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2. Project Description

The building, built in 1989, is a 16,888 square foot two story building sitting on a slab on grade concrete foundation. The front entrance of the building faces a north westerly direction. The frame is structural steel and slab on metal deck at the upper floor. The exterior walls are a combination of brick veneer with either a masonry block back up or wood frame with drywall on the interior face. The upper gable ends are wood framed with sheathing and wood siding. The sloped roof is wood truss framed with asphalt shingles on wood sheathing. The interior is painted drywall with wood trim, painted CMU walls, dropped acoustical tile ceilings and VCT, carpet on concrete floors.

The building presently serves as the public safety building for the town and operates 24/7, but at a reduced rate on the night shifts.

3. Executive Summary

3.1 Introduction:

This report details the recommendations and findings of the audit report conducted for the Windham Public Safety Building located at 375 Gray Road in Windham, Maine. The site visits were conducted on November 11 & 28, 2011. At that time John Monaghan met with Facilities Manager David Dickson, Fire Chief Hammond and Police Chief Lewsen.

This assessment recommends (21) Energy Conservation Measures (ECMs) addressing the electric and heating fuel usage, increasing comfort and cost savings. Details of the findings and recommendations are contained in the assessment.

The priorities are to apply air sealing, rework the insulation at the elevator shaft and stair well, repair penetrations and refit the insulation in the attic/ceiling, improve the lighting, weather strip the overhead doors, replace the boiler and control system, replace the air conditioning equipment, install programmable thermostats, rework the heating loop and install energy misers on the vending machines.

3.2 Identified Energy Conservation Measures:

1. Building Envelope Improvements

a. **Provide general air sealing throughout the building**
b. **Apply 1" of closed cell spray foam insulation at the band joist of the 1st and 2nd floor and the roof /wall intersection**
c. **After air sealing, refit the batt insulation in the attic, and blow in 6" of cellulose insulation in the attic space**
d. **Replace weather stripping at the overhead doors**

2. Energy Efficient Lighting

a. **Re-ballast & re-lamp the existing T12 fixtures to T8's**
b. **Reduce lighting levels by replacing 32 watt lamps with 28 watt lamps where indicated**
c. **Install occupancy sensors where indicated**
d. **Replace incandescent bulbs with CFL's or LED's**
e. **Replace the HPS exterior fixtures with LED's**

3. HVAC System

a. **Develop a boiler replacement plan. The boiler should have an AFUE (Annual Fuel Utilization Efficiency) of 85%. Consideration should be given to installing two boilers that can handle 60% of the load each and be staged**
b. **Replace the existing controls with a building automation system with Direct Digital Controls**
c. **Replace existing thermostats with programmable thermostats that can tied into the DDC system**
d. **Divide the present heating loop into two sections and install VFD (Variable Frequency Drive) circulating pumps.**
e. **Develop an air conditioning plan replacement plan. The system should have a minimum EER of 11**
f. **Add sub zones to the present AC zones with motorized dampers to throttle the CFM back when not in use**
g. **Alter the use of the mini split in the former dispatch area to include the reports space which operates 24/7, and remove it from the AHU (Air Handling Unit) load**
h. **Install a mini split that serves the sleeping quarters and FD day room since it operates 24/7 and remove it from the AHU**
i. **Upgrade the economizer and ventilation system with the Air Conditioning**

j. **Provide a standalone ventilation system for the sleeping area, if it is converted to a mini split system**
k. **Replace the existing control system with a DDC Building Automation System that integrates the various sub system in the HVAC system as the systems are replaced beginning with the boiler for the hot water**
l. **Install three thermal equalizers at the apparatus bay**

5. **Miscellaneous**
   a. **Install Vending Misers on the two vending Machines**

Comments regarding the payback table.

The table below lists the Recommended Energy Conservation Measures (ECM's), the savings in dollars and energy, the cost of the improvement, CO2 savings, simple payback and the savings on investment ratio. Simple pay back is the cost of the improvement divided by the projected annual savings which tells you how many years it will take to recoup your investment. Savings to Investment Ratio (SIR) is the projected annual savings multiplied by the useful life of the improvement, then divided by the cost of the improvement, which tells you how many times the investment will pay for itself over the life of the investment. The SIR should be greater than 1 and the higher the number over 1, the better the investment. The table does not include the maintenance savings or the improvement in thermal comfort for the ECM's.

Not all conservation measures are listed in the table, some have been combined and some are not listed for other reasons.

Windham Public Safety Building Proposed Energy Conservation Measures

Energy Conservation Measure	Annual Cost Savings in Dollars	Annual Electric Savings in kWh	Annual Heating Fuel Savings in MMBtu	Annual CO2 Emissions Savings in tons	Cost of Work	Simple Payback in Years	Savings to Investment Ratio
Bldg. Envelope							
Air seal	$ 1,037	2,747	21.0	**2.9**	$ 3,335	**3.2**	9.33
Retrofit Shafts	$ 495	1,191	14.56	**1.6**	$ 2,156	**4.4**	6.89
Blow in 6" of cellulose in Attic	$ 1,686	3,712	51.1	**5.5**	$ 12,000	**7.1**	4.22
Weather Strip FD OH Door	$ 108	15	6	**0.4**	$ 482	**4.5**	2.24
Weather Strip PD OH Door	$ 36	5	1.1	**0.1**	$ 251	**7.0**	1.43
Subtotal	**$ 3,362**	**7650**	**87**	**9.98**	**$ 18,224**	**5.4**	4.61
Lighting							
Install Sensors, and re-ballast & re-lamp T12 w/ T8's	$1,532	13,233		**6.8**	$7,280	**4.8**	3.16
Install Sensors, and replace T8's w/ low w T8's	$755	6,277		**3.2**	$4,470	**5.9**	2.53
Add sensors in App Bay	$638	5,572		**2.9**	$1,560	**2.4**	6.13
Replace dwn lights w/LED or CFL	$449	3,952		**2.0**	$350	**0.8**	19.24
Exterior							
Replace HPS fixtures with LED	$2,725	13,575		**7.0**	$9,950	3.7	2.74
Lighting Subtotal	**$6,099**	**42,609**		**21.9**	**$16,330**	**2.7**	4.86
HVAC System							
Replace boiler 1	2,747	4,924	**88.2**	**8.7**	$7,500	2.7	7.33
DDC Bldg Automation System 1	1,782	547	70.6	**4.9**	12,500	7.0	1.43
Split Heating Loop	626	162	26.5	**1.9**	12,000	19.2	1.57
New AC system 1	798	798		**0.4**	8,475	10.6	1.88
Subtotal	**$5,953**	**6,431**	**185.2**	**15.9**	**$40,475**	**6.8**	**2.94**
Miscellaneous							
Install energy misers on vending machines	418	3,800	0	2.0	$350	0.8	11.94
ECM Totals	**$ 15,832**	**60,490**	**272**	**50**	**$ 75,379**	**4.8**	**6.09**

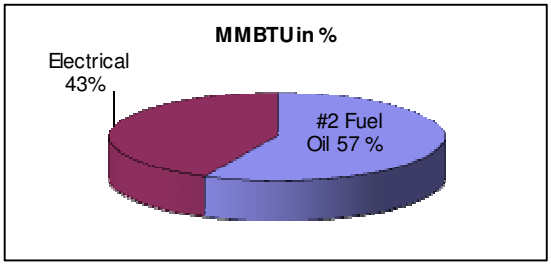
Note: A 5% to 10% contingency should be carried for the cost of work

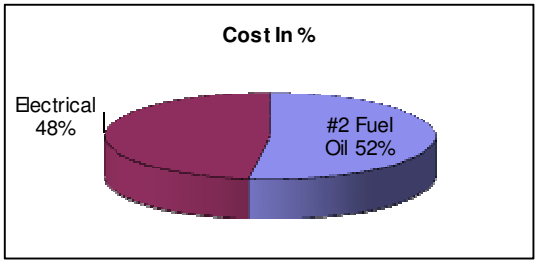
1. Cost represents efficiency upgrade cost only not basic replacement cost

4. Energy Usage

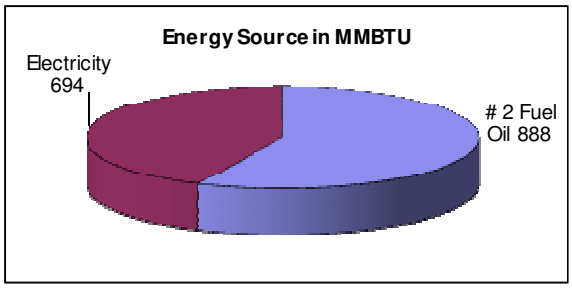
The energy usage of the building is from two sources: electricity for lighting and power; and #2 fuel oil and propane for heat and domestic hot water.

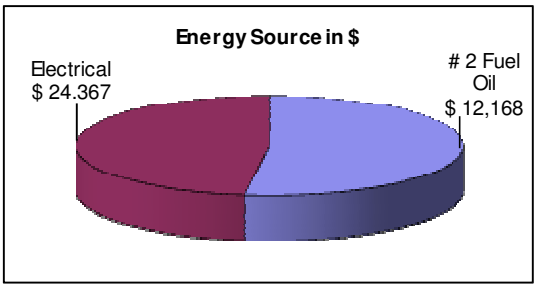
The first series of pie charts show the energy usage in percent for both BTU's, the common energy measurement unit and as the cost of energy.





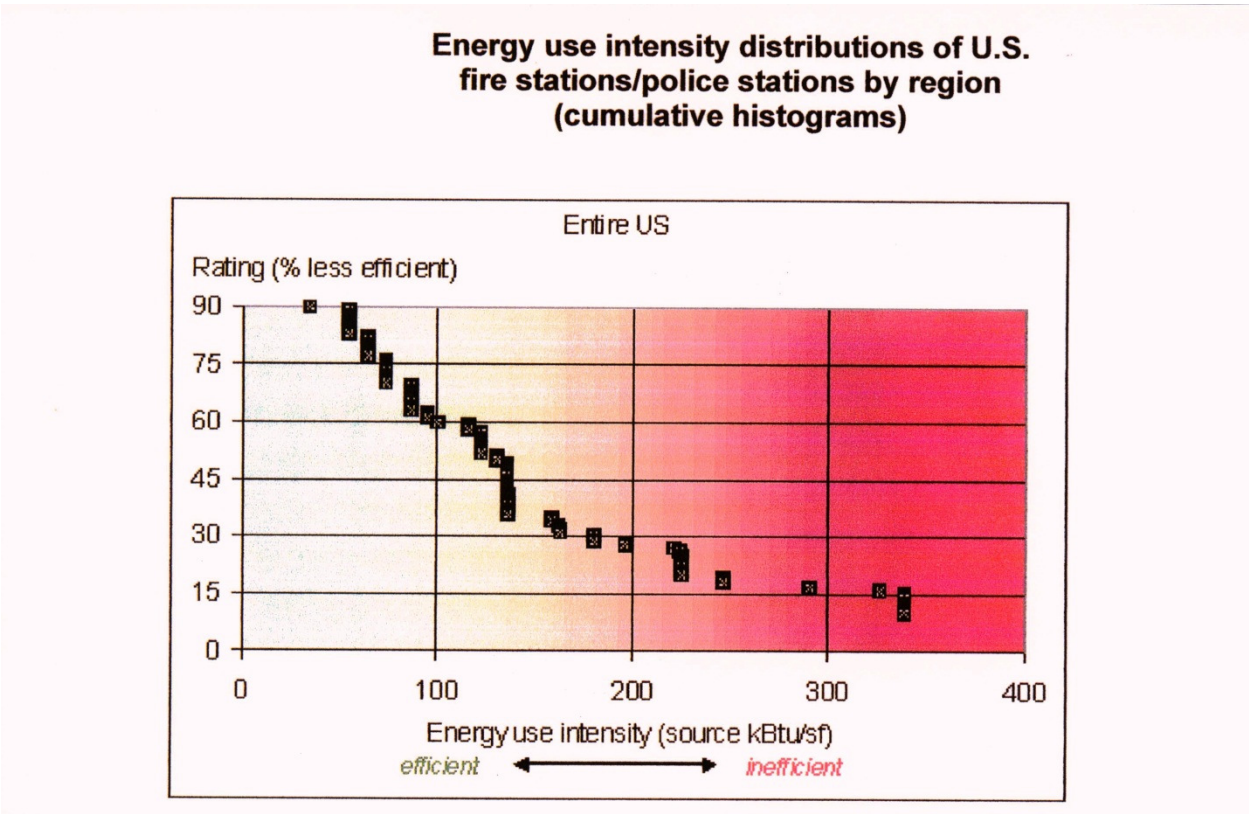
The second series of pie charts shows the energy usage in millions of BTU's (MMBtu) and the cost in dollars.





