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2. Project Description

The building, built in 1973, is a one story building with a mezzanine sitting on a slab on grade concrete foundation with a sub wall. The foot print of the building is 6,930 square feet (s.f.) and the area with the mezzanine is 8,000 s.f. The front entrance of the building faces a north easterly direction. The frame is rolled form steel panels with vertical walls and an arched roof. The exterior walls are exposed metal with either spray foam or a wood frame with drywall on the interior face. The office/ day room area has a block wall common to the apparatus bay with a drywall finish on the interior space. The ceiling is a dropped acoustical tile suspended from a slab on metal deck at the office day room area and exposed metal at the apparatus bay. The mezzanine is open except for two dry wall portioned rooms on the north easterly end. The office/day room area has VCT floors and the apparatus bay is sealed concrete.

The building presently serves as a fire station for the town and operates 12 hrs. per day, 7 days per week.

3. Executive Summary

3.1 Introduction:

This report details the recommendations and findings of the audit report conducted for the Windham North Fire Station located at 718 Roosevelt Trail in Windham, Maine. The site visit was conducted on December 15, 2011. At that time John Monaghan met with Facilities Manager David Dickson and Deputy Fire Chief Wescott.

This assessment recommends (20) Energy Conservation Measures (ECMs) that address the electric and heating fuel usage, increasing comfort and reducing costs. Details of the findings and recommendations are contained in the assessment.

The priorities are to install CFL's, apply air sealing, add an energy miser at the vending machine, change the exterior lights to LED fixtures, install a gas fired tankless hot water system, add an outdoor reset, install programmable thermostats, replace the refrigerator, replace the T12 fixtures with T8's, add rigid insulation at the slab edge, and replace the attic ceiling insulation. Other improvements to consider are developing a boiler replacement plan, insulating the concrete stub wall, adding sensors to the apparatus bay light fixtures and reducing wattage, weather stripping the overhead doors, and replacing the air conditioners with mini splits.

3.2 Identified Energy Conservation Measures:

1. Building Envelope Improvements

a. **Provide general air sealing throughout the building**
b. **Install1" of rigid (XPS) insulation at the perimeter of the exterior slab.**
c. **Install 1.5 " of rigid (XPS) insulation with a protective coating or board at the exterior perimeter of the stub wall**
d. **Remove the blown in fiberglass insulation, install 1" of closed cell spray foam insulation and blow in 8" of cellulose insulation in the attic space. Install air barrier at the gable end wall vents if needed**
e. **Weather strip and insulate the attic access hatch with 4" of rigid (XPS) insulation**
f. **Replace weather stripping at the overhead doors**

2. Energy Efficient Lighting

a. **Replace the existing T12 fixtures with T8's**
b. **Reduce lighting levels by replacing T8 32 watt lamps with 25 or 28 watt lamps where indicated when lamps need replacement**
c. **Reduce lighting levels in the apparatus bay by replacing T5 54 watt lamps with 49 or 51 watt lamps where indicated when lamps need replacement**
d. **Install occupancy sensors where indicated in the lighting table**
e. **Replace incandescent bulbs with CFL's bulbs**
f. **Replace the HPS and CFL exterior fixtures with LED fixtures**

3. HVAC System

a. **Develop a boiler replacement plan. Options include:**

1. Install 2 modulating condensing boilers that can handle 60% of the load and can be staged

2. Split the system so the office/ day room area is heated by a modulating condensing boiler and the apparatus bay is heated by gas fired ceiling hung units. The boiler can also provide domestic hot water

3. When the present boiler is in need of replacement install a midrange triple pass conventional boiler that has a minimum AFUE (Annual Fuel Utilization Efficiency) of 85%

b. **Install a boiler outdoor reset**
c. **Replace existing thermostats with programmable thermostats**
d. **Install four thermal equalizers in the apparatus bay**
e. **When the window air conditioners are in need of replacement install a mini split system**
f. **Replace the existing coil/indirect hot water tank with a natural gas fired on demand tankless system**

5. **Miscellaneous**
   a. **Replace the existing refrigerator with an Energy Star unit**
   b. **Install Vending Misers on the vending machine**

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, and some have been combined.

Windham North Fire Station 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	$ 216	5.06	18.8	**1.3**	$ 1,800	**8.3**	3.6
Install1" of Rigid Insulation at Slab on Grade Edge	$ 218	5.8	9.4	**0.7**	$ 1,638	**7.5**	4.0
Install1.5" of Rigid Insulation at Stub Wall	$ 162	3.8	18.9	**1.3**	$ 2,200	**13.6**	2.2
Install 1" of Foam insulation & Blow in 8" of Cellulose in Attic	$ 1,617	340	51.1	**3.7**	$ 19,750	**12.2**	2.46
Weather Strip OH Door	$ 165	1	1.1	**0.1**	$ 791	**4.8**	1.25
Subtotal	**$ 2,378**	**356**	**99**	**7.10**	**$ 26,179**	**11.0**	2.27
Lighting							
Replace T12's with/ 25w T8's Fixtures	$ 95	679		**0.3**	$ 360	**3.8**	3.96
Install Sensors, and replace 32W T8 lamps w/ 25w lamps *	$ 200	1,429		**0.7**	$ 278	**1.4**	3.60
Install Sensors, and replace 54W T5 Lamps with 51w lamps *	$ 359	2,564		**1.3**	$ 1,925	**5.4**	1.49
Replace Incandescent with CFL's	$ 35	250		**0.1**	$ 9	**0.3**	19.44
Exterior							
Replace HPS fixtures with LED	$ 182	1,300		**0.7**	$ 364	2.0	5.00
Lighting Subtotal	**$871**	**6,222**		**3.2**	**$2,936**	**3.4**	2.97
Heating System							
Replace Boiler							
Opt. 1: 2 Condensing Boilers *	$ 918	154	80.1	5.7	$ 12,500	13.6	1.47
Opt. 2: 1 Condensing Boiler & Unit Heaters *	$ 1,080	181	94.2	6.7	$ 13,000	12.0	1.66
Opt.3 : Triple Pass Boiler *	$ 378	63	33.0	2.3	$ 7,000	18.5	1.35
Install Outdoor Reset	$ 432	72	37.7	2.7	$ 1,200	2.8	5.40
Install Programmable T-stats	$ 320	54	28.3	2.0	$ 900	2.8	5.33
Install 4 De-stratification fans	$ 472	38	37.9	2.6	$ 4,800	10.2	1.97
Subtotal	**$ 2,142**	**318**	**184.0**	**13.0**	**$ 19,400**	**9.1**	**1.93**
Domestic Hot Water							
Install A Nat Gas on Demand Tankless System	**$ 1,195.0**	**39**	**97.4**	**0.7**	**$ 2,800**	**2.3**	**5.12**
Misc.							
Replace Refrigerator	$ 258	1,843		0.9	$ 700	2.7	3.69
Install an Energy Miser	$ 209	1,493		0.8	$ 175	0.8	11.94
Subtotal	**$467**	**3,336**		**1.7**	**$ 875**	**1.9**	**5.34**
ECM Totals	**$ 6,586**	**6,935**	**381**	**24**	**$ 51,315**	**7.8**	**3.07**

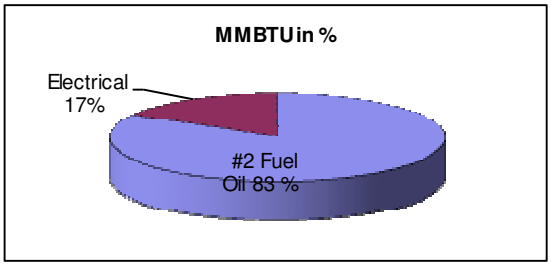
Note: A 5% to 10% contingency should be carried for the cost of work

