513
Ice Arena	0	3,708	\$430	356.2	\$4,923	\$5,353
WWTP	0	271	\$35	79	\$1,419	\$1,454
City Hall	0	158	\$21	69	\$1,238	\$1,259
Public Works	0	429	\$60	233	\$2,819	\$2,879
McConnell Center	0	181	\$21	89	\$1,349	\$1,371
Public Library	0	41	\$6	31	\$470	\$476
Central Fire Station	0	227	\$31	57	\$937	\$968
South End Fire Station	0	111	\$16	103	\$1,959	\$1,975
Pine Hill Chapel	0	27	\$5	35	\$621	\$626
Veteran's Hall	0	0	\$0	20	\$391	\$391
<b>Totals</b>	<b>0</b>	<b>5,155</b>	<b>\$626</b>	<b>1,171</b>	<b>\$17,638</b>	<b>\$18,263</b>

FIM 3: Contract Year 4 Savings



Weatherization savings are derived directly from engineering spreadsheet calculations and adjusted for actual weather. General formulas used are located in Appendix C. The scope of work has been verified to be complete.

## FIM DESCRIPTION

### FIM 4: Energy Management System (EMS) - Upgrades

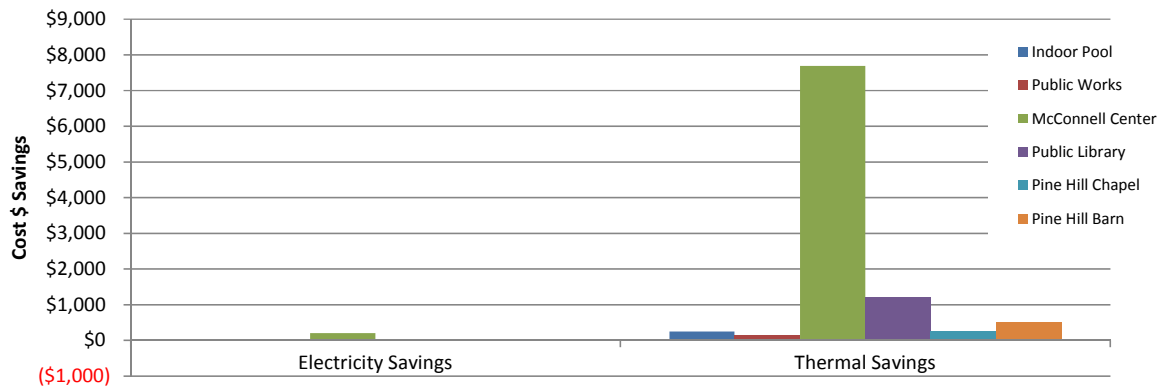
The EMS upgrade project is guaranteed to save 125,107 kWh of electrical energy and 1,138 MMBtu's of thermal energy. All sections of this FIM are further broken down as follows:

#### FIM 4.1: EMS- Building Controls

The building controls measure provides savings by providing a run-time schedule to provide a temperature setback when buildings are unoccupied, thus wasting less energy. The guaranteed annual energy savings for this FIM are calculated to be 1,092 kWh and 581 MMBtu's totaling \$9,184 over the Year 4 period.

FIM 4.1: Building Controls						
Contract Year 4 Energy Cost Avoidance						
Building	Electricity Savings			Thermal Savings		Total Cost \$ Savings
	kW	kWh	Cost \$	MMBtu	Cost \$	
Indoor Pool	0	(10)	(\$1)	16	\$250	\$249
Public Works	0	0	\$0	12	\$150	\$150
McConnell Center	0	1,717	\$201	499	\$7,696	\$7,897
Public Library	0	0	\$0	80	\$1,230	\$1,230
Pine Hill Chapel	0	0	\$0	15	\$270	\$270
Pine Hill Barn	0	0	\$0	28	\$511	\$511
<b>Totals</b>	<b>0</b>	<b>1,708</b>	<b>\$200</b>	<b>649</b>	<b>\$10,107</b>	<b>\$10,308</b>

FIM 4.1: Contract Year 4 Savings



Verified savings are derived from calculations and verified by trending and totalization with FMS. General formulas have been provided in the appendix for reference. Hours of operation, pre-installation control strategies, and pre & post retrofit equipment energy consumption are stipulated.

## FIM DESCRIPTION

### FIM 4.2: EMS- Building Controls / Optimal Start

Savings for Building Controls / Optimal Start are based off of improved starting and running of air systems at the Dover City Hall. By optimizing control, there are guaranteed savings of 121 MMBtu resulting in \$2,212 annually in Year 4.

FIM 4.2: Building Controls / Optimal Start			
Contract Year 4 Energy Cost Avoidance			
Building	Thermal Savings		Total Cost \$ Savings
	MMBtu	Cost \$	
City Hall	136	\$2,470	\$2,470

Verified savings are from calculations and tracked with FMS. Formulas have been provided in Appendix C for reference. Hours of operation, pre-installation control strategies, and pre & post retrofit equipment energy consumption are stipulated.

### FIM 4.3: Air Handling Unit Upgrade- VFD on Fan

The upgrade at the Dover Public Works building was installed for the AHU that serves the repair shop. With the VFD in place, the unit is able to slow down air flow based off occupancy. Thus savings are realized by using less energy on the AHU fan and having to condition less air. This measure has been guaranteed to save 41,564 kWh & 115 MMBtu's per year.

FIM 4.3: Air Handling Unit Upgrade - VFD on Fan								
Contract Year 4 Energy Cost Avoidance								
Building	Electricity Savings			Cooling Savings		Heating Savings		Total Cost \$ Savings
	kW	kWh	Cost \$	kWh	Cost \$	MMBtu	Cost \$	
Public Works	0	0	\$0	0	\$0	0	\$0	\$0

Verified savings were based off calculations and verified through measurement of fan kW, supply & space air temperatures. Calculations are spreadsheet based and general formulas have been provided in the appendix for reference. Hours of operation and motor power are stipulated.

\*\*\* This measure has been removed from the project (in September 2012) due to continued difficulty with parallel controls at the site. Any realized & verified savings realized from this measure have been discontinued as of mid-September and will continue to produce no savings for the remainder of the project, unless the measure is re-visited in the future. There are no current plans to re-install this savings measure.

## FIM DESCRIPTION

### FIM 4.4: Pool Dehumidification- EMS & VFDs

The replacement of the AHU with a new PoolPac™ unit in the Dover Indoor Pool will create savings through the implementation of a temperature setback and slowed fan speeds during unoccupied hours. Additionally, this FIM will eliminate simultaneous heating and cooling in the pool office. These upgrades are guaranteed to save Dover 63,143 kWh and 320 MMBtu's. Additionally, as stipulated in the contract, a capital cost avoidance savings with this measure is valued at \$338,400 over the 10 year term or an annual cost avoidance of \$33,840.

FIM 4.4: Pool Dehumidification - EMS & VFD's							
Contract Year 4 Energy Cost Avoidance							
Building	Electricity Savings			Thermal Savings		Capital Cost Avoidance \$	Total Cost \$ Savings
	kW	kWh	Cost \$	MMBtu	Cost \$		
Indoor Pool	0	65,096	\$7,438	330	\$5,191	\$33,840	\$46,470

Verified savings are from engineering spreadsheet calculations and verified through tracking and trending of pool humidity levels using the BAS and loggers. Hours of operation, equipment energy consumption pre & post retrofit, and pool operational temperatures are stipulated.

### FIM 4.5: Repair Snow Melt Sensor

The snow melt sensor system at the Dover Transportation Center is generally run from mid-November through the end of March; during the winter snow season. By repairing the system and adding sensors to control use, Dover is guaranteed to save 19,308 kWh per winter.

FIM 4.5: Repair Snow Melt Sensor				
Contract Year 4 Energy Cost Avoidance				
Building	Electricity Savings			Total Cost \$ Savings
	kW	kWh	Cost \$	
Dover Transportation Center	0	19,905	\$2,657	\$2,657

Verified savings are derived from calculations involving power draw of the snow melt system and time-of-use of the system while operated manually. Savings are verified through inspection of post installation hours of operation. Calculations are from spreadsheets located in the DEA. Pre-installation hours of operation are a stipulated variable. A consideration is that savings are a function of the severity of the winter.



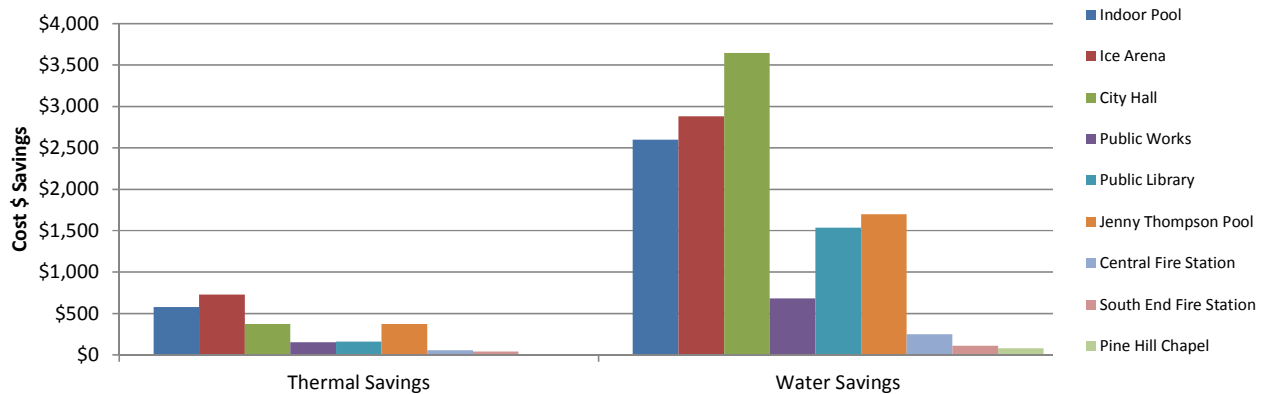
## FIM DESCRIPTION

### FIM 6: Water Conservation

The change in fixtures to more efficient ones is guaranteed to save 1,083 kgal of water annually and 159 MMBtu's in costs associated with heating that water. Total guaranteed savings are \$15,444.

FIM 6: Water Conservation					
Contract Year 3 Energy Cost Avoidance					
Building	Thermal Savings		Water Savings		Total Cost \$ Savings
	MMBtu	Cost \$	kGal	Cost \$	
Indoor Pool	37	\$577	215	\$2,601	\$3,178
Ice Arena	53	\$729	239	\$2,882	\$3,611
City Hall	21	\$376	302	\$3,649	\$4,025
Public Works	12	\$153	56	\$680	\$833
Public Library	10	\$162	127	\$1,537	\$1,699
Jenny Thompson Pool	25	\$372	141	\$1,700	\$2,072
Central Fire Station	3	\$56	21	\$250	\$306
South End Fire Station	2	\$39	9	\$108	\$147
Pine Hill Chapel	0	\$8	7	\$79	\$86
<b>Totals</b>	<b>164</b>	<b>\$2,472</b>	<b>1,117</b>	<b>\$13,486</b>	<b>\$15,958</b>

FIM 6: Contract Year 4 Savings



Verified savings are obtained from calculations and verified through flow measurements of fixtures before and after retrofit. Calculations have been provided in the appendix for reference. Pre-installation operation and occupancy are stipulated variables.

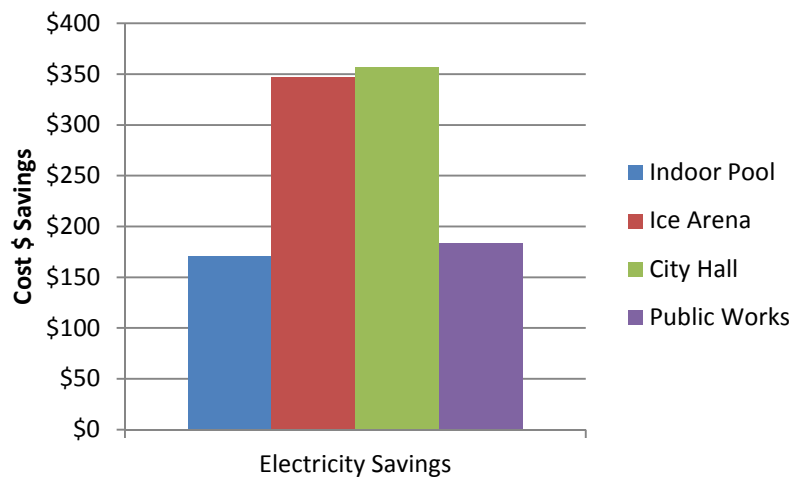
## FIM DESCRIPTION

### FIM 9: Vending Machine Controls

Savings from this FIM are derived from motion sensors which shut off the lights to the vending machine when nobody is around. The annual savings are guaranteed to be 8,146 kWh.

FIM 9: Vending Machine Controls				
Contract Year 4 Energy Cost Avoidance				
Building	Electricity Savings			Total Cost \$ Savings
	kW	kWh	Cost \$	
Indoor Pool	0	1,498	\$171	\$171
Ice Arena	0	2,995	\$347	\$347
City Hall	0	2,621	\$357	\$357
Public Works	0	1,311	\$183	\$183
<b>Totals</b>	<b>0</b>	<b>8,425</b>	<b>\$1,059</b>	<b>\$1,059</b>

**FIM 9: Contract Year 4 Savings**



Verified savings for vending machine controls are directly from engineering calculations. Equations used have been provided in the appendix. The scope of work has been verified to be fully implemented.

FIM DESCRIPTION

**FIM 10: Pool Covers**

Covering the pool when it is not in use eliminates heating need and water losses during unoccupied times. The annual savings that Dover can expect to see by using the pool cover is 45,256 kWh, 543 MMBtu's & 62.4 kgals of water, resulting in a cost savings over Year 4 of \$14,460.

FIM 10: Pool Covers								
Contract Year 4 Energy Cost Avoidance								
Building	Electricity Savings			Thermal Savings		Water Savings		Total Cost \$ Savings
	kW	kWh	Cost \$	MMBtu	Cost \$	kGal	Cost \$	
Indoor Pool	0	46,656	\$5,331	560	\$8,799	64	\$777	\$14,907

Verified savings for the pool covers are directly from engineering calculations. The installation has been inspected for completeness. Operational hours are a stipulated variable.

## FIM DESCRIPTION

### FIM 11: Ice Arena Updates

The Dover Ice Arena updates have been designed to produce an extra 32,649 kWh per year and create 61.8 kW more electrical demand per month (742 kW annually) in order to save 9,370 MMBtu's of natural gas annually. Additionally, from the work performed, there is an Operational Savings of \$11,149 for Year 4 that is realized at the Ice Arena. This is a result of moving the dashers and a decreased cost in overall maintenance costs due to the new electric chiller.

FIM 11: Ice Arena Upgrades								
Contract Year 4 Energy Cost Avoidance								
Building	Electricity Savings			Thermal Savings		Icemax	O&M	Total Cost
	kW	kWh	Cost \$	MMBtu	Cost \$	Cost \$	\$ Savings	\$ Savings
Ice Arena	(741)	(146,573)	(\$22,281)	10,005	\$138,261	\$0	\$12,149	\$128,129

This FIM is measured using IPMVP option C which measures performance through the use of utility bill analysis. Monthly utility invoices have been analyzed and accounted for to determine FIM 11 savings. Calculations and supporting documentation can in the FIM 11 section of Appendix A.

FIM 11: Ice Arena Updates consists of the following measures which contribute to arena savings

- FIM 11.1: Low Emissivity Ceiling
- FIM 11.2: Ice Temperature Control Optimization
- FIM 11.3: Dehumidification Controls
- FIM 11.4: Icemax System \*\*\*\* (Arena discontinued use in December 2012)
- FIM 11.5: Move the Dashers Inboard
- FIM 11.6: Installation of New Chiller
- FIM 11.7: Pumping System – VFD on Pump
- FIM 11.8: Controls Update

Since the implementation of these measures, savings realized over the summer at the Ice Arena are more significant than winter period. This is due to several of the measures providing more savings during warmer weather. For example, the low-e ceiling provides more of a difference in transfer of heat onto the ice surface over the summertime when weather is warmer and the sun's path is higher and longer.

The Dover Ice Arena has recently upgraded its ice surface lighting to LED technology. This is expected to save energy on lighting and decrease heat load which needs to be offset by the ice-making. However, there has been a controls problem outstanding which prevents the pumps from shutting down overnight which has used additional energy over the reporting period. For the purposes of this report, JCI considered these items a wash even though the extra run time on pumps had used significantly more energy than the lighting saved.

## FIM DESCRIPTION

### FIM 12: Power Factor Correction

The power factor correction measure was designed to be applied at the Dover Ice Arena to correct and prevent low power factor. Other ancillary benefits to be gained by power factor correction include lower energy losses and better voltage regulation. It is guaranteed that by using the KVAR Energy Savings System the rink will save 67,810 kWh annually.

Expected completion of this measure took substantially longer than expected due to inability to have the chiller company provide documentation that the warranty on their equipment would not be affected by the implementation of the capacitors. The scope of work has varied slightly from the original scope but the equipment was installed at the ice arena in January 2013.

FIM 12: Power Factor Correction				
Contract Year 4 Energy Cost Avoidance				
Building	Electricity Savings			Total Cost
	kW	kWh	Cost \$	\$ Savings
Ice Arena	50	11,666	\$1,739	\$1,739

Verified savings are obtained from calculations and verified through electric measurements before and after the installation. Additional details are provided in the appendix on the installation of this measure.

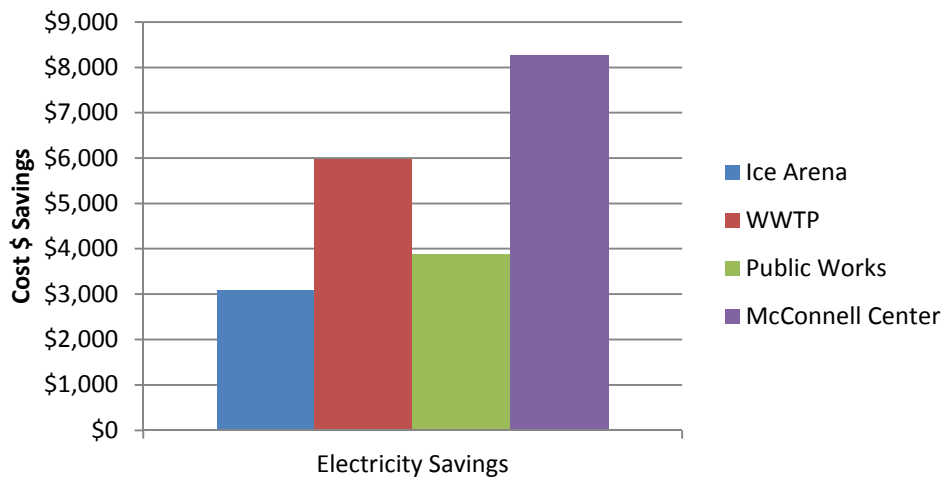
## FIM DESCRIPTION

### FIM 13: Energy Efficient Transformers

Savings associated with FIM 13 are from the replacement of transformers with more efficient ones, thus saving 145,554 kWh annually, with a monthly 25.7 kW reduction in demand (306 kW annually). Contact Year 3 cost savings are guaranteed to be \$20,104.

