Energy Management Plan and Energy Scoping Assessments for:

Falmouth, MA 02540

Date of Site Visit: January 8, 2008
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Introduction

On January 8, 2008, Alan Mulak, an independent consulting engineer working for Cape Light Compact and NGRID, Vicki Marchant of Cape Light Compact, and Domenic Musco of NGRID, met with Town Facilities Manager Shardell Newton, Town Manager Bob Rittenhour, and Town of Falmouth Energy Committee members Paul Raymond and Dick Koehler. The reason for the meeting and subsequent walk thru energy assessment was to identify Energy Conservation Opportunities (ECOs) that exist in the facilities. The ultimate goal of this effort is to take action in an effort to become more energy efficient in a cost effective manner.

The next steps should include:

- A detailed energy evaluation of ECOs to be implemented
- Proposal(s) for work to be performed
- Implementation of approved proposal(s)

This report focuses and elaborates upon these ECOs and in each case, offers typical paybacks and returns on investments (ROIs), discusses energy efficient equipment, and suggests a course of action to accomplish the stated goals. It is an informational document created to increase management awareness of current energy practices and serve as a planning document for future action.

Note: This study has been jointly funded by Cape Light Compact, a Municipal Aggregator responsible for supplying electricity to Cape Cod and Martha’s Vineyard, administering the energy efficiency funds collected from electric ratepayers and for consumer advocacy on behalf of businesses and residences and National Grid. National Grid is the fifth largest distributor of natural gas in the United States and the largest in the Northeast, operating regulated gas utilities in New York, Massachusetts, and New Hampshire that serve 2.6 million customers.
Questions regarding this study should be directed to one of the following:

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Facility Information

Account information:

Falmouth Town Hall

59 Town Hall Square

NSTAR: 1496 855 0013
National Grid: 544201 0990

Falmouth Library

123 Katherine Lee Bates Road

NSTAR: 2807-266-0013
National Grid: 544101 40800

Falmouth Recreation Center

790 Main Street

NSTAR: 1492 031 0019
National Grid: 544201 3090

Morse Pond School

323 Jones Road

NSTAR: 1504 162 0012
National Grid: 544201 2160
The following is a prioritized list of the recommendations found in this report.

Priority #1: Recommended for immediate implementation:

ECO – 1 Survey all Town Facilities with Infrared Camera
ECO – 2 Install Occupancy Sensors
ECO – 3 Replace Obsolete Interior Fluorescent Lighting Systems
ECO – 4 Group Relamp T8 Lighting with High Performance Fluorescent Lighting
ECO – 5 Replace Incandescent Bulbs with Compact Fluorescent Lamps
ECO – 6 Control Plug Load with Sensing Surge Protectors
ECO – 7 Rewire Interior Lighting (Library) to control 24/7 fixtures.
ECO – 8 Install Programmable Set Back Thermostats in all facilities
ECO – 9 Install Vending Machine Controls

Priority #2: Recommended for implementation as soon as practical:

ECO – 10 Replace Hot Water Tanks with On-Demand Units
ECO – 11 Replace Hot Air Units with Ductless Split System Heat Pumps (Recreation Center)
ECO – 12 Replace all Electric Motors with NEMA Premium Efficiency Motors
ECO – 13 Install Full Condensing Boilers (Town Hall, Morse School, and Recreation Center).
ECO – 14 Install Economizers on Walk in Coolers and Freezers
ECO – 15 Install Ultra Spray Nozzle in kitchen
ECO – 16 Control Kitchen Exhaust Hoods
ECO – 17 Boiler Combustion Controls (Morse School)

A note about Cape Light Compact Incentives:

Subject to budget availability, both Cape Light Compact and NGRID offer incentives for some of the recommended Energy Conservation Opportunities. NGRID’s are specified on a case by case basis within the discussion of each ECO. Incentive amounts offered by Cape Light Compact are dependent upon the classification of the customer. As the Town of Falmouth Municipal Facilities are classified as Municipal Facilities, Cape Light Compact will pay 100% of pre-approved work up to $75,000.
Energy Usage Graphs

The graphs on the following pages illustrate energy usage by fuel by facility as well as in aggregate. The most interesting conclusion that can be drawn from the pie charts below is the disproportionately large amount of gas usage in the school. This underscores the low combustion efficiency of the old boilers in use at the school.

[Two pie charts showing gas and electric usage by facility]
Town Hall Electric Usage

Town Hall Demand
Note: The final three months (Oct – Dec) are estimates as no data was available.
Note: The final three months (Oct – Dec) are estimates as no data was available.

Note: The unusually high June gas usage is a mystery.
Energy Conservation Opportunities (ECOs)

This section provides identified potential energy conservation opportunities. In this section of the report, these ECOs have been complied for all facilities. In the following section, each facility and the potential ECOs therein have been broken out separately.

In total, seventeen ECOs have been identified and noted. They are:

ECO – 1  Survey all Town Facilities with Infrared Camera
ECO – 2  Install Occupancy Sensors
ECO – 3  Replace Obsolete Interior Fluorescent Lighting Systems
ECO – 4  Group Relamp T8 Lighting with High Performance Fluorescent Lighting
ECO – 5  Replace Incandescent Bulbs with Compact Fluorescent Lamps
ECO – 6  Control Plug Load with Sensing Surge Protectors
ECO – 7  Rewire Interior Lighting (Library) to control 24/7 fixtures.
ECO – 8  Install Programmable Set Back Thermostats in all facilities
ECO – 9  Install Vending Machine Controls
ECO – 10 Replace Hot Water Tanks with On-Demand Units
ECO – 11 Replace Hot Air Units with Ductless Split System Heat Pumps (Recreation Center)
ECO – 12 Replace all Electric Motors with NEMA Premium Efficiency Motors
ECO – 13 Install Full Condensing Boilers (Town Hall, Morse School, and Recreation Center).
ECO – 14 Install Economizers on Walk in Coolers and Freezers
ECO – 15 Install Ultra Spray Nozzle in kitchen
ECO – 16 Control Kitchen Exhaust Hoods
ECO – 17 Boiler Combustion Controls (Morse School)

In all cases, these ECOs should be reviewed to determine if they are consistent with the actual operational requirements of the facility, the desires of management, and in keeping with any future plans for renovation.

Also, stated savings and paybacks are without taking advantage of Cape Light Compact and National Grid incentives. When added into the equation, these rebates significantly reduce the payback period and thus, improve the ROI.
ECO – 1 Infrared Survey

All facilities (except the new Library) appear to be in need of shell measures such as insulation, windows, and weatherization. The first step in this process is determining where the greatest heat loss takes place. This ECO recommends an Infrared survey of all facilities using town owned IR cameras.

What will an infrared scan show?

An IR scan will point out areas of heat loss, thus indicating where insulation and air sealing are required. In the IR shot shown at right, it is easy to see the extreme heat loss taking place from the basement wall. As a result of this imagery, the facility operator can insulate the basement wall and reduce the heat loss.

Incidentally, this effort would yield best results when it is very cold outside and the heat is on inside the facility or when it is hot outside and the air conditioning is at maximum.

Benefits: Simple, visual results. No calculations required.
Considerations: Camera images must be interpreted by experienced operator.
Likely savings: If insulation is installed, one year.
Incentive available: Possibly from NGRID.
ECO – 2 Install Occupancy Sensors in all facilities.

Occupancy sensors turn off the lights when a room is unoccupied for more than 6 to 12 minutes. These simple, reliable devices are proven energy savers. Throughout the facility in numerous locations such as rest rooms, hallways, and private offices, wall switch and/or overhead occupancy sensors will yield a quick payback.

Note: These sensors should have two means of detection, usually Infrared and Ultrasonic. With two means of detection it is less likely for lights to go out on an occupied room.

Benefits: Turns lights and fans off. Saves electricity.
Considerations: Requires installation.
Likely savings: 1 to 3 year payback depending upon application.
Incentive available: Yes with pre-approved CLC application.

ECO – 3 Replace T12 Lighting with High Performance T8 Lamps and Matching Ballasts

In some areas, old style T12 lighting is in place. This technology is obsolete, inefficient, and renders poor light quality. In all facilities, retrofit to High Performance T8s with matching electronic ballasts.

This technology is 33% more efficient, offers a longer life, and produces an improved light source. A further recommendation in this case is for “Group Relamping” which is simply changing all lamps and ballasts at one time. This will dramatically reduce the cost of labor over the life of the installed lamps.

Considerations: Lamp and ballast change required.
Likely savings: One to two year payback.
Incentive available: Yes with pre-approved CLC application.
ECO – 4  Lighting upgrade to High Performance T8 Lamps and Matching Ballasts

In many areas, T8 lighting is already in place but approaching the end of its useful life. Retrofit to High Performance T8s with matching electronic ballasts.

High Performance or “Super” T8s are simply more efficient than the standard T8s and provide an additional 23% energy savings. A further recommendation in this case is for “Group Relamping” which is simply changing all lamps and ballasts at one time. This will reduce the cost of labor over the life of the installed lamps.

Considerations: Ballast change required.
Likely savings: One to two year payback.
Incentive available: Yes with pre-approved CLC application.

ECO - 5  Replace Incandescent Bulbs

Throughout the facilities, some incandescent bulbs are still in place. These range from 20 to 120 watts. All these lamps are inefficient, short-lived resulting in undue labor expenses, and generate an excessive amount of heat causing the cooling and ventilation systems to work harder than necessary. All of these problems add up and are very expensive. Compact fluorescent lamps (CFLs) have evolved to a level where they are warm in color, use about ¼ the energy, give off ¼ of the heat given off by incandescent, and last 28 times longer, greatly reducing labor and maintenance. They now come in the same shape as the bulbs they are replacing, making the replacement virtually transparent to the occupant.

Benefits: Many choices…all easy to install.
Considerations: More expensive “first” cost.
Likely savings: 1 to 2 year payback.
Incentive available: Yes. Incentive available. Contact CLC for details.

1 There are some new products available that do not require a ballast change. Check with your vendor for more information and the pros and cons of this technology.
2 Some compact fluorescent bulbs have dimming capabilities but caution must be taken when choosing these products. This technology has not yet been perfected and not all manufacturers incorporate a smooth dimming technique. Check with your supplier when making the purchase.
ECO – 6 Plug Load Controls

Based upon observations made during the walk-thru energy assessments, there are many work stations in all facilities. Even though corporate policy recommends when equipment should be turned off and what can and cannot be imported from home, keeping control of the energy consumed by workstations is difficult.

There are basically two approaches to this issue, a simple surge protector approach using a product such as an Isole (shown at right) controlled/uncontrolled system or a web-based controlling system such as NightWatchmen.

For the purposes of this report, the economics of the individual controller such as the Isole would make sense. The more complex (and expensive) web based approach would require and total building management system which is not in place.

Benefits: Easy to set up and install.
Considerations: More expensive than standard surge protector.
Likely savings: 1 to 2 year payback.
Incentive available: No. Does not qualify for rebate unless quantifiable savings can be calculated.

ECO – 7 Rewire Interior Lighting (Library)

Many interior light fixtures cannot be turned off and are therefore on 24/7. Rewiring these fixtures such that they can be controlled in relation to the occupancy would be cost effective.

Benefits: Energy savings.
Considerations: Expense and coordination.
Likely savings: Depending upon number of controlled fixtures, 2 to 3 year payback.
Incentive available: No. Does not qualify for rebate.
ECO – 8  Set-back Programmable Thermostats

In most facilities, the only significant energy controls are the facility operators. Heating, cooling, ventilation, and lighting are all operating without automatic controls. This practice becomes problematic and expensive when systems are inadvertently left “on” during “off” time periods.

Frequently in facilities without automated controls, exhaust fans, heating and cooling devices, are not controlled and run 24/7 even during periods when they could be turned off. Even a simple set back programmable thermostat will eliminate this uncontrolled practice.

Benefits: Saves energy when space is unoccupied.
Considerations: Requires installation (minimal).
Likely savings: Generally a 2 to 4 year payback.
Rebate available: Yes with pre-approved CLC application.

ECO – 9  Vending Machine Controls

Utilizing a custom passive infrared sensor, Vending Miser powers down a vending machine when the area surrounding it is unoccupied and automatically repowers the vending machine when the area is reoccupied. An intelligent controller uses fuzzy logic to learn from the habits of the building occupants, and modifies the time-out period accordingly. Additionally, this device monitors the ambient temperature while the vending machine is powered down. Using this information, it automatically powers up the vending machine at appropriate intervals, independent of occupancy, to ensure that the vended product stays cold.

