

CITY OF DOVER, NH



YEAR 5 MEASUREMENT & VERIFICATION (M&V) REPORT

Annual Contract Savings

(November 1, 2015 – October 31, 2016)

February 2017



CITY OF DOVER, NH

PERFORMANCE CONTRACT

Year 5

Annual M&V Report

Performance Period Dates Covered: November 1, 2015 to October 31, 2016

Contract #: 9236-0143

Contract Year #: 5

Annual Year 5 Guaranteed Savings:

Energy:	\$306,371
Operations & Maintenance (O&M):	\$16,004
Capital Cost Avoidance:	\$33,840
Total Guarantee:	\$356,214

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 fifth full contract (guarantee) year which runs from November 2015 through October 2016. 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 1st 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 5 savings of \$365,130 exceeded the guaranteed amount by \$8,916, or 2.5%. Along with the savings surplus' in Year 3 and 4, 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 by JCI. 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) ⁽¹⁾
Year 2	\$280,169	\$14,227	\$33,840	\$328,236	\$321,420	(\$6,817) ⁽²⁾
Year 3	\$288,644	\$14,796	\$33,840	\$337,280	\$341,079	\$3,799
Year 4	\$297,375	\$15,388	\$33,840	\$346,603	\$354,849	\$8,246
Year 5	\$306,371	\$16,004	\$33,840	\$356,214	\$365,130	\$8,916
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		
Total	\$3,121,103	\$164,244	\$338,400	\$3,623,746	\$1,700,188	N/A

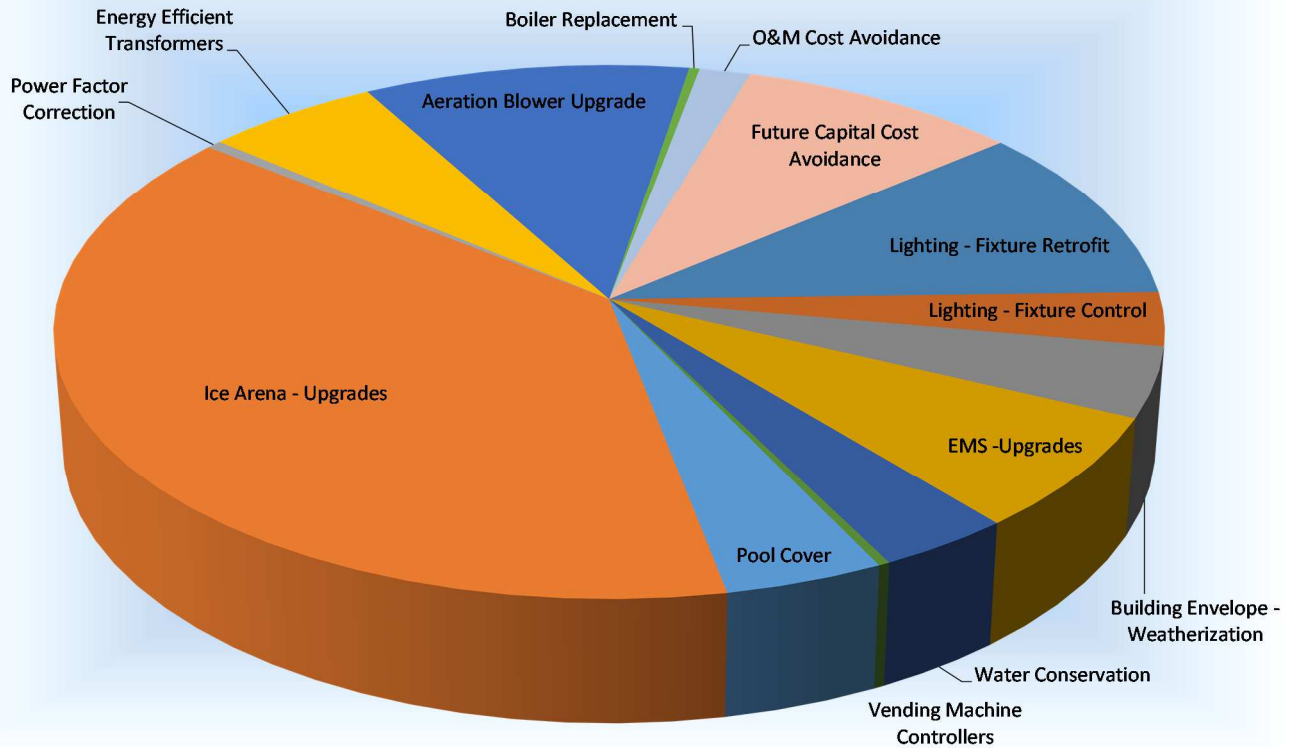
⁽¹⁾ Year 1 variance was due to non-installation of FIM 12- Power Factor Correction during Year 1 as explained in previous reports. The equipment was installed in the first quarter of Year 2 (January of 2013). The City of Dover has been compensated for the variance from guaranteed savings.

⁽²⁾ 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 5 Cost Savings: City of Dover

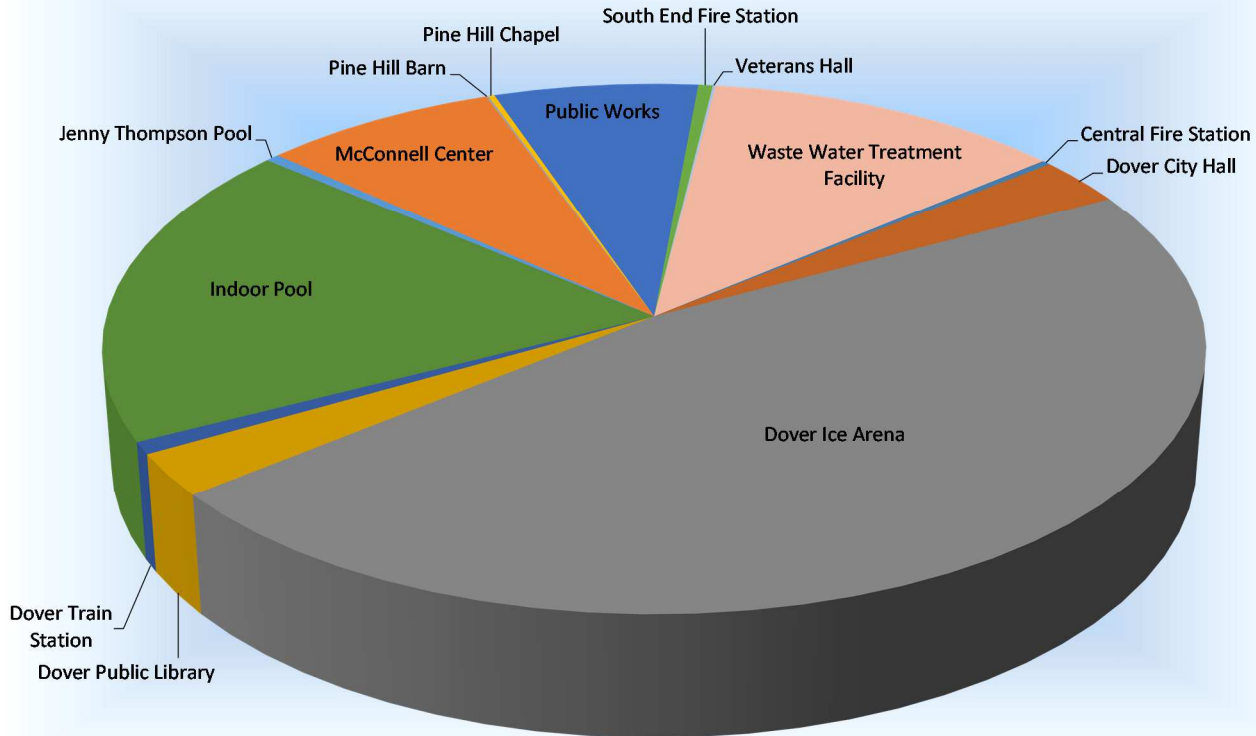


City of Dover, NH - Guarantee Year 5 Savings									
FIM #	FIM Description	Electricity Savings			Thermal Savings		Water Savings		Total Y5 \$ Savings
		kW	kWh	\$	MMBtu	\$	kgal	\$	
1	Lighting - Fixture Retrofit	1,426	263,588	\$41,933	(201)	(\$2,952)	0	\$0	\$38,981
2	Lighting - Fixture Control	310	90,536	\$11,819	0	\$0	0	\$0	\$11,819
3	Bldg. Envelope - Weatherization	0	4,965	\$618	993	\$14,886	0	\$0	\$15,504
4	EMS -Upgrades	0	86,126	\$10,537	955	\$14,913	0	\$0	\$25,450
6	Water Conservation	0	0	\$0	164	\$2,440	1,117	\$10,392	\$12,832
9	Vending Machine Controllers	0	8,425	\$1,091	0	\$0	0	\$0	\$1,091
10	Pool Cover	0	46,656	\$5,493	560	\$9,065	64	\$598	\$15,156
11	Ice Arena - Upgrades	(1,128)	21,581	(\$5,965)	10,348	\$147,336	0	\$0	\$141,371
12	Power Factor Correction	50	11,666	\$1,792	0	\$0	0	\$0	\$1,792
13	Energy Efficient Transformers	318	150,628	\$20,962	0	\$0	0	\$0	\$20,962
14	Aeration Blower Upgrade	724	248,010	\$38,982	0	\$0	0	\$0	\$38,982
15	Boiler Replacement	0	0	\$0	79	\$1,251	0	\$0	\$1,251
Energy Totals		1,701	932,180	\$127,262	12,897	\$186,938	1,181	\$10,991	\$325,190
O&M Cost Avoidance		-	-	-	-	-	-	-	\$6,100
Future Capital Cost Avoidance		-	-	-	-	-	-	-	\$33,840
Totals		1,701	932,180	\$127,262	12,897	\$186,938	1,181	\$10,991	\$365,130

EXECUTIVE SUMMARY

Savings by Facility

Guarantee Year 5 Cost Savings: City of Dover



City of Dover, NH – Guarantee Year 5 Savings									
Facility Location	Electricity Savings			Thermal Savings		Water Savings		O&M / Cap Cost Savings	Total \$ Savings
	kW	kWh	\$	MMBtu	\$	kgal	\$		
Central Fire Station	0	197	\$28	48	\$826	21	\$193	\$0	\$1,046
Dover City Hall	150	36,023	\$5,055	168	\$2,275	302	\$2,812	\$562	\$10,703
Dover Ice Arena	(732)	166,409	\$14,028	10,693	\$152,238	239	\$2,221	\$3,292	\$171,779
Dover Public Library	102	34,267	\$5,193	162	\$2,588	127	\$1,184	\$562	\$9,527
Dover Transportation Ctr.	0	19,905	\$2,738	0	\$0	0	\$0	\$0	\$2,738
Indoor Pool	37	123,676	\$14,921	1,005	\$16,272	280	\$2,603	\$34,402	\$68,197
Jenny Thompson Pool	0	0	\$0	25	\$384	141	\$1,310	\$0	\$1,693
McConnell Center	675	132,834	\$21,457	403	\$6,404	0	\$0	\$562	\$28,422
Pine Hill Barn	0	0	\$0	22	\$301	0	\$0	\$0	\$301
Pine Hill Chapel	0	24	\$4	39	\$674	7	\$61	\$0	\$740
Public Works	685	147,751	\$21,296	171	\$2,169	56	\$524	\$562	\$24,551
South End Fire Station	0	96	\$14	83	\$1,650	9	\$83	\$0	\$1,747
Veterans Hall	0	0	\$0	16	\$320	0	\$0	\$0	\$320
Waste Water Treatment Facility	783	270,999	\$42,529	62	\$837	0	\$0	\$0	\$43,365
Totals	1,701	932,180	\$127,262	12,897	\$186,938	1,181	\$10,991	\$39,940	\$365,130

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			\$796		\$250									\$1,046
Dover City Hall	\$3,393	\$1,084	\$749	\$1,457	\$3,091	\$368							\$562	\$10,703
Dover Ice Arena	\$6,492	\$1,553	\$5,515		\$2,972	\$358		\$141,371	\$1,792	\$8,435			\$3,292	\$171,779
Dover Public Library	\$3,890	\$1,074	\$391	\$1,009	\$1,351							\$1,251	\$562	\$9,527
Dover Transportation Ctr.				\$2,738										\$2,738
Indoor Pool	\$1,377	\$31	\$1,240	\$13,216	\$2,599	\$176	\$15,156						\$34,402	\$68,197
Jenny Thompson Pool					\$1,693									\$1,693
McConnell Center	\$12,126	\$4,808	\$1,125	\$6,447						\$3,354			\$562	\$28,422
Pine Hill Barn				\$301										\$301
Pine Hill Chapel			\$514	\$159	\$66									\$740
Public Works	\$11,703	\$3,269	\$2,365	\$123	\$682	\$189				\$5,658			\$562	\$24,551
South End Fire Station			\$1,620		\$127									\$1,747
Veterans Hall			\$320											\$320
Waste Water Treatment Facility			\$868							\$3,515	\$38,982			\$43,365
Totals / FIM	\$38,981	\$11,819	\$15,504	\$25,450	\$12,832	\$1,091	\$15,156	\$141,371	\$1,792	\$20,962	\$38,982	\$1,251	\$39,940	\$365,130

EXECUTIVE SUMMARY

Savings (\$) by FIM, by Month

Cost savings are provided on a monthly basis for Contract Year 5 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 2016								Fiscal Year 2017				Total Contract Year 5 Savings	Annual Guaranteed Savings
		NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT		
1	Lighting - Fixture Retrofit	\$2,076	\$2,115	\$1,999	\$1,767	\$2,116	\$2,085	\$2,336	\$2,369	\$2,701	\$2,692	\$2,363	\$2,235	\$26,856	\$25,238
	Lighting Fixtures (McConnell Center)	\$925	\$918	\$857	\$820	\$918	\$930	\$1,041	\$1,095	\$1,277	\$1,270	\$1,093	\$981	\$12,126	\$12,037
2	Lighting - Fixture Control	\$576	\$595	\$595	\$525	\$595	\$576	\$595	\$576	\$595	\$595	\$576	\$595	\$6,997	\$6,735
	Lighting Controls (McConnell Center)	\$395	\$408	\$408	\$382	\$408	\$395	\$408	\$395	\$408	\$408	\$395	\$408	\$4,822	\$4,808
3	Building Envelope - Weatherization	\$1,562	\$1,840	\$2,428	\$2,170	\$1,835	\$1,513	\$969	\$107	\$589	\$572	\$680	\$1,239	\$15,504	\$16,292
4.1	EMS - Building Controls	\$883	\$1,098	\$1,584	\$1,412	\$1,094	\$842	\$378	\$87	\$62	\$48	\$153	\$602	\$8,243	\$9,462
4.2	EMS - Building Controls / Optimal Start	\$159	\$197	\$285	\$254	\$197	\$151	\$67	\$13	\$2	\$0	\$25	\$108	\$1,457	\$2,279
4.3	AHU Upgrade - VFD on Fan ⁽³⁾	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$7,453
4.4	Pool Dehumidification - EMS & VFD's	\$1,069	\$1,105	\$1,105	\$998	\$1,105	\$1,069	\$1,105	\$1,069	\$1,105	\$1,105	\$1,069	\$1,105	\$13,012	\$12,621
4.5	Repair Snow Melt Sensor	\$302	\$624	\$624	\$564	\$624	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$2,738	\$2,656
6	Water Conservation	\$1,055	\$1,090	\$1,090	\$984	\$1,090	\$1,055	\$1,090	\$1,055	\$1,090	\$1,090	\$1,055	\$1,090	\$12,832	\$15,911
9	Vending Machine Controllers	\$90	\$93	\$93	\$84	\$93	\$90	\$93	\$90	\$93	\$93	\$90	\$93	\$1,091	\$1,054
10	Pool Covers	\$1,246	\$1,287	\$1,287	\$1,163	\$1,287	\$1,246	\$1,287	\$1,246	\$1,287	\$1,287	\$1,246	\$1,287	\$15,156	\$14,897
11	Ice Arena Upgrades ⁽⁴⁾	\$6,512	\$5,567	\$8,490	\$6,381	\$6,642	\$4,495	\$7,396	\$14,751	\$27,034	\$23,450	\$13,589	\$7,160	\$131,467	\$107,044
12	Power Factor Correction	\$142	\$146	\$146	\$134	\$146	\$142	\$146	\$198	\$162	\$146	\$142	\$146	\$1,792	\$8,098
13	Energy Efficient Transformers	\$1,028	\$1,066	\$1,066	\$933	\$1,066	\$1,028	\$1,066	\$1,028	\$1,066	\$1,066	\$1,028	\$1,066	\$12,507	\$17,383
	E.E. Transformers (Ice Arena)	\$695	\$715	\$715	\$675	\$715	\$695	\$715	\$695	\$715	\$715	\$695	\$715	\$8,455	\$3,329
14	Aeration Blower Upgrade	\$3,211	\$3,302	\$3,302	\$3,028	\$3,302	\$3,211	\$3,302	\$3,211	\$3,302	\$3,302	\$3,211	\$3,302	\$38,982	\$37,665
15	Boiler Replacement	\$136	\$169	\$244	\$218	\$169	\$130	\$57	\$11	\$2	\$0	\$21	\$93	\$1,251	\$1,409
ENERGY COST SAVINGS		\$22,062	\$22,335	\$26,317	\$22,491	\$23,401	\$19,653	\$22,051	\$27,995	\$41,489	\$37,837	\$27,431	\$22,224	\$315,286	\$306,371
O&M Cost Avoidance		\$1,408	\$1,455	\$1,455	\$1,314	\$1,455	\$1,408	\$1,455	\$277	\$1,455	\$1,455	\$1,408	\$1,455	\$16,004	\$16,004
Future Capital Cost Avoidance		\$2,781	\$2,874	\$2,874	\$2,596	\$2,874	\$2,781	\$2,874	\$2,781	\$2,874	\$2,874	\$2,781	\$2,874	\$33,840	\$33,840
TOTAL COST SAVINGS		\$26,251	\$26,665	\$30,647	\$26,401	\$27,731	\$23,843	\$26,380	\$31,053	\$45,818	\$42,166	\$31,620	\$26,554	\$365,130	\$356,214

⁽³⁾ 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.