As shown in the pie charts, heating fuel accounts for the greater portion of the energy usage in cost, 57% in dollars and is the greater in energy units, 52 % of the BTU's.

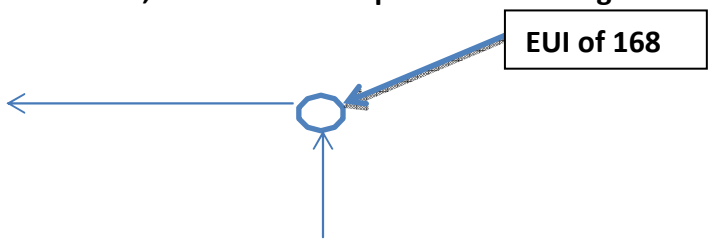
The DOE has established the Energy Use Index (EUI) through Oak Ridge National Laboratory Buildings Technology Center. The EUI is a measure of a building's annual energy utilization per square foot of building. It is a metric used to compare a buildings energy use to similar building types. Based on the information entered into the program the Public Safety building's EUI is 168. Entering that value on the x-x axis of the graph below, projecting



vertically until it intersects the curve and following it horizontally until it intersects the y-y axis the rating has the building falling into 32% range.

This means that of the buildings surveyed 32% are less and 68% are more efficient than the Public Safety Building. Of that number 57% of the energy usage typically is attributed to electricity and the balance is for heating. The Public Safety Building uses the reverse, 57% for heating and 43% for electricity. This indicates that you are using a lot more energy for heating than the typical building in the survey and that heating usage should be examined further.

Some of the information that Oak Ridge has developed is regional, but all that is available for this building type is national, which is not as specific for this region.

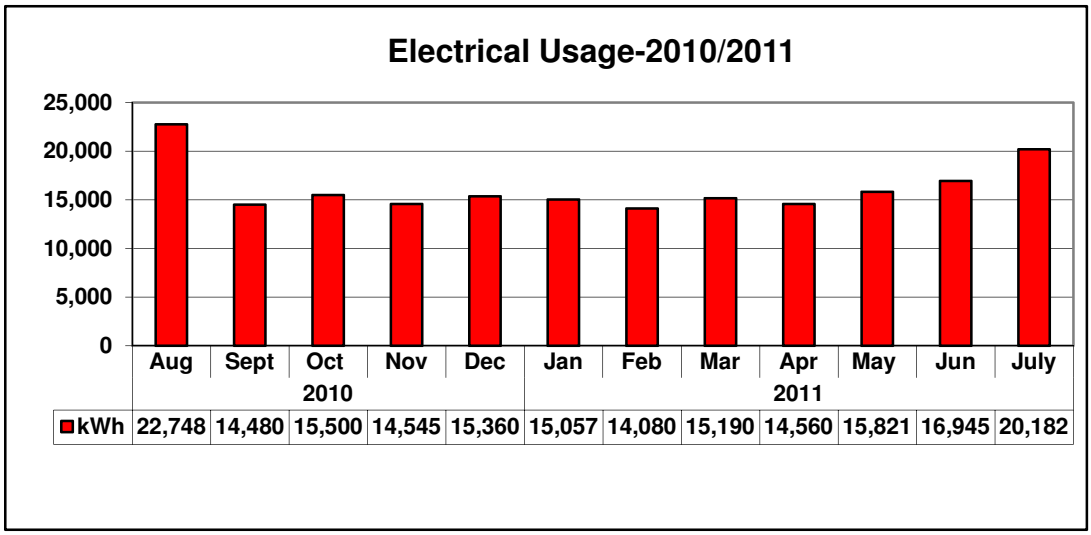


4.1 Historic Energy Consumption

1. Electrical

Usage is shown in the table and graph below for July 2010 through June 2011. The baseline monthly consumption is about 15,550 kWh/month.

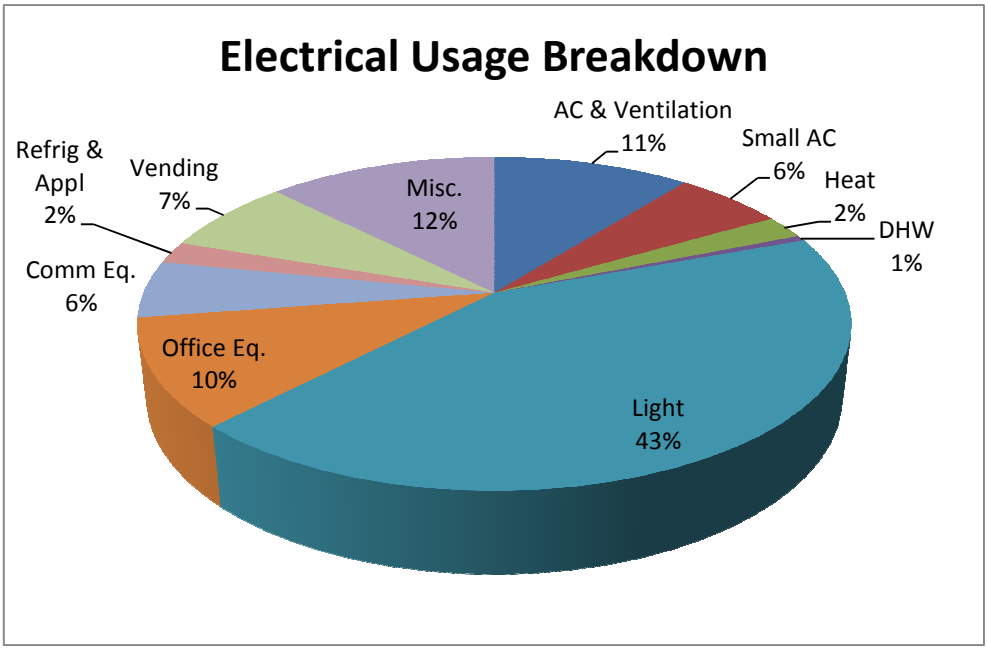
Windham Public Safety Bldg			
Electricity Usage-2010/2011			
		kWh	Cost (incl demand)
2010	Aug	22,748	2,653
	Sept	14,480	1,553
	Oct	15,500	1,640
	Nov	14,545	1,300
	Dec	15,360	1,436
2011	Jan	15,057	1,842
	Feb	14,080	1,728
	Mar	15,190	1,345
	Apr	14,560	1,281
	May	15,821	1,698
	Jun	16,945	1,751
	July	20,182	2,318
	Total	194,468	$ 20,545
12 Mo	Avg	16,206	$1,712
Avg	$/kW		$0.11



Electrical use per square foot is 11.52 kWh as compared to the New England average of 10.8 kWh or 1.07 % of the average for commercial buildings in New England and higher than other fire/police buildings assessed in Maine which averaged 6.4 kWh/sf. The fact that the building operates 24/7 likely accounts for the difference from the typical commercial building that operates about 50 hrs. /week. However, there are still opportunities to improve the electrical usage.

The table and graph below shows the estimated breakdown of electrical usage for the building.

Electrical Usage Breakdown	
Source	**kWh/Year**
AC & Ventilation	20723
Small AC	11578
Heat	4386
DHW	1013
Light	83312
Office Eq.	20200
Comm Eq.	10718
Refrig & Appl	4167
Vending	14206
Misc.	24165

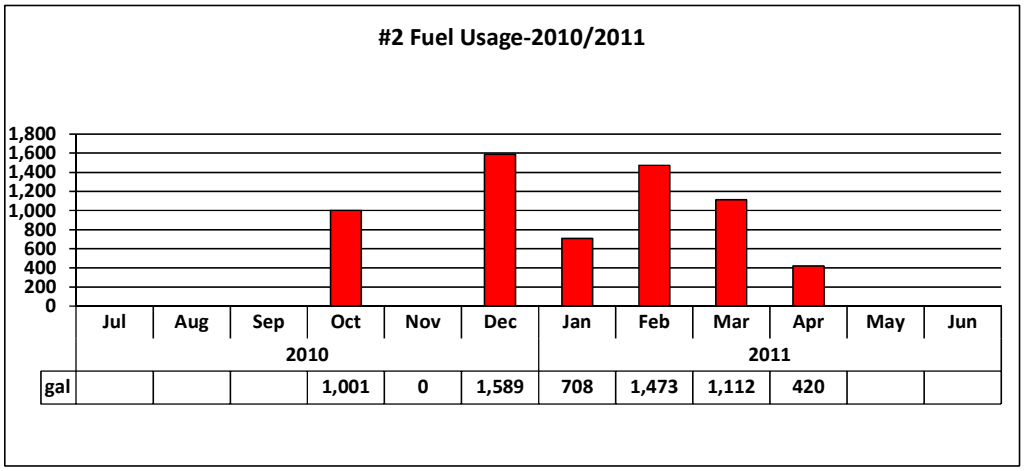


2. Heating Fuel:

The heating fuel usage for July 2010 through June 2011 for #2 fuel oil is shown below in the table and graph. The heating usage mostly coincides with the colder winter weather.

The usage for #2 fuel oil on a square foot basis is .37 gals/SF as opposed to an average of .32 gals/SF and 52,243 BTU/SF as opposed to an average of 44,480 BTU/SF or 117 % of the average for commercial buildings in New England. The heating degree days for the selected the time frame are similar to the 30 year average making it representative of the fuel usage.

Windham Public Safety			
#2 Fuel Usage-2010/2011			
		gal	cost
2010	Jul		
	Aug		
	Sep		
	Oct	1,001	3,499
	Nov	0	0
	Dec	1,589	5,557
2011	Jan	708	2,474
	Feb	1,473	5,149
	Mar	1,112	3,888
	Apr	420	1,470
	May		
	Jun		
	Total	6,302	$22,036
Month	Average	525	$1,836
$/gal	Average		$3.50



5. Building Envelope

The building was built in 1989, and has seen normal maintenance over its life. The building is being viewed as two structures, the Apparatus bay and the balance of the building (main building).