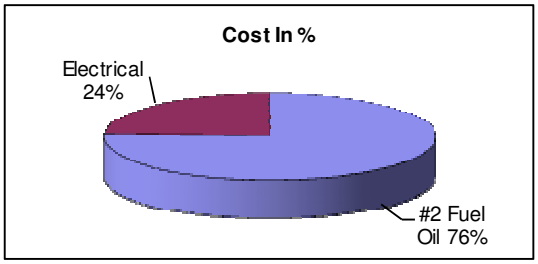
1. Cost represent upgrade at time of replacement

4. Energy Usage

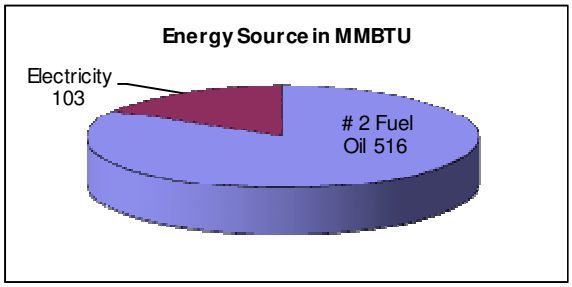
The energy usage of the building is from two sources: electricity for lighting and power; and natural gas for heat and domestic hot water. The heating and hot water source was recently changed from #2 fuel oil to natural gas. The data in the report is based on #2 fuel oil since less than a year's information is available for natural gas.

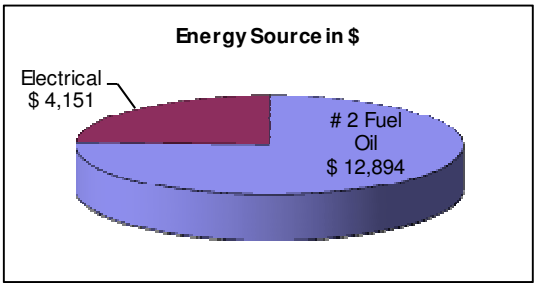
The first series of pie charts show the energy usage in percent for both BTU's, the common energy measurement unit and as the cost of energy.





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

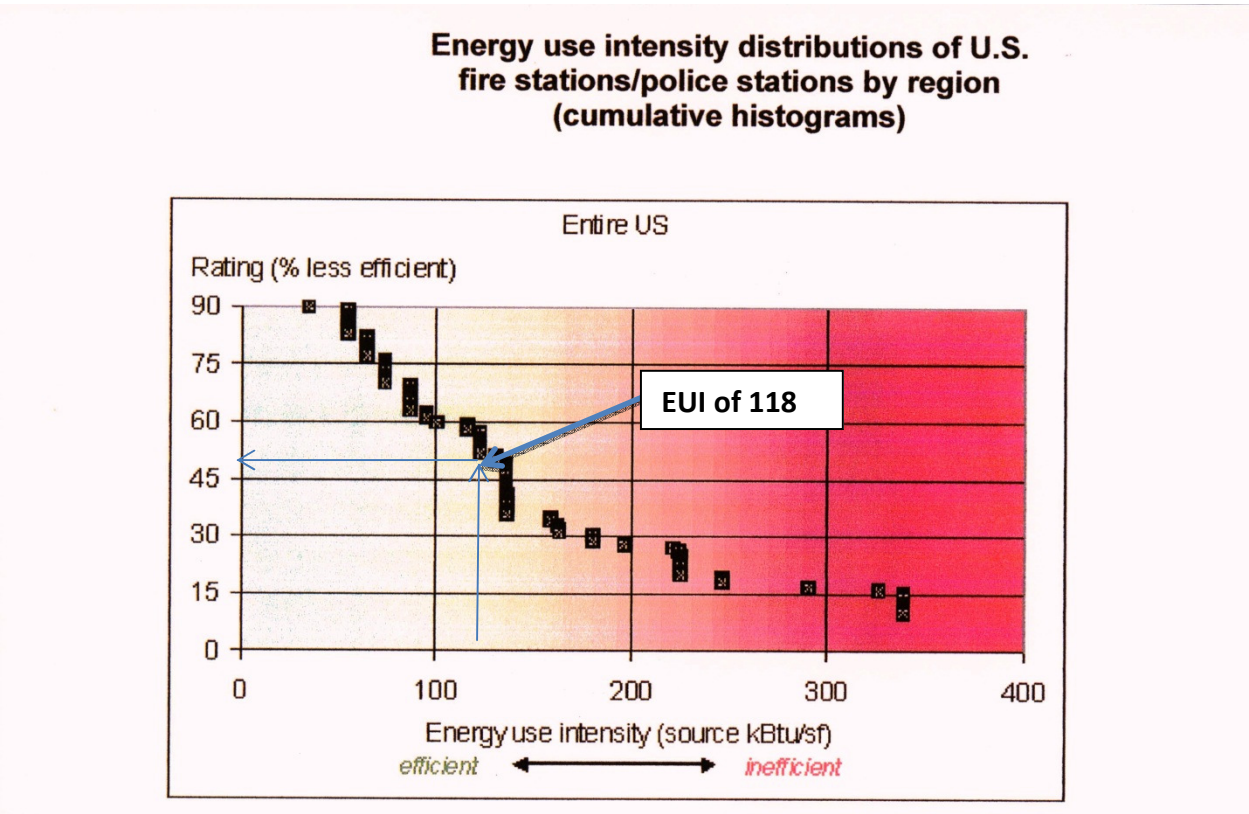




As shown in the pie charts, heating fuel accounts for the greater portion of the energy usage in cost, 76% in dollars and is the greater in energy units, 83 % of the BTU's.

It is estimated that the cost of heating will improve by over 50%. The cost per MMBtu of # 2 fuel oil is $25 and the cost of natural gas per MMBtu is $11.2. In addition, the efficiency of the gas burner should add approximately 5 % in savings.

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 Fire Station'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 47 % range.



This means that of the buildings surveyed 47% are less and 53% are more efficient than the Fire Station. Of that number, 57% of the energy usage typically is attributed to electricity and the balance is for heating. The fire station uses 83% for heating and 17% 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. One reason that the electrical usage is not higher is that the station is open 7 days per week for 12 hours per day and not 24/7.

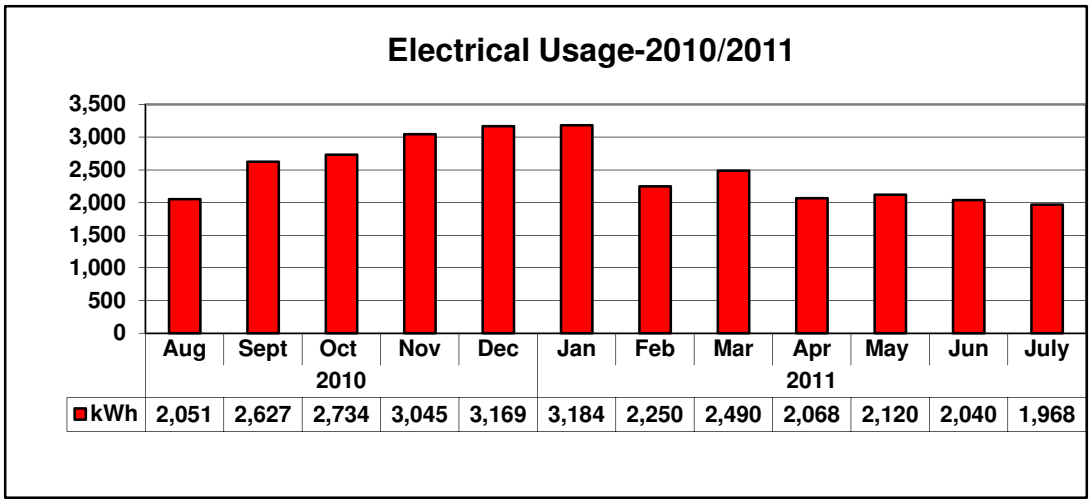
Some of the information that Oak Ridge has developed is regional, but what is available for this building type is the national survey, which is not as specific for this region.

