ENERGY AUDIT
REPORT

Town of Needham
Department of Public Facilities
1471 Highland Avenue
Needham, Massachusetts 02492
Kate Fitzpatrick

ENERGY AUDIT REPORT

of

NEEDHAM FREE PUBLIC LIBRARY

1139 Highland Avenue
Needham, Massachusetts 02492

PREPARED BY:

EMG
222 Schilling Circle, Suite 275
Hunt Valley, Maryland 21031
800.733.0660
410.785.6220 (fax)
www.emgcorp.com

EMG CONTACT:

Kalyana Vadala
Program Manager
800.733.0660, Ext. 6236
kkvadala@emgcorp.com

EMG Project #: 98515.11R-010.268
Date of Report: February 13, 2012
On site Date: September 8, 2011

EMG
DECISION INTELLIGENCE
25th ANNIVERSARY

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1. CERTIFICATION

EMG has completed an Energy Audit of Needham Free Public Library located at 1139 Highland Avenue, Needham, Massachusetts 02492. EMG visited the site on September 8, 2011.

The assessment was performed at the Client's request using methods and procedures consistent with ASHRAE Level II Energy Audit and using methods and procedures as outlined in EMG's Proposal.

This report is exclusively for the use and benefit of the Client identified on the first page of this report. The purpose for which this report shall be used shall be limited to the use as stated in the contract between the client and EMG.

This report is not for the use or benefit of, nor may it be relied upon by any other person or entity, for any purpose without the advance written consent of EMG.

Estimated installation costs are based on EMG's experience on similar projects and industry standard cost estimating tools including *RS Means*. In developing the installed costs, EMG also considered the area correction factors for labor rates for the Greater Boston area. Since actual installed costs may vary widely for particular installation based on labor & material rates at time of installation, EMG does not guarantee installed cost estimates and shall in no event be liable should actual installed costs vary from the estimated costs herein. We strongly encourage the owner to confirm these cost estimates independently. EMG does not guarantee the costs savings estimated in this report. EMG shall in no event be liable should the actual energy savings vary from the savings estimated herein.

EMG certifies that EMG has no undisclosed interest in the subject property and that EMG's employment and compensation are not contingent upon the findings or estimated costs to remedy any deficiencies due to deferred maintenance and any noted component or system replacements.

Any questions regarding this report should be directed to Kalyana Vadala at 800.733.0660, ext. 6236.

Prepared by: John McLurg, P.E.
Energy Auditor
Project Manager

Reviewed by:

Brett Byers, Reviewer for
Kalyana Vadala
Program Manager

2. EXECUTIVE SUMMARY

The purpose of this Energy Audit is to provide Needham Free Public Library and the Town of Needham with a baseline of energy usage and the relative energy efficiency of the facility and specific recommendations for Energy Conservation Measures. Information obtained from these analyses may be used to support a future application to an Energy Conservation Program, Federal & Utility grants towards energy conservation, support performance contracting, justify a municipal bond funded improvement program, or as a basis for replacement of equipment or systems.

The original library building facing the Highland Avenue was completed in 1915. This building is one-story with a basement. The original library was renovated and significantly expanded by a three-story addition completed in 2006. The entire structure totals approximately 46,235 square feet.

The study included a review of the building's construction features, historical energy and water consumption and costs, review of the building envelope, HVAC equipment, heat distribution systems, and lighting.

As mentioned above, the original part of the Needham Free Public Library was constructed in 1915 when energy conservation was not a significant issue. As part of the 2006 building expansion, the original library building was renovated and upgraded with more up-to-date energy conservation features. The 2006 addition was designed and constructed with many energy-conservation features. For this reason, the Library has achieved a LEED Silver rating. In particular, the south and west exposures of the building feature large areas of glazing which allow abundant natural light inside the building. Much of the HVAC equipment features motors controlled by Variable-Frequency Drives (VFD) which reduce unnecessary electrical energy consumption. Rooftop Energy Recovery Units make use of CO_2 sensors to minimize outdoor air requirements. Moreover, the rooftop Energy Recovery Units feature energy-recovery ("heat wheels") which absorb moisture from the outside air drawn into the Energy Recovery Unit. The heat wheels significantly reduce the energy required to condition the outside air. RTU air filters have been upgraded to high-efficiency 2-year filters which conserve fan energy. Light fixtures are energy-conserving fluorescent fixtures with electronic ballasts or Compact-Fluorescent (CFL) lamps. Many interior light fixtures are controlled by motion sensors. The building features water-conserving plumbing fixtures. Finally, the new library features a rain water harvesting system which stores roof storm water runoff in an underground (1,500-gallon) tank. The library uses this rainwater to irrigate the property during the summer.

Summary of Existing Energy Performance

Building's Annual Energy Consumption	3,086,174 kBtu
Total Annual Energy Costs	$128,049

EMG has identified three Energy Conservation Measures (ECMs) for this property. The savings for each measure are calculated using standard engineering methods followed in the industry, and detailed calculations for ECM are provided in Appendix G for reference. A 10% discount in energy savings was applied to account for the interactive effects amongst the ECMs. In addition to the consideration of the interactive effects, EMG has applied a 15% contingency to the implementation costs to account for potential cost overruns during the implementation of the ECMs.

The following table summarizes the recommended ECMs in terms of description, investment cost, energy consumption reduction, and cost savings.

Summary of Financial Information for Recommended Energy Conservation Measures

Item	Estimate
Total Projected Initial ECM Investment	$2,407 *(In Current Dollars)*
Estimated Annual Cost Savings Related to ECMs	$975 *(In Current Dollars)*
Net Effective ECM Payback	2.47 years
Estimated Annual Energy Savings	0.57%
Estimated Annual Cost Savings	0.76%

List of Recommended Energy Conservation Measures		Needham Free Public Library						
ECM #	Description of ECM	Projected Initial Investment	Estimated Annual Energy Savings		Estimated Annual Water Savings	Total Energy Savings	Total Estimated Annual Cost Savings	Simple Payback
		$	Therms	kWh	kgal	MMBtu	$	Years
No/Low Cost Recommendations								
1	Install Energy Saver on Water Fountain Details: Install on water fountain in lobby.	$190	0	690	0	2	$131	1.46
2	Install Automatic Lighting Controls Details: Install Photo Sensors Along Interior of West Elevation.	$942	0	1,111	0	4	$210	4.48
3	Install Chilled Water Reset Control Details: For air-cooled chiller on roof.	$962	0	3,921	0	13	$742	1.30
Totals for No/Low Cost Items		**$2,093**	**0**	**5,722**	**0**	**20**	**$1,083**	**1.93**
	Interactive Savings Discount @ 10%		0	-572		-2	-$108	
	Total Contingency Expenses @ 15%	$314						
Total for Improvements		**$2,407**	**0**	**5,150**	**0**	**18**	**$975**	**2.47**

3. BENCHMARKING/ENERGY PERFORMANCE SUMMARY

3.1. ENERGY STAR PORTFOLIO MANAGER FACILITY SUMMARY

EMG uses the Portfolio Manager tool developed by the Federal Environmental Protection Agency to track relative energy uses of buildings by property type. This tool allows the input of a facility's historic utility data to be compared with normalized data of a large database of its peer facilities.

More than 50% of the building is defined as Library. This building is currently ineligible for a rating.

3.2. EPA ENERGY STAR RATING

The national energy performance rating is a type of external benchmark that helps energy managers to assess how efficiently their buildings use energy, relative to similar buildings nationwide. The rating system's 1-100 scale allows everyone to understand quickly how a building is performing. For example, a rating of 50 indicates an average energy performance, while a rating of 75 or better indicates top performance. The higher the rating, the better the building is performing. Organizations can evaluate energy performance among the buildings in their portfolio, while also comparing their performance with other similar buildings nationwide. Additionally, building owners and managers can use the performance ratings to help identify buildings that offer the best opportunity for energy improvement and recognition.

To receive the energy performance rating, facility-related data entered into the Portfolio Manager, must adhere to a series of operating and energy use conditions. If one or more of these conditions are not met, the facility will receive "N/A" (Not Available) as a rating. "NA" means that the Portfolio Manager is unable to calculate a rating for that particular period ending date, given the operating and energy use conditions provided.

A building must obtain a rating of 75 or better to be eligible to apply for the Energy Star Certification. However, a rating of 75 does not necessarily mean that a building will qualify.

3.3. SOURCE ENERGY AND SITE ENERGY

Buildings use a variety of forms of energy, including Electricity, natural gas, fuel oil, and district steam. In order to provide an un-biased rating, the methodology must add together all of the energy used in a building. To combine energy in an equitable way, the ratings use source energy. Source energy is the energy that is consumed at the site, in addition to the energy used in generation and transmission.

The purpose of the conversion from site energy to source energy is to provide an equitable assessment of building-level energy efficiency. Because billed site energy use includes a combination of primary and secondary forms of energy, a comparison using site energy does not provide an equivalent thermodynamic assessment for buildings with different fuel mixes. In contrast, source energy incorporates all transmission, delivery, and production losses, which accounts for all primary fuel consumption and enables a complete assessment of energy efficiency in a building. When source energy is used to evaluate energy performance, an individual building's performance does not receive either a credit or a penalty for using any particular fuel type. The building's Statement of Energy Performance follows. Associated energy performance documents may be found in Appendix H.

Facility
Needham: Free Public Library
1139 Highland Avenue
Needham, MA 02492

Facility Owner
N/A

Primary Contact for this Facility
N/A

General Information

Needham: Free Public Library	
Gross Floor Area Excluding Parking: (ft^2)	46,235
Year Built	1915
For 12-month Evaluation Period Ending Date:	June 30, 2011

Facility Space Use Summary

Library	
Space Type	Other - Library
Gross Floor Area(ft^2)	46,235
Number of PCs[a]	N/A
Weekly operating hours[a]	N/A
Workers on Main Shift[a]	N/A

Energy Performance Comparison

	Evaluation Periods		Comparisons		
Performance Metrics	**Current** (Ending Date 06/30/2011)	**Baseline** (Ending Date 06/30/2011)	**Rating of 75**	**Target**	**National Median**
Energy Performance Rating	N/A	N/A	75	N/A	N/A
Energy Intensity					
Site (kBtu/ft2)	67	67	0	N/A	92
Source (kBtu/ft2)	175	175	0	N/A	246
Energy Cost					
$/year	$ 125,995.23	$ 125,995.23	N/A	N/A	$ 173,189.32
$/ft2/year	$ 2.73	$ 2.73	N/A	N/A	$ 3.75
Greenhouse Gas Emissions					
$MtCO_2e$/year	286	286	0	N/A	393
$kgCO_2e/ft^2$/year	6	6	0	N/A	8

4. INTRODUCTION

The purpose of this Energy Audit is to provide Needham Free Public Library with a baseline of energy usage, the relative energy efficiency of the facility, and specific recommendations for Energy Conservation Measures. Information obtained from these analyses may be used to support a future application to an Energy Conservation Program, Federal and Utility grants towards energy conservation, as well as support performance contracting, justify a municipal bond-funded improvement program, or as a basis for replacement of equipment or systems. The energy audit consisted of an on site visual assessment to determine current conditions, itemize the energy consuming equipment (i.e., boilers, Make-Up Air Units, DHW equipment); review lighting systems both exterior and interior; and review efficiency of all such equipment. The study also included interviews and consultation with operational and maintenance personnel. The following is a summary of the tasks and reporting that make up the Energy Audit portion of the report.

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ENERGY AND WATER USING EQUIPMENT

- EMG has surveyed the common areas, office areas, classrooms, maintenance facilities, rooftop, and mechanical rooms to document utility-related equipment, including heating systems, cooling systems, air handling systems and lighting systems.

BUILDING ENVELOPE

- EMG has reviewed the characteristics and conditions of the building envelope, checking insulation values and conditions. This review also includes an inspection of the condition of walls, windows, doors, roof areas, insulation and special use areas. Where we anticipated significant losses, we utilized infrared thermographs to analyze heat loss across the envelope.

RECOMMENDATIONS FOR ENERGY SAVINGS OPPORTUNITIES

- Based on the information gathered during the on site assessment, the utility rates, as well as recent consumption data and engineering analysis, EMG has identified opportunities to save energy and provide probable construction costs, projected energy/utility savings and provide a simple payback analysis.

ANALYSIS OF ENERGY CONSUMPTION

- Based on the information gathered during the on site assessment and a minimum of one year of utility billing history, EMG has conducted an analysis of the energy usage of all equipment, and identified which equipment is using the most energy and what equipment upgrades may be necessary. As a result, equipment upgrades or replacements are identified that may provide a reasonable return on the investment and improve maintenance reliability.

ENERGY AUDIT PROCESS

- Interviewing staff and review plans and past upgrades
- Performing an energy audit for each use type
- Performing a preliminary evaluation of the utility system
- Analyzing findings, utilizing ECM cost-benefit worksheets
- Making preliminary recommendations for system energy improvements and measures
- Estimating initial cost and changes in operating and maintenance costs based on implementation of energy efficiency measures
- Ranking recommended cost measures, based on the criticality of the project and the largest payback

REPORTING

The EMG Energy Audit Report includes:

- A comprehensive study identifying all applicable Energy Conservation Measures (ECMs) and priorities, based on initial cost and payback
- A narrative discussion of building systems/components considered and a discussion of energy improvement options;
- A summary of ECMs including initial costs and simple paybacks based on current utility rates and expected annual savings.

5. FACILITY OVERVIEW AND EXISTING CONDITIONS

5.1. BUILDING OCCUPANCY

The Library is open to the public Monday-Thursday from 9:00 am to 9:00 pm. On Fridays, the Library closes at 5:30 pm. Saturday hours are from 9:00 am to 5:00 pm. Sunday hours are 1:00 pm to 5:00 pm, except during July and August when the Library is closed on Sunday. During the week, the maintenance staff arrives at 7:00 am and departs at closing.

It is difficult to estimate the occupancy of the building with any degree of precision. Assuming that 50% of the building is devoted to book stacks and reading areas gives a theoretical occupancy of approximately 360 persons.

Facility Occupancy (avg. people/day)	360
Standard Operating Hours/day	15.5
Maintenance/ Staff Hours/day	7 AM-10 PM

Summary of Facility Operating Hours

	Hours Open to the Public	Hours Open to Employees
Monday-Friday	9 AM-9 PM (5:30 Fri.)	7 AM-9 PM (5:30 Fri.)
Saturday	9 AM-5 PM	9 AM-5 PM
Sunday	1 PM-5 PM (Closed July, August)	1 PM-5 PM (Closed July, August)

5.2. BUILDING ENVELOPE

The building envelope consists of the exterior shell, made up of the walls, windows, roof, and floor. The envelope provides building integrity and separates the exterior from the interior conditioned space.

According to the structural drawings, the 2006 building foundation consists of a conventional, reinforced concrete, slab-on-grade foundation with exterior wall and column footings. The original 1915 building has bearing-wall footing foundations.