The apparatus bay has brick veneer walls, block back up and 1.5" of rigid insulation in the cavity. The estimated R value is R-10.3. The gable ends are drywall on the interior, wood framed 2x6's, 6" of batt insulation, sheathing and wood siding on the exterior. The estimated R value is R-10.7. The roof is sloped with wood 2x10 framing, 2/8" sheathing, 3" of rigid insulation, sleepers, another layer of sheathing and asphalt shingles. The estimated R value is R-16.8. When it is time to replace the shingles at the roof adding 2" of polyisocyanurate is recommended, this will increase the R value to an estimated R-31. The foundation is a slab on grade, a frost wall and 2" of rigid insulation at the perimeter. The man doors are estimated to have and R value of R-3.2, and the overhead doors R-4.5. The windows are doubled paned aluminum awning windows with an estimated to have an R value of R-2.5.

The main section of the building is a brick veneer. At the ground level the backup is block back up and there is 1.5" of rigid insulation in the cavity from the reports area around the NE side of the building to the back. The estimated R value is R-10.3. The balance of the first floor and the upper floor has wood framed 2x6's, 6" of batt insulation, sheathing and dry wall on the interior. The estimated R value is R-10.7. The flat attic has 2x6" wood trusses, drywall at the ceiling, one layer of 5.5" batt insulation nested between the bottom cord and another layer of 4" batt insulation running perpendicular to it. Much of it has been disturbed and is not well fitted. The estimated R value is R-20. The foundation is a slab on grade, with a frost wall and 2" of rigid insulation at the perimeter. The windows are doubled paned aluminum awning windows with an estimated R value of R-2.5. The man doors are estimated to have an R value of R-3.2, the entrance doors R-2.6 and the overhead doors R-4.

Based on tests of similar buildings the ACH (Air Changes per Hour) and studies, the estimated ACH is .9 to 1 for the apparatus bay and .7 to.85 for the main building. This would place the building into the semi- loose to loose category, according to Manual N for Commercial Buildings published by the ACCA. For the apparatus bay, a tight building has an ACH of .25 ACH and an average building is .8 ACH. For the main section, a tight building has an ACH of .15 ACH and an average building is .5 ACH. The goal is to have a tight building, but at a minimum in the average range of .50 to .8 ACH. The air infiltration indicates the building is a good candidate for air sealing.

The current Energy Code specifies an R-20 at the apparatus bay and R-38 at the main building roof and an R-13 at the walls. These are minimum R values; better performing buildings have an R-20 at the walls and an R-40 to 50 at the roofs.

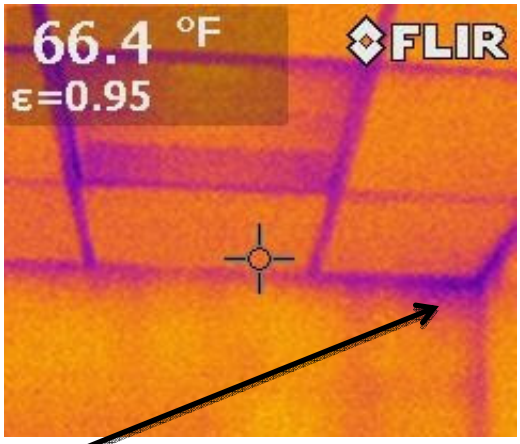
Listed below are the recommendations to improve the building envelope. Penetrations, cracks, gaps and voids at the walls and ceilings are recommended to be air sealed. In addition, where accessible, it is recommended to spray foam a 6" band 1" thick at the wall and second floor intersection and the wall and attic insulation intersection. At the perimeter of windows that are showing gaps a neat bead of caulking should be installed. This should reduce the heat loss and gain from air infiltration by 20%.

The top of the elevator shaft and stair well into the storage area have caps that extend above the attic ceiling. Both of these are poorly insulated and show signs of air infiltration. The area should be examined and properly air sealed, the insulation refitted at the walls, 2" of rigid insulation installed over the walls and a foot above the top of the shaft, the joints taped and a band installed around the top of the rigid insulation. The old batt insulation should be removed from the cap and cellulose blown in filling between the studs and for 12" above them. This should reduce the heat loss and gain at the caps by 60 to 70%.

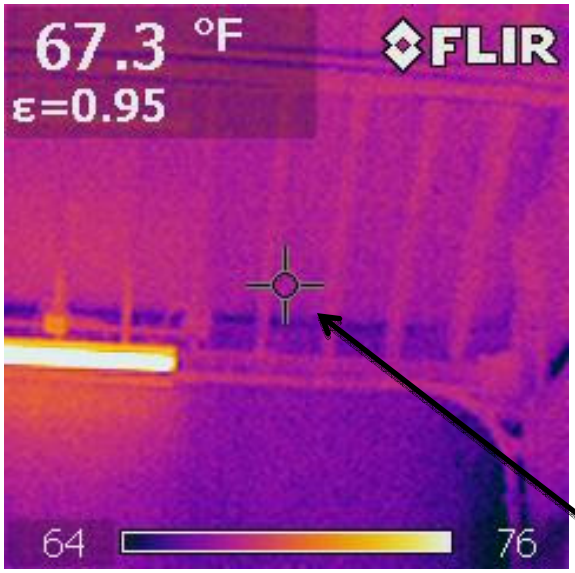
The next recommendation before the attic is air sealed is to repair all of the holes, then air seal, refit any disturbed insulation and have 6" of cellulose blown over the top of the existing insulation to bring the R value to an estimated R- 40. This will reduce the heat loss through the ceiling by an estimated 45 % and reduce the fuel consumption by 5%.

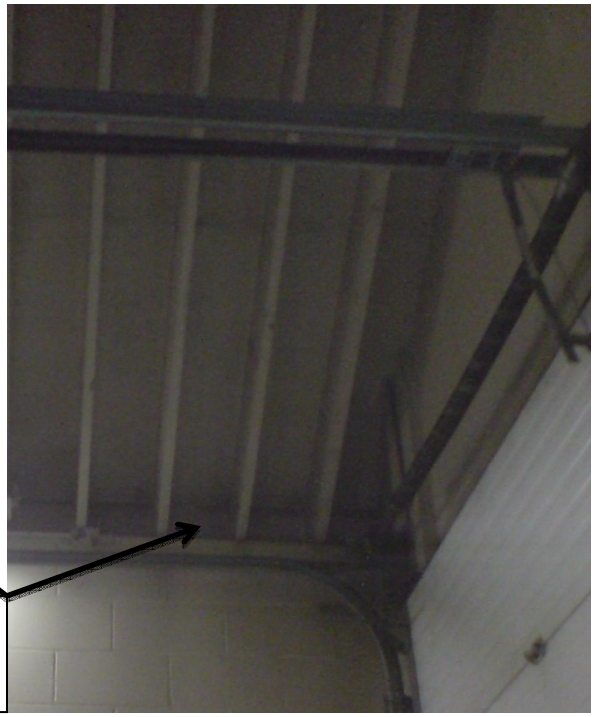
The final recommendation is to install weather stripping on the overhead doors, especially at the apparatus bay. The weather stripping should be commercial grade (Gossen Corp Jambseal or equal). It is estimated this will reduce the fuel usage by 1%. Also, the man doors should be adjusted and weather stripped.

The purpose of including the following photos is to offer a visual representation of the present condition of the building envelope so the reader may have a better understanding of the situation and why the recommendations are being made.

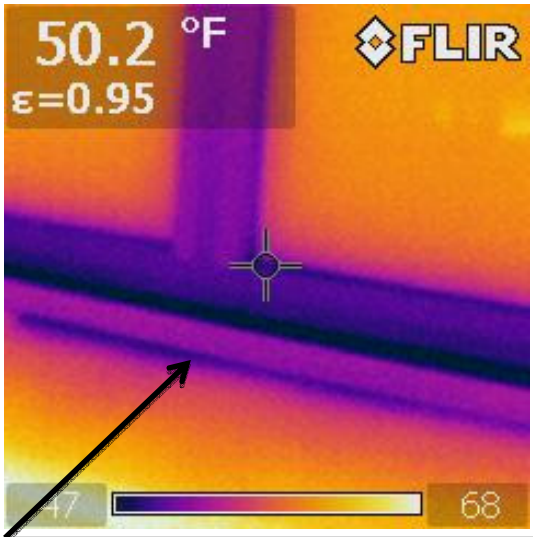


View of air infiltration at PD Chiefs Office

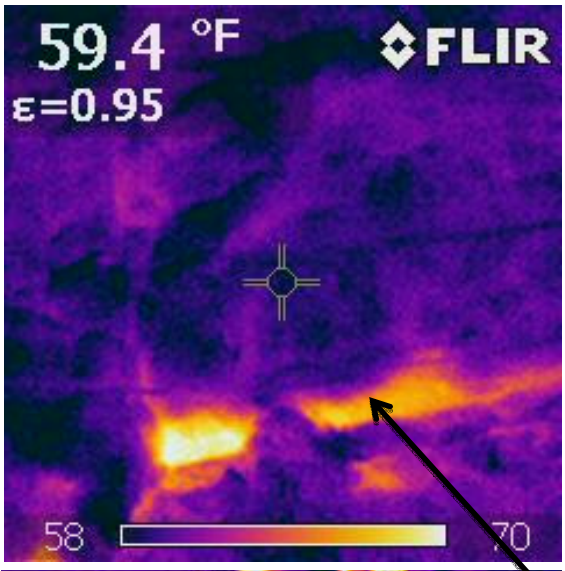


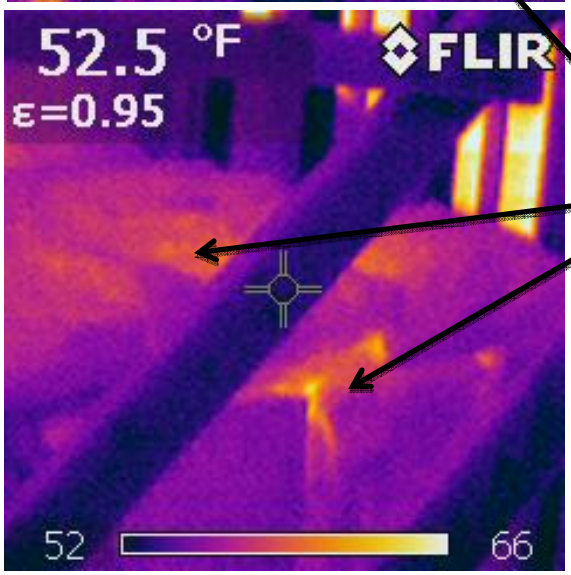


Apparatus Bay- note air infiltration at wall & roof slope

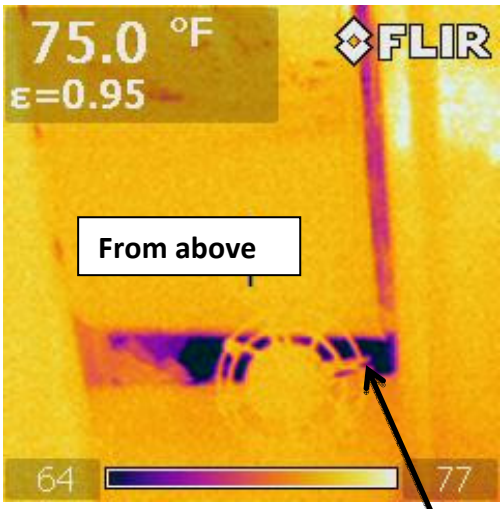


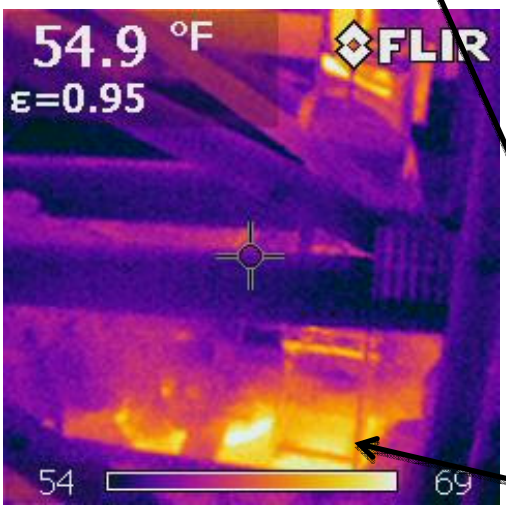
View of PD Lt's window showing air infiltration at sill to frame