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 2,000 kWh/month.

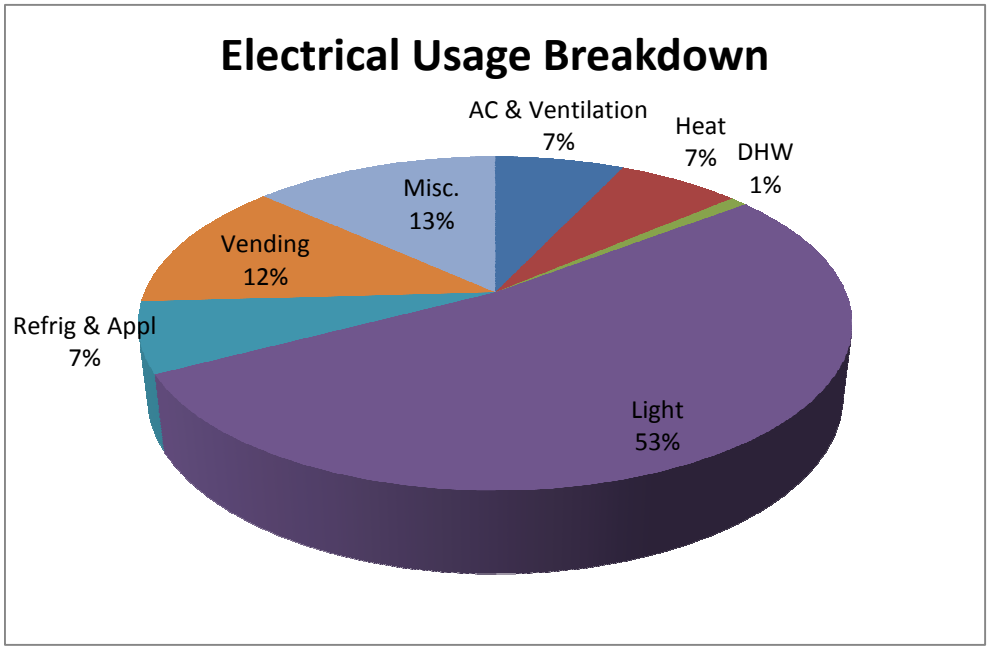
Windham North Fire Station			
Electricity Usage-2010/2011			
		kWh	Cost (incl demand)
2010	Aug	2,051	284
	Sept	2,627	352
	Oct	2,734	367
	Nov	3,045	407
	Dec	3,169	423
2011	Jan	3,184	425
	Feb	2,250	372
	Mar	2,490	385
	Apr	2,068	290
	May	2,120	301
	Jun	2,040	276
	July	1,968	269
	Total	29,746	$ 4,151
12 Mo	Avg	2,479	$346
Avg	$/kW		$0.14



Electrical use per square foot is 4.29 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 lower than other fire/police buildings assessed in Maine which averaged 6.4 kWh/sf. The fact that the building operates 12 hours 7 days per week likely accounts for the difference from the typical fire station that operates 24/7. 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	2,082
Heat	1,980
DHW	278
Light	15,684
Refrig & Appl	2,024
Vending	3,743
Misc.	3,955



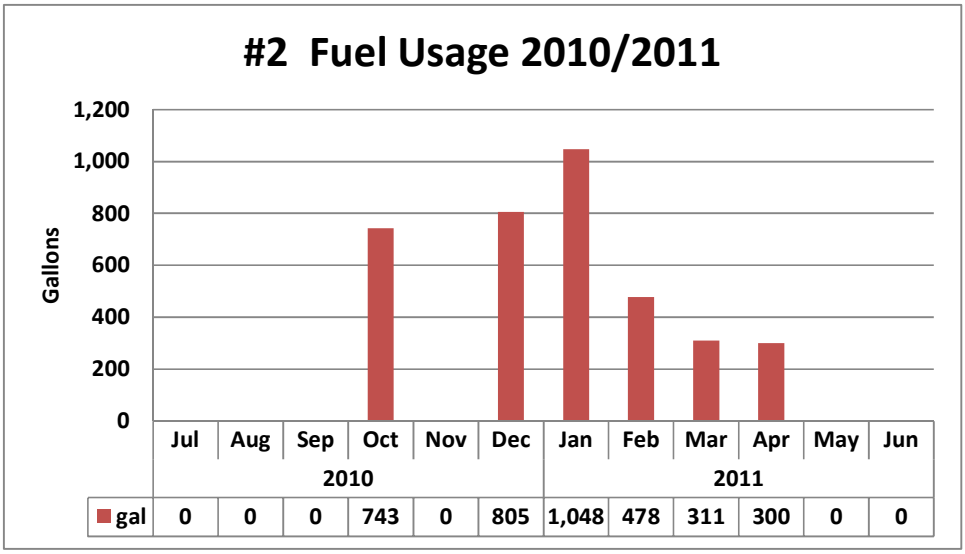
2. Heating Fuel

The heating and hot water 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 .53 gals/SF as opposed to an average of .32 gals/SF and 74,424 BTU/SF as opposed to an average of 44,480 BTU/SF or 167 % of the average for commercial buildings in New England. The heating degree days for the selected time frame are similar to the 30 year average making it representative of the fuel usage.

One consideration that must be kept in mind is that a fire station loses much more heat when the overhead doors are opened and closed than an average building. Without knowing the number of the door uses, it is hard to quantify the impact this has on the heat loss.

Windham North Fire Station			
#2 Fuel Usage-2010/2011			
		gal	cost
2010	Jul	0	
	Aug	0	
	Sep	0	
	Oct	743	2,601
	Nov	0	0
	Dec	805	2,816
2011	Jan	1,048	3,666
	Feb	478	1,673
	Mar	311	1,089
	Apr	300	1,050
	May	0	
	Jun	0	
	Total	3,685	$12,895
Month	Average	307	$1,075
$/gal	Average		$3.50



Prior to the 2011/2012 heating season the burner was changed on the boiler to a natural gas burner which should improve the fuel usage. Assuming that the new natural gas burner will be 5% more efficient than the old oil burner the equivalent savings in oil would be 368 gallons or $5,885. The limited data for one month of this heating season (12/7/ 2011 to 1/9/20120 indicates an improvement of Btu's/ HDD of 8%. (Note HDD is heating degree days).

5. Building Envelope

The building was built in 1973, and has seen normal maintenance over its life. The structure resembles an airplane type hanger. Within the shell of the building, an office/day room space was built on the ground level and on mezzanine level, two small framed rooms on the north east end of the floor. The building rests on a concrete stub wall and slab on grade floor.

There are no signs of any insulation below the slab or at the perimeter of the slab on grade. Considering the age of the building this practice was not used and no insulation is assumed.

The stub wall is 12" thick and about 3' high. The wall does not have minimal insulation and has an R value of R-4.

The main section of the building is formed steel panels with vertical walls and an arched roof. The upper ceiling of the building is formed steel panels and also acts as the bottom cord of the arched roof to hold the structure together. The inside face of the walls have 1.5" of older sprayed foam insulation with an estimated value of R-6.6. The original windows have been replaced with windows that are double paned sliders, with an estimated R value of R-2. The front and side man doors are newer with an estimated R value of R-3.2 and R-3.7

respectively. The overhead doors were installed in 2005 by Overhead Door Company are model #- 551 and have an estimated R value of R-6.2.

The attic space above the apparatus bay has older blown in fiber glass of varying depths 2 to 8 inches. The gable ends of the arched roof are also vented. This provides an opportunity for air wash over the insulation and considerably reduces its R value. The estimated R value of the ceiling/attic is R-8.