The 2006 building has structural steel columns supporting the first floor, second floor and roof. The first and second floors have concrete-topped metal decks supported by open-web joists. The 1915 building has a shallow basement and a brick bearing wall structure. The first floor is a wood-joist and floorboard structure.

The roof of the original 1915 library is a hip roof finished with roofing slates over wood boards. The sloped roof surfaces of the 2006 addition are finished with roofing slates over rigid insulation and a metal deck. The flat roof surfaces of the 2006 addition are finished with stone ballast over a single ply membrane which is laid over ZCC rigid insulation board panels and metal decking.

The exterior walls of the original 1915 library are solid brick masonry bearing walls. The 2006 addition has a variety of exterior curtain wall systems. These walls are framed with 6″ metal studs. The curtain walls are finished with glazing, metal panels, slate or brick veneer. Curtain walls finished with metal or slate are insulated with 6″ batt insulation. The walls finished with brick veneer are insulated with 2-1/2″ rigid insulation board. No cracks or infiltration issues were observed.

Item	Construction Type
Foundation	1915 Building: Bearing wall footings. 2006 Addition: Slab-on-grade with column footings and bearing wall footings.
Structure	1915 Building: Bearing wall with timber-framed floor and roof. 2006 Addition: Steel-framed with open-web joists and roof trusses.
Exterior Walls	1915 Building: Brick bearing walls 2006 Addition: Curtain walls; masonry cavity walls, metal wall system or slate siding
Roof	1915 Building: Wood planks finished with slates 2006 Addition: Metal Roof Deck with membrane and stone ballast or slate

The following table describes the observed or reported insulation levels at the property:

Building Element	Type Observed	Observed R-values
Roof and Attic	1915 Building: 6-13″ FG batt 2006 Addition: 4″ rigid board	R-20/R38
Floors	None	Not accessible
Exterior Walls Above Grade	1915 Building: none 2006 Addition: 6″ FG batt or 2.5″ rigid board	R-19(batt) or R-12(board)
Basement Walls and Slab Perimeter	Rigid insulation (slab)	R-14
Windows	1915 Building: Storm windows 2006 Addition: Insulated double-pane glass	Unknown
Exterior Doors	Solid wood, insulated double-glass or insulated metal	Unknown

The windows are part of an aluminum framed storefront system incorporating the entry doors. The windows are glazed with insulated panes set in metal frames. The entrance doors of the 2006 addition are fully glazed, aluminum framed doors set in the storefront framing system. Caulking and weather stripping are in good condition.

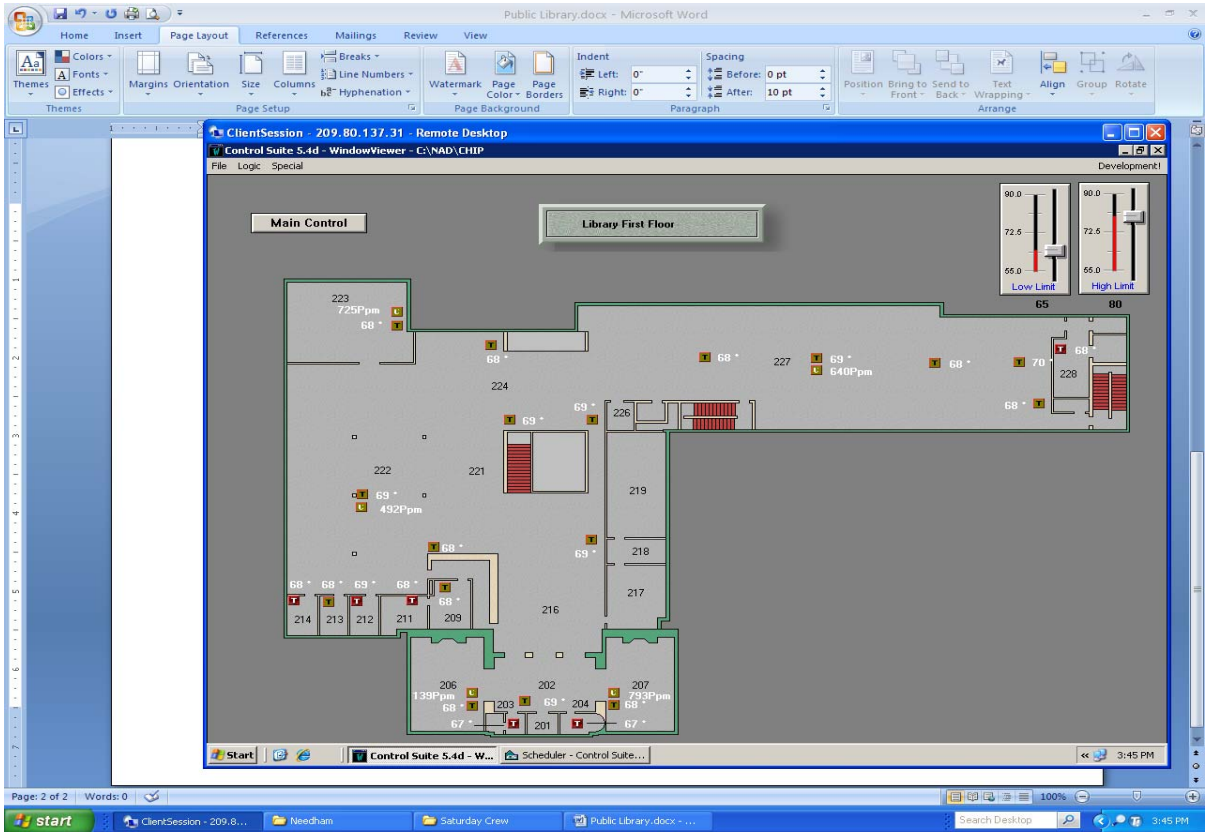
The windows of the 2006 addition are aluminum-framed, double-pane glazed units. The windows of the 1915 building are wood-framed, single pane-glazed units with storm windows. The caulking was in good condition. Air infiltration was not reported near the windows. No window issues such as infiltration or condensation were observed.

The additional entrance doors of the 1915 Building were wooden doors with insulated, double-pane glass panels. Service doors or fire exit doors were insulated steel doors. Caulking and weatherstripping were observed to be in good condition.

5.3. BUILDING HEATING, VENTILATION, AND AIR-CONDITIONING (HVAC)

Building Automation System (BAS)

The building HVAC system is controlled by a Barber-Coleman 8000 Building Automation System (BAS). The BAS controls all HVAC equipment to maintain a winter indoor temperature setpoint of 68°F and a summer temperature setpoint of 73°F. The building temperature is measured by sensors located throughout the building which transmit to the BAS. The BAS controls valves, dampers, fans and pumps to maintain setpoint temperatures. The following is a "screen shot" of the BAS showing Library first floor space temperatures and CO_2 concentrations.



The HVAC system is configured to run in "occupied" mode from 6 or 7 AM until 11 PM (Monday-Thursday). On Friday, Saturday and Sunday, the system runs 7am-11pm. As mentioned above, the Library is closed on Sundays during July and August. During "unoccupied" periods, the HVAC system is "setback" to 85° (summer) and 60° (winter).

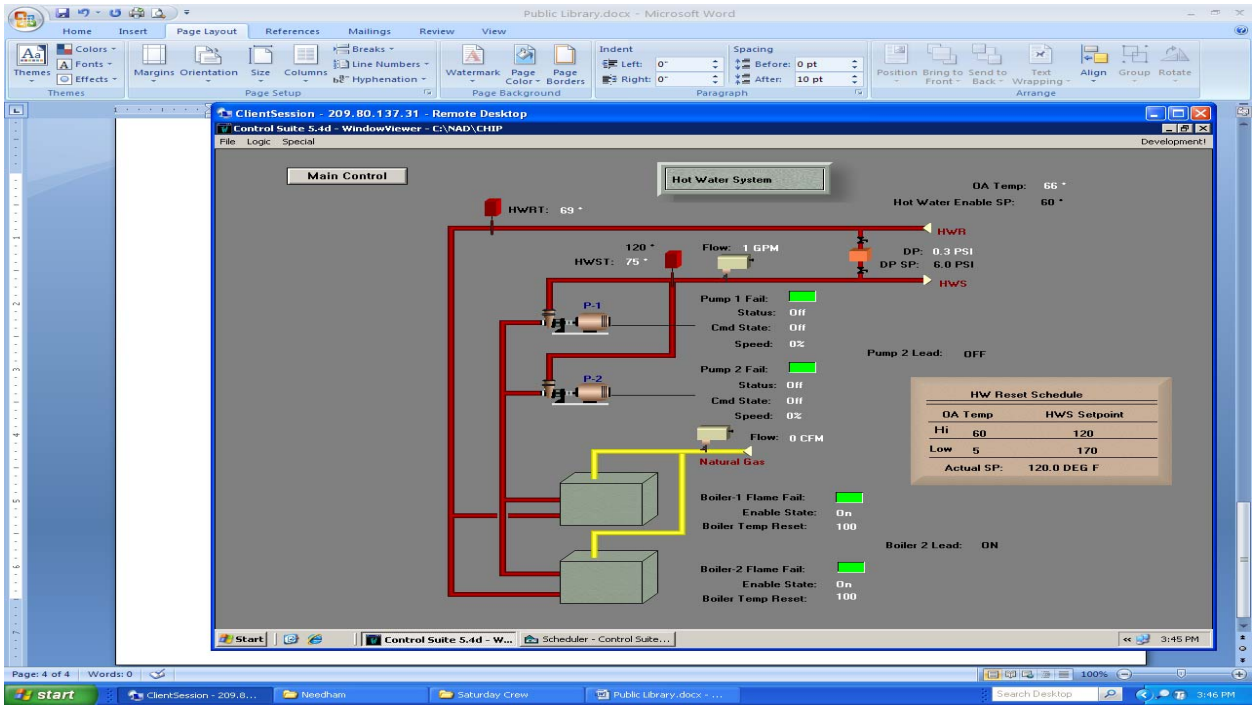
Building Heating

Each rooftop Energy Recovery unit supply fan draws Outside Air through the Energy Recovery Wheel ("Heat Wheel"). The Energy Recovery Wheel absorbs moisture from the Exhaust Air and transfers it to the incoming Outside Air. The Outside Air then passes through the unit hot water coils which heat air directly and distributes heated air into ductwork and then into the fan coil units and, finally, into the space.

The building boilers heat water and pumps distribute it to convection heating equipment located throughout the building which then heats the air inside the space.

The building has two gas-fired condensing (90% efficient) hot water boilers located in Room 23. The boilers operate during heating season, only. Under normal circumstances, only one boiler will operate and the other remains in standby. Each boiler rotates monthly between standby and on-line operation. Normal hot water supply temperature setpoint is 160°F. During moderate weather (above 60°F), the heating water temperature will reset to 120°F. During extreme cold weather (below 5°F), both boilers will be on line and heating water temperature setpoint will be 170°F. Two 5 horsepower (150gpm @ 75') pumps circulate heated water through a two-pipe system to the hydronic heating equipment located throughout the building spaces. Normally, only one pump will operate but both pumps will operate when the heating system requires maximum flow. The circulating pump motors feature Variable Frequency Drives (VFD). The BAS controls the speed of the pump motors and heated water flow to match heating demand, thus reducing unnecessary electric energy consumption. Hydronic heating devices in the building space include fin-tube units, unit heaters, cabinet unit heaters and fan-coil units with hot water reheat coils.

The following BAS "screenshot" shows a schematic of the Library hydronic system:



The building hydronic fin-tube units are designed to provide heat to the perimeter spaces of the building. Each unit is connected to a thermostat which operates a control valve to control the flow of heated water through the fin-tube unit.

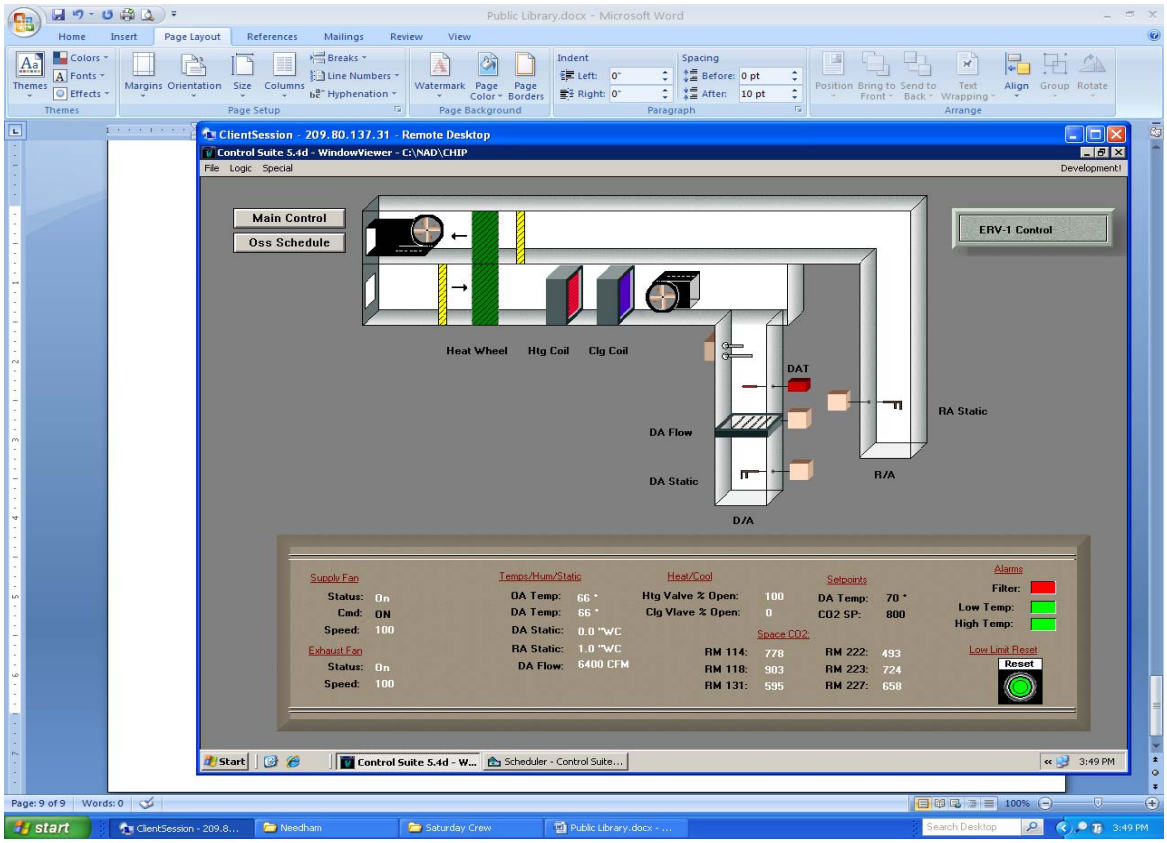
Cabinet Unit Heaters are located in the vestibules at the main building entrances. These units are mounted flush with the interior wall surfaces. These units are similar in operation to the fin tube units but they have fans which blow warmed air into the vestibules.