FIM 13: Transformers				
Contract Year 4 Energy Cost Avoidance				
Building	Electricity Savings			Total Cost \$ Savings
	kW	kWh	Cost \$	
WWTP	114	39,255	\$5,981	\$5,981
Public Works	0	27,750	\$3,882	\$3,882
McConnell Center	146	60,869	\$8,274	\$8,274
Ice Arena	59	22,754	\$3,092	\$3,092
<b>Totals</b>	<b>318</b>	<b>150,628</b>	<b>\$21,230</b>	<b>\$21,230</b>

### FIM 13: Contract Year 4 Savings



Verified savings for transformers are based off calculations and verified through field measurements of power, harmonics, and efficiency. Calculation equations have been provided in the appendix for reference. Operational hours and input power are stipulated variables.

## FIM DESCRIPTION

### FIM 14: Aeration Blowers – Retrofit

This measure was guaranteed to save \$36,559 over Year 4 through the replacement of three older positive displacement blowers with new high efficiency turbine blowers. Guaranteed annual energy savings for this FIM are obtained by reducing the electricity consumption by 272,264 kWh and monthly demand by 62.2 kW. In March of 2012, the odor control unit and silencer which provides ability to run the unit 24-7 were installed and scheduled to run full time to prevent odiferous concentration in the tanks. The energy usage of this blower has been subtracted from the verified overall blower savings but does not modify the guarantee.

FIM 14: Aeration Blowers Retrofit				
Contract Year 4 Energy Cost Avoidance				
Building	Electricity Savings			Total Cost \$ Savings
	kW	kWh	Cost \$	
WWTP	724	248,010	\$37,837	\$37,837

Additional controls work has been provided since full installation by both Dover and JCI to allow for further control of the units. This will assist the WWTP in control of the units and provide unrealized additional energy and operations savings based.

Verified savings are obtained from calculations and verified using measurements of power draw on the previous and new system. Methods of calculation have been provided in Appendix C for reference. Pre- installation loading and hours of operation are stipulated variables.

### FIM 15: Boiler Replacement

Savings for this measure are based on an increase in boiler efficiency from the old boiler to the high efficiency gas-fired boiler by approximately 7%. It is assumed that the boiler runs roughly from the middle of September through the middle of April. The annual savings associated with FIM 15 are calculated to be 88 MMBtu’s annually or an estimated \$1,368 in Year 4.

FIM 15: Boiler Replacement			
Contract Year 4 Energy Cost Avoidance			
Building	Thermal Savings		Total Cost \$ Savings
	MMBtu	Cost \$	
Public Library	102	\$1,574	\$1,574

Verified savings are obtained from calculations and verified by testing the improved efficiency of the new boiler after emergency replacement of the old one, adjusted for weather. Calculations have been provided in the appendix for reference. Pre- installation boiler efficiency is a stipulated variable.

## ENVIRONMENTAL BENEFITS

### Greenhouse Gas Emissions

Total estimated emissions reductions are as follows:







Estimated Emissions Reductions: Contract Year 4- Tons of CO <sub>2</sub> -e						
FIM #	Facility Improvement Measure	Electricity	Natural Gas	#2 Fuel Oil	Propane	Total
FIM 1	Lighting Fixtures	100.7	(12.5)	(1.3)	0.0	86.9
FIM 2	Lighting Controls	35.3	0.0	0.0	0.0	35.3
FIM 3	Weatherization	2.0	47.0	13.4	6.6	68.9
FIM 4	EMS Upgrades	32.9	49.7	13.1	0.0	95.7
<i>FIM 4.1</i>	<i>Building Controls</i>	0.6	32.2	3.1	0.0	36.0
<i>FIM 4.2</i>	<i>Building Controls / Optimal Start</i>	0.0	0.0	9.9	0.0	9.9
<i>FIM 4.3</i>	<i>AHU Upgrade – VFD on Fan</i>	0.0	0.0	0.0	0.0	0.0
<i>FIM 4.4</i>	<i>Pool Dehumidification</i>	24.7	17.5	0.0	0.0	42.2
<i>FIM 4.5</i>	<i>Snow Melt Sensor</i>	7.6	0.0	0.0	0.0	7.6
FIM 6	Water Conservation	0.0	7.5	1.5	0.1	9.2
FIM 9	Vending Machine Controls	3.2	0.0	0.0	0.0	3.2
FIM 10	Pool Cover	17.7	29.7	0.0	0.0	47.4
FIM 11	Ice Rink Upgrades	(55.6)	531.4	0.0	0.0	475.8
FIM 12	Power Factor Correction	4.4	0.0	0.0	0.0	4.4
FIM 13	Energy Efficient Transformers	57.2	0.0	0.0	0.0	57.2
FIM 14	Aeration Blower Upgrade	94.1	0.0	0.0	0.0	94.1
FIM 15	Boiler Replacement	0.0	5.4	0.0	0.0	5.4
<b>Totals</b>		<b>291.9</b>	<b>658.2</b>	<b>26.8</b>	<b>6.7</b>	<b>983.6</b>



## ENVIRONMENTAL BENEFITS

### Dover Contract Year 4 Equivalency Savings

The project's reduced emissions would be equivalent to:

CO <sub>2</sub> sequestered by	<b>25,220</b>	tree seedlings grown for 10 years in an urban scenario	
CO <sub>2</sub> sequestered by	<b>224</b>	acres of pine or fir forests	
CO <sub>2</sub> emissions from	<b>180</b>	passenger vehicles	
CO <sub>2</sub> emissions from	<b>2,287</b>	barrels of oil consumed	
CO <sub>2</sub> emissions from the <i>energy</i> use of	<b>87</b>	homes for one year	
CO <sub>2</sub> emissions from burning	<b>5</b>	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).

Version:

Energy Project GHG Calculator. USA Version 3.0. January 7, 2009.

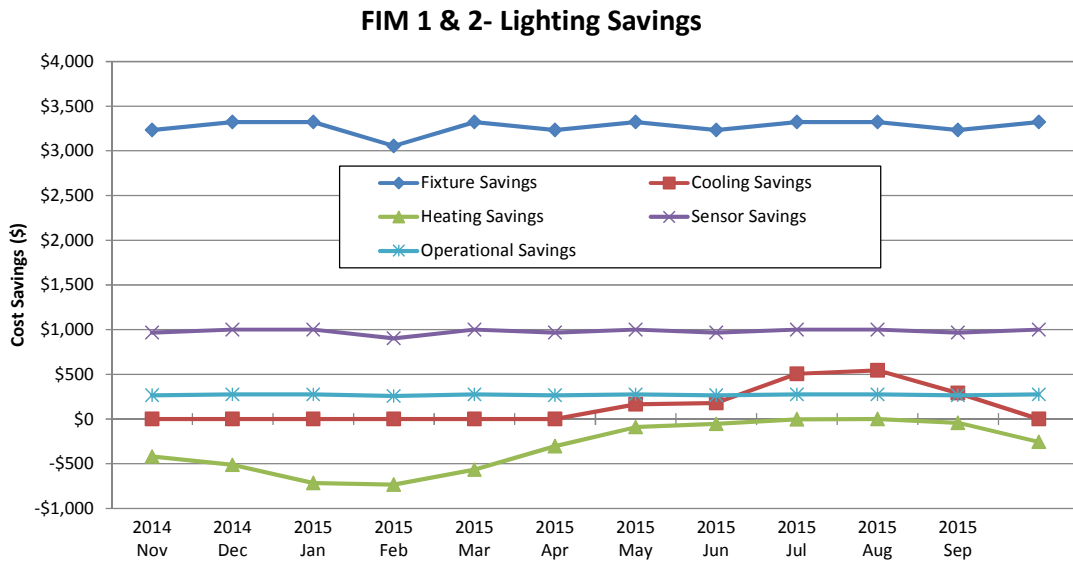
APPENDIX A

FIM 1 & 2: Lighting Fixture Retrofit & Controls

In the FIM 1 table below, energy savings are calculated using a combination of weather and days in order to provide a seasonal weighting towards cooling savings and heating losses. McConnell Center savings are included in this chart.

FIM 1: Lighting – Fixture Retrofit										
Contract Year 4 Energy Cost Avoidance										
Month	Year	Electricity Savings			Cooling Savings		Heating Savings		O&M	Total Cost
		kW	kWh	Cost \$	kWh	Cost \$	MMBtu	Cost \$	\$ Savings	\$ Savings
November	2014	119	20,668	\$3,232	0	\$0	(29)	(\$419)	\$266	\$2,814
December	2014	119	21,356	\$3,322	0	\$0	(35)	(\$512)	\$274	\$2,809
January	2015	119	21,356	\$3,322	0	\$0	(49)	(\$717)	\$274	\$2,605
February	2015	119	19,290	\$3,054	0	\$0	(50)	(\$733)	\$257	\$2,321
March	2015	119	21,356	\$3,322	0	\$0	(39)	(\$566)	\$274	\$2,756
April	2015	119	20,668	\$3,232	0	\$0	(21)	(\$303)	\$266	\$2,929
May	2015	119	21,356	\$3,322	1,358	\$164	(6)	(\$90)	\$274	\$3,396
June	2015	119	20,668	\$3,232	1,488	\$180	(4)	(\$54)	\$266	\$3,358
July	2015	119	21,356	\$3,322	4,194	\$507	(0)	(\$3)	\$274	\$3,826
August	2015	119	21,356	\$3,322	4,517	\$546	(0)	(\$0)	\$274	\$3,867
September	2015	119	20,668	\$3,232	2,415	\$292	(3)	(\$40)	\$266	\$3,484
October	2015	119	21,356	\$3,322	0	\$0	(17)	(\$253)	\$274	\$3,068
<b>Contract Yr 4</b>		<b>1,426</b>	<b>251,455</b>	<b>\$39,235</b>	<b>13,973</b>	<b>\$1,689</b>	<b>(253)</b>	<b>(\$3,691)</b>	<b>\$3,240</b>	<b>\$37,233</b>

FIM 1&2 savings are shown monthly below for the Contract Year:



APPENDIX A

FIM 1 & 2: Lighting Fixture Retrofit & Controls

The FIM 2 table breaks down the measure by month over the year. McConnell Center savings are included in this chart.

FIM 2: Lighting – Fixture Controls					
Contract Year 4 Energy Cost Avoidance					
Month	Year	Electricity Savings			Total Cost \$ Savings
		kW	kWh	Cost \$	
November	2014	26	7,654	\$968	\$968
December	2014	26	7,909	\$1,000	\$1,000
January	2015	26	7,909	\$1,000	\$1,000
February	2015	26	7,143	\$903	\$903
March	2015	26	7,909	\$1,000	\$1,000
April	2015	26	7,654	\$968	\$968
May	2015	26	7,909	\$1,000	\$1,000
June	2015	26	7,654	\$968	\$968
July	2015	26	7,909	\$1,000	\$1,000
August	2015	26	7,909	\$1,000	\$1,000
September	2015	26	7,654	\$968	\$968
October	2015	26	7,909	\$1,000	\$1,000
<b>Contract Yr 4</b>		<b>310</b>	<b>93,119</b>	<b>\$11,775</b>	<b>\$11,429</b>

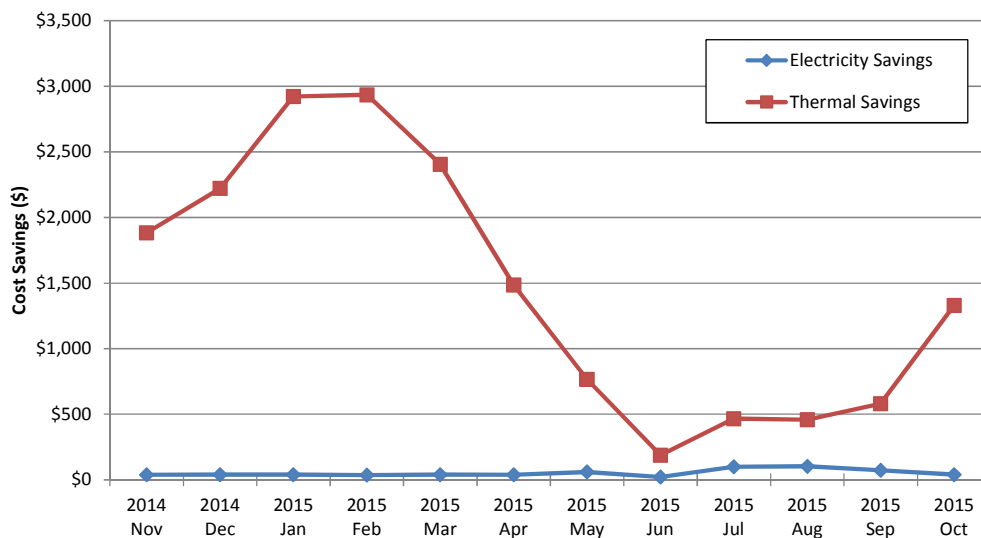
APPENDIX A

FIM 3: Weatherization

In the FIM 3 table below, energy savings are calculated using a combination of weather and days in order to provide a seasonal weighting towards cooling and heating savings. As such, cooling savings are more concentrated during warmer weather and heating savings are larger during colder weather when more heating is necessary.

FIM 3: Weatherization							
Contract Year 4 Energy Cost Avoidance							
Month	Year	Electricity Savings			Thermal Savings		Total Cost \$ Savings
		kW	kWh	Cost \$	MMBtu	Cost \$	
November	2014	0	332	\$38	123	\$1,883	\$1,921
December	2014	0	343	\$40	144	\$2,220	\$2,260
January	2015	0	343	\$40	188	\$2,924	\$2,963
February	2015	0	310	\$36	189	\$2,936	\$2,972
March	2015	0	343	\$40	156	\$2,405	\$2,445
April	2015	0	332	\$38	98	\$1,486	\$1,524
May	2015	0	484	\$59	53	\$766	\$825
June	2015	0	154	\$21	12	\$187	\$208
July	2015	0	778	\$99	34	\$466	\$565
August	2015	0	811	\$103	33	\$456	\$560
September	2015	0	582	\$72	41	\$580	\$653
October	2015	0	343	\$40	88	\$1,329	\$1,369
<b>Contract Yr 4</b>		<b>0</b>	<b>5,155</b>	<b>\$626</b>	<b>1,156</b>	<b>\$17,638</b>	<b>\$18,263</b>

FIM 3- Weatherization Savings



APPENDIX A

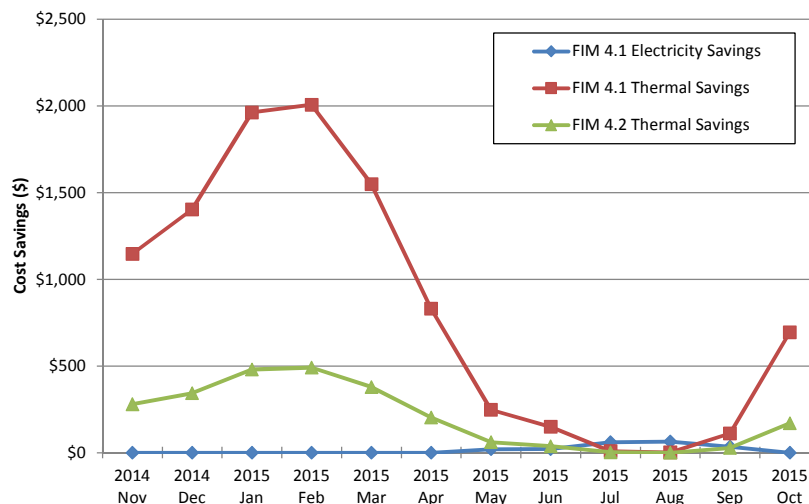
FIM 4: Energy Management System Upgrades

FIM 4.1: EMS – Building Controls & FIM 4.2: EMS – Building Controls / Optimal Start

In the FIM 4.1 & 4.2 table below, weather is used to provide a seasonal weighting towards cooling and heating savings. As such, cooling savings are more concentrated during warmer weather and heating savings are concentrated during colder weather when more heating is necessary.