The office/day room area occupies 1,890 s.f. or 27% of the foot print on the south east end of the building. The upper floor is concrete on metal deck and the common wall with the apparatus bay is masonry. The three remaining walls adjacent to the outer walls are built out with metal studs and drywall on the interior. There was no sign of insulation in the built out walls. The estimated R value of built out walls R-7.

The building's ACH (Air Changes per Hour) is estimated to be .7 to .9 for the apparatus bay and .6 to.8 for the office/day room area. 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 .17 ACH and an average building is .6 ACH. For the office/day room section, a tight building has an ACH of .23 ACH and an average building is .8 ACH. The goal is to have a tight building, but at a minimum in the average range of .6 to .8 ACH. The air infiltration indicates the building is a good candidate for air sealing.

The other consideration is the heat loss through the overhead doors which can be considerable. Every time the door is opened in the winter an estimated 7,000 Btu's can be lost on a cold day: for each call the heat loss is 14,000 Btu.

The current Energy Code specifies an R-20 at the ceiling/attic and an R-14.5 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 should be air sealed. This should reduce the heat loss and gain from air infiltration by an estimated 15 to 20%.

It is recommended that the edge of the slab on grade be exposed on three sides of the building and 1" of rigid insulation (extruded-XPS) be installed with a protective coating on the three sides of the building that do not have paving. This will reduce the heat loss through the slab by an estimated 35 to 40%. The rigid insulation is also recommended to be extended up the concrete stub wall on all sides of the building to the bottom of the metal wall flashing. A piece of counter flashing will need to be added at the top of the insulation to form a good

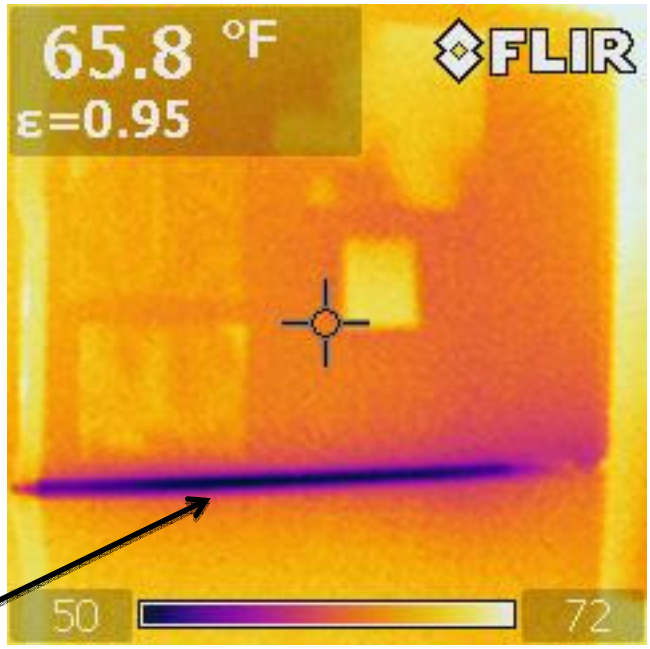
drip edge and the insulation should have a hard protective layer such as Hardy Plank at least on the front of the building. This will reduce the heat loss through the slab by an estimated 50 to 60% and improve the R value to an estimated R-11. By placing the insulation on the exterior it acts as a thermal break for the concrete wall and allows it to use its thermal mass to retain heat rather than conduct it.

The interior face of the metal wall was assessed to receive an additional 2" of closed cell foam insulation with the proper fire coating. This will reduce the heat loss through the wall by an estimated 50 to 60% and improve the R value to an estimated R-19. Note should be made that some spray foam products have the fire rating material mixed in with the insulation and this method can be a more economical approach. The state fire Marshall's office should be consulted for details and acceptable products. Due to the long payback it is not listed as an improvement.

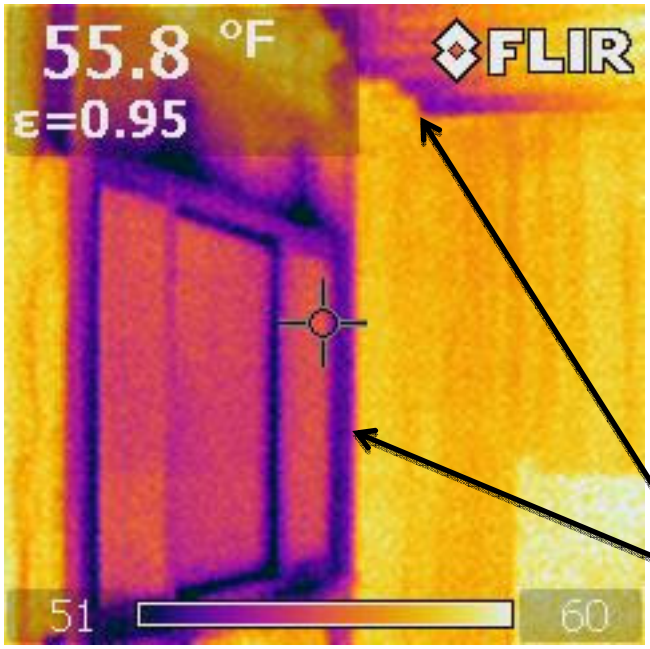
The ceiling/attic area is another major source of heat loss and air infiltration. The present insulation provides little heat loss and air infiltration prevention and should be removed and replaced. A layer of 1" spray closed cell foam followed by 8" of blown in cellulose should be applied, which will air seal the ceiling/attic plane and improve the R value to an estimated R-30. This will reduce the heat loss through the ceiling/attic plane by an estimated 60 t0 70% and reduce the air infiltration. Any of the vented gable ends that are below or near the insulation should be air blocked to prevent air washing and alternative area created. A rule of thumb is to have 3 s.f. of ventilation area for every 100 s.f. of attic area. For 6,900 s.f. of attic area, 207 s.f. of ventilation area would be needed. Also the attic hatch should be insulated with 4" of rigid (XPS) insulation.

The final recommendation is to install new weather stripping on the overhead doors 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%.

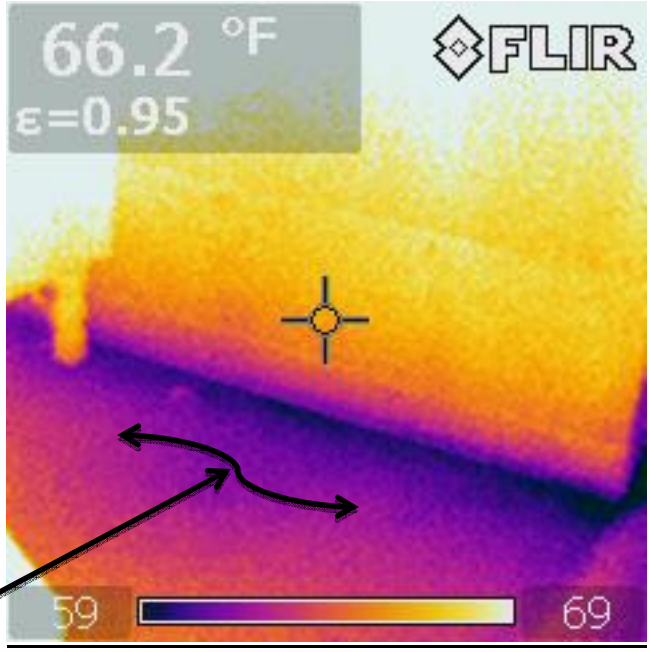
The purpose of including the following photos is to offer a visual representation of the present condition of the building envelope so the reader may have a better understanding of the situation and why the recommendations are being made.