Benefits: Simple technology.
Considerations: Not for ice cream or dairy products.
Likely savings: Three to five year payback.
Incentive available: Yes with pre-approved CLC application
Upon burnout, electric and gas fired hot water tanks should be replaced with gas fired tankless DHW units.

Installing a tankless water heater would eliminate the need to keep the existing electric hot water tanks “on” 24/7. These economical devices would easily handle the domestic hot water needs of all facilities. Tankless hot water heaters have no standby losses.

A typical demand water heater is up to 50 percent more energy efficient than a traditional natural gas water heater and up to 70 percent more efficient than an electric water heater.

These products utilize on-demand water heater technology which is more efficient because it only heats water when it is needed.

**Benefits:** Energy savings.
**Considerations:** Outside venting required
**Likely savings:** Generally a 2 to 3 year payback.
**Incentives available:** Possibly but further discussion required
ECO – 11  Ductless Split System Heat Pumps

Wherever electric heat and window air condition units are being used, an efficient alternative would be to install several split system ductless heat pumps and energy recovery ventilation systems.

Benefits: Independent control, energy savings, quiet operation.
Considerations: Expense and installation required.
Likely savings: Generally a 2 to 4 year payback.
Rebate available: Possibly, further evaluation will be required.

ECO – 12  NEMA Premium Efficiency Motors

As motors approach the end of their useful life and burnout, replace with NEMA premium efficiency motors.

This plan should be in place ASAP to deal with motors as they burn out as when this happens, it often needs to be addressed immediately. With a prepared plan in place, the decision is simplified.

NEMA premium efficiency motors are generally 5 to 10% more efficient which results in a significant reduction in electric expenses. Motors such as those on the circulating pumps are 80% efficient and run as much as 4000 hours per year. The cost of replacement with premium efficiency motors will be realized in energy savings in roughly two years. Free software from www.eere.energy.gov/industry/bestpractices/software.html#mm can be of great value in compiling a motor plan and inventory.

Note: the greatest savings from this ECO will be realized when existing motors are replaced upon burnout, not via wholesale replacement.

Note: the incentive for NEMA Premium Efficiency motors can be paid directly to the contractor.

Benefits: Proven technology.
Considerations: Installation required.
Likely savings: Two to three year payback.
Incentive available: Yes with pre-approved CLC application
ECO – 13  Full Condensing Boilers

Hot water heat in some facilities is generated by atmospheric, standard efficiency gas fired hydronic boilers. When maintenance and operation costs drive up the annual life cycle cost to the unacceptable level, this ECO (Energy Conservation Opportunity) recommends replacement with full condensing boilers.

This technology is now common and the technology has been tested and proven. In practice a conventional boiler would have an efficiency of 81% to 84% because as well as the latent heat, further flue gas heat is lost. A condensing boiler will give between 96% to 98% as all the latent heat is captured and flue losses are smaller.

Further study is required for this Energy Conservation Opportunity but conservatively, a 20% reduction in fuel consumption could be expected.

Benefits: Efficient heating, reduced maintenance.
Considerations: Expense and availability of gas.
Likely savings: Three to four year payback.
Rebate available: Rebates available through National Grid’s High-Efficiency Heating and Water Heating Rebate Program Schedule.

ECO – 14  Walk-in Cooler and Freezer Economizers

Coolers and freezers run 24/7. Most of the time, the door is shut and the “chilled” air eventually stratifies. This results in the refrigeration system to run in an effort to mix the air. Economizers sense this layering effect, bypass the refrigeration system and simply run the fans, thus solving the problem at 1/6 the expense of running the refrigeration system.

Benefits: Simple technology, saves energy.
Considerations: Requires installation (minimal).
Likely savings: Three to five year payback.
Incentive available: Yes with pre-approved CLC application.
ECO – 15 Kitchen Pre-Rinse Valve

A high velocity pre-rinse valve mounted on the flexible hose in the kitchen will save water, sewer, and hot water heating expenses. It will also save labor. These simple devices are mandatory in California where water and sewer expenses are very high.

Benefits: Simple technology, saves energy.
Considerations: Requires installation (minimal).
Likely savings: Three to five year payback.
Incentive available: Rebates available through National Grid’s High-Efficiency Heating and Water Heating Rebate Program Schedule

ECO – 16 Kitchen Exhaust Hood

At the Morse Pond School, kitchen hood exhaust fans operate at 100%, without control, even when minimal exhausting is required. One such product, know as the Melink Kitchen Hood Controller could result in significant energy savings.

From their website: The Melink Intelli-Hood® Controls can be installed in any commercial kitchen including schools.

The controls are extremely simple to operate. At the beginning of each day, the chef or cook simply presses the light and fan buttons on the keypad. The hood lights turn on and the fans reach a preset minimum speed of between 10 and 50 percent. When the cooking applications are turned on, the fan speed increases based on exhaust air temperature. During actual cooking, the speed increases to 100 percent until smoke and heat are removed.

Benefits: Energy savings potential.
Considerations: Somewhat expensive.
Likely savings: Paybacks generally less than five years.
Incentives available: Possibly with pre-approved CLC application.

Comment [JB1]: Does KeySpan have a rebate for this measure?
ECO – 17 Boiler Combustion Controls

At the Morse Pond School, in lieu of replacing the boiler, the installation of a totally integrated control system embodying precise boiler/burner management control and safety with logic based ancillary devices and functions may improve efficiency of the existing system. When properly installed, Boiler Combustion Controls (BCCs) maximize efficiency, reduce operating costs, and increase productivity.

Benefits: Energy savings potential.
Considerations: Expensive.
Likely savings: Paybacks generally less than five years.
Incentives available: Rebates available through National Grid’s High-Efficiency Heating and Water Heating Rebate Program Schedule.
Facility Specific Energy Conservation Opportunities

This section provides identified potential Energy Conservation Opportunities (ECOs) per facility.

Facility: Falmouth Town Hall

Occupancy: Normal Business Hours
ECO’s: 1, 2, 5, 6, 8, 10, 11, 12, 13

Additional Recommendations:
1. This facility may need shell measures. The study with an IR camera would identify this need.
2. Once the ECO’s have been implemented, this facility will be re-run in the EPA Energy Star Portfolio Manager.

Priority #1: Recommended for immediate implementation:
ECO – 1 Survey all Town Facilities with Infrared Camera
ECO – 2 Install Occupancy Sensors
ECO – 5 Replace Incandescent Bulbs with Compact Fluorescent Lamps
ECO – 6 Control Plug Load with Sensing Surge Protectors
ECO – 8 Install Programmable Set Back Thermostats in all facilities

Priority #2: Recommended for implementation as soon as practical:
ECO – 10 Replace Hot Water Tanks with On-Demand Units
ECO – 11 Replace Hot Air Units with Ductless Split System Heat Pumps (Recreation Center)
ECO – 12 Replace all Electric Motors with NEMA Premium Efficiency Motors
ECO – 13 Install Full Condensing Boilers (Town Hall, Morse School, and Recreation Center).
Facility: Library
Occupancy: Public Use Facility Extended
Hours
ECO’s: 6, 7, 8, 10

Additional Recommendations:
1. This facility is state of the art. The HVAC controls issues are being corrected.
2. Once the ECO’s have been implemented, this facility will be re-run in the EPA Energy Star Portfolio Manager (treated as an office).

Priority #1: Recommended for immediate implementation:

ECO – 6 Control Plug Load with Sensing Surge Protectors
ECO – 7 Rewire Interior Lighting (Library) to control 24/7 fixtures.
ECO – 8 Install Programmable Set Back Thermostats in all facilities

Priority #2: Recommended for implementation as soon as practical:

ECO – 10 Replace Hot Water Tanks with On-Demand Units
Facility: Morse Pond School

Occupancy: Extended School Hours

ECO’s: 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17

Additional Recommendations:
1. The boiler in this facility is old and inefficient. The gas usage in this boiler is very high.
2. Controls in the school need to be tuned and synchronized.
3. Once the ECO’s have been implemented, this facility will be re-run in the EPA Energy Star Portfolio Manager.

Priority #1: Recommended for immediate implementation:

ECO – 1 Survey all Town Facilities with Infrared Camera
ECO – 2 Install Occupancy Sensors
ECO – 3 Replace Obsolete Interior Fluorescent Lighting Systems
ECO – 4 Group Relamp T8 Lighting with High Performance Fluorescent Lighting
ECO – 5 Replace Incandescent Bulbs with Compact Fluorescent Lamps
ECO – 6 Control Plug Load with Sensing Surge Protectors
ECO – 8 Install Programmable Set Back Thermostats in all facilities
ECO – 9 Install Vending Machine Controls

Priority #2: Recommended for implementation as soon as practical:

ECO – 10 Replace Hot Water Tanks with On-Demand Units
ECO – 11 Replace Hot Air Units with Ductless Split System Heat Pumps (Recreation Center)
ECO – 12 Replace all Electric Motors with NEMA Premium Efficiency Motors
ECO – 13 Install Full Condensing Boilers (Town Hall, Morse School, and Recreation Center).
ECO – 14 Install Economizers on Walk in Coolers and Freezers
ECO – 15 Install Ultra Spray Nozzle in kitchen
ECO – 16 Control Kitchen Exhaust Hoods
ECO – 17 Boiler Combustion Controls (Morse School)
Facility: Recreation Center

Occupancy: Public Use Facility

ECO’s: 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13

Additional Recommendations:

1. Once the ECO’s have been implemented, this facility will be re-run in the EPA Energy Star Portfolio Manager (treated as an office).

Priority #1: Recommended for immediate implementation:

ECO – 1 Survey all Town Facilities with Infrared Camera
ECO – 2 Install Occupancy Sensors
ECO – 3 Replace Obsolete Interior Fluorescent Lighting Systems
ECO – 4 Group Relamp T8 Lighting with High Performance Fluorescent Lighting
ECO – 5 Replace Incandescent Bulbs with Compact Fluorescent Lamps
ECO – 6 Control Plug Load with Sensing Surge Protectors
ECO – 8 Install Programmable Set Back Thermostats in all facilities
ECO – 9 Install Vending Machine Controls

Priority #2: Recommended for implementation as soon as practical:

ECO – 10 Replace Hot Water Tanks with On-Demand Units
ECO – 11 Replace Hot Air Units with Ductless Split System Heat Pumps (Recreation Center)
ECO – 12 Replace all Electric Motors with NEMA Premium Efficiency Motors
ECO – 13 Install Full Condensing Boilers (Town Hall, Morse School, and Recreation Center).
Energy Star Award Application by Facility

ESB Introduction and Summary.

As part of the U.S. EPA Energy Star program, buildings can be benchmarked and compared against buildings across the country in the same categories using the Energy Star Portfolio Manager. An office building will be compared against other office buildings, a K-12 school against other K-12 schools and so on with the data adjusted for climate differences. Buildings that achieve a score of 75% or higher can apply for an Energy Star rating / award as well. The plaque is shown at right. These awards carry enormous PR value wherein they demonstrate superior energy performance. The award is based upon comparison of energy consumption per unit area, normalized for climate conditions. All fuel data must be considered.

Even if a building cannot achieve Energy Star award status, the benchmarking score can be a very valuable tool as it guides the facility manager in his or her effort to improve the efficiency of the building. Obviously, a low score would be an indication that there may be work to be done. A score that improves over the years would be an indication that the efficiency efforts were paying off. A building that does not qualify for an award now may qualify later after the improvements are implemented. Portfolio Manager can be found at the following site:


From the EPA website: “Buildings achieving a rating of 75 or higher and professionally verified to meet current indoor environment standards are eligible to apply for the ENERGY STAR. Display the ENERGY STAR plaque to convey superior performance to tenants, customers, and employees. Highlighting the ENERGY STAR qualified buildings in your portfolio sends a positive message to lenders, appraisers, owners, investors, and potential tenants or customers. Rate the performance of your buildings on a scale of 1-100 relative to similar buildings nationwide using EPA's national energy performance rating system. The rating system accounts for the impacts of year-to-year weather variations, as well as building size, location, and several operating characteristics. Buildings rating 75 or greater may qualify for the ENERGY STAR.”

Not all building types can be benchmarked by Energy Star’s Portfolio Manager but the list is continually expanding. If your building does meet the current criteria, your representative would be happy to do the initial benchmarking upon receipt of the utility bills and heating oil/propane consumption data (if applicable).
Energy Star Building Discussion

The facilities entered into Portfolio Manager are the Library (entered as an office), Town Hall, Morse Pond School, and Recreation Center. The scores are as follows:

Library – 67  
Town Hall – 33  
Morse Pond School – 35  
Recreation Center – 49

Per building comments:
1. Library – The score will rise once the 24/7 lighting issue is resolved and the HVAC controls are recommissioned. Once these two ECOs are implemented and if the score rises to greater than 75%, it may be worthwhile to investigate a LEED EB score for this building.
2. Town Hall – Once any shell measures are addressed, this building needs to be run again. There is some suspicion that incorrect billing data was used the first time thru.
3. Morse Pond School – The boilers are the largest gas consuming item in the facility. They are old and inefficient. Not much improvement can be expected until these are replaced.
4. Recreation Center - This facility should have scored better. Once the ECOs are implemented, suggest re-running ESB and revisiting the facility if the score does not improve significantly.