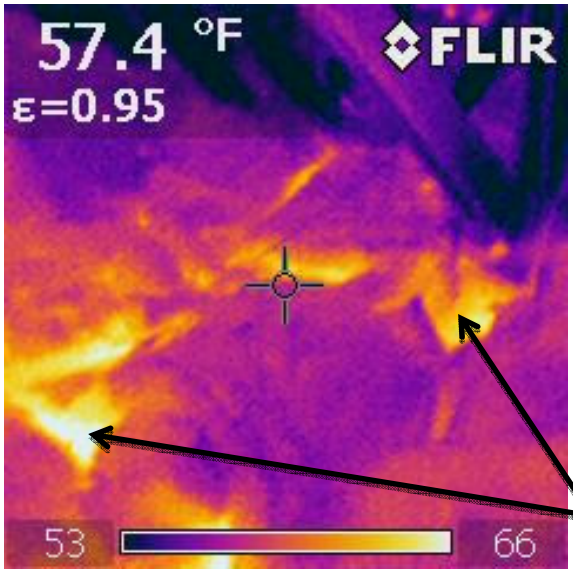


View of elevator shaft (RT) & stairwell, note shoot on digital and heat loss at base, sides and cap. These also have a chimney affect

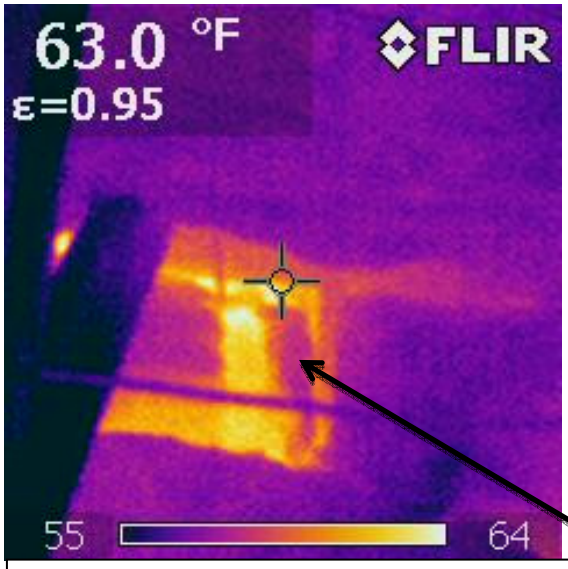




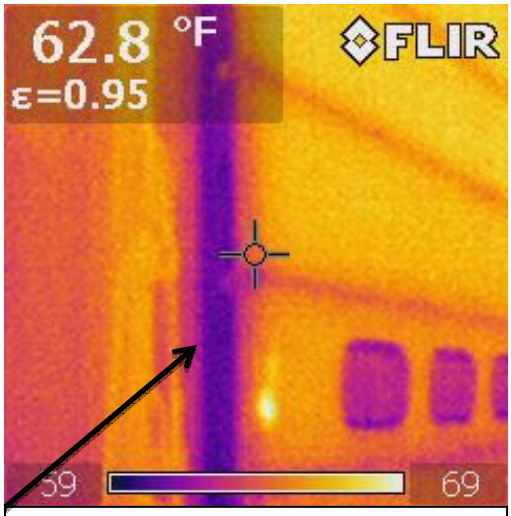
View of hole, from above & below, at men's shower ceiling showing heat loss and air in filtration



View representing how heat is generally escaping through flaws in insulation & low level of insulation



View of heat escaping through an unsealed hole & where insulation has been disturbed



View of apparatus bay door with IR shot showing air leakage at jamb & digital shots of door from interior and exterior. Note; no weather stripping at jamb

6. Lighting

The predominant interior lighting fixtures are linear fluorescents, some are newer T8's and a number of older T12's. In addition, there are some incandescent and CFL's fixtures mixed in. The primary measure is to re-lamp and re-ballast the existing T12 fixtures with high performance T8's with newer 800 series lamps and reducing the wattage to 25 or 28 watts. It Also it is recommended to replace the first generation T8's, which are going away, with newer 800 series lamps and reducing the wattage to 25 or 28 watts. Some of the fixtures are recommended to have a Low Ballast Factor ballast to further reduce the wattage. A table showing the fixture, wattage and ballast factor (BF) is included to be used with the lighting table for determining BF. In addition, the recommended control strategy is to add sensors in rooms and areas to turn off lights when not occupied. This can be a hidden cost when lights are left on in rooms that are not occupied for extended periods of time. Where sensors are recommended programmable ballasts should be installed to maintain the life of the lamps.

Some of the stair and hallway 2x2 fixtures are on 24/7 and installing LED fixtures are offered as an alternate to re-ballasting and re-lamping. The payback period is reasonable and this is a good opportunity to introduce interior LED fixtures. Where 24/7 incandescent or CFL fixtures exist it is recommended they be replaced with LED lamps. The estimated cost is $350/fixture, if 1 lamp replacement is deducted from the fixture cost the cost is about $300. The estimated savings is $ 140 per fixture annually for T12's which yields a 2 year payback.

Retrofitting the Apparatus Bay fixtures by adding sensors to the outer rows of fixtures and leaving the two center rows on a switch will save energy and still provide adequate lighting when not occupied.

The recommendations are to replace exterior metal halide (MH) lamps and man door fixtures with LED fixtures. LED replacement lamps and fixtures are becoming more cost effective, the price is being reduced by half every two to three years, they are the least expensive to operate, work well in cold weather, are dimmable, work with photo sensors and reduce replacement costs because of their long life.

The tables below provide an approximate potential for energy savings opportunities to reduce electrical lighting consumption throughout the facility by upgrading a number of the lighting fixtures. These recommendations should result in better lighting control, more comfortable lighting and save lighting expense.

Fixture Type	System Wattage	Ballast Factor	
3L 2x4 T8 25w	58	0.77	Low
1L 1x4 T8 25w	20	0.77	Low
2L 2x4 T8 28w	43	0.77	Low
2L 2x2 T8 28w	39	0.77	Low
2L 2x4 T8 28w	50	0.88	Normal
3L 2x4 T8 28w	74	0.88	Normal

Note; Ballast factor listed are typical, they may vary somewhat.

Windham Public Safety Building Lighting Table													
1	Location	Fixture type	# of units	Watts per Unit	Max Total kW	Hrs/ Day	# of Days	Annual Operating Hours	Annual Total kWh	Annual kWh Cost	Potential Annual Savings	Annual kWh Saved	Potential Reduced kW
	Level 1									$0.11			
Existing	Ent Canopy	1L Dwn Inc	3	120	0.36	12	365	4380	1,577	$181			
Retrofit		1L Dwn LED	3	15	0.045	12	365	4380	197	$23	$158	1,380	0.315
Existing	Foyer	3L 2x4 T8 32w	3	86	0.258	10	260	2600	671	$77			
Retrofit		3L 2x4 T8 25w	3	58	0.174	10	260	2600	452	$52	$25	218	0.084
Existing	At Counter	1L 1x4 T8 32w	2	29	0.058	10	260	2600	151	$17			
Retrofit		1L 1x4 T8 25w	1	20	0.02	10	260	2600	52	$6	$11	99	0.038
Existing		1L Dwn Inc	1	120	0.12	24	365	8760	1,051	$120			
Retrofit		1L Dwn LED	1	15	0.015	24	365	8760	131	$15	$105	920	0.105
Existing		1L Dwn CFL	1	23	0.023	24	365	8760	201	$23			
Retrofit		1L Dwn LED	1	15	0.015	24	365	8760	131	$15	$8	70	0.008
Existing	Rest Rm	3L 2x4 T8 32w	1	77	0.077	6	260	1560	120	$14			
Retrofit	Add Sensor	2L 2x4 T8 28w	1	43	0.043	1	260	260	11	$1	$12	109	0.034
Existing	PD Hall 1	2L 2x2 T12 32w U	2	80	0.16	10	260	2600	416	$48			
Retrofit		2L 2x2 T8 25w U	2	39	0.078	10	260	2600	203	$23	$24	213	0.082
Existing		2L 2x2 T12 32w U	2	80	0.16	24	365	8760	1,402	$160			
Retrofit	Add Sensor	2L 2x2 T8 25w U	2	39	0.078	18	365	6570	512	$59	$102	889	0.082
Existing	Interview	4L 2x4 T12 34w	1	160	0.16	2	260	520	83	$10			
Retrofit		2L 2x4 T8 28w	1	50	0.05	2	260	520	26	$3	$7	57	0.11
Existing	Records	1L Dwn Inc Dim	6	120	0.72	10	260	2600	1,872	$214			
Retrofit		1L Dwn CFL	6	23	0.138	10	260	2600	359	$41	$173	1,513	0.582
Existing		2L 1x4 T8 32w	1	80	0.08	10	260	2600	208	$24			
Retrofit		2L 1x4 T8 28w	1	50	0.05	10	260	2600	130	$15	$9	78	0.03
Existing		2L 2x2 T12 32w U	1	80	0.08	10	260	2600	208	$24			
Retrofit		2L 2x2 T8 25w U	1	39	0.039	10	260	2600	101	$12	$12	107	0.041
Existing	Rest Rm	2L 2x2 T12 32w U	1	80	0.08	6	260	1560	125	$14			
Retrofit		2L 2x2 T8 25w U	1	39	0.039	1	260	260	10	$1	$13	115	0.041
Existing	Disp Office	3L 2x4 T8 32w	1	86	0.086	10	260	2600	224	$26			
Retrofit		3L 2x4 T8 28w	1	74	0.074	10	260	2600	192	$22	$4	31	0.012
Red indicates estimate									Annual Total kWh	Annual kWh Cost	Potential Annual Savings	Annual kWh Saved	Potential Reduced kW
										$0.11			
Estimated Annual Lighting Usage and Cost									8,308	$ 951			
Table 1 Estimated Annual Lighting Savings											$ 664	5,799	2

