New Hampshire Local Audit Exchange Program

Energy Audit Report
Plainfield Highway Garage

January, 2012

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A. EXECUTIVE SUMMARY

Program Introduction

Plainfield's Highway Garage was one of 38 buildings selected to receive a Level II Energy Audit through the New Hampshire Local Audit Exchange (LAX) Program. The LAX Program was developed by the NH Office of Energy and Planning (NHOEP) as a means to provide no-cost energy audits to New Hampshire municipalities and school districts. Phase one of the LAX Program involves conducting comprehensive energy audits of municipal buildings across New Hampshire. Phase two will include analyzing the results of the audits and posting summarized information on the program website (nhlocalenergyaudits.com). The information will be grouped by building type which will allow other interested municipalities to browse the site for building types that match their own. This will allow those not directly involved in the program to identify similar recommendations and energy efficiency upgrade opportunities (as well as the associated costs and paybacks).

The objective of the audit is to identify energy conservation measures that reduce the net energy consumption thereby reducing operating costs and the consumption of non-renewable fossil fuel energies. In addition to energy conservation, the evaluations and recommendations presented herein consider occupant comfort and holistic building performance consistent with its intended use and function. The information obtained as part of this audit has been used to develop Energy Efficiency Measures (EEM's). These EEM's provide the basis for future building improvements and modifying the manner in which the building is operated.

This material is based upon work supported by the Department of Energy, American Recovery and Reinvestment Act of 2009 and the New Hampshire State Energy Program, under Award Number DE-EE0000228.

The LAX Program provides an ASHRAE Level 2 audit of selected municipal buildings and schools. The energy audits identify all appropriate energy efficiency measures for a facility, and a financial analysis based on implementation costs, operating costs, and attainable savings. The ultimate goal is to identify the amount to be saved, the amount the measure will cost, and the estimated payback period for each EEM. In addition, the audit discusses any changes to operations and maintenance procedures. Each municipal facility will have an in-depth field survey consisting of a site-visit that takes into consideration the following:

- Building Characteristics
- Building Use and Function
- Envelope Systems
- Heating and Cooling Systems
- Ventilation Systems
- Domestic Hot Water Systems
- Lighting
- Other Electric Loads

Following completion of the field evaluation, the data and information are reviewed to develop proposed recommendations or Energy Efficiency Measures (EEMs) for the building(s). All information, data, and recommendations are then compiled into a comprehensive report. The final report is then distributed to the municipality to assist with implementation and budgeting of the proposed EEMs. The reports will then be shared on the public website where they can be accessed by other NH municipalities and schools. The information provided in the reports will assist these municipalities with determining the best value EEMs for their facilities. In addition to the facility information, the reports will identify potential financial resources available to help fund EEMs.

Summary of Findings in Plainfield's Highway Garage

- Electrical usage is considerably higher in the winter which is in large part due to a block heater used for the back hoe left outside but is suspected to also be due to electric baseboards in the office area and ground floor lavatory.

- As with many highway garages throughout the state, the indoor air quality is not good. The two exhaust fans serve air exchange to some degree but cause significant heat loss without achieving healthy air.

- The 1998 Jackson & Church furnace is sized to heat the space very quickly, which can be comforting on a cold day after the doors have been opened, but not as efficient as a furnace sized for the peak load of an enclosed building.

Below is a summary table identifying the proposed recommendations, EEM costs, estimated annual energy cost savings, and simple payback period. Part E provides a more detailed explanation of these recommendations and divides them into Tiers based on initial costs.

Table 1 EEM Descriptions

EEM Description	Est Cost	Energy kWh	Saved Oil	Est. Annual $ Savings	Years Payback
Set back hot water temp to 120º	$5	300		$57	0.1
Install filters on return registers	$35	125	5	$42	0.8
Replace thermostat with programmable	$85	200	65	$279	0.3
Insulate ceiling hatch and gasket seal	$100	50	8	$39	3
Insulate all water pipes with min R6 foam sleeves	$100	230		$44	2
Install Stop Molding on both overhead doors	$192		21	$78	2
Install thermapane storm	$200	50	12	$52	4
Air seal windows and doors	$250	65	14	$64	4
Replace hinged windows with TP awnings	$900	375	10	$109	8
Install therma pane storms on (7) fixed units	$1,400	200	23	$124	11
Insulate the foundation wall	$2,800	250	60	$273	10
Air seal ceiling plane and add insulation	$5,500	600	105	$480	11
Totals	**$11,567**	**2,445**	**323**	**$1,642**	**7**
Reduction percentages		**14%**	**24%**	**20%**	

The EEM costs, estimated savings and resulting payback are based upon each independent measure implemented for the building in its current condition and function. Estimates are not warranted, or intended as exact predictions, but informed estimates for planning purposes only. There may be dependencies among measures that will affect the realized energy savings (parametric function). Costs are provided for budgetary planning only. They are estimated based on current industry pricing. A detailed cost estimate should be developed prior to appropriating capital funds for the more costly measures.

Other suggestions for consideration

Suggested for further exploration	Est Cost	Energy kWh	Saved Oil	Est. Annual $ Savings	Years Payback
Research for a new energy supplier	$0			$356	
Consider waste oil furnace	$7,500			$2500*	3*
Solar wall with ventilation[1]	$15,000		150	$557	27
Air Vac Filtration for improved air quality	$12,000	-1592		-$296	
* savings and payback depend on how much waste oil can be obtained					

[1] Solar wall is suggested to supplement heat while also improving air quality for low energy input

B. HISTORIC UTILITY CONSUMPTION

Utility Data

Utility data for the Highway Department was provided by Nancy Moglielnicki. Table 2 summarizes 12 months of the electric grid consumption and oil consumption in 2010-2011. Electricity is supplied by NHEC. Table 3 breaks down the annual electrical use by month.

Table 2 – Annual Utility Use and Cost Summary 2011

Energy	Annual Use	Units	Consumption	2012 Prices
Electric	Sept '10 - Aug '11	kWh	17,818	$3,408
Oil	Oct '10 – May '11	gallons	1,342	$4,979
Total				**$8,387**

Based on the total energy consumption above, the total Btu's used is 249,692,834Btu's or 249.7MMBtu's. Based on a total floor area of 5,350 ft2, the Energy Unit Intensity is 46.5KBtu per square foot. This is slightly less than average for NH Highway Department buildings.

Table 3 – Electrical Utility Data by Month

Month	Year	Electric Use (kWh)	Electric Cost
September	2010	738	$136
October	2010	811	$199
November	2010	1,513	$212
December	2010	1,806	$333
January	2011	2,687	$495
February	2011	2,634	$489
March	2011	2,327	$429
April	2011	2,137	$394
May	2011	1,088	$200
June	2011	831	$157
July	2011	875	$161
August	2011	731	$203
	Totals:	**17,818**	**$3,408**

Annual electric usage for the building is 17,818 kWh at a cost of $3,408. The monthly electrical usage (Table 3) reveals a fairly consistent usage each month between June and October with a significant but similar increase throughout the shoulder months, and winter usage (Dec-March) nearly tripling that of summer usage. Increased usage in winter is likely do to space heating and extra truck maintenance. The average cost for electricity is .191 cents for kWh. Although the total annual electricity use is somewhat consistent with the expected use for the building size and function, there are potential measures that will reduce electrical energy consumption.

An estimation of energy consumption by end use (shown below in Table 4) is necessary in order to develop energy conservation measures with estimated energy reductions and dollar savings. These values were determined using observations from the field audit, interview responses from occupants, and typical energy consumption data for inventoried equipment and appliances.

Table 4 – Itemized Electrical Consumption

Equipment Type	ESTIMATED Consumption kWh/yr	ESTIMATED Total Consumption	ESTIMATED Annual Cost
Plug Loads	4,761	27%	$911
H20 Heating	1,900	11%	$363
Cooling	450	3%	$86
Lighting	5,567	31%	$1,065
Heating	5,140	29%	$983
TOTALS	**17,818**	**100%**	**$3,408**

Based on the estimation of energy by use category, the loads are relatively consistent for plug loads, lighting and mechanical loads for a building of this size and use. Plug loads represent about 27% of the electricity consumption. Lighting systems represent 31% of the annual electrical use (5,567 kWh) and electricity used 29% (5,140) for heating includes power for the blower fans and some electric baseboard.

Heating fuel is #2 heating oil and delivered by Simple Energy. The building used 1,342 gallons in 2011. At the time of this writing, the average market price in NH is $3.69, but the NHOEP projects an average of $3.71 for the 2012 season which is the amount used for this report.

Table 5 – Oil Delivery for 2011

Month	Gallons	Cost
January	499	$1,851
February	378	$1,402
March	286	$1,061
April		$334
December	89	$330
TOTALS	**1,342**	**$4,979**

BUILDING INFORMATION & EXISTING CONDITIONS

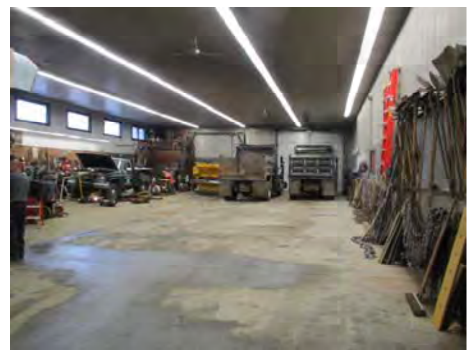
Site

The Plainfield Highway Garage is located on a level and open site at 351 Stage Road in Plainfield, NH. Plainfield is in Sullivan County and is considered in Climate Zone 6 by the EPA for determining insulation requirements in the International Energy Conservation Code. There has been an average of 8021 heating degree days (HDD) and 255 cooling degree days (CDD).

History and Current Use

The slab on grade building was constructed in 1982 to serve the Plainfield Highway Department.

There is a 350 ft2 second floor area which has an office, common room, and lavatory with shower. Under the office area are two storage rooms and a lavatory. Another storage room at the opposing end is roughly 10' x 12'. The rest of the building consists of repair areas and garage for the eight trucks and a back loader.



Occupancy Schedule

Winter hours for the employees are 6:30am to 3:30 PM, five days a week, plus during any storms or events which impact roads or travel in the town. Most of these work hours are spent out on the roads, though a certain percentage is inside servicing equipment. The vehicles typically leave in the morning and come back in at night. The doors are open for the time it takes to bring them in or out, then typically stay closed in the winter and summer. Summer hours (July and August) shift to 5:30 to 4:30 for four days a week.

Anecdotal Information

-Most of the vehicles run on diesel fuel. The thermostat for the one furnace is not programmable and is kept between 55º and 60ºF.

-If turned up slightly or after doors have been opened, the building heats up "very quickly".