I recommend running the program each month to measure the gain (or loss). Significant gains can be made by implementing the recommended energy conservation measures. Greater gains may be achieved by implementing an aggressive “turn it off / down” program.

Looking into the future, as existing equipment nears the end of its useful life, replacement with higher efficiency units as recommended in this report will result in continued improvements.
**Next Steps**

If you are interested in proceeding with any of the Energy Efficiency Opportunities suggested within this report, please contact:

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Thank you for your interest - we look forward to serving you soon.
Appendix

The following is a *Generic* Energy Management Plan for provided as a guide for future energy purchases and activities.
Energy Conservation Opportunities (ECOs)

The purpose of this section is to provide guidance with regards to the purchase of and retrofits to energy efficiency technology. This document is intended to be a series of recommendations that will direct the future energy management effort to high efficiency equipment and technologies.

A. Lighting

Note: The energy efficient approach to lighting installations is to reduce the lighting power density (LPD) in watts per square foot from the baseline lighting design defined by the Massachusetts State Building Code, while maintaining Illuminating Engineering Society of North America (IESNA) recommended foot-candle levels.

Lighting ECOs:

- ECO - L1 T5 or High Performance T8 lighting
- ECO - L2 Pulse start Metal Halide exterior lighting
- ECO - L3 Compact Fluorescent lamps and fixtures
- ECO - L4 LED Exit Signs and Lighting

B. Controls

Occupancy sensors detect the presence or absence of people and turn lights on and off accordingly. They may reduce lighting energy consumption by 50 percent or more in some circumstances, but the savings for any given installed sensor can be much less. In facilities that are unoccupied for as many hours as they are occupied, lighting controls have a huge savings potential.

Lighting controls help to make commercial buildings more comfortable, productive, and energy efficient. These controls can turn lights off when they are not needed or dim light output so that no more light than necessary is produced. The two functions can be employed individually or in tandem to provide even greater benefits. The equipment needed to achieve these functions ranges from simple timers to intricate electronic dimming circuits.

Lighting Control ECOs:

- ECO - LC1 Occupancy Sensors
- ECO - LC2 Daylight dimming
- ECO - LC3 Plug load controls

3 When discussing lighting, “T” stands for thickness in 1/8’s on an inch. A T8 is therefore 8/8’s of an inch, a T5 is 5/8’s, and so on.
C. Heating Ventilation Air Conditioning (HVAC)

The cost-effectiveness of high-efficiency HVAC equipment depends on several factors, including cooling and heating loads, operating hours, and the local cost of electricity. Further, sizing is vitally important. An undersized unit will not be able to provide sufficient heating or cooling, but if a unit is oversized (the more frequent occurrence), it not only costs more but will lead to higher costs for associated ductwork and other auxiliaries. Operating costs increase too, because oversized equipment spends more time at less-efficient part-load conditions. Specifies and designers commonly overestimate loads because they fail to take into account the reduced air-conditioning loads that result from energy-efficient lighting, and they overestimate plug loads by using nameplate ratings of office equipment in the building.

HVAC ECOs:

- ECO – HVAC1 Demand Control Ventilation
- ECO – HVAC2 Gas fired tankless hot water units
- ECO – HVAC3 High efficiency air conditioning units
- ECO – HVAC4 Install programmable, set back thermostats
- ECO – HVAC5 NEMA Premium Efficiency Motors
- ECO – HVAC6 Infrared Heat
- ECO – HVAC7 Kitchen ECOs (Cooler and Freezer economizers, etc)
- ECO – HVAC8 Equipment Controls (Vending Machines, Fans, Hoods, etc.)
- ECO – HVAC9 Variable Speed Drives
- ECO – HVAC10 Phase out all oil fired equipment

D. Other Related Recommendations

In addition to technology, efficiencies can result from other actions or resources as well. The following is a list of suggested low-cost or no-cost actions and resources that can greatly aid in the effort to achieve energy efficiency.

Additional ECOs:

- ECO – A1 Employ a City re-commissioning agent
- ECO – A2 Building Operator Certification Program
- ECO – A3 Infrared Survey of all City Buildings
- ECO – A4 Energy Star Portfolio Manager Benchmarking
- ECO – A5 Implement a Computerized Maintenance Management System
- ECO – A6 FEMP O&M Best Practices Guide
Detailed Description of Recommended ECOs

The following is a detailed explanation of each recommendation.

**ECO – L1 Energy Efficient Interior Fluorescent Lighting**

Suggestions:
1. Relamp all interior office and classroom fluorescent lamps to High Performance T8s with matching ballasts.
2. Change all lighting critical areas to indirect fixtures.
3. Employ “Group Relamping” practice.
4. Utilize Unitil incentives.

Notes:
Indirect lighting with either T5 or High Performance T8 technologies is energy efficient while providing excellent illumination. This approach to space lighting typically features fixtures suspended from the ceiling that distribute the light mainly upward, and the indirect lighting is often combined with a certain portion of direct lighting, task lighting, or both. Indirect lighting minimizes glare on computer screens and creates a soft, inviting environment for concentrated work. The accompanying increases in productivity and occupant satisfaction are hard to quantify, but the benefits are significant. Indirect lighting also offers the potential to reduce energy use.

Indirect and indirect/direct fixtures typically use T8 or T5 lamps with electronic ballasts. T5 lamps are thinner, more efficient, and offer a higher intensity of light output than their T8 predecessors. The high intensity of T5 lamps means that rows of indirect fixtures can be placed as much as 12 to 15 feet apart on ceilings as low as 9 feet (some manufacturers claim that the fixtures can be used on ceilings that measure 8 feet 6 inches or lower) and still provide uniform ceiling illumination levels. With T8 lamps, the standard spacing is 10 to 12 feet, and ceilings have to be at least 9 feet 6 inches high—higher than most conventional office ceilings. Wider spacing means that fewer fixtures need to be used in a given space, and the overall cost for an installation can be reduced accordingly.

T5 lamps are available in two types: standard output and high output (HO). The HO versions put out almost twice as much light as a T8 lamp of the same length, and therefore the number of single-lamp T5 fixtures required in a given space can be cut almost in half compared with single-lamp T8 units. Thus, indirect
lighting systems that use T5 HO lamps can be less expensive than a T8 indirect system, despite the fact that T5 lamps themselves are still more expensive than T8s. The cost advantage should grow as T5s become more popular and the manufacturing volume increases. The lamp price should eventually fall below that for T8s, because their small size means that they inherently require less material to manufacture. Single-lamp fixtures also boast an advantage over two-lamp fixtures, because light distribution is easier to control with one lamp than two. An advantage occurs at the end of lamp life as well—a single T5 lamp is easier to dispose of than a pair of T8s, because there is less material involved.

Other Recommendations:

1. Specify requirements found in the Commonwealth of Massachusetts State Building Code, Massachusetts Electrical Code, and the Illuminating Engineering Society of North America:
2. In these codes, the lighting design levels are as follows:
   a. General open office – 40 foot candles
   b. Perimeter offices – 50 foot candles
   c. Corridors – 30 foot candles
   d. Toilets – 25 foot candles
3. Specify lighting power density as follows:
   a. Total facility less than 1.3 watts per square foot
4. All fluorescent lamps shall be either “High Performance” T8 or T5 technology but not both.
ECO – L2 Energy Efficient Exterior Lighting

Suggestions:
1. Relamp all exterior HID Metal Halide fixtures to Pulse Start Metal Halide technology. This is primarily sports fields and facility security lighting.
2. Employ “Group Relamping” practice.
3. Utilize Unitil incentives.

Notes:

The right lamps, appropriate fixtures, proper maintenance, and lighting design that follows the Illuminating Engineering Society of North America’s (IESNA’s) Guideline for Security Lighting for People, Property, and Public Spaces (G-1-03) result in a feeling of safety for building occupants/tenants and employees. Additionally, vagrants are less likely to consider criminal activity in a place where it is easy to be seen.

In its Lighting Handbook, the Illuminating Engineering Society of North America recommends parking lots be lit at an average of 1 foot-candle or less of light, but most parking lots are designed with far more lighting than that. Using lower-wattage bulbs can actually increase the safety of your lot: An overlit lot can be dangerous to drivers if their eyes cannot adjust quickly enough in the transition from highly lit to dark areas. When designing lighting for a new parking lot, consider using low-wattage metal halide lamps, instead of high-pressure sodium lamps, in fixtures that direct the light downward. Even with a lower wattage, an office building could safely use fewer lamps if this choice is made. Metal halide is less efficient than high-pressure sodium in conventional terms, but it puts out more light in the blue part of the spectrum, which turns out to be easier for our eyes to see under low-light conditions.

Recommendations:
1. All exterior lighting shall be full cut off style with zero net light pollution.
2. Specify Pulse Start Metal Halide technology.
ECO – L3 Compact Fluorescent Lamps

Suggestions:
1. Remove all incandescent bulbs and replace with Compact Fluorescent lamps.
2. Utilize Unitil incentives.

Notes:
Compact fluorescent lamps (CFLs) are a quick, easy replacement for typical screw-base incandescent lamps. CFLs use about one-third as much energy as incandescent to deliver the same amount of light. They also save on materials and maintenance costs because they last 10 times as long—an average of 10,000 hours compared with fewer than 1,000 hours for an incandescent bulb. CFLs initially cost more—on the order of $3 to $10. Even so, depending on the application, they can pay for themselves pretty quickly. The longer the hours of operation, the shorter the payback period. A CFL operating for typical business hours of 2,500 hours or more per year will pay for itself in less than a year.

What Are the Options?
Shapes and configurations. CFLs come in a variety of shapes, as shown in Figure 1 below. The various shapes provide different light densities and distribution and fit better in certain fixtures. CFL products also come with and without reflectors. Non-reflectorized lamps are usually used in table lamps, floor lamps, and other fixtures designed to put out diffuse light. Reflectorized lamps provide a more directional light. CFLs may also be covered in various ways to mimic standard incandescent lamp shapes, such as A-lamps and PAR lamps.
Recommendations:

1. Select a lamp that meets Energy Star requirements. Through the Energy Star program, the U.S. Environmental Protection Agency and the U.S. Department of Energy have developed a set of specifications for cost-effective, energy-efficient CFLs. Manufacturers test their products against these guidelines, and the Energy Star web site spells out the requirements and lists all qualifying products.

2. Use Energy Star fixtures. The Energy Star program has also developed a set of specifications for residential and commercial fixtures. The specs and a complete list of qualifying products are available on the web.

3. Replace all incandescent bulbs with CFLs.
ECO – L4 Install LED Exit Signs and Lighting

Suggestions:
1. Install LED exit signs in all City facilities.
2. Use LED Energy Star rated exit signs.
3. In parking garages, install LED ceiling mounted fixtures.
4. Utilize Unitil incentives.

Notes:

From the Energy Advisor website:

*In traditional exit signs, two incandescent lamps typically light the sign. They draw 24 to 40 watts of power (Table 1), so depending on local prices, a single exit sign can run up electricity bills of more than $30 per year. More importantly, exit signs are required to be on all the time and therefore the lamps burn out in a matter of months. The cost of replacement lamps and the labor to install them can add up to $24 per year per sign, not to mention increasing the risk of having a sign out of order at the wrong time.*

<table>
<thead>
<tr>
<th>Light source</th>
<th>Wattage</th>
<th>Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent lamp</td>
<td>24 to 40</td>
<td>2 to 8 months</td>
</tr>
<tr>
<td>LEDs</td>
<td>&lt;1 to 5</td>
<td>10+ years</td>
</tr>
<tr>
<td>CFLs</td>
<td>10 to 24</td>
<td>1 to 2 years</td>
</tr>
<tr>
<td>Electroluminescent panels</td>
<td>&lt;1</td>
<td>10+ years</td>
</tr>
<tr>
<td>Photoluminescent materials</td>
<td>0</td>
<td>10+ years</td>
</tr>
<tr>
<td>Cold cathode</td>
<td>5</td>
<td>10 years</td>
</tr>
</tbody>
</table>

Source: Platts

*The most cost-effective alternatives are the newest light-emitting diode (LED) exit signs (Figure 1). They use only 1 to 5 watts of power per surface and cost less than $5 per year to operate, depending on the model and local utility costs. Because LEDs also last considerably longer than incandescent lamps, lifecycle savings are dramatic. Over a 10-year period, first costs, energy expenditures, and maintenance requirements for an incandescent sign could run about $570, depending on local conditions, whereas a comparable LED unit with a 10-year life would incur overall costs of about $125.*

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4 This is an energy code requirement for all new construction starting in 2007.
When LED signs were introduced, high first costs limited them to a few niche applications. In 1994, an LED unit cost roughly five times as much as an incandescent model, but that gap has narrowed—and in some cases vanished altogether. For example, there is no longer a price difference for commodity-grade signs with battery backup.