City of Dover		FIM 4.1: EMS - Building Controls						FIM 4.2: Building Controls / Optimal Start		
		Contract Year 4 Energy Cost Avoidance						Contract Year 4 Energy Cost Avoidance		
Month	Year	Electricity Savings			Thermal Savings		Total Cost \$ Savings	Thermal Savings		Total Cost \$ Savings
		kW	kWh	Cost \$	MMBtu	Cost \$		MMBtu	Cost \$	
November	2014	0	0	\$0	74	\$1,146	\$1,146	15	\$280	\$280
December	2014	0	0	\$0	90	\$1,403	\$1,403	19	\$343	\$343
January	2015	0	0	\$0	126	\$1,962	\$1,962	26	\$480	\$480
February	2015	0	0	\$0	129	\$2,007	\$2,007	27	\$491	\$491
March	2015	0	0	\$0	99	\$1,549	\$1,549	21	\$379	\$379
April	2015	0	0	\$0	53	\$830	\$830	11	\$203	\$203
May	2015	0	166	\$19	16	\$247	\$267	3	\$60	\$60
June	2015	0	182	\$21	10	\$149	\$170	2	\$36	\$36
July	2015	0	513	\$60	1	\$8	\$68	0	\$2	\$2
August	2015	0	552	\$65	0	\$1	\$65	0	\$0	\$0
September	2015	0	295	\$35	7	\$111	\$145	1	\$27	\$27
October	2015	0	0	\$0	45	\$694	\$694	9	\$170	\$170
<b>Contract Yr 4</b>		<b>0</b>	<b>1,708</b>	<b>\$200</b>	<b>649</b>	<b>\$10,107</b>	<b>\$10,308</b>	<b>136</b>	<b>2,470</b>	<b>\$2,470</b>

FIM 4.1/4.2- EMS Building Controls



APPENDIX A

FIM 4: Energy Management System Upgrades

FIM 4.3: AHU Upgrade – VFD on Fan

Savings for fan electricity are based off fan run-time while conditioning savings are weighted based off monthly weather and temperature profiles. This VFD installed as part of this unit was removed in September of 2012 due to difficulty of operation and multiple ongoing problems. JCI has paid to restore the system to previous operation capability. There is no current plan to re-install the VFD on this unit

FIM 4.3: AHU Upgrade - VFD on Fan									
Contract Year 4 Energy Cost Avoidance									
Month	Year	Fan Electricity Savings			Cooling Savings		Thermal Savings		Total Cost \$ Savings
		kW	kWh	Cost \$	kWh	Cost \$	MMBtu	Cost \$	
November	2014	0	0	\$0	0	\$0	0	\$0	\$0
December	2014	0	0	\$0	0	\$0	0	\$0	\$0
January	2015	0	0	\$0	0	\$0	0	\$0	\$0
February	2015	0	0	\$0	0	\$0	0	\$0	\$0
March	2015	0	0	\$0	0	\$0	0	\$0	\$0
April	2015	0	0	\$0	0	\$0	0	\$0	\$0
May	2015	0	0	\$0	0	\$0	0	\$0	\$0
June	2015	0	0	\$0	0	\$0	0	\$0	\$0
July	2015	0	0	\$0	0	\$0	0	\$0	\$0
August	2015	0	0	\$0	0	\$0	0	\$0	\$0
September	2015	0	0	\$0	0	\$0	0	\$0	\$0
October	2015	0	0	\$0	0	\$0	0	\$0	\$0
<b>Contract Yr 4</b>		<b>0</b>	<b>0</b>	<b>\$0</b>	<b>0</b>	<b>\$0</b>	<b>0</b>	<b>\$0</b>	<b>\$0</b>

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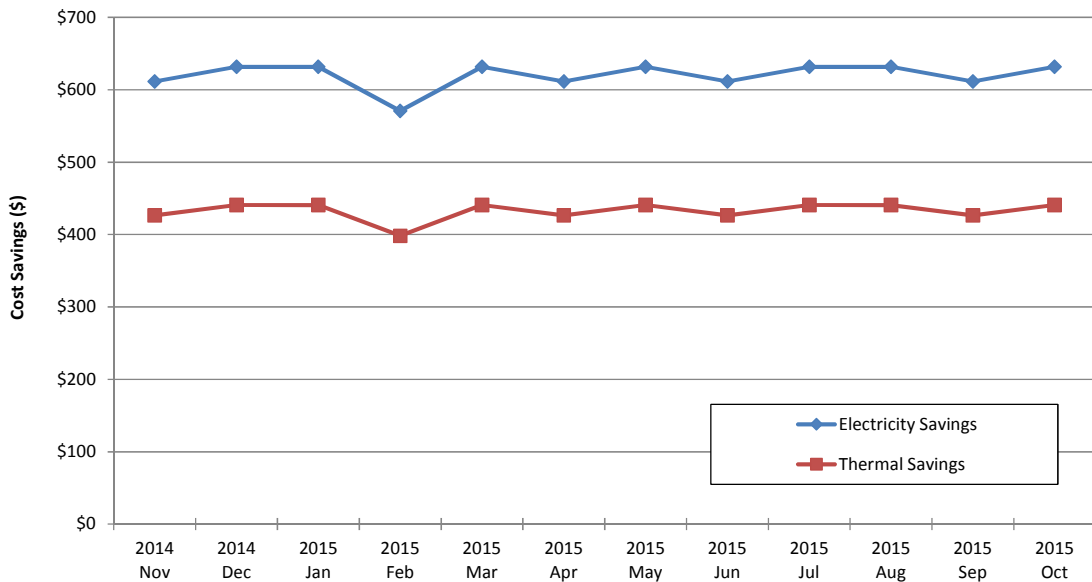
FIM 4: Energy Management System Upgrades

FIM 4.4: Pool Dehumidification – EMS & VFD’s

In the FIM 4.4 table below, electricity and thermal savings are realized by the Indoor Pool as follows:

FIM 4.4: Pool Dehumidification - EMS & VFD's								
Contract Year 4 Energy Cost Avoidance								
Month	Year	Electricity Savings			Thermal Savings		Capital Cost	Total Cost
		kW	kWh	Cost \$	MMBtu	Cost \$	\$ Avoidance	
November	2014	0	5,350	\$611	27	\$427	\$2,774	\$3,812
December	2014	0	5,529	\$632	28	\$441	\$2,866	\$3,939
January	2015	0	5,529	\$632	28	\$441	\$2,866	\$3,939
February	2015	0	4,994	\$571	25	\$398	\$2,681	\$3,650
March	2015	0	5,529	\$632	28	\$441	\$2,866	\$3,939
April	2015	0	5,350	\$611	27	\$427	\$2,774	\$3,812
May	2015	0	5,529	\$632	28	\$441	\$2,866	\$3,939
June	2015	0	5,350	\$611	27	\$427	\$2,774	\$3,812
July	2015	0	5,529	\$632	28	\$441	\$2,866	\$3,939
August	2015	0	5,529	\$632	28	\$441	\$2,866	\$3,939
September	2015	0	5,350	\$611	27	\$427	\$2,774	\$3,812
October	2015	0	5,529	\$632	28	\$441	\$2,866	\$3,939
<b>Contract Yr 4</b>		<b>0</b>	<b>65,096</b>	<b>\$7,438</b>	<b>330</b>	<b>\$5,191</b>	<b>\$33,840</b>	<b>\$46,470</b>

FIM 4.4- Pool Dehumidification Savings



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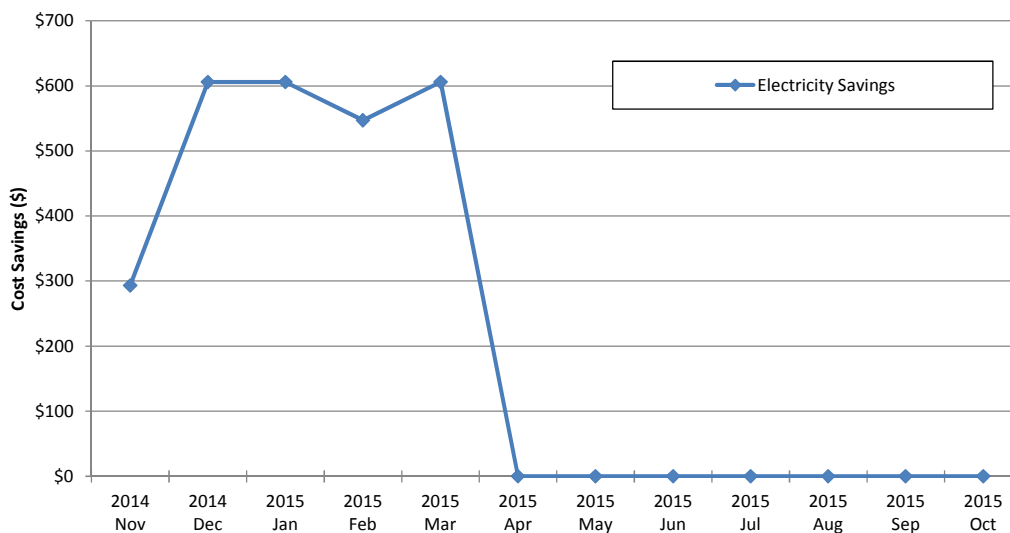
FIM 4: Energy Management System Upgrades

FIM 4.5: Repair Snow Melt Sensor

The snow melt sensor is assumed to be operational from mid November through March during the snow season. Savings are concentrated over that period.

FIM 4.5: Repair Snow Melt Sensor					
Contract Year 4 Energy Cost Avoidance					
Month	Year	Electricity Savings			Total Cost \$ Savings
		kW	kWh	Cost \$	
November	2014	0	2,195	\$293	\$293
December	2014	0	4,537	\$606	\$606
January	2015	0	4,537	\$606	\$606
February	2015	0	4,098	\$547	\$547
March	2015	0	4,537	\$606	\$606
April	2015	0	0	\$0	\$0
May	2015	0	0	\$0	\$0
June	2015	0	0	\$0	\$0
July	2015	0	0	\$0	\$0
August	2015	0	0	\$0	\$0
September	2015	0	0	\$0	\$0
October	2015	0	0	\$0	\$0
<b>Contract Yr 4</b>			<b>19,905</b>	<b>\$2,657</b>	<b>\$2,657</b>

FIM 4.5- Snow Melt Sensor Savings





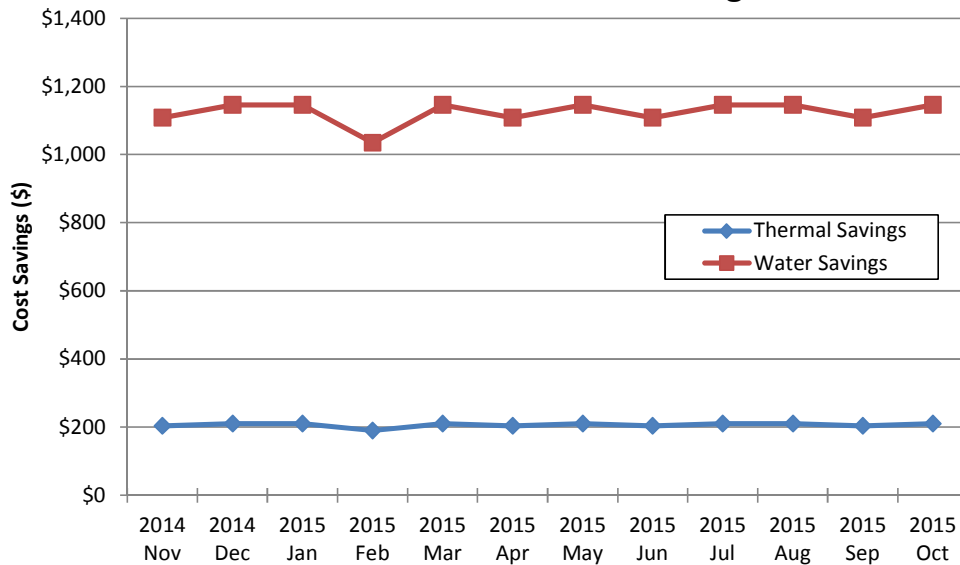
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FIM 6: Water Conservation

The FIM 6 table and chart breaks down the monthly savings by month over Contract Year:

FIM 6: Water Conservation						
Contract Year 4 Energy Cost Avoidance						
Month	Year	Thermal Savings		Water Savings		Total Cost \$ Savings
		MMBtu	Cost \$	kGal	Cost \$	
November	2014	13	\$203	92	\$1,108	\$1,312
December	2014	14	\$210	95	\$1,145	\$1,355
January	2015	14	\$210	95	\$1,145	\$1,355
February	2015	13	\$190	86	\$1,035	\$1,224
March	2015	14	\$210	95	\$1,145	\$1,355
April	2015	13	\$203	92	\$1,108	\$1,312
May	2015	14	\$210	95	\$1,145	\$1,355
June	2015	13	\$203	92	\$1,108	\$1,312
July	2015	14	\$210	95	\$1,145	\$1,355
August	2015	14	\$210	95	\$1,145	\$1,355
September	2015	13	\$203	92	\$1,108	\$1,312
October	2015	14	\$210	95	\$1,145	\$1,355
<b>Contract Yr 4</b>		<b>164</b>	<b>\$2,472</b>	<b>1,117</b>	<b>\$13,486</b>	<b>\$15,958</b>

FIM 6- Water Conservation Savings



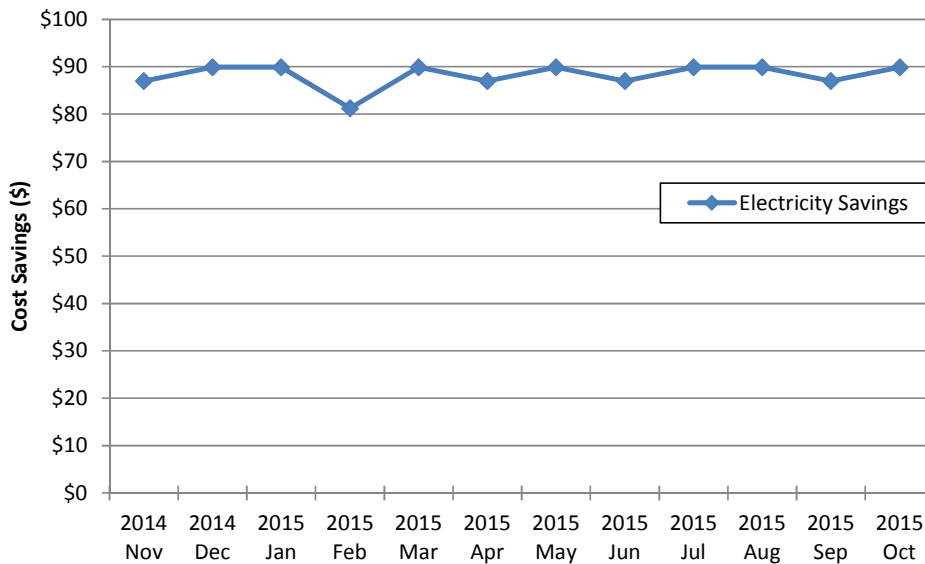
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FIM 9: Vending Machine Controls

The FIM 9 table breaks down the measure by month over Year 4.

FIM 9: Vending Machine Controls					
Contract Year 4 Energy Cost Avoidance					
Month	Year	Electricity Savings			Total Cost \$ Savings
		kW	kWh	Cost \$	
November	2014	0	692	\$87	\$84
December	2014	0	716	\$90	\$87
January	2015	0	716	\$90	\$87
February	2015	0	646	\$81	\$79
March	2015	0	716	\$90	\$87
April	2015	0	692	\$87	\$84
May	2015	0	716	\$90	\$87
June	2015	0	692	\$87	\$84
July	2015	0	716	\$90	\$87
August	2015	0	716	\$90	\$87
September	2015	0	692	\$87	\$84
October	2015	0	716	\$90	\$87
<b>Contract Yr 4</b>		<b>0</b>	<b>8,425</b>	<b>\$1,059</b>	<b>\$1,059</b>

FIM 9- Vending Controls Savings



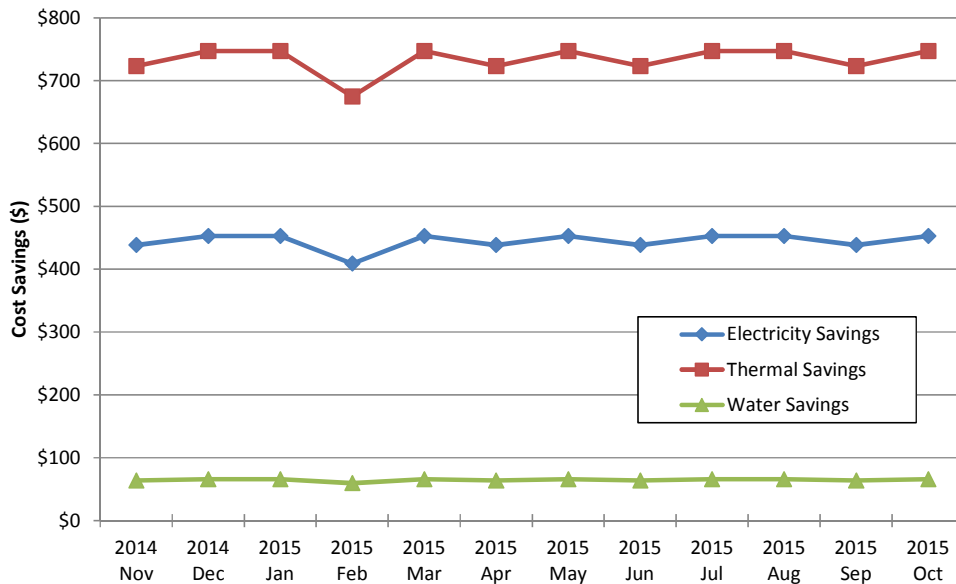
APPENDIX A

FIM 10: Pool Cover

The following FIM 10 table and chart break down the measure by month over the year.

FIM 10: Pool Cover									
Contract Year 4 Energy Cost Avoidance									
Month	Year	Electricity Savings			Thermal Savings		Water Savings		Total Cost \$ Savings
		kW	kWh	Cost \$	MMBtu	Cost \$	kGal	Cost \$	
November	2014	0	3,835	\$438	48	\$723	5.5	\$64	\$1,225
December	2014	0	3,963	\$453	46	\$747	5.3	\$66	\$1,266
January	2015	0	3,963	\$453	48	\$747	5.5	\$66	\$1,266
February	2015	0	3,579	\$409	48	\$675	5.5	\$60	\$1,144
March	2015	0	3,963	\$453	43	\$747	4.9	\$66	\$1,266
April	2015	0	3,835	\$438	48	\$723	5.5	\$64	\$1,225
May	2015	0	3,963	\$453	46	\$747	5.3	\$66	\$1,266
June	2015	0	3,835	\$438	48	\$723	5.5	\$64	\$1,225
July	2015	0	3,963	\$453	46	\$747	5.3	\$66	\$1,266
August	2015	0	3,963	\$453	48	\$747	5.5	\$66	\$1,266
September	2015	0	3,835	\$438	48	\$723	5.5	\$64	\$1,225
October	2015	0	3,963	\$453	46	\$747	5.3	\$66	\$1,266
<b>Contract Yr 4</b>		<b>0</b>	<b>46,656</b>	<b>\$5,331</b>	<b>560</b>	<b>\$8,799</b>	<b>64</b>	<b>\$777</b>	<b>\$14,907</b>

FIM 10- Pool Cover Savings



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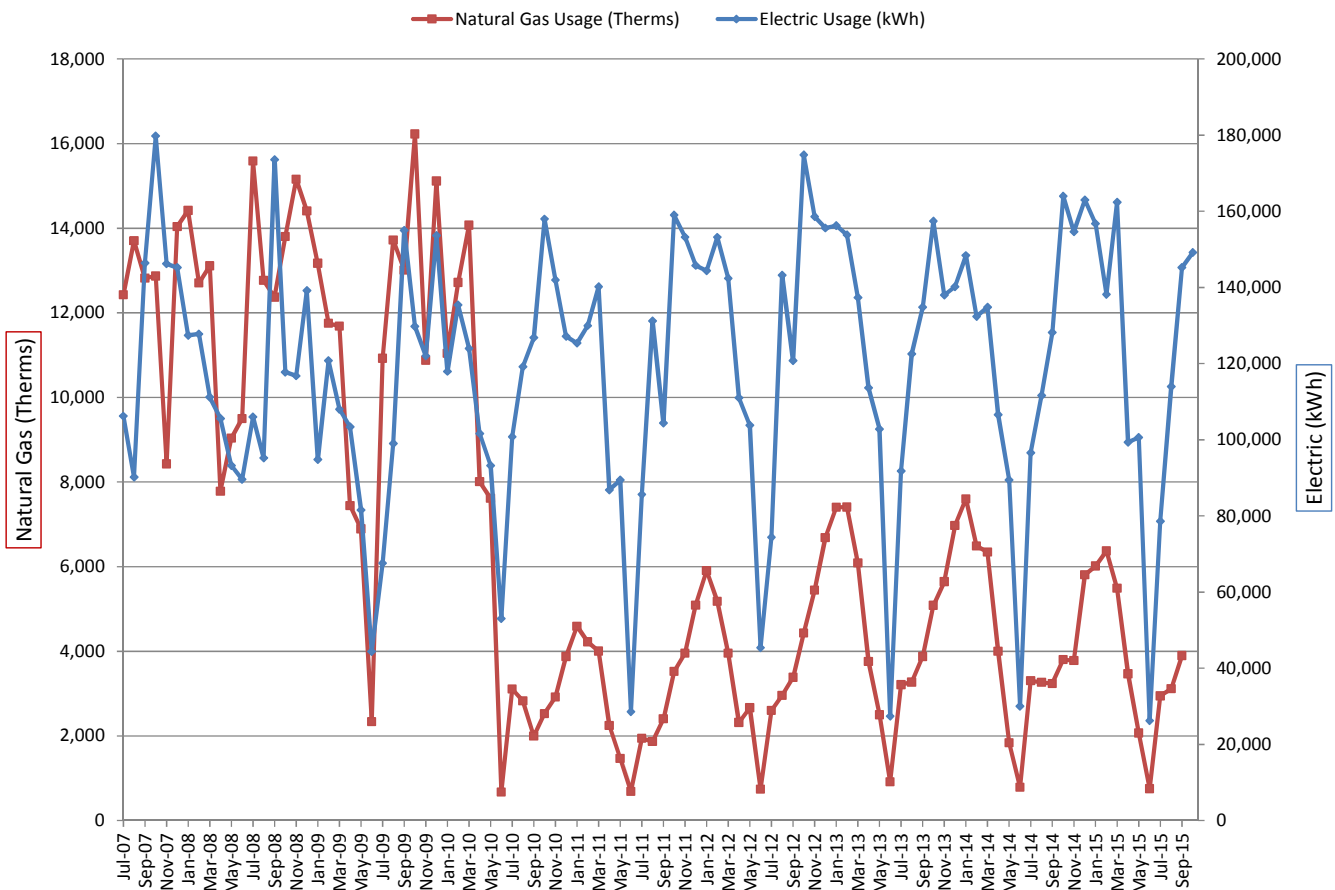
### FIM 11: Ice Arena Upgrades

#### Overall Utility Comparison

The Ice Arena part of this project consists of many items that together will achieve savings. The measurement method of FIM 11 is done via entire building utility comparison analysis. This analysis compares the usage of electricity and natural gas before and after the changes occurred. It applies the change in utilities use to track the effectiveness and calculate the savings of the work done.