2	Location	Fixture type	# of units	Watts per Unit	Max Total kW	Hrs/ Day	# of Days	Annual Operating Hours	Annual Total kWh	Annual kWh Cost	Potential Annual Savings	Annual kWh Saved	Potential Reduced kW
										$0.11			
Existing	Reports	2L 1x4 T8 32w	5	57	0.285	24	365	8760	2,497	$286			
Retrofit	Add Sensor	2L 1x4 T8 28w	5	50	0.25	18	365	6570	1,643	$188	$98	854	0.035
Existing	Lock Up	3L 2x4 T8 32w	4	86	0.344	4	365	1460	502	$58			
Retrofit		3L 2x4 T8 28w	4	74	0.296	4	365	1460	432	$49	$8	70	0.048
Existing	PD Hall 2	2L 2x2 T12 34w U	3	80	0.24	24	365	8760	2,102	$241			
Retrofit	Add Sensor	2L 2x2 T8 25w U	3	39	0.117	18	365	6570	769	$88	$153	1,334	0.123
Existing	Sally Port	2L 2x4 T8 32w	4	57	0.228	4	365	1460	333	$38			
Retrofit		2L 2x4 T8 28w	4	50	0.2	4	365	1460	292	$33	$5	41	0.028
Existing	Blk Evidence	2L 2x4 T8 32w	4	57	0.228	2	100	200	46	$5			
Retrofit		2L 2x4 T8 28w	4	50	0.2	2	100	200	40	$5	$1	6	0.028
Existing	Wash	2L 2x4 T8 32w	4	57	0.228	4	365	1460	333	$38			
Retrofit		2L 2x4 T8 28w	4	50	0.2	4	365	1460	292	$33	$5	-252	0
Existing	PD Hall 3	2L 2x2 T12 32w U	1	80	0.08	24	365	8760	701	$80			
Retrofit	Add Sensor	2L 2x2 T8 25w U	1	39	0.039	18	365	6570	256	$29	$51	445	0.041
Existing	SGT	2L 1x4 T12 34w	2	80	0.16	18	365	6570	1,051	$120			
Retrofit		2L 1x4 T8 28w	2	39	0.078	18	365	6570	512	$59	$62	539	0.082
Existing	Kit Break Rm	2L 1x4 T12 34w	4	80	0.32	12	365	4380	1,402	$160			
Retrofit	Add Sensor	2L 1x4 T8 28w	4	39	0.156	6	365	2190	342	$39	$121	1,060	0.164
Existing	Boiler Rm	2L 1x4 T12 34w	4	80	0.32	2	50	100	32	$4			
Retrofit		2L 1x4 T8 28w	4	50	0.2	2	50	100	20	$2	$1	12	0.12
Existing	Storage	2L 1x4 T12 34w	1	80	0.08	1	50	50	4	$0			
Retrofit		2L 1x4 T8 28w	1	50	0.05	1	50	50	3	$0	$0	2	0.03
Existing	Janitor	2L 1x4 T12 34w	1	80	0.08	3	260	780	62	$7			
Retrofit		2L 1x4 T8 28w	1	50	0.05	3	260	780	39	$4	-$4	-37	0
Existing	FD Hall 1	2L 2x2 T12 34w U	2	80	0.16	10	260	2600	416	$48			
Retrofit		2L 2x2 T8 25w U	2	39	0.078	10	260	2600	203	$23	$24	213	0.082
Existing		2L 2x2 T12 34w U	2	80	0.16	24	365	8760	1,402	$160			
Retrofit		2L 2x2 T8 25w U	2	39	0.078	24	365	8760	683	$78	$82	718	0.082
Existing	Office 1	2L 1x4 T12 34w	1	80	0.08	3	260	780	62	$7			
Retrofit		2L 1x4 T8 28w	1	50	0.05	3	260	780	39	$4	$3	23	0.03
Existing	Office 2	2L 1x4 T12 34w	1	80	0.08	3	260	780	62	$7			
Retrofit		2L 1x4 T8 28w	1	50	0.05	3	260	780	39	$4	$3	23	0.03
Red indicates estimate									Annual Total kWh	Annual kWh Cost	Potential Annual Savings	Annual kWh Saved	Potential Reduced kW
										$0.11			
Estimated Annual Lighting Usage and Cost									11,007	$ 1,260			
Table 2 Estimated Annual Lighting Savings											$ 612	5,051	1

3	Location	Fixture type	# of units	Watts per Unit	Max Total kW	Hrs/ Day	# of Days	Annual Operating Hours	Annual Total kWh	Annual kWh Cost	Potential Annual Savings	Annual kWh Saved	Potential Reduced kW
										$0.11			
Existing	Emg Mgt	2L 1x4 T12 34w	1	80	0.08	3	260	780	62	$7			
Retrofit		2L 1x4 T8 28w	1	50	0.05	3	260	780	39	$4	$3	23	0.03
Existing	Day Rm	2L 1x4 T8 32w	3	56	0.168	24	365	8760	1,472	$169			
Retrofit	Add Sensor	2L 1x4 T8 28w	3	44	0.132	16	365	5840	771	$88	$80	701	0.036
Existing		2L 1x4 T8 32w	1	56	0.056	24	365	8760	491	$56			
Retrofit		2L 1x4 T8 28w	1	44	0.044	24	365	8760	385	$44	$12	105	0.012
Existing	FD Kitchen	2L 1x4 T8 32w	1	56	0.056	24	365	8760	491	$56			
Retrofit	Add Sensor	2L 1x4 T8 28w	1	44	0.044	16	365	5840	257	$29	$27	234	0.012
Existing	Apparatus Bay	4L 2x4 T5 54w	5	216	1.08	20	365	7300	7,884	$903			
Retrofit	Add Sensor	4L 2x4 T5 54w	5	216	1.08	12	365	4380	4,730	$542	$361	3,154	0
Existing		2L 1x4 T8 32w	8	56	0.448	18	365	6570	2,943	$337			
Retrofit	Add Sensor	2L 1x4 T8 28w	8	44	0.352	18	365	6570	2,313	$265	$277	2,418	0.728
Existing		4L 2x4 T5 54w	4	216	0.864	18	365	6570	5,676	$650			
Retrofit		4L 2x4 T5 54w	4	216	0.864	18	365	6570	5,676	$650	$0	0	0
Existing	El. Mach Rm	2L 1x4 T8 32w	1	56	0.056	1	365	365	20	$2			
Retrofit		2L 1x4 T8 28w	1	44	0.044	1	365	365	16	$2	$1	4	0.012
Existing	Stg 1	2L 1x4 T8 32w	1	56	0.056	1	365	365	20	$2			
Retrofit		2L 1x4 T8 28w	1	44	0.044	1	365	365	16	$2	$1	4	0.012
Existing	Stg 2	2L 1x4 T8 32w	1	56	0.056	1	365	365	20	$2			
Retrofit		2L 1x4 T8 28w	1	44	0.044	1	365	365	16	$2	$1	4	0.012
Existing	Comm Rack Rm	2L 1x4 T8 32w	1	56	0.056	1	50	50	3	$0			
Retrofit		2L 1x4 T8 28w	1	44	0.044	1	50	50	2	$0	$0.1	1	0.012
Existing	Front Str	2L 2x2 T8 32w U	3	56	0.168	10	260	2600	437	$50			
Retrofit		2L 2x2 T8 25w U	3	39	0.117	10	260	2600	304	$35	$15	133	0.051
Existing		1L Wall CFL	3	13	0.039	10	260	2600	101	$12			
Retrofit		1L Wall CFL	3	13	0.039	10	260	2600	101	$12	$0	0	0
Existing	Back PD Str	2L 2x2 T8 32w U	3	56	0.168	24	365	8760	1,472	$169			
Retrofit		2L 2x2 T8 25w U	2	39	0.078	24	365	8760	683	$78	$90	788	0.09
Existing		1L Wall CFL	3	13	0.039	24	365	8760	342	$39			
Retrofit		1L Wall LED	3	9	0.027	24	365	8760	237	$27	$12	105	0.012
Existing	Back FD Str	2L 2x2 T8 32w U	3	56	0.168	24	365	8760	1,472	$169			
Retrofit		2L 2x2 T8 25w U	2	39	0.078	24	365	8760	683	$78	$90	788	0.09
Existing		1L Wall CFL	3	13	0.039	24	365	8760	342	$39			
Retrofit		1L Wall LED	3	9	0.027	24	365	8760	237	$27	$12	105	0.012
Red indicates estimate									Annual Total kWh	Annual kWh Cost	Potential Annual Savings	Annual kWh Saved	Potential Reduced kW
										$0.11			
Estimated Annual Lighting Usage and Cost									23,143	$ 2,650			
Table 3 Estimated Annual Lighting Savings											$ 981	8,568	1

4	Location	Fixture type	# of units	Watts per Unit	Max Total kW	Hrs/ Day	# of Days	Annual Operating Hours	Annual Total kWh	Annual kWh Cost	Potential Annual Savings	Annual kWh Saved	Potential Reduced kW
	Level 2									$0.11			
Existing	FD Hall 1 L2	2L 2x2 T12 34w U	2	80	0.16	24	365	8760	1,402	$160			
Retrofit	Add Sensor	2L 2x2 T8 25w U	2	39	0.078	12	365	4380	342	$39	$121	1,060	0.082
Existing		2L 2x2 T12 34w U	1	80	0.08	24	365	8760	701	$80			
Retrofit		2L 2x2 T8 25w U	1	39	0.039	24	365	8760	342	$39	$41	359	0.041
Existing		2L 2x2 T12 34w U	1	80	0.08	4	260	1040	83	$10			
Retrofit		2L 2x2 T8 25w U	1	39	0.039	4	260	1040	41	$5	$5	43	0.041
Existing	Bunk 1	2L 2x2 T12 34w U	1	80	0.08	4	365	1460	117	$13			
Retrofit		2L 2x2 T8 25w U	1	39	0.039	4	365	1460	57	$7	$7	60	0.041
Existing	Bunk 2	2L 2x2 T12 34w U	2	80	0.16	4	365	1460	234	$27			
Retrofit		2L 2x2 T8 25w U	2	39	0.078	4	365	1460	114	$13	$14	120	0.082
Existing	Wm's Room	2L 2x2 T12 34w U	2	80	0.16	2	365	730	117	$13			
Retrofit		2L 2x2 T8 25w U	2	39	0.078	2	365	730	57	$7	$7	60	0.082
Existing	Mn's Room	2L 2x2 T12 34w U	2	80	0.16	2	365	730	117	$13			
Retrofit		2L 2x2 T8 25w U	2	39	0.078	2	365	730	57	$7	$7	60	0.082
Existing	PD Hall 1 L2	2L 2x2 T12 34w U	3	80	0.24	10	260	2600	624	$71			
Retrofit		2L 2x2 T8 25w U	3	39	0.117	10	260	2600	304	$35	$37	320	0.123
Existing		2L 2x2 T12 34w U	3	80	0.24	10	260	2600	624	$71			
Retrofit		2L 2x2 T8 25w U	3	39	0.117	10	260	2600	304	$35	$37	320	0.123
Existing	Sm Conf Rm	2L 2x2 T8 32w U	3	56	0.168	2	260	520	87	$10			
Retrofit		2L 2x2 T8 25w U	2	39	0.078	2	260	520	41	$5	$5	47	0.09
Existing		1L Dwn Inc	4	120	0.48	2	50	100	48	$5			
Retrofit		1L Dwn CFL	4	15	0.06	2	50	100	6	$1	$5	42	0.42
Existing	PD Chief	3L 2x2 T8 32w U	4	86	0.344	6	260	1560	537	$61			
Retrofit		3L 2x2 T8 25w U	4	66	0.264	6	260	1560	412	$47	$14	125	0.08
Existing	PD Lt	3L 2x4 T12 34w	3	130	0.39	6	260	1560	608	$70			
Retrofit		2L 2x4 T8 28w	3	50	0.15	6	260	1560	234	$27	$43	374	0.24
Existing	Admin	3L 2x4 T12 34w	3	130	0.39	10	260	2600	1,014	$116			
Retrofit		2L 2x4 T8 28w	3	50	0.15	10	260	2600	390	$45	$71	624	0.24
Existing	Detectives Ent	3L 2x4 T12 34w	1	86	0.086	10	260	2600	224	$26			
Retrofit		2L 2x4 T8 28w	1	66	0.066	10	260	2600	172	$20	$6	52	0.02
Existing	Interview 1	4L 2x4 T12 34w	1	160	0.16	4	260	1040	166	$19			
Retrofit		2L 2x4 T8 32w	1	53	0.053	4	260	1040	55	$6	$13	111	0.107
Existing	Interview 2	3L 2x4 T12 34w	1	160	0.16	2	260	520	83	$10			
Retrofit		2L 2x4 T8 28 w	1	53	0.053	2	260	520	28	$3	$6	56	0.107
Red indicates estimate									Annual Total kWh	Annual kWh Cost	Potential Annual Savings	Annual kWh Saved	Potential Reduced kW
										$0.11			
Estimated Annual Lighting Usage and Cost									6,785	$ 777			
Table 4 Estimated Annual Lighting Savings											$ 439	3,832	2