-There is an electric baseboard in the first floor lavatory and one along the south wall of the common room upstairs. While it is not intentionally turned on, the thermostat is set to somewhere "left of off" so is quite possibly providing some heat all winter long.

- One industrial fan mounted in the wall serves as the primary mechanical ventilation. It is turned on whenever the welder is in use or when the air is partially opaque. A second exhaust fan in a storage area on the west end is rarely used.

- In the winter, the doors are opened for about five minutes in the morning to let the trucks out and every afternoon to let them back in. Doors may also be opened one to three times during the day to service a vehicle, again, for just a few minutes.
-The road agent does a lot of the maintenance and repairs for the department, including servicing the 1998 furnace.

Building Envelope

The following sections present the building envelope systems and insulation values for each assembly.

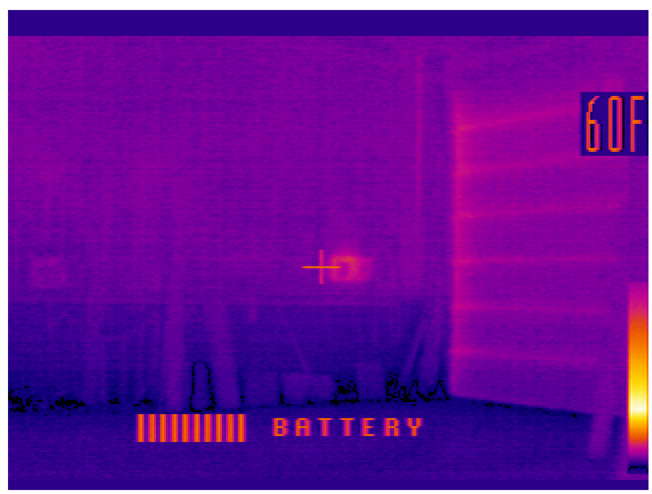
Foundation

The building is built on uninsulated slab on grade. Metal wrapped along the slab edge suggests the possibility of foam board insulation, typically EPS, though its presence or condition is unknown. The IR image below suggests there is no insulation against the concrete, or if there is some, it is of minimal value.

Wall Systems

Drawings or plans were not available for the building at the time of this report.

A poured concrete wall section extends about 32" up from the slab. A 2x6 wood framed wall forms the rest of the wall. The cavities are insulated with presumably 6" fiberglass batts. Infra red scans indicate that the insulation fills the cavities. The interior finished surface above the concrete is sheetrock, with some plywood panels to hold tools. On the exterior are sheets of T-111 plywood, more recently covered in vinyl siding. The vinyl is in generally good condition with several specific damaged areas which are capable of allowing water entry.



The IR image to the right shows the bottom portion of the wall, made of poured concrete and lacking insulation, conducting heat more rapidly than the insulated section above. The edges of the east facing overhead door are brighter most likely because of the morning sun radiating onto its surface and quickly through to the interior surface. The brightest spot locates the electric panel on the wall and heat from circuitry.

Two (2) 12x12 overhead doors are west and opposing east walls. The doors are made by Overhead and appear to be somewhat insulated but lacking gaskets or air seals around its edges. It does have a continuous facing which reduces air infiltration.

Ceiling Systems

The sheet rock ceiling defines the upper most component of the thermal boundary. The roof structure is a truss system, with 2x6 wood framing serving as ceiling joists. Fiberglass batts are laid in the joists bays, on the drywall, and several inches of cellulose have been spread on top. Access to the attic is through an un-insulated and un-sealed trap door in the lavatory on the 2nd floor. Other penetrations in the ceiling plane include wiring for lights, the chimney, ceiling fixtures, supports for garage door openers and more. Propa vents connect the soffit vents to the ridge vented roof.

Roofing Systems

Wood trusses and horizontal boards spaced evenly apart form the structure for standing seam metal roofing. The roof forms a two foot overhang over the south facing wall where large windows line top of the wall. The north roof slope extends less than eight inches over the north facing wall, indicating that the southern overhang was an intentional design element for shading the high solar heat gain windows on the south wall. The metal roofing appears to be in good condition. Snow slides off quickly, and should continue to do so even if improved insulation and air sealing reduces heat loss into the attic.

Cellulose 'topping' over fiberglass batts, trusses and roof strapping

The structure of the roof framing would have to be assessed for load carrying capacity if solar panels or other roof mounted technologies are explored.

Windows

There are 11 windows in the building for a total glazing area of 157 ft2 or less than 4% total wall area. Seven (7) of the 11 windows are large fixed double paned windows located just under the roof eave of the south facing wall. Both panes appear to be clear glass with high solar heat gain offering some passive solar heating as well a significant amount of day lighting across the entire room. If the windows were lower down on the wall, they would tend to heat the room in the summer more and the much of the day light would not reach across the floor. Therefore it is presumed that this was a thoughtful solar design. An eighth window of similar size and orientation is operable and hinged to open into the common room. It has considerable air leakage.

Doors

The building has two metal entry doors and two (2) 12 x 12 overhead doors. Based on observations and IR thermal imaging, the seals on all door jambs and thresholds are incomplete or missing, allowing uncontrolled air leakage. The entry door on the east wall is functional but in need of painting. The ages of overhead doors is not known, but are made by Norwood Overhead Door Company. They appear to be the style that has sprayed foam for insulation, with thin metal seams in the sections. The doors close fully buy do not have gasket seals so lose considerable heat around their edges.

The overhead doors are opened and closed between four and ten times a day for about five minutes each opening. That would mean the doors are open no more than one total hour (as an estimated frame of reference) each day. Certainly the building loses heat during that hour, but it also means the doors are closed 23 hours each day and night, or 96% of the time. While the exact amount of time can't be known, nor, therefore, the heat lost, the point is that there is a perception that warehouses and garage bays with large overhead doors must lose so much heat through the doors that it doesn't make sense to insulate or seal them well. It is the opinion of this auditor that the building is in a 'closed' position the vast majority of the time, especially at night during the coldest temperature, and yet still being heated. Therefore insulation and air sealing in these buildings will make a difference.

Air Infiltration

A blower door test was not conducted on the day of the site visit due to concerns around air quality. Air exchange rates have been estimated based on infra red scanning, visual inspection, "feeling" air movement and experience. They have also attempted to account for overhead doors opening six to eight times a day. An estimated air exchange rate of .5ACHnat would suggest nearly half the heat loss is attributed to uncontrolled air leakage. This rate could be reduced by ceiling gaps around the overheads doors and other holes outlined in the recommended EEM's.

Building Summary

The tables below are estimated analyses to describe, simply: "what happens to the 1,342 gallons of heating fuel?" Where does the heat go? The analysis is based on the above assessment of the effective envelope performance, heating equipment and distribution losses, approximate thermostat settings, and non heating fuel uses; all within the context of the winter climate patterns of Plainfield. The actual heating of the building includes heat outputs from office equipment, lighting, and people, referred to as internal heat gains. Therefore, improving energy efficiency of lighting, for example, can result in slight increases fuel use, to make up for the lost Btu's from the less efficient lighting.

Table 6 – Estimated Breakdown of heating oil usage in the Highway Garage

Estimated uses of 1,342 gallons oil	Gallons		%	
Envelope related heat losses		**1015**		**76%**
Uncontrolled Air Leakage	459		45%	
Concrete Walls	146		14%	
Ceiling	138		14%	
Framed Walls	126		12%	
Slab	67		7%	
Windows	43		4%	
Overhead Doors	23		2%	
Entry Doors	13		1%	
Furnace and distribution losses		**345**		**24%**
Internal and Solar Heat Gains (Btu's)		**-18**		
		1,342		**100%**

These dynamics are considered in the overall recommendations of this report, but mentioned here in the context of heating inputs. Please also note that it is believed that the electric baseboards are also contributing approximately 10MMBtu's to heat the building. This has been included in the overall analysis but omitted from the chart below for the sake of 'keeping it simple'.

Spreadsheet calculations and algorithms were used to determine the building's peak heat loss. The heating system was assessed for combustion efficiency and standby losses, and it was estimated to account for between 25 % and 30% of the total Btu's from fossil fuel based fuels used for space heating. Heat losses through the various components of the thermal envelope accounted for up to 75% of Btu's from fuels. This analysis helps determine the impact, and cost effectiveness of making improvements to one or more envelope components.

Changes in thermostat settings and upgrades to any of the above components can have a direct impact on fuel usage. So can improving the effective performance of the envelope or the efficiency of the equipment and distribution system. However it is important to note the dynamics in thermodynamics and that buildings operate as whole systems, therefore predicting estimated savings depends on the totality of what is changed at any even given time.

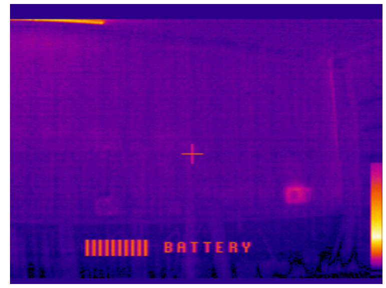
The estimated peak heat loss for the building at a design temperature of -3ºF is 120,400Btu/hr. Peak heat loss refers to the amount of heat that would be lost through the envelope (foundation, walls, ceilings, windows, doors, and air infiltration) during the coldest, or one of the coldest hour s o the winter. The design temperature is the temperature used for the peak heat loss calculation. The American Society of Heating, Refrigeration, and Air Conditioning, Engineers suggests using the coldest temperature for the area 96% of the time, which excludes most extreme lows usually only lasting a few hours. The importance of this 'peak heat load number' is that is how heating equipment is properly sized for optimal efficiency.

Thermal Imaging Survey

The thermal imaging survey was completed on the morning of the site visit. The survey was conducted using a black and white, high resolution (240x320) Monroe HR infra-red (IR) camera. Images were later colorized using Monroe software IR daq 32, but no other adjustments were made. The survey was conducted on the interior of the envelope, however conditions were not ideal since the difference between inside and outside temperatures was less than 15 degrees.

Thermographic equipment depicts anomalies in surface temperatures which can be used to identify heat transfer through building envelopes. The infra red camera only depicts surface temperatures, but it can provide helpful information when integrated with other information and details we know about the building itself. With proper interpretation, they can also be helpful in diagnosing potential moisture problems, electrical system overloading, heat loss through ducting and piping, high energy lighting fixtures, and energy intensive plug load equipment. They can also help tell the 'thermodynamic story' of a room.

In the image to the right, we can see heat (brighter colors) radiating through the overhead doors, particularly though sectional edges, and the slab. Also note the warmth emitting from the louvered vent in the vented attic.



After a thermographic scan from the inside of exterior surfaces, the following observations were noted:

- Windows and doors are a significant source of air infiltration and exfiltration.
- Framed walls have cavity insulation. The concrete walls supporting them appear to be uninsulated.