**Recommendations:**

1. Select an Energy Star-certified product. Through the Energy Star program, the U.S. government has developed specifications for cost-effective, energy-efficient exit signs. A sign may carry the Energy Star label if it:
   a. consumes less than 5 watts of power per face,
   b. exceeds the National Fire Protection Association Safety Code 101 guidelines, and
   c. carries at least a five-year manufacturer warranty for defective parts.
2. Manufacturers test their products against these guidelines, and the Energy Star Web site lists all qualifying products. You'll find that most of the qualifying signs are made with LEDs. New Energy Star specifications—version 3.0—are in the works as of late 2003 and are planned for implementation starting August 1, 2004. The new specs, if adopted as they now stand, would allow self-illuminating signs such as those that use photoluminescent materials.
ECO – LC1 Occupancy Sensors

Suggestions:

1. Install dual sensing occupancy sensors in every classroom, restroom, private office, conference room, and other similar spaces.
2. Utilize Unitil incentives.

Notes:

Occupancy sensors turn off the lights when a room is unoccupied for more than 6 to 20 minutes. These simple, reliable devices are proven energy savers. Throughout the facilities in numerous locations such as private offices, conference rooms, and restrooms, wall switch and/or ceiling mounted occupancy sensors will yield a quick payback.

Note: These sensors should have two means of detection, usually Infrared and Ultrasonic. With two means of detection it is less likely for lights to go out on an occupied room.

Recommendations:

1. All office areas, conference rooms, bathrooms, and storage areas shall be controlled via occupancy sensors.
2. All sensors should have two means of detection, usually Infrared and Ultrasonic.
ECO – LC2 Daylight Dimming Lighting

Suggestions:

1. In spaces adjacent to exterior walls with windows, install a daylight dimming or “harvesting” system.
2. Utilize Unitil incentives.

Notes:

From the Energy Advisor website:

In many areas, natural lighting is available to illuminate the areas adjacent to these large windows. When this is available, light fixtures in the immediate area can be dimmed without losing any of the available light for student activities. Continuous daylight dimming controls can be used to automatically turn lights on or off, or dim them, depending on the available daylight available in the space. Daylight dimming can maintain the desired light level while providing a smooth, barely noticeable transition to or from electric lighting as daylight increases or decreases.

Daylight or continuous dimming controls let users adjust lighting levels over a wide range of lighting output. They offer far more flexibility than step dimming and are used in a wide variety of applications, including mood-setting and daylight dimming. Dimming can be accomplished on all lamp types found in commercial buildings: incandescent, fluorescent, and high intensity discharge (HID).

Incandescent lamps are the easiest to dim. The introduction of semiconductor-based dimming controls for these lamps means that dimming is also accompanied by a reduction in energy consumption. However, these dimmers cause the filament to run cooler, reducing color temperature and making the lamp appear more yellow. In addition, power does not vary linearly with light output, and lamp efficacy is reduced during dimming. However, voltage is also reduced, which increases the life of standard incandescent lamps but may reduce life in halogen bulbs.

Fluorescent lamps may be dimmed for two purposes: energy savings and architectural effect. Energy-saving dimmers typically dim down to 20 percent, while architectural dimmers may reduce light levels to 1 percent or less. Unlike incandescent dimming, fluorescent dimming does not extend lamp life, and long periods at very low light levels may shorten life. Dimming ballasts are often used to reduce artificial light output whenever sunlight is available. In one test, dimming ballasts helped cut peak demand by almost 40 percent (see Figure 2). Dimming can also be used in load-shedding strategies—better to have employees work under slightly lower light levels than be forced to send them home because of a power failure.
In a test at the Florida Solar Energy Center, dimming cut average workday power consumption for lighting from 157 watts (W) to 70 W.

**Dimming** is accomplished through the use of either low-voltage control or power line control. Most ballasts are controlled by a separate, low-voltage circuit. This approach requires additional control wiring, but the ballasts are compatible with a wide variety of dimming controls. For example, low-voltage controlled ballasts can easily be connected to energy management systems that offer 0- to 10-volt output channels. Power line controlled ballasts can dim fluorescent lamps with standard incandescent wall dimmers installed directly on the line-voltage switch leg—no extra wires necessary. The ballasts are not compatible with all dimmers, however, so ballast and dimmer should be checked for compatibility.

**Recommendation:** Consider day light dimming systems for all spaces with windows to the exterior.

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**Figure 2: Power levels for dimming and non-dimming systems**

Dimming is accomplished through the use of either low-voltage control or power line control. Most ballasts are controlled by a separate, low-voltage circuit. This approach requires additional control wiring, but the ballasts are compatible with a wide variety of dimming controls. For example, low-voltage controlled ballasts can easily be connected to energy management systems that offer 0- to 10-volt output channels. Power line controlled ballasts can dim fluorescent lamps with standard incandescent wall dimmers installed directly on the line-voltage switch leg—no extra wires necessary. The ballasts are not compatible with all dimmers, however, so ballast and dimmer should be checked for compatibility.

**Recommendation:** Consider day light dimming systems for all spaces with windows to the exterior.
ECO – LC3 Plug Load Controls

Suggestions:

1. In workstations and individual cubicles, install controls for all workstations.
2. Utilize Uunitl incentives.

Notes:

There are many work stations in all City facilities. Even if corporate policy recommends when equipment should be turned off and what can and cannot be imported from home, keeping control of the energy consumed by workstations is difficult.

There are basically two approaches to this issue, a simple surge protector approach using an Isole controlled/uncontrolled system or a web-based controlling system such as NightWatchmen.

For the purposes of this report, the economics of the Isole based controller approach has been studied. The more complex web based approach would require further study.

From the Energy Advisor network:

*The modern office is full of energy-using equipment—computers, printers, copiers, task lights, fans, and other devices—much of which is left on, unnecessarily, throughout the workday and, in some cases, for 24 hours a day, 365 days a year. The U.S. Environmental Protection Agency (EPA) estimates that 80 percent of the printers used in offices, 70 percent of copiers, and 20 to 30 percent of computer monitors and task lights are left on overnight. The result is wasted money for building owners and operators.*

*To reduce energy consumption, "smart" power strips use a variety of monitors, timers, and sensors to turn unused equipment off, saving enough electricity to enable payback periods of less than two years in many cases. Smart power strips can be used to control a variety of devices that can be turned off when not in use, including calculators, coffee warmers, space heaters, and computer monitors. Devices that must stay on—fax machines, modems, computer central processing units, and certain printers—can simply be plugged into outlets that are not controlled by smart power strips.*

*Here are some of the main features you'll encounter when shopping for smart power strips:*
Occupancy sensors. These products sense the presence or absence of office workers and turn the attached equipment on and off accordingly. Passive infrared (PIR) sensors are the most common type of occupancy sensor and are able to "see" heat emitted by occupants. The sensor is triggered when a change in infrared levels is detected, such as when a warm object moves in or out of view of one of the sensor's "eyes." PIR sensors are quite resistant to false triggering. They are best used within a 15-foot range for two reasons: There are potential "dead" spots between their wedge-shaped sensory patterns that get wider with distance (see Figure below) and, being passive, they do not send out any signal; instead, they depend on the intensity of the heat output of the moving part of the subject, which drops with the square of the distance.

Figure 1: Sensor coverage diagram

Ultrasonic sensors can detect motion at any point within the contour lines. Passive infrared sensors see only in the wedge-shaped zones, and they don’t generally see as far as ultrasonic units. The ranges are representative; actual sensors may be more or less sensitive.

Ultrasonic sensors emit a high frequency signal (over 20,000 cycles per second), above human and animal audibility ranges, and listen for a change in frequency of the reflected signal. By emitting a signal instead of only receiving it, they are able to cover larger areas than PIR sensors and are noticeably more sensitive. They are also more prone to false triggering. For example, air motion created by a person running past a doorway or the on/off cycling of an HVAC system can cause false triggers.

Timers. Smart power strips can turn office equipment on and off based on the calendar or clock time, in addition to occupancy sensors. However, timers are especially effective in cases where it does not make sense to control equipment based on occupancy. For example, if an infrequently used laser printer or copier requires a long warm-up period and is kept in an area that lacks frequent foot traffic, the productivity lost while people waited for the printer or copier to warm up would quickly negate the savings from
reduced energy use. Turning the device on and off based on a simple clock would ensure energy savings overnight, and a calendar function would enable weekend and holiday savings as well.

Monitors. Other smart power strips determine when equipment is in use or in an idle state by monitoring equipment activity—for example, the flow of data to a printer—or by monitoring the flow of current to the equipment. If the equipment is idle for a length of time specified by the user, it will be shut off and awakened when activity resumes. Some strips monitor the current from one device, such as a computer, to determine when to shut off or turn on all devices connected to the strip. This allows the strip to automatically shut off all peripheral equipment, such as monitors and printers, when the computer is shut off. These options can also be used together: a clock might turn a printer on at the same time each morning, and an activity monitor or occupancy sensor might turn it off when activity stops at the end of the day.

Bundled together or add-on power strips. Some products come with the power strip and occupancy sensor as an integral unit. These products also often provide two sets of outlets: one controlled by the occupancy sensor, the other uncontrolled. This configuration allows equipment that must be kept on all the time, such as fax machines, to be plugged into the same strip. Other products feature a sensor and a relay device that can be plugged into a separate power strip to cover multiple devices. For companies that already own power strips, this could be the best choice.

What to do?

Determine if smart power strips are cost-effective. Many buyers base their purchase decision on a simple visual observation that office equipment is left on longer than necessary. But to determine whether or not an investment in this type of equipment will really be cost-effective, buyers can monitor particular groups of equipment to see how much power they draw, how many hours they are left on, and how often they could be turned off. One company offers a device for measuring plug load power draw. Data from this device can be combined with a sensor to track energy usage and occupancy and estimate the savings that can be achieved through control of plug loads. Energy loggers can also be used to determine office equipment power draw and time of use. Once the equipment power draw, times of use, and occupancy schedules are known, a simple calculation, such as that shown in the sidebar, can be performed to determine the payback period of a smart power strip.

Calculating Payback on Smart Power Strips

Although prices vary, the average smart power strip could add a premium of about $20 to the cost of a regular power strip with equivalent surge protection. If the strip controlled 50 watts worth of task lights and a monitor using 100 watts, and electricity cost an average of 10 cents per kilowatt-hour, the device would pay for itself after preventing about 1,333 hours of operating time—a matter of less than two months if equipment otherwise would be left on 24 hours a day. How did we get this number? By
multiplying the power saved (in kilowatts) by the energy rate, then dividing the cost premium by that product: $20 ÷ (0.15 kW x $0.10/kWh) = 1,333 hours.

To determine how long it would take to eliminate 1,333 hours of operating time, first determine how many hours a day a smart power strip might prevent that equipment from operating. For example, a typical workday might be 9.5 hours long, during which monitors are inactive for 5.5 hours. Assume that the equipment is turned off at night and that the occupancy sensor time delay adds a half hour per day of operating time before the equipment is turned off. Then the smart power strip would save about five hours per day of operating time and pay for itself in 267 working days, or just over one year. If equipment is otherwise left on nights and weekends, the savings would be 143 hours per week for a payback of less than 10 weeks.

Pick the right type. Smart power strips equipped with ultrasonic or PIR occupancy sensors will work in a typical office setting if they are installed carefully, as described below. However, each type has limitations. Ultrasonic sensors are more sensitive to movement than PIR devices, but they’re also more prone to false triggering. PIR sensors experience dead spots but are generally a better choice in a typical workstation, where the line-of-sight requirement of a PIR sensor can be easily met. In low-occupancy areas, strips that use equipment activity monitors or timers might be a better solution.

Decide on an area of coverage. Some smart power strips come with small-range occupancy sensors that only sense a presence in the workstation; others cover a wider area and detect the presence of people in the office around the workstation. Choose the latter if you want equipment to turn off less frequently and turn on sooner.