5	Location	Fixture type	# of units	Watts per Unit	Max Total kW	Hrs/ Day	# of Days	Annual Operating Hours	Annual Total kWh	Annual kWh Cost	Potential Annual Savings	Annual kWh Saved	Potential Reduced kW
										$0.11			
Existing	Detectives	3L 2x4 T12 34w	3	86	0.258	10	260	2600	671	$77			
Retrofit	Add Switch Multi	3L 2x4 T8 28w	3	53	0.159	10	260	2600	413	$47	$29	257	0.099
Existing	Lab 2-Swithes	3L 2x4 T12 34w	3	86	0.258	4	50	200	52	$6			
Retrofit		3L 2x4 T8 28w	3	53	0.159	4	50	200	32	$4	$2	20	0.099
Existing	Evidence/ Rack	2L 1x4 T12 34w	4	80	0.32	2	260	520	166	$19			
Retrofit		2L 1x4 T8 28w	4	44	0.176	2	260	520	92	$10	$9	75	0.144
Existing	Dark Rm	2L 2x2 T12 34w U	1	80	0.08	1	50	50	4	$0			
Retrofit		2L 2x2 T8 25w U	1	39	0.039	1	50	50	2	$0	$0	2	0.041
Existing	PD Mn's Lkr Rm	3L 2x4 T12 34w	2	130	0.26	20	365	7300	1,898	$217			
Retrofit	Sensor	2L 2x4 T8 28w	2	53	0.106	8	365	2920	310	$35	$182	1,588	0.154
Existing		3L 2x4 T12 34w	1	130	0.13	20	365	7300	949	$109			
Retrofit	Sensor	3L 2x4 T8 28w	1	74	0.074	8	365	2920	216	$25	$84	733	0.056
Existing		3L 2x4 T8 32w	1	86	0.086	20	365	7300	628	$72			
Retrofit		3L 2x4 T8 28w	1	74	0.074	8	365	2920	216	$25	$47	412	0.012
Existing	PD Wn's Lkr Rm	4L 2x4 T12 34w	1	160	0.16	2	260	520	83	$10			
Retrofit		4L 2x4 T8 28w	1	86	0.086	2	260	520	45	$5	$4	38	0.074
Existing		2L 1x4 T12 34w	1	80	0.08	2	260	520	42	$5			
Retrofit		2L 1x4 T8 28w	1	44	0.044	2	260	520	23	$3	$2	19	0.036
Existing	PD Hall 2 L2	2L 2x2 T12 34w U	4	80	0.32	10	260	2600	832	$95			
Retrofit		2L 2x2 T8 25w U	4	39	0.156	10	260	2600	406	$46	$49	426	0.164
Existing	PD Hall 2 L2	2L 2x2 T12 34w U	2	80	0.16	10	260	2600	416	$48			
Retrofit		2L 2x2 T8 25w U	2	39	0.078	10	260	2600	203	$23	$24	213	0.082
Existing		2L 2x2 T12 34w U	2	80	0.16	24	365	8760	1,402	$160			
Retrofit	Sensor	2L 2x2 T8 25w U	2	39	0.078	16	365	5840	456	$52	$108	946	0.082
Existing	Str Hall	2L 2x2 T12 34w U	1	80	0.08	24	365	8760	701	$80			
Retrofit		2L 2x2 T8 25w U	1	39	0.039	24	365	8760	342	$39	$41	359	0.041
Existing	Stg	2L 1x4 T12 34w	1	80	0.08	1	260	260	21	$2			
Retrofit		2L 1x4 T8 28w	1	39	0.039	1	260	260	10	$1	$1	11	0.041
Existing	Janitor	2L 1x4 T12 34w	1	80	0.08	3	260	780	62	$7			
Retrofit		2L 1x4 T8 28w	1	39	0.039	3	260	780	30	$3	$4	32	0.041
Red indicates estimate									Annual Total kWh	Annual kWh Cost	Potential Annual Savings	Annual kWh Saved	Potential Reduced kW
										$0.11			
Estimated Annual Lighting Usage and Cost									7,926	$ 908			
Table 5 Estimated Annual Lighting Savings											588	5,132	1

6	Location	Fixture type	# of units	Watts per Unit	Max Total kW	Hrs/ Day	# of Days	Annual Operating Hours	Annual Total kWh	Annual kWh Cost	Potential Annual Savings	Annual kWh Saved	Potential Reduced kW
										$0.11			
Existing	Rest Rm	2L 1x4 T12 34w	1	80	0.08	2	260	520	42	$5			
Retrofit		2L 1x4 T8 28w	1	39	0.039	2	260	520	20	$2	$2	21	0.041
Existing	Community Rm	3L 2x4 T12 34w	9	130	1.17	8	150	1200	1,404	$161			
Retrofit		3L 2x4 T8 28w	9	74	0.666	8	150	1200	799	$92	$69	605	0.504
Existing	Kitchenette	2L 2x2 T12 34w U	1	80	0.08	3	260	780	62	$7			
Retrofit		2L 2x2 T8 25w U	1	39	0.039	3	260	780	30	$3	$4	32	0.041
Existing	Sgt	3L 2x4 T12 34w	1	130	0.13	6	260	1560	203	$23			
Retrofit		3L 2x4 T8 28w	1	74	0.074	6	260	1560	115	$13	$10	87	0.056
Existing	IT	4L 2x4 T12 34w	1	160	0.16	6	260	1560	250	$29			
Retrofit		2L 2x4 T8 28w	1	53	0.053	6	260	1560	83	$9	$19	167	0.107
Existing	FD Chief	2L 2x2 T12 34w U	2	80	0.16	10	260	2600	416	$48			
Retrofit		2L 2x2 T8 25w U	2	45	0.09	10	260	2600	234	$27	$21	182	0.07
Existing	Stg Abv App Bay	2L 1x4 T12 34w	6	80	0.48	2	260	520	250	$29			
Retrofit		2L 1x4 T8 28w	6	39	0.234	2	260	520	122	$14	$15	128	0.246
Existing	AHU Rm	2L 1x4 T12 34w	2	80	0.16	1	50	50	8	$1			
Retrofit		2L 1x4 T8 28w	2	39	0.078	1	50	50	4	$0	$0.5	4	0.082
	Exterior												
Existing	Parking Lot Ltg's	1L MH 400 w	6	458	2.748	12	365	4380	12,036	$1,378			
Retrofit		1L LED 150 w	6	150	0.9	12	365	4380	3,942	$451	$927	8,094	1.848
Existing		1L MH 250 w	2	293	0.586	12	365	4380	2,567	$294			
Retrofit		1L LED 90 w	2	90	0.18	12	365	4380	788	$90	$204	1,778	0.406
Existing	App Bay OH Dr	1L MH 175 w	3	210	0.63	12	365	4380	2,759	$316			
Retrofit		1L LED 52 w	3	60	0.18	12	365	4380	788	$90	$226	1,971	0.45
Existing	PD Gorge Drs	1L MH 175 w	2	210	0.42	12	365	4380	1,840	$211			
Retrofit		1L LED 26 w	2	30	0.06	12	365	4380	263	$30	$181	1,577	0.36
Existing	Wall pack	1L MH 175 w	1	210	0.21	12	365	4380	920	$105			
Retrofit		1L LED 26 w	1	30	0.03	12	365	4380	131	$15	$90	788	0.18
Existing	Man Dr Ltgs	1L Inc	3	75	0.225	12	365	4380	986	$113			
Retrofit		1L LED 10 w	3	13	0.039	12	365	4380	171	$20	$93	815	0.186
Existing	Flag Pole Ltg	1L HPS 100 w	1	130	0.13	8	150	1200	156	$18			
Retrofit		1L LED Spot	1	22.5	0.023	8	150	1200	27	$3	$15	129	0.1075
Existing	Bollards	1L CFL	6	130	0.78	8	150	1200	936	$107			
Retrofit		1L CFL	6	22.5	0.135	8	150	1200	162	$19	$89	774	0.645
Red indicates estimate									Annual Total kWh	Annual kWh Cost	Potential Annual Savings	Annual kWh Saved	Potential Reduced kW
										$0.11			
Estimated Annual Lighting Usage and Cost									23,897	$ 2,736			
Table 6 Estimated Annual Lighting Savings											$ 1,964	17,153	5

These tables are for informational purposes only. Always consult your lighting professional before specifying a new technology for your facility.

The estimated annual savings are based on a general walk through of the building and the reported operating hours.

Detailed energy savings should be determined by your electrician, supplier or manufacturer before a purchase is completed.

Your electrician, supplier or manufacturer must confirm that the proposed lighting meets the Efficiency Maine prescriptive cash incentives.

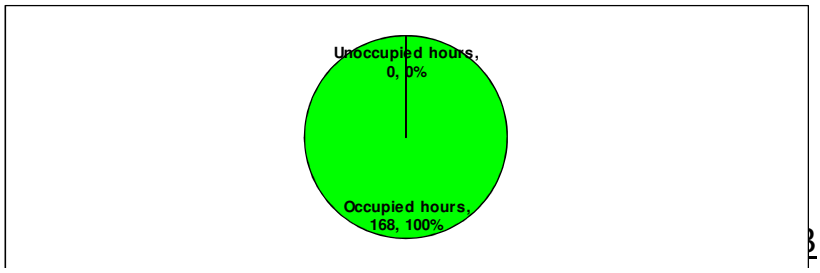
You can find Efficiency Maine incentives at www.efficiencymaine.com/pdfs/Prescriptive-Cash-Incentives.pdf.