Electrical Systems

Supply & Distribution

Grid electricity is supplied by New Hampshire Electric Co-Op through a single meter located on the east side of the building. (Meter #83535) The main service panel is located in the east corner to the left of the overhead door.

Table 7 Lighting Inventory and Consumption

Lighting Inventory							
Location	**Fixture Description**	**# of Fixs.**	**W/Fix. (Def.)**	**Watts per circuit**	**Oper. Hrs (Def.)**	**Annual kWh**	**$Cost**
common room	F, (2) 4' T8, 30 watt elec ball	3	60	180	300	54	$10
lavatory	F, (2) 4' T8, 30 watt elec ball	1	60	60	150	9	$2
Office	F, (2) 4' T8, 30 watt elec ball	4	60	240	900	216	$42
Apparatus Room	F, (2) 4' T8, 30 watt elec ball	14	60	840	700	588	$112
Apparatus Room	F, (2) 4' T8, 30 watt elec ball	16	60	960	700	672	$128
Apparatus Room	F, (2) 4' T8, 30 watt elec ball	24	60	1440	400	576	$110
Apparatus Room	F, (2) 4' T8, 30 watt elec ball	18	60	1080	500	540	$103
Apparatus Room	F, (2) 4' T8, 30 watt elec ball	8	60	480	2000	960	$184
Apparatus Room	F, (2) 4' T8, 30 watt elec ball	16	60	960	500	480	$92
Droplights	Incandescent	8	75	600	750	450	$86
Lavatory	F, (2) 4' T8, 30 watt elec ball	2	80	160	200	32	$6
Storage	F, (2) 4' T8, 30 watt elec ball	2	80	160	100	16	$3
Work Bench	F, (2) 4' T8, 30 watt elec ball	6	80	480	400	192	$37
under stairs	F, (2) 4' T8, 30 watt elec ball	2	80	160	200	32	$6
Exterior	Metal Halide	3	100	300	2500	750	$143
		127			**TOTALS**	**5,567**	**$1,065**

Lighting Systems

Lighting fixtures in the building consist mainly of four foot, electronic ballasted, T-8 30 watts.

The lighting densities of the apparatus bays were not measured. A total of 96 four foot fixtures with two lamps each serve the apparatus room on six circuits. Careful planning of the circuitry provides even lighting in increasing intensity over two separate sides of the building, making it possible to optimize lighting patterns for a variety of situations and indoor conditions. .

Plug Loads

Plug loads were determined based on equipment nameplate information and by real-time metering. The operating time for each item is based on observations, occupant loading and schedule, and typical operating time for the equipment.

Table 8 Plug Load Inventory and Consumption

Other Plug Loads						
Equipment Description	**Model**	**Manufacturer**	**Watts**	**Ann. Oper. Hrs.**	**Annual kWh**	**Costs**
Calculator	Office Jet 6500	HP	40	200	8	$2
Refrigerator	Coldspot	Sears	300	2000	600	$115
Coffee Maker	Accel	Mr. Coffee	900	250	225	$43
Toaster	T4569B	Black & Decker	1500	100	150	$29
Toaster	E195159	Wal-Mart	600	200	120	$23
microwave	JES1033WB01	GE -1999	1530	100	153	$29
Vacuum		Kirby	150	75	11	$2
Water Cooler	Soft Touch	Sun Roc	150	1000	150	$29
phone	answering	ATT	25	2500	63	$12
VCR/DVD			75	300	23	$4
floor fans (3)			430	800	344	$66
ceiling fans (4)			400	1200	480	$92
Door Openers (2)	1995		700	250	175	$33
Ceiling fans	3 blade		75	2200	165	$32
Air Compressor			500	100	50	$10
Exhaust Fan			400	500	200	$38
Exhaust Fan			500	75	38	$7
Air Compressor			300	500	150	$29
Drill Press			750	130	98	$19
Grinder	Serial P0101	Baldor	350	300	105	$20

Chop Saw			1200	200	240	$46
Welder			2000	250	500	$96
Battery Charger			150	500	75	$14
Diagnostic Tool	Multi-tester 200		200	200	40	$8
engine block heater			500	1200	600	$115
Window A/C		N/A	750	600	450	$86
TOTALS					**5,211**	**$997**

Based on this analysis, the total annual plug load is 5,211 kWh from a wide range of specialized equipment and tools typical in a repair or mechanics shop.

The common room is equipped with a few kitchen appliances. Following are some things to consider when replacing appliances that no longer work:

- Select Energy Star certified appliances. Energy Star ratings mean a product uses less energy than another product with the same features – but it doesn't mean it uses less than a similar functioning product. For examples: side by side refrigerators draw use more energy than top freezer models and larger TV's use more energy than similar sets with smaller screens. Go beyond Energy Star, and select appliances whose features consume less energy.

- Coffee pots with electric burners consume a lot of energy keeping the coffee hot. A far more efficient model is one which heats the water once, then stores the coffee in an insulated carafe, staying hot for hours without using any electricity at all.

- Water dispensers are a convenience in an office, but maintaining hot and cold water around the clock typically uses more energy than heating individual servings when wanted or filling a re-useable container and storing it in an already cold refrigerator.

Plumbing Systems

Water Supply

Water is provided by the Town's water supply. Water demand for the building serves two sinks, a deep sink for janitorial services, and a sparsely used kitchen. The largest use is for washing vehicles once a week.

Heating Systems

Domestic hot water (DHW) is supplied by one, electric, 40 gallon, American water heater installed in December 2004. The life expectancy of an electric water heater depends in part on the hardness of the water, but can range from 8 to 10-15 or even 20 years. It would not be surprising to have to replace the water heater within the next few years, less likely that it last another 10 years. Water temperatures were measured at the deep sink and ground floor lavatory sink. Temperatures ranged from 130ºF to 135ºF. There was no pipe insulation observed.

Space heating is provided primarily from a 1998 Jackson and Church ceiling mounted, duct less furnace, model number 01-560-545. Approximate blower RPM is 736.

Assuming the peak heat load calculation of 140KBtu/hr is correct, that is the size, or heating capacity, needed for Plainfield's Highway Garage. The fact that the existing furnace has a 450Btu/hr capacity means that 1) it can get the building up to temperature very quickly and 2) it will rarely if ever operate at its own peak efficiency potential, instead short cycle: turn on and off again in a few minutes.

The overall combustion efficiency is estimated, therefore, between 70% and 78% .

Cooling

Cooling is provided to the office only through a window a/c unit which is installed every June and removed in the fall. There is no plate information but it is presumed to have an EER of 9 or less. The electrical use is included in other plug loads.

Mechanical Equipment Energy Consumption

The electrical energy consumption for space and water heating was determined according to nameplate information and building function and occupancy schedules. The table below presents a summary of the mechanical equipment and estimated annual energy usage. Total mechanical consumption is estimated to be 7,040 kWh/year compared to 5,567 kWh/year for lighting and 4,461 kWh/year for plug loads.

Table 9 Heating Electrical Equipment and Use

Equipment Description	Model	Manufacturer	Watts	Ann. Oper. Hrs.	Annual kWh	Costs
450KBtu Furnace	01 560-545	Jackson & Church	1220	2000	2440	$466
Electric Resistance hot water heater	N/A	N/A	1500	1800	2700	$516
			3800	500	1900	$363
TOTALS					**7,040**	**1,346**

Exhaust Ventilation Systems

Two wall mounted industrial sized fans serve as mechanical ventilation. Anecdotally, the one over the workbench is turned on with the welder and 'whenever it's needed'. Louvered dampers close when the fan is off, but not tightly and the housing is a significant source of heat loss.

The other exhaust fan is located in the lavatory and rarely used shower. The fan is vented through a long flex duct run above the ceiling to an outside soffit.

Indoor Air Quality

Indoor air quality (IAQ) is typically based upon temperature (°F), relative humidity (%), and carbon dioxide (CO_2) measured in parts per million (ppm). This data provides the best representation of building ventilation performance and occupant comfort. They are also indicative of conditions that may be detrimental to building systems including moisture intrusion, mold and mildew formation, and fungi related damage of building materials. In the Plainfield highway department building, as with any building which has garage bays for trucks and other vehicles, the risks to indoor air quality are greater and more complex, but testing for all possible contaminants is beyond the scope of this audit.

Recommended temperatures vary based on the season, occupant activity, and relative humidity levels. Generally, recommended set point heating temperatures in northern New England range between 68°F and 72°F and recommended cooling set point temperatures range between 73°F and 76°F. In this building, the thermostat stays between 55 and 60 in part because employees remain fairly active and are often wearing outdoor clothing, but in part as an effort to save energy. Relative humidity (RH) levels fluctuate consistent with seasonal atmospheric conditions, and in this environment, how much water, snow, or ice comes in with each of the vehicles.

Regardless of outdoor conditions or indoor activity, the recommended ranger for (most, non plant growing) indoor environments is between 30% and 50% relative humidity. While there are no known adverse health effects related to elevated CO_2 concentrations, it can cause acute illness including headaches, drowsiness, lethargy, and nausea. For this reason, the US Environmental Protection Agency (EPA) has established a recommended threshold concentration of 1,000 ppm.

The IAQ was measured during the site visit in the afternoon in the common room on the second level and in the apparatus bay near the furnace (which was not running). The ground level was found to be 64.4ºF; 61.8% RH, and 850ppm CO2. The common room was 67.7º, at 51.6%RH and 1246ppm CO2. Both humidity and CO2 levels were higher than the recommended thresholds.

C. EPA PORTFOLIO MANAGER BENCHMARKING

The EPAs ENERGY STAR© Portfolio Manager for Commercial Buildings is updated to reflect current utility data. This benchmarking program accounts for building characteristics, regional climatic data, and user function. It then ranks a building within its defined category amongst all other buildings entered in the program to date. The defining metric is the building Energy Use Intensity (EUI). If a building scores at or above the 75th percentile in its category then it becomes eligible for ENERGY STAR© certification pending an on-site validation review by a licensed Professional Engineer. Currently the program does not have categories for every commercial building type but they can still be entered into the program and checked against similar buildings to determine where the building ranks compared to the current national average. The average energy intensity for every building type category is constantly changing and theoretically is it reducing as more efficient buildings are constructed and existing buildings implement energy conservation measures. Therefore, buildings that currently meet the eligibility requirements may not be eligible next year when they apply for annual re-certification.

Table 10– Annual Energy Consumption

Energy	Site Usage MMBtu
Electric - Grid	62
Oil	189.4
Total Energy:	**251.4**

Table 11 – SEP Benchmarking Summary

Location	Site EUI ($kBtu/ft^2/yr$)	Source EUI ($kBtu/ft^2/yr$)
Plainfield Garage	47	74
National Average	82	146
	% Difference:	**-49%**
	Portfolio Manager Score:	**N/A**

Compared to the building category facilities that have entered data Portfolio Manager to date, the Highway Department building offices uses less energy than the national average. With a source EUI of 74kBtu/ft^2/yr, it has a lower EUI than the current National average of 146kBtu/ft2/yr. This means that the building utilizes less source energy than similar facilities nationwide. It should be noted that this is a nationwide average and does not indicate how it compares to other New Hampshire or New England buildings.