Install sensors carefully. As is the case for wall- and ceiling-mounted occupancy sensors, the sensors that come with smart power strips are easily visible and can potentially be improperly adjusted, stolen, vandalized, or fooled into perceiving a human presence when a space is unoccupied. For continued energy savings, users should take the following precautions:

- Involve building personnel in planning for the sensors.
- Train maintenance personnel and office occupants to keep sensors operational rather than disconnecting them when problems occur.
- Position sensors carefully so that they only see the area that you want them to see; the biggest cause of false triggering is incorrect sensor positioning.
- Pick a product with an adjustable time delay. Smart power strip products may come with either adjustable or factory-set time delays that determine how long a period of nonoccupancy or inactivity must be before the equipment is turned off. A product with an adjustable time delay allows adjustment of the smart power strips to suit individual work habits.

The next step for smart power strips is integration into a total workspace controller. One company recently moved in that direction with a product that consists of an occupancy sensor, an infrared transmitter, and controls for outlet switching and fluorescent
dimming. It not only controls office equipment based on occupancy, but it also allows occupants to control a variety of circuits themselves without leaving their seats. It can operate with any of the company's smart power strips, enabling the user to start or stop any device that is plugged into a controlled outlet. It can also be used to dim overhead fluorescent fixtures linked to an infrared controller.
ECO – HVAC Demand Control Ventilation

Suggestions:

1. In large conference rooms, auditoriums, and other large areas controlled by a dedicated HVAC system, install CO2 controls for Demand Control Ventilation.
2. Utilize Unitil incentives.

Notes:

From the Energy Advisor Website:

Occupancy fluctuations offer an opportunity for annual energy savings that can amount to as much as $1.00 per square foot (ft^2) annually. Instead of continuously ventilating the space at a constant rate designed to accommodate the maximum number of occupants, building operators can implement demand-controlled ventilation (DCV) so that the amount of outside air drawn in for ventilation depends on the building's actual occupancy at any given time. This strategy results in energy savings because it reduces the amount of air that needs to be conditioned as well as the fan energy used to move that air. DCV primarily refers to when actual occupancies are approximated by measuring carbon dioxide (CO2) levels within a building with sensors.

CO2 sensor technology has improved substantially in recent years, and prices have dropped dramatically. Although these sensors ranged in price from $500 to more than $800 in the mid-1990’s, some are now priced below $200, and several manufacturers offer CO2 sensors bundled with temperature and humidity or dew point sensors in the same housing, which further reduces total costs. In addition, technological developments have resulted in sensors that remain accurate far longer than their predecessors, substantially reducing sensor calibration costs.

CO2 sensors sold today use one of several types of self-calibration techniques to maintain the accuracy of their measurements, so they require calibration far less frequently than their predecessors did. As a result, several manufacturers now recommend that their sensors be calibrated no more often than once every 5 years, and two prominent manufacturers guarantee the calibration of their sensors over the devices’ anticipated 10- to 15-year lives. This contrasts starkly with earlier sensors, which required calibration every year—or even every few months. That high maintenance requirement was certainly labor-intensive, and it probably also resulted in periods of under- or over ventilation due to sensor inaccuracy.

Recommendations:
This guide will help you determine the number and placement of carbon dioxide (CO2) sensors that will be required to implement demand-controlled ventilation in any given facility.

<table>
<thead>
<tr>
<th>Building arrangement</th>
<th>One HVAC unit or system</th>
<th>Two or more HVAC units or systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single space, single zone Area less than 5,000 ft²</td>
<td>One sensor</td>
<td>One sensor per unit</td>
</tr>
<tr>
<td>Single space, single zone Area larger than 5,000 ft²</td>
<td>Quantity as required The area covered by each sensor should be less than 5,000 ft²</td>
<td>One sensor per unit Up to 5,000 ft² each</td>
</tr>
<tr>
<td>Multiple spaces, single zone Total area less than 5,000 ft²</td>
<td>One sensor Locate sensor in space that is most ventilation sensitive</td>
<td>One sensor per unit</td>
</tr>
<tr>
<td>Multiple spaces, single zone Total area larger than 5,000 ft²</td>
<td>One sensor per space</td>
<td>One sensor per unit</td>
</tr>
<tr>
<td>Multiple spaces, multiple zones</td>
<td>One sensor per zone</td>
<td>One sensor per zone</td>
</tr>
</tbody>
</table>

Note: ft² = square feet. 

Implementing DCV on a newer DCV-ready rooftop unit with an existing economizer will cost between $300 and $900 per rooftop unit. The lower end of this range would apply where installation amounts to no more than wiring the sensor into the existing rooftop unit terminals. Installation costs will rise to the higher end of this range when a digital controller is needed to interface with the rooftop unit.
ECO – HVAC2  Tankless Hot Water Heaters

Suggestions:

1. In all City applications as existing water heating devices fail, replace with tankless on demand hot water devices.
2. Utilize Unitil incentives.

Notes:

This ECO recommends the installation of gas fired tankless DHW units. Installing tankless water heaters would eliminate the need to keep the existing boiler hot water units “on” 24/7. These economical devices would easily handle the domestic hot water needs for all facilities. Tankless hot water heaters have no standby losses. A popular product, the Rinnai Continuum is up to 50 percent more energy efficient than a traditional natural gas water heater and up to 70 percent more efficient than an electric water heater.

These products utilize on-demand water heater technology which is more efficient because it only heats water when it is needed.

From the Energy Advisor network:

_Tankless water heaters, also known as instantaneous or on-demand water heaters, provide hot water without using a storage tank. Like tank water heaters, tankless water heaters use either gas or electricity to operate. Cold water travels through a pipe into the unit, and either a gas burner (see **Figure at right**) or an electric element heats the water. Tankless water heaters can be supplementary units placed at the point of use or can replace a centralized tank water heater._

_When a flow sensor detects cold water entering the unit’s heat exchanger, the fan provides combustion air and the controls fire the burner to indirectly heat the water. The controls adjust burner output in proportion to the amount of water flow to produce hot water at the setpoint temperature._
Tankless water heaters are very efficient because unlike conventional water heaters, they do not have standby losses incurred by continuous use of energy to maintain water in a tank to a set temperature. They are also space savers, which can be particularly useful for a small business or where a faucet or shower is some distance from the current water heater. Although they theoretically provide endless hot water, most tankless water heaters, especially electric units, provide it more slowly than conventional tank water heaters. This limits the number of sources that can draw hot water at one time.

**What Are the Options?**

Gas or electric. Choose a gas water heater whenever possible, because the cost of gas is approximately one-third that of electricity on a per-Btu basis. Gas tankless systems also have wider applications because they produce hot water at higher flow rates. An electric tankless system is an appropriate choice only when gas is not an option and no space is available for a tank hot water heater.

**Efficiency.** The term "energy factor" characterizes the efficiency of both tank and tankless water heaters. The energy factor is the portion of the energy going into the water heater that gets turned into usable hot water under average conditions. It takes into account heat loss through the walls of the tank, up the flue, and in combustion. The higher the energy factor, the more efficient the heater. Because tankless water heaters don't have the losses associated with tanks, their energy factors are normally higher (although well-insulated, ultra-efficient tank heaters also have high energy factors). Energy factors for gas tankless water heaters range from around 0.78 to 0.85, compared with 0.58 to 0.67 for a conventional gas tank and 0.86 for an ultra-efficient gas tank heater. Conventional electric tank water heaters have an energy factor of 0.90 to 0.95 compared to 0.99 for electric tankless water heaters.

**Standing pilot or electronic ignitions.** Gas tankless water heaters with standing pilot lights waste energy, but they can be cost-effective in applications where water use is high. Where water use is lower (as in a residence), use a tankless water heater with an electronic ignition.

**Energy inputs.** Electric heating element and gas requirements for tankless water heaters are much larger than for storage water heaters. A typical gas storage water heater has a gas input of 40,000 Btu per hour. A centralized gas tankless heater, though, will require
at least 160,000 Btu/h and so may require larger gas lines and vents than conventional water heaters. The switch to larger gas lines in a retrofit may make the installation cost-prohibitive if the unit is installed far from the gas meter. Similarly, although a typical residential electric storage water heater draws at most 7,000 watts, a centralized electric tankless heater can draw as much as 38,000 watts and may require upgraded copper wiring and possibly upgraded electrical service. Specifications for tankless water heaters also include requirements for minimum flow rates to activate them—usually around 1/2 to 3/4 gallons per minute (gpm), as well as minimum and maximum water pressure (usually 15 to 150 pounds per square inch).

How to Make the Best Choice

Pick the right size. The method for sizing tankless water heaters is different from that for storage water heating equipment. Choose an appropriate model based on peak demand, incoming water temperature, and desired outgoing water temperature. Most water heater purchases are centralized units, but in some cases a point-of-use unit is desirable to cut down on the waiting time for hot water when a sink is a long way from the main water heater. For point-of-use installations, an electric unit is the most likely choice because it doesn’t require venting. Centralized units that are advertised as “whole-house” will provide 2 to 4 gpm of hot water at a 75° Fahrenheit temperature rise. (See Table on previous page.) Choose the model of water heater closest to your flow rate and temperature rise needs.

Gas tankless water heaters can provide hot water at higher flow rates than electric tankless heaters. When choosing a tankless model, be sure that flow rates will meet your peak demand at the temperature rise you need.

To figure out your peak demand, list the number of devices you expect to draw hot water at one time, and add up their flow rates. This is the desired flow rate for the demand of water. For example, assume that you want a tankless water heater to operate a shower and two sinks at the same time. Assume your peak demand is 2.5 gpm for the shower and 0.75 gpm for each sink, for a total peak demand of 4 gpm.

Calculate cost-effectiveness. Gas tankless water heaters can be cost-effective, especially when used in high water-use applications and new construction where incremental installation costs are lower than retrofit applications. Because there are so many variables involved in calculating cost-effectiveness, it’s a good idea to do your own analysis.

Analysis of a hypothetical situation reveals that payback periods for tankless heaters are significantly longer in lower-water-use applications than in high-water-use applications. In the example shown in Table below, tankless water heaters have paybacks ranging
from approximately 8 to 25 years in low-water-use applications compared to approximately 2 to 6 years in high-water-use applications.

For a conventional 50-gallon residential-size gas tank unit, the installed cost is approximately $600. The incremental costs for an installed gas tankless unit differ depending on whether the unit is installed in a new building, replaces a failed unit in an existing building, or replaces operable equipment in a retrofit. The installation costs for replacements are typically much more expensive than for new construction, because frequently the gas line will need to be replaced due to the higher input capacity, the venting system will need to be replaced, and there will be electrical requirements as well that require hiring an electrician. In a retrofit application, where a tankless water heater is installed in place of an operational existing water heater, the economic calculation must account for the full cost of the new unit.

<table>
<thead>
<tr>
<th>Application</th>
<th>Energy factor</th>
<th>Incremental cost ($)</th>
<th>Average usage</th>
<th>High usage</th>
<th>At average usage</th>
<th>At high usage</th>
<th>Playback (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gas conventional water heater</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any application</td>
<td>0.58</td>
<td>NA</td>
<td>324</td>
<td>1,116</td>
<td>NA</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td><strong>Gas tankless water heater</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New construction</td>
<td>0.82</td>
<td>700</td>
<td>227</td>
<td>783</td>
<td>8</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Replacement upon failure</td>
<td>0.82</td>
<td>1,000–1,500</td>
<td>227</td>
<td>783</td>
<td>12–18</td>
<td>3–5</td>
<td></td>
</tr>
<tr>
<td>Retrofit</td>
<td>0.82</td>
<td>1,600–2,100</td>
<td>227</td>
<td>783</td>
<td>19–25</td>
<td>5–6</td>
<td></td>
</tr>
</tbody>
</table>

Notes: NA = not applicable
a. Average usage is considered to be 64.3 gallons/day, high usage is 260 gallons/day.
Assumption: Natural gas rate is $1.10/therm, water temperature rise is 77° Fahrenheit.

Tankless heaters become more attractive when replacement costs are considered, because tank water heaters must be replaced between 6 and 10 years and tankless heaters last about 20 years, according to manufacturers.

What's on the Horizon?

The next frontier for tankless water heaters is a condensing gas tankless unit. This unit will likely be somewhat larger than existing units because the improved efficiency comes from a larger, and therefore more effective, heat-exchange area. But it will also probably be easier to install due to a simple venting system consisting of a polyvinyl chloride (PVC) pipe that passes through the side of a building. One manufacturer so far has introduced such a product and it seems likely that more are on the way.
ECO – HVAC3  High Efficiency HVAC Equipment

Suggestions:

1. As existing HVAC equipment fails, replace with high efficiency units.
2. Install Dual Enthalpy controls on the economizers.