Summary Lighting Table

	Location	Fixture type	# of units	Watts per Unit	Max Total kW	Hrs/ Day	# of Days	Annual Operating Hours	Annual Total kWh	Annual kWh Cost	Potential Annual Savings	Annual kWh Saved	Potential Reduced kW
										$0.11			
Estimated Annual Lighting Usage and Cost									81,067	$ 9,282			
TOTAL Estimated Annual Lighting Savings											$ 5,247	45,534	12
Estimated Carbon Dioxide (CO2) Savings Tons Per Year												35.7	

Based on 168 hours in a week

Occupied hours	Unoccupied hours
168	0



7. Mechanical Systems

The mechanical systems are comprised of the heating, air conditioning, controls, ventilation and domestic hot water systems. The building can be looked at as two building spaces; the Apparatus Bay and the main building. The Apparatus Bay is heat is supplied from the boiler through piping to three ceiling hung unit heaters. Is controlled by a thermostat acting as a sensor which activates the unit heaters. The area is not part of the air conditioning or ventilation system. The space has its own newer vehicle exhaust system for the equipment located in the Apparatus Bay. The main building has hydronic heat, air conditioning, ventilation, domestic hot water and a central control system. Within the main building the former dispatch area and server room have newer mini split systems for air conditioning. The heating system is separate from the air conditioning and ventilation system; however they both share a common control system.

Because of the nature of the building's use portions of the building are in service 24/7, although at a reduced rate. The system was designed to serve the design load for the building but the majority of the time the building is under partial load, usually 60% or less. The HVAC systems do not operate as efficiently under partial loads. The goal is to match the supply to the load and therefore reducing the operation of the equipment, saving energy and wear on the equipment.

The focus of the review will be on the heating system the central air conditioning and ventilation system and the controls which are old, antiquated, inefficient and at the end of or approaching the end of their useful life.

7.1 Heating System

The heating system is a forced hot water system using fin tube in the office area and unit heaters in the garages and apparatus bay. The heat source is a736, 000 Btu (gross) Burnham model PF-505 boiler with a two stage Carlin 701 CRD burner, firing at 2.25 gph on low and 3.25 gph on high. The burner is reported to shoot up on low fire, but the boiler is 22 years old and approaching the end of its useful life, which is in the 20 to 25 year range. The seasonal efficiency is estimated to be in the 50% to 65% range based on industry studies.

The system is a single primary loop two pipe arrangement that feeds various terminal heating devices; cabinet unit heaters, ceiling hung unit heaters and fin tube base board. The terminal devices are piped from the supply line and piped back to the return line. The flow from the supply line to the terminal heating devices is controlled by zone valves with local thermostats acting as sensing devices. The hot water in the primary loop is controlled by an outdoor reset and the high low setting on the boiler aqua stat. The original design was based on the concept

that the exterior loop along with the interior heat gains would provide enough heat that interior spaces would not require radiation. In some interior spaces this did not work and supplemental baseboard was added controlled by thermostatic valves mounted on the based board.

During the audit the system was found to be over heating resulting, in simultaneous cooling and heating. There was a variation of temperature in spaces, such as the FD day room reading 77.5^0, with an open window reading and a thermostat set at 59^0. The control system is old, antiquated and wasting energy.

Two primary issues are the age and efficiency of the boiler and the control system. Another issue is the single and long primary loop that feeds the system.

Replacing the boiler is the first consideration. Preliminary heat load calculations estimates the heat loss for the building is around 385,000 Btu without consideration for heat loss at the doors, particularly the overhead doors when they are opened and closed. The current high fire nozzle on the boiler is 3.25 gph on high fire which equates to 455,000 btu's per hour. This is in line with the heat loss of 20% boiler efficiency is assumed, which would size the boiler at about 480,000 btu/hr.

Natural gas is within a half mile of the building and every effort should be made to extend it to the building. For 2010/2011 heating season the building required 882 MMBtu. Based on the price of natural gas used at the Town Office, natural gas cost the town $15/mmbtu and the #2 fuel cost for the town at the Public Safety Building was $25/MMBtu. That is a $10/MMBtu difference or 40% less per MMBtu. Bringing natural gas to the building without any improvements has the potential to save an estimated $8,880/ year.

Installing a new properly sized triple pass boiler with an AFUE of 85, gas or oil, should improve the fuel usage by an estimated 12%. A boiler typically operates at 20% to 60% load for about 90% of the time and at 60% load for about 55% of the time. Installing two boilers that would handle 60% of the load and stage them is estimated to save 15% in fuel usage or 950 gallons and $3,325 at the current price of $3.50/gallon the town is paying. If the second boiler added $10 to $12k to the cost of replacement it would pay for itself in 3 to 4 years and extend life to the system.

Replacing the existing control system with a new system is estimated to improve fuel usage by 10% to 15%. The system should have an outdoor reset, be interfaced with the space temperature sensors and water temperature of the system. This would be an integrated system that will optimize boiler run and circulation time. In addition the thermostats should all be replaced with programmable thermostats that can interface with new DDC controls.

The final recommendation is to modify the piping and split the loop into two sections. From the point near the sally port on the NW side back to the apparatus bay to the boiler would be one zone and from the sally port to the back side of the building to the boiler would be the second zone. How to quantify the savings would take an engineering review more in depth than this audit calls for but there would be some energy savings, plus reduction on equipment ware and better thermal comfort. It would also help prevent simultaneous heating and cooling. If the system is modified or not the circulating pumps are recommended to be replaced with variable speed drives (VFD's). This is estimated to reduce the electrical consumption of the circulating pumps by 30% or more.

A replacement plan should be in place for the boiler since it could need major repairs or replacement in the near future. The other significant measure that should be under taken is to improve the building envelope which would allow the size of the boiler to be reduced by an estimated 10%.

Replacement of the control system is recommended and will be discussed further in the control section

Below is a table showing the dollar reduction in fuel costs based up on a percentage improvement in fuel use. This table only pertains to # 2 fuel burned by the boiler.

Estimated Fuel Oil Savings for Your Building Based on Cost Per Gallon						
Gallons of fuel oil used 2010/2011	6,302					
Fuel oil cost per gallon	$3.50	$3.50	$4.00	$4.50	$4.75	$5.00
10 percent savings	$2,206	$2,206	$2,521	$2,836	$2,993	$3,151
15 percent savings	$3,309	$3,309	$3,781	$4,254	$4,490	$4,727
20 percent savings	$4,411	$4,411	$5,042	$5,672	$5,987	$6,302
25 percent savings	$5,514	$5,514	$6,302	$7,090	$7,484	$7,878
30 percent savings	$6,617	$6,617	$7,562	$8,508	$8,980	$9,453

7.2 Air Conditioning

The air conditioning consists of a split system for the main part of the building and two mini-splits. The split system has two air handling units (AHU) located in the mechanical room above the apparatus bay and the condensing units outside the SW corner of the apparatus bay. Both of the units are Trane's, AHU #1 is a 12 ton which serves the upper floor and unit #2 is a 7 ton that serves the ground floor. Similar to the boiler they are 21 years old and showing their age, especially the condensing units that are outside. The Energy Efficiency Ratio (EER) is estimated to be 7.5 for Unit #1 and 7.8 for unit # 2 assuming they are in good condition. This is an efficiency rating for air conditioners over 5 tons and the current energy code calls for an EER of 11. This makes the 12 ton unit 25% and the 7 ton unit 22% below the current standards. The system does have economizers that are working and will provide free cooling under the right conditions. The system is controlled by five thermostats, two on the 1st floor and one located on the NW and on located on the SE side of the building. On the second floor the arrangement is similar but a third thermostat is located in the small conference room. The control system is part of the building controls, which is antiquated and does not offer efficient control of the air conditioning. The estimated cost of the air conditioning is $1,506.00, represents 13,696 kWh and 7% of the electric bill. This does not include the cost of the mini-split system that are more heat driven by the equipment in the spaces they serve. Because of the nature of the building's use portions of the building are in service 24/7, although at a reduced rate.

A split air conditioning system is a good system and suited for the building, but as sated the present system is antiquated and old. A newer split system that is more efficient and has improved control capabilities is recommended when the time comes for replacement. Considering the condition of the system a replacement plan should be in place. In addition the present layout of the system has limited zoning and this should be improved.

The new system should meet the 2009 Energy Code and ASHRAE 90.1-2007 criteria. The condensing unit should be two staged cooling, scroll compressors, efficient fan motors and 410 refrigerants. The Indoor AHU should have and economizer, premium efficient motors and a VFD to better match the supply to the load. The condenser and AHU should be properly matched, both capable of operating with DDC controls and be properly sized.

Some of the spaces operate 24/7 as mentioned earlier and maybe part of a larger zone that would operate around the clock to keep a smaller area cooled. Other areas are having a low occupancy rate during the typical daytime hours. The former dispatch area received has a

mini split, if that space is to change use and not require dedicated cooling, utilizing the mini split in the reports area that has 24/7 use should be considered. The sleeping quarters and day room are other areas that could be served by a mini split system and provide cooling during the day or night 7 days a week. These measures would reduce the load on the central system, provide individual cooling and be use specific. It is recommended to install motorized dampers in spaces that have varied use and are interlocked with an occupancy sensor that can throttle back the CFM should be considered. Areas such as the detectives, 2nd floor sergeants and community room are suggested.

Replacement of the controls that serve the AC is recommended and will be discussed further in the control section. Replacing the existing control system with a DDC Building Automation System is estimated to improve electrical usage by 10% to 15%.

The two standalone mini split air conditioners are Sayno model CLM2472 providing 24,000 Btu's. One serves the former dispatch area and has two outlets. The other serves the second floor server room that also acts as an evidence room and has a single outlet. Both are new, efficient and are in good condition.

7.3 Ventilation

The ventilation for the main building is part of the AC system and is understood to provide outside air for the heating system. The present system does provide outside air for ventilation but it is not known if it complies with the present code requirements. Replacement and improvement of the ventilation will be part of the AC system upgrade with the exception of how it is controlled and any associated devices. The system should be capable of meeting the outdoor air requirements in accordance with ASHRAE 62.1-2007. The minimum requirement is roughly 500 cfm, but should be properly calculated when sizing replacement equipment. It is recommended that a heat recovery unit be part of the system to reduce the preheat for outside air during cold weather. Approximately 30 to 40% of the heat in exhaust air can be recovered. The ventilation system shall be controlled by the BAS and is discussed in more detail in the controls section.

If the sleeping quarters are converted to mini split system for air conditioning a separate ventilation system will need to be installed that will have a minimum requirement that is roughly 40 cfm, but should be properly calculated when sizing replacement equipment. This can be controlled locally through and occupancy and temperature sensor.

The rest rooms and locker rooms have local exhaust systems that appear to provide adequate ventilation and complied with code when the building was built.

Installing "de-stratification" thermal equalizing fans in the Apparatus Bay is recommended. These fans use new air flow technology that collimates the air from the ceiling and transports it to the floor creating thermal equalization more efficiently than ceiling fans. They can provide comfort and reduce energy consumption in facilities with high ceilings.

Ceiling fans mix the air, but in high bay areas they typically do not mix the air at the lower levels (where the people are). The new turbo fans take up significantly less room than a ceiling fan and they are very effective at reducing dead zones, cold spots and hot spots within the room. The turbo fans stabilize the temperature in the entire air column and reduce the heat/cool on/off cycle that is typical in high bay spaces.