The EPA's Portfolio Manager is a very good piece of software to take a "snapshot" of one's annual energy use and presents the analysis in a simple, comprehensive, and intuitive way. Unfortunately, there are still limitations with Portfolio Manager and shortcomings occasionally occur. In this case and multiple-use buildings in general, Portfolio Manager is unable to generate a benchmark score because a highway garage is categorized as the space type "Other," which triggers the following error message:

> Floor Area for "Other" Space Type(s) Is Greater than 10% of Total Floor Space. Currently, Portfolio Manager cannot compute an energy performance rating for properties where more than 10% of gross square footage is comprised of a space type that is designated as "Other" - nor can such properties apply for an ENERGY STAR label.

However, site and source energy usage scores are good alternatives in determining energy based comparisons to similar types of buildings.

D. RECOMMENDATIONS

Energy Conservation Measures

Based on the observations and measurements of the Plainfield Highway Department building, several energy conservation measures (EEMs) are proposed for consideration. These recommendations are grouped into three tiers based on the cost and effort required to implement the EEM. EEMs are ranked within each tier based on the cost for implementation.

Tier I EEMs are measures that can be quickly implemented with little effort for no or little cost. They include routine maintenance items that can often be completed by facility maintenance personnel and changes to occupant behavior or building operation. Tier II items generally require contracted tradesmen to complete but can generally be implemented at low cost and within operating building maintenance budgets. EEMs that require large capital expenditure and budgetary planning (one year or greater) are categorized as Tier III measures.

Simple payback is calculated for the proposed EEMs. The cost to implement the measure is estimated based on current industry labor and equipment costs and the annual cost savings represents the reduced costs for energy savings. The net energy and cost savings for smaller EEMs is based on the estimated reduction of the associated energy consumption as defined in the model and equipment inventory. Using these costs, the payback period is then calculated as the number of years at which the cost of implementation equals the accumulated energy cost savings. Other qualitative considerations that do not influence the Simple Payback Method calculation but should be considered by the owner during the decision-making process include:

- Occupant comfort
- Relative operation and maintenance requirements
- Remaining useful life of equipment and systems to be replaced
- Building durability
- Indoor air quality

Energy cost savings are based on the current net electric utility charge of **$0.191** per kWh (NHEC). Heating oil cost of **$3.71** per gallon is based on NHOEP's predicted average cost for a gallon of oil for the 2011-2012 heating season.

Tier I Energy Efficiency Measures

Tier I EEMs are measures that can be quickly implemented with little effort for no or little cost. They include routine maintenance items that can often be completed by facility maintenance personnel and changes to occupant behavior or building operation. Five (5) EEMs are recommended based on the observations made during the site review.

Table 12 Tier One EEM

EEM Description TIER ONE	Est Cost	Energy kWh	Saved Oil	Est Yrly $ Savings	Years Payback
Set back hot water temp to 120°	$5	300		$57	0.1
Install filters on return registers	$35	125	5	$42	0.8
Replace thermostat with programmable	$85	200	65	$279	0.3
Insulate ceiling hatch and gasket seal	$100	50	8	$39	3
Insulate all water pipes with min R6 foam sleeves	$100	230		$44	2
	$325	**905**	**78**	**$462**	1

Further descriptions:

Water temperatures were measured at or above 130ºF at two taps. Lowering the setting to achieve 120ºF at the taps is recommended.

There is a limit to efficiency improvements available for the furnace, but installing a filter on the return and annual servicing is recommended.

A programmable thermostat will allow for consistent nighttime and weekend setbacks to 50º and an automatic reset in the event it is manually overridden for a period of time.

It is recommended to add a minimum of 2" XPS foam board and gasket a seal to the attic access hatch.

There is somewhat limited access to water pipes, but it is recommended to insulate all those accessible, mostly in and just outside the first floor lavatory, with minimum R6 foam sleeves.

Tier II Energy Efficiency Measures

Tier II items generally require contracted tradesmen to complete but can generally be implemented at relatively low cost and sometimes within operating building maintenance budgets.

Table 13 Tier Two EEM

EEM Description TIER TWO	Est Cost	Energy kWh	Saved Oil	Est yrly $ Savings	Years Payback
Install Stop Molding on both overhead doors	$192		21	$78	2
Install thermapane storm	$200	50	12	$52	4
Air seal windows and doors	$250	65	14	$64	4
Totals	**$642**	**115**	**47**	**$194**	**3**

Further descriptions:

Infra red scanning indicates considerable air leakage around the two overhead doors. Professional installation of stop molding is recommended.

There are three windows in the common room on the 2nd level. Electric resistance baseboard provides supplemental heat, which is 100% efficient and yet the highest Btu/ft2 of all heating technologies. Improving the thermal performance of the walls, windows, and ceiling even for this area alone will reduce the need for any supplemental heating. All three windows are recommended to be improved. The Tier Two EEM is to have an interior therma pane storm made for this window opening and install it each fall with effective gasket seal to prevent any air leakage. This becomes an annual chore, yet can be stored right on the adjoining wall just as the A/C is stored for the winter. The biggest impact of a new replacement window would be the possibility of better air seal, which sometimes doesn't happen. A therma pane interior storm will cost less money for superior performance.

Tier III Energy Efficiency Measures

EEMs that require large capital expenditure and budgetary planning (one year or greater) are categorized as Tier III measures.

Table 14 Tier Three EEM

EEM Description TIER THREE	Est Cost	Energy kWh	Saved Oil	Estimated $ Savings	Years Payback
Replace hinged windows with therma pane awning	$900	375	10	$109	8
Install therma pane storms on (7) fixed units	$1,400	200	23	$124	11
Insulate the foundation wall	$2,800	250	60	$273	10
Target air seal ceiling and add 10" cellulose	$5,500	600	105	$480	11
Totals	**$10,600**	**1425**	**198**	**$985**	**11**

Capital costs are provided for budgetary planning only. They are estimated based on current industry pricing. A detailed cost estimate should be developed prior to appropriating capital funds for the more costly measures.

The other two windows recommended for replacement are listed in Tier Three based on the costs of good windows to affect a real energy savings. Awning windows which open at the bottom are recommended for the shape of the opening and because they effect a tight seal.

The thermal barrier at the ceiling plane of has several deficiencies and there are several possible approaches that would reduce energy costs within a fairly reasonable time period. Targeted air sealing of all penetrations, including wires, equipment supports, and metal flashing around the chimney, is an important first step before adding insulation. Foam sealing on top of and around perimeter top plates is also key to form an air barrier. Ideally, all fiberglass would be removed and an even layer of 18" cellulose installed. The added costs typically extends the payback period though it is unquestionable the superior strategy for the long term. For a less costly approach, blow cellulose on top of what is there. This will create air pockets and compress the existing fiberglass which reduces its insulating performance by 50% or more. Insulation is only truly effective when in contact with an air barrier on all six sides and the low density nature of fiberglass makes this particularly true in its case. Further, batts rarely make full contact with framing. It is advised to get quotes for both strategies and if at all possible, select the one which removes the existing fiberglass and replaces it loose fill cellulose for superior performance.

Indoor Air Quality Measures

The following are measures recommended for improving air quality and other safety concerns but may not yield energy savings:

Table 15 Indoor Air Quality Improvements

Indoor Air Quality Improvement Suggestions	Est Cost	Energy kWh	Saved Oil	Est. Annual $ Savings	Years Payback
Air Vac	$12,000	-	-	-	N/A
Solar wall with ventilation (as above)	$15,000		150	$557	27

There is a standard three pronged approach to improving air quality in buildings:

1. **Eliminate** the contaminate; in other words: don't bring anything in the building that will cause poor air quality (ie too much moisture; toxic materials; combustion fumes; vehicle exhaust; etc…)

2. **Isolate** contaminants; for examples: moisture management basement; systems sealed combustion appliances; or hose connected exhaust systems designed for fire stations.

3. **Ventilate**, if the above does not achieve good air quality, or as in this case, is not practical or possible.

The purpose of a highway garage is to house and service trucks and other equipment Converting to a B-20 biodiesel fuel (as Keene did) will greatly reduce petroleum based fumes, but not eliminate. . Unlike a fire station, trucks may come in at various times and be parked in differing configurations so the hose connections are not always practical. Therefore ventilation often becomes the most viable strategy and is recommended for the Plainfield Highway garage because of the concentrations of CO_2 as well as fumes.

However there is another form of 'isolation' which may be a good complimentary solution. There are advanced filtration systems which are designed specifically for fire stations and highway garages because they don't just suck the bad air to the outside (where it remains air pollution) but filters it inside which removes the contaminant from all air and recycles warmed air within the building.

This would not eliminate the need for controlled fresh air ventilation but greatly reduce the amount of fresh air needed and thereby reduce the energy penalty. The Town of Danville, NH installed such a system for their Safety Complex several years ago and have been very impressed with the results.

Further, based on conversations with town residents and the interest in optimizing solar opportunities, it is worth at least exploring a 'solar wall' to supplement heating and pre warm ventilation air. This is not a recommendation for a specific product but a technological concept which may be very appropriate for this building. For more information, visit http://solarwall.com/en/products/solarwall-air-heating/how-it-works.php for a good introduction to the concept.

Energy Saving Measures not recommended at this time

1. Replace overhead doors with more efficient, aged R12 or better, units.

2. If and when siding needs to be replaced, install rigid foam panels on exterior of T-111 for insulation and drainage plane and re-side with air space for back venting/drying. If a solar wall is installed, insulating even just the south wall behind the new metal siding is recommended. Buildings of this type (utilitarian, simple lines, few windows, of little or no historic or aesthetic value and providing a necessary long term service) provide an excellent opportunity for super insulating. This measure is not recommended at this time because the estimated payback exceeds 20 years. However, integrating such 'deep energy retrofit' projects as part of other capital improvements or measures can substantially improve the economic analysis and provide deep reductions for 50 years or more.

Suggested Money Saving Measures

1. Research other sources of electricity suppliers. NEHC would still be the primary utility but some towns have been able to negotiate electricity costs down one or two cents per kWh which could save $300-$400 per year. A list of possible options can be found in Appendix C.

2. Consider replacing the existing furnace with a more efficient waste oil furnace. Again, the Town of Danville has had good success with their new waste oil furnace, though the success depends entirely on the availability of waste oil in the town or area. It should also be made clear that this does not reduce GHG emissions and may even increase pollution to some degree. An EPA study has been included as Appendix D. The existing furnace is not old enough to warrant replacement, but it is considerably larger than necessary which decreases its efficiency. Replacement at this time would be most justifiable if it was to a furnace which could burn waste oil (no cost) or a blend of waste and #2 oil.