The natural gas and electric usage are affected by the measures implemented at the Ice Arena. There is major mechanical equipment at the site that runs on both gas and electric. As part of this project, an electric chiller was installed as the lead unit which was previously gas, so there is a relationship between the two energy usages. Below is a graph showing the history of both since July 2007. As a note, most FIM 11 work was completed between June and September 2010.

**Dover Ice Arena- Monthly Electric & Gas Usage**



APPENDIX A

FIM 11: Ice Arena Upgrades

As part of the utility bill comparison, normalization of utility data is done through the use of Metrix software. This takes weather history and other entered variables into account in order to provide bills in different years and scenarios on an equal playing field. Weather degree days have been provided in Appendix B.

The one entered variable needed in this case is shown below. In order to properly take into account the load seen by the chillers and rink scheduling, this 'Chiller- Ice Hours' variable was created and used in the regression analysis performed. Below is the simple calculation table and equations used to create the variable.

Dover Ice Arena Chiller- Ice Hours Variable Calculation						
Month	Avail Hours	Arena 1	Arena 2	Ice Hours	2nd Rink Startup	Chiller- Ice Hours
August	744	100%	0%	744	0	744
September	720	100%	23%	888	540	1,428
October	744	100%	100%	1,488	186	1,674
November	720	100%	100%	1,440	0	1,440
December	744	100%	100%	1,488	0	1,488
January	744	100%	100%	1,488	0	1,488
February	696	100%	100%	1,392	0	1,392
March	744	100%	100%	1,488	0	1,488
April	720	100%	0%	720	0	720
May	744	100%	0%	744	0	744
June	720	0%	0%	0	0	0
July	744	100%	0%	744	0	744

$$\text{Ice Hours} = \text{Available Hours} \times (\text{Arena 1} + \text{Arena 2})$$

$$\text{Chiller-Ice Hours} = \text{Ice Hours} + \text{2nd Rink Startup}$$

$$\text{2nd Rink Startup}_{\text{Sept.}} = \frac{168 \frac{\text{Hours}}{\text{Week}} \times 30 \frac{\text{Days}}{\text{Month}} \times \frac{3}{4} \text{ Months Run Time}}{7 \frac{\text{Days}}{\text{Week}}}$$

$$\text{2nd Rink Startup}_{\text{Oct.}} = \frac{168 \frac{\text{Hours}}{\text{Week}} \times 31 \frac{\text{Days}}{\text{Month}} \times \frac{1}{4} \text{ Months Run Time}}{7 \frac{\text{Days}}{\text{Week}}}$$

APPENDIX A

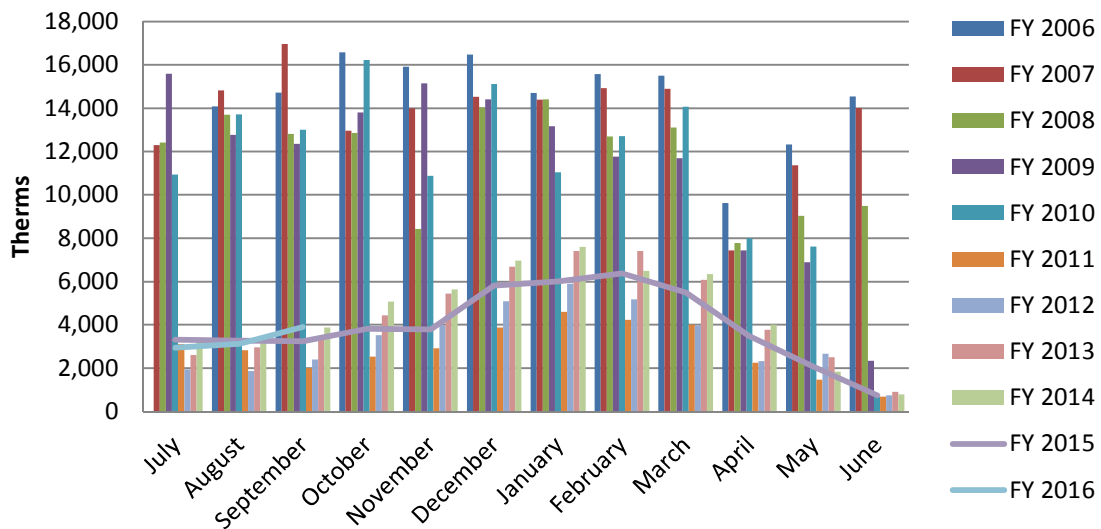
FIM 11: Ice Arena Upgrades- Natural Gas

Natural Gas

Savings from FIM 11 are realized through comparison of utility bills. Below is the natural gas usage per month obtained from bills since August 2007. Baseline data in the chart below is in green, year 1 data is in yellow, year 2 period in light blue, year 3 period is in pink, and year 4 period is in blue.

Dover Ice Arena Natural Gas Billable Usage (Therms)									
Month	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
August	13,703	12,769	13,718	2,828	1,869	2,959	3,271	3,267	3,114
September	12,817	12,369	13,008	1,995	2,403	3,384	3,877	3,241	3,901
October	12,869	13,804	16,225	2,527	3,522	4,433	5,084	3,806	3,806
November	8,430	15,155	10,880	2,917	3,956	5,443	5,643	3,782	
December	14,039	14,410	15,114	3,875	5,092	6,689	6,970	5,811	
January	14,419	13,171	11,041	4,593	5,911	7,404	7,598	6,016	
February	12,708	11,754	12,717	4,225	5,183	7,410	6,489	6,373	
March	13,110	11,687	14,072	4,003	3,955	6,090	6,343	5,486	
April	7,784	7,441	8,006	2,246	2,323	3,762	4,001	3,466	
May	9,038	6,892	7,616	1,470	2,665	2,500	1,838	2,067	
June	9,495	2,336	675	688	742	915	789	750	
July	15,589	10,925	3,110	1,943	2,599	3,210	3,308	2,947	

Dover Ice Arena- Monthly Natural Gas Usage



APPENDIX A

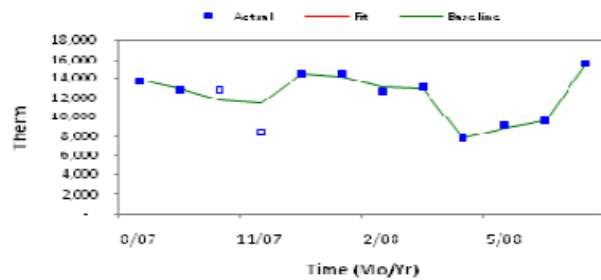
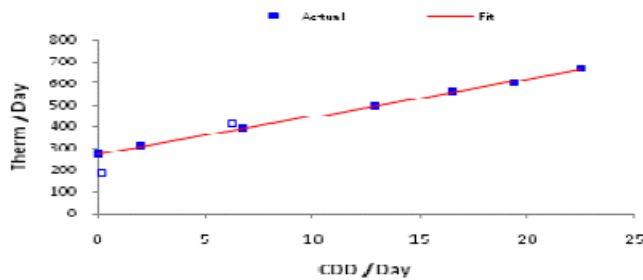
FIM 11: Ice Arena Upgrades- Natural Gas

Using Metrix regression analysis software, a natural gas usage baseline was developed for the Ice Arena to be used in comparing bills with different weather and arena usage. The meter tuning contract for natural gas is included below. This provides the calculation of how the FIM 11 baseline for natural gas was developed.

Meter Tuning Contract

Project: Dover, NH  
 Area: Dover Ice Arena  
 Account: 4170121-4061358

Site: Dover, NH  
 Meter: Natural Gas  
 Unit: Therm(Qty OnPk)



From	To	# Days	Reading	Incl?	HDD	CDD	Chiller-Ice Hours	Offset	Baseline	Deviation
08/01/07	08/31/07	31	13,703	<input checked="" type="checkbox"/>	29.5	601.0	744	-	13,869	1.2%
09/01/07	09/30/07	30	12,817	<input checked="" type="checkbox"/>	109.0	386.0	1,428	-	12,980	1.3%
10/01/07	10/31/07	31	12,869	<input type="checkbox"/>	293.0	192.5	1,674	-	11,844	-8.0%
11/01/07	11/30/07	30	8,430	<input type="checkbox"/>	782.5	4.5	1,440	-	11,437	35.7%
12/01/07	12/31/07	31	14,439	<input checked="" type="checkbox"/>	1162.5	0.0	1,488	-	14,368	-0.5%
01/01/08	01/31/08	31	14,419	<input checked="" type="checkbox"/>	1134.5	0.5	1,488	-	14,168	-1.7%
02/01/08	02/29/08	29	12,708	<input checked="" type="checkbox"/>	1051.5	0.0	1,392	-	13,173	3.7%
03/01/08	03/31/08	31	13,110	<input checked="" type="checkbox"/>	970.5	0.0	1,488	-	12,941	-1.3%
04/01/08	04/30/08	30	7,784	<input checked="" type="checkbox"/>	491.5	58.5	720	-	7,829	0.6%
05/01/08	05/31/08	31	9,038	<input checked="" type="checkbox"/>	258.0	210.0	744	-	8,815	-2.5%
06/01/08	06/30/08	30	9,495	<input checked="" type="checkbox"/>	38.0	496.5	-	-	9,644	1.6%
07/01/08	07/31/08	31	15,589	<input checked="" type="checkbox"/>	0.0	697.5	744	-	15,316	-1.8%
<b>Sum/Average/Max</b>		<b>366</b>	<b>144,401</b>		<b>6320.5</b>	<b>2647.0</b>	<b>13,350</b>	<b>-</b>	<b>146,383</b>	<b>0% +/- 1.9%</b>

**Natural Gas (Account # 4170121-4061358): Tuning Period is 366 days from 8/1/2007 until 7/31/2008.**  
 Below is the equation used to calculate the Baseline values for the tuning period and all future periods:  

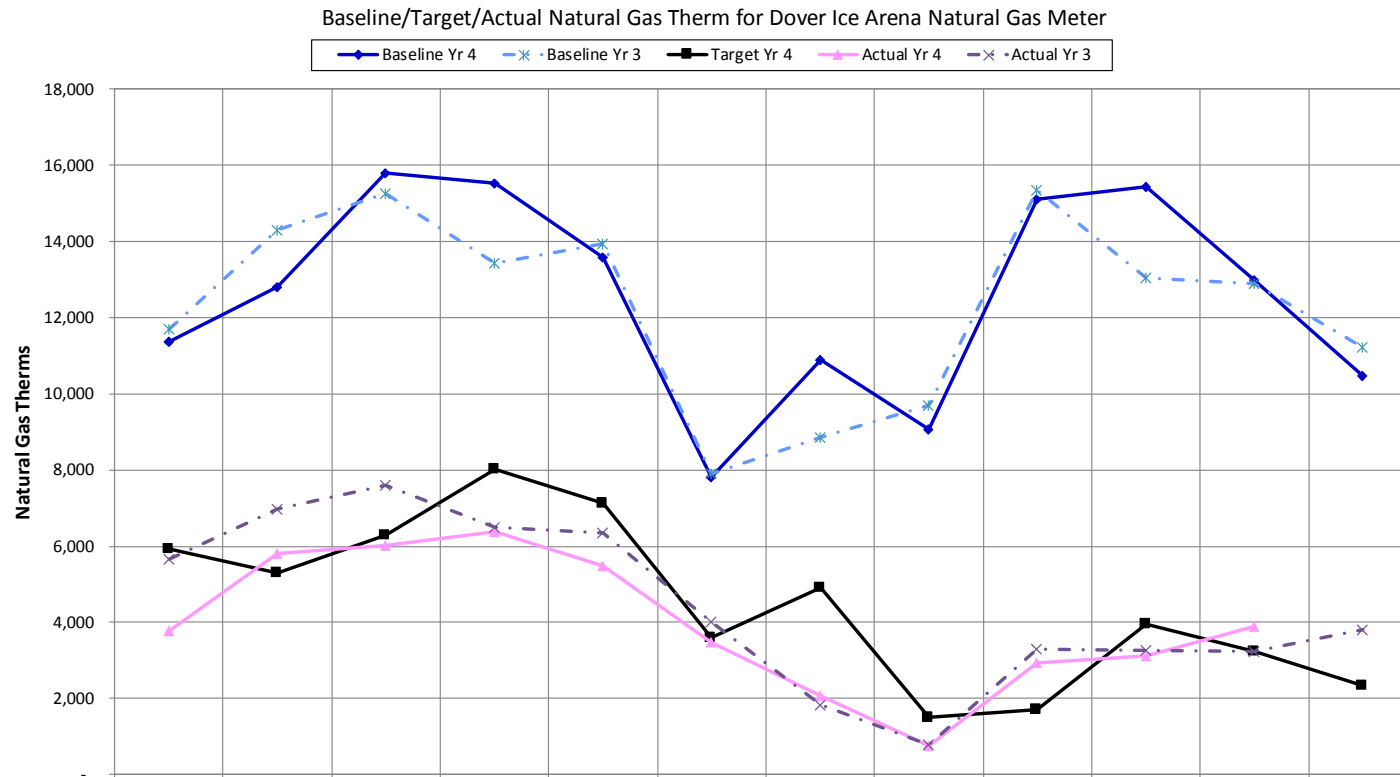
$$\text{Baseline (Therm)} = 26.26 \times \# \text{Days} + 7.43 \times \text{HDD} + 17.27 \times \text{CDD} + 3.3 \times \text{Chiller-Ice Hours}$$
  
 The Baseline Equation has a Net Mean Bias of 0% and a Monthly Mean Error of +/-1.9%. The underlying regression has a R<sup>2</sup>=0.991  
 Baseline Costs are calculated using Average Total Cost/Consumption, but no less than \$1.242132/ Therm.  
**Explanations and Assumptions:**  
 (empty checkbox) under 'Incl?' indicates that the bill is excluded from the regression. However the Baseline Equation is always applied for all billing periods, even those excluded from the regression.  
 HDD = Heating Degree-Days calculated for ROCHESTERNH for a 63.0 F° balance point.  
 CDD = Cooling Degree-Days calculated for ROCHESTERNH for a 49.0 F° balance point.  
 Multiplier is derived from Modification(s) in effect during the tuning period and is replicated annually for all future periods.

The regression has a R<sup>2</sup> value of 0.991 excluding two of the twelve baseline points, which is exceptionally better than required. As per the contract, the natural gas baseline is within 1.4% of the actual utility data complying with the necessary 2% mark.