Unit Heaters are located in mechanical rooms. These units are similar to the cabinet unit heaters but they are used in areas where aesthetic appearance is not important.

Most interior spaces of the Library are heated by fan coil units equipped with hydronic reheat coils. The fan coil units are supplied with conditioned or "tempered" air from the rooftop Energy Recovery Units. The air entering the fan coil is heated by the hydronic reheat coils to the desired temperature and then it enters the space and mixes with the air in the space to maintain the desired space setpoint temperature.

Each rooftop Energy Recovery unit supply fan draws Outside Air through the Energy Recovery Wheel ("Heat Wheel"). The Energy Recovery Wheel absorbs moisture from the Exhaust Air and transfers it to the incoming Outside Air. This helps to maintain space humidity at a comfortable level during the winter. The Outside Air then passes through the unit hot water coils which heat the air directly and the Supply Fan which distributes heated air into ductwork. The heated air then passes through Fan-Coil Units where it is reheated, if necessary, by the unit reheat coils to the desired temperature. The air then passes through ceiling diffusers and mixes with the room air to maintain the room temperature at the setpoint as controlled by the BAS.

The following BAS "screenshot" shows a schematic view of an Energy Recovery unit:



Ventilation

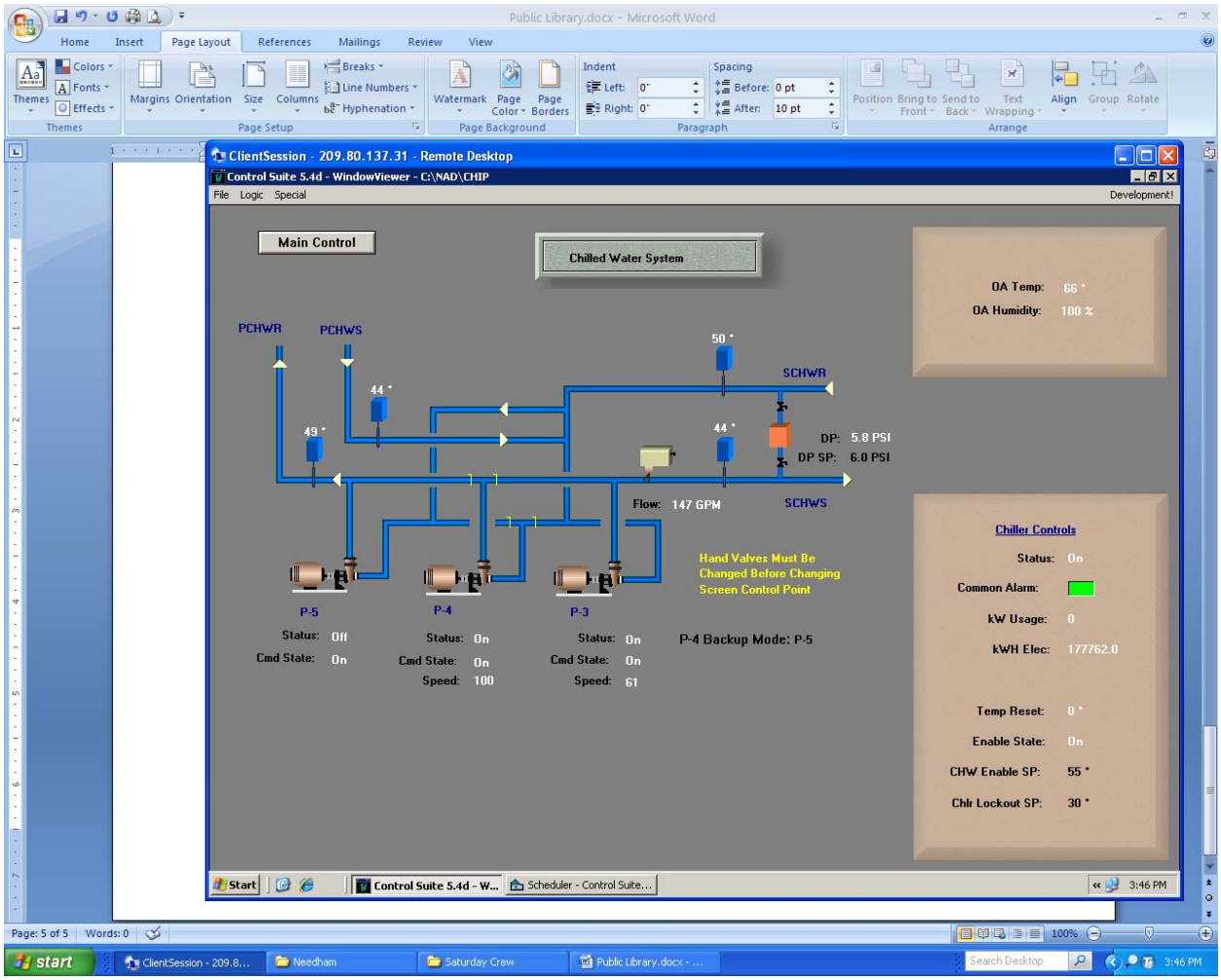
The three building exhaust fans (EF) draws air from the restrooms. General Ventilation of the remaining Library spaces is provided by the rooftop Energy Recovery Units which exhaust Return Air into the atmosphere. This exhaust air is replaced with Outside Air which is drawn through the Energy Recovery Unit. The BMS controls the volume of Outside Air in response to CO_2 concentrations in the interior spaces. This reduces the volume of Outside air drawn into the Energy Recovery Unit to what is actually required for occupant's health and comfort. This process is known as "Demand Controlled Ventilation" and it enables significant energy savings since energy is otherwise required to heat (or cool) Outside Air. The BAS controls the Energy Recovery Unit Supply and Exhaust Fan speeds by means of Variable Frequency Drives (VFD). When the space CO_2 concentration exceeds the desired level, the BAS increases the speed of the Exhaust Fan to remove more air from the space. Simultaneously, the Supply Fan speed increases to draw in more Outside Air to replace the Exhaust Air. This intake of "fresh air" reduces space CO□ concentration to the desired level.

Air-conditioning

Cooling air is supplied to most of the building spaces by the Energy Recovery Units. Cooling is provided to the Archive Rooms and telephone/data rooms by small split-system units (R407C refrigerant). Each rooftop Energy Recovery unit supply fan draws Outside Air through the Energy Recovery Wheel ("Heat Wheel"). The Energy Recovery Wheel absorbs moisture from the Outside Air and transfers it to the outgoing Exhaust Air. This helps to maintain space humidity at a comfortable level during the summer and reduces the amount of energy required to condition the Outside Air. The Outside Air then passes through the unit chilled water coils which cool the air directly and the Supply Fan which distributes cooled air into ductwork. The cooled air then passes through Fan-Coil Units where it is further cooled, if necessary, by the unit chilled water coils to the desired temperature. The air then passes through ceiling diffusers and mixes with the room air to maintain the room temperature at the setpoint as controlled by the BAS.

A rooftop air-cooled (128 ton/10.2 EER, R-22 refrigerant) Chiller removes heat from the Primary chilled water circuit and reduces the water temperature to approximately 44□F. The Primary pump (P5) circulates chilled water through the Primary Circuit. The Secondary chilled water pumps (P3, P4) pump the chilled water supply (CWS) from the Primary chilled water circuit into secondary circuits which supply Energy Recovery Unit chilled water coils as well as the fan coil unit chilled water coils. These units transfer heat into the chilled water. The heated water enters the Primary circuit and is pumped to the chiller where it is again mechanically chilled to approximately 44□F. The secondary pumps are equipped with VFD motors which vary the speed of the pump in response to space cooling demand, thus providing significant energy savings.

The following BAS "screenshot" illustrates the Chilled Water system:



Item	Measured Values
Major Heating system type/capacity	2 Hot-Water Boilers/3,150 MBH, total
Major Cooling System type/capacity	1 Chiller/128 tons, total
Heating hot water supply temperature	160°F (normal)
Chilled water supply/return temperatures	44°F/49°F
Condenser water supply/return temperatures	Not applicable (air-cooled condensers)
Outside Air temperature and Relative Humidity (%) at time of audit	66°F/81%
Interior space temperatures and Relative Humidity (RH%)	67-71°F/47-53%
Supply Air Temperature (SAT)/Return Air Temperature (RAT)	64-66-°/71-74°
Avg. Supply Air rate (CFM/Sq.ft)	.22cfm/sq-ft.
Avg. Interior space thermostat set-point	68°(winter)/73°(summer)
Avg. Outside Air rate (% & CFM/Sq.ft or CFM/person)	.22cfm/sq-ft; 28.6cfm/person

The Mechanical Equipment Schedule in Appendix E contains a summary of the HVAC Equipment at the property.

5.4. BUILDING LIGHTING

Interior light circuits are controlled by the a Lighting Control System (LCS). Operation times approximate the operation times of the HVAC system.

Exterior light circuits are controlled by a combination of timer controls and photosensors. These are adjusted according to the seasons so that exterior lighting is illuminated only during the hours of darkness.

Most Library public spaces such as lobbies, reading rooms, book stacks, corridors, and restrooms have light fixtures controlled by light switches. Mechanical room lighting is also controlled by light switches. Light fixtures in most private offices and study rooms are controlled by motion detectors. Each motion detector will switch the room lights "off" if it does not detect motion within a 15-minute interval. This conserves energy by turning light fixtures "off" when the room is unoccupied.

Offices are furnished with lay-in ceilings so most lighting in these areas is provide by linear-fluorescent fixtures with two 28-watt T5 lamps, reflectors, and electronic ballasts. Other public areas such as reading areas and book stacks have similar fixtures, except they are pendant-mounted for greater efficiency. Additional lighting is furnished by recessed "can" fixtures using mostly 26W CFL lamps. Corridor lighting features recessed "can" fixtures with 26W CFL lamps. Surface-mounted CFL light fixtures on the exterior walls provide the exterior building with site illumination. Recessed CFL light fixtures are located in the exterior soffits. Parking lot lighting is provided by property-owned 150W metal halide fixtures. The poles are spaced along the drive aisles throughout the parking areas.

Generally speaking, building lighting is adequate. No "burned out" lamps were observed. During the energy audit, light levels were taken in the many of the rooms. The various rooms have been grouped by function such as reading rooms, library stacks, hallways, restrooms, etc. For each functional group, the light readings were averaged and the results obtained appear in the following table along with recommended light levels:

Space type	Measured Light Levels (Lux/foot candles)	ASHRAE/IESNA Recommended Levels (foot candles)
Reading Areas	430 Lux/40 FC	50
Library Stacks	236 Lux/22 FC	35
Hallways	140 Lux/13 FC	2.5 - 5
Restrooms	96 Lux/9 FC	20
Lobbies	215 Lux/20 FC	10 - 20
Avg. Building Lighting Density, W/Sq.Ft	0.803 W/Sq.Ft	1.2 W/Sq.Ft

Note: 1 foot candle = 10.764 lux

The table shows that building hallways have higher illumination levels than recommended. Otherwise, most spaces appear to have adequate to slightly lower light levels compared to recommended levels. The building lighting density of 0.8 Watts/square foot indicates that the Library lighting was carefully designed so that illumination levels are not excessive.

However, many spaces in the building are exposed to abundant natural light and additional energy savings could be realized by reducing artificial lighting at times when natural light is adequate. This is particularly true for the building stacks and reading rooms exposed to large windows on the west side of the building. Also, the second floor corridor has a large window area which provides abundant natural light.

The Lighting Systems Schedules in Appendix F contain a summary of the Existing Lighting Systems at the property, along with proposed Lighting Energy Conservation Measures.

5.5. BUILDING ELEVATORS AND CONVEYING SYSTEMS

There are two hydraulic passenger elevators. The elevator machinery is located in a room adjacent to the shafts.

5.6. BUILDING DOMESTIC HOT WATER

Domestic water is supplied to the building from the Town of Needham. The building water meter is located in Room 123.

The 1915 building has a single lavatory with an electric "instantaneous" water heater. The remaining five restrooms in the 2006 addition are supplied with hot water by three 6-gallon electric water heaters.

The common area restrooms have commercial-grade fixtures and accessories, including water closets and lavatories. The toilets consist of flush valves. The typical flush volume was 1.6 GPF. The lavatories are equipped with aerators rated at 2.2 GPM. The lavatories are operated by manual hand valves. Men's restrooms are furnished with waterless urinals.

DHW type	Gas
Storage Tank Capacity	18-gallon (total)
Heating/tank set-point	Unknown
DHW temperature at faucet	Approximately 105°-120°
Building faucets, GPM	2.2
Water closets/toilets, GPF	1.6

5.7. BUILDING NATURAL GAS AND ELECTRICITY

The building is connected to the natural gas utility (NStar). The gas main on the adjacent public street supplies the natural gas service. The gas meter and regulator is located along the exterior wall of the building. The gas distribution piping within the building is malleable steel (black iron).

The facility is master-metered for natural gas. There is a natural gas meter located at the east side of the building.

The electrical supply lines run underground from a pad-mounted transformer to an interior-mounted electrical meter.

The main electrical service size is 16,000amps, 480/277-volt, three-phase, four-wire alternating current (AC). The electrical wiring is copper, installed in metallic conduit. Circuit breaker panels are located throughout the building.

The facility is master-metered for Electricity. There is one electric meter at the property, located in Room 121.

Emergency lighting is provided by backup battery-powered emergency fixtures.

Electrical Transformer Type (Wye, Delta)	Unknown
Mounting	Pad-mounted
Location	East side of Building
Main Building Electric service	Underground
Primary Volts	Unknown
Secondary Volts	480/277
Phase	3
Wire	4
Amp	
On site Generator (Y/N)	no
Generator Capacity, KVA	
Generator Fuel Type	N/A

Electric Meter type (Master/Sub/Direct)	Master	Natural Gas Meter type (Master/Sub/Direct)	Master
Meter Location	Room 121	Meter Location	Building Exterior
Main meter number	5105568	Main meter number	

6. UTILITY ANALYSIS

Establishing the energy baseline begins with an analysis of the utility cost and consumption of the building. Utilizing the historical energy data and local weather information, we evaluate the existing utility consumption and assign it to the various end-uses throughout the buildings. The Historical Data Analysis breaks down utilities by consumption, cost and annual profile.

This data is analyzed, using standard engineering assumptions and practices. The analysis serves the following functions:

- Allows our engineers to benchmark the energy and water consumption of the facilities against consumption of efficient buildings of similar construction, use and occupancy.
- Generates the historical and current unit costs for energy and water
- Provides an indication of how well changes in energy consumption correlate to changes in weather.
- Reveals potential opportunities for energy consumption and/or cost reduction. For example, the analysis may indicate that there is excessive, simultaneous heating and cooling, which may mean that there is an opportunity to improve the control of the heating and cooling systems.