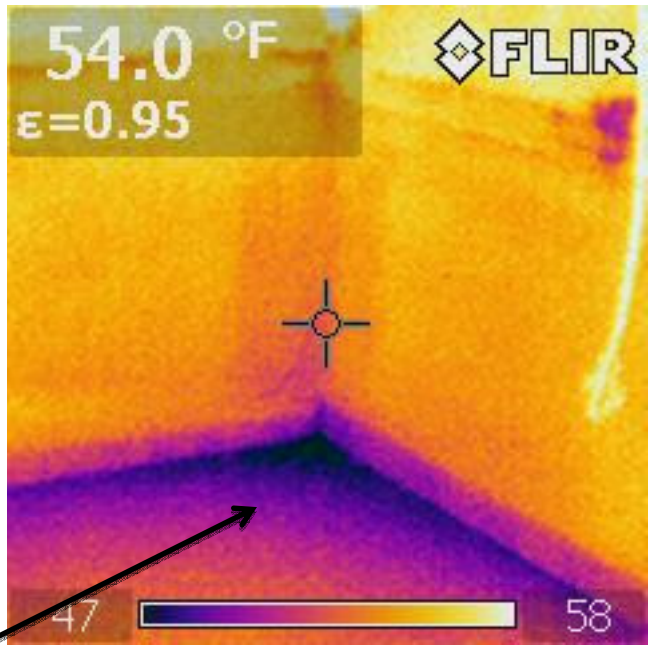
View of window in kitchen showing air infiltration at sill, air sealing will improve the situation



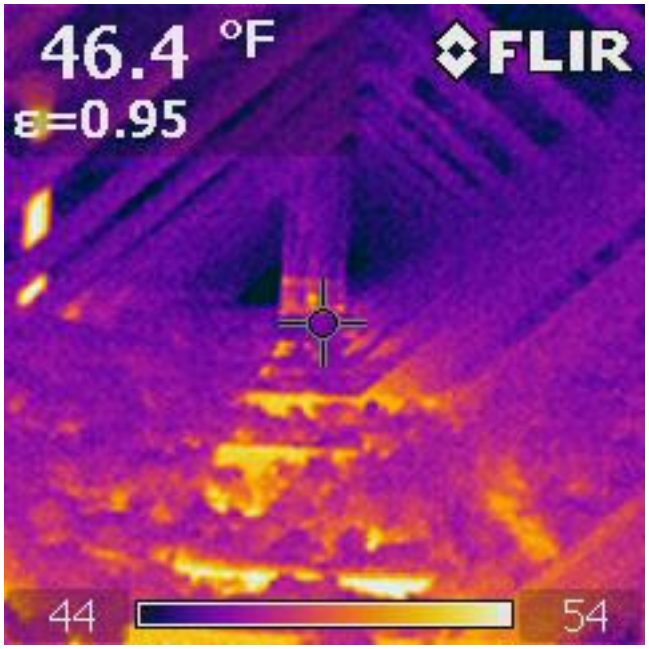
View of mezzanine window and wall, note air infiltration at window perimeter and wall to ceiling intersection



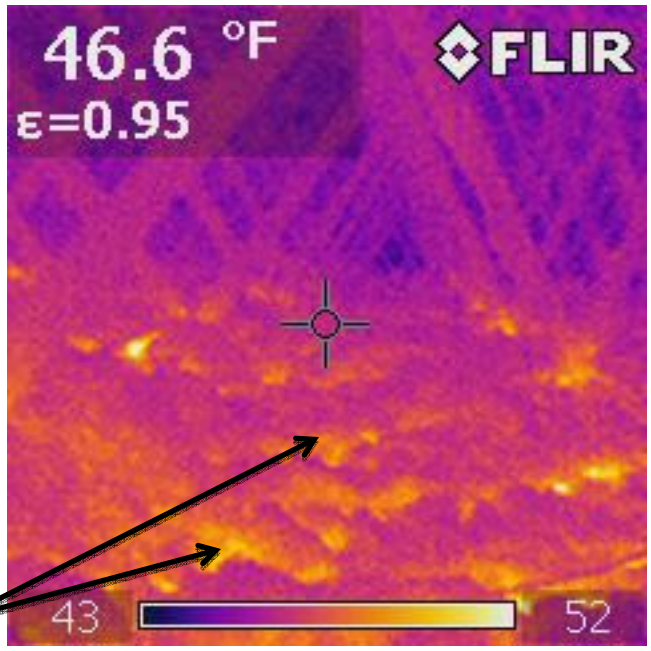
Cold from un-insulated slab edge by day room door, adding rigid insulation will improve the situation



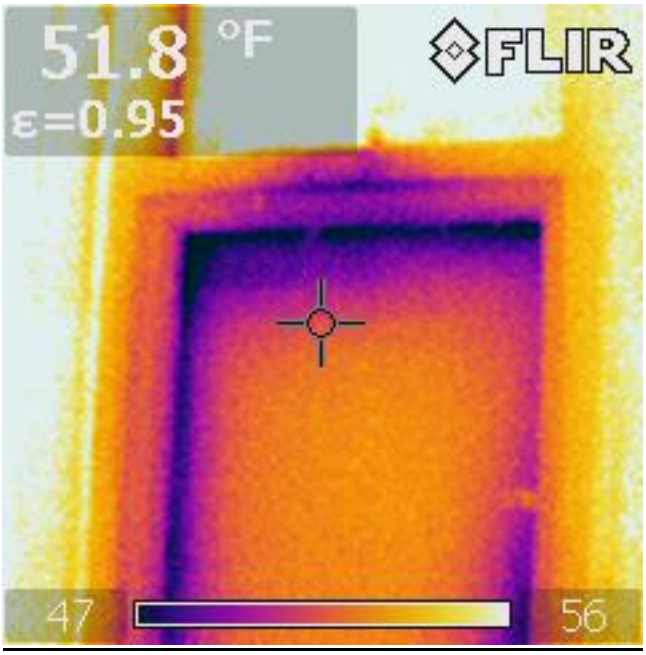
View of cold slab edge at hose drying area

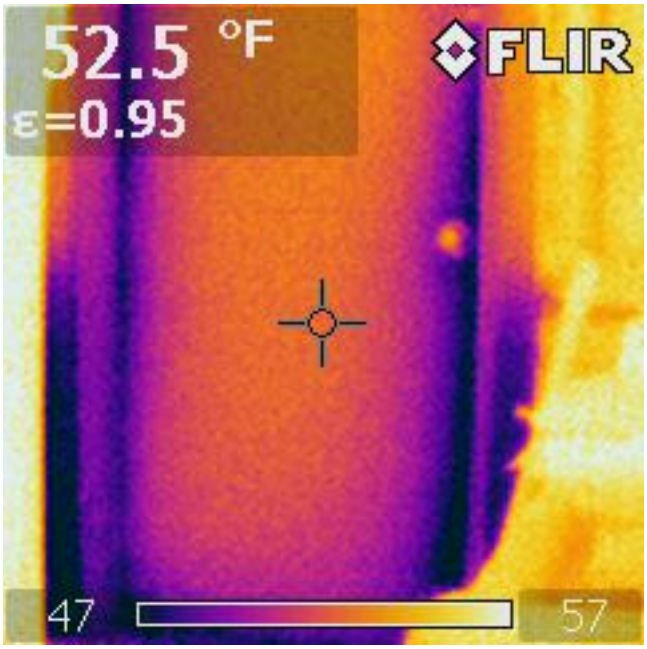


View of attic area showing heat loss through ceiling into the attic, note uneven and old insulation



General views of attic insulation. IR photo shows heat loss through insulation & digital photo shows vented gable end & view of insulation





View of apparatus man door showing air infiltration around jambs & header. Weather stripping is an ongoing maintenance issue that requires attention

6. Lighting

The fire station has recently received some upgrades to the lighting system. However, the data for electrical usage reflects the prior fixtures. Therefore, two tables have been prepared. One shows the prior and existing fixtures so the electrical usage associated with the prior fixtures could be determined. The second is the existing and proposed so the potential savings can be estimated if improvements are made.