Operations and Management and other Recommendations

1. Replace filters on furnace

2. Consider adopting an equipment policy which evaluates efficiency of donations and purchases before accepting. An Energy Star Only policy may make it easier. Also consider the energy related expertise of donated materials, labor, or services.

Renewable Energy Considerations

While renewable energy systems generally require a higher capital investment, they provide a significant reduction in the consumption of non-renewable fossil fuel energies. Other obvious benefits include a reduction in ozone depleting gas emissions (as measured by CO_2 equivalency), otherwise referred to as the "carbon footprint". Renewable energy systems also reduce the reliance upon fossil fuels derived from foreign nations and mitigate pricing fluctuations in a volatile and unpredictable market.

Evaluating the practicality of a renewable energy system for a specific facility should consider several facility specific variables including:

- Geographical location.
- Building orientation.
- Adjacent and abutting land features.
- Site footprint and open space.
- Building systems configuration and condition.
- Local zoning or permitting restrictions.
- Currently available financial resources (grants, utility provider rebates/incentives, tax incentives).

Table 19 provides a summary description of the more common and proven renewable energy technologies. The Table also provides a preliminary feasibility assessment for implementing each technology at the Plainfield Highway Garage. A more rigorous engineering evaluation should be completed if the Town is considering implementing any renewable energy system.

Table 16 – Renewable Energy Considerations

Renewable Energy System	System Description & Site Feasibility
Solar Photovoltaic Systems	***System Description:*** Photovoltaic (PV) systems are composed of solar energy collector panels that are electrically connected to DC/AC inverter(s). Collector arrays can be rooftop or ground-mounted. The inverter(s) then distributes the AC current to the building electrical distribution system. Surplus energy is sent into the utility grid via net metering and reimbursed by the utility at a discounted rate. The capital investment cost for PV systems is high but the technology is becoming increasingly more efficient thereby lowering initial costs.

	Site Feasibility: The building orientation is ideal for a PV system on the roof, though the roof structure itself would need to be evaluated for increased loads. The size of the south facing roof (about 6000ft2) offers about three times more surface area than would be needed for a PV array matched to the building's current usage. Following recommended conservation measures, a mid-size PV system (14 kW) would supplement grid electricity and to return surplus energy, if any, to the grid through net metering. This would require a design and permitting process with the local utility. Current utility incentives and renewable energy grants could help offset the capital cost for the system. It should be noted that the utility would still be supplying electricity from the grid so the monthly fees for transmission would still be charged. Energy generated from the roof top array would essentially be bought back by the utility supplier at the same rate the Town is charged, thereby offsetting 50% of the monthly bill.
Solar Domestic Hot Water	***System Description:*** Solar domestic hot water (DHW) systems include a solar energy collector system which transfers the thermal energy to domestic water thereby heating the water. These are typically used in conjunction with an existing conventional DHW system as a supplemental water heating source. Because of the high capital cost, solar DHW systems are only feasible for facilities that have a relatively high demand for DHW.
	Site Feasibility: Based on the relatively low demand for domestic hot water, a solar hot-water system is likely not a practical consideration for the building.
Geothermal Heating & Cooling	***System Description:*** Geothermal heating systems utilize solar energy residing in the upper crust of the earth. Cooling is provided by transferring heat from the building to the ground. There are a variety of heating/cooling transfer systems but the most common consists of a deep well and piping loop network. All systems include a compressor and pumps which require electrical energy. Geothermal systems are a proven and accepted technology in the New England region. Site constraints and building HVAC characteristics define the practicality.
	Site Feasibility: A geothermal heating and cooling system is not likely a practical consideration for the building. While the parcel provides adequate area for well installation and spacing, the low cooling load and relatively small heating load does not warrant the capital investment involved.

Wind Turbine Generator	***System Description:*** Wind turbine generators (WTGs) simply convert wind energy into electrical energy via a turbine unit. WTGs may be pole mounted or rooftop mounted however system efficiency improves with increased elevation. Due to cost and site related constraints, WTG technology in New England is only practical for select sites. Constraints include local geographical and manmade features that alter wind direction, turbulence, or velocity. Other technology constraints include local variability of wind patterns and velocity. Additionally, WTGs require permitting and local zoning that may restrict systems due to height limitations, and/or, visual detraction of the local landscape. Presently, WTG technology is not widely used in New England based on the relatively high capital cost compared to the energy savings.
	Site Feasibility: It is not likely that wind is a viable renewable resource for this location, at least with present turbine technologies. There are many constraints that determine if WTG is prudent for a particular site including: • Local zoning restrictions. • Detraction of the local landscape and abutter opinion. • Permitting requirements. • Local wind characteristics. Determining the local wind characteristics would require a wind study of the site.
Combined Heat & Power (CHP)	***System Description:*** Combined heat and power (CHP) systems are reliant on non-renewable energies. Systems are composed of a fossil-fuel powered combustion engine and electrical generator. Electrical current is distributed to the building distribution system to reduce reliance on grid supplied electricity. Byproduct thermal energy derived from the combustion engine is recovered and used to heat the building (this is generally considered to be renewable energy). Another benefit of CHP systems is that they provide electrical energy during power outages in buildings that do not have emergency power backup. Larger CHP units require a substantially large fuel supply and if natural gas is not available then a large LPG tank must be sited.
	Site Feasibility: Because there is no hydronic heating system in place, CHP system is not a practical technology at this time.

Biomass Heating Systems	***System Description:*** Biomass heating systems include wood chip fueled furnaces and wood pellet fueled furnaces. For several reasons, wood chip systems are generally practical only in large scale applications. Wood pellet systems can be practical in any size. Wood chip systems are maintenance intensive based on the market availability and procurement of woodchip feedstock and variability of woodchip characteristics (specie, size, moisture content, bark content, Btu value) which affect the operating efficiency of the furnace and heating output. They require a constant feed via a hopper and conveyor system and feed rates must vary according to feedstock Btu value and heating demand. For these reasons they typically require full-time maintenance and are practical only in large scale applications. Wood pellet systems are much less maintenance intensive and feedstock availability and consistency is less of an issue. Both systems reduce the dependency on fossil-fuels and feedstock can be harvested locally.
	Site Feasibility: A pellet boiler may be a good option when it comes time to replace the furnace though it would require converting to a hydronic system. Such a capital investment may prove cost effective if the price of oil continues to rise. A feature of a pellet boiler and radiating heat source which compliments the highway building is that radiating heat sources typically compliment mass storage and heating objects (such as concrete and large metal vehicles) as opposed to heating air which can more quickly lose btu's when overhead doors are open and closed.

Existing Measures

Existing measures includes EEMs and initiatives that were observed during the evaluation. They identify the facilities commitment to reducing energy consumption, enhancing occupant comfort, and improving overall building performance.

1. Efficient lighting fixtures and lamps have been installed.
2. Multiple (six) circuit light switches allow for turning on enough light fixtures, but no more.
3. The ground level thermostat is kept between 55 and 60 degrees.
4. Effort is made to open and close overhead doors quickly.

E. ENERGY EFFICIENCY INCENTIVES AND FUNDING OPPORTUNITIES

The State of New Hampshire along with the utility companies offer multiple programs designed to improve the energy efficiency of municipal and school buildings through financial incentives and technical support. Some of the currently available programs are presented herein however building managers are encouraged to explore all funding and incentive opportunities as some programs end and new programs are developed.

New Hampshire Public Utilities Commission's Renewable Energy Rebates

The Sustainable Energy Division provides an incentive program for solar electric (photovoltaic or PV) arrays and solar thermal systems for domestic hot water, space and process heat, with a capacity of 100 kW or equivalent thermal output or less. The rebate for PV systems as follows: $1.00 per Watt, capped at 25% of the costs of the system or $50,000, whichever is less. For solar hot water (SHW) systems, the base rebate is $0.07 per rated or modeled kBtu/year, capped at 25% of the cost of the facility or $50,000, whichever is less, as a one-time incentive payment. For more information, visit http://www.puc.state.nh.us/Sustainable%20Energy/RenewableEnergyRebates-CI.html, or contact Kate Epsen at (603) 271-6018 or kate.epsen@puh.nh.gov.

NHEC Energy Solutions

This program identifies opportunities to enhance energy efficiencies within a small business (those using less than 100 kilowatts) while reducing energy costs. The Co-op will conduct a assessment of a company's energy consumption, recommend efficiencies through products and services to reduce consumption, and provide rebates of up to 50% toward the cost of implementing the recommendations. Visit www.nhec.coop.com

F. PROCEDURES & METHODOLOGY

Standards and Protocol

The American Society for Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) has developed the most widely accepted process for completing energy audits at commercial facilities. ASHRAE document RP-669, SP-56, *Procedures for Commercial Building Energy Audits* defines several levels of audits. The appropriate level of audit for a particular facility depends on the availability of existing data and information, owner objectives, and owner budget. Levels range from simple benchmarking to a comprehensive review of all building systems. The most common audit is a Level II which is typically conducted as an initial audit to identify EEMs and establish budgetary costs for implementation. Level II audits are commonly referred to as "Investment Grade Audits".

Basic elements of a Level II Investment Grade Audit include the following:

- A review of existing facility data including energy usage.
- Benchmarking the facilities energy usage relative to similar use facilities.
- An on-site inspection and survey of all building systems.
- On-site measurements and data collection.
- Informal owner and occupant interviews.
- Energy use analysis and development of conservation measures.
- Developing a simple payback cost estimate for each recommended measure.
- Development of a comprehensive report that clearly presents all findings and provides recommended energy conservation measures and the associated costs.

In addition to the ASHRAE standard for commercial audits, there are industry and code-based standards that must be considered when analyzing building systems and evaluating energy conservation measures. All recommendations must be consistent with the intent of these standards. For example, the US Environmental Protection Agency (EPA) has established a recommended carbon dioxide (CO_2) threshold concentration of 1,000 parts per million (ppm) to promote a healthy indoor air environment. ASHRAE defines recommended temperatures, relative humidity levels, minimum ventilation rates, and energy standards. The Illuminating Engineering Society of North America (IESNA) prescribes recommended lighting densities based on the designated space use. The International Code Council (ICC) is the adopted standard for all building and energy codes (2009) in the state of New Hampshire. New Hampshire has also adopted ASHRAE Standards 62.1 and 90.1.