By performing this analysis and leveraging our experience, our engineers prioritize buildings and pinpoint systems for additional investigation during the site visit, thereby maximizing the benefit of their time spent on site and minimizing time and effort by the customer's personnel.

Based upon the utility information provided about the Needham Free Public Library, the following energy rates are utilized in determining existing and proposed energy costs.

Utility Rates used for Cost Analysis

Electricity (Blended Rate)	Natural Gas
0.19 $/kWh	1.12 $/therm

The data analyzed provides the following information: 1) breakdown of utilities by consumption, 2) cost and annual profile, 3) baseline consumption in terms of energy/utility at the facility, 4) the Energy Use Index, or Btu/sq ft, and cost/sq ft. For multiple water meters, the utility data is combined to illustrate annual consumption for each utility type.

6.1. ELECTRICITY

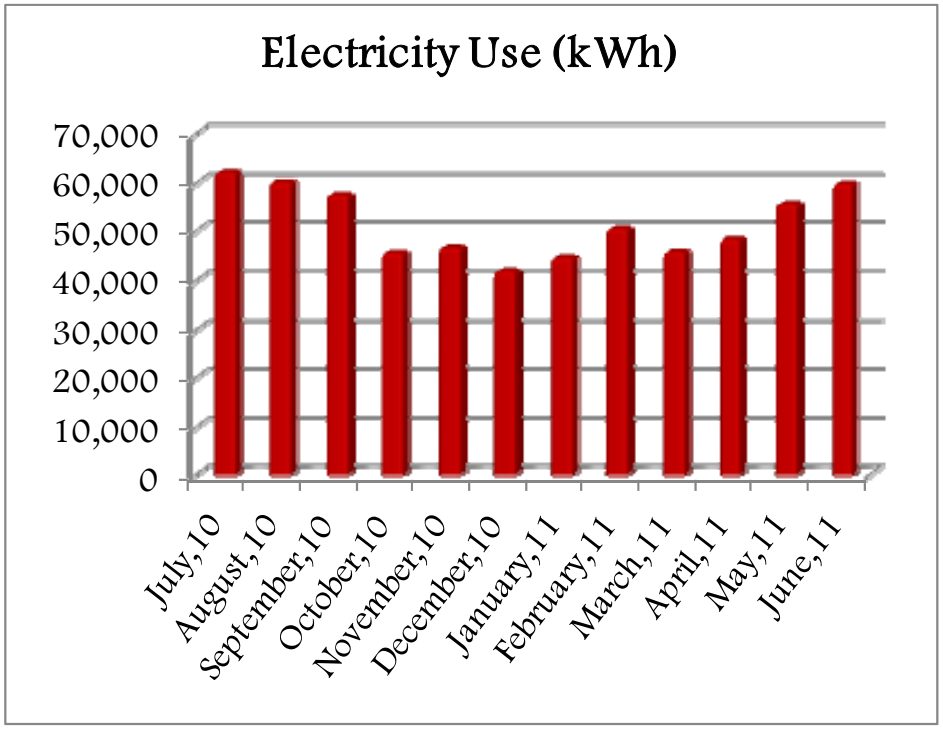
NStar satisfies the Electricity requirements of the facility. The building electric meter records electric power consumption in kilowatt-hours (kWh). The electric utility bills the consumer based on fixed charges and actual consumption which is variable. Variable charges are based on actual consumption but the utility levies "peak demand charges" as well. Large power consumers who consume electricity in excess of a certain threshold (peak load) at certain times of the day are subject to peak demand charges. In order to meet peak electrical demands which usually occur during the summer, electrical utilities must have excess generating capacity which is idle during the remainder of the year. In order to cover the additional cost of excess capacity and to discourage consumption, utilities are permitted to levy peak demand charges.

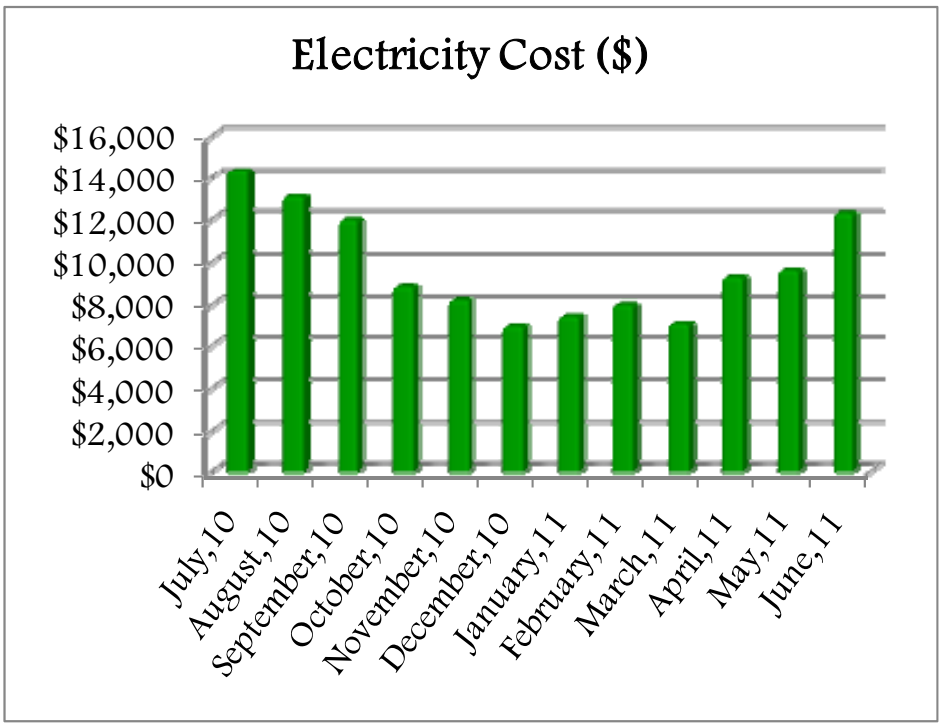
During heating season, lighting comprises the largest component of electrical consumption. The remainder of the consumption is taken up with hard-wired equipment such as fans, pumps, and other equipment. Additional power is consumed by office equipment and appliances connected to receptacles ("plug load") such as computers, copiers, etc. All of these loads form the "base load" which remains fairly constant during the year. The consumption during December probably approximates the base load. During the warmer months, the air-conditioning chiller operates and this adds significantly to the building electrical power consumption. Examination of the following charts shows that summer power consumption was somewhat higher as compared with the winter months. Also, unit cost was significantly higher during high-consumption months. This may be a result of peak demand charges during those months.

Based on the 2010/2011 electric usage & costs, the average price paid during the year was $0.19 per kWh. The total annual Electricity consumption for the 12-month period analyzed is 619,248 kWh for a total cost of $117,183.87.

Electricity Consumption and Cost Data

Billing Month	Electricity Consumption (kWh)	Unit Cost/kWh	Total Cost
July,10	62,256	$0.23	$14,345.60
August,10	60,264	$0.22	$13,106.44
September,10	57,696	$0.21	$11,998.96
October,10	45,576	$0.19	$8,875.37
November,10	46,632	$0.18	$8,252.73
December,10	41,904	$0.17	$6,915.73
January,11	44,616	$0.17	$7,371.76
February,11	50,448	$0.16	$8,016.39
March,11	45,768	$0.15	$7,040.25
April,11	48,336	$0.19	$9,314.04
May,11	55,824	$0.17	$9,640.06
June,11	59,928	$0.21	$12,306.54
Total	**619,248**	**$0.19**	**$117,183.87**


Electricity Use (kWh)
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
July,10
August,10
September,10
October,10
November,10
December,10
January,11
February,11
March,11
April,11
May,11
June,11


Electricity Cost ($)
$16,000
$14,000
$12,000
$10,000
$8,000
$6,000
$4,000
$2,000
$0
July,10
August,10
September,10
October,10
November,10
December,10
January,11
February,11
March,11
April,11
May,11
June,11

6.2. NATURAL GAS

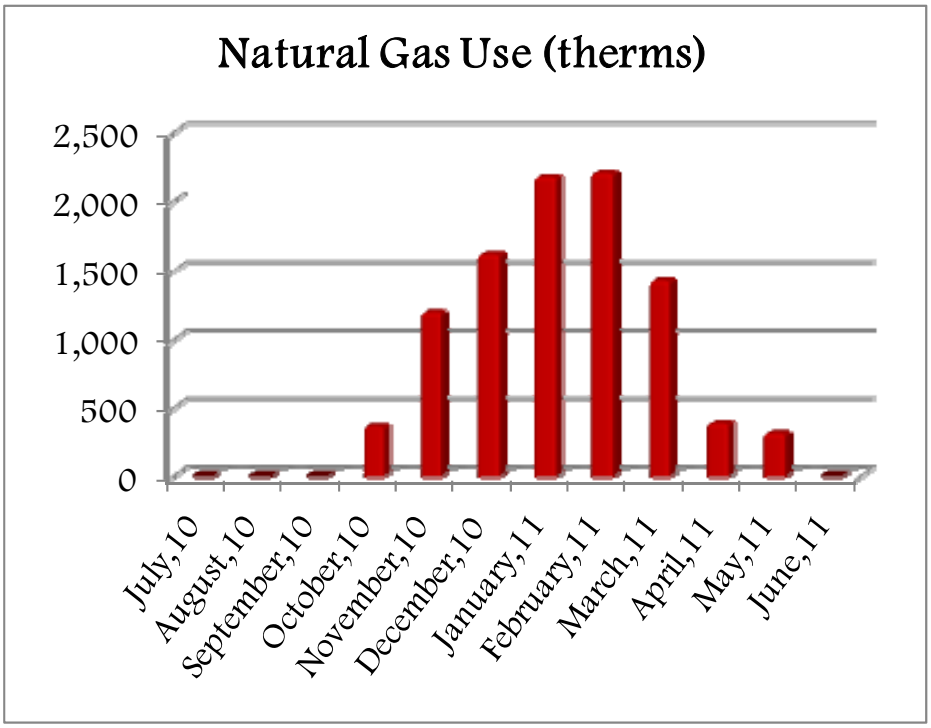
NStar satisfies the natural gas requirements of the facility.

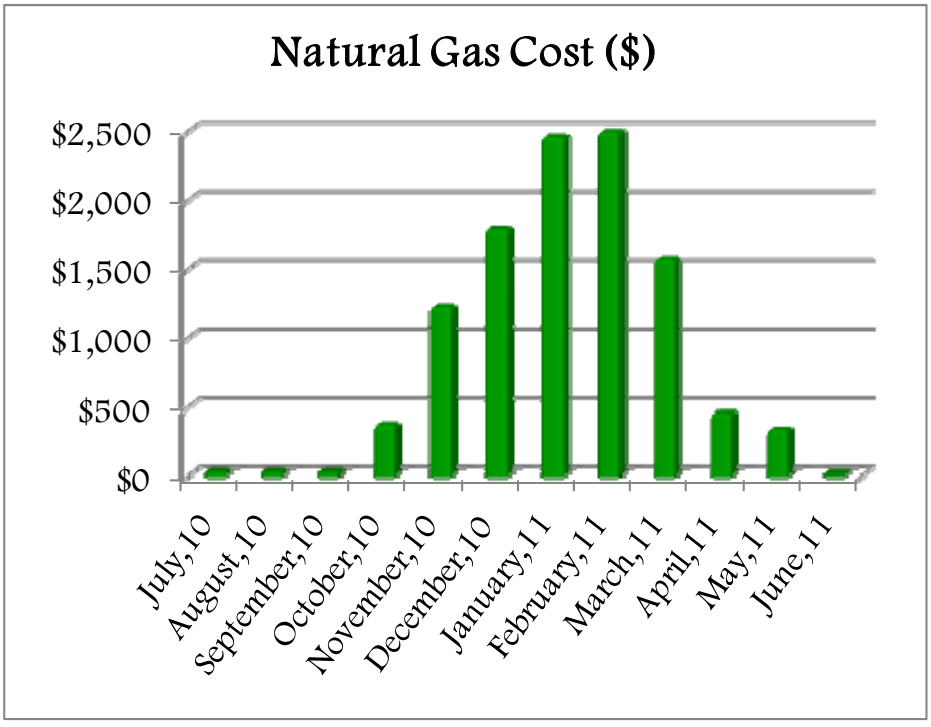
The gas monthly gas bill is has a fixed monthly charge plus a variable charge based on gas consumption as recorded by the building meter. The meter records gas consumption in hundreds of cubic-feet (CCF) or "therms" which are approximately equivalent.

Natural gas is used as the fuel for the Library hot-water boilers. The building water heaters are electric so, outside of heating season, there is no gas consumption at the Library. The chart below shows the gas monthly consumption and bill. During the months of July, August and September, gas consumption was zero. The monthly bill for those months reflects fixed charges and not consumption. As would be expected, gas consumption increases significantly during the winter months.

Based on the 2010/2011 natural gas usage & costs, the average price paid during the year was $1.12 per therm. The total annual natural gas consumption for the 12-month period analyzed is 9,733 therms for a total cost of $10,865.01.