A number of the older existing T12 fixtures have been replaced or re-lamped and re-ballasted which will reduce usage considerably. However, there are still some T12's and, high pressure sodium fixtures and some of the light levels were high. The typical 700 series T8 32 watt lamps that were used to replace the older T12 34 watt lamps save about 20% in electricity and deliver about 20% more average lumens (brightness) then the older lamps. This often results in more lumens then recommended and/or needed. Using the newer 28 watt 800 series T8 lamp can save an additional 14% in electricity and deliver about 4% less average lumens, (brightness). Using the newer 25 watt 800 series T8 lamp can save an additional 21% in electricity and deliver about 8% less average lumens then the 32 watt 700 series lamp. Typically a reduction in lumens of under 10% is seldom perceived. It is recommended as lamps wear out that they be replaced with 25 or 28 watt/4100 K lamps,preferably the 25 watt lamp. The 700 series lamps that do not meet the Energy Policy Act will not be manufactured after 2012. A wall mounted Vacancy Sensor in the Deputy Chief's office and a ceiling mounted dual technology motion sensor in the day room is recommended. These should have a programmed start ballast to extend the life of the ballast and fixture.

The older T12 fixtures in the Rescue space, work room, open mezzanine, mezzanine office and TV room should be replaced with T8 series 800 25 watt lamps and new fixtures. The work room should have a wall mounted Vacancy Sensor.

The apparatus bay has new T5 fixtures with 54 watt lamps and the ballast factor is assumed to be 1. The recommended foot candles are 30 for this type of area and the average measured foot candles were in excess of that number. Manufacturers such as GE and Sylvania are producing T5 lamps that are 49 and 51 watts with the same or more lumens and reduce electrical usage by 12 and 10%. As lamps burn out it is recommended that they be replaced with the lower wattage lamps. In addition installing fixture mounted sensors on the fixtures in 3 rows of the 4 rows of lamps is recommended. The row closet to the office /day room area should be left on a switch. A future recommendation as the ballasts wear out is to replace them with a lower ballast factor unit that can further reduce the usage by 10%.

Any incandescent lamps are recommended to be replaced with CFL's or Cold Cathode CFL's.

The man door fixtures have 1 CFL and 1 HPS and are recommended to be replaced with a 10 watt LED fixture such as the RAB WPLED10/PC or equivalent. These will perform much better in the cold weather than a CFL and not require the replacement frequency of both the CFL and HPS. The HPS flag pole fixture is recommended to be replaced by an LED fixture such as the RAB FFLED 18Y/PC or equivalent.

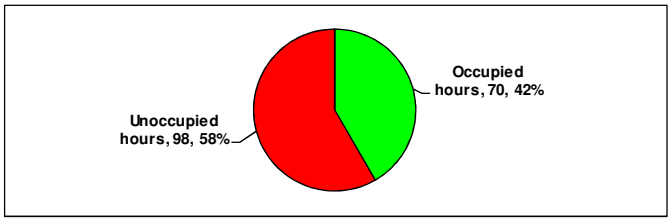
With regard to T5 in spaces such as the apparatus bay, when T5 fixtures first came onto the market they were the recommended replacement. As time has progressed spaces that are viewed as high bay, over 20', and medium height bays, less than20' in height have different recommendations. For the medium height spaces, many lighting consultants are recommending High Performance T8's in lieu of T5's. The initial cost, lamp replacement cost and operating costs are less. In the future, if medium bay height spaces that are being considered for fixture replacement, the T8 replacement is recommended over the T5. LED fixtures should also be considered as the price continues to come down and the efficiency improves.

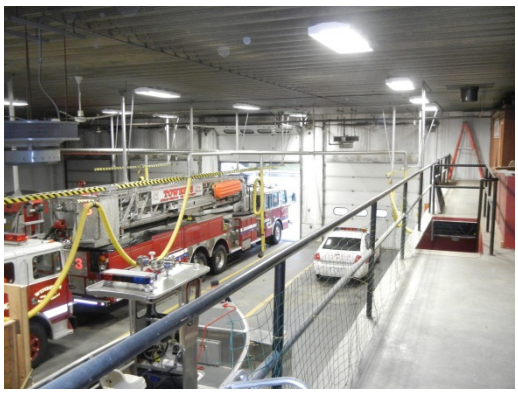
Lighting is estimated to account for about 50% of the buildings electrical use.

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.

Based on 168 hours in a week

Occupied hours	Unoccupied hours
70	98





View of apparatus bay showing light level that can be reduced and still meet lighting levels

Lighting Table for Prior & Existing Conditons													
1	Location	Fixture type	# of Fixt	Watts per Fixt	Total kW	Hrs/ Day	# of Days	Annual Operating Hours	Annual Total kWh	Annual kWh Cost	Estimated Annual Savings	Annual kWh Saved	Estimated Reduced kW
										$0.14			
Prior	Day Room	4L 2x4 T12	5	152	0.76	10	365	3650	2,774	$388			
Existing		4L 2x4 T8	5	115	0.575	10	365	3650	2,099	$294	$95	675	0.185
Prior		2L 2x2 T12 U	1	80	0.08	10	365	3650	292	$41			
Existing		2L 2x2 T8 U	1	60	0.06	10	365	3650	219	$31	$10	73	0.02
Prior	Kitchen	4L 2x4 T12	5	152	0.76	4	365	1460	1,110	$155			
Existing		4L 2x4 T8	5	115	0.575	4	365	1460	840	$118	$38	270	0.185
Prior	Mens Room	1L Inc	4	40	0.16	1	365	365	58	$8			
Existing		1L CFL	4	10	0.04	1	365	365	15	$2	$6	44	0.12
Prior		2L CFL	1	13	0.013	1	365	365	5	$1			
Existing		2L CFL	1	13	0.013	1	365	365	5	$1	$0	0	0
Prior	Womens Rm	1L Inc	1	60	0.06	1	365	365	22	$3			
Existing		1L CFL	1	13	0.013	1	365	365	5	$1	$2	17	0.047
Prior	Deputy Chief	4L 2x4 T12	3	152	0.456	10	156	1560	711	$100			
Existing		4L 2x4 T8	3	115	0.345	10	156	1560	538	$75	$24	173	0.111
Prior	Police Office	4L 2x4 T12	1	152	0.152	2	260	520	79	$11			
Existing		4L 2x4 T8	1	115	0.115	2	260	520	60	$8	$3	19	0.037
Prior	Apparatus Bay	2L 1x8 T12	30	168	5.04	8	365	2920	14,717	$2,060			
Existing		2L 2x4 T5	15	216	3.24	8	365	2920	9,461	$1,325	$736	5,256	1.8
Prior	Rescue	2L 1x8 T12	1	168	0.168	1	200	200	34	$5			
Existing		2L 1x8 T12	1	168	0.168	1	200	200	34	$5	$0	0	0
Prior	Work Room	2L 1x8 T12	1	168	0.168	10	365	3650	613	$86			
Existing		2L 1x8 T12	1	168	0.168	10	365	3650	613	$86	$0	0	0
Prior	Open Mezzine	2L 1x8 T12	1	168	0.168	1	365	365	61	$9			
Existing		2L 1x8 T12	1	168	0.168	1	365	365	61	$9	$0	0	0
Prior	Mezzine Office	4L 2x4 T12	2	168	0.336	2	260	520	175	$24			
Existing		4L 2x4 T12	2	168	0.336	2	260	520	175	$24	$0	0	0
Prior	TV Room	4L 2x4 T12	2	168	0.336	2	300	600	202	$28			
Existing		4L 2x4 T12	2	168	0.336	2	300	600	202	$28	$0	0	0
Prior	Boiler Rm	1L Inc	2	60	0.12	1	105	105	13	$2			
Existing		1L Inc	2	60	0.12	1	105	105	13	$2	$0	0	0
Prior	Extr Wall Packs	1L HPS	3	195	0.585	12	365	4380	2,562	$359			
Existing		1L LED	3	22	0.066	12	365	4380	289	$40	$318	2,273	0.519
Prior	Man Door	1L HPS	1	100	0.1	12	365	4380	438	$61			
Existing		1L CFL	1	13	0.013	12	365	4380	57	$8	$53	381	0.087
Prior	Man Door	1L HPS	1	100	0.1	12	365	4380	438	$61			
Existing		1L HPS	1	100	0.1	12	365	4380	438	$61	$0	0	0
Prior	Flag Pole	1L HPS	1	195	0.195	12	365	4380	854	$120			
Existing		1L HPS	1	195	0.195	12	365	4380	854	$120	$0	0	0
Red indicates estimate									Annual Total kWh	Annual kWh Cost	Potential Annual Savings	Annual kWh Saved	Potential Reduced kW
										$0.14			
Estimated Annual Lighting Usage and Cost									25,157	$ 3,522			
Table 1 Estimated Annual Lighting Savings											$ 1,285	9,182	3