APPENDIX A

FIM 11: Ice Arena Upgrades- Natural Gas

This regression analysis graph was run for **natural gas therm usage**. The three solid lines shown represent the calculated Year 4 baseline (blue), target utility use based off calculations and guarantees (black), and actual Year 4 ice arena utility use from utility invoices (pink). Year 3 data baseline (dashed light blue) and actual (dashed purple) have been superimposed on the chart (dashed lines) for reference as shown below:



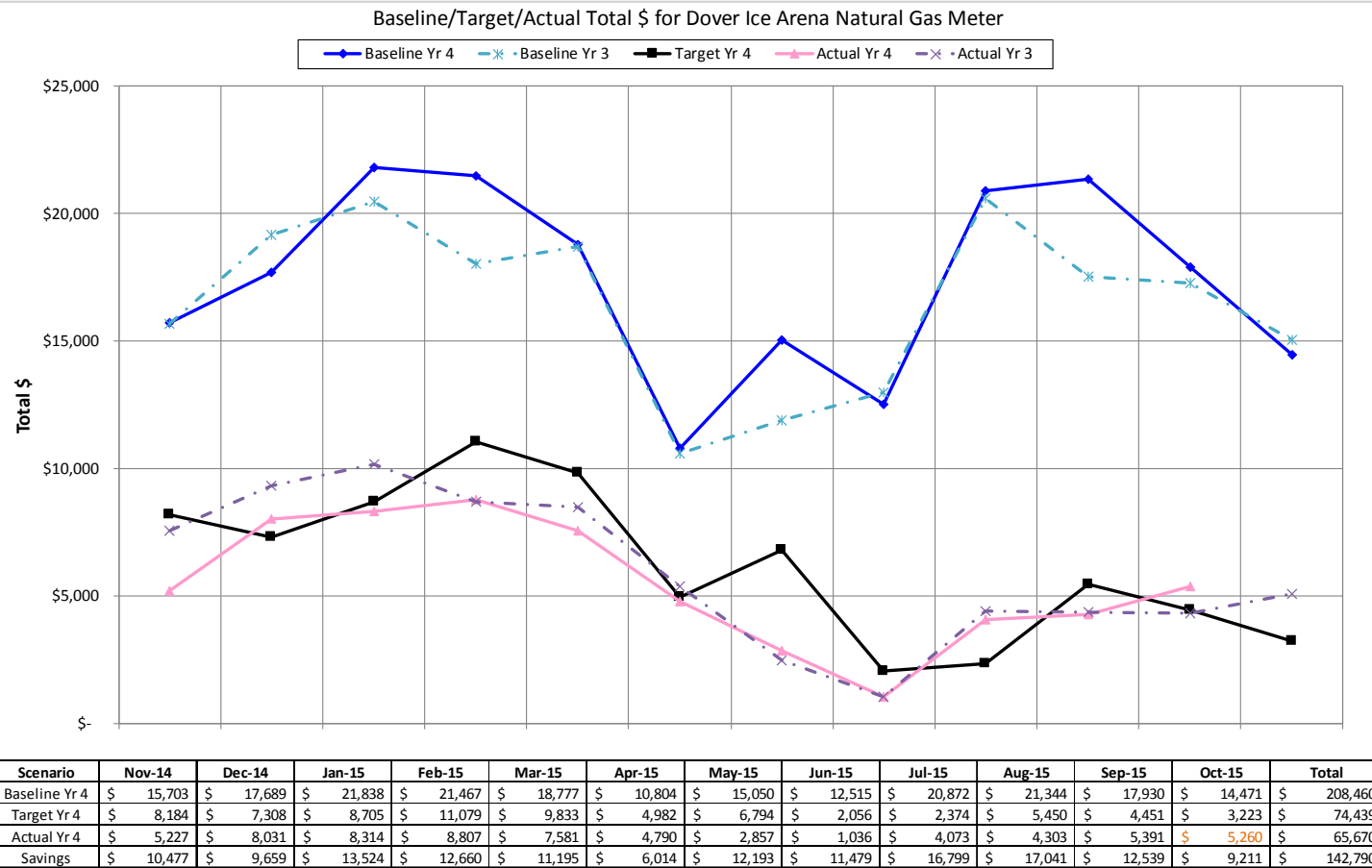
Scenario	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Total
Baseline Yr 4	11,363	12,800	15,802	15,534	13,587	7,818	10,890	9,056	15,103	15,445	12,974	10,471	150,843
Target Yr 4	5,922	5,288	6,299	8,017	7,115	3,605	4,916	1,488	1,718	3,944	3,221	2,332	53,865
Actual Yr 4	3,782	5,811	6,016	6,373	5,486	3,466	2,067	750	2,947	3,114	3,901	3,806	47,519
Savings	7,581	6,989	9,786	9,161	8,101	4,352	8,823	8,306	12,156	12,331	9,073	6,665	103,324



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### FIM 11: Ice Arena Upgrades- Natural Gas

This regression analysis graph was run for **natural gas cost**. The three solid lines shown represent the calculated Yr 4 baseline (blue), target utility cost based off calculations and guarantees (black), and actual Yr 4 contractual ice arena utility cost from utility use & contractual rates (pink). Year 3 cost baseline (dashed light blue) and actual (dashed purple) have been superimposed on the chart (dashed lines) for reference as shown below:



APPENDIX A

FIM 11: Ice Arena Upgrades- Natural Gas

Since there are measures included at the Ice Arena that are not to be measured by utility bill analysis, they must be subtracted from the overall savings as to not be counted twice. Below is a table of Year 4 natural gas savings from all other measures at the Ice Arena:

FIM 11: Ice Arena Upgrades			
Year 4 Savings from Other FIMs			
FIM #	FIM Description	Thermal Savings	
		MMBtu	Cost \$
1	Lighting Fixtures	(81)	(\$1,123)
2	Lighting Controls	0	\$0
3	Weatherization	356	\$4,923
6	Water Conservation	53	\$729
9	Vending Controls	0	\$0
12	Power Factor	0	\$0
13	Transformers	0	\$0
<b>Total</b>		<b>328</b>	<b>\$4,529</b>

Natural Gas consumption savings from the analysis are 103,324 therms for Year 4. Of those, as seen in the first table above, 328 MMBtu = 3,277 therms are from different measures within this project. So the total reported savings from FIM 11 in Year 4 is 100,047 therms.

The natural gas cost savings from the analysis are \$142,790 with \$4,529 in savings coming from other FIMs. By isolating and removing savings from the other measures, the total FIM 11 natural gas utility analysis cost savings is \$138,261.

FIM 11: Ice Arena Upgrades		
Contract Year 4 Energy Cost Avoidance		
Building	Thermal Savings	
	MMBtu	Cost \$
Ice Arena	10,005	\$138,261

APPENDIX A

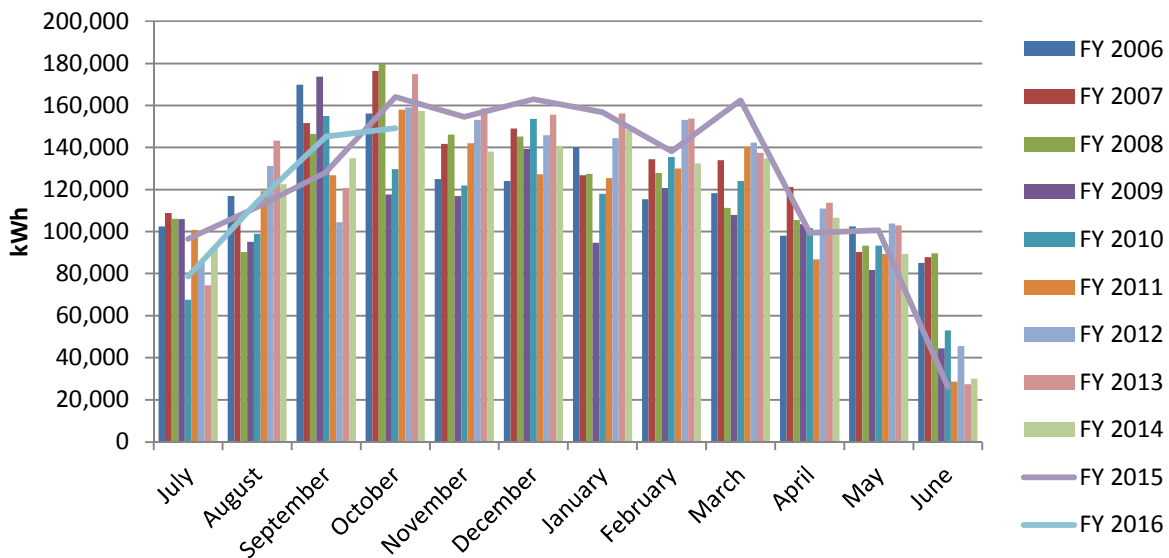
FIM 11: Ice Arena Upgrades- Electric

Electric

Savings from FIM 11 were obtained through utility bill analysis. Below is the electric consumption per month obtained from bills for the baseline year through the installation period. Baseline data is in green, year 1 data is in yellow, year 2 period in light blue, year 3 period is in pink, and year 4 is in blue.

Dover Ice Arena Electric Consumption (kWh)									
Month	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
September	146,400	173,600	155,000	126,800	104,400	120,800	134,800	128,200	145,200
October	179,800	117,800	129,800	158,000	159,000	174,800	157,400	164,000	149,200
November	146,200	116,800	122,000	142,000	153,200	158,600	138,000	154,600	
December	145,200	139,200	153,600	127,200	145,800	155,600	140,200	163,000	
January	127,400	94,800	118,000	125,400	144,400	156,200	148,400	156,800	
February	127,800	120,800	135,400	130,000	153,200	153,800	132,400	138,200	
March	111,200	108,000	124,000	140,200	142,400	137,400	134,800	162,400	
April	105,600	103,400	101,600	86,800	111,000	113,600	106,600	99,400	
May	93,200	81,600	93,200	89,400	103,800	102,800	89,400	100,600	
June	89,600	44,400	53,000	28,600	45,400	27,400	30,000	26,200	
July	106,000	67,600	100,800	85,600	74,400	91,800	96,600	78,600	
August	95,200	99,000	119,200	131,200	143,200	122,600	111,600	114,000	

Dover Ice Arena- Monthly Electricity Usage



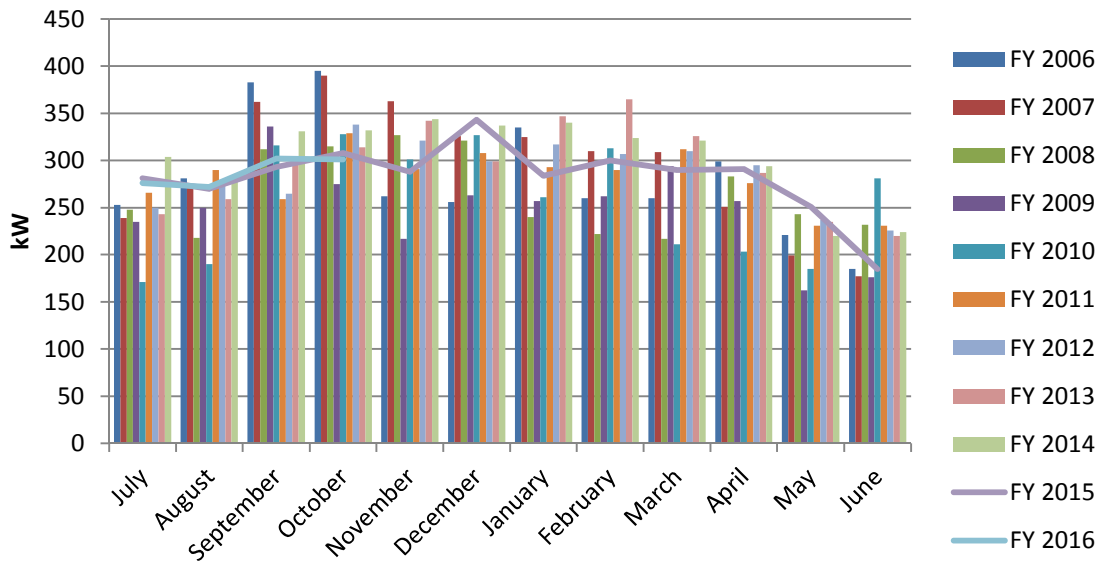
APPENDIX A

FIM 11: Ice Arena Upgrades- Electric

Below is the electric demand per month obtained from bills from the baseline year through the installation period. Baseline data is in green, year 1 data is in yellow, year 2 period in light blue, and year 3 period is in pink, and year 4 is in blue.

Dover Ice Arena Electric Demand (kW)									
Month	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16
September	312	336	316	259	265	303	331	293	302
October	315	275	328	329	338	314	332	308	301
November	327	217	301	291	321	342	344	288	
December	321	263	327	308	299	299	337	343	
January	240	257	261	293	317	347	340	284	
February	222	262	313	290	307	365	324	300	
March	217	294	211	312	310	326	321	290	
April	283	257	203	276	295	287	294	291	
May	243	162	185	231	237	235	220	251	
June	232	176	281	231	226	220	224	185	
July	235	171	266	250	243	304	281	276	
August	250	190	290	275	259	279	270	272	

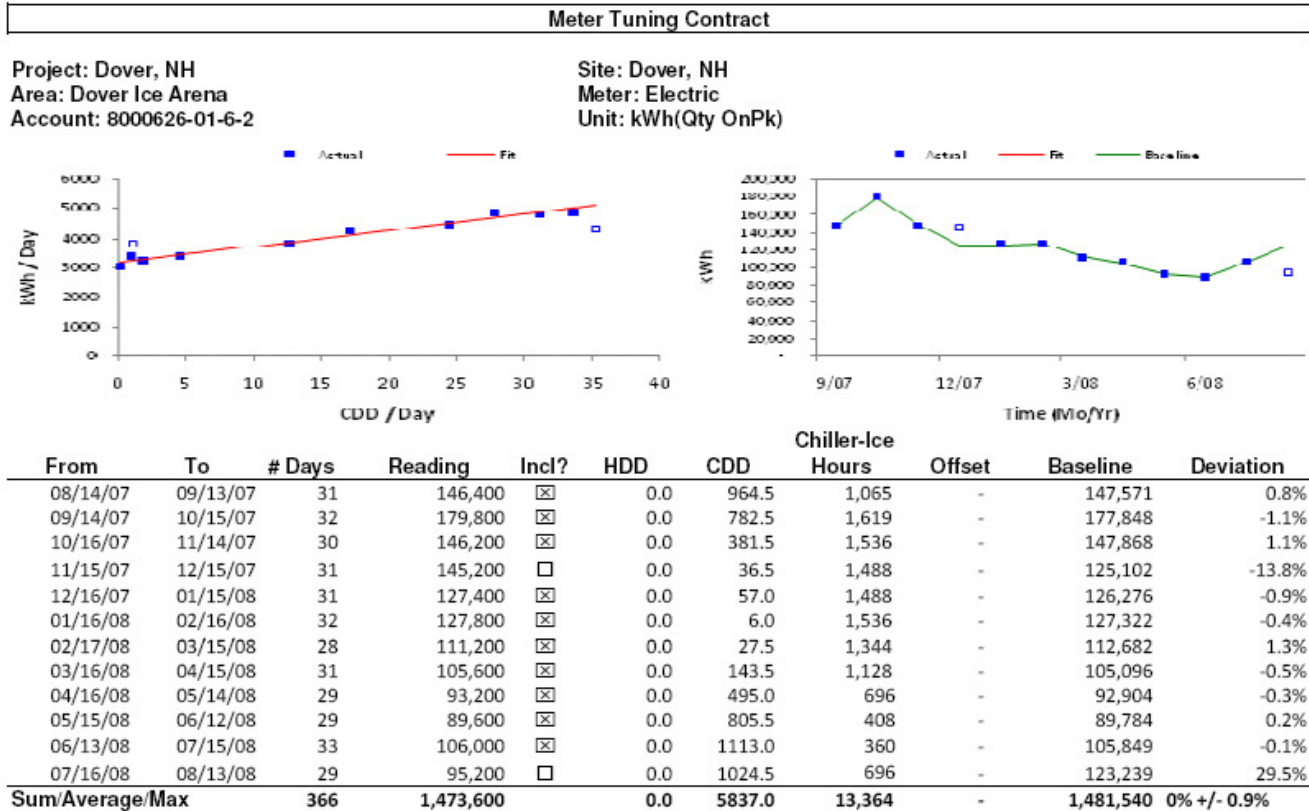
Dover Ice Arena- Monthly Electricity Demand



APPENDIX A

FIM 11: Ice Arena Upgrades- Electric

Using Metrix regression analysis software, a electric consumption baseline was developed for the Ice Arena to be used in comparing bills with different weather and arena usage. The meter tuning contract for electric kWh is included below. This provides the calculation of how the baseline for electric consumption was developed.



Electric (Account # 8000626-01-6-2): Tuning Period is 366 days from 8/14/2007 until 8/13/2008.  
 Below is the equation used to calculate the Baseline values for the tuning period and all future periods:  

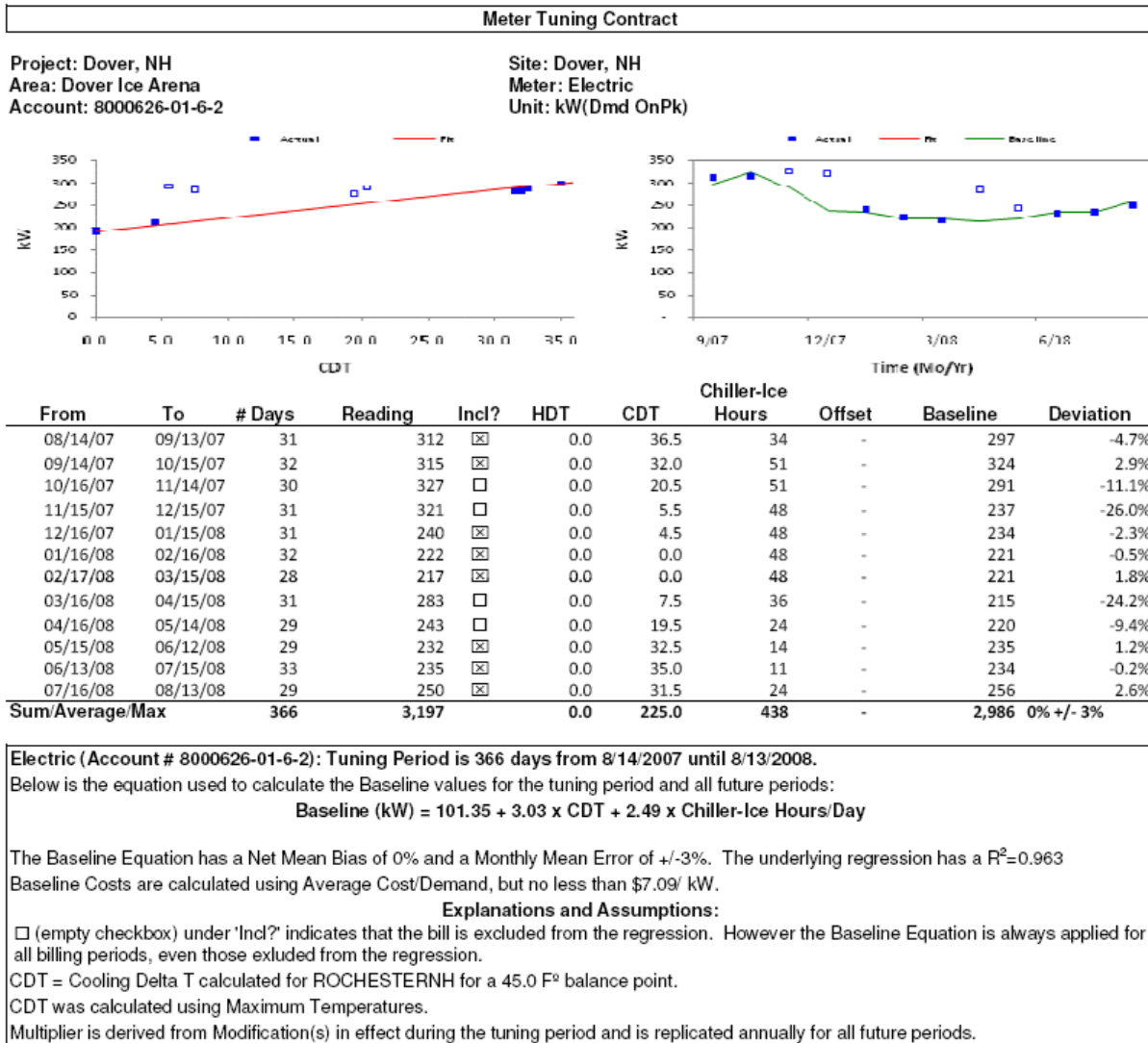
$$\text{Baseline (kWh)} = 483.36 \times \# \text{Days} + 57.29 \times \text{CDD} + 72.6 \times \text{Chiller-Ice Hours}$$
 The Baseline Equation has a Net Mean Bias of 0% and a Monthly Mean Error of +/-0.9%. The underlying regression has a R<sup>2</sup>=0.998  
 Baseline Costs are calculated using Average Cost/Consumption, but no less than \$0.106/ kWh.  
**Explanations and Assumptions:**  
 (empty checkbox) under 'Incl?' indicates that the bill is excluded from the regression. However the Baseline Equation is always applied for all billing periods, even those excluded from the regression.  
 CDD = Cooling Degree-Days calculated for ROCHESTERNH for a 34.0 F<sup>a</sup> balance point.  
 Multiplier is derived from Modification(s) in effect during the tuning period and is replicated annually for all future periods.