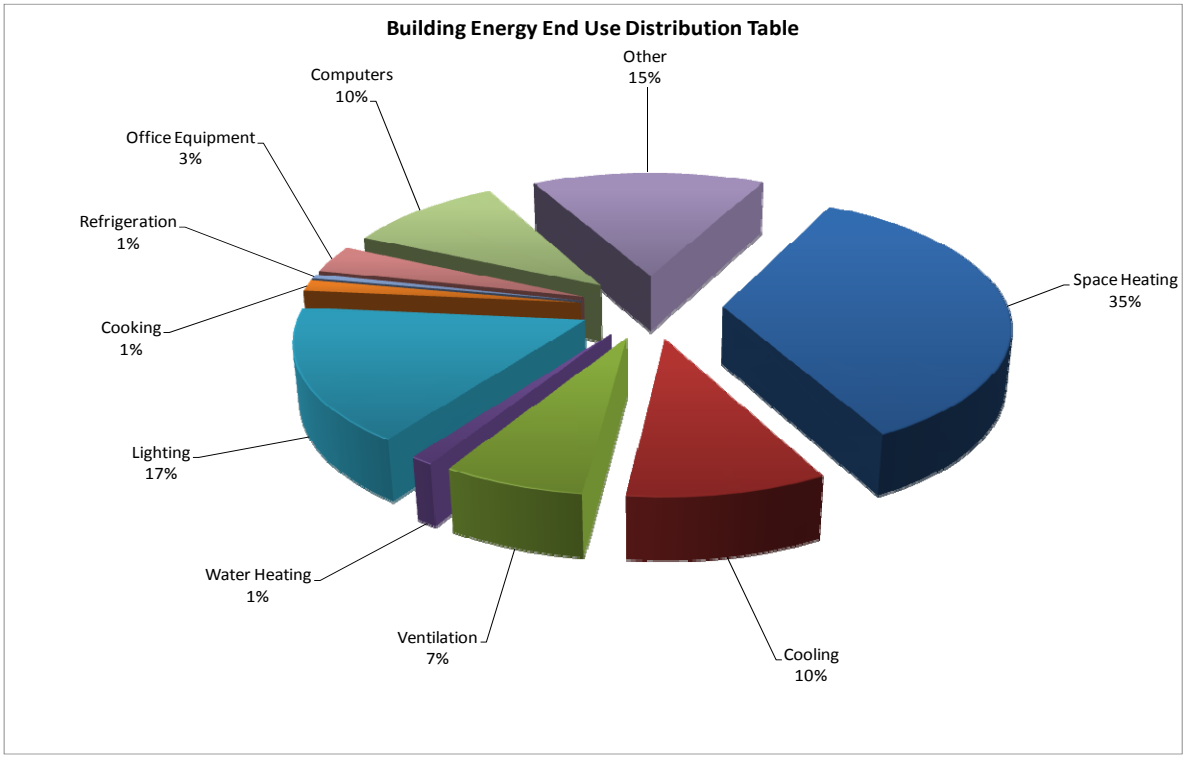
Billing Month	Natural gas Consumption (Therms)	Unit Cost/therm	Total Cost
July,10	0	$0.00	$30.24
August,10	0	$0.00	$30.24
September,10	0	$0.00	$30.24
October,10	373	$1.02	$379.72
November,10	1,198	$1.03	$1,234.19
December,10	1,626	$1.11	$1,801.25
January,11	2,190	$1.12	$2,462.04
February,11	2,218	$1.13	$2,498.47
March,11	1,424	$1.11	$1,576.66
April,11	395	$1.17	$461.28
May,11	309	$1.12	$345.30
June,11	0	$0.00	$15.38
Total	**9,733**	**$1.12**	**$10,865**


Natural Gas Use (therms)
2,500
2,000
1,500
1,000
500
0
July,10
August,10
September,10
October,10
November,10
December,10
January,11
February,11
March,11
April,11
May,11
June,11


Natural Gas Cost ($)
$2,500
$2,000
$1,500
$1,000
$500
$0
July,10
August,10
September,10
October,10
November,10
December,10
January,11
February,11
March,11
April,11
May,11
June,11

7. END USE ENERGY DISTRIBUTION

Components of Annual Energy Use												
	Electricity (1 kWh = 3.412 kBtu)				Natural Gas				Total Energy		Total Cost	
	%	kWh	kBtu	Cost	%	therms	kBtu	Cost	MBtu	% Total	Total- $	% Total
Space Heating	***4.8%***	29,952	102,196	$5,667.99	***100.0%***	*9,733*	972,911	0	1075.1	***34.8%***	$5,668	***4.8%***
Cooling	***14.0%***	86,448	294,961	$16,359.05			0	0	295.0	***9.6%***	$16,359	***14.0%***
Ventilation	***10.0%***	61,925	211,287	$11,718.39			0	0	211.3	***6.8%***	$11,718	***10.0%***
Water Heating	***1.6%***	10,000	34,120	$1,892.36			0	0	34.1	***1.1%***	$1,892	***1.6%***
Lighting	***24.3%***	150,781	514,465	$28,533.16			0	0	514.5	***16.7%***	$28,533	***24.3%***
Cooking	***2.0%***	12,385	42,257	$2,343.68			0	0	42.3	***1.4%***	$2,344	***2.0%***
Refrigeration	***0.8%***	5,202	17,748	$984.34			0	0	17.7	***0.6%***	$984	***0.8%***
Office Equipment	***5.0%***	30,962	105,644	$5,859.19			0	0	105.6	***3.4%***	$5,859	***5.0%***
Computers	***15.0%***	92,887	316,931	$17,577.58			0	0	316.9	***10.3%***	$17,578	***15.0%***
Other	***22.4%***	138,705	473,263	$26,248.02			0	0	473.3	***15.3%***	$26,248	***22.4%***
Total	100.0%	**619,247**	2,112,872	$117,183.8	*100.0%*	***9,733***	972,911	0	**3085.8**	100.0%	**$117,184**	100.0%



8. ENERGY CONSERVATION MEASURES (ECM)

EMG has identified a total of three Energy Conservation Measures (ECMs) for this property. All the ECMs are broken into two major categories:

1. **No/Low Cost Recommendations**: No/Low cost is defined as any project with initial investment of less than $1,000.
2. **Capital Cost Recommendations**: Capital cost defined as any project with initial investment equal to or greater than $1,000.

EMG screens ECMs using two financial methodologies. ECMs which are considered financially viable must meet both criteria.

1. Simple Payback Period –The number of years required for the cumulative value of energy or water cost savings less future non-fuel or non-water costs to equal the investment costs of the building energy or water system, without consideration of discount rates. ECMs with a payback period greater than the Expected Useful Life (EUL) of the project are not typically recommended, as the cost of the project will not be recovered during the lifespan of the equipment. These ECMs are recommended for implementation during future system replacement. At that time, replacement may be evaluated based on the premium cost of installing energy efficient equipment.

$$Simple\ Payback = \frac{Initial\ Cost}{Annual\ Savings}$$

2. Savings-to-Investment Ratio (SIR) – The savings-to-investment ratio is the ratio of the present value savings to the present value costs of an energy or water conservation measure. The numerator of the ratio is the present value over the estimated useful life (EUL) of net savings in energy or water and non-fuel or non-water operation and maintenance costs attributable to the proposed energy or water conservation measure. The denominator of the ratio is the present value of the net increase in investment and replacement costs less salvage value attributable to the proposed energy or water conservation measure. It is recommended that energy efficiency recommendations should be based on a calculated SIR, with larger SIRs receiving a higher priority. A project is typically only recommended if SIR is greater than or equal to 1.0, unless other factors outweigh the financial benefit.

$$SIR = \frac{Present\ Value\ (Annual\ Savings, i\%, EUL)}{Initial\ Cost}$$

Key Metrics to Benchmark the Subject Property's Energy Usage Profile

- Building Site Energy Use Intensity - The sum of the total site energy use in thousand of Btu per unit of gross building area. Site energy accounts for all energy consumed at the building location only not the energy consumed during generation and transmission of the energy to the site.
- Building Source Energy Use Intensity – The sum of the total source energy use in thousand of Btu per unit of gross building area. Source energy is the energy consumed during generation and transmission in supplying the energy to your site.
- Building Cost Intensity - This metric is the sum of all energy use costs in dollars per unit of gross building area.

- Greenhouse Gas Emissions - Although there are numerous gases that are classified as contributors to the total for Greenhouse Emissions, the scope of this energy audit focuses on carbon dioxide (CO_2). Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement).

Site Energy Use Intensity (EUI)	Rating
Current Site Energy Use Intensity (EUI)	67 kBtu/ft^2
Post ECM Site Energy Use Intensity (EUI)	66.37 kBtu/ft^2
Source Energy Use Intensity (EUI)	**Rating**
Current Source Energy Use Intensity (EUI)	175 kBtu/ft^2
Post ECM Source Energy Use Intensity (EUI)	173 kBtu/ft^2
Building Cost Intensity (BCI)	**Rating**
Current Building Cost Intensity	$2.77/ft^2
Post ECM Building Cost Intensity	$2.75/ft^2

Summary of the Greenhouse Gas Reductions from Recommended Energy Conservation Measures

The following table provides a summary of the projected Greenhouse Gas Emissions reductions as a result of the recommended Energy Conservation Measures:

Greenhouse Gas Emissions Reduction	Rating	
Estimated kWh Reduction	5,150	kWh
Estimated Annual Thermal Energy Reduction	0	Therms
Total CO_2 Emissions Reduced	2	$MtCO_2/yr$
Total Cars Off The Road (Equivalent)*	0	
Total Acres of Pine Trees Planted (Equivalent)*	0	

*Equivalent reductions per DOE emissions calculation algorithms.

The following table describes each recommended ECM in terms of initial investment, Electricity and natural gas savings, water savings, annual energy cost and maintenance savings, payback and SIR.

List of Recommended Energy Conservation Measures		Needham Free Public Library											
ECM #	Description of ECM	Projected Initial Investment	Estimated Annual Energy Savings		Estimated Annual Water Savings	Total Energy Savings	Estimated Cost Savings	Estimated Annual O&M Savings	Total Estimated Annual Cost Savings	Simple Payback	S.I.R.	Life Cycle Savings	Expected Useful Life (EUL)
		$	Therms	kWh	kgal	MMBtu	$	$	$	Years		$	Years
No/Low Cost Recommendations													
1	Install Energy Saver on Water Fountain Details: Install on water fountain in lobby.	$190	0	690	0	2	$131	$0	$131	1.46	8.20	$1,369	15.00
2	Install Automatic Lighting Controls Details: Install Photo Sensors Along Interior of West Elevation.	$942	0	1,111	0	4	$210	$0	$210	4.48	2.67	$1,568	15.00
3	Install Chilled Water Reset Control Details: For air-cooled chiller on roof.	$962	0	3,921	0	13	$742	$0	$742	1.30	9.21	$7,897	15.00
Totals for No/Low Cost Items		**$2,093**	**0**	**5,722**	**0**	**20**	**$1,083**	**$0**	**$1,083**	**1.93**			
	Interactive Savings Discount @ 10%		0	-572		-2	-$108	$0	-$108				
	Total Contingency Expenses @ 15%	$314											
Total for Improvements		**$2,407**	**0**	**5,150**	**0**	**18**	**$975**	**$0**	**$975**	**2.47**			

If all of the above mentioned ECM's are implemented, Needham Free Public Library could potentially save approximately $975 per year with an investment of $ 2,407 yielding a net effective payback of 2.47years.

8.1. ECM CALCULATION ASSUMPTIONS

EMG has made the following assumptions in calculation of the Energy Conservation Measures.

- Building operating hours, as detailed in section 5.1 are assumed to be 100 hours per week (during the year, assumed to be 52 weeks long).
- The facility occupancy is assumed to be 360 people.
- Annual Heating Equipment Operating Hours are derived from actual climatological records to be 3,144 hours/year
- Annual Cooling Equipment Operating Hours are derived from actual climatological records to be 677 hours/year
- Typical lighting operating hours are assumed to be 14.28 per day or 5,200 hours per year.

8.2. NO/LOW COST ECM DESCRIPTIONS

EMG has identified three No/Low Cost Energy Conservation Measures (ECMs) for this property. This includes all measures which can be implemented below the cost threshold of $1,000. The following paragraphs describe each of these ECMs along with the initial installed costs, annual energy savings, and payback periods.

8.2.1. Install Energy Controllers On Electric Water Cooler

Electric Water Coolers and soft drink vending machines are usually designed to operate all day round irrespective of the occupancy level in the office. This means that the vending machines operate for more than 12 hours a day when not required in case of commercial establishments.

There is an Electric Water Cooler near the main entrance lobby. EMG recommends installing a vend misers on this unit, which will automatically reduce the running time of the unit during weekends and unoccupied hours. There are two types of vend misers; one has a timer in it, which is programmed to turn off or tune down the vending machines after the office hours and bring it back up an hour before the office opens. The other is a motion sensor based system that tunes down the machines upon detecting no-occupancy for a pre-programmed duration of time.

EMG estimates the total installation cost of a vending miser at $190. EMG projects annual savings of 690 kilowatt-hours.

8.2.2. Install Automatic Lighting Controls

One of the best ways to save energy is to turn off lights that are not needed. This saves energy, as well as extends the replacement time on lamps. (While frequent switching may in some cases shorten lamp life, the savings in electrical power will more than compensate).

The operating time of lighting systems can be reduced either automatically or manually. Automated controls are more reliable for ensuring that energy savings are achieved. Local switches can be labeled to encourage occupants to turn off lights when leaving an area. Individual switches in perimeter offices permit occupants to reduce lighting levels on sunny days. Sophisticated lighting control systems are available, but they are costly to retrofit. They should be considered when the lighting system is being replaced. With the exception of security lights, storeroom lighting can be placed on timed switches that shut off after the selected interval. All exterior lighting, as well as interior lighting in glass-enclosed vestibules, should be placed on photocell and/or timer control.

In spaces exposed to natural light, EMG recommends installing a photo control sensor that shall control the ON/OFF function of the overhead lights. The photo controls can be pre-programmed to turn on the overhead lamps when the ambient lighting levels falls below a pre-determined level. This ensures that each space is sufficiently lit, even on cloudy days.

The west elevation of the Library has large expanses of glazing which may reduce the need for artificial illumination. It should be possible to connect the lighting circuits in the library stacks and reading areas along the west side of the building to photosensors which will turn the lights in these areas "off" whenever natural lighting levels are sufficient.

EMG estimates the total installation cost of 10 photosensors at $942. EMG projects annual savings at 1,111 kilowatt-hours.

8.2.3. Activate Chilled Water(CHW) Reset Control

HVAC equipment is usually sized to meet conditions at the design peak load. Coil water temperature set points are also chosen to meet the design load. However, during most hours of operation, the equipment operates at part-load. Use of design set points on water loops at part-load results in unnecessary thermal losses and equipment inefficiencies. Resetting the set point reduces energy consumption by matching hot or chilled water supply set points to the actual equipment load.

Reset of supply water temperature may be based on the outside air temperature or on the hot or chilled water demand. Except for buildings with dominant internal loads, the space load generally may be considered to be a function of the outdoor temperature. For example, as the outside air temperature rises, chilled water temperature is adjusted upward and hot water temperature is adjusted downward. Alternatively, a more accurate method is to reset the water temperature based on instrumentation readings. For further discussion on the reset strategies and the selection algorithms of the hot and chilled water temperature setpoints, refer to a report by the National Bureau of Standards, Control Algorithms for Building Management and Control Systems--Hot Deck/Cold Deck/ Supply Air Reset, Day/Night Setback, Ventilation Purging, and Hot and Chilled Water Reset (NBS 1984a).

The chiller has reset controls in place. EMG recommends activating the control feature through BMS to attain savings. EMG projects annual savings at 3,921 kilowatt-hours.

8.3. CAPITAL COST ECM DESCRIPTIONS

EMG has identified no Capital Cost Energy Conservation Measures (ECMs) for this property. This list includes recommended measures which have an estimated implementation cost of greater than $1,000. The following paragraphs describe each of these ECMs, in addition to their initial installed costs, annual energy savings, and payback periods.

8.4. ECMs EVALUATED FOR CONSIDERATION

EMG has identified no Energy Conservation Measures (ECMs) which were evaluated for this property but not recommended based on financial criteria. EMG screens ECMs using two financial methodologies. ECMs which are considered financially viable must meet both criteria.

9. IMPLEMENTION OF AN OPERATIONS AND MAINTENANCE PLAN

The quality of the maintenance and the operation of the facility's energy systems have a direct effect on its overall energy efficiency. Energy-efficiency needs to be a consideration when implementing facility modifications, equipment replacements, and general corrective actions. The following is a list of activities that should be performed as part of the routine maintenance program for the property. These actions, which have been divided into specific and general recommendations, will insure that the energy conservation measures identified in this report will remain effective. The following general recommendations should be continued or implemented.