Lighting Table Exisiting & Proposed Conditons

2	Location	Fixture type	# of Fixt	Watts per Fixt	Total kW	Hrs/ Day	# of Days	Annual Operating Hours	Annual Total kWh	Annual kWh Cost	Estimated Annual Savings	Annual kWh Saved	Estimated Reduced kW
										$0.14			
Existing	Day Room	4L 2x4 T8	5	115	0.575	10	365	3650	2,099	$294			
Proposed	Add Sensor	4L 2x4 T8 25w	5	90	0.45	8	365	2920	1,314	$184	$110	785	0.125
Existing		2L 2x2 T8 U	1	58	0.058	10	365	3650	212	$30			
Proposed		2L 2x2 T8 U 25w	1	45	0.045	7	365	2555	115	$16	$14	97	0.013
Existing	Kitchen	4L 2x4 T8	2	115	0.23	4	365	1460	336	$47			
Proposed		4L 2x4 T8 25w	2	90	0.18	4	365	1460	263	$37	$10	73	0.05
Existing	Men's Room	1L Inc	4	40	0.16	1	365	365	58	$8			
Proposed		1L CFL	4	10	0.04	1	365	365	15	$2	$6	44	0.12
Existing		2L CFL	1	13	0.013	1	365	365	5	$1			
Proposed		2L CFL	1	13	0.013	1	365	365	5	$1	$0	0	0
Existing	Women's Rm	1L Inc	1	60	0.06	1	365	365	22	$3			
Proposed		1L CFL	1	13	0.013	1	365	365	5	$1	$2	17	0.047
Existing	Deputy Chief	4L 2x4 T8	3	115	0.345	10	156	1560	538	$75			
Proposed	BF .8/ sensor	4L 2x4 T8 25w	3	80	0.24	7	156	1092	262	$37	$39	276	0.105
Existing	Police Office	4L 2x4 T8	1	115	0.115	2	260	520	60	$8			
Proposed	BF .8	4L 2x4 T8 25w	1	80	0.08	2	260	520	42	$6	$3	18	0.035
Existing	Apparatus Bay	4L 2x4 T5	15	216	3.24	8	365	2920	9,461	$1,325			
Proposed	Chng BF .8/ sensors	2L 2x4 T5	15	180	2.7	7	365	2555	6,899	$966	$359	2,562	0.54
Existing	Rescue	2L 1x8 T12	1	168	0.168	1	200	200	34	$5			
Proposed		2L 2x2 T8 25w	1	45	0.045	1	200	200	9	$1	$3	25	0.123
Existing	Work Room	2L 1x8 T12	1	168	0.168	10	365	3650	613	$86			
Proposed	Add Sensor	2L 2x2 T8 25w	1	45	0.045	6	365	2190	99	$14	$72	515	0.123
Existing	Open Mezzanine	2L 1x8 T12	3	168	0.504	1	365	365	184	$26			
Proposed	BF .8/ new Fix	3L 2x4 T8 25w	2	60	0.12	1	365	365	44	$6	$20	140	0.384
Existing	Mezzanine	4L 2x4 T12	2	168	0.336	2	260	520	175	$24			
Proposed	BF .8	4L 2x4 T8 25w	2	80	0.16	2	260	520	83	$12	$13	92	0.176
Existing	TV Room	4L 2x4 T12	2	168	0.336	2	300	600	202	$28			
Proposed	BF .8/ new Fixt	3L 2x4 T8 25w	2	60	0.12	2	300	600	72	$10	$18	130	0.216
Existing	Boiler Rm	1L Inc	2	60	0.12	1	105	105	13	$2			
Proposed		1L CFL	2	13	0.026	1	105	105	3	$0	$1	10	0.094
Existing	Extr Wall Packs	1L LED 20w	3	22	0.066	12	365	4380	289	$40			
Proposed		1L LED	3	22	0.066	12	365	4380	289	$40	$0	0	0
Existing	Man Door	1L CFL	1	13	0.013	12	365	4380	57	$8			
Proposed		1L LED 10w	1	10	0.01	12	365	4380	44	$6	$2	13	0.003
Existing	Man Door	1L HPS	1	100	0.1	12	365	4380	438	$61			
Proposed		1L LED 10w	1	10	0.01	12	365	4380	44	$6	$55	394	0.09
Existing	Flag Pole	1L HPS	1	195	0.195	12	365	4380	854	$120			
Proposed		1L LED 18w	1	20	0.02	12	365	4380	88	$12	$107	767	0.175
Red indicates estimate									Annual	Annual	Potential	Annual	Potential
										$0.14			
Estimated Annual Lighting Usage and Cost									15,648	$ 2,191			
Table 1 Estimated Annual Lighting Savings											$ 834	5,956	2

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.

7. Mechanical Systems

The mechanical systems are comprised of the heating, air conditioning, domestic hot water, and ventilation systems. The building can be looked at as two building spaces; the Apparatus Bay and the main building. The Apparatus Bay heat is supplied from the boiler through piping to three ceiling hung unit heaters. The Apparatus Bay heat is controlled by a thermostat acting as a sensor that 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.
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 to reduce the operation of the equipment, saving energy and wear on the equipment.

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 apparatus bay. The heat source is a 600,000 Btu (gross) H.B. Smith I-9 Series 5 boiler with a Carlin 301 single stage gas burner. The burner was replaced late this fall; the previous burner was an oil fired burner firing at 3.5 GPH. The combustion efficiency was estimated to be in the 80% range. The seasonal efficiency was estimated to be in the 50% to 65% range based on industry studies. The new burner is estimated to be 5 to10% more efficient.

The system feeds various terminal heating devices; ceiling hung unit heaters and fin tube base board. The apparatus bay is heated by 4 Modine 139,000 Btu ceiling hung horizontal unit heaters, fed by a two pipe system and controlled by a thermostat on the masonry wall common to the office area. The office and day room area is heated by fin tube radiation, fed by a single pipe system in series and controlled by a thermostat in the deputy chief's office and another in the day room.

The office/day room area represents 20% of the area of the building, is estimated to use 24% of the heat and the apparatus bay to use 76% of the heat. During the audit visit, the office/ day room area called for heat more often than the apparatus bay unless the doors were opened. In addition the spaces did not call for heat at the same time and the office/day room

is kept about 5 to 7 degrees higher. This indicates that the prevalent load is much smaller than the boiler capacity estimated to be 600,000 Btu. This imbalance of loads results in short cycling of the boiler even on a cold day when the office/day room calls for heat. Replacing the burner with a two staged or modulating burner would have been a more efficient solution that would have allowed the system to better match the different loads.