Table 17 – Relevant Industry Codes and Standards

Standard	Description
28 CFR Part 36	ADA Standards for Accessible Design
ANSI/ASHRAE Standard 55	Thermal Environmental Conditions for Occupancy
ANSI/ASHRAE Standard 62.1	Ventilation for Acceptable Indoor Air Quality
ANSI/ASHRAE/IESNA Standard 90.1	Energy Standards for Buildings Except Low-Rise Residential Buildings
ICC 2009	International Building Code (IBC)
ICC 2009	International Existing Building Code (IEBC)
ICC 2009	International Energy Conservation Code (IECC)
IESNA Lighting Handbook	Reference and Application
NFPA 70	National Electrical Code (NEC)

While the primary objective of an energy audit is identify energy conservation measures, such measures cannot adversely affect occupant comfort and indoor air quality. For example, if a building ventilation system is inadequate then it would be recommended that additional ventilation capacity be added. The electrical power required to operate the added ventilation equipment would increase energy consumption. Typically, the net energy usage incorporating the sum of the recommended conservation measures would still be less than the current usage even with the added ventilation equipment.

It is noted that although there is a prescriptive approach to commercial building audits, that every building is unique in many ways. Buildings should be evaluated consistent with the characteristics that define its need and appropriate function. This includes the following.

- Building system characteristics, and more importantly, how each system integrates within the composite facility ultimately determining building function and energy usage.
- Current building use and occupant needs.
- The manner in which the operator controls the building systems.

Benchmarking

Facility benchmarking is completed to analyze overall building performance relative to other buildings with similar use and operating characteristics. The most widely accepted benchmarking program is the ENERGY STAR® program developed by the US Environmental Protection Agency (EPA). The *ENERGY STAR® for Commercial Buildings* program ranks buildings based on how much energy they use as compared to buildings located throughout the United States. There are several categories for buildings as determined by use and function. If a building ranks at or above the 75th relative percentile, then it is eligible to receive the ENERGY STAR® certification.

Site Visit and Data Collection

Margaret Dillon of S.E.E.D.S., the Auditor assigned to the Plainfield Highway Garage audit, conducted a comprehensive site visit and building inspection of the building on November 30th, 2011 and followed standard protocol for a Level II audit, described below.

All building systems that impact energy consumption are evaluated including the building envelope, heating and cooling, ventilation, electrical, plumbing, and mechanical. The evaluation also considers whole building performance that measures how well the integrated building systems function as a composite system.

In addition to collecting equipment information, several data measurements are obtained as part of the facility site review. This data is necessary to identify potential building issues and to collect the information needed to develop an accurate energy analysis. Measurements include:

- Infra-red thermal imaging survey of the building envelope.
- Blower door testing to quantify and qualify air infiltration rates and impacts.
- Indoor air quality (IAQ) measurements (temperature, relative humidity, and CO_2).
- Lighting metering to determine energy use and operating schedules.
- Lighting output density.
- Metering of energy intensive plug-loads to determine energy use and operating schedules.

Data Gap Review and Analysis

Once the facility site review and data measurements are substantially complete, the auditor begins reviewing and processing all of the collected data. Any data gaps discovered during this process are addressed prior to completing the audit report. The information collected on site, including historic energy use data, and extensive photographs are analyzed to understand how energy is used in the building. From this comprehensive review and analysis, a series of energy conservation measures are developed to establish an estimate of net energy savings for each EEM. Capital investment costs for these measurements are developed, and based on the estimated cost savings associated with the energy reduction measure, the payback term calculated. Other noted recommendations relate to indoor air quality, code compliance, and life safety. .

Cost Estimating and Payback

The cost for implementing each evaluated EEM is then estimated by the Auditor. This provides a net estimated energy savings per dollar invested. Simple payback calculations determine the number of years required for the capital investment cost to equal the present day cost savings realized from energy reductions.

Appendix A


North facing


East facing


South facing

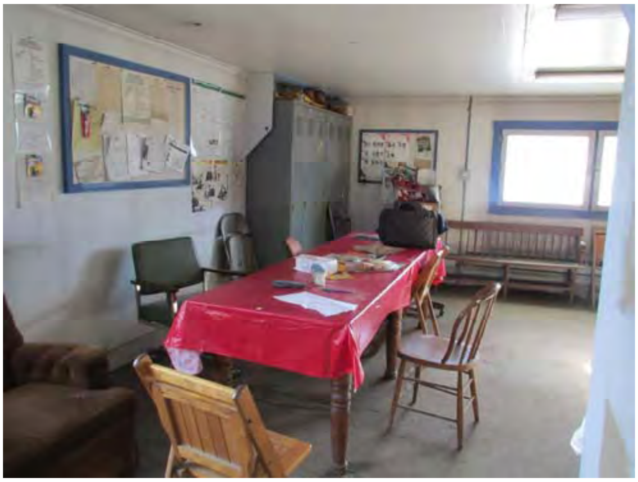

2' overhangs shade summer sun

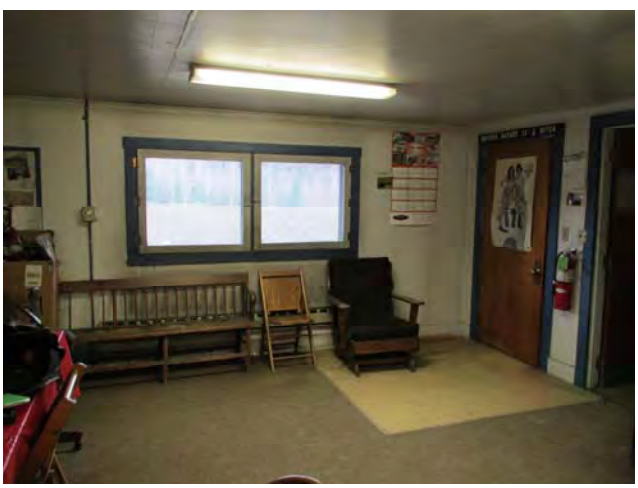

West facing

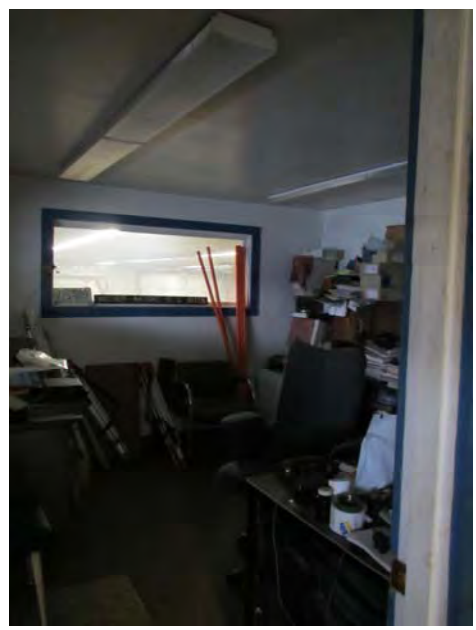

Equipment Bays


Common Room & Office
Furnace

Common room with kitchen area







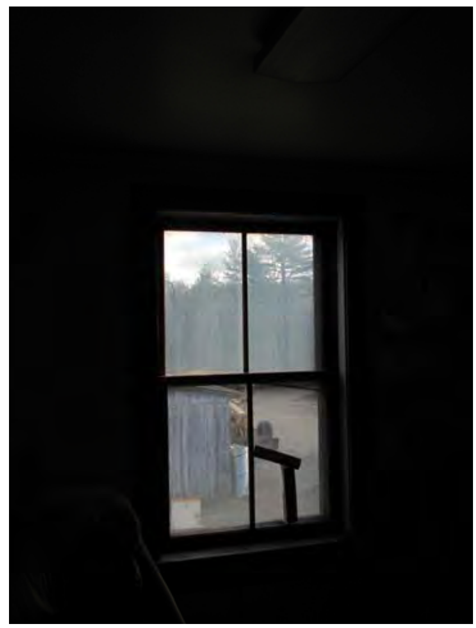
Office overlooks equipment bays

Cellulose topping over 6" fiberglass batts

Attic access

Note the faint staining on walls and ceilings, where studs and joists are located. Thermal bridging, and cold corners, means these areas will be colder and dirt in the air adheres to light condensation

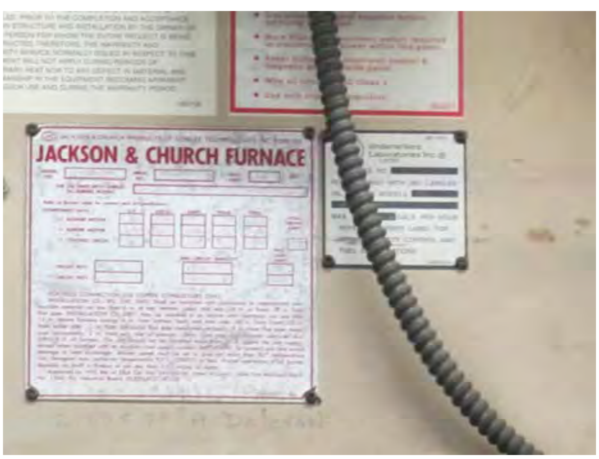
The few operable windows.



An old window air conditioner, floor and ceiling fans provide some relief from summer heat.

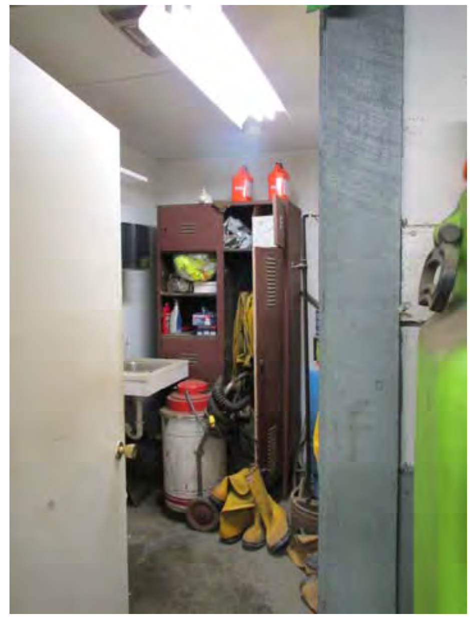
The primary source of heat is the 1998, 450KBtu, ceiling mounted Jackson and Church furnace (bottom right). It has two to three times the heating capacity needed for the building and is able to warm apparatus room without distributing through ducts simply because of the amount of heat it can put out. Electric resistance baseboards are installed in the downstairs lavatory and common room on the upper level to supplement warmer temps in those spaces.