The regression has a R<sup>2</sup> value of 0.998 excluding two of the twelve baseline points, which is exceptionally better than required. As per the contract, the electric consumption baseline is within 0.5% of the actual utility data complying with the necessary 2% mark.

## APPENDIX A

### FIM 11: Ice Arena Upgrades- Electric

Using Metrix regression analysis software, a electric demand baseline was developed for the Ice Arena to be used in comparing bills with different weather and arena usage. The meter tuning contract for electric kW is included below. This provides the calculation of how the baseline for electric demand was developed.

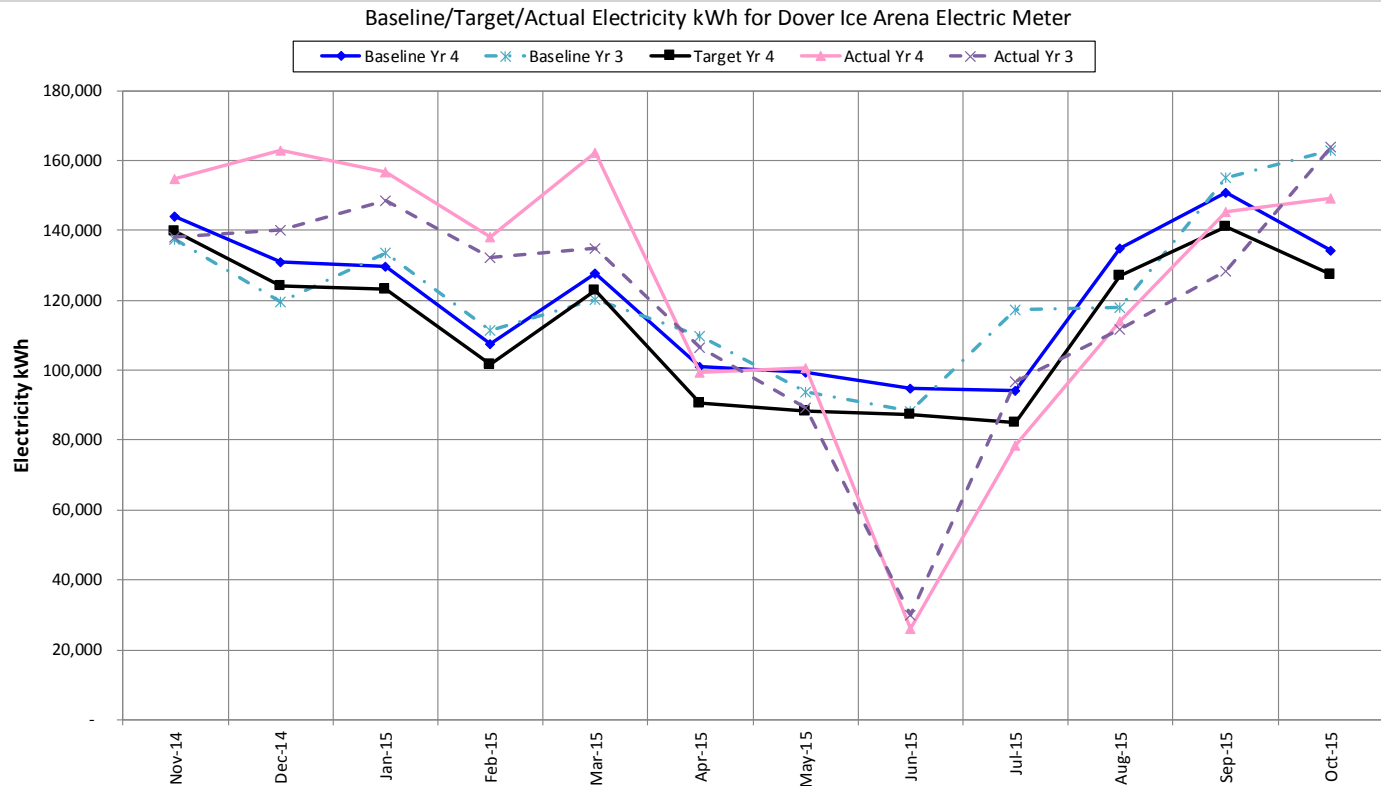


The regression has a  $R^2$  value of 0.963 excluding four of the twelve baseline points, which is better than required. The electric consumption baseline is within 6.6% of the actual utility data. Since demand is not as cut and dry as other measures, it is difficult to determine a solution that would fall within the 2% difference. The difference of 4.6% is on the lower end of the baseline which in the end benefits the City of Dover. Johnson Controls accepts this difference and believes it is the best and most sensible option moving forward.

## APPENDIX A

### FIM 11: Ice Arena Upgrades- Electric

This regression analysis graph was run for **electric kWh consumption**. The three solid lines shown represent the calculated Year 4 baseline (blue), target utility use based off calculations and guarantees (black), and actual Year 4 ice arena utility use from utility invoices (pink). Year 3 data baseline (dashed light blue) and actual (dashed purple) have been superimposed using dotted lines for reference as shown below:

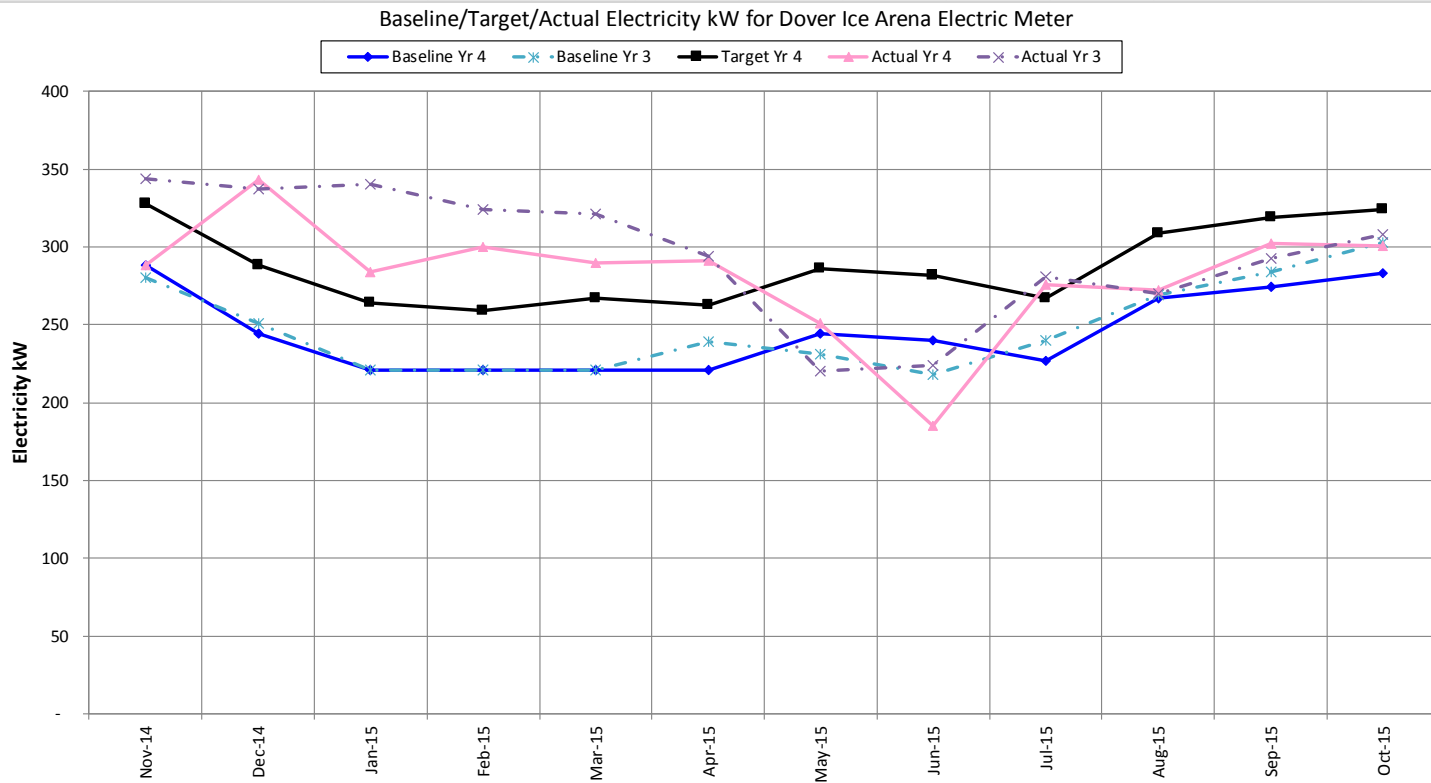


Scenario	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Total
Baseline Yr 4	144,014	130,817	129,729	107,396	127,724	101,099	99,398	94,880	94,153	134,823	150,849	134,184	1,449,066
Target Yr 4	139,675	124,064	123,000	101,782	122,833	90,711	88,376	87,200	84,925	127,144	140,959	127,274	1,357,943
Actual Yr 4	154,600	163,000	156,800	138,200	162,400	99,400	100,600	26,200	78,600	114,000	145,200	149,200	1,488,200
Savings	(10,586)	(32,183)	(27,071)	(30,804)	(34,676)	1,699	(1,202)	68,680	15,553	20,823	5,649	(15,016)	(39,134)

## APPENDIX A

### FIM 11: Ice Arena Upgrades- Electric

This regression analysis was run for **electric kW demand**. The three lines shown represent the calculated Year 4 baseline (blue), target utility use based off calculations and guarantees (black), and actual Year 4 ice arena utility use from utility invoices (pink). Year 3 data baseline (dashed light blue) and actual (dashed purple) have been superimposed using dotted lines for reference as shown below:



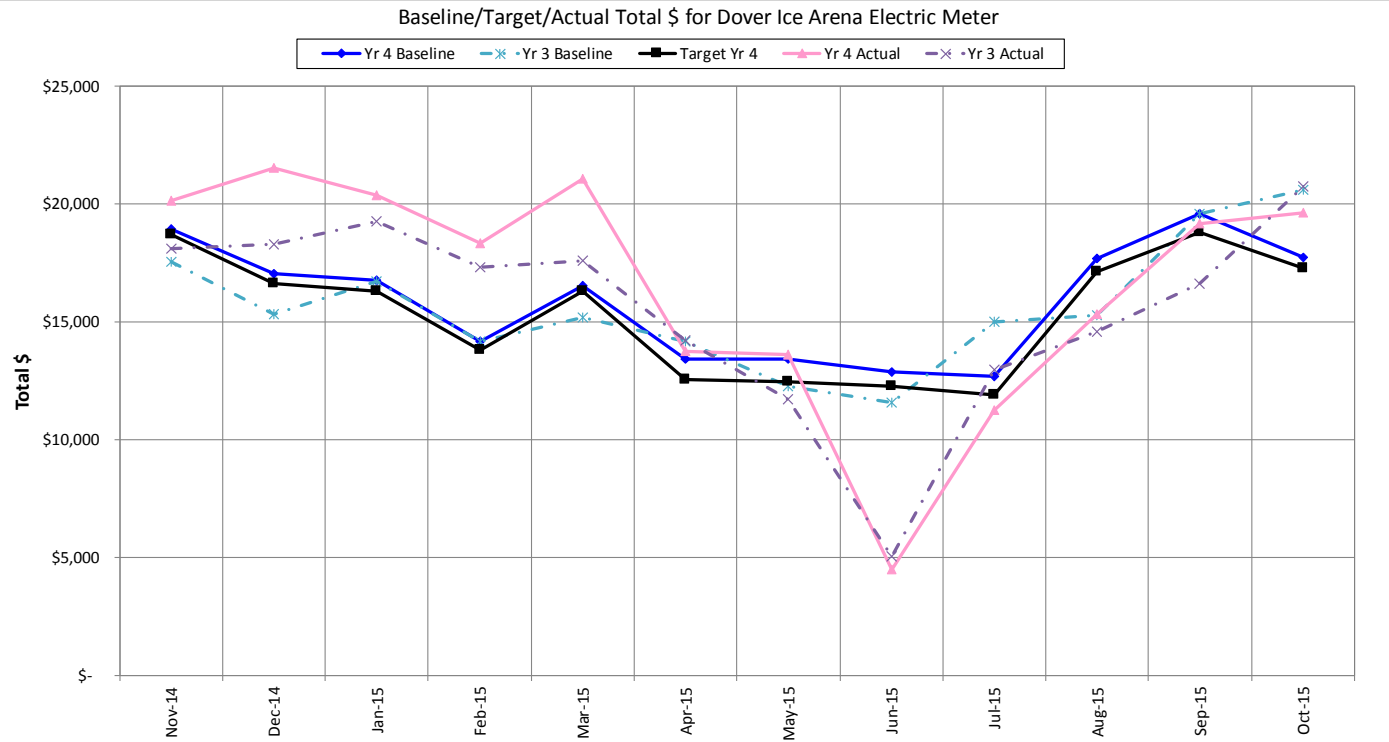
Scenario	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Total
Baseline Yr 4	288	244	221	221	221	221	244	240	227	267	274	283	2,951
Target Yr 4	328	288	264	259	267	263	286	282	267	309	319	324	3,456
Actual Yr 4	288	343	284	300	290	291	251	185	276	272	302	301	3,383
Savings	0	(99)	(63)	(79)	(69)	(70)	(7)	55	(49)	(5)	(28)	(18)	(432)



## APPENDIX A

### FIM 11: Ice Arena Upgrades- Electric

This regression analysis was run for **electric cost** which includes both demand and consumption. The three solid lines shown represent the calculated Year 4 baseline (blue), target utility use based off calculations and guarantees (black), and actual Year 4 cost from utility invoices and contractual rates (pink). Year 3 cost baseline (dashed light blue) and actual (dashed purple) have been superimposed using dotted lines for reference as shown below:



Scenario	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15	Total
Yr 4 Baseline	\$ 18,926	\$ 17,055	\$ 16,751	\$ 14,162	\$ 16,518	\$ 13,432	\$ 13,413	\$ 12,859	\$ 12,674	\$ 17,698	\$ 19,610	\$ 17,748	\$ 190,846
Target Yr 4	\$ 18,733	\$ 16,614	\$ 16,304	\$ 13,806	\$ 16,308	\$ 12,554	\$ 12,461	\$ 12,294	\$ 11,914	\$ 17,133	\$ 18,812	\$ 17,265	\$ 184,198
Yr 4 Actual	\$ 20,153	\$ 21,553	\$ 20,377	\$ 18,345	\$ 21,073	\$ 13,778	\$ 13,607	\$ 4,471	\$ 11,251	\$ 15,323	\$ 19,172	\$ 19,628	\$ 198,731
Savings	(\$1,227)	(\$4,498)	(\$3,626)	(\$4,183)	(\$4,554)	(\$346)	(\$194)	\$8,387	\$1,423	\$2,375	\$438	(\$1,880)	(\$7,885)

APPENDIX A

FIM 11: Ice Arena Upgrades- Electric

Again, since there are measures included at the Ice Arena that are not to be measured by utility bill analysis, they need to be subtracted from the overall savings as to not be counted twice. Below is a table of electric contract year savings from all other FIMs at the Ice Arena:

FIM 11: Ice Arena Upgrades				
Year 4 Savings from Other FIMs				
FIM #	FIM Description	Electricity Savings		
		kW	kWh	Cost \$
1	Lighting Fixtures	142	53,314	\$7,279
2	Lighting Controls	59	13,002	\$1,507
3	Weatherization	0	3,708	\$430
6	Water Conservation	0	0	\$0
9	Vending Controls	0	2,995	\$347
12	Power Factor	50	11,666	\$1,739
13	Transformers	59	22,754	\$3,092
<b>Total</b>		<b>309</b>	<b>107,439</b>	<b>\$14,395</b>

Electric consumption savings from the analysis are an increase of 39,134 kWh. Of that, 107,439 kWh are from different measures within this project. So the total reported additional usage from FIM 11 is an additional 146,573 kWh.

Similarly, the electric demand savings from the graphical analysis are a 432 kW increase. 309 kW were saved from other measures not to be included in the FIM 11 utility bill analysis. This leaves a demand increase of 741 kW over the reporting period.

Lastly, electric cost savings from the regression analysis are an additional \$7,885. Savings from other measures total electric savings of \$14,395. By isolating and removing the other FIM cost savings, the total FIM 11 electric utility additional cost usage is \$22,280.