As the boiler ages and requires replacement a plan should be developed. The ideal solution would be to install two modulating boilers that are staged coupled with an outdoor reset. This would provide for the various loads and allow the efficiency of a condensing boiler for most of the heating season. Each boiler would be able to accommodate 60% of the building load. This has the potential to improve the current systems seasonal efficiency by 10 to 20 %

One option is to install a triple pass conventional boiler and utilize the present burner. This has the potential to improve the current system seasonal efficiency by 5 to 10 %.

Another option is to install gas fired ceiling hung condensing units and a separate boiler. This would separate the two loads and reduce the boiler size significantly. The boiler could be a condensing unit that could also provide domestic hot water, significantly reducing the cost of heating hot water during the summer by the boiler. This has a 15 to 25% energy savings potential but also has the greatest initial cost.

The above measures are longer range, however adding an outdoor reset, programmable thermostats and thermal equalizers are immediate recommendations that can improve the heating fuel consumption. The outdoor reset is estimated to reduce the fuel consumption by 10 to 15%, the thermostats 5 to 10% and the thermal equalizer 10 to 15%. The thermal equalizer will be discussed in more detail in the ventilation section.

Below is a table showing the dollar reduction in fuel costs based up on a percentage improvement in fuel use. This table pertains to the projected amount of natural gas expected to be burned by the gas fired boiler based on a 8% improvement due to fuel switching. It provides the potenial cost savings for natural gas based on a percent improved basis if ECM's are implemented.

Estimated Natural Gas Savings for Your Building Based on Cost Per Therm					
Equivelant Therms of gas used in 2011/2012	4,642				
Gas cost per therm	$1.12	$1.20	$1.30	$1.40	$1.50
10 percent savings	$520	$557	$603	$650	$696
15 percent savings	$780	$836	$905	$975	$1,044
20 percent savings	$1,040	$1,114	$1,207	$1,300	$1,393
25 percent savings	$1,300	$1,393	$1,509	$1,625	$1,741
30 percent savings	$1,560	$1,671	$1,810	$1,950	$2,089
35 percent savings	$1,820	$1,950	$2,112	$2,275	$2,437
40 percent savings	$2,080	$2,228	$2,414	$2,600	$2,785
45 percent savings	$2,340	$2,507	$2,716	$2,924	$3,133
50 percent savings	$2,600	$2,785	$3,017	$3,249	$3,482

7.2 Air Conditioning:

The air conditioning consists of two window units; one is a 12,000 Btu unit for the day room and the other is a 10,000 Btu unit for the office area. The SEER rating is estimated to be about a SEER 11 and they are 6 years old. The 2009 Energy Code requires a minimum SEER of 13 on units manufactured today. The units are estimated to have approximately 5 more years of useful life. The units used an estimated 1,973 kWh of electricity during the average cooling season, cost $ 276.00 at today's rates. However the real cost of these units is the cost of installing and removing them each year. As the units wear out, consideration should be given to replacing them with mini split air conditioning units. A 24,000 Btu unit with two indoor outlets and a SEER of 15 or greater is recommended. These units will use 40% or less electricity, will not require installation and removal each year and will last about 50% longer than the window units. When electrical savings and annual installation costs are considered the estimated pay back is 6.8 years and the SIR is 1.47.

7.3 Ventilation:

The ventilation for the building consists of local exhaust ventilation for the bathrooms, a PlymoVent vehicle exhaust system and paddle fans in the apparatus bay. The building does not have any outside capabilities and is grand fathered from the code. Because the building is fairly loose, the opening and closing of overhead doors is significant and the natural air changes relatively high, adding an outside air capability to the building should not be a serious concern. If the building usage and tightness changes than it should be reassessed.

The vehicle exhaust system is relatively new and appears to be code compliant. No recommendation is made regarding the system.

The current paddle fans are not very efficient for mixing the air or as an energy saving device.

Installing four "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 a heating coil in an indirect hot water tank which is obviously quite old and inefficient. It is recommended that it be replaced by a natural gas fired on-demand tankless hot water system rated at 9 gpm.

View of the indirect hot water tank

The table below shows the estimated possible peak and gallons per day of hot water 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	1	2	10	20	365	7300
Dishwasher	1	2	10	20	105	2100
Restroom Sink	2	0.5	5	5	365	1825
Room showers	1	2	10	20	105	2100
Utility Sink	1	2	10	20	365	7300
Peak use in gallons per minute (all fixtures on simultaneously)						9
Estimated total gallons of hot water per year						**20,625**
Days per year hot water is used						**365**
Estimated gallons of hot water used per day						**57**
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.						

The table below shows the estimated fuel usage with the current hot water tank, the proposed on demand tankless system and the expected savings.

NGas-Fired Hot Water Heater -- Replace with Natural Gas On-demand Tankless Water Heater												
	Location	Fixture type	# of units	Therms per hour	Therms per day	Hrs/ Day	# of Days	Annual Operating hours	Yearly Total Therms	Annual Cost Therms	Potential Annual Savings	Annual Gallons Saved
									Fuel	$1.51		
Existing	Boiler Room	Indirect Hot Water Coil	1	3	2.895	0.965	365	352.225	1057	$1,596		
Retrofit	Boiler Room	Natural gas tankless hot water heater	1	1.5	0.8	0.5	210	105	157.5	$433	$1,162	1,057
											Potential Annual Savings	Annual Gallons Saved
										Annual Estimated Savings	$1,162	1,057
										Estimated Carbon Dioxide (CO2) Savings Tons Per Year		6.6
The estimated annual savings is based on the reported or average hours of operation for the device.												
A commercial tankless hot water heater provides approximately 5 gallons of hot water a minute in Maine (based on ground water temperature) at a rise in water temperature of 70°F (50°F to 120°F - see Rinnai specs at www.rinnai.us).												
Your estimated hot water usage is approximately 60 gallons per day. Based on a delivery of 5 gallons a minute, the propane tankless unit will fire under 12 minutes (60 gals/5 gals = 12 mins). Use .5 hour for peak load.												

The final table shows the estimated cost to install the tank and the projected payback of 2.4 years. The SIR is estimated to be 4.2.

Estimated cost to Install Tankless Propane Heater			
Equipment/Labor	**Qty**	**cost each**	**Total**
Tankless water heater with controller	1	$1,900	$1,900
Installation Labor- plumber	5	$80	$400
Installation Labor -Electrician	2	$75	$150
Misc materials	1	$250	$250
Contingency	1	$100	$100
Estimated installed capital cost			**$2,800**
Eff Maine Incentives	1	$0	**$0**
Cost to Implement (capital cost-incentives)			**$2,800**
*Projected Yearly Energy Savings			**$1,162**
Simple Payback in Years			**2.4**
Tankless water heater is commercial grade rated at 200,000 Btu's and a a max temperature of 180°F.			

8. Kitchen and Miscellaneous Equipment

The station has a kitchen with typical cooking, refrigeration and dish washing appliances. They are all fairly old and should be replaced with Energy Star appliances as they wear out. The refrigerator is especially inefficient and should be considered for replacement. It runs an estimated 6 hrs. per day, uses an estimated 1,840 kWh per year and cost $ 258 for electricity annually. New Energy Star units use about ½ the power and due to better insulation run for less hours using about 1/3 the electricity and expense. A new $700 refrigerator would pay for its self in 4 years and should last 10 years or more.

The station has one vending machine with refrigeration. It is recommended to install a vending miser on the 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 (1)		
Estimated Annual Savings		$209.00
Miser Cost		$175.00
Simple Payback- yrs		0.84

The station also has a hose dryer that is relatively new, fairly efficient and has low usage. No recommendation is made regarding this equipment

9. Electronic Equipment

The use of computer equipment is not significant in the fire station. One set was observed in each office for a total of two. However it is important that the equipment be set to its lowest setting on standby and be shut off when not in use.

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.