Notes:

From the Energy Advisor website:

Approximately half of all U.S. commercial floor space is cooled by self-contained, packaged air-conditioning units, most of which sit on rooftops. Also called unitary air conditioners or simply “packaged units,” these mass-produced machines include cooling equipment, air-handling fans, and sometimes gas or electric heating equipment. Rooftop units (RTUs) are available in sizes ranging from 1 ton to more than 100 tons of air-conditioning capacity (1 ton of cooling capacity will remove 12,000 Btu of heat per hour). Rooftop units are the workhorses of commercial air conditioning and are used widely in industrial facilities as well.

The three main power consumers in a rooftop unit—compressor, supply fan, and condenser fan—account for approximately 83, 10, and 7 percent, respectively, of the rooftop unit’s peak power. However, because supply fans are often used to provide ventilation even when the compressor is not in use, the compressor’s annual energy usage can be as low as 55 percent of the total energy use, with fans accounting for the remaining 45 percent.

How to Make the Best Choice:

1. Select the right size. An undersized unit won’t be able to provide sufficient cooling, but if a unit is oversized (the more frequent occurrence), it not only costs more but will lead to higher costs for associated ductwork and other auxiliaries. Operating costs increase too, because oversized equipment spends more time at less-efficient part-load conditions. Specifiers and designers commonly overestimate loads because they fail to take into account the reduced air-conditioning loads that result from energy-efficient lighting, and they overestimate plug loads by using nameplate ratings of office equipment in the building.

It is also critical to use diversity factors when calculating internal loads. For example, consider a school: Peak load for the classrooms occurs when the classrooms are full, peak for the auditorium happens during an assembly, and peak for a gym occurs during a
basketball game with the stands full. However, peak load for the school is not the sum of these loads, because they do not all occur simultaneously.

2. Consider high-efficiency levels recommended by CEE. The Consortium for Energy Efficiency (CEE) offers a program known as the High-Efficiency Commercial Air Conditioning & Heat Pumps Initiative. The initiative's goal is to encourage the use of high-efficiency unitary (single-packaged and split-system) central air-conditioning and heat pump equipment in commercial buildings. CEE currently suggests two efficiency levels for commercial equipment that are approximately 22 percent greater than the current federal standard. The CEE specification is promoted by participating utilities through education and rebate programs.

3. Energy Star is a joint program of the U.S. Environmental Protection Agency and the U.S. Department of Energy (DOE) that establishes an efficiency specification above the federal standards. Equipment that meets these specifications is awarded the Energy Star label, which helps consumers and others readily identify high-efficiency products. The current efficiency level for Energy Star was set in 2002 and is the same as that of the CEE.

4. Identify high-efficiency models. ARI is the main source of information about energy-efficient rooftop unit products. The organization maintains directories (available in both print and electronic formats) on its web site that include products from all ARI member-manufacturers.

5. Evaluate high-efficiency models by performing a cost-effectiveness calculation. The cost-effectiveness of a high-efficiency rooftop unit depends on several factors, including cooling loads, operating hours, and the local cost of electricity.

6. In addition, the Pacific Northwest National Laboratory offers a free life-cycle cost estimation tool that can be used to compare high-efficiency units with standard ones. This tool is more detailed and has the added benefit of displaying results graphically. Pay attention to design, commissioning, and maintenance. No matter what equipment you choose, it's also important to make sure that the overall system is designed to be efficient, that it is commissioned to operate as planned, and that it is properly maintained. A low-static-pressure duct system will reduce control problems, noise, and the fan power required. Comprehensive testing, adjusting, and balancing of the installed unit and its controls will maximize installed efficiency and comfort. Conducting regular tune-ups, correcting refrigerant charge, cleaning and adjusting the system to correct airflow and improve heat transfer, and repairing major duct leaks can yield surprising energy savings at low cost. CEE offers installation guidelines for commercial air-conditioning equipment.
Rooftop unit components, designed for energy efficiency:

The ideal packaged rooftop unit (pictured below) is designed to maximize energy efficiency. Some available systems are built just like this, but many are not, or they have some but not all of these energy features. The rooftop unit shown contains electric cooling and gas heating components.

Source: Platts
ECO – HVAC4 Programmable Setback Thermostats

Suggestions:

1. Install Programmable Setback Thermostats.
2. Utilize Unitil incentives.

Notes:

A setback or programmable thermostat automatically raises or lowers building set-point temperatures at preselected times. During the heating season, the temperature is lowered for unoccupied times such as evenings or weekends. The thermostat brings the building back to a comfortable temperature before anyone arrives the following workday. During the summer, the set-point temperature is raised for unoccupied times and lowered for working hours.

Automatic savings:

By automatically adjusting your building's temperatures, a setback thermostat can save an average of 5% off your annual heating and cooling bills. The cost of a setback thermostat may be recovered in energy savings in just one year. You could achieve the same savings by adjusting your thermostat manually, but a programmable thermostat does it automatically everyday. And everyone can arrive to a comfortable building in the morning and leave without worrying about wasting energy while the building is unoccupied.

Recommendations:

1. Many different models of setback thermostats are available, but all use a timing device and a heat sensor. The simplest type is a single-zone time clock which can control an entire building or just one area. For more flexibility, a multizone programmable thermostat can vary temperatures in different areas of a building at different times to suit the needs of the occupants.
2. The cost of a setback thermostat typically increases with the addition of optional features. However, you may want to consider purchasing a model that offers the following features:
3. A seven-day program that allows you to fine-tune your weekly schedule.
4. Battery backup to keep the timer on schedule in case power is interrupted.
5. An override function that lets you temporarily change the preselected program.
6. A locking device or cover to prevent unauthorized changes to the program.
7. Setback thermostats work best with forced-air heating and air-conditioning systems. You should consult with your contractor before installing one on infrared, heat pump or hot water heating systems.
ECO – HVAC5 NEMA Premium Efficiency Motors

1. Upon burnout, replace all electric motors with NEMA Premium Efficiency Motors.
2. Use Motor Master software to prepare plan of action. Software is free and can be found at: http://www1.eere.energy.gov/industry/bestpractices/software.html#mm

Notes:

From the Energy Advisor website:

Motors: AC Induction Motors

Some of the largest opportunities to save energy and reduce operating costs in buildings and industrial facilities come from optimizing electric motor systems. About half of all electricity consumed in the U.S. flows through motors, 90 percent of which are alternating-current (AC) induction motors. The U.S. Department of Energy (DOE) estimates that on average, the manufacturing sector could reduce industrial electric motor energy use 11 to 18 percent by using proven efficiency technologies and practices. In a single year, a motor often consumes energy worth about 10 times its initial cost. That's why even small improvements in efficiency can pay back quickly. The key is to choose the right-sized, energy-efficient motor and to integrate it into an optimized drivepower system.

What Are the Options?

The major choice facing motor specifiers is whether or not to select a motor that complies with an efficiency specification developed by the National Electrical Manufacturer's Association (NEMA)—known as NEMA Premium. To meet NEMA Premium specifications, a motor must exceed the minimum efficiency mandated by law (through the 1992 Energy Policy Act in the U.S. and the Canadian Standards Association’s 1995 Standard C-747) by between 0.4 and 3.0 percentage points, depending upon the size and type of motor.

In retrofit situations, users have the choice of repairing failed motors or replacing them. It is becoming common practice among energy-conscious companies to replace all failed, moderate-duty induction motors up to about 125 horsepower (hp) with new premium-efficiency models rather than repairing and rewinding the failed motor. This is because motor rewinds often degrade motor efficiency by 1 to 3 percent—or more, in some cases.

If hand calculations aren’t your cup of tea, consider using a computer program called MotorMaster+. It contains an extensive database of motors, including efficiency and price for each, which allows the user to easily compare the economics of different motor selections. For information on the MotorMaster+ motor selection software, contact Motor Challenge Information Clearinghouse, Olympia, WA, tel 800-862-2086, fax 206-586-8303.

For more detailed analyses, the DOE offers MotorMaster+, a free program that can help you perform a thorough economic analysis by drawing on its database of high-efficiency motors. The software can be downloaded, free of charge, or used online by going to the
**MotorMaster+ web site.** MotorMaster+ can create a list of motors that meet a user’s specific requirements, and it can be used to calculate the savings and simple payback period for premium-efficiency motors as compared with standard-efficiency units.

**Think systematically.** The full potential of an efficient motor can best be captured if it is integrated into an optimized drivepower system. This may be difficult to do in retrofit applications, but it is very important when designing new systems, for which all components can be right-sized from the start. Properly optimized motor systems often use less than half the energy of systems designed according to standard rules of thumb. To create an efficient drivepower system, select efficient, properly sized models of the equipment that the motor will drive, such as pumps and fans. (The DOE also offers a free Pump System Assessment Tool that can help industrial users assess the efficiency of their pumping system operations. For more information on sizing fans, see the Purchasing Advisor HVAC: Fans. Check to see that pressure drops in coils, heat exchangers, or other auxiliary devices are optimized for good life-cycle economics. Use efficient, properly aligned belts, cogged belts, or direct-drive connections between the motor and the equipment to minimize power loss through friction. Select the right controls to regulate motor and equipment operation.

**Buy the right size of motor.** Motors operate at their highest efficiency between about 60 percent and 100 percent of their full-rated load, dropping off sharply in efficiency below 50 percent loading (see Figure 3). About one-third of motors in the field are so oversized that they operate below 50 percent of rated load most of the time. Motors only operate at their peak efficiency if they are sized correctly for the load they drive. In addition to operating inefficiently, oversized motors carry a higher first cost than right-sized units. They can also contribute to reduced power factor, which increases loads on the building’s electrical systems.

Motor efficiency remains fairly flat between 100 percent and 50 percent of rated load and falls off sharply below 50 percent load. The yellow shading shows the range of standard-efficiency motors, which make up much of the existing and used motor stock but which are no longer manufactured in the U.S. because of federal motor-efficiency standards. The red shading shows the range of new energy-efficient motors manufactured today for sale in the U.S.
**Watch your speed.** When replacing an old motor with a new premium-efficiency model in fan and pump applications, make sure the new motor's full-load speed is the same as or slower than that of the old motor (making certain, of course, that it meets the minimum speed necessary for the application). The energy required by many fan and pump applications varies with the cube of the rotational speed of the fan or pump, so increasing its speed by only 10 percent can increase energy use by more than 33 percent. Therefore, putting in a premium-efficiency motor that rotates faster than the old standard-efficiency one may negate predicted energy savings. It may be necessary to adjust fan sheaves or pump impeller diameters to achieve the correct motor speed. The MotorMaster+ software can help you correctly allow for speed differences in calculating energy savings.

**Evaluate the cost-effectiveness of ASDs.** Adjustable-speed drives (ASDs) are electronic or mechanical devices that allow a motor designed for single-speed operation to drive a load at variable speeds. By controlling load speed so that it closely corresponds to varying load requirements, ASDs can reduce energy consumption—and in some cases, energy savings can exceed 50 percent. Variable-frequency drives—electronic ASDs that vary the voltage and frequency of the power provided to the motor—can also improve power factor and provide performance benefits such as soft-starting and overspeed capability. ASDs require a small amount of power to operate, so motors with an ASD consume more power at full load than single-speed motors. However, it takes very little time operating at part load to make up this difference. ASDs can be cost-effective in cases with average loadings as high as 90 percent, but an analysis should be performed for each individual case based on the time spent at part-load conditions and efficiency with and without the ASD.

**Account for the motor's impact on power factor.** Power factor is an indicator of how much of a power system's capacity is available for productive work. Low power factor is undesirable because it increases the load on a building's electrical system, and utilities sometimes charge customers a penalty for facilities with low power factor. Because power factor is lower when a motor is lightly loaded, be sure to choose the right-sized motor. You can also specify a motor with a high power factor, but such models sometimes have lower efficiency. The ultimate selection depends in part on whether a facility is subject to power factor penalty charges. A facility with a significant number of induction motors and a low power factor can solve the problem with premium-efficiency motors that are properly sized. If new motors are not an option, other power factor correction methods are available, including static capacitor banks, rotary condensers, and static and dynamic volt-ampere reactive (VAR) devices.
ECO – HVAC6  Infrared Heat

1. Upon burnout, replace all hot air blowers with gas fired Infrared Heat.
2. Utilize Unitil incentives.

Notes:

In many high bay areas, hot air blowers are used for heating. These, when working, are inefficient. A gas-fired, totally enclosed, IR tube would reduce energy consumption by 50% and actually provide heat in the intended area. A typical auto maintenance garage shown at right has replaced all blowers with IR heat. Case studies for IR heat can be found at the Gas Networks website:
http://www.gasnetworks.com/efficiency/applications.asp
ECO – HVAC7      Kitchen ECOs

1. Utilize Unitil incentives.

Notes:

Commercial kitchens are great places for energy conservation. The kitchens in all City buildings are no exception. The following are the recommended energy conservation measures.