⁽⁴⁾ The City of Dover Ice Arena discontinued using IceMax in January 2013

EXECUTIVE SUMMARY

Savings by Source

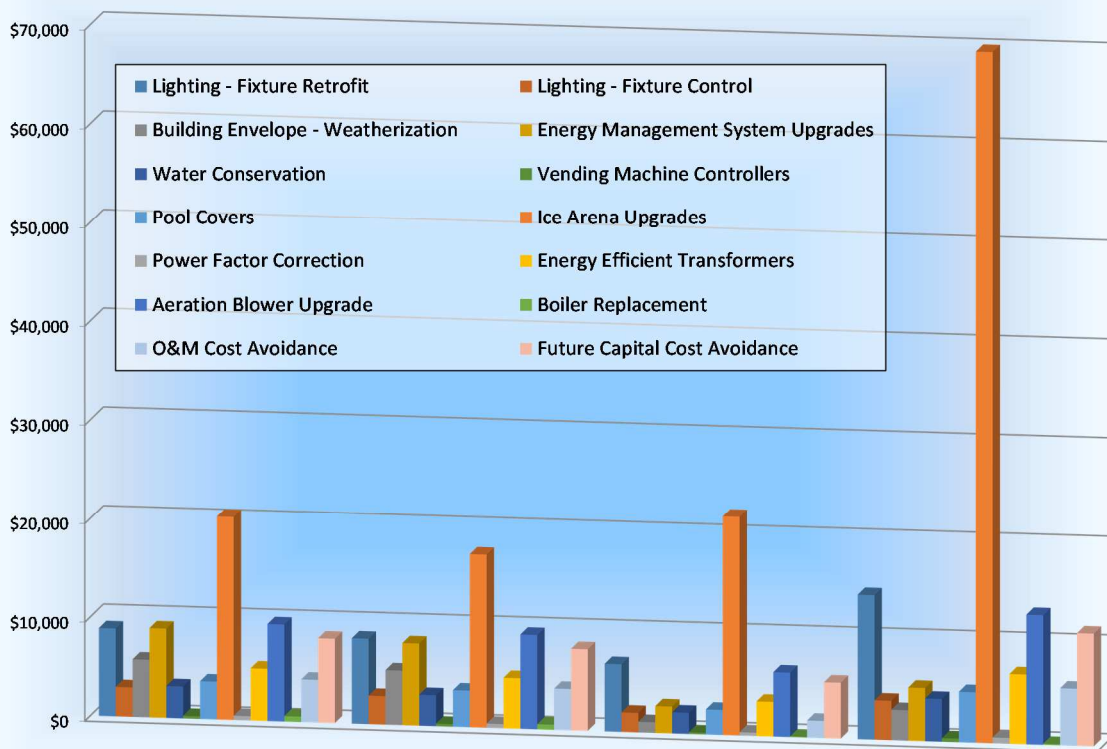
Savings under the project can also be understood as coming from the following sources:

- 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	932,180 kWh	\$127,262
Electricity Demand	1,701 kW	
Thermal (Oil/Gas/Propane)	106,032 MMBtu	\$186,938
Water / Sewer Savings	1,181 kGal	\$10,991
O&M / Capital Cost Avoidance	-	\$39,940

Guarantee Year 5 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

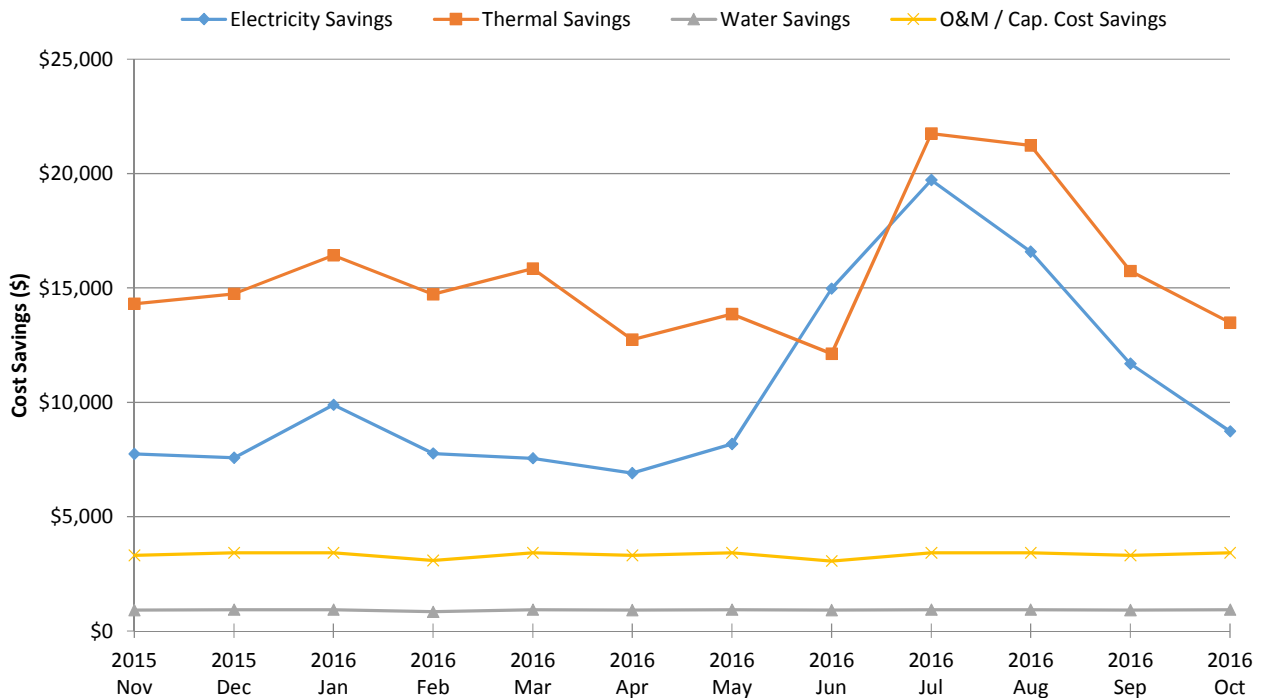
EXECUTIVE SUMMARY

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 5 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	2015	135	54,261	\$7,737	7,648	\$14,308	97	\$903	\$3,303	\$26,251
December	2015	149	51,205	\$7,576	7,614	\$14,743	100	\$933	\$3,413	\$26,665
January	2016	127	72,005	\$9,884	8,114	\$16,417	100	\$933	\$3,413	\$30,647
February	2016	138	54,745	\$7,758	7,278	\$14,718	91	\$843	\$3,083	\$26,401
March	2016	136	51,805	\$7,543	8,391	\$15,841	100	\$933	\$3,413	\$27,731
April	2016	84	50,962	\$6,896	6,604	\$12,741	97	\$903	\$3,303	\$23,843
May	2016	161	56,080	\$8,174	8,006	\$13,859	100	\$933	\$3,413	\$26,380
June	2016	138	114,902	\$14,973	7,525	\$12,119	97	\$903	\$3,058	\$31,053
July	2016	139	154,009	\$19,721	14,047	\$21,751	100	\$933	\$3,413	\$45,818
August	2016	198	123,878	\$16,593	13,697	\$21,227	100	\$933	\$3,413	\$42,166
September	2016	152	86,423	\$11,682	9,687	\$15,732	97	\$903	\$3,303	\$31,620
October	2016	143	61,903	\$8,725	7,420	\$13,482	100	\$933	\$3,413	\$26,554
Contract Yr 5		1,701	932,180	\$127,262	106,032	\$186,938	1,181	\$10,991	\$39,940	\$365,130

Monthly Project Savings



FIM DESCRIPTION

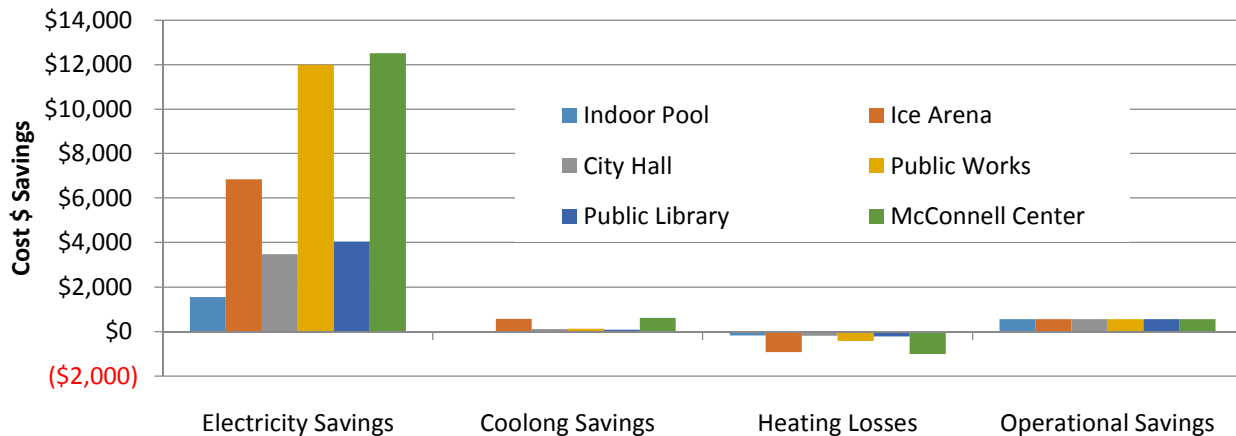
FIM 1: Lighting – Fixture Retrofit

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. Operational Savings are stipulated at \$3,369 for Year 5 for this measure.

FIM 1: Lighting – Fixture Retrofit									
Contract Year 5 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	\$1,548	85	\$10	(11)	(\$181)	\$562	\$1,939
Ice Arena	142	47,806	\$6,842	4,782	\$571	(65)	(\$921)	\$562	\$7,054
City Hall	88	24,717	\$3,468	823	\$116	(14)	(\$191)	\$562	\$3,954
Public Works	382	83,305	\$12,007	824	\$119	(33)	(\$423)	\$562	\$12,265
Public Library	102	26,608	\$4,032	539	\$82	(14)	(\$224)	\$562	\$4,452
McConnell Center ⁽⁵⁾	675	58,936	\$12,524	5,079	\$614	(64)	(\$1,013)	\$562	\$12,687
Totals	1,426	251,455	\$40,422	12,133	\$1,511	(201)	(\$2,952)	\$3,369	\$42,350

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

FIM 1: Contract Year 5 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

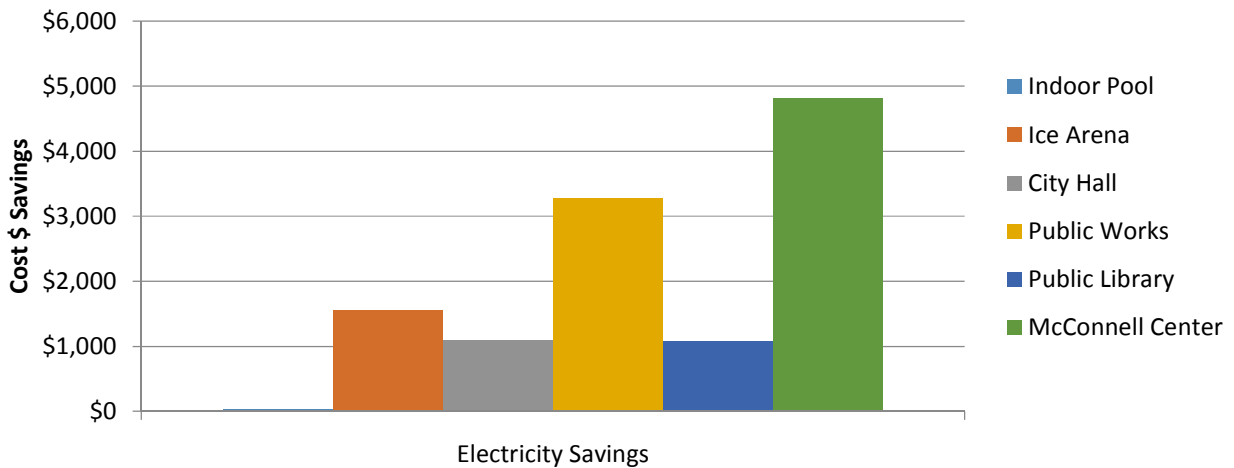
FIM 2: Lighting – Fixture Controls

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.

FIM 2: Lighting – Fixture Controls				
Contract Year 5 Energy Cost Avoidance				
Building	Electricity Savings			Total Cost \$ Savings
	kW	kWh	Cost \$	
Indoor Pool	1	260	\$31	\$31
Ice Arena	59	13,002	\$1,553	\$1,553
City Hall	61	7,726	\$1,084	\$1,084
Public Works	189	22,683	\$3,269	\$3,269
Public Library	0	7,084	\$1,074	\$1,074
McConnell Center ⁽⁶⁾	0	39,780	\$4,808	\$4,808
Totals	310	90,536	\$11,819	\$11,819

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

FIM 2: Contract Year 5 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.

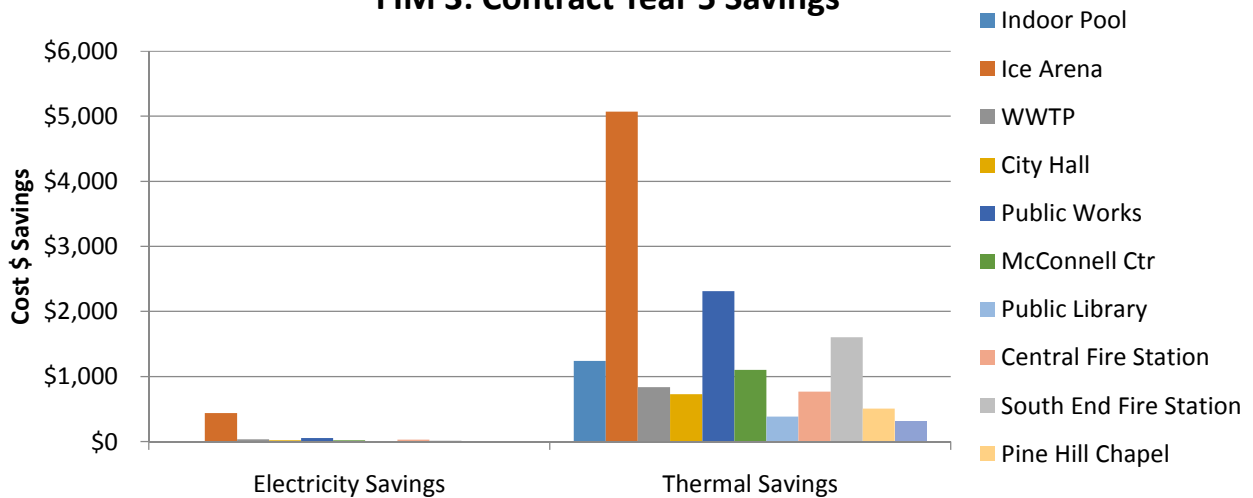
FIM DESCRIPTION

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.

FIM 3: Building Envelope- Weatherization						
Contract Year 5 Energy Cost Avoidance						
Building	Electricity Savings			Thermal Savings		Total Cost \$ Savings
	kW	kWh	Cost \$	MMBtu	Cost \$	
Indoor Pool	0	4	\$0	77	\$1,240	\$1,240
Ice Arena	0	3,708	\$443	356	\$5,072	\$5,515
WWTP	0	235	\$31	62	\$837	\$868
City Hall	0	137	\$19	54	\$730	\$749
Public Works	0	372	\$54	182	\$2,311	\$2,365
McConnell Center	0	157	\$19	70	\$1,106	\$1,125
Public Library	0	35	\$5	24	\$386	\$391
Central Fire Station	0	197	\$28	45	\$768	\$796
South End Fire Station	0	96	\$14	81	\$1,606	\$1,620
Pine Hill Chapel	0	24	\$4	27	\$509	\$514
Veteran's Hall	0	0	\$0	16	\$320	\$320
Totals	0	4,965	\$618	993	\$14,886	\$15,504

FIM 3: Contract Year 5 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

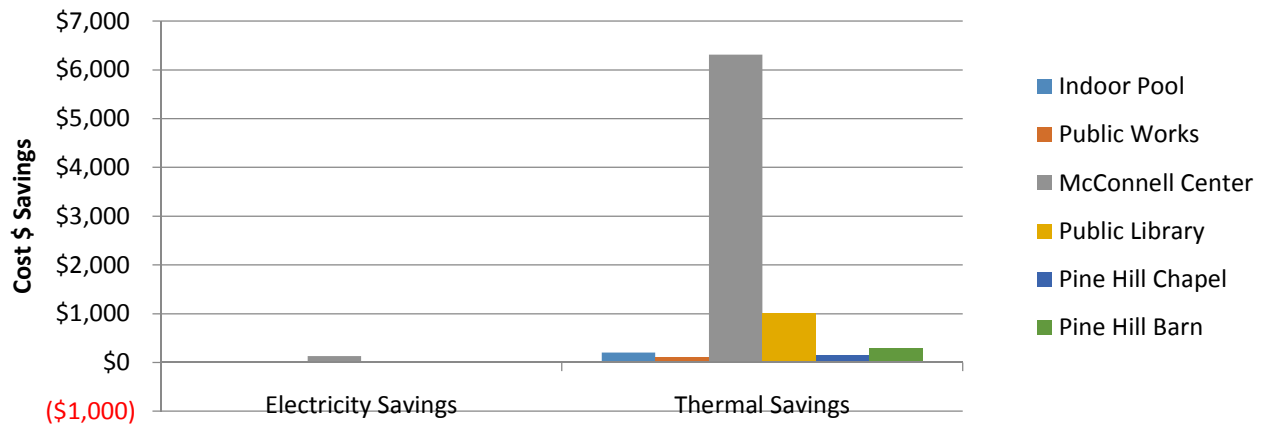
The EMS upgrade project is guaranteed to save 125,107 kWh of electrical energy and 1,138 MMBtu's of thermal energy. All sections of this FIM are further broken down as follows:

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.

FIM 4.1: Building Controls						
Contract Year 5 Energy Cost Avoidance						
Building	Electricity Savings			Thermal Savings		Total Cost \$ Savings
	kW	kWh	Cost \$	MMBtu	Cost \$	
Indoor Pool	0	(6)	(\$1)	13	\$205	\$204
Public Works	0	0	\$0	10	\$123	\$123
McConnell Center	0	1,132	\$137	397	\$6,310	\$6,447
Public Library	0	0	\$0	63	\$1,009	\$1,009
Pine Hill Chapel	0	0	\$0	12	\$159	\$159
Pine Hill Barn	0	0	\$0	22	\$301	\$301
Totals	0	1,125	\$136	516	\$8,107	\$8,243

FIM 4.1: Contract Year 5 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 in Year 5.

FIM 4.2: Building Controls / Optimal Start			
Contract Year 5 Energy Cost Avoidance			
Building	Thermal Savings		Total Cost \$ Savings
	MMBtu	Cost \$	
City Hall	108	\$1,457	\$1,457

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 5 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 5 Energy Cost Avoidance							
Building	Electricity Savings			Thermal Savings		Capital Cost Avoidance \$	Total Cost \$ Savings
	kW	kWh	Cost \$	MMBtu	Cost \$		
Indoor Pool	0	65,096	\$7,663	330	\$5,348	\$33,840	\$46,852

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 5 Energy Cost Avoidance				
Building	Electricity Savings			Total Cost \$ Savings
	kW	kWh	Cost \$	
Dover Transportation Center	0	19,905	\$2,738	\$2,738

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.

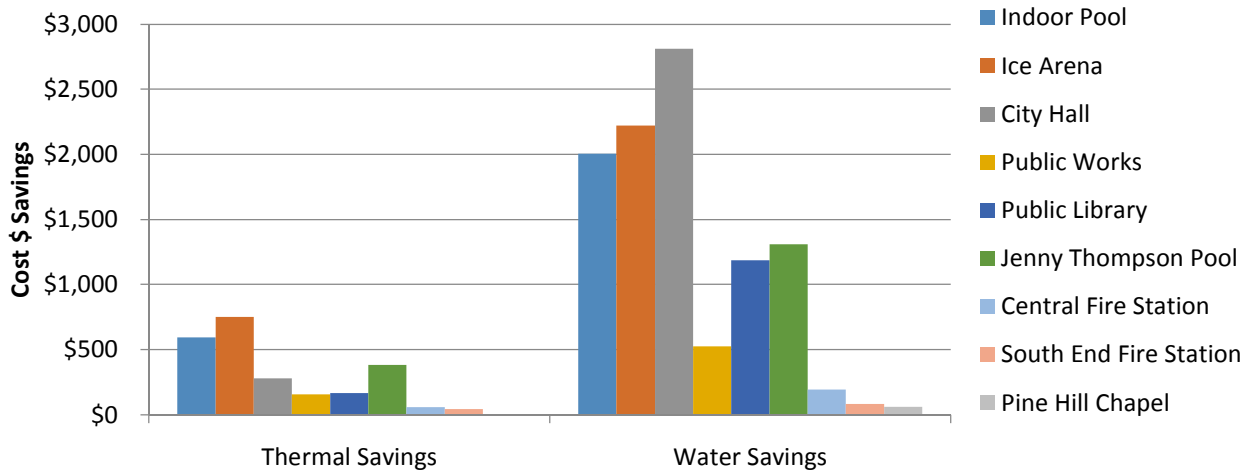
FIM DESCRIPTION

FIM 6: Water Conservation

The change in fixtures to more efficient ones is guaranteed to save 1,083 kgals of water annually and 159 MMBtu's in costs associated with heating that water.