It is also important to understand that the thermostats are typically installed at approximately five feet above the finished floor. Rooms with high ceilings have to heat the entire air column to satisfy the thermostat setting which typically results in a peak ceiling temperature that is 5 to 10 degrees warmer than the floor temperature. Therefore, thermal equalization enhances comfort and reduces energy consumption.

This technology may help in reducing heating cost. Many business owners have reported reduced energy consumption (between 10% to 30%) after installing these de-stratification fans.

This technology can be viewed at: http://www.mainegreenbuilding.org/Instance-20.html .

Airius Thermal Equalizers							
Model	Height	Diameter	Weight	Watts @ 60 Hz	Volts	Coverage*	Ceiling Height*
10	22 in.	13 in.	12 lbs.	15	120/230	1200 sq. ft.	Up to 12 feet
15	22 in.	13 in.	12 lbs.	17	120/230	1200 sq. ft.	Up to 18 feet
25	22 in.	13 in.	12 lbs	35	120/230/277	1200 sq. ft	Up to 30 feet
35	22 in.	13 in.	12 lbs.	76	120/230/277	1200 sq. ft.	Up to 40 feet

7.4 Domestic Hot Water

Hot water is provided by an indirect 65 gallon hot water tank by Vaughan Manufacturing with an electric element that can be used for heating hot water during the summer months when the boiler is not operating. Hot water is supplied 24 hour per day 7 days and installing a timer is not practical. The tank is in good condition and provides hot water in an economical fashion considering the operation of the building.

View of the 65 gallon indirect hot water tank

The table below shows the estimated possible peak and gallons per day of hot the building uses. It is not likely that every fixture that could use hot water would be on at once and 50% to 70% of the possible peak use is more likely.

Estimated Hot Water Peak Demand and Yearly Use						
Fixture	**Units**	**Gals per minute**	**mins / day**	**gals / day**	**days / year**	**Gal Year**
Kitchen Sink	3	1.5	10	45	300	13500
Utility Sink	1	1.5	7	10.5	300	3150
Restroom Sink	9	0.5	5	22.5	300	6750
Dishwasher	1	2	15	30	300	9000
Room showers	5	2	5	50	365	18250
Peak use in gallons per minute (all fixtures on simultaneously)						22.5
Estimated total gallons of hot water per year						**32,400**
Days per year hot water is used						**300**
Estimated gallons of hot water used per day						**108**
These are estimates based on the number of fixtures and estimated use.						
Actual domestic hot water usage should be calculated by the supplier who is proposing the equipment.						

No recommendation is made regarding the domestic hot water.

7.5 HVAC System Controls

As stated the controls for the system are old, antiquated, do not work properly and in-efficient. It is recommended that a new DDC Building Automation System be installed. The advancement and cost effectiveness of new digital controlled systems make them feasible for retrofitting buildings such as the Public Safety Building. A Distributed Direct Digital Control System is best suited for the HVAC system because of the different heating and air conditioning/ventilation components. Each component will have a dedicated controller (CPU) which will be tied to a network communications module and can accommodate a PC or modem for monitoring and control purposes. The system should accept modules, be expandable and an open protocol. The system should be primarily a closed and proportional/integral loop. The system should set priorities for the control in ascending order; safety, reliability, control and regulation and energy efficiency.

The audit is not meant to provide specification for the control system and the typical functions are part of the present system. However, a number of points should be made regarding considerations to be incorporated into the system. The recommendations below assume that the improvements to the HVAC system will be made at some time.

7.5 HVAC System Recommendations

1. **Heating System**
    a. **The outdoor reset control should have an indoor temperature sensor and have a minimum temperature setting. This will allow the reset to take into account to compensate for inter gains, give feedback on indoor temperature and prevent the boiler from running from running below a specified hot water return temperature that could cause condensing.**
    b. **The system control for the circulating pump should operate not only when the outdoor reset calls for heat but when one or more of the thermostats are calling for heat in combination with the reset.**
    c. **When VFD is installed on the circulating pump the system should control it to match the pump load.**
    d. **The system should be able to monitor and learn from the operation by shutting off the boiler, allowing the circulator to run with the residual heat in the hot water satisfying the space temperature requirement.**
    e. **The system should be able to alternate circulating pump operation automatically some run time is equalized.**
    f. **If two boilers are installed as a replacement the system should stage the boilers and when only one boiler is operated equalize the run time.**

g. **The system should be able to shut off the unit heaters if the OH door is left open for more than 10 minutes when the area is in a heating mode and send an alarm.**

2. **Air conditioning, economizer and ventilation:**
   a. **The system should use enthalpy control to sense not only temperature but moisture before operating the economizer and lock out the economizer if the criteria is not met. This measure should be able to lock out the air conditioning when the economizer is operating.**
   b. **The system should use enthalpy control to sense not only temperature but moisture before operating the economizer. It should also the control the moisture of return and outside air.**
   c. **Installing occupancy sensors that will adjust motorized dampers to set back mode.**
   d. **The system should control the VFD on the supply fan to match the load.**
   e. **The system should be interface with the AC and economizer, adjust the cfm to design standard, cut it back to minimum and go into unoccupied mode.**

7.5 HVAC System Summary

Based on the field visit and subsequent review replacing the boiler and controls is the most urgent and provides the best opportunity for savings. The control system should have the capability to accommodate any subsequent measures as they are added on to the system. The next measure would be to replace the air conditioning, economizer and ventilation portion of the system. Installing a mini split ac and dedicates ventilation system for the sleeping quarters would be next. The final measure would be to divide the main loop of the heating loop into two smaller loops.

If natural gas is not available when the boiler is replaced than the boiler selection should be one that has a dual fuel capability or can have the burner change to a natural gas burner.

8. Elevator

The elevator was reviewed but because of minimal use and it good condition no further action is recommended.

9. Electronic Equipment

Based on the computer, copier and count of other periphery equipment, it is estimated that the buildings office equipment uses about 20,202 kWh per year or 10% of the electrical usage. The office and computer area has 24 computers and monitors which can account for 50% to 60 % of the power used for office equipment. The settings and hours of use for the computers could not determined during the audit because of the different departments and varied use. However, listed below is some information regarding procedures for savings and some examples of the type of savings that can be realized by following the recommended procedures.

The DOE through Energy Star has a Computer Power Management program for businesses both large and small, which can be accessed through www.energystar.gov/powermangement.

By setting your equipment to the standby or hibernate mode it is reported, based on historical data, that $25 to $75 per station can be saved.

Most new office equipment is Energy Star compliant and has energy saving software installed. Consult your manual for activating this feature.

In addition Smart Strips can shut off your equipment when not being used. These strips can operate manually, by motion or timer and can be purchased on the internet. They also can provide surge protection.

Simply shutting off the computer monitor when not in use saves the equivalent of turning off a 60 to 100 watt light bulb. "Screen Savers" require as much energy as leaving your monitor on. "Sleep" mode lowers energy consumption to about 25 watts or less. Establish an office policy to shut down all non-essential computers nightly (i.e., servers and computers that are not externally accessed after office hours). See table below for a typical desktop computer savings.

You can expect potential annual savings from $23-150 a year per computer by simply shutting the computer off at the end of the work day and programming the sleep mode during the work day. Examples below:

The first example is a computer left on 24/7. The retrofit illustrates potential savings by turning the computer off at the end of each work day of 8 hours and on the weekends.

	Location	Unit Type	Number of Units	Watts per Unit	Total kW	Hours/ day	Number of Days	Annual Operating Hours	Total kWh	Annual Cost @ $.15/kWh	Potential Annual Savings	Annual kWh Saved
Existing	Office	Computer on 24 hrs/day/7 days	1	150	0.15	24	365	8760	1314	$197		
Retrofit	Office	Computer on 8 hrs/day/5 days	1	150	0.15	8	260	2080	312	$47	$150	1002
										SAVINGS	$150	1002
The energy consumption is an estimate: computer towers at 75 watts and monitors at 75 watts based on average published energy usage.												
The assumption is that the screen saver is not selected and is on the same amount of time the computer is on.												
There were no actual energy measurements taken on any of the electronic equipment.												

The second example shows a computer left on for the duration of the work week but shut off for the weekend. The retrofit illustrates potential savings by turning the computer off at the end of each work day and on the weekends.

	Location	Unit Type	Number of Units	Watts per Unit	Total kW	Hours/ day	Number of Days	Annual Operating Hours	Total kWh	Annual Cost @ $.15/kWh	Potential Annual Savings	Annual kWh Saved
Existing	Office	Computer on 24 hrs/day/5 days	1	150	0.15	24	260	6240	936	$140		
Retrofit	Office	Computer on 8 hrs/day/5 days	1	150	0.15	8	260	2080	312	$47	$94	624
										SAVINGS	$94	624
The energy consumption is an estimate: computer towers at 75 watts and monitors at 75 watts based on average published energy usage.												
The assumption is that the screen saver is not selected and is on the same amount of time the computer is on.												
There were no actual energy measurements taken on any of the electronic equipment.												

The last example shows a computer on 8 hours a day for a 5 day work week versus a computer programmed for sleep mode with an average on-time of 4 hours a day for a typical 5 day work week.

	Location	Unit Type	Number of Units	Watts per Unit	Total kW	Hours/ day	Number of Days	Annual Operating Hours	Total kWh	Annual Cost @ $.15/kWh	Potential Annual Savings	Annual kWh Saved
Existing	Office	Computer on 8 hrs/day/5 days	1	150	0.15	8	260	2080	312	$47		
Retrofit	Office	Computer sleep mode on 4 hrs/day/5 days	1	150	0.15	4	260	1040	156	$23	$23	156
										SAVINGS	$23	156
The energy consumption is an estimate: computer towers at 75 watts and monitors at 75 watts based on average published energy usage.												
The assumption is that the screen saver is not selected and is on the same amount of time the computer is on.												
There were no actual energy measurements taken on any of the electronic equipment.												

As you can see, it is important to have an office policy regarding computers. Education is a key component in achieving savings with computers such as publishing the potential savings

on the employee bulletin board. In a typical office, people attend meetings, take coffee and lunch breaks, etc. which are all opportunities for computer energy savings.

There are a number of measures that may be applicable to help you generate and sustain energy savings such as ensuring copy machines and other equipment are programmed for sleep modes. Therefore, standing by the copier waiting for the 30 second warm up period can result in energy savings. Ensuring the copier machine is off or programmed for sleep mode after hours and weekends will result in significant savings.

10. Miscellaneous Equipment

The station has two vending machines, one that has refrigeration. It is recommended to install vending misers on each machine

A typical vending machine consumes approximately $300 of electricity per year. By using a Vending Miser http://www.vendingmiserstore.com, you can reduce electricity use of each cold drink vending machine by an average of 40%. Since the drink dispenser vending machine is a refrigerator, the heat exhausted from the condensing coil in the back of the vending machine can reach over 100ºF. This adds to the heat load of the building. Ensure the machine does not get placed next to a thermostat, ice machine, etc.

View of vending machine in apparatus bay

Vending Machines		
Pepsi Machine (2)		
Estimated Annual Savings		$418.00
Miser Cost		$350.00
Simple Payback- yrs		0.84