Walk-in Freezer Economizer. Coolers and freezers run 24/7. Most of the time, the door is shut and the "chilled" air eventually stratifies. This results in the refrigeration system to run in an effort to mix the air. Economizers sense this layering effect, bypass the refrigeration system and simply run the fans, thus solving the problem at 1/6 the expense of running the refrigeration system.

From the Energy Advisor network:

In virtually all coolers and freezers, small or large, air is cooled by forced-circulation evaporators containing propeller fans powered by fractional-horsepower motors. Typically these fans run continuously, even though, on average, full airflow is only required about half of the time. In the most common applications (those that use single-phase power), motors for the fans are typically shaded-pole or permanent-split-capacitor types, both of which are very inefficient.

Inexpensive controllers are currently available that slow these fans when full-speed operation is unnecessary. They do this simply and inexpensively by taking advantage of a basic principle of motor operation: The lower the voltage applied to a motor, the less rotational force it produces. Reducing the operating speed also reduces the energy consumption of the fan. In addition, the motor produces less heat at slower speeds, which means that the compressor has less heat to remove from the refrigerated compartment. In field tests for controllers from one manufacturer, documented savings varied from 10 percent to 60 percent of overall refrigeration energy, and some users report paybacks as low as one year. Savings vary widely, however, as they are dependent primarily on duty cycle, evaporator motor power, and local utility rates.

Anecdotal evidence also suggests that product quality in walk-in coolers can be improved. Because less air is circulated when the fan speed is reduced, items such as flowers, produce, or meat do not dehydrate as much.

Options?

Evaporator fan controllers operate by cutting the voltage to the motor by almost 80 percent (from 110-115 volts to 20 volts in typical single-phase applications). This reduces the motor's speed—typically from about 1,600 to 400 rpm. The lower speed is considered the bare minimum required to provide defrosting and prevent air in the cooler from stratifying into layers of higher and lower temperature.
There are two manufacturers that produce evaporator fan controllers. One manufacturer, RS Services (formerly known as EnergyNSync Inc.) produces two models intended for walk-in coolers that use single-phase power evaporator fans: the ENS Fansaver 4000 and the ENS Fansaver 5000. These units reduce fan speed when they sense that the refrigerant has ceased to flow through the evaporator coil. Each can handle 10 amps of current, which is typically enough to control six fans on a single evaporator coil. The Fansaver 5000 also has a built-in datalogger that records time and power used in both low-speed and high-speed fan operation (Figure at left). A personal computer can be connected to the unit via a serial port to access this data.

The ENS Fansaver conserves energy by sensing refrigerant flow through walk-in cooler evaporators and reducing evaporator fan speeds when there is no flow.

The other manufacturer, Energy Control Equipment Inc., produces a controller called Frigitek that can be used in either coolers or walk-in freezers (Figure below). The Frigitek reduces fan speed in response to a signal from the thermostat to stop the flow of refrigerant. Though the Frigitek operates in a very similar way to the ENS Fansaver, its performance has not been independently verified. For single-phase power applications, it is available in configurations that can handle from 3.5 to 25.0 amps and from 115 to 480 volts (V). These units also have a field-adjustable low-speed setting to accommodate unique application requirements. For three-phase power applications, one available configuration uses a master control unit that can handle 480 V and motors of up to 20 horsepower. Additional power units are added for multiple evaporators.

For single-phase controllers, prices start at about $500. Three-phase applications are considerably more expensive, particularly if fans from multiple evaporators are to be controlled. Installation costs for single-phase units are typically about $100 per unit, but they will vary depending on the region, the number of fans controlled, and the installer. Check with manufacturers

How to Make the Best Choice

Controllers don’t work for every application, so you should give some consideration to several issues (Table below) before you decide to install one on a cooler.
Table 1: When to use an evaporator fan controller.

<table>
<thead>
<tr>
<th>Do use controller if . . .</th>
<th>Do not use controller if . . .</th>
</tr>
</thead>
<tbody>
<tr>
<td>The compressor does not run all the time, and</td>
<td>The compressor runs all the time, or</td>
</tr>
<tr>
<td>The evaporator fan runs at full speed all the time, and</td>
<td>The evaporator fan does not run at full speed all the time (for example, it turns off with the compressor or it switches between full speed and half speed), or</td>
</tr>
<tr>
<td>The evaporator fan motor in single-phase applications is of shaded-pole or permanent-split-capacitor design.</td>
<td>The evaporator fan motor in single-phase applications is any type other than shaded-pole or permanent-split-capacitor design.</td>
</tr>
</tbody>
</table>

Source: E Source

The cost-effectiveness of the controller must be evaluated on a cooler-by-cooler basis. For coolers with three-phase fans, which are typically found in warehouses or distribution centers, cost-effectiveness calculations can be complicated. They need to factor in the cost of installing conduit and wiring to reach multiple evaporator coils potentially spread across a large area, and the number of master control and power units needed will vary widely by application. But because single-phase applications don’t have these issues, and the controllers for single-phase fans and their installation are relatively inexpensive and usually highly cost-effective, evaluations for their cost-effectiveness need not be especially detailed or complicated. Both manufacturers offer tools to help evaluate the cost-effectiveness of the application of their products.

Melink Exhaust Systems.

Commercial kitchen exhaust hoods often run uncontrolled, consuming excessive amounts of energy while creating a negative pressure in the entire facility. Both of these issues can be remedied with a smoke sensing controller.

One brand, the Melink Intelli-Hood® controls are the new industry standard for commercial kitchen ventilation systems. Engineers, consultants and operators are specifying them on thousands of hoods for both new and existing stores.

Savings and Benefits

The Intelli-Hood® controls improve hood efficiency up to 50%. Typical annual operating savings are $1500-$3000 per hood, with a payback of 1-3 years. They also improve kitchen comfort, indoor air quality, and fire safety.

Simple to Use
To operate, the cook/chef presses the light and fan switch on the Keypad. The hood lights then turn on and the fans go to a preset minimum speed of 10-50%. When the cooking appliances are turned on, the fan speed increases based on exhaust air temperature. During actual cooking, the speed increases to 100% until smoke/vapor is removed.

**Fisher Water Nozzle Devices.**

From the Western Utility Energy Services Website:

A new weapon in the ongoing battle to conserve water offers substantial energy and water savings for a very low investment, and has the added benefit of helping small businesses control costs.

The low-flow, pre-rinse spray valve may be the magic bullet in water conservation. Restaurants and cafeteria kitchens use pre-rinse spray valves to rinse off dirty dishes before running them through a dishwasher. Standard spray valves or nozzles use more than three gallons of hot water per minute, plus the energy that goes into heating the water. Low-flow valves, by comparison, use only 1.6 gallons per minute.

Depending on the quantity purchased, a new spray valve costs between $30 and $50, about $5 more than a standard valve. Each low-flow valve saves more than 50,000 gallons of water annually, along with heating costs. Where natural gas is the heat source, the payback period for replacing a standard valve with a $50 low-flow valve is two months or less.
1. Utilize Unitil incentives.

**Notes:**

This ECM recommends the installation of controls on Vending Machines.

Utilizing a custom passive infrared sensor, a product known as “VendingMiser” powers down a vending machine when the area surrounding it is unoccupied and automatically repowers the vending machine when the area is reoccupied.

**From the Energy Advisor network:**

Refrigerated vending machines operate 24 hours per day, seven days a week. In addition to consuming 2,500 to 4,400 kilowatt-hours (kWh) of energy per year, they add to cooling loads in the spaces they occupy. At average electricity costs of about US$0.08/kWh, annual operating costs can range from $200 to $350.

New, efficient vending machines are available that can greatly reduce operating costs. Additionally, the use of timers or occupancy sensors can lead to big savings, because they allow the machines to turn on only when a customer is present or when the compressor must run to maintain the product at the desired temperature.

**Occupancy sensing.** At least one device now on the market uses a passive infrared occupancy sensor (PIR) to turn off the compressor and fluorescent lights in the vending machine when no one is around. In addition, a temperature sensor powers up the machine at appropriate intervals to keep the products cool enough.

**Figure 1: Vending machines controlled by occupancy sensors**

This soda machine sits between two others, each of which has its own occupancy sensor and controller. Sensors need to be mounted away from ceiling air ducts to prevent false triggering.
In typical operation, power is cut to the vending machine after the area has been vacant for 15 minutes. The device is designed so that a machine in a room that's around 70 degrees Fahrenheit will be shut down for up to two hours if no one walks by. At that point, the machine is turned back on to run a compressor cycle, after which it turns back off if the occupancy sensor still indicates that no one is in the area. When someone approaches, the sensor sends a signal to turn the lights and other electronic components back on, and the compressor runs a cooling cycle if needed.

The control logic ensures that after the machine is repowered, the compressor is allowed to run a complete cooling cycle before it is powered down again. A sensor also determines whether the compressor is running and prevents the machine from shutting down until the cycle has been completed. Both of these features ensure that a high-head-pressure start, which would strain the compressor, never occurs. An indicator light goes on if the compressor has been running for more than two hours—a signal that maintenance may be required.

Savings for vending machines equipped with these devices range from 24 to 76 percent, depending on usage patterns, occupancy in the area, and ambient conditions. Occupancy sensors can be most cost-effective when the machine is located in such a way that people trigger the sensor only when they want to purchase something.

Location. Vending machines located in cool and shaded areas tend to last longer, use less energy, and demand less power. Ambient conditions, such as high temperatures or direct solar gain, can make the compressor work harder to maintain the appropriate environment for snacks and beverages.

Improved lighting. A typical modern vending machine with a lighted front display panel uses two or three 4- or 5-foot high-output T12 fluorescent lamps powered by conventional magnetic ballasts, drawing as much as 180 watts of power. This continuous load consumes 1,580 kWh per year (for an annual total of $126 at 8¢ per kWh). The heat from the lights also increases the machine’s refrigeration load. Instead, look for or request machines that use low-temperature electronic ballasts paired with T8 lamps, which could reduce lamp power to about 80 watts. In addition, high-color-rendering T8s can significantly improve the appearance of the translucent front panel.

In one test, disconnecting a vending machine’s lights cut energy use by 35 percent. However, users’ attempts to get operators to disconnect the lights don’t always meet with success. Adding a simple timing mechanism to turn the lights off in the late evening is another option.

Energy Star appliances. Vending machines that comply with Energy Star specifications use efficient compressors, fan motors, and lighting systems and are up to 50 percent more efficient than standard models. In order to receive the Energy Star label, a vending machine must meet the energy consumption criteria set forth by the most current version of the specification and must incorporate software that can operate the vending machine.
in a low-power light state, low-power refrigeration state, or a whole-machine low-power state..

What to do?

Talk to your vendor. Whether you are in the middle of your contract or entering a new one, request Energy Star vending machines or the highest-efficiency models possible. These high-efficiency machines will reduce operating costs.

Focus on location. The parameter that has the greatest impact on energy savings is location: the higher the traffic, the lower the savings. For example, in one test, when occupancy sensors were added to a machine located in a busy hotel lobby, relatively low energy savings resulted—roughly 25 percent. Generally speaking, locations that are unoccupied during nights and on weekends present the best opportunities for savings, although some energy can be saved as long as the area is unoccupied for more than 15 minutes at a time. Teachers’ lounges, break rooms, office buildings, and school cafeterias are good potential sites for saving energy with occupant sensing.

The temperature of the space where the machine is located also affects energy consumption. Lower ambient temperatures typically increase energy savings.

Assess how often the compressor runs. Other factors that affect energy savings relate to how often the compressor needs to turn on to keep the products cool. If a room’s temperature is warmer than normal, the compressor will have to turn on more frequently. Likewise, if one machine has a product that is popular, that machine will be stocked with room-temperature products more often, causing the compressor to work harder to cool the product.

Because vending machines, like refrigerators, emit heat during operation, reducing "on" time will also reduce total air-conditioning loads when the vending machine is located in an air-conditioned space. It is unlikely, however, that occupancy sensing will reduce peak air-conditioning loads, as those loads generally correspond with peak occupancy rates.
Variable Speed Drives

1. Install VSDs on all pumps, motors, and other non-constantly turning devices.
2. Utilize Unitil incentives.

Notes:

A Variable Speed Drive will allow the motors and pumps to run at an optimum speed based on demand. All motors and pumps that do not need to operate at 100% load, 100% of the time should be equipped with a Variable Speed Drive.