FIM 6: Water Conservation					
Contract Year 5 Energy Cost Avoidance					
Building	Thermal Savings		Water Savings		Total Cost \$ Savings
	MMBtu	Cost \$	kGal	Cost \$	
Indoor Pool	37	\$595	215	\$2,005	\$2,599
Ice Arena	53	\$751	239	\$2,221	\$2,972
City Hall	21	\$279	302	\$2,812	\$3,091
Public Works	12	\$158	56	\$524	\$682
Public Library	10	\$167	127	\$1,184	\$1,351
Jenny Thompson Pool	25	\$384	141	\$1,310	\$1,693
Central Fire Station	3	\$58	21	\$193	\$250
South End Fire Station	2	\$44	9	\$83	\$127
Pine Hill Chapel	0	\$6	7	\$61	\$66
Totals	164	\$2,440	1,117	\$10,392	\$12,832

FIM 6: Contract Year 5 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.

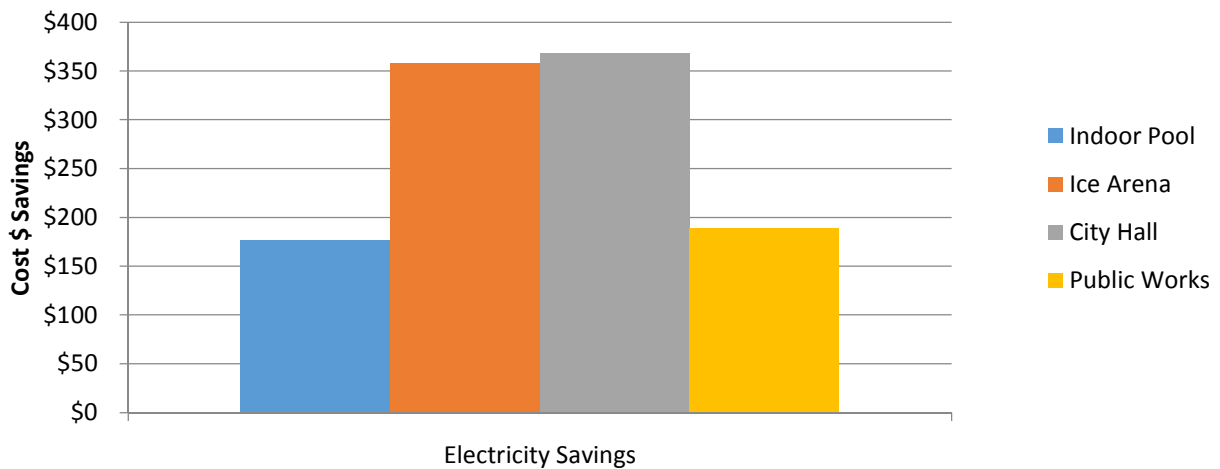
FIM DESCRIPTION

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 5 Energy Cost Avoidance				
Building	Electricity Savings			Total Cost \$ Savings
	kW	kWh	Cost \$	
Indoor Pool	0	1,498	\$176	\$176
Ice Arena	0	2,995	\$358	\$358
City Hall	0	2,621	\$368	\$368
Public Works	0	1,311	\$189	\$189
Totals	0	8,425	\$1,091	\$1,091

FIM 9: Contract Year 5 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.

FIM 10: Pool Covers								
Contract Year 5 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	\$5,493	560	\$9,065	64	\$598	\$15,156

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 \$12,634 for Year 5 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 newer electric chiller.

FIM 11: Ice Arena Upgrades								
Contract Year 5 Energy Cost Avoidance								
Building	Electricity Savings			Thermal Savings		Icemax	O&M	Total Cost
	kW	kWh	Cost \$	MMBtu	Cost \$	Cost \$	\$ Savings	\$ Savings
Ice Arena	(1,128)	21,581	(\$5,965)	10,348	\$147,336	(\$9,904)	\$12,634	\$144,101

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 5 Energy Cost Avoidance				
Building	Electricity Savings			Total Cost
	kW	kWh	Cost \$	\$ Savings
Ice Arena	50	11,666	\$1,792	\$1,792

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.

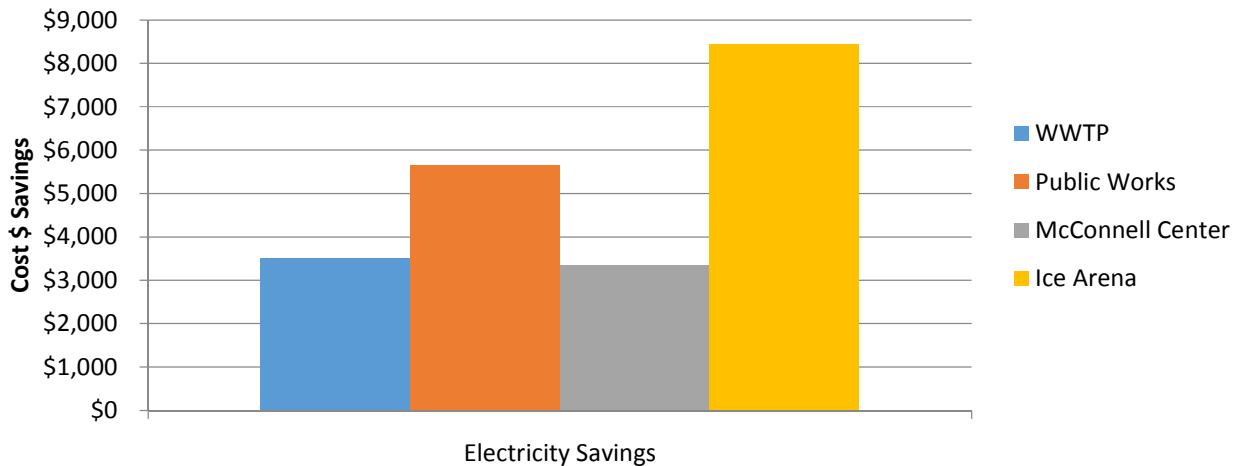
FIM DESCRIPTION

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).

FIM 13: Transformers				
Contract Year 5 Energy Cost Avoidance				
Building	Electricity Savings			Total Cost \$ Savings
	kW	kWh	Cost \$	
WWTP	59	22,754	\$3,515	\$3,515
Public Works	114	39,255	\$5,658	\$5,658
McConnell Center	0	27,750	\$3,354	\$3,354
Ice Arena	146	60,869	\$8,435	\$8,435
Totals	318	150,628	\$20,962	\$20,962

FIM 13: Contract Year 5 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 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 5 Energy Cost Avoidance				
Building	Electricity Savings			Total Cost \$ Savings
	kW	kWh	Cost \$	
WWTP	724	248,010	\$38,982	\$38,982

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.

FIM 15: Boiler Replacement			
Contract Year 5 Energy Cost Avoidance			
Building	Thermal Savings		Total Cost \$ Savings
	MMBtu	Cost \$	
Public Library	79	\$1,251	\$1,251

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

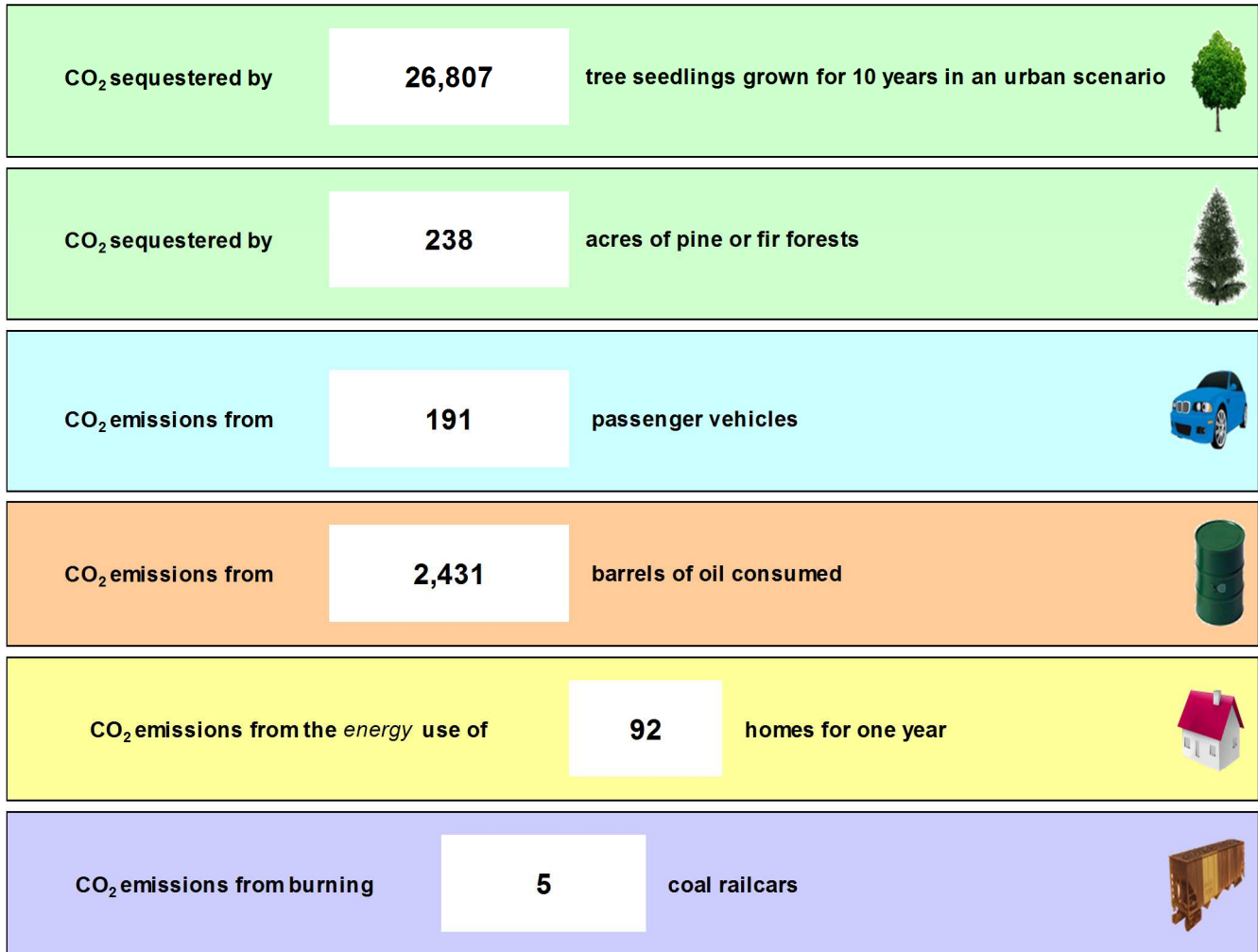
Total estimated emissions reductions are as follows:

Estimated Emissions Reductions: Contract Year 5- Tons of CO ₂ -e						
FIM #	Facility Improvement Measure	Electricity	Natural Gas	#2 Fuel Oil	Propane	Total
FIM 1	Lighting Fixtures	100.0	(9.9)	(1.0)	0.0	89.1
FIM 2	Lighting Controls	34.4	0.0	0.0	0.0	34.4
FIM 3	Weatherization	1.9	40.8	10.5	5.1	58.3
FIM 4	EMS Upgrades	32.7	43.2	10.4	0.0	86.3
<i>FIM 4.1</i>	<i>Building Controls</i>	0.4	25.6	2.5	0.0	28.6
<i>FIM 4.2</i>	<i>Building Controls / Optimal Start</i>	0.0	0.0	7.9	0.0	7.9
<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	8.2	549.6	0.0	0.0	557.8
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	4.2	0.0	0.0	4.2
Totals		353.7	665.1	21.4	5.3	1,045.5

ENVIRONMENTAL BENEFITS

Dover Contract Year 5 Equivalency Savings

The project's reduced emissions would be equivalent to:



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

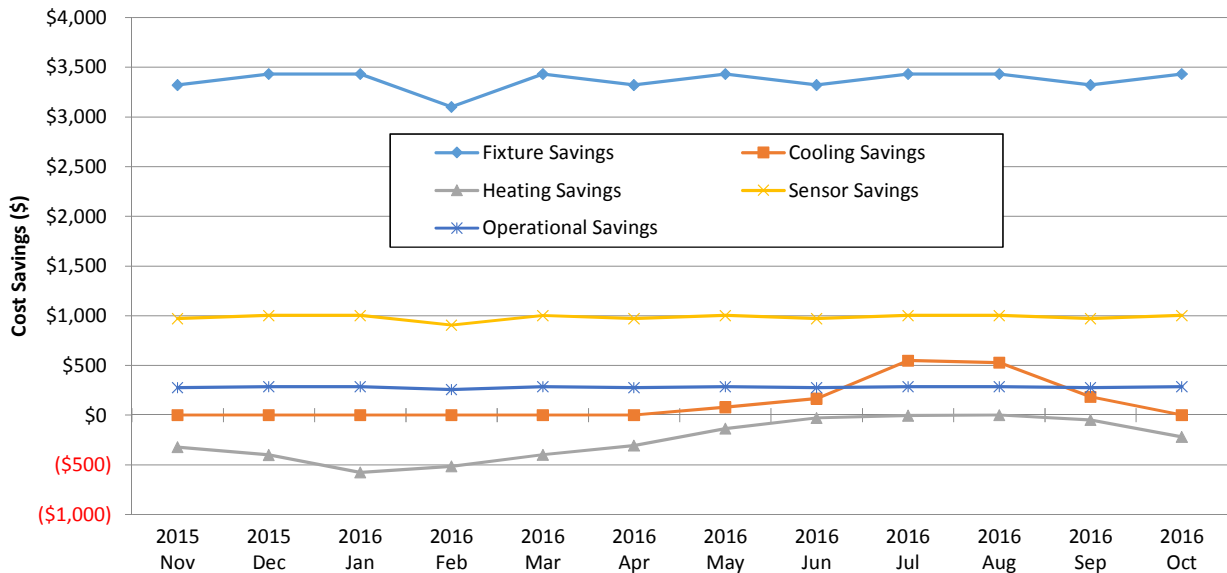
FIM 1 & 2: Lighting Fixture Retrofit & Controls

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 5 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	2015	119	20,668	\$3,322	0	\$0	(22)	(\$321)	\$277	\$3,278
December	2015	119	21,356	\$3,433	0	\$0	(27)	(\$400)	\$286	\$3,319
January	2016	119	21,356	\$3,433	0	\$0	(39)	(\$577)	\$286	\$3,142
February	2016	119	19,290	\$3,101	0	\$0	(35)	(\$514)	\$258	\$2,845
March	2016	119	21,356	\$3,433	0	\$0	(27)	(\$398)	\$286	\$3,321
April	2016	119	20,668	\$3,322	0	\$0	(21)	(\$307)	\$277	\$3,293
May	2016	119	21,356	\$3,433	636	\$79	(9)	(\$135)	\$286	\$3,663
June	2016	119	20,668	\$3,322	1,346	\$168	(2)	(\$26)	\$277	\$3,741
July	2016	119	21,356	\$3,433	4,412	\$549	(0)	(\$4)	\$286	\$4,264
August	2016	119	21,356	\$3,433	4,244	\$529	0	\$0	\$286	\$4,248
September	2016	119	20,668	\$3,322	1,477	\$184	(3)	(\$50)	\$277	\$3,734
October	2016	119	21,356	\$3,433	19	\$2	(15)	(\$219)	\$286	\$3,503
Contract Yr 4		1,426	251,455	\$40,422	12,133	\$1,511	(201)	(\$2,952)	\$3,369	\$42,350

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

FIM 1 & 2- Lighting Savings



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 5 Energy Cost Avoidance					
Month	Year	Electricity Savings			Total Cost \$ Savings
		kW	kWh	Cost \$	
November	2015	26	7,441	\$971	\$971
December	2015	26	7,689	\$1,004	\$1,004
January	2016	26	7,689	\$1,004	\$1,004
February	2016	26	6,945	\$907	\$907
March	2016	26	7,689	\$1,004	\$1,004
April	2016	26	7,441	\$971	\$971
May	2016	26	7,689	\$1,004	\$1,004
June	2016	26	7,441	\$971	\$971
July	2016	26	7,689	\$1,004	\$1,004
August	2016	26	7,689	\$1,004	\$1,004
September	2016	26	7,441	\$971	\$971
October	2016	26	7,689	\$1,004	\$1,004
Contract Yr 5		310	90,536	\$11,819	\$11,819

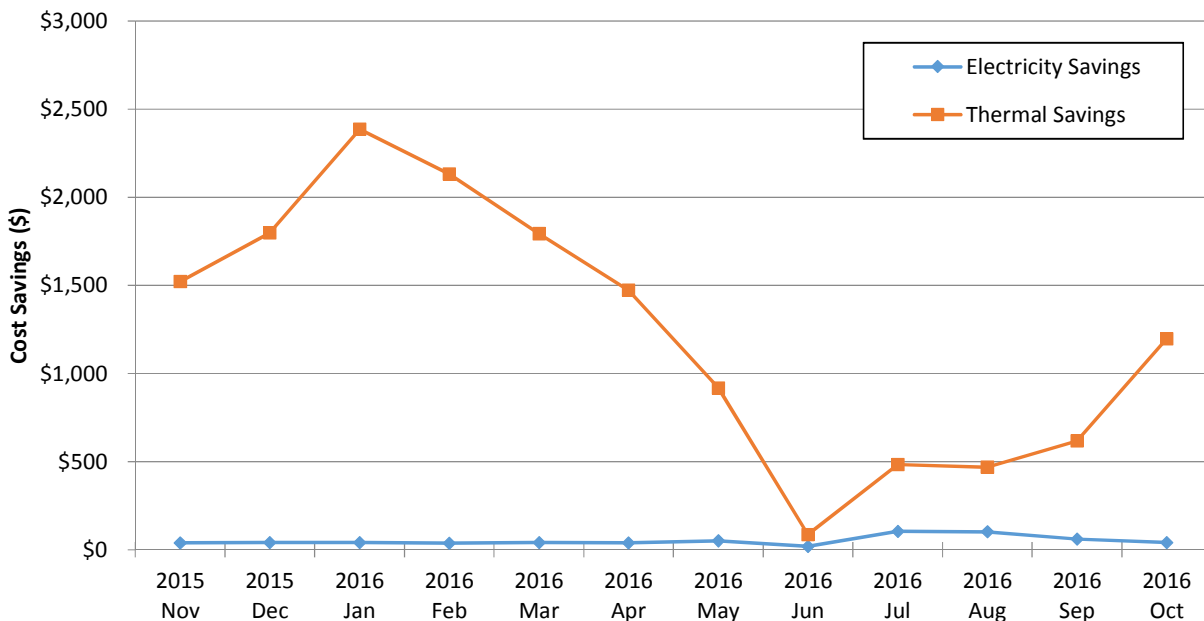
APPENDIX A

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 5 Energy Cost Avoidance							
Month	Year	Electricity Savings			Thermal Savings		Total Cost \$ Savings
		kW	kWh	Cost \$	MMBtu	Cost \$	
November	2015	0	332	\$40	101	\$1,523	\$1,562
December	2015	0	343	\$41	119	\$1,799	\$1,840
January	2016	0	343	\$41	157	\$2,387	\$2,428
February	2016	0	310	\$37	141	\$2,133	\$2,170
March	2016	0	343	\$41	119	\$1,794	\$1,835
April	2016	0	332	\$40	98	\$1,473	\$1,513
May	2016	0	409	\$50	62	\$919	\$969
June	2016	0	139	\$19	6	\$88	\$107
July	2016	0	800	\$105	34	\$484	\$589
August	2016	0	783	\$102	33	\$469	\$572
September	2016	0	485	\$61	43	\$619	\$680
October	2016	0	345	\$41	80	\$1,198	\$1,239
Contract Yr 5		0	4,965	\$618	993	\$14,886	\$15,504