FIM 11: Ice Arena Upgrades			
Contract Year 4 Energy Cost Avoidance			
Building	Electricity Savings		
	kW	kWh	Cost \$
Ice Arena	(741)	(146,573)	(\$22,280)

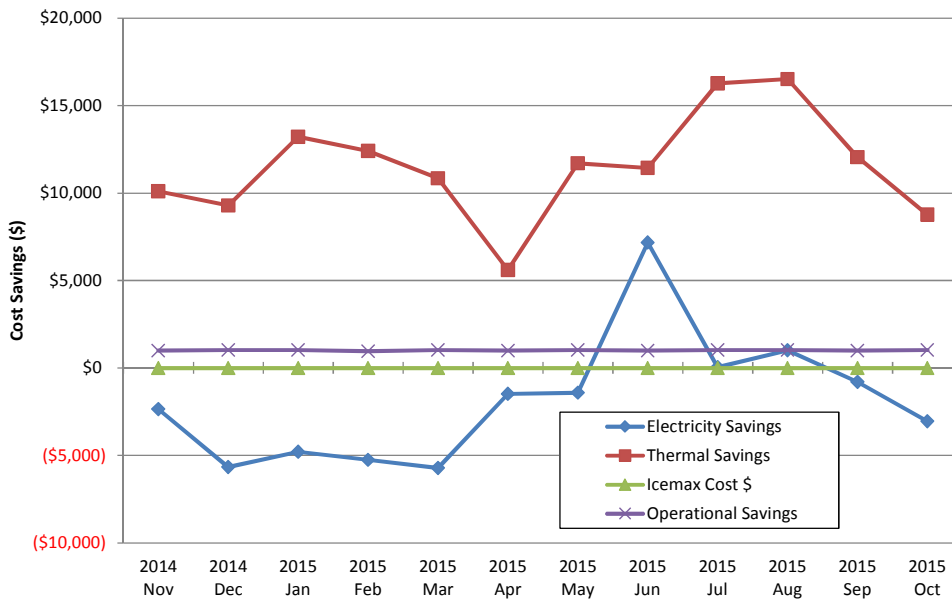
APPENDIX A

FIM 11: Ice Arena Upgrades

Breaking out the energy savings on a monthly basis and combining all previous figures, the total FIM 11 savings for Year 3 are listed below:

FIM 11: Ice Arena Upgrades									
Contract Year 4 Energy Cost Avoidance									
Month	Year	Electricity Savings			Thermal Savings		Icemax	O&M	Total Cost
		kW	kWh	Cost \$	MMBtu	Cost \$	Cost \$	\$ Savings	\$ Savings
November	2014	(25)	(18,991)	(\$2,357)	731	\$10,103	\$0	\$996	\$8,742
December	2014	(124)	(40,868)	(\$5,661)	673	\$9,297	\$0	\$1,029	\$4,665
January	2015	(88)	(35,756)	(\$4,789)	957	\$13,224	\$0	\$1,029	\$9,464
February	2015	(104)	(38,649)	(\$5,248)	898	\$12,416	\$0	\$963	\$8,130
March	2015	(94)	(43,361)	(\$5,717)	785	\$10,850	\$0	\$1,029	\$6,162
April	2015	(95)	(6,706)	(\$1,476)	406	\$5,606	\$0	\$996	\$5,126
May	2015	(32)	(10,423)	(\$1,418)	847	\$11,703	\$0	\$1,029	\$11,314
June	2015	23	60,020	\$7,173	827	\$11,435	\$0	\$996	\$19,604
July	2015	(76)	5,215	\$53	1,178	\$16,283	\$0	\$1,029	\$17,365
August	2015	(30)	10,357	\$1,006	1,196	\$16,524	\$0	\$1,029	\$18,558
September	2015	(53)	(3,708)	(\$803)	872	\$12,050	\$0	\$996	\$12,243
October	2015	(43)	(23,701)	(\$3,043)	635	\$8,770	\$0	\$1,029	\$6,757
<b>Contract Yr 4</b>		<b>(741)</b>	<b>(146,573)</b>	<b>(\$22,280)</b>	<b>10,005</b>	<b>\$138,261</b>	<b>\$0</b>	<b>\$12,149</b>	<b>\$128,129</b>

FIM 11- Ice Arena Savings



## APPENDIX A

### FIM 12: Power Factor Correction

This measure was fully installed on January 26, 2013 on the following devices at the Ice Arena:

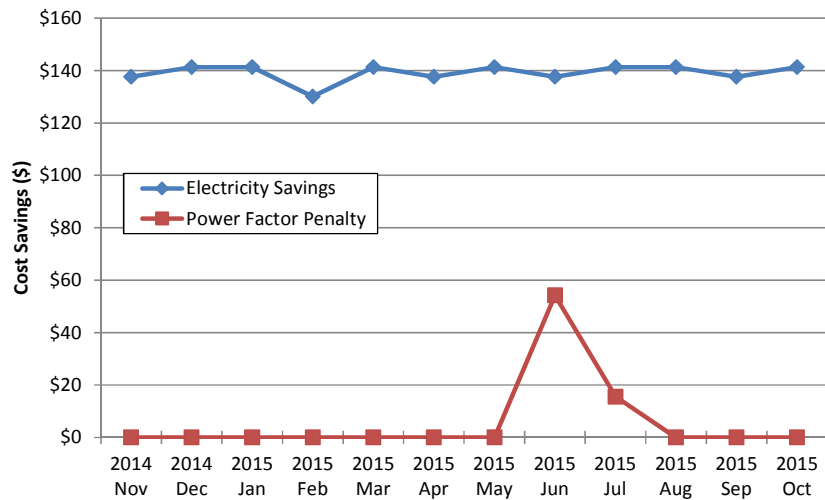
A1 63kw Compressor / B1 63kw Compressor / A2 45kw Compressor

15 HP Electric Chiller Pump / 30 HP Backup Pump

Savings for FIM 12 will be obtained from the date of installation going forward.

FIM 12: Power Factor Correction							
Contract Year 4 Energy Cost Avoidance							
Month	Year	Electricity Savings			Power Factor Penalty Savings		Total Cost \$ Savings
		kW	kWh	Cost \$	kW	Cost Savings \$	
November	2014	3	959	\$138	0	\$0	\$138
December	2014	3	991	\$141	0	\$0	\$141
January	2015	3	991	\$141	0	\$0	\$141
February	2015	3	895	\$130	0	\$0	\$130
March	2015	3	991	\$141	0	\$0	\$141
April	2015	3	959	\$138	0	\$0	\$138
May	2015	3	991	\$141	0	\$0	\$141
June	2015	3	959	\$138	7	\$54	\$192
July	2015	3	991	\$141	2	\$16	\$157
August	2015	3	991	\$141	0	\$0	\$141
September	2015	3	959	\$138	0	\$0	\$138
October	2015	3	991	\$141	0	\$0	\$141
<b>Contract Yr 4</b>		<b>41</b>	<b>11,666</b>	<b>\$1,669</b>	<b>9</b>	<b>\$66</b>	<b>\$1,739</b>

FIM 12- Power Factor Savings



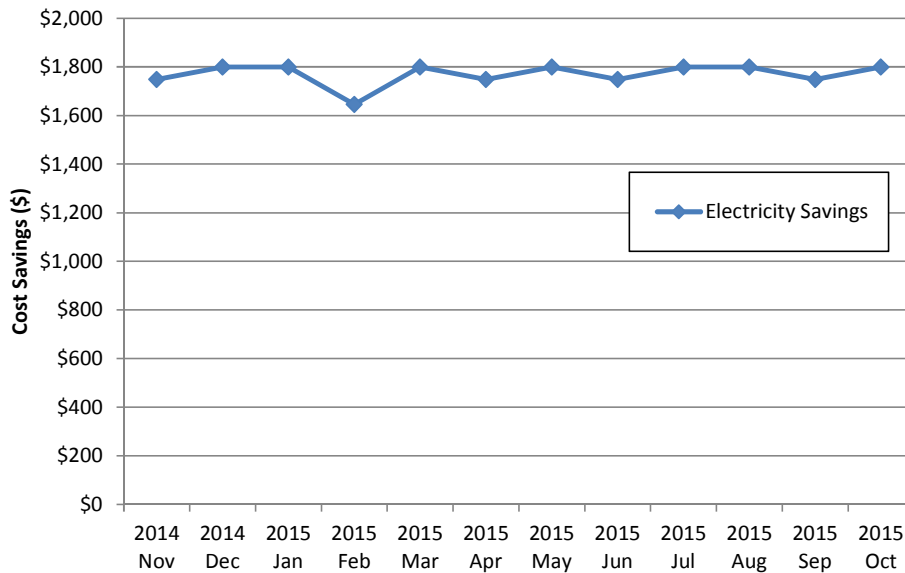
APPENDIX A

FIM 13: Transformers

The FIM 13 table breaks down the measure by month over the contract year. Savings for the replacement of transformers come from the Ice Arena, Waste Water Treatment Plant, Public Works, and McConnell Center.

FIM 13: Transformers					
Contract Year 4 Energy Cost Avoidance					
Month	Year	Electricity Savings			Total Cost \$ Savings
		kW	kWh	Cost \$	
November	2014	27	12,380	\$1,748	\$1,748
December	2014	27	12,793	\$1,799	\$1,799
January	2015	27	12,793	\$1,799	\$1,799
February	2015	27	11,555	\$1,645	\$1,645
March	2015	27	12,793	\$1,799	\$1,799
April	2015	27	12,380	\$1,748	\$1,748
May	2015	27	12,793	\$1,799	\$1,799
June	2015	27	12,380	\$1,748	\$1,748
July	2015	27	12,793	\$1,799	\$1,799
August	2015	27	12,793	\$1,799	\$1,799
September	2015	27	12,380	\$1,748	\$1,748
October	2015	27	12,793	\$1,799	\$1,799
<b>Contract Yr 4</b>		<b>318</b>	<b>150,628</b>	<b>\$21,230</b>	<b>\$21,230</b>

FIM 13- Transformers Savings



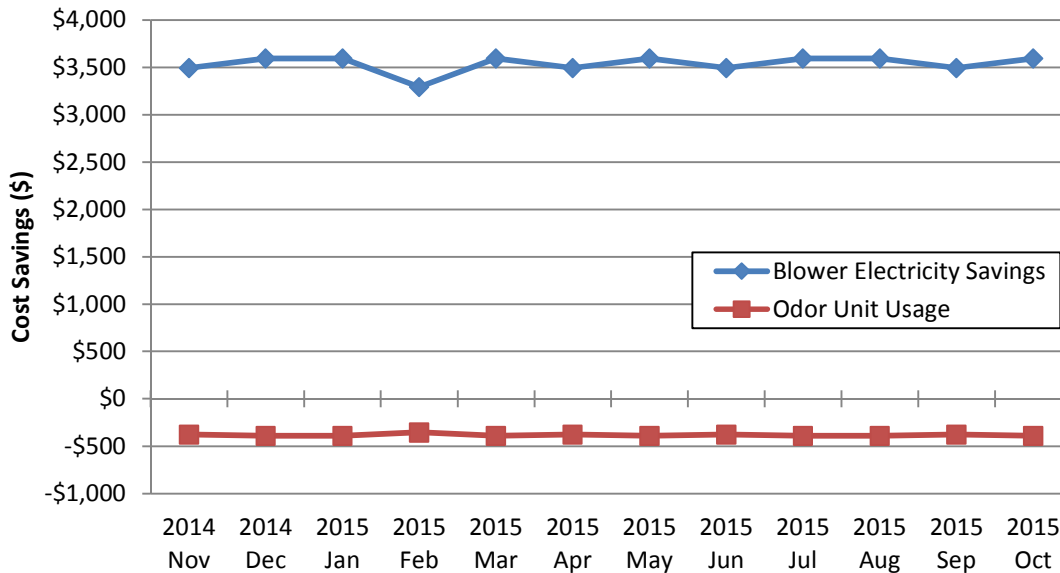
APPENDIX A

FIM 14: Aeration Blower Upgrade

The FIM 14 table breaks down the measure over the contract year. A silencer was added to the unit in March 2012 allowing for the recommended 24-7 run time to control odors. This has been included in the savings below.

FIM 14: Aeration Blower Upgrade					
Contract Year 4 Energy Cost Avoidance					
Month	Year	Electricity Savings			Total Cost \$ Savings
		kW	kWh	Cost \$	
November	2014	60	20,384	\$3,116	\$3,116
December	2014	60	21,064	\$3,205	\$3,205
January	2015	60	21,064	\$3,205	\$3,205
February	2015	60	19,025	\$2,939	\$2,939
March	2015	60	21,064	\$3,205	\$3,205
April	2015	60	20,384	\$3,116	\$3,116
May	2015	60	21,064	\$3,205	\$3,205
June	2015	60	20,384	\$3,116	\$3,116
July	2015	60	21,064	\$3,205	\$3,205
August	2015	60	21,064	\$3,205	\$3,205
September	2015	60	20,384	\$3,116	\$3,116
October	2015	60	21,064	\$3,205	\$3,205
<b>Contract Yr 4</b>		<b>724</b>	<b>248,010</b>	<b>\$37,837</b>	<b>\$37,837</b>

FIM 14- Aeration Blower Savings



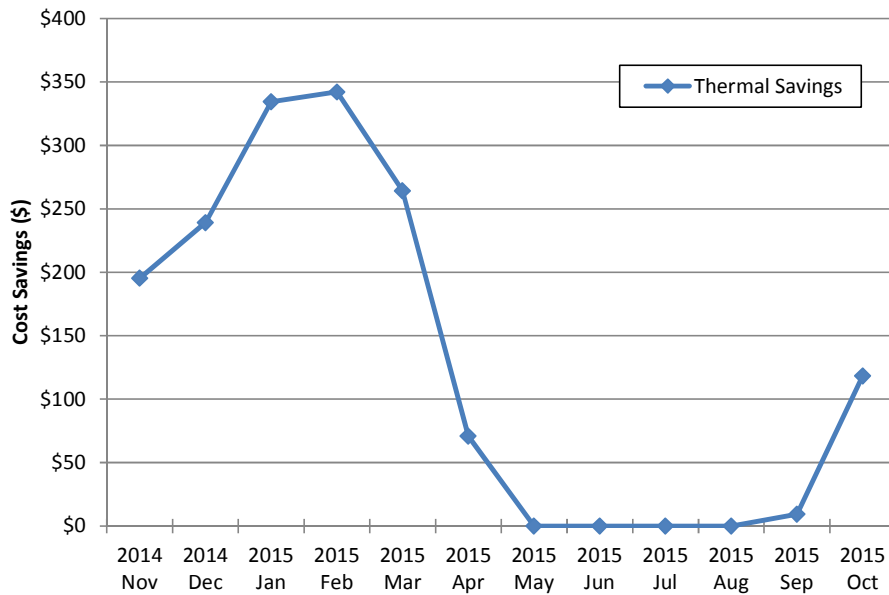
APPENDIX A

FIM 15: Boiler Replacement

Annual savings are concentrated over the winter months from mid-September through mid-April with a partial weighting for weather over that time.

FIM 15: Boiler Replacement				
Contract Year 4 Energy Cost Avoidance				
Month	Year	Thermal Savings		Total Cost \$ Savings
		MMBTU	Cost \$	
November	2014	13	\$195	\$195
December	2014	15	\$239	\$239
January	2015	22	\$334	\$334
February	2015	22	\$342	\$342
March	2015	17	\$264	\$264
April	2015	5	\$71	\$71
May	2015	0	\$0	\$0
June	2015	0	\$0	\$0
July	2015	0	\$0	\$0
August	2015	0	\$0	\$0
September	2015	1	\$9	\$9
October	2015	8	\$118	\$118
<b>Contract Yr 4</b>		<b>99</b>	<b>\$1,574</b>	<b>\$1,574</b>

FIM 15- Boiler Replacement Savings



APPENDIX B

Performance Contract Project Progress

City of Dover- Year 4 Performance Contracting Tracking			
Quarter	<sup>(7)</sup> Annual Guaranteed Savings	Total Reported Savings	% Savings of Guarantee
1 (Nov,Dec,Jan)	-	\$84,941	24.5%
2 (Feb,Mar,Apr)	-	\$79,367	22.9%
3 (May,Jun)	-	\$65,033	18.8%
4 (Jul,Aug,Sep,Oct)	-	\$125,508	36.2%
Total	\$346,603	\$354,849	102.4%

<sup>(7)</sup>Annual guaranteed savings are guaranteed on an annual basis

Year 3 total reported savings to date include November 2013 through October 2014 as per the November 1<sup>st</sup> start date of the performance period.

City of Dover Performance Contracting Tracking				
Period	Date Range	<sup>(8)</sup> Total Guaranteed Savings	Reported Savings	Variance
Installation	Sep '09 – Oct '11	\$0	\$400,730	N/A
Year 1	Nov '11 – Oct '12	\$319,463	\$317,642	<sup>(9)</sup> (\$1,821)
Year 2	Nov '12 – Oct '13	\$328,236	\$321,420	<sup>(10)</sup> (\$6,817)
Year 3	Nov '13 – Oct '14	\$337,280	\$341,147	\$3,799
Year 4	Nov '14 – Oct '15	\$346,603	\$354,849	\$8,246
Year 5	Nov '15 – Oct '16	\$356,214		
Year 6	Nov '16 – Oct '17	\$366,122		
Year 7	Nov '17 – Oct '18	\$376,336		
Year 8	Nov '18 – Oct '19	\$386,865		
Year 9	Nov '19 – Oct '20	\$397,719		
Year 10	Nov '20 – Oct '21	\$408,909		
<b>Total Contract</b>	<b>N/A</b>	<b>\$3,623,746</b>	<b>N/A</b>	<b>N/A</b>

<sup>(8)</sup> Guaranteed Savings baseline has been adjusted from original contract to reflect CO # 9236-0142-CO2 associated with the McConnell Center (added lighting and lighting controls)

<sup>(9)</sup> Variance is due in part to non-installation of FIM 12- Power Factor Correction through Year 1

<sup>(10)</sup> Year 2 variance is due to Ice Arena controls & equipment overrides. Items have been corrected.



APPENDIX B

Weather Degree Days

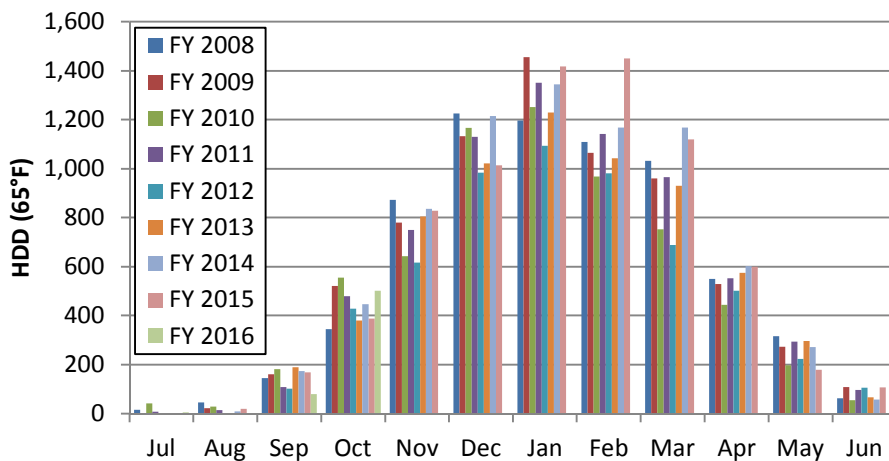
Weather data obtained from Skyhaven Airport Weather Station, Rochester, NH for Base 65°F.

Rochester, NH Weather Heating Degree Days (Base 65°F)

Report Period	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2015
July	16.5	0.0	41.5	8.5	0.0	0.0	2.5	0.0	6.0
August	46.0	23.0	29.0	14.0	3.5	2.5	10.0	20.0	0.5
September	145.5	160.5	181.0	109.0	102.0	189.0	174.0	168.5	80.0
October	344.0	521.5	555.0	480.0	427.5	380.0	447.0	387.0	501.5
November	872.5	780.0	643.0	749.0	616.0	804.0	836.0	828.0	
December	1,224.5	1,133.0	1,166.0	1,130.5	983.5	1,021.5	1,215.0	1,013.5	
January	1,196.5	1,456.0	1,251.5	1,350.5	1,094.0	1,229.0	1,343.0	1,417.5	
February	1,109.5	1,064.5	968.5	1,141.5	981.5	1,043.0	1,168.0	1,450.0	
March	1,032.5	960.5	752.5	965.5	688.0	931.0	1,167.5	1,119.5	
April	550.5	529.0	445.0	552.5	502.0	574.5	602.0	600.0	
May	315.0	272.5	197.5	294.0	223.5	295.5	271.0	178.5	
June	63.0	108.5	55.5	97.0	106.0	67.0	57.0	107.5	

The baseline period is highlighted in green, year 1 period is yellow, year 2 period in light blue, year 3 period is in pink, and year 4 is in blue.