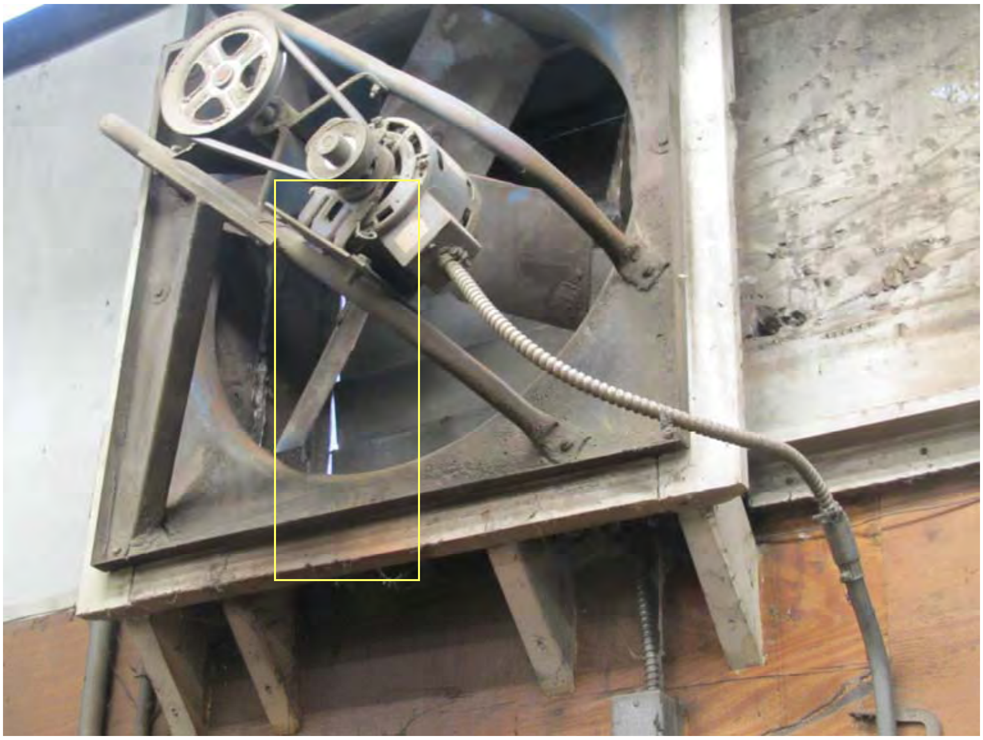
Jackson & Church 1998
01 560-545   450KBtu/Hr



Wayne
Oil Burner Model EHASR
Firing Range GPS 0.75-3.00
120 Volts-60HZ-5.5 AMPS
Specification Number 140-472
Serial No 1199

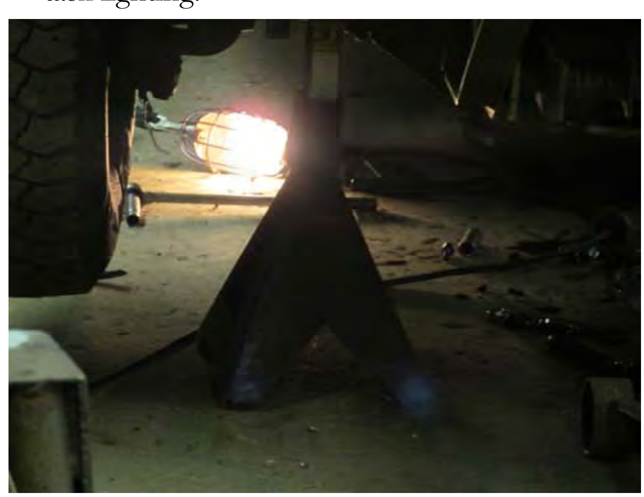
Domestic hot water for hand washing, and possibly a shower in the future, is provided by the 40 gallon electric hot water heater below.

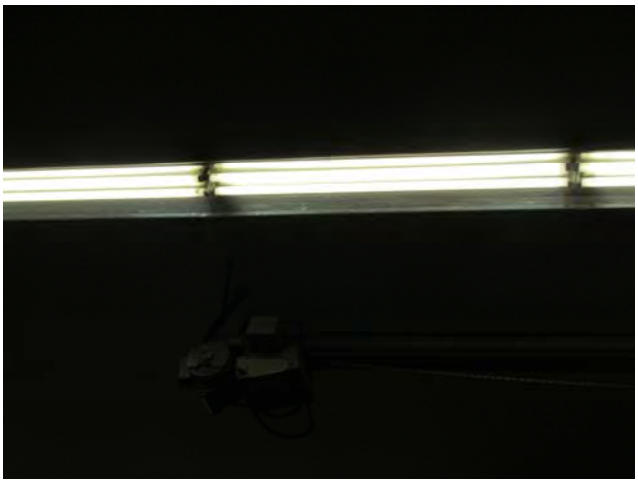




Sources of air leakage

Eight corded drop lights provide excellent task lighting.



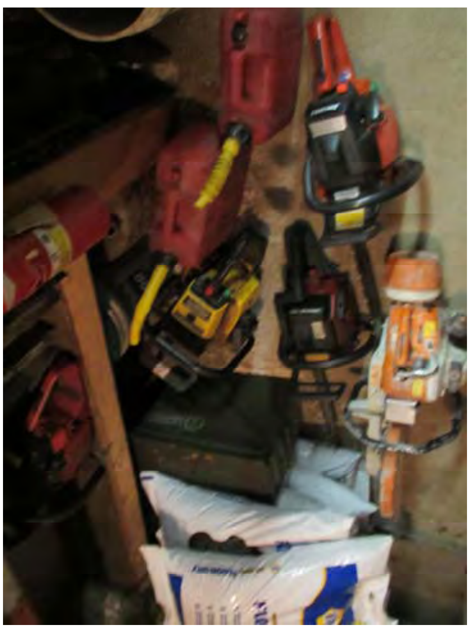


30W 4100K Sylvania supersaver ecologic 3

Six circuits control main 4’ lighting which allow for optimal control in any situation.

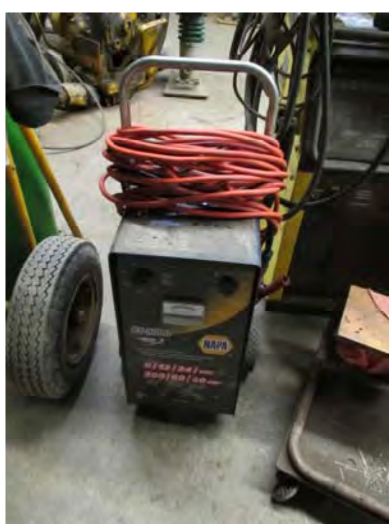
Mechanical ventilation is limited to two exhaust fans (above). On the day of the site visit, CO2 level was just above the recommended 1000ppm maximum and air quality was visibly poor. Air quality in many if not most DPW buildings in the state is generally very poor. Conventional fresh air ventilation comes with a high energy penalty and standard filtration systems on heat recovery ventilation systems cannot handle the amount of contaminants in the air.

Solvents, products with volatile organic compounds (VOC's), gas and diesel fumes, and other chemicals all contribute to overall air quality in a DPW building

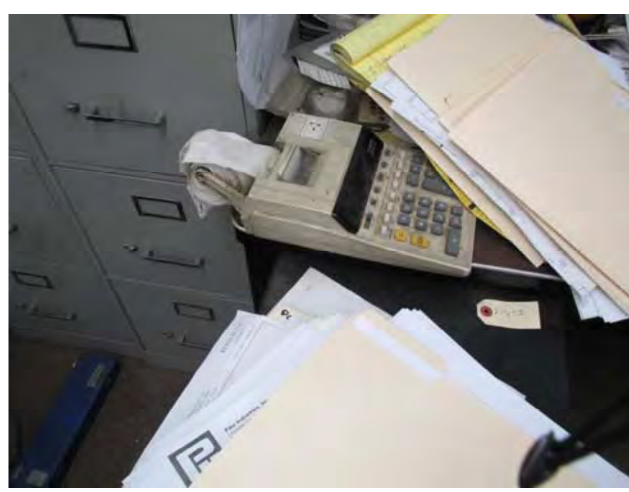


Damage to vinyl and what is presumed may be a layer of protection for some thin foundation insulation. Exposed areas of T-111 will be prone to moisture damage, though there is drying potential.

Miscellaneous tools of the trade



Plug in appliances



APPENDIX B

ENERGY SUPPLIERS currently registered to sell energy in the NHEC area.

Constellation NewEnergy, Inc.
116 Huntington Ave., Suite 700,
Boston, MA 02116
Phone: 888-635-0827
E-mail: cnesalesnh@constellation.com
Website: http://www.constellation.com
Currently Serving Commercial & Industrial Accounts Only

Glacial Energy of New England, Inc.
24 Route 6A, Suites 1, 2 and 3
Sandwich, MA 02563
Phone: 1-877-569-2841
E-mail: customercare@glacialenergy.com
Website: www.glacialenergy.com

Hess Corporation
14 May Lane
Pelham, NH 03076
Contact: Mark Gilday
Phone: 1-603-635-3297
or 1-800-437-7872
E-mail: mgilday@hess.com
Website: www.hessenergy.com

South Jersey Energy Company
d/b/a Halifax American Energy Company
816 Elm St. Ste 364
Manchester, NH 03101
Phone: 1-603-625-2244
Email: sales@haecpower.com
Website: www.southjerseyenergy.com

ELECTRICTY AGGREGATORS who are currently registered to operate in NH. For a complete list of aggregators registered to serve the Plainfield area, visit:

http://www.puc.nh.gov/Consumer/energysuppliers.htm

ALTERNATIVE ENERGY SUPPLIERS

Levco Energy
Levco Energy can get you electricity for less. Levco is a leader in the deregulated electric market and will work to save you money on electric.

Delaware Valley Energy Solutions
Green Energy and energy management are only a couple of the options that seperates Delaware Valley Energy Solutions from other electricity suppliers. Work with DelVal Energy to get Cheap Electric prices and save money on energy.

Cheap Electric Inc.
Cheap Electric is good at one thing...getting the customer cheap electric. Get the best electric rates and price and work with a power supplier who can save your residential or commercial facility money on electric. Fill out form for electric quote.

CLEAN BURN ENERGY SYSTEMS

The World Leader In Used-Oil Heating Systems™

Versatile Hot Water Technology

Used-Oil Coil Tube Boilers

Models CB-200-CTB, CB-350-CTB and CB-500-CTB

Clean Burn offers the industry's only coil tube boilers engineered from the ground up to burn used oils. They efficiently recycle used oils as a free fuel source to generate hot water, and are remarkably versatile for a wide range of applications, such as car wash facilities, baseboard heating, space heating, in-floor heating and ice melt applications.

Only Clean Burn offers three sizes of used-oil coil tube boilers, each UL listed for use in central heating systems. These can be used in combination to create a boiler system perfectly sized for any facility.

As the industry gold standard for robust construction, reliability and long service life, Clean Burn provides a greater return on investment than any other equipment of its kind. And Clean Burn distributors provide unrivaled service and support.