FIM 3- Weatherization Savings



APPENDIX A

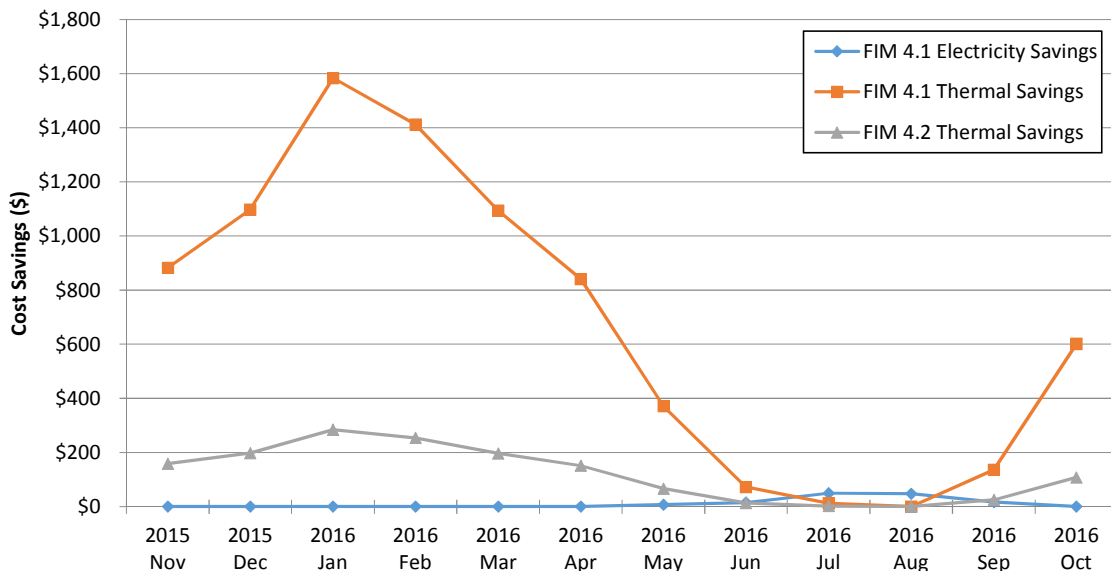
FIM 4: Energy Management System Upgrades

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		
Month	Year	Contract Year 5 Energy Cost Avoidance						Contract Year 5 Energy Cost Avoidance		
		Electricity Savings			Thermal Savings		Total Cost \$ Savings	Thermal Savings		Total Cost \$ Savings
		kW	kWh	Cost \$	MMBtu	Cost \$		MMBtu	Cost \$	
November	2015	0	0	\$0	56	\$883	\$883	12	\$159	\$159
December	2015	0	0	\$0	70	\$1,098	\$1,098	15	\$197	\$197
January	2016	0	0	\$0	101	\$1,584	\$1,584	21	\$285	\$285
February	2016	0	0	\$0	90	\$1,412	\$1,412	19	\$254	\$254
March	2016	0	0	\$0	70	\$1,094	\$1,094	15	\$197	\$197
April	2016	0	0	\$0	54	\$842	\$842	11	\$151	\$151
May	2016	0	59	\$7	24	\$371	\$378	5	\$67	\$67
June	2016	0	125	\$15	5	\$72	\$87	1	\$13	\$13
July	2016	0	409	\$49	1	\$12	\$62	0	\$2	\$2
August	2016	0	394	\$48	0	\$0	\$48	0	\$0	\$0
September	2016	0	137	\$17	9	\$136	\$153	2	\$25	\$25
October	2016	0	2	\$0	38	\$602	\$602	8	\$108	\$108
Contract Yr 5		0	1,125	\$136	516	\$8,107	\$8,243	108	\$1,457	\$1,457

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 5 Energy Cost Avoidance									
Month	Year	Fan Electricity Savings			Cooling Savings		Thermal Savings		Total Cost \$ Savings
		kW	kWh	Cost \$	kWh	Cost \$	MMBtu	Cost \$	
November	2015	0	0	\$0	0	\$0	0	\$0	\$0
December	2015	0	0	\$0	0	\$0	0	\$0	\$0
January	2016	0	0	\$0	0	\$0	0	\$0	\$0
February	2016	0	0	\$0	0	\$0	0	\$0	\$0
March	2016	0	0	\$0	0	\$0	0	\$0	\$0
April	2016	0	0	\$0	0	\$0	0	\$0	\$0
May	2016	0	0	\$0	0	\$0	0	\$0	\$0
June	2016	0	0	\$0	0	\$0	0	\$0	\$0
July	2016	0	0	\$0	0	\$0	0	\$0	\$0
August	2016	0	0	\$0	0	\$0	0	\$0	\$0
September	2016	0	0	\$0	0	\$0	0	\$0	\$0
October	2016	0	0	\$0	0	\$0	0	\$0	\$0
Contract Yr 5		0	0	\$0	0	\$0	0	\$0	\$0

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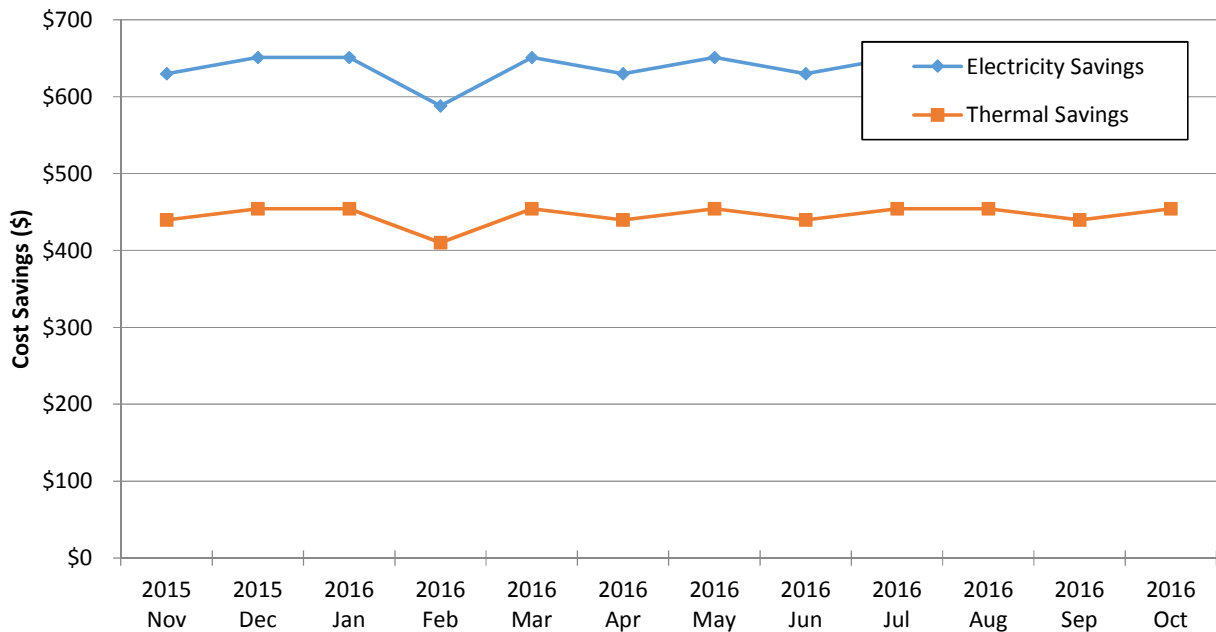
FIM 4: Energy Management System Upgrades

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 5 Energy Cost Avoidance								
Month	Year	Electricity Savings			Thermal Savings		Capital Cost	Total Cost
		kW	kWh	Cost \$	MMBtu	Cost \$	\$ Avoidance	
November	2015	0	5,350	\$630	27	\$440	\$2,781	\$3,851
December	2015	0	5,529	\$651	28	\$454	\$2,874	\$3,979
January	2016	0	5,529	\$651	28	\$454	\$2,874	\$3,979
February	2016	0	4,994	\$588	25	\$410	\$2,596	\$3,594
March	2016	0	5,529	\$651	28	\$454	\$2,874	\$3,979
April	2016	0	5,350	\$630	27	\$440	\$2,781	\$3,851
May	2016	0	5,529	\$651	28	\$454	\$2,874	\$3,979
June	2016	0	5,350	\$630	27	\$440	\$2,781	\$3,851
July	2016	0	5,529	\$651	28	\$454	\$2,874	\$3,979
August	2016	0	5,529	\$651	28	\$454	\$2,874	\$3,979
September	2016	0	5,350	\$630	27	\$440	\$2,781	\$3,851
October	2016	0	5,529	\$651	28	\$454	\$2,874	\$3,979
Contract Yr 5		0	65,096	\$7,663	330	\$5,348	\$33,840	\$46,852

FIM 4.4- Pool Dehumidification Savings



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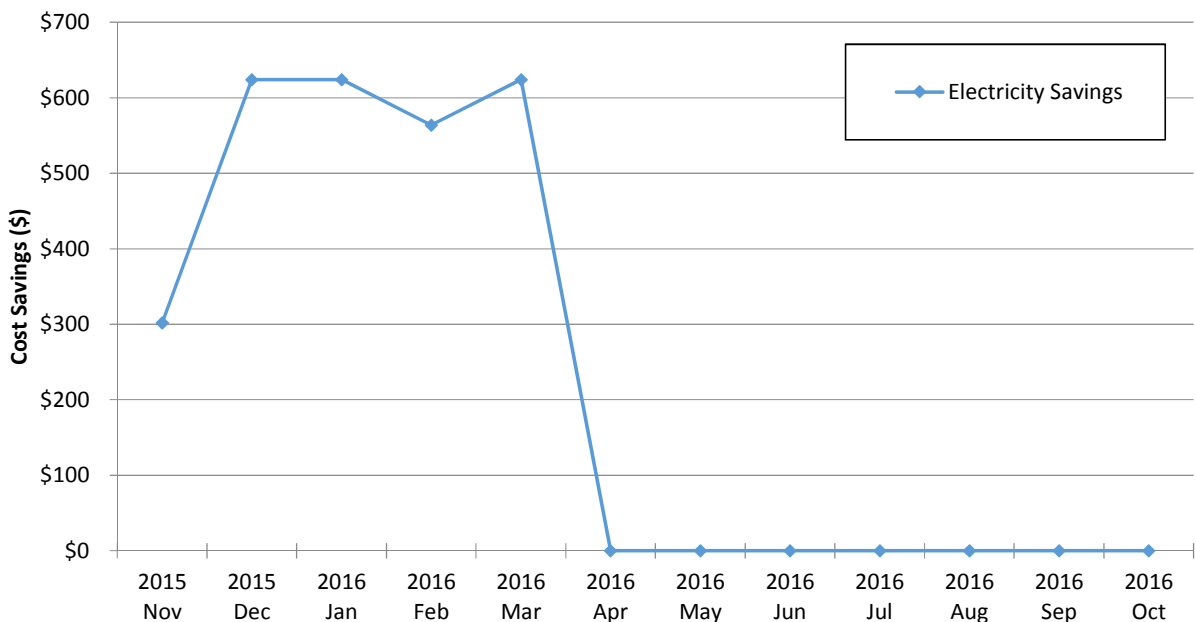
FIM 4: Energy Management System Upgrades

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 5 Energy Cost Avoidance					
Month	Year	Electricity Savings			Total Cost \$ Savings
		kW	kWh	Cost \$	
November	2015	0	2,195	\$302	\$302
December	2015	0	4,537	\$624	\$624
January	2016	0	4,537	\$624	\$624
February	2016	0	4,098	\$564	\$564
March	2016	0	4,537	\$624	\$624
April	2016	0	0	\$0	\$0
May	2016	0	0	\$0	\$0
June	2016	0	0	\$0	\$0
July	2016	0	0	\$0	\$0
August	2016	0	0	\$0	\$0
September	2016	0	0	\$0	\$0
October	2016	0	0	\$0	\$0
Contract Yr 5			19,905	\$2,738	\$2,738

FIM 4.5- Snow Melt Sensor Savings



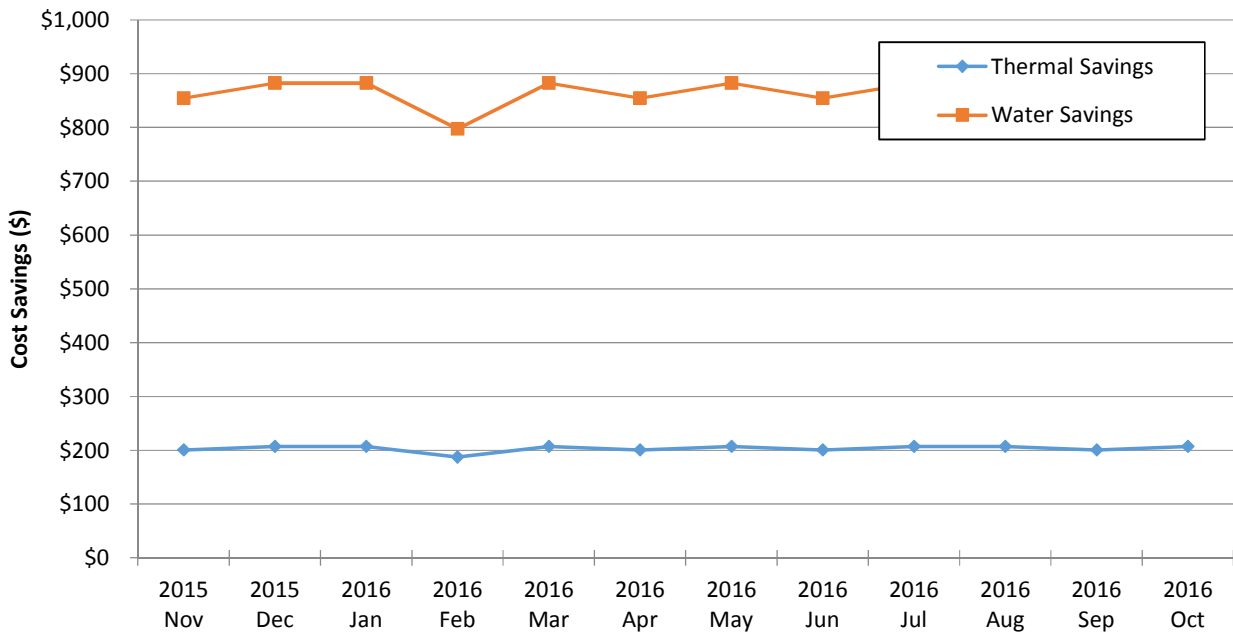
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FIM 6: Water Conservation

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

FIM 6: Water Conservation						
Contract Year 5 Energy Cost Avoidance						
Month	Year	Thermal Savings		Water Savings		Total Cost \$ Savings
		MMBtu	Cost \$	kGal	Cost \$	
November	2015	13	\$201	92	\$854	\$1,055
December	2015	14	\$207	95	\$883	\$1,090
January	2016	14	\$207	95	\$883	\$1,090
February	2016	13	\$187	86	\$797	\$984
March	2016	14	\$207	95	\$883	\$1,090
April	2016	13	\$201	92	\$854	\$1,055
May	2016	14	\$207	95	\$883	\$1,090
June	2016	13	\$201	92	\$854	\$1,055
July	2016	14	\$207	95	\$883	\$1,090
August	2016	14	\$207	95	\$883	\$1,090
September	2016	13	\$201	92	\$854	\$1,055
October	2016	14	\$207	95	\$883	\$1,090
Contract Yr 5		164	\$2,440	1,117	\$10,392	\$12,832

FIM 6- Water Conservation Savings



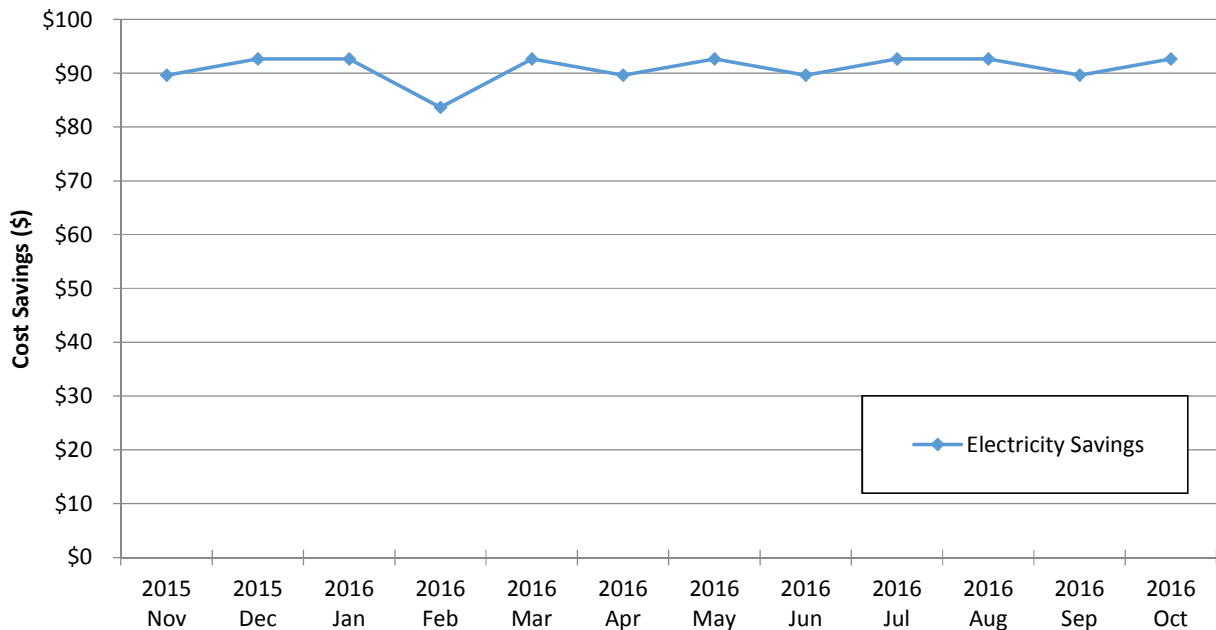
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FIM 9: Vending Machine Controls

The FIM 9 table breaks down the measure by month over Year 5.