Monthly Heating Degree Days



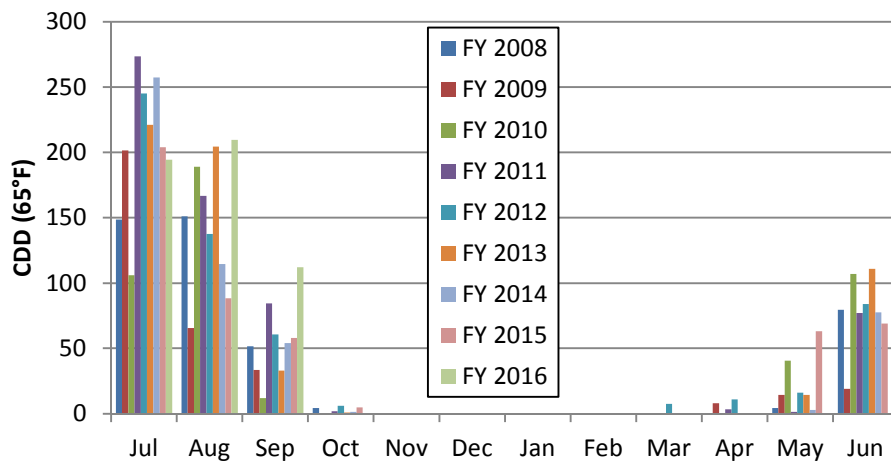
APPENDIX B

Rochester, NH Weather Cooling Degree Days (Base 65°F)

Report Period	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016
July	148.5	201.5	106.0	273.5	245.0	221.0	257.5	204.0	194.5
August	151.0	65.5	189.0	166.5	137.5	204.5	114.5	88.5	209.5
September	51.5	33.5	12.0	84.5	60.5	33.0	54.0	58.0	112.0
October	4.5	0.0	0.0	2.0	6.0	1.0	1.5	5.0	0.0
November	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
December	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
January	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
February	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
March	0.0	0.0	0.0	0.0	7.5	0.0	0.0	0.0	
April	0.0	8.0	0.0	3.5	11.0	0.0	0.0	0.0	
May	4.5	14.5	40.5	1.5	16.0	14.5	3.0	63.0	
June	79.5	19.0	107.0	77.0	84.0	111.0	77.5	69.0	

The baseline period is highlighted in green, year 1 period is yellow, year 2 period in light blue, year 3 period is in pink, and year 4 is in blue.

Monthly Cooling Degree Days



APPENDIX B

Utility Rate Schedule

Below are the contractual utility rates obtained from Schedule C: Part III of the contract. The rates below are the contractual rate escalated by the contractual 3% per year.

The below rates have been escalated by 9.27% for the third guarantee year (3 x 3%) as per the contract.

Rate Summary Table							
Contract Year 3 Rates							
City of Dover, NH Building Location	Electric		Natural Gas	Oil	Propane	Water	Sewer
	\$/kW	\$/kWh	\$/Therm	\$/Therm	\$/Therm	\$/HCF	\$/HCF
Indoor Pool	\$9.64	\$0.114	\$1.572	-	-	\$4.10	\$4.93
Dover Ice Arena	\$7.75	\$0.116	\$1.382	-	-		
Waste Water Treatment Facility	\$7.68	\$0.130	-	\$1.823	-		
Dover City Hall	-	\$0.136	-	\$1.823	-		
Public Works	-	\$0.140	\$1.233	-	-		
McConnell Center	\$7.76	\$0.117	\$1.544	-	-		
Dover Public Library	-	\$0.147	\$1.546	-	-		
Jenny Thompson Pool	-	\$0.138	\$1.475	-	-		
Central Fire Station	-	\$0.137	\$1.671	-	-		
South End Fire Station	-	\$0.140	-	-	\$1.933		
Pine Hill Chapel	-	\$0.185	-	\$1.823	-		
Pine Hill Barn	-	\$0.219	-	\$1.823	-		
Veterans Hall	-	\$1.805	\$1.971	-	-		
Dover Train Station	-	\$0.133	\$2.092	-	-		

Note: Unblended cost if demand charges are available, if not blended cost

\*\*\*\*\*These rates are used to cover all months between November 2014 – October 2015\*\*\*\*\*

The above contract rates for Oil and Propane are listed in \$/Therm. The below conversions are provided for both to give the rates in \$/Gallon:

Oil rate at \$1.823 per Therm = \$2.534 per Gallon  
Propane rate at \$1.933 per Therm = \$1.771 per Gallon

## APPENDIX B

### Glossary

Actual Utility Usage (FIM 11)- Amount of electricity or natural gas used; Obtained from invoices received through utility companies

Baseline- The adjusted pre-retrofit bills (usually one year) used to compare to the post-retrofit energy usage in order to provide a basis for calculating savings; can be adjusted for variables such as weather, hours, etc.

Construction Period- The period between the commencement date and the first day of the month following the date of Substantial Completion

Contract Savings- Savings obtained over the course of the contract, in this case from the start of Year 1

Contract (Guarantee) Year Savings- Savings occurring over the course of a contract year; this contract's year runs from November through October

Cost Avoidance- Dollars that would have been spent if the energy conservation measures had not been installed.

Degree Day- A unit of measurement equal to a difference of one degree between the mean outdoor temperature on a certain day and a reference temperature (can be summed monthly or yearly). For example, a daily outdoor average temperature of 30°F would be 35 Heating Degree Days with a base temperature of 65°F.

FIM- Facility improvement measure, sometimes referred to as energy conservation measure (ECM)

Fiscal Year Savings- Savings occurring over the course of a fiscal year; Dover's runs from July through June

Guarantee Period- The period of time typically after the date of Substantial Completion. This period starts the reporting and monitoring of the performance contract.

Guaranteed Savings- The amount of savings guaranteed to be achieved.

Installation Savings- FIMs installed during the construction period and being of beneficial use prior to the date of Substantial Completion are monitored to determine savings.

Savings to Date- Savings obtained through a portion of a period

Substantial Completion- Sufficient materials and services have been provided to permit the intended benefit from the work. This term can apply to individual measures and the overall project.

Target Savings- Savings figures estimated to be achieved, determined by calculations and measurements

## APPENDIX C

### **FIM 1- Lighting: Formulas & Calculations Used**

$$\text{Lighting kW Savings} = \sum (\text{Fixture Wattage}_{\text{Pre}} - \text{Retrofit Fixture Wattage}_{\text{Post}})$$

$$\text{Lighting kWh Savings} = \sum (\text{Lighting kW Savings} \times \text{Hours of Operation})$$

$$\text{kWh Cooling Savings}_{\text{Period}} = \frac{\text{CDD}_{\text{Period}}}{\text{CDD}_{\text{Annual}}} \times \text{kWh Cooling Savings}_{\text{Annual}}$$

$$\text{MMBtu Heating Losses}_{\text{Period}} = \frac{\text{HDD}_{\text{Period}}}{\text{HDD}_{\text{Annual}}} \times \text{MMBtu Heating Losses}_{\text{Annual}}$$

### **FIM 2- Lighting Controls: Formulas & Calculations Used**

$$\text{Lighting Controls kWh Savings} = \sum \text{Retrofit Fixture Wattage}_{\text{Post}} \times (\text{Lighting Runtime}_{\text{Pre}} - \text{Hours of Occupancy})$$

### **FIM 3- Weatherization: Formulas & Calculations Used**

Spreadsheet based- General Formulas used include:

$$\text{CFM}_{\text{Infiltration}} [\text{Winter}] = \text{Wind Speed} \times \text{Area of Cracks} \times \% \text{ Area Heated} \times \% \text{ Windward Diversity}$$

$$\text{CFM}_{\text{Infiltration}} [\text{Summer}] = \text{Wind Speed} \times \text{Area of Cracks} \times \% \text{ Area with AC} \times \% \text{ Windward Diversity}$$

$$\text{Existing Btu Saved}_{\text{Occupied}} = 1.08 \times \text{CFM}_{\text{Infiltration}} \times \Delta T \times \text{Bin Hours}_{\text{Occupied}}$$

$$\text{Existing Btu Saved}_{\text{Unoccupied}} = 1.08 \times \text{CFM}_{\text{Infiltration}} \times \Delta T \times \text{Bin Hours}_{\text{Unoccupied}}$$

$$\text{kWh Saved} = \frac{\text{Cooling Btu Saved} \times 12}{12,000 \frac{\text{Btu}}{\text{Ton}} \times \text{EER}}$$

$$\text{MMBtu Saved} = \frac{\text{Heating Btu Saved}}{1 \times 10^6 \frac{\text{Btu}}{\text{MMBtu}} \times \text{Boiler Efficiency} (\%)}$$

APPENDIX C

**FIM 4.1- EMS Building Controls: Formulas & Calculations Used**

Spreadsheet based- General Formulas used include:

$$\text{Cooling kWh} = \frac{(\text{Envelope Load} + \text{Infiltration Load}) \times \frac{1 \times 10^6 \text{ Btu}}{\text{MMBtu}} \times \text{Cooling} \frac{\text{kW}}{\text{Ton}}}{12,000 \frac{\text{Tons}}{\frac{\text{Btu}}{\text{Hr}}}}$$

$$\text{Heating MMBtu} = \frac{(\text{Envelope Load} + \text{Infiltration Load})}{\text{Boiler Efficiency (\%)}}$$

$$\text{Envelope Load} = \frac{1}{\text{Rvalue}} \times \text{Exposed Area} \times \left[ \sum (\text{Air Temp}_{\text{Outdoor}} - \text{Setpoint}_{\text{Occupied}}) \times \text{Occupied Hours} + \sum (\text{Air Temp}_{\text{Outdoor}} - \text{Setpoint}_{\text{Unoccupied}}) \times \text{Unoccupied Hours} \right]$$

$$\text{Infiltration Load} = \frac{1.08 \times \text{Infiltration CFM}}{1 \times 10^6} \times \left[ \sum (\text{Air Temp}_{\text{Outdoor}} - \text{Setpoint}_{\text{Occupied}}) \times \text{Occupied Hours} + \sum (\text{Air Temp}_{\text{Outdoor}} - \text{Setpoint}_{\text{Unoccupied}}) \times \text{Unoccupied Hours} \right]$$

**FIM 4.2- EMS Building Controls/ Optimal Start: Formulas & Calculations Used**

Spreadsheet based- General Formulas used include:

$$\text{Baseline MMBtu} = 1.08 \times \text{CFM} \times \% \text{ Speed at Warmup} \times (\text{Air Temp}_{\text{Outdoor}} - \text{Air Temp}_{\text{Room}}) \times \text{Warmup Hours}$$

$$\text{Proposed MMBtu} = \frac{\frac{\text{Envelope Load} + \text{Infiltration Load}}{1 \times 10^6} \times \text{Warmup Hours}}{\text{Morning Run Hours}}$$

Warmup Hours = Hours before Occupancy Unit Ventilators Turned to Occupied Mode

$$\text{MMBtu Savings} = \frac{\text{Baseline MMBtu} - \text{Propose MMBtu}}{\text{Boiler Efficiency (\%)}}$$

## APPENDIX C

### **FIM 4.3-AHU Upgrade / VFD on Fan: Formulas & Calculations Used**

Spreadsheet based- General Formulas used include:

$$\text{Cooling kWh} = \frac{\left( \text{Sensible Cooling} \left( \frac{\text{Btu}}{\text{Hr}} \right) + \text{Latent Cooling} \left( \frac{\text{Btu}}{\text{Hr}} \right) \right) \times \text{Cooling} \frac{\text{kW}}{\text{Ton}} \times \text{Bin Hours}}{12,000 \frac{\text{Tons}}{\frac{\text{Btu}}{\text{Hr}}}}$$

$$\text{Sensible Cooling} \left( \frac{\text{Btu}}{\text{Hr}} \right) = 1.08 \times \text{CFM}_{\text{Mixed Air}} \times (\text{Temp}_{\text{Mixed Air}} - \text{Temp}_{\text{Cooling Coil}})$$

$$\text{Latent Cooling} \left( \frac{\text{Btu}}{\text{Hr}} \right) = 0.68 \times \text{CFM}_{\text{Mixed Air}} \times (\text{Relative Humidity}_{\text{Mixed Air}} - \text{RH Setpoint}_{\text{Discharge Air}})$$

$$\text{Heating MMBtu} = \frac{\text{Preheat} \left( \frac{\text{Btu}}{\text{Hr}} \right) + \text{Reheat} \left( \frac{\text{Btu}}{\text{Hr}} \right)}{1 \times 10^6 \text{ Boiler Efficiency (\%)}} \times \text{Bin Hours}$$

$$\text{Preheat} \left( \frac{\text{Btu}}{\text{Hr}} \right) = 1.08 \times \text{CFM}_{\text{Mixed Air}} \times (\text{Temp}_{\text{Preheat Coil}} - \text{Temp}_{\text{Mixed Air}})$$

$$\text{Reheat} \left( \frac{\text{Btu}}{\text{Hr}} \right) [\text{Cooling Season}] = 1.08 \times \text{CFM}_{\text{Mixed Air}} \times (\text{Temp}_{\text{Discharge Air; Summer}} - \text{Temp}_{\text{Cooling Coil}})$$

$$\begin{aligned} \text{Reheat} \left( \frac{\text{Btu}}{\text{Hr}} \right) [\text{Heating Season}] \\ = 1.08 \times \text{CFM}_{\text{Mixed Air}} \times [\text{Temp}_{\text{Discharge Air; Winter}} - \text{Max}(\text{Temp}_{\text{Preheat Coil}}, \text{Temp}_{\text{Mixed Air}})] \end{aligned}$$

$$\text{CFM}_{\text{Mixed Air}} = \text{CFM}_{\text{Total Supply}} \times \% \text{ Fan Speed}$$

$$\text{Temp}_{\text{Mixed Air}} = \frac{\text{CFM}_{\text{Outside Air}}}{\text{CFM}_{\text{Mixed Air}}} \times \text{Temp}_{\text{Outside Air}} + \frac{\text{CFM}_{\text{Return Air}}}{\text{CFM}_{\text{Mixed Air}}} \times \text{Temp}_{\text{Return Air}}$$

$$\text{Relative Humidity}_{\text{Mixed Air}} = \frac{\text{CFM}_{\text{Outside Air}}}{\text{CFM}_{\text{Mixed Air}}} \times \text{RH}_{\text{Outside Air}} + \frac{\text{CFM}_{\text{Return Air}}}{\text{CFM}_{\text{Mixed Air}}} \times \text{RH}_{\text{Return Air}}$$

## APPENDIX C

### **FIM 4.4- Pool Dehumidification: Formulas & Calculations Used**

Spreadsheet based-

See DEA Appendix for Calculations

### **FIM 4.5- Snow Melt Sensor: Formulas & Calculations Used**

Spreadsheet based-

See DEA Appendix for Calculations

### **FIM 6- Water Conservation: Formulas & Calculations Used**

$$\text{Water Savings} = \sum (\text{Fixture Water Flow}_{\text{Pre}} - \text{Retrofit Fixture Water Flow}_{\text{Post}})$$

$$\text{Water Cost Savings} = \sum (\text{Water Savings}) \times \text{Fixture Usage}$$



## APPENDIX C

### **FIM 9- Vending Controls: Formulas & Calculations Used**

$$\text{Electric Savings} = \sum (\text{Energy Usage}_{\text{Pre}} - \text{Energy Usage}_{\text{Post}})$$

$$\text{Energy Usage} = \sum (\text{Lighting kWh} + \text{Compressor kWh})$$

$$\text{Lighting}_{\text{Pre}} \text{ kWh} = \sum (\text{Lighting kW} \times \text{Hours per Day} \times \text{Days per Year})$$

$$\text{Lighting}_{\text{Post}} \text{ kWh} = \sum \text{Lighting kW} \times (\text{Hours}_{\text{Occupied}} + (\text{Hours}_{\text{Unoccupied}} \times \text{Night Duty Cycle}))$$

$$\text{Compressor Hours}_{\text{Post}} = \sum (\text{Hours}_{\text{Occupied}} \times \text{Existing Duty Cycle}) + (\text{Hours}_{\text{Unoccupied}} \times \text{Night Duty Cycle})$$

$$\text{Compressor}_{\text{Pre}} \text{ kWh} = \sum \left( \frac{\text{Volts} \times \text{Amps} \times 80\% \text{ P. F.}}{\frac{1,000 \text{ W}}{1 \text{ kW}}} - \text{Lighting kW} \right) \times \frac{\text{Hours}_{\text{Pre}}}{\text{Year}} \times \text{Duty Cycle}$$

$$\text{Compressor}_{\text{Post}} \text{ kWh} = \sum \left( \frac{\text{Volts} \times \text{Amps} \times 80\% \text{ P. F.}}{\frac{1,000 \text{ W}}{1 \text{ kW}}} - \text{Lighting kW} \right) \times \frac{\text{Compressor Hours}_{\text{Post}}}{\text{Year}}$$

### **FIM 10- Pool Cover: Formulas & Calculations Used**

Spreadsheet based-

See DEA Appendix for Calculations

### **FIM 11- Ice Arena Upgrades: Formulas & Calculations Used**

Savings based on Utility Invoices & Metrix Meter Tuning Contracts contained in previous sections of this report.

## APPENDIX C

### **FIM 12- Power Factor: Formulas & Calculations Used**

Electric kWh Savings =  $\sum(kW_{Pre} - kW_{Post}) \times Runtime\ Hrs$

$$kW = \frac{\sqrt{PHase} \times Volts \times Amps \times Power\ Factor}{1,000 \frac{Watts}{kW}}$$

Power Factor Penalty  $kW_{Savings} = kW_{CHarged} - kW_{Used}$

### **FIM 13- Transformers: Formulas & Calculations Used**

Electric Savings =  $\sum (Transformer\ Losses_{Pre} - Transformer\ Losses_{Post})$

Transformer Losses =  $\sum [kVA \times Load \times Load\ Factor \times (\frac{1}{\% \text{ Efficiency}} - 1)]$

### **FIM 14- Aeration Blowers: Formulas & Calculations Used**

Electric Savings =  $kWh\ Use_{Pre} - kWh\ Use_{Post}$

$$kWh\ Use = \frac{Voltage \times Amperage \times PF \times \sqrt{3}}{\frac{1,000\ W}{kW}} \times Hours$$

### **FIM 15- Boiler Replacement: Formulas & Calculations Used**

Fuel Savings = Fuel Usage  $\times \frac{Fuel\ to\ Heat\ Efficiency_{Pre}}{Fuel\ to\ Heat\ Efficiency_{Post}}$

Fuel to Heat Efficiency (%) =  $Combustion\ Efficiency \times (1 - Radiant\ Jacket\ Losses) \times (1 - Distribution\ Losses)$