Model CB-350-CTB

Model CB-500-CTB

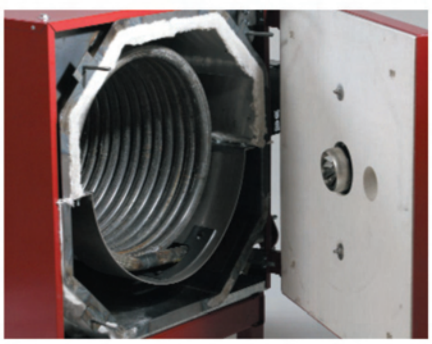
Model CB-200-CTB

environmentally friendly EPA approved

Clean Burn is a strong advocate of environmental protection and energy conservation. Our multi-oil heating systems, storage tanks and recycling centers eliminate extra handling and transportation of used oils and, consequently, help avoid the possibility of used oils entering our water supplies.

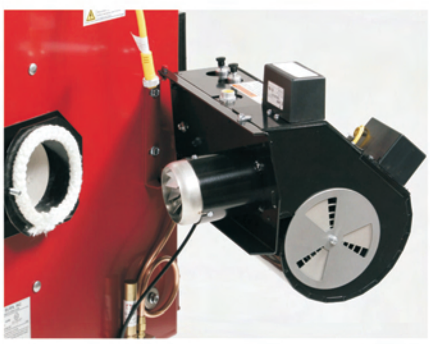
ENERGY STAR

The first choice for reliability, economy and return on investment



Easier maintenance

With Clean Burn Coil Tube Boilers, you spend 30 minutes cleaning every 750-1000 hours of operation. With competitive units, you spend 2 hours cleaning every 400 hours of operation.



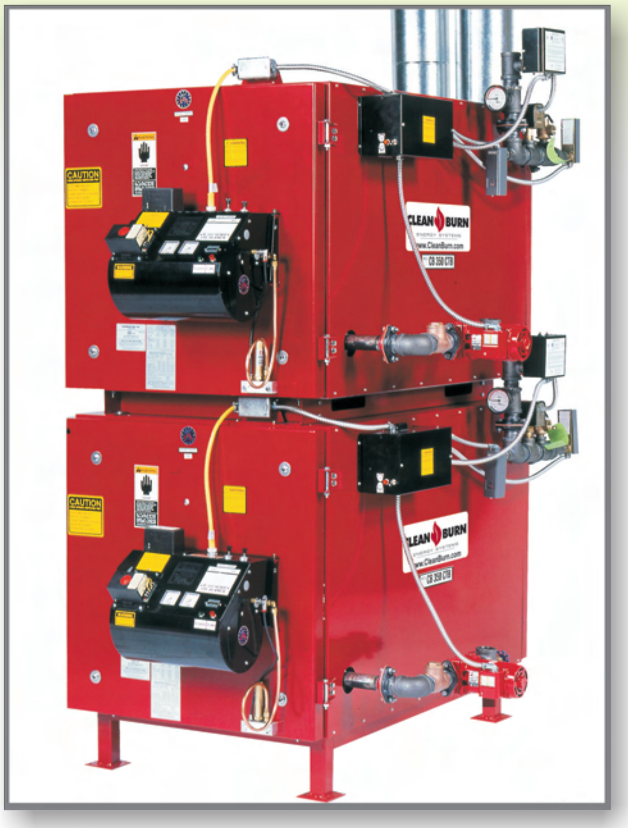
Patented burner technology

The Clean Burn burner swings out for easy cleaning, maintenance and service. An exclusive heater block, atomizer and combustion mechanism make Clean Burn unmatched for reliability, performance and long service life.

Wired, plumbed for installation

Clean Burn Coil Tube Boilers arrive with wiring and plumbing in place, helping make installation much faster and easier. They meet all national fire and safety codes.

The world's most reliable, most technically advanced used-oil boilers, only from Clean Burn.



Multiple Clean Burn Boilers can be used to create larger systems.

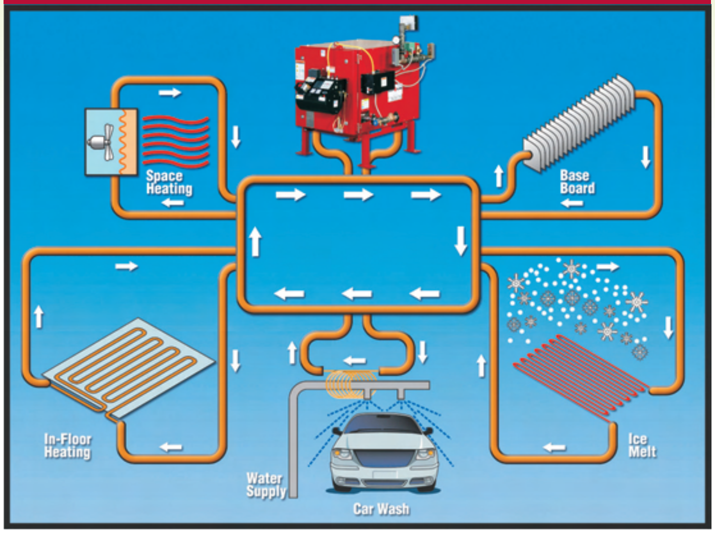
Clean Burn Coil Tube Boilers are uniquely designed for installation flexibility. Each is engineered for use as a single boiler unit, or as part of a series of boilers working as a larger system.

- Three-pass heat exchanger captures more heat for greater efficiency
- Low-mass water design provides quick start-up and reduces stack heat loss
- Patented burner engineered exclusively for used-oil combustion
- System is pre-plumbed, pre-wired, ready for installation
- Narrow cabinet designs provide installation flexibility

ENERGY STAR PARTNER · Used Oil Let's Recycle It!

UL listed, ASME tested and approved.

Typical Boiler Applications



Clean Burn used-oil boiler systems are so versatile that they are used for a wide range of applications, from heating water in a car wash to in-floor heating systems and more.

MODEL	CB-200-CTB	CB-350-CTB	CB-500-CTB
BTU/hour input:	200,000 / 58.6 kW	350,000 / 102 kW	500,000 / 146.5 kW
BTU/hour output:	148,500 / 43.5 kW	260,000 /76.2 kW	372,000 /109.0 kW
Fuels: Used oils Fuel oils	Crankcase, ATF and hydraulic #2, #4, #5	Crankcase, ATF and hydraulic #2, #4, #5	Crankcase, ATF and hydraulic #2, #4, #5
Heating surface	39 sq. ft. / 3.6 sqM	68 sq. ft. / 6.3 sqM	97 sq. ft. / 9.0 sqM
Boiler water volume	5 gal. / 19 L	12 gal. / 45.4 L	20.6 gal. / 78 L
Design water flow per coil	15 gpm / 57 lpm	25 gpm / 95 lpm	37 gpm / 140 lpm
Cabinet dimensions	39.5" L x 29" W x 29" H 1003 mm x 737 mm x 737 mm	56" L x 34.25" W x 34.5" H 1422 mm x 870 mm x 876 mm	66.5" L x 39.75" W x 41.75" H 1689 mm x 1009 mm x 1060 mm
Overall dimensions (with burner/breach/plumbing)	57.5" L x 33.25" W x 37" H 1460 mm x 844 mm x 939 mm	74" L x 39.25" W x 41" H 1880 mm x 997 mm x 1041 mm	85.25" L x 43.5" W x 47.85" H 2165 mm x 1105 mm x 1215 mm
Approximate weight	677 lbs. / 304.7 kg	1240 lbs. / 562.4 kg	1600 lbs. / 725.7 kg
Electrical requirements	115 VAC 60 Hz single phase*	115 VAC 60 Hz single phase*	115 VAC 60 Hz single phase*
Maximum oil consumption	1.4 GPH / 5.3 lph	2.5 GPH / 9.5 lph	3.57 GPH / 13.5 lph
Stack size	8" / 203 mm	8" / 203 mm	10" / 254 mm
Air compressor req's	2.0 CFM @ 25 PSI 3.4 m^3/h @ 1.7 bar	2.5 CFM @ 25 PSI 4.25 m^3/h @ 1.7 bar	2.5 CFM @ 25 PSI 4.25 m^3/h @ 1.7 bar
Recommended clean-out	750 hours	1000 hours	1000 hours

*230V / 50 Hz units also available

CLEAN BURN

The #1 Waste Oil Furnace In Customer Satisfaction™

1835 Freedom Road
Lancaster, PA USA 17601
1-800-331-0183 Fax: 717-656-0952
www.CleanBurn.com

All Clean Burn products are backed by unmatched professional factory installation and service

CTB 200-350-500 OCT 08

OMB No. 2060-0347

STATEMENT OF ENERGY PERFORMANCE
Plainfield Highway Garage

Building ID: 3024396
For 12-month Period Ending: August 31, 2011[1]
Date SEP becomes ineligible: N/A

Date SEP Generated: February 13, 2012

Facility
Plainfield Highway Garage
351 Stage Road
Plainfield, NH 03781

Facility Owner
TRC Energy Services
155 Fleet Street
Portsmouth , NH 03801

Primary Contact for this Facility
N/A

Year Built: 1982
Gross Floor Area (ft²): 5,350

Energy Performance Rating[2] (1-100) N/A

Site Energy Use Summary[3]	
Electricity - Grid Purchase(kBtu)	62,023
Fuel Oil (No. 2) (kBtu)	189,451
Natural Gas - (kBtu)[4]	0
Total Energy (kBtu)	251,474

Energy Intensity[4]	
Site (kBtu/ft²/yr)	47
Source (kBtu/ft²/yr)	74

Emissions (based on site energy use)	
Greenhouse Gas Emissions (MtCO$_2$e/year)	21

Electric Distribution Utility
New Hampshire Electric Coop Inc

National Median Comparison	
National Median Site EUI	82
National Median Source EUI	146
% Difference from National Median Source EUI	-49%
Building Type	Fire Station/Police Station

Stamp of Certifying Professional

Based on the conditions observed at the time of my visit to this building, I certify that the information contained within this statement is accurate.

Meets Industry Standards[5] **for Indoor Environmental Conditions:**	
Ventilation for Acceptable Indoor Air Quality	**N/A**
Acceptable Thermal Environmental Conditions	**N/A**
Adequate Illumination	**N/A**

Certifying Professional
N/A

Notes:
1. Application for the ENERGY STAR must be submitted to EPA within 4 months of the Period Ending date. Award of the ENERGY STAR is not final until approval is received from EPA.
2. The EPA Energy Performance Rating is based on total source energy. A rating of 75 is the minimum to be eligible for the ENERGY STAR.
3. Values represent energy consumption, annualized to a 12-month period.
4. Values represent energy intensity, annualized to a 12-month period.
5. Based on Meeting ASHRAE Standard 62 for ventilation for acceptable indoor air quality, ASHRAE Standard 55 for thermal comfort, and IESNA Lighting Handbook for lighting quality.