FIM 9: Vending Machine Controls					
Contract Year 5 Energy Cost Avoidance					
Month	Year	Electricity Savings			Total Cost \$ Savings
		kW	kWh	Cost \$	
November	2015	0	692	\$90	\$90
December	2015	0	716	\$93	\$93
January	2016	0	716	\$93	\$93
February	2016	0	646	\$84	\$84
March	2016	0	716	\$93	\$93
April	2016	0	692	\$90	\$90
May	2016	0	716	\$93	\$93
June	2016	0	692	\$90	\$90
July	2016	0	716	\$93	\$93
August	2016	0	716	\$93	\$93
September	2016	0	692	\$90	\$90
October	2016	0	716	\$93	\$93
Contract Yr 5		0	8,425	\$1,091	\$1,091

FIM 9- Vending Sensor Savings



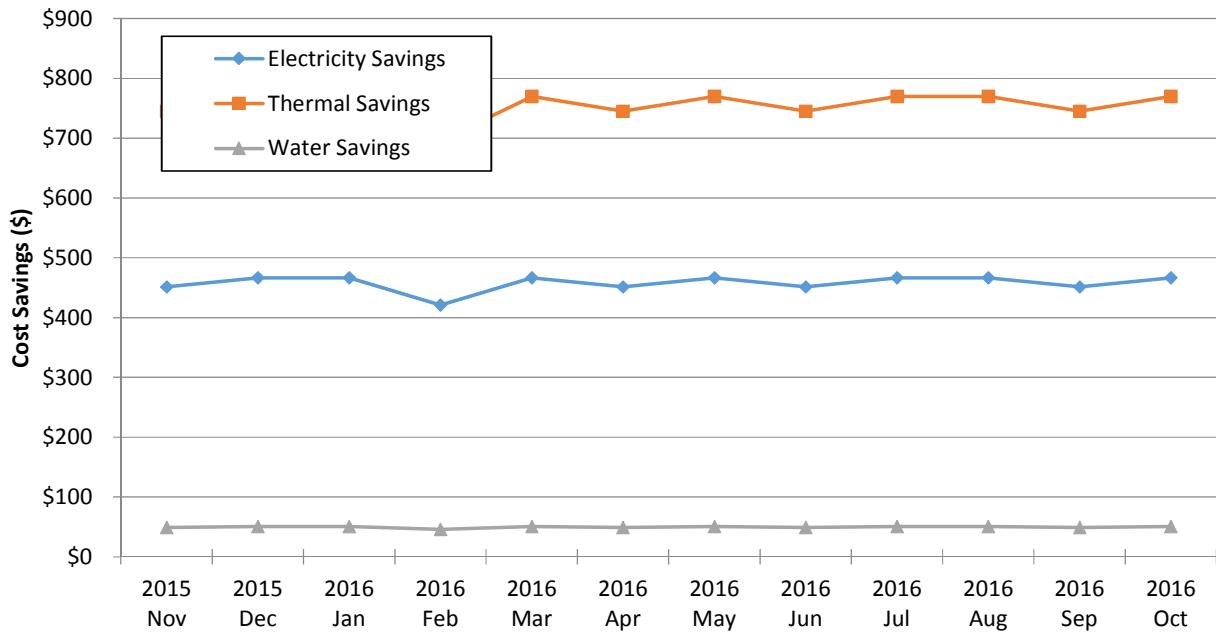
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FIM 10: Pool Cover

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

FIM 10: Pool Cover									
Contract Year 5 Energy Cost Avoidance									
Month	Year	Electricity Savings			Thermal Savings		Water Savings		Total Cost \$ Savings
		kW	kWh	Cost \$	MMBtu	Cost \$	kGal	Cost \$	
November	2015	0	3,835	\$451	46	\$745	5.3	\$49	\$1,246
December	2015	0	3,963	\$466	48	\$770	5.5	\$51	\$1,287
January	2016	0	3,963	\$466	48	\$770	5.5	\$51	\$1,287
February	2016	0	3,579	\$421	43	\$695	4.9	\$46	\$1,163
March	2016	0	3,963	\$466	48	\$770	5.5	\$51	\$1,287
April	2016	0	3,835	\$451	46	\$745	5.3	\$49	\$1,246
May	2016	0	3,963	\$466	48	\$770	5.5	\$51	\$1,287
June	2016	0	3,835	\$451	46	\$745	5.3	\$49	\$1,246
July	2016	0	3,963	\$466	48	\$770	5.5	\$51	\$1,287
August	2016	0	3,963	\$466	48	\$770	5.5	\$51	\$1,287
September	2016	0	3,835	\$451	46	\$745	5.3	\$49	\$1,246
October	2016	0	3,963	\$466	48	\$770	5.5	\$51	\$1,287
Contract Yr 5		0	46,656	\$5,493	560	\$9,065	64	\$598	\$15,156

FIM 10- Pool Cover Savings



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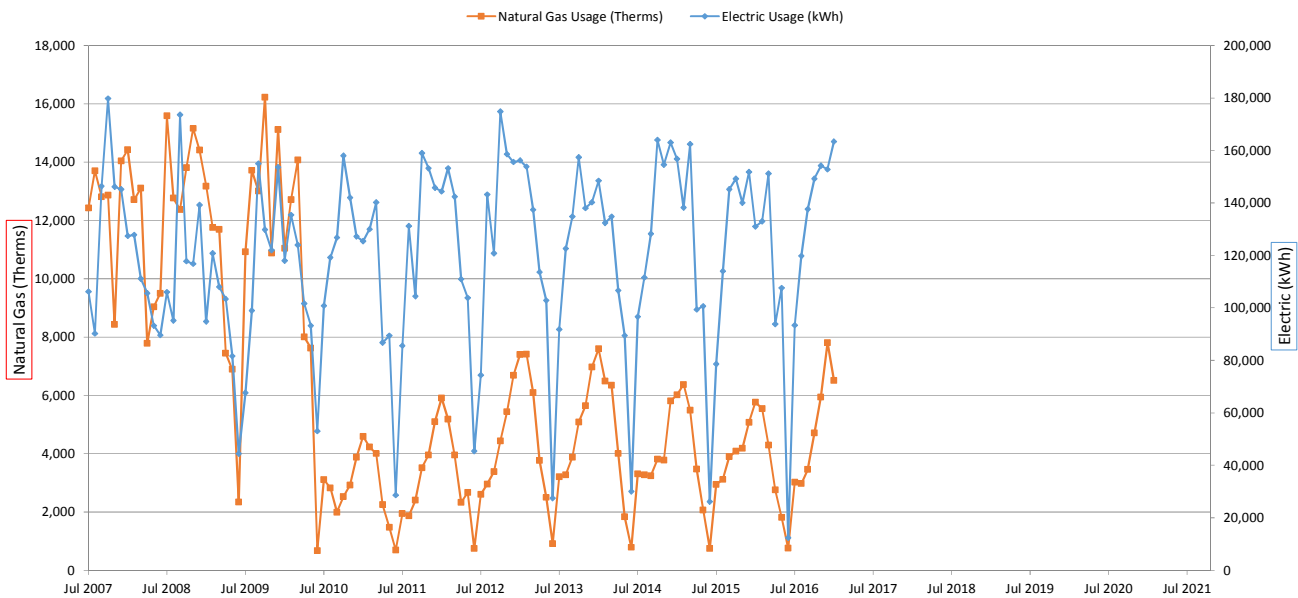
FIM 11: Ice Arena Upgrades

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



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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

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

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

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

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

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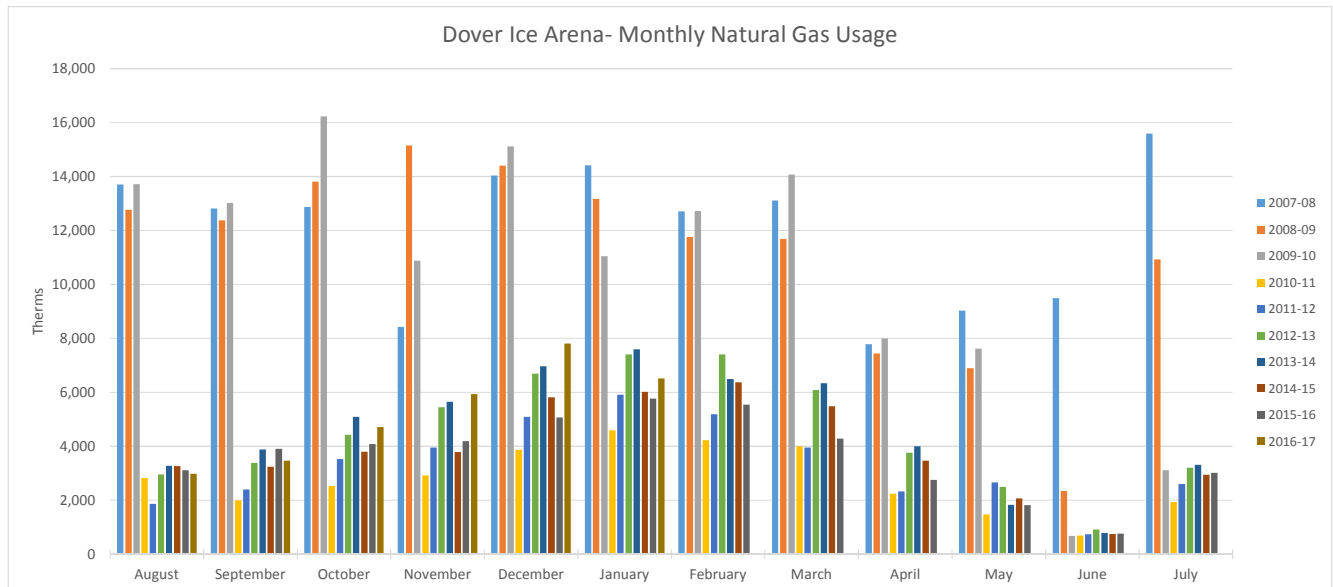
FIM 11: Ice Arena Upgrades- Natural Gas

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, year 4 period is in purple, year 5 is in lime green.

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	2016-17
August	13,703	12,769	13,718	2,828	1,869	2,959	3,271	3,267	3,114	2,978
September	12,817	12,369	13,008	1,995	2,403	3,384	3,877	3,241	3,901	3,462
October	12,869	13,804	16,225	2,527	3,522	4,433	5,084	3,806	4,079	4,707
November	8,430	15,155	10,880	2,917	3,956	5,443	5,643	3,782	4,190	5,938
December	14,039	14,410	15,114	3,875	5,092	6,689	6,970	5,811	5,074	7,807
January	14,419	13,171	11,041	4,593	5,911	7,404	7,598	6,016	5,764	6,515
February	12,708	11,754	12,717	4,225	5,183	7,410	6,489	6,373	5,542	
March	13,110	11,687	14,072	4,003	3,955	6,090	6,343	5,486	4,287	
April	7,784	7,441	8,006	2,246	2,323	3,762	4,001	3,466	2,758	
May	9,038	6,892	7,616	1,470	2,665	2,500	1,838	2,067	1,815	
June	9,495	2,336	675	688	742	915	789	750	760	
July	15,589	10,925	3,110	1,943	2,599	3,210	3,308	2,947	3,019	



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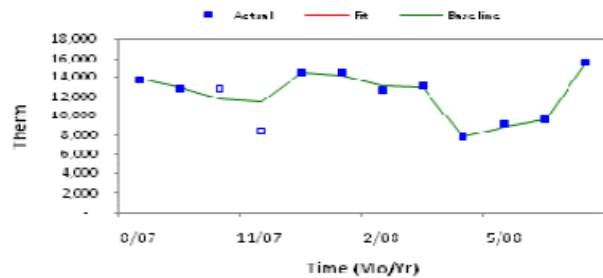
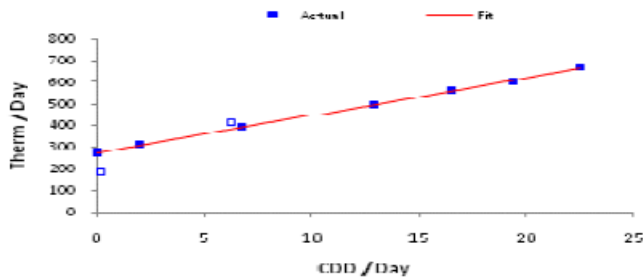
FIM 11: Ice Arena Upgrades- Natural Gas

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%
Sum/Average/Max		366	144,401		6320.5	2647.0	13,350	-	146,383	0% +/- 1.9%

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 $R^2=0.991$
 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.

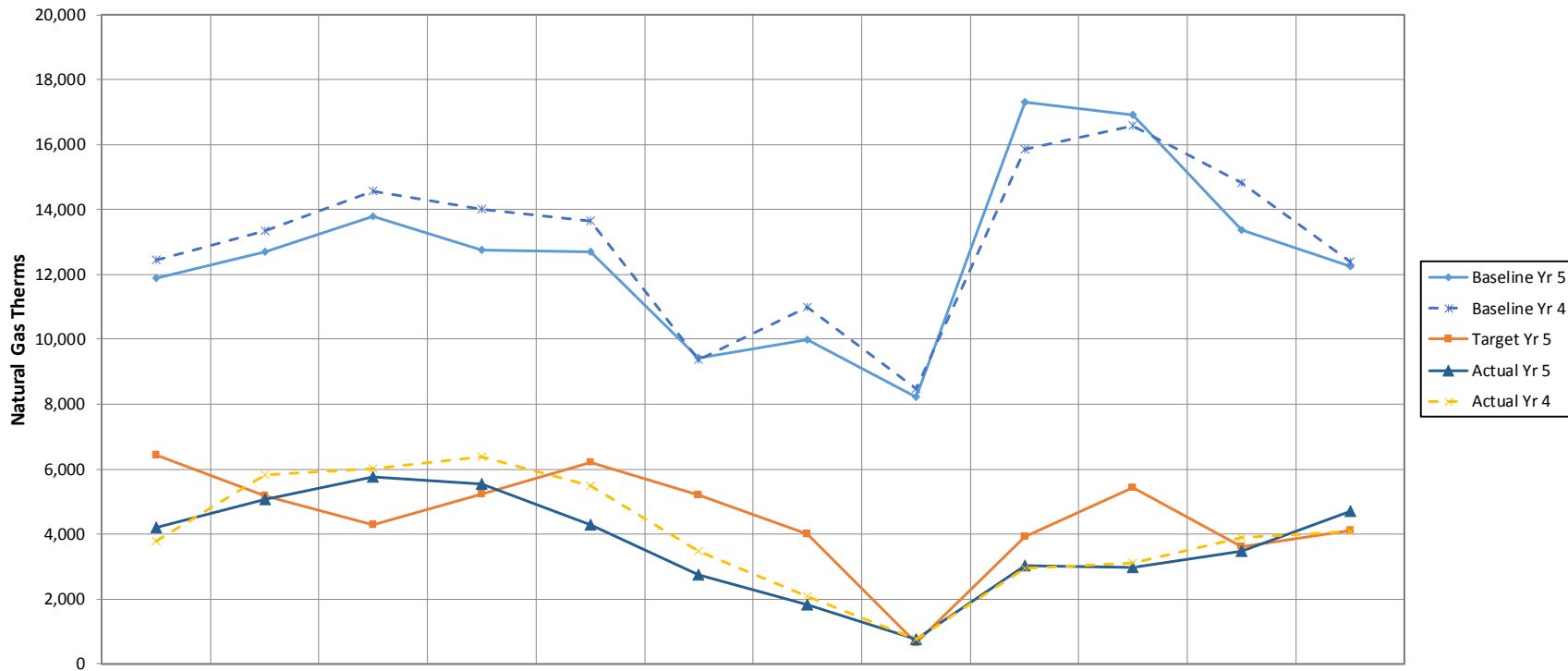
The regression has a R^2 value of 0.991 excluding two of the twelve baseline points, which is exceptionally better than required. As per the contract, the natural gas baseline is within 1.4% of the actual utility data complying with the necessary 2% mark.

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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 5 baseline (light blue), target utility use based off calculations and guarantees (orange), and actual Year 5 ice arena utility use from utility invoices (dark blue). Year 4 data baseline (dashed light blue) and actual (dashed yellow) have been superimposed on the chart (dashed lines) for reference as shown below:

Baseline / Target / Actual Therms for Dover Ice Arena Natural Gas Meter



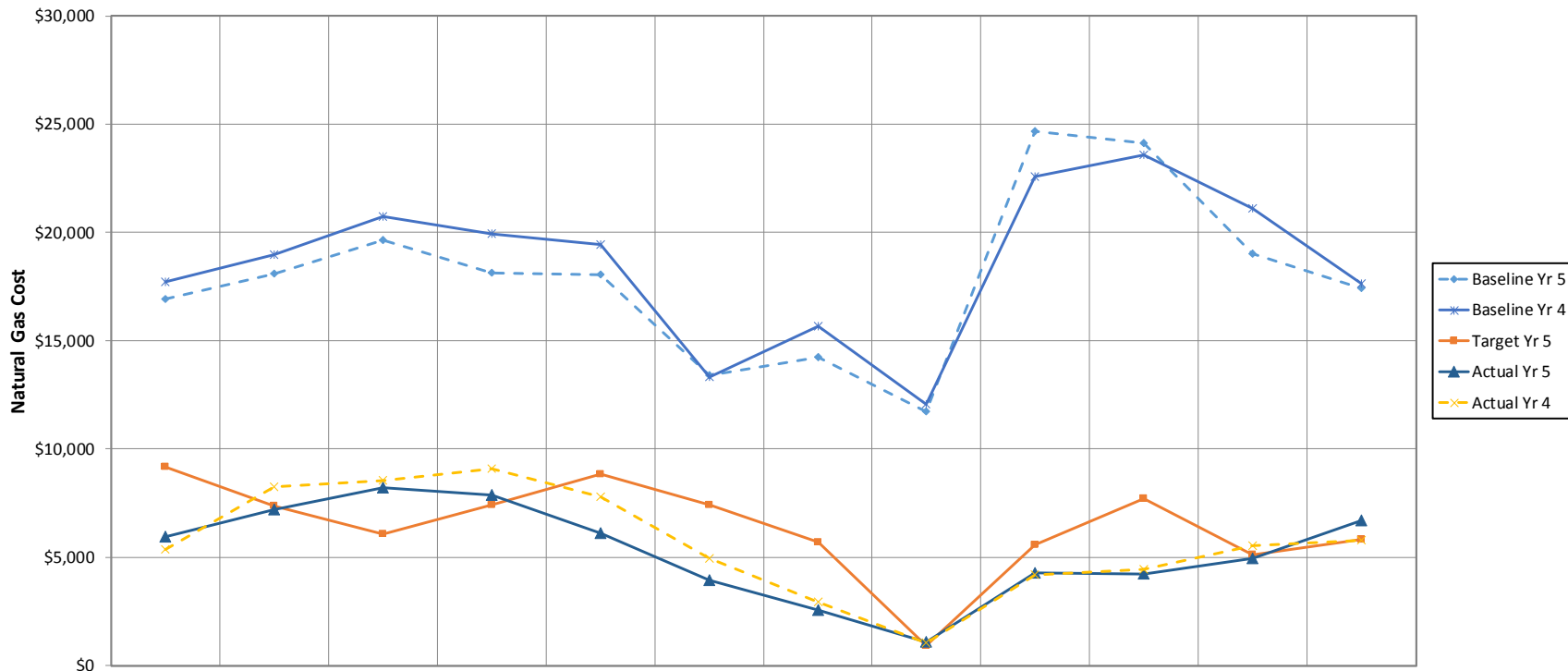
Scenario	Nov-2015	Dec-2015	Jan-2016	Feb-2016	Mar-2016	Apr-2016	May-2016	Jun-2016	Jul-2016	Aug-2016	Sep-2016	Oct-2016	Total
Baseline Yr 5	11,888	12,699	13,781	12,737	12,690	9,421	9,991	8,226	17,316	16,926	13,363	12,246	151,283
Target Yr 5	6,447	5,188	4,278	5,220	6,217	5,208	4,017	658	3,931	5,424	3,609	4,106	54,302
Actual Yr 5	4,190	5,074	5,764	5,542	4,287	2,758	1,815	760	3,019	2,978	3,462	4,707	44,357
Savings	7,697	7,624	8,018	7,195	8,402	6,663	8,176	7,466	14,296	13,949	9,900	7,539	106,926

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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 5 baseline (light blue), target utility cost based off calculations and guarantees (orange), and actual Yr 5 contractual ice arena utility cost from utility use & contractual rates (dark blue). Year 4 cost baseline (dashed light blue) and actual (dashed yellow) have been superimposed on the chart (dashed lines) for reference as shown below:

Baseline / Target / Actual Total \$ for Dover Ice Arena Natural Gas Meter



Scenario	Nov-2015	Dec-2015	Jan-2016	Feb-2016	Mar-2016	Apr-2016	May-2016	Jun-2016	Jul-2016	Aug-2016	Sep-2016	Oct-2016	Total
Baseline Yr 5	\$16,926	\$18,080	\$19,621	\$18,134	\$18,067	\$13,413	\$14,225	\$11,712	\$24,654	\$24,099	\$19,025	\$17,436	\$215,392
Target Yr 5	\$9,179	\$7,386	\$6,091	\$7,432	\$8,851	\$7,415	\$5,719	\$937	\$5,597	\$7,723	\$5,138	\$5,847	\$77,314
Actual Yr 5	\$5,966	\$7,225	\$8,206	\$7,891	\$6,104	\$3,927	\$2,584	\$1,082	\$4,299	\$4,240	\$4,930	\$6,701	\$63,154
Savings	\$10,959	\$10,855	\$11,415	\$10,243	\$11,963	\$9,486	\$11,641	\$10,630	\$20,355	\$19,860	\$14,096	\$10,734	\$152,238

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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 5 natural gas savings from all other measures at the Ice Arena:

FIM 11: Ice Arena Upgrades			
Year 5 Savings from Other FIMs			
FIM #	FIM Description	Thermal Savings	
		MMBtu	Cost \$
1	Lighting Fixtures	(65)	(\$921)
2	Lighting Controls	0	\$0
3	Weatherization	356	\$5,072
6	Water Conservation	53	\$751
9	Vending Controls	0	\$0
12	Power Factor	0	\$0
13	Transformers	0	\$0
Total		344	\$4,902

Natural Gas consumption savings from the analysis are 106,926 therms for Year 5. Of those, as seen in the first table above, 344 MMBtu = 3,443 therms are from different measures within this project. So the total reported savings from FIM 11 in Year 5 is 103,483 therms.