Building Envelope

Proposed Improvements

1. Caulking and weather stripping functional and effective at all times
2. Walls observed weekly and holes patched in the building envelope as required
3. Windows inspected monthly for damaged panes and failed thermal seals

Heating and Cooling

Existing Maintenance

1. Boiler and tubes inspected and cleaned annually
2. Air filters inspected monthly (or quarterly in the case of 2-year filters) and replaced prior to excessive visual buildup (May increase filter costs, but will reduce fan energy costs)

Proposed Improvements

1. The burners cleaned and fuel/air ratios optimized during routine maintenance checks
2. Temperature settings reduced in unoccupied areas and set points seasonally adjusted.
3. Control valves and dampers checked for functionality monthly and repaired, when needed
4. Equipment inspected for worn or damaged parts as part of a monthly maintenance check
5. Ductwork visually inspected and checked for leaks or damaged insulation as part of a monthly maintenance check
6. Hot air registers and return air ductwork clean and unobstructed
7. Air dampers operating correctly
8. Test and balance completed annually to ensure heating uniform throughout the spaces
9. Evaporator coils and condenser coils regularly checked and cleaned

Domestic Hot Water

Existing Maintenance

1. Domestic hot water heater temperature set to the minimum temperature required

Proposed Improvements

1. Hot water piping checked routinely for damaged insulated and leaks
2. Tank-type water heaters flushed monthly

Lighting

Existing Maintenance

1. Only energy-efficient replacement lamps used and in-stock for replacement
2. Lighting fixture reflective surfaces and translucent covers clean
3. Walls clean and bright to maximize lighting effectiveness
4. Timers and/or photocells operating correctly on exterior lighting

Proposed Improvements

1. Over-lit areas managed by photocell controls

Existing Equipment and Replacements

Existing Maintenance

1. Refrigerator and freezer doors closed and sealed correctly

Proposed Improvements

1. Install "smart" power strips which place Office/ computer equipment either in the "sleep" or "off" mode when the equipment is not in use
2. All other recommended equipment specific preventive maintenance actions conducted
3. Usage demands on the building/ equipment not changed significantly since the original building commissioning or the most recent retro-commissioning

In addition, equipment replacement performed assuring that:

1. All equipment replacements not over/undersized for the particular application
2. All equipment replacements with energy conserving and/or high efficiency devices

10. APPENDICES

APPENDIX A: Photographic Record
APPENDIX B: Site Plan
APPENDIX C: Records of Communication
APPENDIX D: Glossary of Terms
APPENDIX E: Mechanical Equipment Inventory
APPENDIX F: Lighting Systems Schedules
APPENDIX G: ECM Calculations
APPENDIX H: Supporting Documents

APPENDIX A:
PHOTOGRAPHIC RECORD

EMG PHOTOGRAPHIC RECORD

Project No.: 98515.11R-010.268 **Project Name: Needham Free Public Library**

Photo #1:	Original building-main entrance

Photo #2:	Original building and 2006 Addition-north elevation

Photo #3:	2006 Addition-east elevation

Photo #4:	2006 Addition-west elevation

Photo #5:	2006 Addition-west elevation

Photo #6:	Insulated replacement window in main entrance door of 1915 building

EMG PHOTOGRAPHIC RECORD

Project No.: 98515.11R-010.268 **Project Name: Needham Free Public Library**

Photo #7:	Building water meter in Room 023

Photo #8:	Building gas meter

Photo #9:	Building main transformer

Photo #10:	Building electric meter

Photo #11:	Condensing hot water boilers

Photo #12:	Hot water circulating pumps

EMG PHOTOGRAPHIC RECORD

Project No.: 98515.11R-010.268 **Project Name: Needham Free Public Library**

Photo #13:	Typical fin-tube unit

Photo #14:	Typical unit heater

Photo #15:	Space fan-coil unit above lay-in ceiling

Photo #16:	Rooftop energy-recovery unit

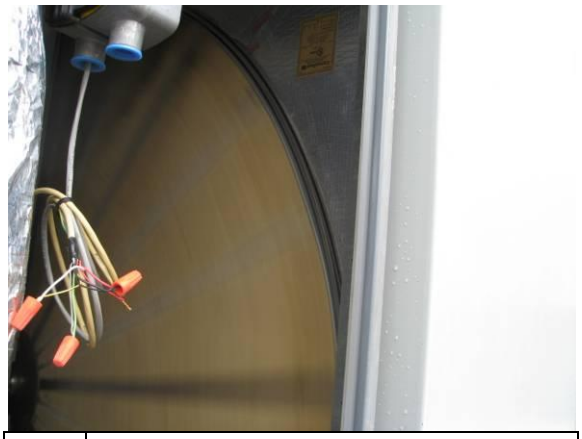


Photo #17:	Rooftop energy-recovery unit (energy-recovery wheel)

Photo #18:	Air-cooled chiller

EMG PHOTOGRAPHIC RECORD

Project No.: 98515.11R-010.268 **Project Name: Needham Free Public Library**

Photo #19:	Attic of original building-HVAC ductwork

Photo #20:	Lighting control panel

Photo #21:	Chilled water piping at rooftop chiller

Photo #22:	West elevation of building

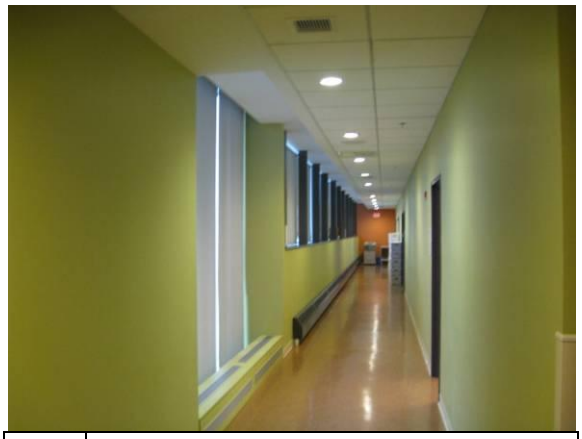
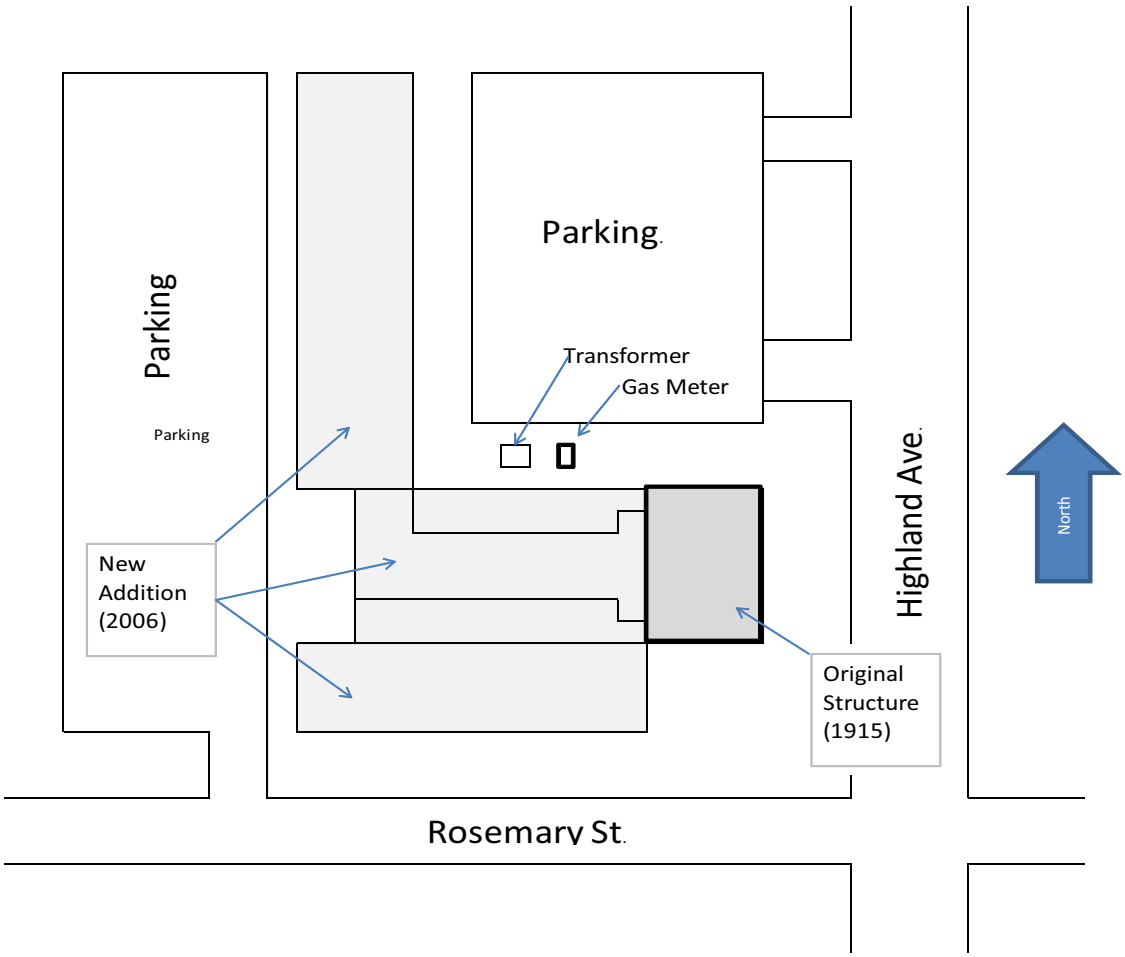


Photo #23:	Second floor corridor

Photo #24:	Library LEED Silver Certificate

APPENDIX B:
SITE PLAN

SITE PLAN



Needham Free Public Library

1139 Highland Ave.

Needham, Ma. 02494

APPENDIX C:
RECORDS OF COMMUNICATION

RECORD OF COMMUNICATION

Date:	**September 7, 2011**	**Time:**	**10:00 AM**
Project Number:	**98515.11R-010.268**	**Recorded by:**	**J. McLurg Field Observer/Project Manager**
Project Name:	**Needham Free Public Library**		

Communication with: **Chip Laffey**
of: **Town of Needham**
Phone: **781-455-0861**

Communication via:

- **X** **Telephone Conversation**
- **Discussions During Site Assessment**
- **Office Visitation/Meeting at:**
- **Other:**

RE: Needham Free Public Library Energy Audit

Summary of Communication:

Made arrangements for site visit on September 8.

RECORD OF COMMUNICATION

Date:	**September 8, 2011**	**Time:**	**8:00am-2:00pm**
Project Number:	**98515.11R-010.268**	**Recorded by:**	**J. McLurg Field Observer/Project Manager**
Project Name:	**Needham Free Public Library**		

Communication with: **Chip Laffey and Angel**
of: **Town of Needham**
Phone:

Communication via:

- **Telephone Conversation**
- **X** **Discussions During Site Assessment**
- **Office Visitation/Meeting at:**
- **Other:**

RE: Needham Free Public Library Energy Audit

Summary of Communication:

Chip met me at the site at approximately 8am and showed me the mechanical room and briefed me on the equipment there. Angel (custodial staff) accompanied me during September 8 Site Visit and assisted me with building drawings.

APPENDIX D:
GLOSSARY OF TERMS

Glossary of Terms and Acronyms

ECM – Energy Conservation Measures are projects recommended to reduce energy consumption. These can be No/Low cost items implemented as part of routine maintenance or Capital Cost items to be implemented as a capital improvement project.

Initial Investment – The estimated cost of implementing an ECM project. Estimates typically are based on R.S. Means Construction cost data and Industry Standards.

Annual Energy Savings – The reduction in energy consumption attributable to the implementation of a particular ECM. These savings values do not include the interactive effects of other ECMs.

Cost Savings – The expected reduction in utility or energy costs achieved through the corresponding reduction in energy consumption by implementation of an ECM.

Simple Payback Period –The number of years required for the cumulative value of energy or water cost savings less future non-fuel or non-water costs to equal the investment costs of the building energy or water system, without consideration of discount rates.

EUL – Expected Useful Life is the estimated lifespan of a typical piece of equipment based on industry accepted standards.

RUL – Remaining Useful Life is the EUL minus the effective age of the equipment and reflects the estimated number of operating years remaining for the item.

SIR - The savings-to-investment ratio is the ratio of the present value savings to the present value costs of an energy or water conservation measure. The numerator of the ratio is the present value of net savings in energy or water and non-fuel or non-water operation and maintenance costs attributable to the proposed energy or water conservation measure. The denominator of the ratio is the present value of the net increase in investment and replacement costs less salvage value attributable to the proposed energy or water conservation measure. It is recommended that energy-efficiency recommendations be based on a calculated SIR, with larger SIRs receiving a higher priority. A project typically is recommended only if the SIR is greater than or equal to 1.0, unless other factors outweigh the financial benefit.

Life Cycle Cost - The sum of the present values of (a) **I**nvestment costs, less salvage values at the end of the study period; (b) Non-fuel operation and maintenance costs: (c) Replacement costs less salvage costs of replaced building systems; and (d) Energy and/or water costs.

Life Cycle Savings – The sum of the estimated annual cost savings over the EUL of the recommended ECM, expressed in present value dollars.

Building Site Energy Use Intensity - The sum of the total site energy use in thousand of Btu per unit of gross building area. Site energy accounts for all energy consumed at the building location only not the energy consumed during generation and transmission of the energy to the site.

Building Source Energy Use Intensity – The sum of the total source energy use in thousand of Btu per unit of gross building area. Source energy is the energy consumed during generation and transmission in supplying the energy to your site.

Building Cost Intensity - This metric is the sum of all energy use costs in dollars per unit of gross building area.

Greenhouse Gas Emissions - Although there are numerous gases that are classified as contributors to the total for Greenhouse Emissions, the scope of this energy audit focuses on carbon dioxide (CO_2). Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and also as a result of other chemical reactions (e.g., manufacture of cement).