The natural gas cost savings from the analysis are \$152,238 with \$4,902 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 \$147,336.

FIM 11: Ice Arena Upgrades		
Contract Year 5 Energy Cost Avoidance		
Building	Thermal Savings	
	MMBtu	Cost \$
Ice Arena	10,348	\$147,336

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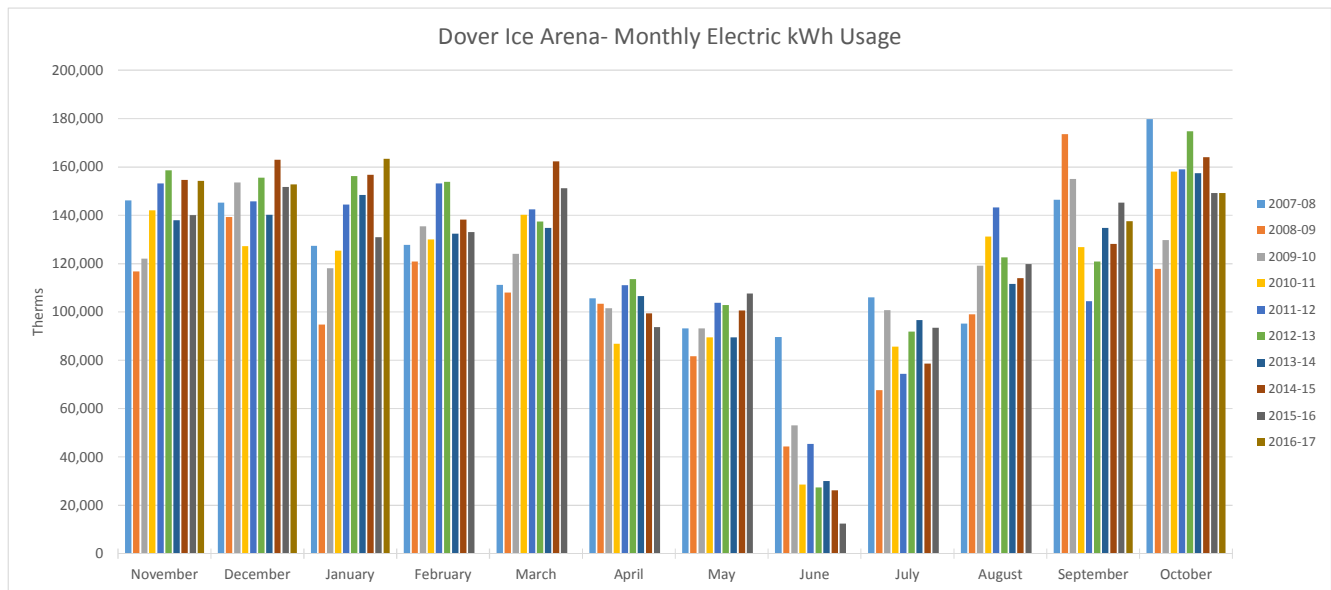
FIM 11: Ice Arena Upgrades- Electric

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 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, year 4 period is in purple, year 5 is in lime green.

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	2016-17
September	146,400	173,600	155,000	126,800	104,400	120,800	134,800	128,200	145,200	137,600
October	179,800	117,800	129,800	158,000	159,000	174,800	157,400	164,000	149,200	149,200
November	146,200	116,800	122,000	142,000	153,200	158,600	138,000	154,600	140,000	154,200
December	145,200	139,200	153,600	127,200	145,800	155,600	140,200	163,000	151,800	152,800
January	127,400	94,800	118,000	125,400	144,400	156,200	148,400	156,800	131,000	163,400
February	127,800	120,800	135,400	130,000	153,200	153,800	132,400	138,200	133,000	
March	111,200	108,000	124,000	140,200	142,400	137,400	134,800	162,400	151,200	
April	105,600	103,400	101,600	86,800	111,000	113,600	106,600	99,400	93,800	
May	93,200	81,600	93,200	89,400	103,800	102,800	89,400	100,600	107,600	
June	89,600	44,400	53,000	28,600	45,400	27,400	30,000	26,200	12,400	
July	106,000	67,600	100,800	85,600	74,400	91,800	96,600	78,600	93,400	
August	95,200	99,000	119,200	131,200	143,200	122,600	111,600	114,000	119,800	

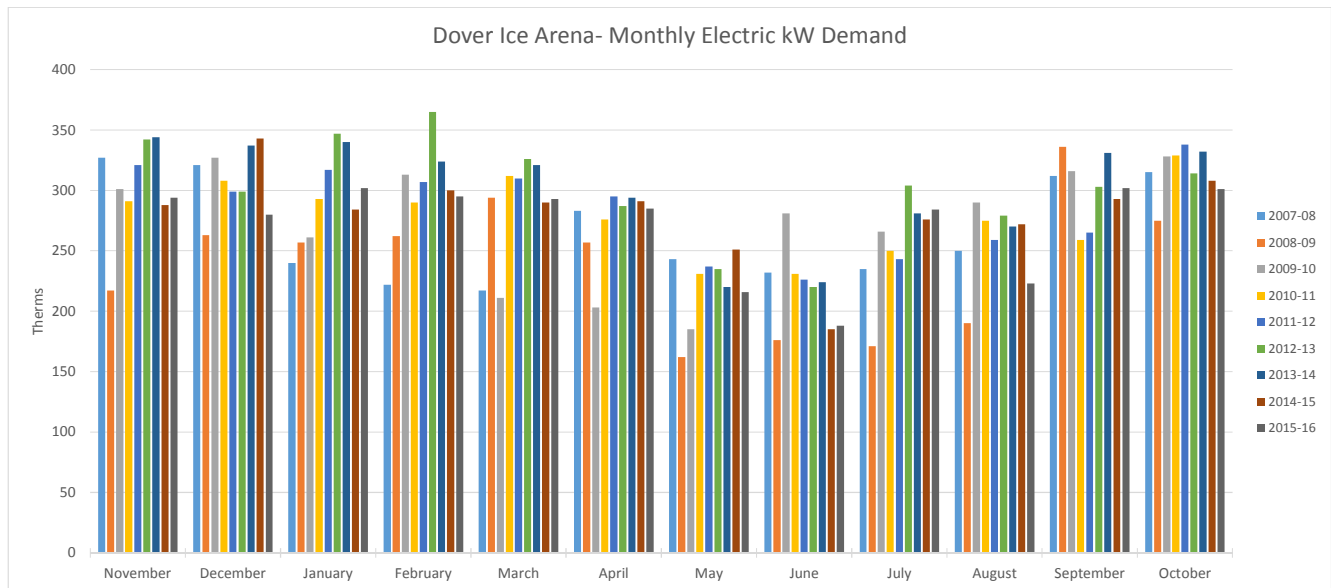


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FIM 11: Ice Arena Upgrades- Electric

Below is the electric demand per month obtained from bills from the baseline year through the installation period. Baseline data 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, year 4 period is in purple, year 5 is in lime green.

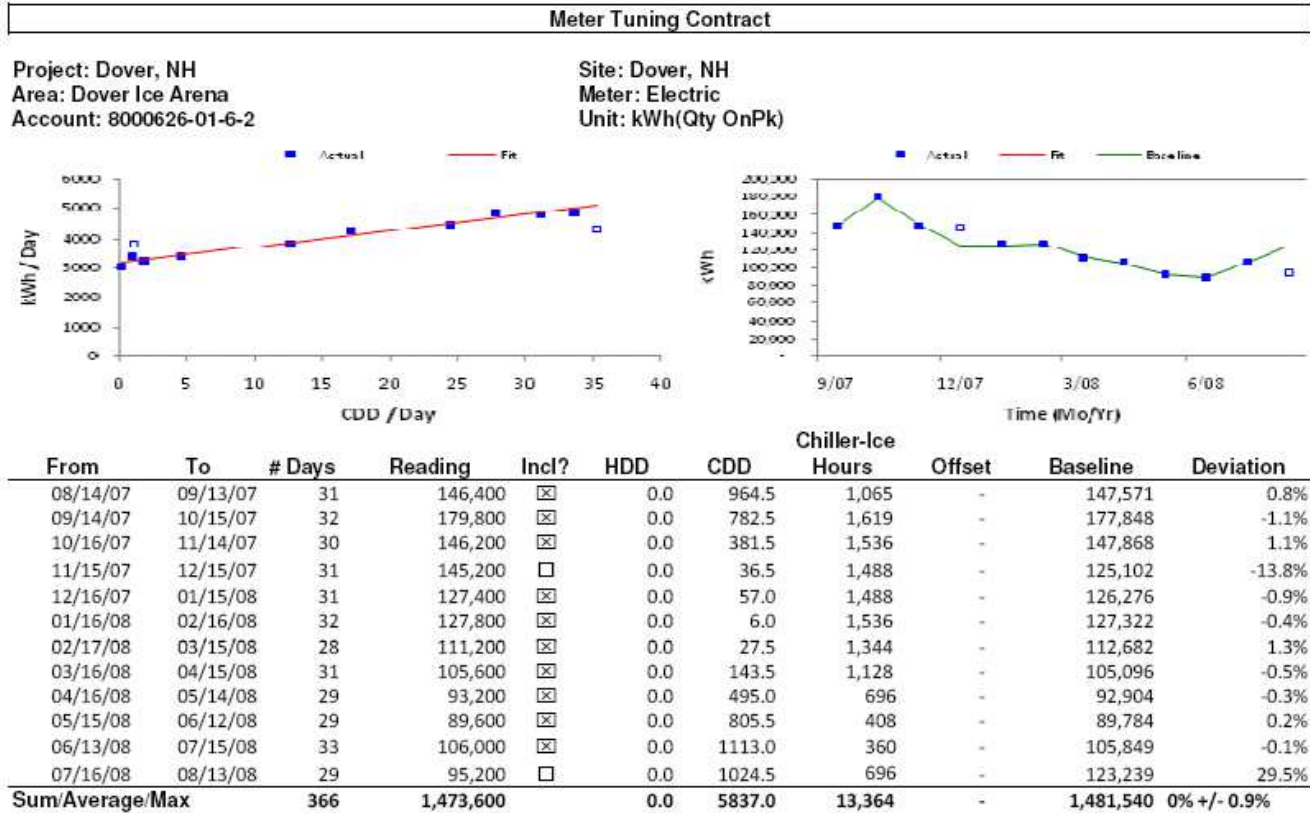
Month	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
September	312	336	316	259	265	303	331	293	302	295
October	315	275	328	329	338	314	332	308	301	301
November	327	217	301	291	321	342	344	288	294	274
December	321	263	327	308	299	299	337	343	280	280
January	240	257	261	293	317	347	340	284	302	285
February	222	262	313	290	307	365	324	300	295	
March	217	294	211	312	310	326	321	290	293	
April	283	257	203	276	295	287	294	291	285	
May	243	162	185	231	237	235	220	251	216	
June	232	176	281	231	226	220	224	185	188	
July	235	171	266	250	243	304	281	276	284	
August	250	190	290	275	259	279	270	272	223	



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 R²=0.998
 Baseline Costs are calculated using Average Cost/Consumption, but no less than \$0.106/ kWh.

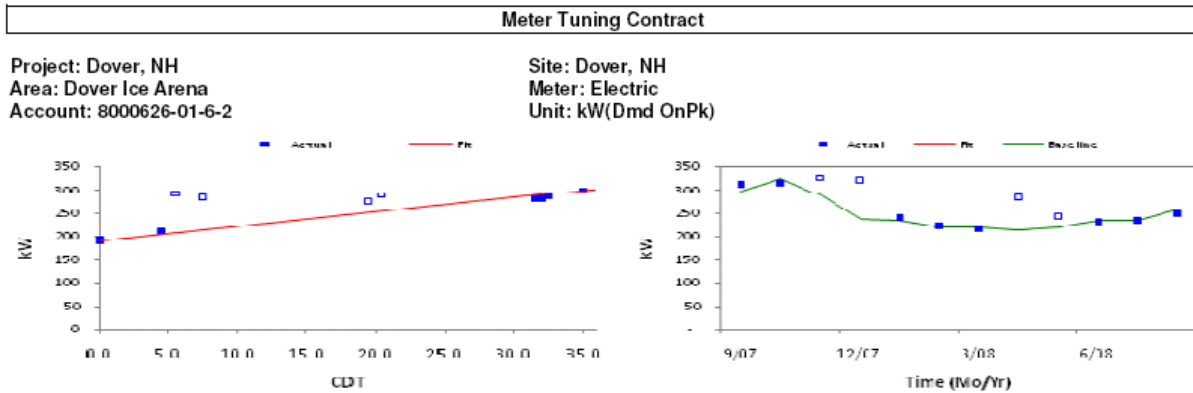
Explanations and Assumptions:
 (empty checkbox) under 'Incl?' indicates that the bill is excluded from the regression. However the Baseline Equation is always applied for all billing periods, even those excluded from the regression.
 CDD = Cooling Degree-Days calculated for ROCHESTERNH for a 34.0 F^o 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 R² 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.



From	To	# Days	Reading	Incl?	HDT	CDT	Chiller-Ice		Offset	Baseline	Deviation
							Hours				
08/14/07	09/13/07	31	312	<input checked="" type="checkbox"/>	0.0	36.5	34	-		297	-4.7%
09/14/07	10/15/07	32	315	<input checked="" type="checkbox"/>	0.0	32.0	51	-		324	2.9%
10/16/07	11/14/07	30	327	<input type="checkbox"/>	0.0	20.5	51	-		291	-11.1%
11/15/07	12/15/07	31	321	<input type="checkbox"/>	0.0	5.5	48	-		237	-26.0%
12/16/07	01/15/08	31	240	<input checked="" type="checkbox"/>	0.0	4.5	48	-		234	-2.3%
01/16/08	02/16/08	32	222	<input checked="" type="checkbox"/>	0.0	0.0	48	-		221	-0.5%
02/17/08	03/15/08	28	217	<input checked="" type="checkbox"/>	0.0	0.0	48	-		221	1.8%
03/16/08	04/15/08	31	283	<input type="checkbox"/>	0.0	7.5	36	-		215	-24.2%
04/16/08	05/14/08	29	243	<input type="checkbox"/>	0.0	19.5	24	-		220	-9.4%
05/15/08	06/12/08	29	232	<input checked="" type="checkbox"/>	0.0	32.5	14	-		235	1.2%
06/13/08	07/15/08	33	235	<input checked="" type="checkbox"/>	0.0	35.0	11	-		234	-0.2%
07/16/08	08/13/08	29	250	<input checked="" type="checkbox"/>	0.0	31.5	24	-		256	2.6%
Sum/Average/Max		366	3,197		0.0	225.0	438	-		2,986	0% +/- 3%

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:

$$\text{Baseline (kW)} = 101.35 + 3.03 \times \text{CDT} + 2.49 \times \text{Chiller-Ice Hours/Day}$$

 The Baseline Equation has a Net Mean Bias of 0% and a Monthly Mean Error of +/-3%. The underlying regression has a $R^2=0.963$
 Baseline Costs are calculated using Average Cost/Demand, but no less than \$7.09/ kW.
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.
 CDT = Cooling Delta T calculated for ROCHESTERNH for a 45.0 F° balance point.
 CDT was calculated using Maximum Temperatures.
 Multiplier is derived from Modification(s) in effect during the tuning period and is replicated annually for all future periods.