APPENDIX E:
MECHANICAL EQUIPMENT INVENTORY

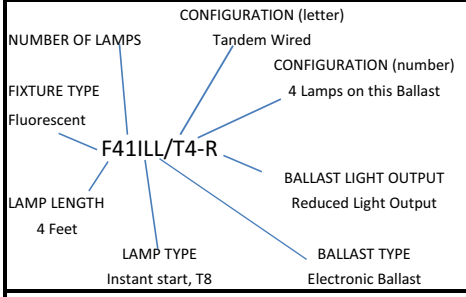
Mechanical Equipment Inventory								
Equipment	**Manufacturer**	**Age**	**Location**	**Model/ Type**	**Capacity**	**Serves**	**Operating Hours/Year**	**Remarks**
ERV-1	Greenheck	2005	Roof	ERCH-90H-30	6,400 cfm	Library	8,760	Energy Recovery Unit
ERV-2	Greenheck	2005	Attic	ERCH-20M-15	1,400 cfm	Library	8,760	Energy Recovery Unit
ERV-3	Greenheck	2005	Roof	ERCH-45L-15	2,500 cfm	Library	8,760	Energy Recovery Unit
AC-1	Mitsubishi	2005	Roof	PL18AK/PU18EK	1.5 ton	Room 22 (data)	677	Split-System A/C
AC-2	Mitsubishi	2005	Roof	MMD36E-PHSDA/PFH037A-PL3	2.75 ton	Room 119 (Archives)	677	Split-System A/C
CH-1	York	2005	Roof	YCAS0148EB17YGA	128 ton	Chilled Water System	677	Air-Cooled Chiller
B1, 2	Cleaver-Brooks	2005	Rm 23	MCF-700-1800-60HW	1,575 MBH	Hydronic System	3,144	HW Boiler
P-1,2	Armstrong	2005	Rm 23	3x2x10, 4030	150 gpm	Hydronic System	3,144	HW Pumps
P-3,4	Armstrong	2005	Rm 23	HB01Q4FKA	10 HP	Chilled Water System (Secondary)	677	CW Pumps
P5	Armstrong	2005	Room 23	HBY754FKA	7.5 HP	Chilled Water System (Primary)	677	CW Pump
CUH-1,2	Mestek	2005	Vestibules	Vulcan 08	79.3 MBH		3,144	Cabinet Unit heater
UH-1	Mestek	2005		HV-18	11.7 MBH		3,144	Unit Heater
UH-2	Mestek	2005		HV108	78.4 MBH	Room 23	3,144	Unit Heater
EUH	Benko	2005		HUHAA520	350 cfm	Electrical Room	3,144	Unit Heater

Mechanical Equipment Inventory								
Equipment	**Manufacturer**	**Age**	**Location**	**Model/ Type**	**Capacity**	**Serves**	**Operating Hours/Year**	**Remarks**
EF-1	Cook	2005	Roof		cfm		1,758	Exhaust Fan
EF-2	Cook	2005	Roof		cfm	Restroom	1,758	Exhaust Fan
EF-3	Cook	2005	Roof		cfm		1,758	Exhaust Fan

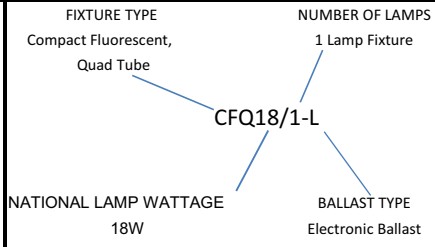
APPENDIX F:
LIGHTING SYSTEMS SCHEDULES

Fixture Code Legend and Notes

Sample Linear Fluorescent Fixture Code



Sample of Other Fixture Code:



Code Explanations

Fixture Type

CF	Compact Fluorescent
CFD	Compact Fluorescent, double-D shape
CFS	Compact Fluorescent, Spiral
CFT	Compact Fluorescent, Twin tube (including "Biaxial" fixtures)
CFQ	Compact Fluorescent, Quad tube
ECF	Exit sign, Compact Fluorescent
EI	Exit sign, Incandescent
ELED	Exit sign, LED
F	Fluorescent, linear
FC	Fluorescent, Circline
FU	Fluorescent, U-tube
H	Halogen
HLV	Halogen, Low Voltage
HPS	High Pressure Sodium
I	Incandescent
LED	Light Emitting Diode (LED) traffic signal
MH	Metal Halide
MHPS	Metal Halide, Pulse Start
MV	Mercury Vapor
QL	Induction

Lamp Type

for fluorescent fixtures

A	"F25T12" - 25 watt, 4ft, T12 lamp
IL	T8, Instant start
SIL	T8, Instant start, Super 30 watt
SSIL	T8, Instant start, Super 28 watt
L	T8, rapid start
G	T5, standard
GH	T5, standard, High output lamp
E	T12, Energy efficient
EH	T12, Energy efficient, High output lamp
EI	T12, Energy efficient, Instant start
EV	T12, Energy efficient, Very high output
S	T12, Standard
SIL	T12, Standard, Instant start
SH	T12, Standard, High output lamp
SV	T12, Standard, Very high output lamp
T	T10, Standard

for LED traffic signals

12GA	12" Green Arrow
12GB	12" Green Ball
12RA	12" Red Arrow
12RB	12" Red Ball
8GB	8" Green Ball
8RB	8" Red Ball
PH	Pedestrian Hand signal

Ballast Type

for fluorescent fixtures

L	Electronic
S	Standard magnetic
E	Emergy efficient magnetic

Configuration (letter)

T	Tandem wired fixture
D	Delamped fixture, i.e. some lamps permanently removed but ballasts remain

Configuration (number)

for delamped fixtures

Number signifies the total number of ballasts in the fixture: e.g. An "F42EEID2" is an "F44EE" with two lamps removed so that there is one extaneous ballast

for tandem wired ballasts

Number signifies the total number of lamps being run by the ballast: e.g. An "F42LLIT4" would indicate that a four-lamp ballast is wired to run two-lamp fixtures.

with no preceding letter

Number indicates the number of ballasts in an ambiguous multiple ballast fixture: e.g. An "F43ILU2" indicates a three-lamp fixture with two ballasts (as is often the case if there is A/B switching).

Ballast Light Output

R	Reduced light output
H	High light output
V	Very high light output

Notes:

1) The column labeled Watts/Fixtures in the data table includes ballast loads.

2) The fixture wattage values represent an average value, rounded to the nearest whole watt.

Existing Facilities Program Lighting Form:

Performance Based

Applicant Name:	
Facility Name:	Needham Free Public Library
Building Address	1139 Highland Avenue Needham Ma. 02494
Date: 9/17/2011	

Existing Control Legend	
LS	Light Switch
PS	Photosensor
TM	Timer
MS	Motion Sensor
NC	Little or No Control (on all day)

INSTRUCTIONS Coding Legend			
CF	Compact Fluorescent	I	Incandescent
F	Fluorescent, linear	LED	Light Emitting Diode
H	Halogen	MH	Metal Halide
HPS	High Pressure Sodium	MV	Mercury Vapor
I	Incandescent	QL	Induction

PRE-INSTALLATION

Line Item	ECM	Type of ECM Code (Refer to ECM Code Worksheet)	Floor	Area Description	Light Reading (Record if ECM)	Usage	Usage	Existing Control	Pre Fixt. No.	Pre Fixt Code (Refer to Wattable Table Worksheet)	Pre Watts / Fixt	Pre kW / Space	Baseline Annual Hours	Annual kWh Consumed
Integer line number	(Type 'ECM" if used)	ECM CODE Worksheet Link	Floor fixture is on	Description of location that matches site map	Lux (link to light standards)	hrs/ week	Weeks/Year	control device (refer to legend above)	# of existing fixtures	Wattage Table Link	Watts/Fixt from Wattage Table	(Pre Watts/Fixt) * (Pre Fixt No.)	Existing annual hours for the usage group	(PreFixt #*PreWatts/Fixt * Baseline Hrs)
Ex.			*10*	*Men's Room*		*5*	*52*	*LS*	*3*	*F44ILL*	*112*	*0.34*	*3,000*	*1,008*
1			1,2	Public Restrooms		100	52	LS	4	F42GL	63	0.25	2,405	606
2			1,2	Public Restrooms		100	52	LS	22	F41GL	32	0.70	2,405	1,693
3			2	Staff RR	98	100	52	LS	2	CFQ26/1-L	27	0.05	2,405	130
4			2	Staff RR	98	100	52	LS	2	CFT32/1-L	34	0.07	5,200	354
5			2	Staff RR	98	100	52	LS	2	F42GL	63	0.13	5,200	655
6			2	Admin Offices		32	52	MS	10	F42GL	63	0.63	2,405	1,515
7			G	14-Childrens Books	289	100	52	LS	2	F36ILL-R	134	0.27	2,405	645
8			G	14-Childrens Books	289	100	52	LS	45	CFQ26/1-L	27	1.22	2,405	2,922
9			G	14-Childrens Books	289	100	52	LS	30	F41GL	32	0.96	2,405	2,309
10			G	18-Childrens Reference	136	100	52	LS	5	CFQ26/1-L	27	0.14	2,405	325
11	ECM	PS	G	31-Popular Stacks-West	280	100	52	LS	70	F41GL	32	2.24	5,200	11,648
12			G	31-Popular Stacks	280	100	52	LS	70	F41GL	32	2.24	2,886	6,465
13			1	123-Young Adult	385	100	52	LS	12	CF10/2D-L	12	0.14	2,886	416
14	ECM	PS	1	127-Non Fiction Stacks-West	254	100	52	LS	64	F41GL	32	2.05	5,200	10,650
15			1	127-Non Fiction Stacks	254	100	52	LS	64	F41GL	32	2.05	5,200	10,650
16			G	18-Childrens Reference	136	100	52	LS	40	CFQ26/1-L	27	1.08	2,405	2,597
17			1	116-Gallery	200	100	52	LS	5	CF42/1-L	48	0.24	5,200	1,248
18			1	116-Gallery	200	100	52		3	CFQ26/1-L	27	0.08	5,200	421
19			1	116-Gallery	200	100	52		5	CF42/1-L	48	0.24	5,200	1,248
20			1	116-Gallery	200	100	52		15	H100/1	100	1.50	2,886	4,329
21			G,1	Lobbies	246	100	52		26	CFQ26/1-L	27	0.70	5,200	3,650
22			G,1	Lobbies	246	100	52	LS	12	F42GL	63	0.76	5,200	3,931
23			1	Lobbies	246	100	52	LS	10	F36ILL-R	134	1.34	5,200	6,968
24	ECM	PS	2	Corridors	137	100	52	LS	22	CFQ26/1-L	27	0.59	5,200	3,089
25			G,1,2	Stairs	157	100	52	LS	9	F42GL	63	0.57	5,200	2,948
26	ECM	PS	1	122-Reference room	468	100	52	LS	90	F41GL	32	2.88	5,200	14,976
27			1	122-Reference room	468	100	52	LS	3	CFQ26/1-L	27	0.08	5,200	421
28			1	Reading Rooms	595	100	52	LS	34	MH70/1	95	3.23	5,200	16,796
29			1	Reading Rooms	595	100	52	LS	13	CFQ26/1-L	27	0.35	5,200	1,825
30			1	Reading Rooms	595	100	52	LS	5	CF42/1-L	48	0.24	5,200	1,248
31			G,2	Crafts,Tech Services	560	32	52	MS	20	F42GL	63	1.26	1,664	2,097
32			G,2	Mechanical Rooms		100	52	LS	8	F42GL	63	0.50	5,200	2,621
33			G	29-Office		32	52	MS	1	F42GL	63	0.06	1,664	105
34			G,1,2	Storage Rooms, Janitor Closet		100	52	LS	12	F42GL	63	0.76	5,200	3,931
35			G	10-Story Hour		100	52	LS	8	F41GL	32	0.26	5,200	1,331
36			1	111-114 Study Rooms	368	50	52	MS	10	F42GL	63	0.63	2,600	1,638
37			G	7-Pantry		100	52	LS	3	F41GL	32	0.10	5,200	499
38	ECM	PS	2	218-Custodian Office	380	100	52	LS	3	F42GL	63	0.19	5,200	983
39			2	222-Mending		100	52	LS	3	F42GL	63	0.19	5,200	983
40			1	128-Delivery		100	52	LS	3	F42GL	63	0.19	5,200	983
41			1	201-Book Storage		40	52	LS	7	F42GL	63	0.44	2,080	917
42			2	Circulation Desk, etc.		100	52	MS	12	CFT40/2-BX	72	0.86	5,200	4,493
43			2	217-Staff Break Room	30	20	52	MS	6	F42GL	63	0.38	1,040	393
44	ECM	PS	2	206-Conference Room	125	40	52	LS	12	MH50/1	72	0.86	2,080	1,797
45	ECM	PS	1	206-Conference Room	125	40	52	LS	7	MH100/1	128	0.90	2,080	1,864
46			1	129-Dock		100	52	LS	1	F42GL	63	0.06	5,200	328
47			G	22-Data		100	52	LS	1	F42GL	63	0.06	5,200	328
48			1	111-Reference Office		32	52	MS	2	F42GL	63	0.13	1,664	210
49			G	Pole Light Fixtures		42	52	TM	14	MH150/1	190	2.66	2,184	5,809
50			G	Security Fixtures		84	52	TM	12	CFQ13/1	17	0.20	4,368	891
51			G	Security Fixtures		84	52	TM	2	CFT32/1-L	34	0.07	4,368	297
52			G	Security Fixtures		84	52	TM	4	MH35/1	44	0.18	4,368	769
53			G	Security Fixtures		84	52	TM	4	CF42/1-L	48	0.19	4,368	839
								Total Pre Fixt.	**851**		**Total Pre kW**	**38.141**	**Total Annual kWh Consumed**	**150,781**

Existing Facilities Program Lighting Form:

Performance Based

Applicant Name: Town of Needham

Facility Name: Needham Free Public Library

Date: 9/17/2011 Building Address 1139 Highland Ave.