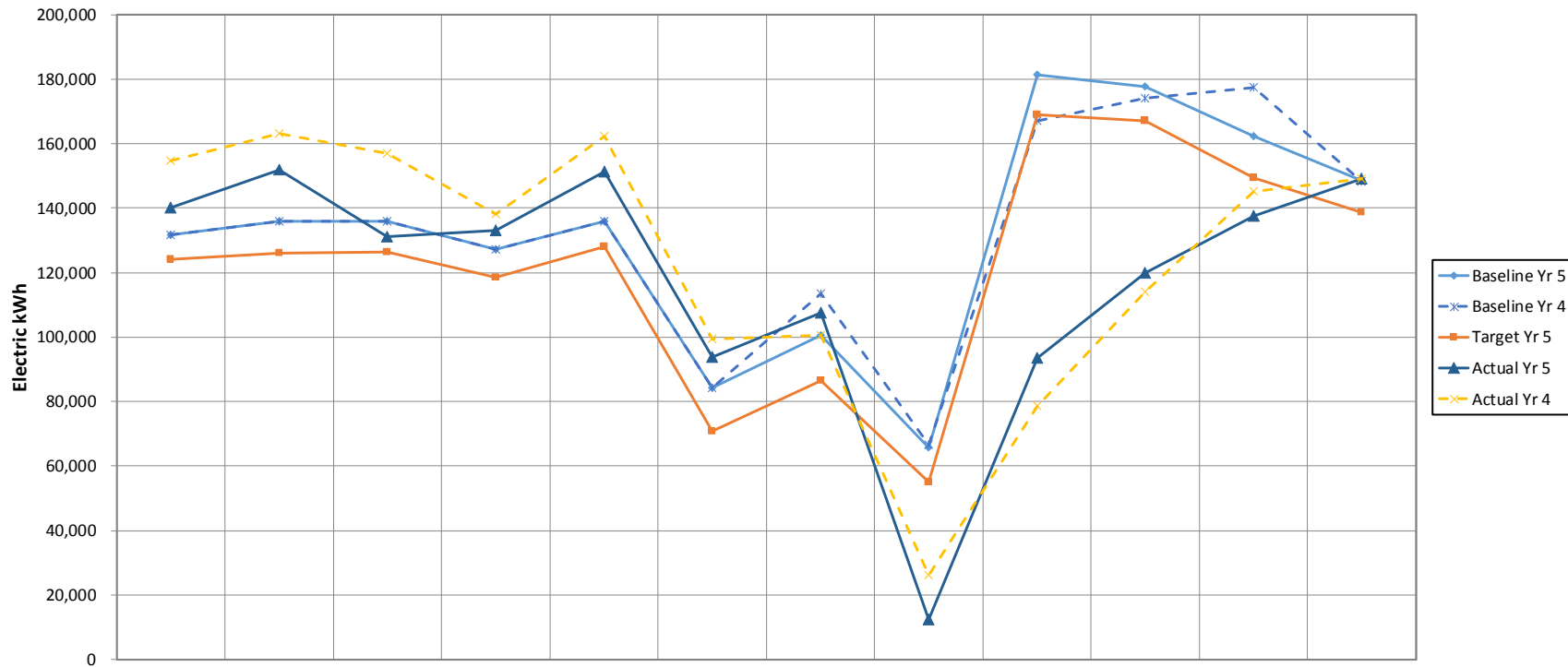
The regression has a R^2 value of 0.963 excluding four of the twelve baseline points, which is better than required. The electric consumption baseline is within 6.6% of the actual utility data. Since demand is not as cut and dry as other measures, it is difficult to determine a solution that would fall 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 5 baseline (light blue), target utility use based off calculations and guarantees (orange), and actual Year 5 ice arena utility use from utility invoices (dark blue). Year 4 data baseline (dashed light blue) and actual (dashed yellow) have been superimposed using dotted lines for reference as shown below:

Baseline / Target / Actual kWh for Dover Ice Arena Electric Meter



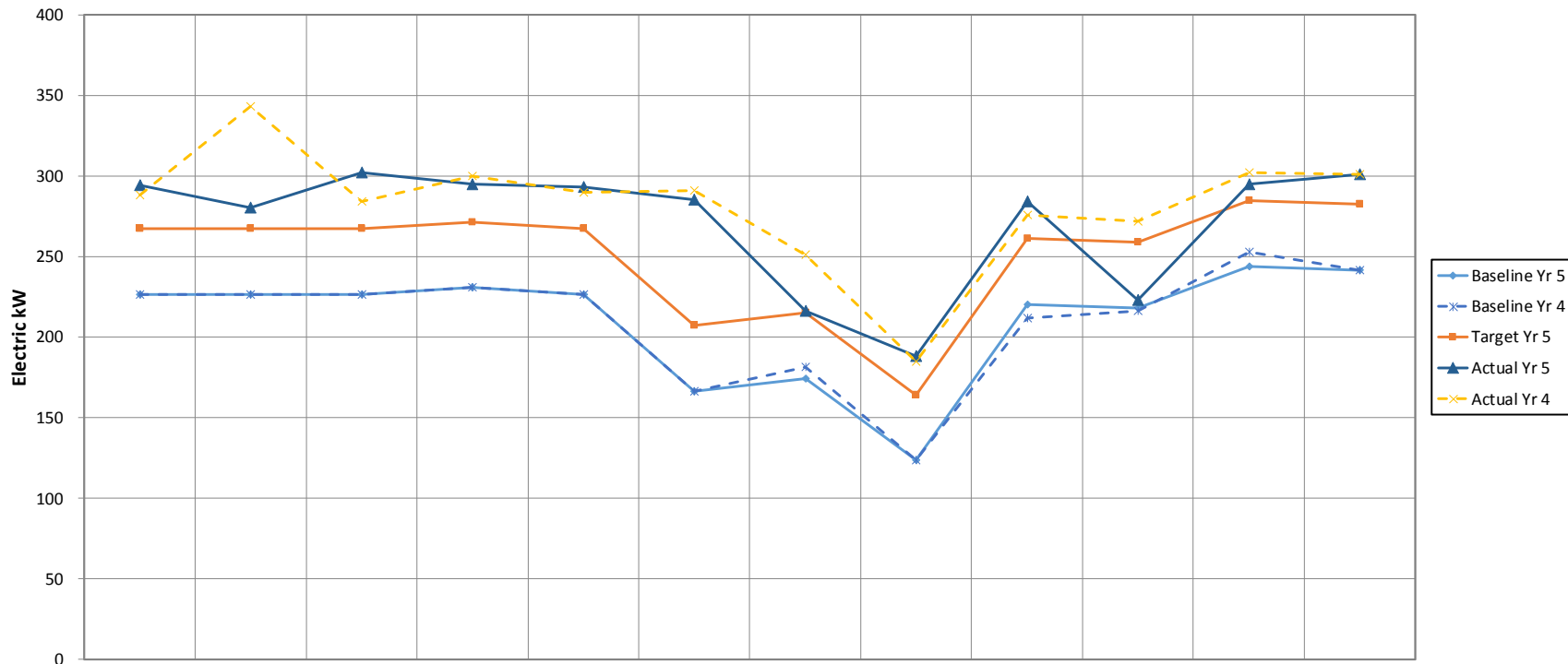
Scenario	Nov-2015	Dec-2015	Jan-2016	Feb-2016	Mar-2016	Apr-2016	May-2016	Jun-2016	Jul-2016	Aug-2016	Sep-2016	Oct-2016	Total
Baseline Yr 5	131,562	135,947	135,947	127,177	135,947	84,258	100,650	65,718	181,349	177,753	162,334	148,567	1,587,209
Target Yr 5	124,214	126,186	126,211	118,554	128,048	70,861	86,620	55,030	169,114	167,066	149,435	138,649	1,459,988
Actual Yr 5	140,000	151,800	131,000	133,000	151,200	93,800	107,600	12,400	93,400	119,800	137,600	149,200	1,420,800
Savings	(8,438)	(15,853)	4,947	(5,823)	(15,253)	(9,542)	(6,950)	53,318	87,949	57,953	24,734	(633)	166,409

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 5 baseline (light blue), target utility use based off calculations and guarantees (orange), and actual Year 5 ice arena utility use from utility invoices (dark blue). Year 4 data baseline (dashed light blue) and actual (dashed yellow) have been superimposed using dotted lines for reference as shown below:

Baseline / Target / Actual kW for Dover Ice Arena Electric Meter



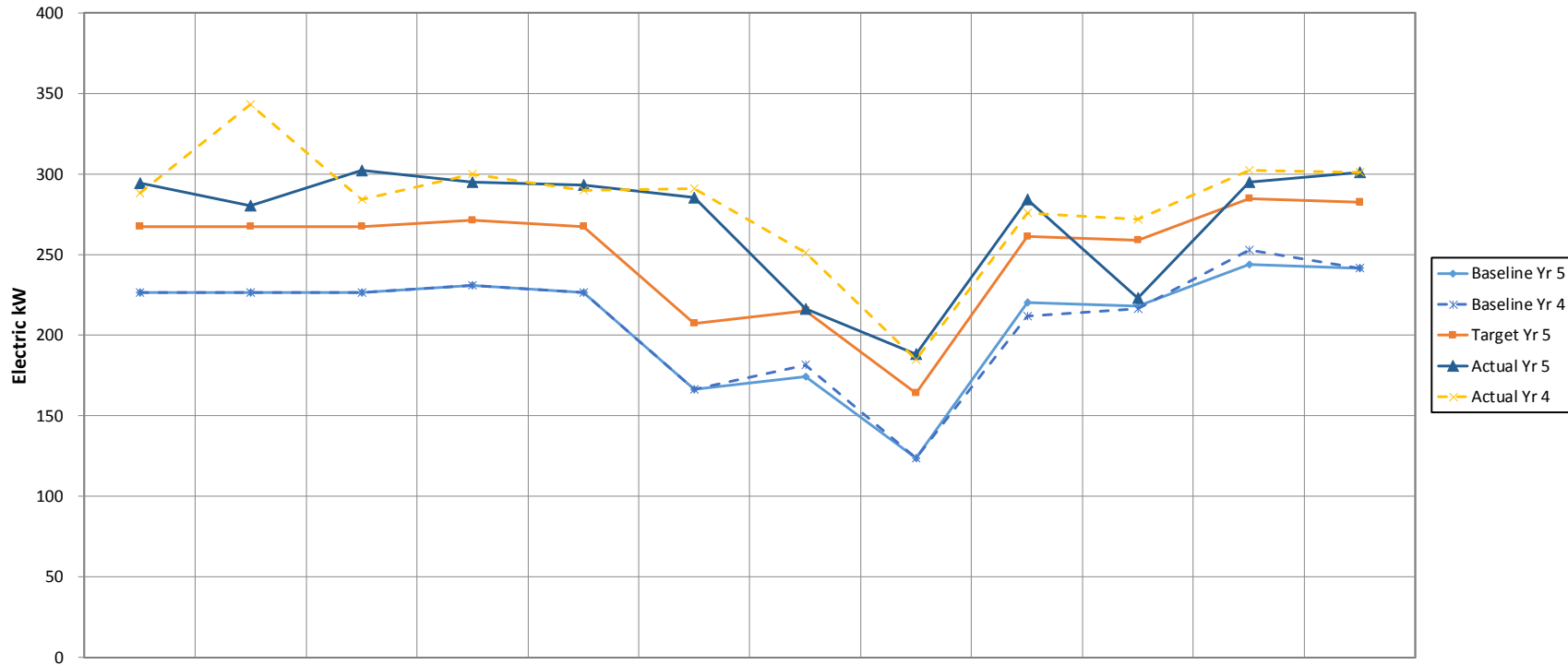
Scenario	Nov-2015	Dec-2015	Jan-2016	Feb-2016	Mar-2016	Apr-2016	May-2016	Jun-2016	Jul-2016	Aug-2016	Sep-2016	Oct-2016	Total
Baseline Yr 5	226	226	226	231	226	166	174	123	220	218	244	242	2,524
Target Yr 5	267	267	267	271	267	207	215	164	261	259	285	282	3,014
Actual Yr 5	294	280	302	295	293	285	216	188	284	223	295	301	3,256
Savings	(68)	(54)	(76)	(64)	(67)	(119)	(42)	(65)	(64)	(5)	(51)	(59)	(732)

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 5 baseline (light blue), target utility use based off calculations and guarantees (orange), and actual Year 5 cost from utility invoices and contractual rates (dark blue). Year 4 cost baseline (dashed light blue) and actual (dashed orange) have been superimposed using dotted lines for reference as shown below:

Baseline / Target / Actual Total \$ for Dover Ice Arena Electric Meter



Scenario	Nov-2015	Dec-2015	Jan-2016	Feb-2016	Mar-2016	Apr-2016	May-2016	Jun-2016	Jul-2016	Aug-2016	Sep-2016	Oct-2016	Total
Baseline Yr 5	\$17,520	\$18,043	\$18,043	\$17,030	\$18,043	\$11,391	\$13,411	\$8,833	\$23,416	\$22,970	\$21,335	\$19,672	\$209,707
Target Yr 5	\$16,968	\$17,203	\$17,206	\$16,326	\$17,426	\$10,117	\$12,061	\$7,883	\$22,280	\$22,020	\$20,121	\$18,813	\$198,425
Actual Yr 5	\$19,067	\$20,364	\$18,056	\$18,239	\$20,397	\$13,478	\$14,575	\$2,982	\$13,422	\$16,088	\$18,789	\$20,222	\$195,679
Savings	(\$1,548)	(\$2,321)	(\$13)	(\$1,209)	(\$2,353)	(\$2,087)	(\$1,164)	\$5,851	\$9,993	\$6,882	\$2,547	(\$550)	\$14,028

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 5 Savings from Other FIMs				
FIM #	FIM Description	Electricity Savings		
		kW	kWh	Cost \$
1	Lighting Fixtures	142	52,588	\$7,413
2	Lighting Controls	59	13,002	\$1,553
3	Weatherization	0	3,708	\$443
6	Water Conservation	0	0	\$0
9	Vending Controls	0	2,995	\$358
12	Power Factor	50	11,666	\$1,792
13	Transformers	146	60,869	\$8,435
Total		396	144,829	\$19,993

Electric consumption savings from the analysis are an increase of 166,409 kWh. Of that, 144,829 kWh are from different measures within this project. So the total reported additional usage from FIM 11 is an additional 21,581 kWh.

Similarly, the electric demand savings from the graphical analysis are a 732 kW increase. 396 kW were saved from other measures not to be included in the FIM 11 utility bill analysis. This leaves a demand increase of 1,128 kW over the reporting period.

Lastly, electric cost savings from the regression analysis are \$14,028. Savings from other measures total electric savings of \$19,993. By isolating and removing the other FIM cost savings, the total FIM 11 electric utility additional cost usage is \$5,965.

FIM 11: Ice Arena Upgrades			
Contract Year 5 Energy Cost Avoidance			
Building	Electricity Savings		
	kW	kWh	Cost \$
Ice Arena	(1,128)	21,581	(\$5,965)

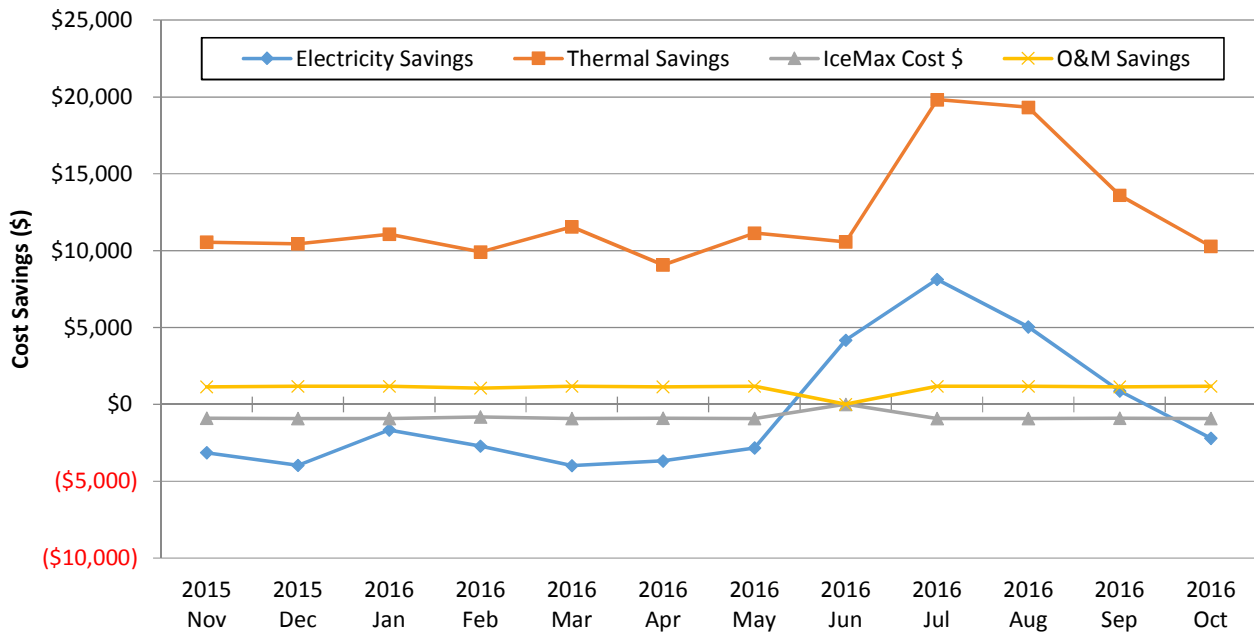
APPENDIX A

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 5 are listed below:

FIM 11: Ice Arena Upgrades									
Contract Year 5 Energy Cost Avoidance									
Month	Year	Electricity Savings			Thermal Savings		IceMax	O&M	Total Cost
		kW	kWh	Cost \$	MMBtu	Cost \$	Cost \$	\$ Savings	\$ Savings
November	2015	(100)	(19,976)	(\$3,144)	7,405	\$10,544	(\$887)	\$1,131	\$7,644
December	2015	(86)	(27,775)	(\$3,964)	7,338	\$10,447	(\$916)	\$1,169	\$6,736
January	2016	(108)	(6,975)	(\$1,656)	7,770	\$11,062	(\$916)	\$1,169	\$9,659
February	2016	(97)	(16,592)	(\$2,714)	6,969	\$9,922	(\$828)	\$1,056	\$7,437
March	2016	(99)	(27,175)	(\$3,996)	8,115	\$11,554	(\$916)	\$1,169	\$7,811
April	2016	(151)	(21,080)	(\$3,683)	6,367	\$9,066	(\$887)	\$1,131	\$5,627
May	2016	(74)	(19,123)	(\$2,837)	7,831	\$11,150	(\$916)	\$1,169	\$8,566
June	2016	(104)	41,582	\$4,175	7,428	\$10,576	\$0	\$0	\$14,751
July	2016	(98)	74,287	\$8,127	13,923	\$19,823	(\$916)	\$1,169	\$28,203
August	2016	(37)	44,358	\$5,040	13,574	\$19,327	(\$916)	\$1,169	\$24,619
September	2016	(83)	12,614	\$880	9,549	\$13,596	(\$887)	\$1,131	\$14,720
October	2016	(92)	(12,563)	(\$2,193)	7,213	\$10,270	(\$916)	\$1,169	\$8,329
Contract Yr 5		(1,128)	21,581	(\$5,965)	103,483	\$147,336	(\$9,904)	\$12,634	\$144,101

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:

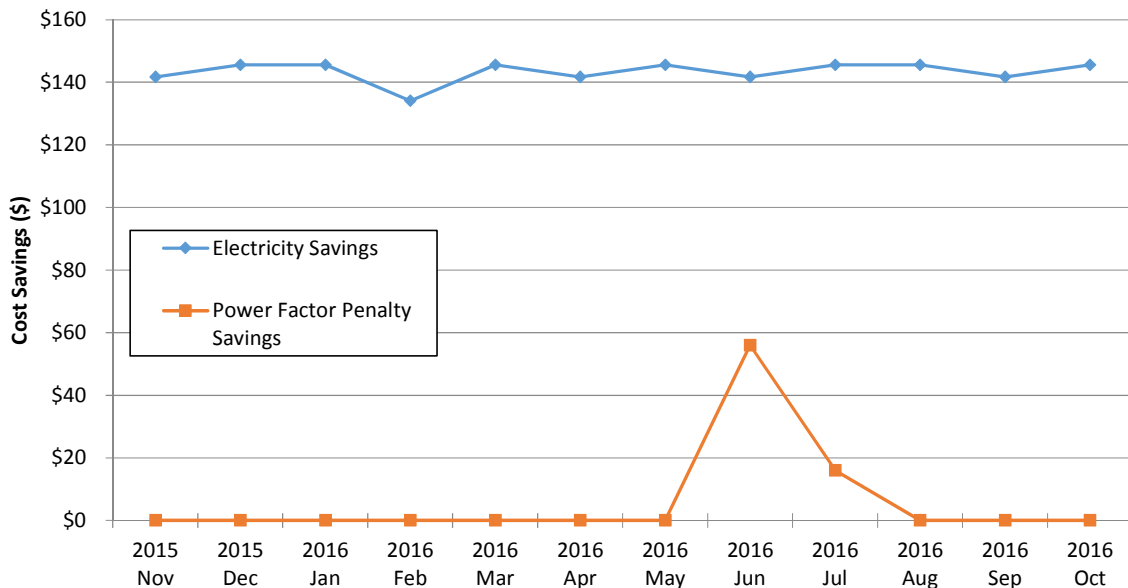
A1 63kw Compressor / B1 63kw Compressor / A2 45kw Compressor

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 5 Energy Cost Avoidance							
Month	Year	Electricity Savings			Power Factor Penalty Savings		Total Cost \$ Savings
		kW	kWh	Cost \$	kW	Cost Savings \$	
November	2015	3.4	959	\$142	0	\$0	\$142
December	2015	3.4	991	\$146	0	\$0	\$146
January	2016	3.4	991	\$146	0	\$0	\$146
February	2016	3.4	895	\$134	0	\$0	\$134
March	2016	3.4	991	\$146	0	\$0	\$146
April	2016	3.4	959	\$142	0	\$0	\$142
May	2016	3.4	991	\$146	0	\$0	\$146
June	2016	3.4	959	\$142	7	\$56	\$198
July	2016	3.4	991	\$146	2	\$16	\$162
August	2016	3.4	991	\$146	0	\$0	\$146
September	2016	3.4	959	\$142	0	\$0	\$142
October	2016	3.4	991	\$146	0	\$0	\$146
Contract Yr 5		41	11,666	\$1,720	9	\$72	\$1,792

FIM 12- Power Factor Savings



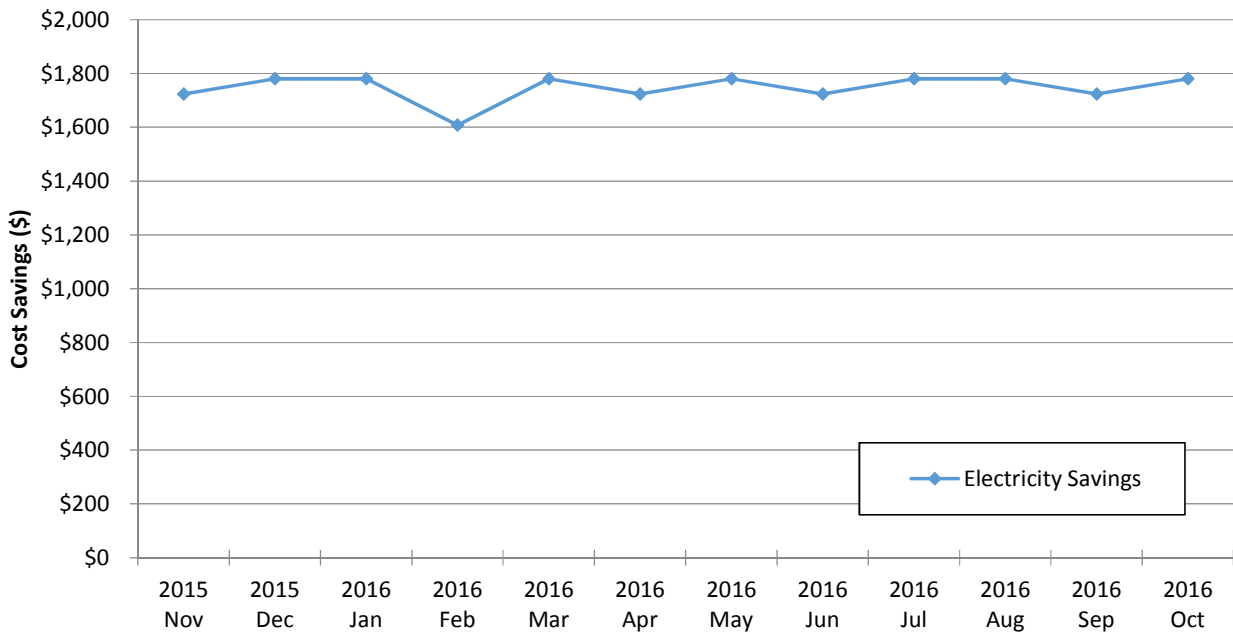
APPENDIX A

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 5 Energy Cost Avoidance					
Month	Year	Electricity Savings			Total Cost \$ Savings
		kW	kWh	Cost \$	
November	2015	27	12,380	\$1,723	\$1,723
December	2015	27	12,793	\$1,780	\$1,780
January	2016	27	12,793	\$1,780	\$1,780
February	2016	27	11,555	\$1,608	\$1,608
March	2016	27	12,793	\$1,780	\$1,780
April	2016	27	12,380	\$1,723	\$1,723
May	2016	27	12,793	\$1,780	\$1,780
June	2016	27	12,380	\$1,723	\$1,723
July	2016	27	12,793	\$1,780	\$1,780
August	2016	27	12,793	\$1,780	\$1,780
September	2016	27	12,380	\$1,723	\$1,723
October	2016	27	12,793	\$1,780	\$1,780
Contract Yr 5		318	150,628	\$20,962	\$20,962

FIM 13- Transformer Savings



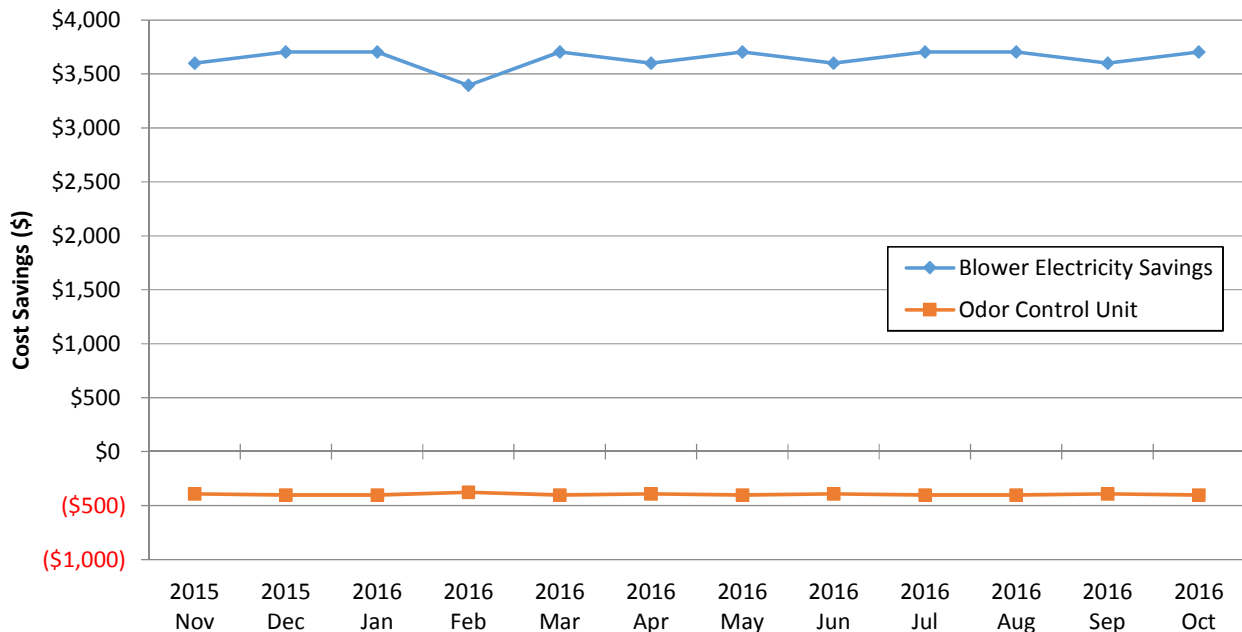
APPENDIX A

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 5 Energy Cost Avoidance					
Month	Year	Electricity Savings			Total Cost \$ Savings
		kW	kWh	Cost \$	
November	2015	60	20,384	\$3,211	\$3,211
December	2015	60	21,064	\$3,302	\$3,302
January	2016	60	21,064	\$3,302	\$3,302
February	2016	60	19,025	\$3,028	\$3,028
March	2016	60	21,064	\$3,302	\$3,302
April	2016	60	20,384	\$3,211	\$3,211
May	2016	60	21,064	\$3,302	\$3,302
June	2016	60	20,384	\$3,211	\$3,211
July	2016	60	21,064	\$3,302	\$3,302
August	2016	60	21,064	\$3,302	\$3,302
September	2016	60	20,384	\$3,211	\$3,211
October	2016	60	21,064	\$3,302	\$3,302
Contract Yr 5		724	248,010	\$38,982	\$38,982

FIM 14- Aeration Blower Savings



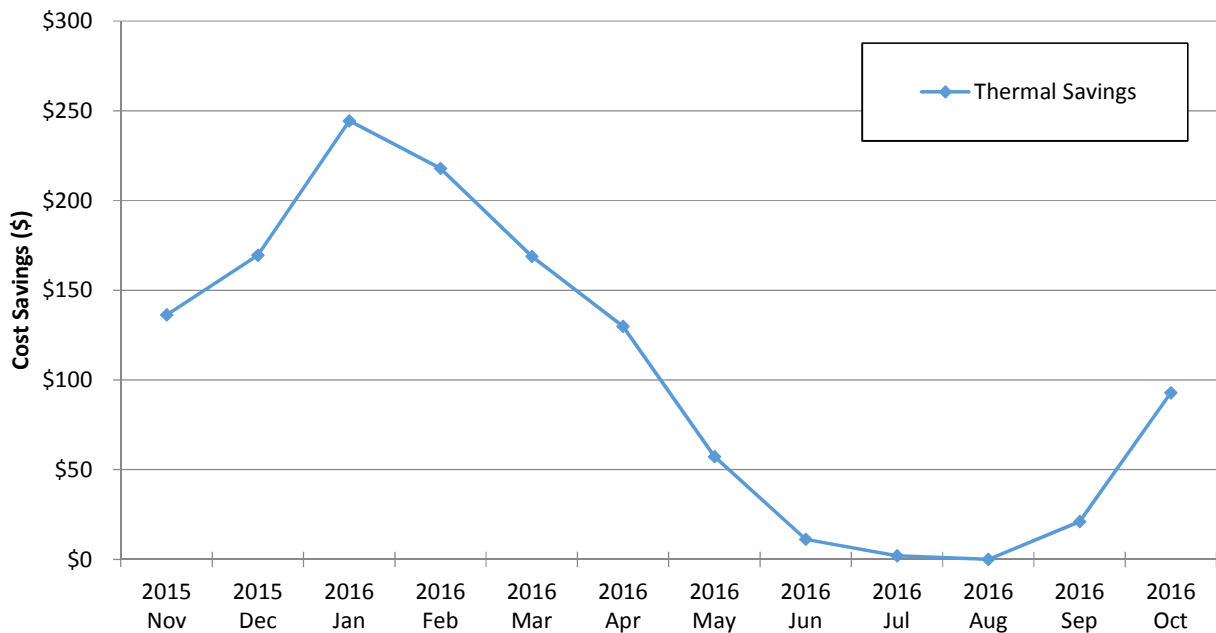
APPENDIX A

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 5 Energy Cost Avoidance				
Month	Year	Thermal Savings		Total Cost \$ Savings
		MMBTU	Cost \$	
November	2015	9	\$136	\$136
December	2015	11	\$169	\$169
January	2016	15	\$244	\$244
February	2016	14	\$218	\$218
March	2016	11	\$169	\$169
April	2016	8	\$130	\$130
May	2016	4	\$57	\$57
June	2016	1	\$11	\$11
July	2016	0	\$2	\$2
August	2016	0	\$0	\$0
September	2016	1	\$21	\$21
October	2016	6	\$93	\$93
Contract Yr 5		79	\$1,251	\$1,251

FIM 15- Boiler Replacement Savings



APPENDIX B

Performance Contract Project Progress

City of Dover- Year 5 Performance Contracting Tracking			
Quarter	⁽⁷⁾ Annual Guaranteed Savings	Total Reported Savings	% Savings of Guarantee
1 (Nov,Dec,Jan)	-	\$83,563	23.5%
2 (Feb,Mar,Apr)	-	\$77,975	21.9%
3 (May,Jun)	-	\$57,433	16.1%
4 (Jul,Aug,Sep,Oct)	-	\$146,159	41.0%
Total	\$356,214	\$365,130	102.5%

⁽⁷⁾Annual guaranteed savings are guaranteed on an annual basis

Year 5 total reported savings to date include November 2015 through October 2016 as per the November 1st start date of the performance period.

City of Dover Performance Contracting Tracking				
Period	Date Range	⁽⁸⁾ 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	⁽⁹⁾ (\$1,821)
Year 2	Nov '12 – Oct '13	\$328,236	\$321,420	⁽¹⁰⁾ (\$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	\$365,130	\$8,916
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		
Total Contract	N/A	\$3,623,746	N/A	N/A

⁽⁸⁾ 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)

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

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

APPENDIX B

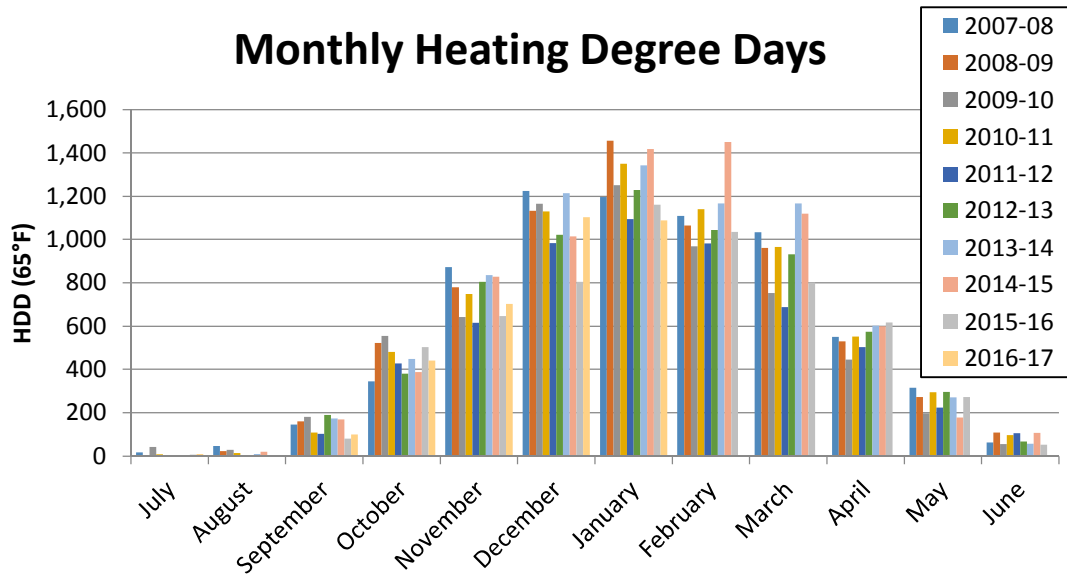
Weather Degree Days

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

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

Report Month	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
July	17	0	42	9	0	0	3	0	6	9
August	46	23	29	14	4	3	10	20	1	0
September	146	161	181	109	102	189	174	169	80	100
October	344	522	555	480	428	380	447	387	502	441
November	873	780	643	749	616	804	836	828	647	703
December	1225	1133	1166	1131	984	1022	1215	1014	805	1103
January	1197	1456	1252	1351	1094	1229	1343	1418	1161	1087
February	1110	1065	969	1142	982	1043	1168	1450	1035	
March	1033	961	753	966	688	931	1168	1120	802	
April	551	529	445	553	502	575	602	600	617	
May	315	273	198	294	224	296	271	179	272	
June	63	109	56	97	106	67	57	108	53	

The baseline data in the chart above is in green, year 1 data is in yellow, year 2 period in light blue, year 3 period is in pink, year 4 period is in purple, year 5 is in lime green.



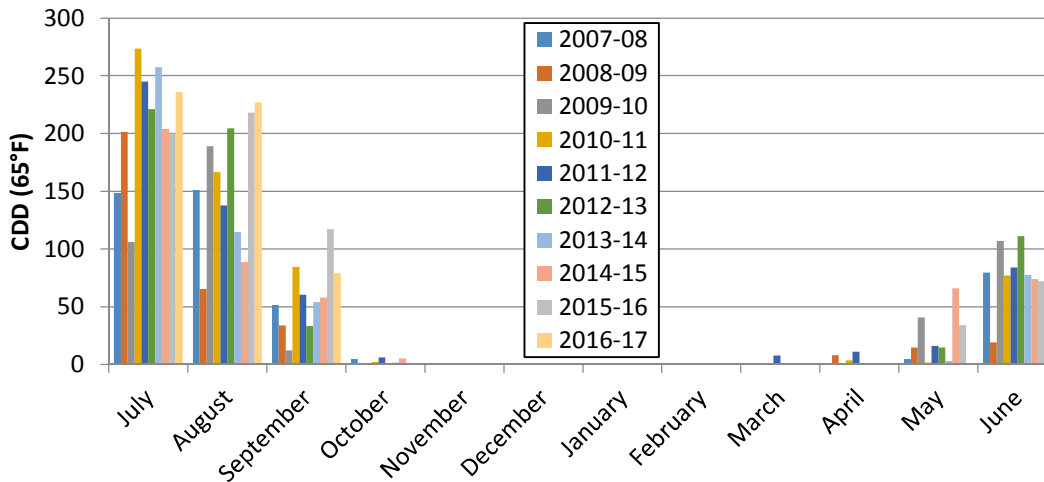
APPENDIX B

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

Report Month	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17
July	149	202	106	274	245	221	258	204	200	236
August	151	66	189	167	138	205	115	89	218	227
September	52	34	12	85	61	33	54	58	117	79
October	5	0	0	2	6	1	2	5	0	1
November	0	0	0	0	0	0	0	0	0	0
December	0	0	0	0	0	0	0	0	0	0
January	0	0	0	0	0	0	0	0	0	0
February	0	0	0	0	0	0	0	0	0	0
March	0	0	0	0	8	0	0	0	0	0
April	0	8	0	4	11	0	0	0	0	0
May	5	15	41	2	16	15	3	66	34	0
June	80	19	107	77	84	111	78	74	72	0

The baseline data in the chart above is in green, year 1 data is in yellow, year 2 period in light blue, year 3 period is in pink, year 4 period is in purple, year 5 is in lime green.

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 12.55% for the fifth guarantee year (4 x 3%) as per the contract.

Rate Summary Table							
Contract Year 5 Rates							
City of Dover, NH Building Location	Electric		Natural Gas	Oil	Propane	Water	Sewer
	\$/kW	\$/kWh	\$/Therm	\$/Therm	\$/Therm	\$/HCF	\$/HCF
Indoor Pool	\$9.93	\$0.118	\$1.619	-	-	\$4.22	\$5.08
Dover Ice Arena	\$7.99	\$0.119	\$1.424	-	-		
Waste Water Treatment Facility	\$7.92	\$0.134	-	\$1.878	-		
Dover City Hall	-	\$0.140	-	\$1.878	-		
Public Works	-	\$0.144	\$1.271	-	-		
McConnell Center	\$8.00	\$0.121	\$1.590	-	-		
Dover Public Library	-	\$0.152	\$1.593	-	-		
Jenny Thompson Pool	-	\$0.142	\$1.520	-	-		
Central Fire Station	-	\$0.141	\$1.722	-	-		
South End Fire Station	-	\$0.145	-	-	\$1.992		
Pine Hill Chapel	-	\$0.191	-	\$1.878	-		
Pine Hill Barn	-	\$0.225	-	\$1.878	-		
Veterans Hall	-	\$1.859	\$2.031	-	-		
Dover Train Station	-	\$0.138	\$2.155	-	-		

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

*****These rates are used to cover all months between November 2015 – October 2016*****

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 \$1.878 per Therm = \$2.610 per Gallon
Propane rate at \$1.992 per Therm = \$1.825 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:

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

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

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

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

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

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