Existing Control Legend	
LS	Light Switch
PS	Photosensor
T	Timer
MS	Motion Sensor
EC	Emergency Control

INSTRUCTIONS Coding Legend			
CF	Compact Fluorescent	I	Incandescent
F	Fluorescent, linear	LED	Light Emitting Diode
H	Halogen	MH	Metal Halide
HPS	High Pressure Sodium	MV	Mercury Vapor
I	Incandescent	QL	Induction

	PRE-INSTALLATION												POST-INSTALLATION									
Line Item	**ECM**	**Type of ECM Code** (Refer to ECM Code Worksheet)	**Floor**	**Area Description**	**Light Reading** (Record if ECM)	**Usage**	**Baseline Annual Hours**	**Existing Control**	**Pre Fixt. No.**	**Pre Fixt Code**	**Pre Watts / Fixt**	**Pre kW / Space**	**Post Fixt No.**	**Pre Fixt Code** (Refer to Wattable Table Worksheet)	**Post Watts/ Fixt**	**Post kW / Space**	**Proposed Weekly Hours**	**Proposed Operational Weeks**	**Proposed Annual Hours**	**Proposed Control**	**kW Saved**	**Annual kWh Saved**
Integer line number	(Type "ECM" if applied)	ECM CODE Worksheet Link	Floor fixture is on	Description of location that matches site map	Lux (link to light standards)	hrs/ week	Existing annual hours for the usage group	Pre-installation control device	# of existing fixtures	Wattage Table Link	Watts/Fixt from Wattage Table	(Pre Watts/Fixt) * (Pre Fixt No.)	# of existing fixtures	Wattage Table Link	Watts/Fixt from Wattage Table	(Post Watts/Fixt) * (Post Fixt No.)	hrs / wk	Wks/Yr	Proposed annual hours for the usage group	Post-installation control device	Pre kW/Space - Post kW/Space	(PreFixt #*PreWatts/Fixt * Baseline Hrs) - (PostFixt#*PostWatts/Fixt * Proposed Hours)
Ex.		*RB*	*10*	*Men's Room*		*5*	*3,000*	*Light Switch*	*3*	*F44ILL*	*112*	*0.34*	*3*	*F42ILL*	*59*	*0.18*			*2,000*	*Motion Sensor*	*0.16*	*477*
11	ECM	PS - Installing Photo Sensor	G	31-Popular Stacks-West	280	100	5,200	LS	70	F41GL	32	2	70	F41GL	32	2.24	80.00	52	4,160	PS	0.00	2,330
14	ECM	PS - Installing Photo Sensor	1	127-Non Fiction Stacks-West	254	100	5,200	LS	64	F41GL	32	2	64	F41GL	32	2.048	80.00	52	4,160	PS	0.00	2,130
24	ECM	PS - Installing Photo Sensor	2	Corridors	137	100	5,200	LS	22	CFQ26/1-L	27	1	22	CFQ26/1-L	27	0.594	80.00	52	4,160	PS	0.00	618
26	ECM	PS - Installing Photo Sensor	1	122-Reference room	468	100	5,200	LS	90	F41GL	32	3	90	F41GL	32	2.88	80.00	52	4,160	PS	0.00	2,995
38	ECM	PS - Installing Photo Sensor	2	218-Custodian Office	380	40	5,200	LS	3	F42GL	63	0	3	F42GL	63	0.189	20.00	52	1,040	MS	0.00	786
44	ECM	PS - Installing Photo Sensor	2	206-Conference Room	125	40	2,080	LS	12	MH50/1	72	1	12	MH50/1	72	0.864	20.00	52	1,040	MS	0.00	899
45	ECM	PS - Installing Photo Sensor	1	206-Conference Room	125	40	2,080	LS	7	MH100/1	128	1	7	MH100/1	70	0.49	20.00	52	1,040	MS	0.41	1,354
								Total Pre Fixt.	**268**		**Total Pre kW**	**9.71**	**268**	**Total Post kW**	**328.00**	**9.31**				**Total kW Saved**	**0.41**	**11,111.36**

APPENDIX G:
ECM CALCULATIONS

UIC	**Install Chilled Water Reset Control**
EAC6	**Details: For air-cooled chiller on roof.**

Please Input The Total Number of Chillers in The Building: 1.00

Cost/kWh: **$0.19**

Without CHW Reset			**With CHW Reset**		
Insert Current Chilled Water Circulation Temperature *Typically 42-43 F*	**44**	°F	**Insert Proposed Reset Chilled Water Circulation Temperature** *Never go Abvoe 48F*	**48**	°F
Insert the tonnage of the chiller:	128.00	Ton	Tonnage of The Proposed Chiller: *(Assumed to Be of the same size and capacity)*	128.00	Ton
Insert the existing EER the chiller:	10.20	EER	Please input the new EER with CHW reset:	10.61	EER
Existing kW/ton:	1.18		New kW/ton:	1.13	
Estimated Annual Operating Hours: (Annual Cooling Hours)	677.00	Hrs	Estimated New Annual Operating Hours: *(Same as Existing)*	677.00	Hrs
Existing Annual kWh Consumption For The Chiller:	101948.24	kWh	Annual kWh Consumption For The Chiller With Chilled Water Reset:	98027.15	kWh

CHW reset Energy Saving Results

Annual kWh savings from all chillers with Chiller Reset Control:	3921.09	kWh
Estimated total annual cost savings:	$742	$$
Estimated installed cost Per CHW reset	$962	$$
Simple Payback (years):	1.30	Yrs

Type of Recommendation

No/Low Cost ECM Recommendation

UIC	Install Energy Saver on Water Fountain
EAC8	Details: Install on water fountain in lobby.

No. of Vending Machines: 0.00 Qty

No. of Beverage Cooling Machines: 1.00 Qty

No. of Snack Machines 0.00 Qty

Vending Machines (Cold Beverage Vending Machines)

Estimated Annual kWh Consumption of Vending Machine:	3500.00	kWh
Estimated Annual kWh of Vending Machine With VendMiser:	1890.00	kWh
Total annual kWh savings:	1610.00	kWh
Total Annual kWh Savings for All Vending Machines:	0.00	kWh

Beverage Cooling Machines

Estimated Annual kWh Consumption of Beverage Cooling Machine:	2300.00	kWh
Estimated Annual kWh of Cooling Machine With CoolerMiser:	1610.00	kWh
Total Annual kWh savings:	690.00	kWh
Total Annual kWh Savings For All Cooling Machines:	690.00	kWh

Snack Vending Machines

Estimated Annual kWh Consumption of Individual Snack Machine:	873.60	kWh
Estimated Annual kWh of Individual Snack Machines With VendMiser:	366.91	kWh
Total Annual kWh savings:	506.69	kWh
Total Annual kWh Savings For All Water Fountain Coolers:	0.00	kWh

Cost Analysis

Total estimated annual kWh savings withEnergy Misers:	**690.00**	kWh
Cost/kWh:	**$0.19**	
Estimated Cost of Vendmiser/ Vending Machine:	$200	
Estimated Cost of Coolermiser/ Water cooler:	$190	
Estimated Cost of Vendmiser/ Snack Machine:	$70	
Estimated total installed cost of all VendMisers:	**$190**	
Estimated Total Annual Electricity Savings Using VendingMisers and CoolerMisers:	**$131**	
Simple Payback:	1.46	years

Type of Recommendation No/Low Cost ECM Recommendation

UIC	**Install Automatic Lighting Controls**		
EAL5	**Details: Install Photo Sensors Along Interior of West Elevation.**		
	Type of Sensor	Internal Photosensors	
Step: 1	Total Number of Sensors	10	
Step: 2	Purchase Cost/Lighting Control Sensors	$15	
Step: 3	Installation Cost /Sensor	$65	
Step:4	Total Installation Costs	$941.60	
Step:5	Total Energy Savings	1111.00	kWh
Step:6	Electric Tariff Rate	**$0.19**	$
Step:7	Total Cost Savings	$210.24	
Step:8	Simple Pay Back Period	4.48	Years
Type of Recommendation		No/Low Cost ECM Recommendation	

APPENDIX H:
SUPPORTING DOCUMENTS

OMB No. 2060-0347

STATEMENT OF ENERGY PERFORMANCE
Needham: Free Public Library

Building ID: 2856280
For 12-month Period Ending: June 30, 2011[1]
Date SEP becomes ineligible: N/A
Date SEP Generated: October 12, 2011

Facility
Needham: Free Public Library
1139 Highland Avenue
Needham, MA 02492

Facility Owner
N/A

Primary Contact for this Facility
N/A

Year Built: 1950
Gross Floor Area (ft²): 47,500

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

Site Energy Use Summary[3]

Electricity - Grid Purchase(kBtu)	2,107,667
Natural Gas (kBtu)[4]	986,818
Total Energy (kBtu)	3,094,485

Energy Intensity[5]

Site (kBtu/ft²/yr)	65
Source (kBtu/ft²/yr)	170

Emissions (based on site energy use)

Greenhouse Gas Emissions ($MtCO_2e$/year)	286

Electric Distribution Utility
NSTAR Electric Co

National Average Comparison

National Average Site EUI	104
National Average Source EUI	246
% Difference from National Average Source EUI	-31%
Building Type	Library

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.

Certifying Professional
N/A

Meets Industry Standards[6] **for Indoor Environmental Conditions:**

Ventilation for Acceptable Indoor Air Quality	**N/A**
Acceptable Thermal Environmental Conditions	**N/A**
Adequate Illumination	**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.

ENERGY STAR® Data Checklist for Commercial Buildings

In order for a building to qualify for the ENERGY STAR, a Professional Engineer (PE) or a Registered Architect (RA) must validate the accuracy of the data underlying the building's energy performance rating. This checklist is designed to provide an at-a-glance summary of a property's physical and operating characteristics, as well as its total energy consumption, to assist the PE or RA in double-checking the information that the building owner or operator has entered into Portfolio Manager.

Please complete and sign this checklist and include it with the stamped, signed Statement of Energy Performance.
NOTE: You must check each box to indicate that each value is correct, OR include a note.

CRITERION	VALUE AS ENTERED IN PORTFOLIO MANAGER	VERIFICATION QUESTIONS	NOTES	☑
Building Name	Needham: Free Public Library	Is this the official building name to be displayed in the ENERGY STAR Registry of Labeled Buildings?		☐
Type	Library	Is this an accurate description of the space in question?		☐
Location	1139 Highland Avenue, Needham, MA 02492	Is this address accurate and complete? Correct weather normalization requires an accurate zip code.		☐
Single Structure	Single Facility	Does this SEP represent a single structure? SEPs cannot be submitted for multiple-building campuses (with the exception of acute care or children's hospitals) nor can they be submitted as representing only a portion of a building		☐
Library (Other)				
CRITERION	**VALUE AS ENTERED IN PORTFOLIO MANAGER**	**VERIFICATION QUESTIONS**	**NOTES**	☑
Gross Floor Area	47,500 Sq. Ft.	Does this square footage include all supporting functions such as kitchens and break rooms used by staff, storage areas, administrative areas, elevators, stairwells, atria, vent shafts, etc. Also note that existing atriums should only include the base floor area that it occupies. Interstitial (plenum) space between floors should not be included in the total. Finally gross floor area is not the same as leasable space. Leasable space is a subset of gross floor area.		☐
Number of PCs	N/A(Optional)	Is this the number of personal computers in the space?		☐
Weekly operating hours	N/A(Optional)	Is this the total number of hours per week that the space is 75% occupied? This number should exclude hours when the facility is occupied only by maintenance, security, or other support personnel. For facilities with a schedule that varies during the year, "operating hours/week" refers to the total weekly hours for the schedule most often followed.		☐
Workers on Main Shift	N/A(Optional)	Is this the number of employees present during the main shift? Note this is not the total number of employees or visitors who are in a building during an entire 24 hour period. For example, if there are two daily 8 hour shifts of 100 workers each, the Workers on Main Shift value is 100.		☐

ENERGY STAR® Data Checklist for Commercial Buildings

Energy Consumption

Power Generation Plant or Distribution Utility: NSTAR Electric Co

Fuel Type: Electricity

Meter: 27473150012 (kWh (thousand Watt-hours))
Space(s): Entire Facility
Generation Method: Grid Purchase

Start Date	End Date	Energy Use (kWh (thousand Watt-hours))
05/06/2011	06/05/2011	55,824.00
04/06/2011	05/05/2011	48,336.00
03/06/2011	04/05/2011	45,768.00
02/06/2011	03/05/2011	50,448.00
01/06/2011	02/05/2011	44,616.00
12/06/2010	01/05/2011	41,904.00
11/06/2010	12/05/2010	46,632.00
10/06/2010	11/05/2010	45,576.00
09/06/2010	10/05/2010	57,696.00
08/06/2010	09/05/2010	60,264.00
07/06/2010	08/05/2010	62,256.00
27473150012 Consumption (kWh (thousand Watt-hours))		**559,320.00**
27473150012 Consumption (kBtu (thousand Btu))		**1,908,399.84**
Total Electricity (Grid Purchase) Consumption (kBtu (thousand Btu))		**1,908,399.84**
Is this the total Electricity (Grid Purchase) consumption at this building including all Electricity meters?		☐

Fuel Type: Natural Gas

Meter: 27683580032 (therms)
Space(s): Entire Facility

Start Date	End Date	Energy Use (therms)
05/06/2011	06/05/2011	309.00
04/06/2011	05/05/2011	395.00
03/06/2011	04/05/2011	1,424.00
02/06/2011	03/05/2011	2,218.00
01/06/2011	02/05/2011	2,190.00
12/06/2010	01/05/2011	1,626.00
11/06/2010	12/05/2010	1,198.00
10/06/2010	11/05/2010	373.00
09/06/2010	10/05/2010	0.00
08/06/2010	09/05/2010	0.00
07/06/2010	08/05/2010	0.00

27683580032 Consumption (therms)	**9,733.00**
27683580032 Consumption (kBtu (thousand Btu))	**973,300.00**
Total Natural Gas Consumption (kBtu (thousand Btu))	**973,300.00**
Is this the total Natural Gas consumption at this building including all Natural Gas meters?	☐

Additional Fuels	
Do the fuel consumption totals shown above represent the total energy use of this building? Please confirm there are no additional fuels (district energy, generator fuel oil) used in this facility.	☐

On-Site Solar and Wind Energy	
Do the fuel consumption totals shown above include all on-site solar and/or wind power located at your facility? Please confirm that no on-site solar or wind installations have been omitted from this list. All on-site systems must be reported.	☐

Certifying Professional

(When applying for the ENERGY STAR, the Certifying Professional must be the same PE or RA that signed and stamped the SEP.)

Name: _____ Date: _____

Signature: _____

Signature is required when applying for the ENERGY STAR.

FOR YOUR RECORDS ONLY. DO NOT SUBMIT TO EPA.

Please keep this Facility Summary for your own records; do not submit it to EPA. Only the Statement of Energy Performance (SEP), Data Checklist and Letter of Agreement need to be submitted to EPA when applying for the ENERGY STAR.

Facility
Needham: Free Public Library
1139 Highland Avenue
Needham, MA 02492

Facility Owner
N/A

Primary Contact for this Facility
N/A

General Information

Needham: Free Public Library	
Gross Floor Area Excluding Parking: (ft^2)	47,500
Year Built	1950
For 12-month Evaluation Period Ending Date:	June 30, 2011

Facility Space Use Summary

Library	
Space Type	Other - Library
Gross Floor Area(ft^2)	47,500
Number of PCs[o]	N/A
Weekly operating hours[o]	N/A
Workers on Main Shift[o]	N/A

Energy Performance Comparison

	Evaluation Periods		Comparisons		
Performance Metrics	**Current** (Ending Date 06/30/2011)	**Baseline** (Ending Date 06/30/2011)	**Rating of 75**	**Target**	**National Average**
Energy Performance Rating	N/A	N/A	75	N/A	N/A
Energy Intensity					
Site (kBtu/ft^2)	65	65	0	N/A	104
Source (kBtu/ft^2)	170	170	0	N/A	246
Energy Cost					
$/year	$ 125,995.23	$ 125,995.23	N/A	N/A	$ 201,128.23
$/$ft^2$/year	$ 2.65	$ 2.65	N/A	N/A	$ 4.23
Greenhouse Gas Emissions					
$MtCO_2e$/year	286	286	0	N/A	457
$kgCO_2e/ft^2$/year	6	6	0	N/A	10

More than 50% of your building is defined as Library. This building is currently ineligible for a rating. Please note the National Average column represents the CBECS national average data for Library. This building uses X% less energy per square foot than the CBECS national average for Library.

Notes:
o - This attribute is optional.
d - A default value has been supplied by Portfolio Manager.