Variable Speed drives (VSDs) allow induction-motor-driven loads such as pumps and fans to operate in speed ranges as wide as 10 to 300 percent of fixed speed. (They are also called variable-frequency drives, variable-speed drives, variable-frequency inverters, or frequency converters.) By controlling motor speed so that it finely corresponds to varying load requirements, VSD installations can increase energy efficiency (in some cases energy savings can exceed 50 percent), improve power factor and process precision, and afford other performance benefits such as soft starting and over speed capability. They also can eliminate the need for expensive and energy-wasting throttling mechanisms such as control valves and outlet dampers.

From the Energy Advisor website:

Motors: Adjustable-Speed Drives

Adjustable-speed drives (ASDs) allow induction-motor-driven loads such as fans and pumps to operate in speed ranges as wide as 10 to 300 percent of fixed speed. (They are also called variable-frequency drives, variable-speed drives, variable-frequency inverters, or frequency converters.) By controlling motor speed so that it finely corresponds to varying load requirements, ASD installations can increase energy efficiency (in some cases energy savings can exceed 50 percent), improve power factor and process precision, and afford other performance benefits such as soft starting and overspeed capability. They also can eliminate the need for expensive and energy-wasting throttling mechanisms such as control valves and outlet dampers.

Loads ideal for ASD application: The large majority of ASDs are installed on loads where torque increases with speed, including centrifugal pumps, fans, blowers, and most kinds of compressors.
**Loads requiring careful ASD application:** Constant-torque loads require the same torque regardless of speed. Examples are reciprocating compressors, positive-displacement pumps, conveyors, center winders, and drilling/milling machines. Although constant-torque loads are suitable for ASDs, operation of these loads at low rpm will be limited, and the ASD must be carefully sized to ensure adequate starting torque.

**Loads difficult for ASD application:** Loads in which torque decreases with speed usually involve very high inertia loads such as vehicular (for example, railway traction) drives or flywheel-loaded applications; it takes less torque to keep these loads turning than to accelerate them. Loads of this type are difficult, but not impossible, for ASD application. Custom-engineered solutions are often required to handle the extra heat generated in starting and stopping such loads.

**What Are the Options?**

There are several types of ASD, each with its own benefits and drawbacks. Many hybrid forms combine characteristics of two or more of the basic ASD types listed below:

- Current source inverter
- Voltage source inverter
- Load-commutated inverter
- Pulse-width modulated inverter
- Cycloconverter
- Vector control

Historically, the six-step voltage source drive has been the industry workhorse. However, mass production and pricing pressure have enabled the pulse-width modulated drive to become increasingly dominant, particularly for ASDs under 200 hp.

All ASDs have the same basic structure, which includes a rectifier, filter, and inverter. The rectifier converts three-phase AC line power to DC power. The components used in the rectifier are typically thyristors or diodes. The filter sits between the rectifier and inverter and provides harmonic and power ripple filter (using inductors or chokes) as well as power storage (using capacitors). These components work to smooth and regulate, respectively, the current and voltage supplied to the motor. The inverter portion typically consists of thyristors or transistors that are carefully controlled to sequence the proper voltage and current to the phase windings of the motor, depending on the speed and load required.

Present-day economics favor pulse-width modulated drives for applications under 200 hp, and, in most cases, these drives will provide excellent service. In both retrofit and new applications, the user should consider heating and cabling distance to make sure the supplier will guarantee long-term performance. Some applications may also use the older, but very reliable, six-step voltage-source inverter technology. Many thousands of
these drives are in service, and many companies still design and manufacture them for applications under 200 hp.

Larger systems may use current source, load-commutated, or cycloconverter type drives. Specifying and implementing larger systems usually will involve more detailed design, close technical support, and, in some cases, custom engineering.

How to Make the Best Choice

What motor/load systems would benefit from adjustable-speed operation? Consider the following factors when evaluating potential ASD applications:

**Output profile of the application.** In general, all loads with throttled output should be evaluated for ASD retrofit. To qualify as an economical ASD application, the output from a motor/load system must have significant operation at less than rated output, thus an output profile is a necessary tool for evaluation. The output profile documents the output required from the system, rather than motor loading. It involves charting the output from the motor/load system (downstream of any throttling valves) versus rated full-load output. If a 100-gallon-per-minute (gpm) pump is throttled to 30 gpm, this represents a 30 percent system loading. The motor in this case may actually be operating at about 70 percent of its full load, with the extra energy dissipated across the throttling valve. Adding an ASD so that the pump puts out exactly 30 gpm with no throttling will drop the motor’s load from 70 to about 4 percent, providing a dramatic savings in energy for exactly the same output. The average loading at which adding an ASD becomes economical will depend, as with other energy efficiency investment decisions, on the local cost of electricity, on how many hours the motor and driven equipment operate, and at what output. Most loads throttled continuously at 70 percent or less of rated output are good candidates for adjustable speed. Motor and load systems that deliver rated flow less than 40 percent of the time are also good variable-speed prospects, particularly if their average throughput over time is below 60 percent.

**Duty cycle of the motor.** In general, the longer a motor operates, the more attractive it becomes as an ASD retrofit candidate. A motor/load system operating for 6,000 hours per year with throttled output will be three times more attractive for ASD retrofit than the same motor operating 2,000 hours per year. To determine the duty cycle, the user must record how many hours the motor operates for a set time and then estimate the yearly operating hours. Some motors have "run meters" that will record the total number of hours. However, it is also important to note how the hours relate to the motor’s load. For example, in a pumping application, 130 hours of operation at 70 percent load wastes about the same amount of energy as only 100 hours throttled at 40 percent output. In general, the more throttled the output—and the longer the operation at throttled output—the more attractive the economics of an ASD retrofit.
**Motor choice.** For an increasing number of applications, alternative variable-speed technologies such as permanent-magnet or switched reluctance motors may offer benefits over an induction motor/ASD system. This is especially true for applications that require very high speeds or a large range of speeds, high torque at low speed, or four-quadrant (motor, brake, and generator) performance. Poorly selected or applied ASDs can increase, rather than decrease, energy bills. To avoid this problem, consider the following when specifying an ASD:

**Which motor to use.** Standard or energy efficient? Energy efficient motors have emerged as the preferred motor for ASD applications. In fact, most inverter-duty motors (designed especially for service with an ASD) sold today are based on the best energy efficient motor designs. In addition to having better efficiency at all speeds and loads and improved design and construction, energy efficient motors offer a number of advantages for ASD service, including better thermal management, wider speed ranges, and better insulation systems.

**No savings at full load.** ASDs provide dramatic energy savings by optimizing the motor/load system—not by improving the actual efficiency of the motor in isolation, as an energy efficient motor retrofit would (Figure 1). In fact, an induction motor/ASD system is about 4 to 6 percent less efficient at full load than an induction motor alone. A process that requires continuous full-load output from a motor/load system will require more energy with an ASD, not less. However, it takes relatively little operation at reduced load to save more energy than is lost at full load.

![Efficiency Graph](https://via.placeholder.com/150)

Source: E Source; Manufacturers' data
Harmonics and power factor. Although they can improve displacement power factor (DPF), modern ASDs also have an electrical disadvantage—they can create harmonics, which reduce real power factor (Table 1). (Real power factor includes harmonics and DPF.) For instance, while an ASD can improve DPF to close to 1.0, the harmonics generated by the ASD can cause the real power factor to decline to between 0.75 and 0.80. These harmonic currents (most often the fifth and seventh harmonics) tend to exacerbate resistance losses and can even negate the transformer capacity benefits of improved DPF.

<table>
<thead>
<tr>
<th></th>
<th>No ASD</th>
<th>With ASD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor size (hp)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Motor load</td>
<td>75%</td>
<td>75%</td>
</tr>
<tr>
<td>Motor duty</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>System displacement power factor</td>
<td>0.854</td>
<td>1.0</td>
</tr>
<tr>
<td>Resistive losses (kWh per year)</td>
<td>639</td>
<td>466</td>
</tr>
<tr>
<td>Cost of losses ($ per year at 6¢ per kWh)</td>
<td>$38</td>
<td>$28</td>
</tr>
<tr>
<td>Savings per year</td>
<td>—</td>
<td>$10</td>
</tr>
</tbody>
</table>

Note: This analysis assumes 100-hp motors fed by 100 feet of #00 conductors with a resistance of 0.00811 ohms per foot.

Source: E Source

To minimize harmonics problems, an increasing number of ASD manufacturers are packaging harmonics-mitigating equipment (such as line reactors or isolation transformers) with drives. These features can allow users to enjoy the full benefits of power factor improvement. In addition, this added equipment can significantly reduce the impact of ASD-generated harmonics on other electronic equipment—a benefit that should be especially attractive to value-conscious commercial and industrial users.

Problems at low speeds and light loads. Most induction motors currently in use can operate with modern ASDs through moderate speed ranges (around 30 to 100 percent speed). Sustained operation at low speeds and, in particular, high load at low speeds may require a special or larger drive and special measures to cool the motor. Induction motors will operate hotter with an ASD because of harmonics and other impurities in the electric power they provide to the motor and also as a result of the slower rotating speed of the motor’s integral cooling fans. This is usually not a problem at continuous speeds above about 40 percent or for brief periods of slow-speed operation. Prolonged operation at or below about 30 percent speed, especially when driving significant loads, can cause rapid and potentially damaging heat in motors not designed to accommodate this service. Selecting a drive that allows the user to set a minimum operating speed can deal with this problem. Additional cooling for the motor (such as external fans) may also be appropriate.
ASDs decrease starting torque. In ASD/motor systems, starting torque typically is determined not by the motor but by the drive—particularly how much electrical current it can deliver. For conventional ASD applications, the ASD/motor system will have a peak starting torque of about 130 percent of rated full-load torque—significantly less than what the motor could develop by itself. This level of starting torque is acceptable for most variable-speed loads, but some loads (especially constant-torque loads such as conveyors, escalators, augers, or reciprocating compressors) may require greater starting torque. To improve starting torque for these applications:

• **Specify an ASD with a higher horsepower rating.** Purchasing an ASD with a horsepower rating higher than that of the motor (for example, using a 100-hp drive with a 75-hp motor) enables higher starting torque. This is because starting torque in an ASD/motor system is limited by the current-handling capabilities of the drive’s power electronic components. The larger drive costs more, however, and care must be taken to specify protection levels that prevent the larger ASD from supplying too much current to the motor.

• **Use programmable ASD starting features.** High-quality ASDs have programmable features that can improve starting capability for ASD/motor systems. For instance, programming a gentle acceleration ramp causes the drive to slowly start a high-inertia load. Dwell, another configurable feature, causes the ASD to initially energize the motor, then wait a second or two to allow the motor’s magnetic fields to reach full strength before accelerating to higher speeds. Finally, configuring voltage boost so that the ASD provides higher-than-normal voltage to the motor at low speeds facilitates a more vigorous response.

**Motor damage from ASDs located too far from motor.** Pulse-width modulated (PWM) drives can cause significant damage to motors if the length of cable between the ASD and the motor exceeds 50 to 100 feet. (The number seems to differ by manufacturer.) Older motors with long cable runs may have shortened lives using PWM ASDs. Carefully watch motor lead lengths, consider buying an inverter-duty motor, or select an ASD system that will specifically guard against this hazard with inductive filters or other methods.

**Mechanical resonance frequencies.** As with any variable-speed system, it is important to determine any mechanical resonance frequencies and to program the ASD to avoid steady operation at those speeds. These resonance frequencies, common in large fans, gears, and belt-driven systems, can cause significant damage through vibration. Users can identify these frequencies by monitoring noise and vibration while instructing the ASD to gradually increase speed from low to high speed. When used as part of regular system maintenance, this technique can reveal weaknesses in bearings, fan or impeller unbalances, bent shafts, and other problems that may escape notice at constant speed.

**Motor-ASD compatibility.** To ensure that the ASD and motor are compatible, both motor and drive can be purchased from the same company, or the ASD may be designed and tested by the manufacturer for compatibility with another company’s line of motors. In either case, the user must carefully specify load, duty, and other critical system requirements.
**ECO – HVAC10  Phase out Oil Fired Equipment**

1. As oil fired boilers and water heaters approach the end of their life, replace with either gas–fired models or switch technology to ductless split system heat pumps.
2. Utilize Unitil incentives.

Notes:

As a generic policy, this report recommends the phase out of all oil fired equipment. Not only is the fuel (oil) expensive and subject to extreme price variability, the equipment that burns oil is not efficient by today’s standards.

**VERY IMPORTANT**: when converting from oil to gas, specify high efficiency equipment such as full condensing boilers. If you trade standard efficiency oil fired for standard efficiency gas fired, you will actually lose ground.
ECO – A1  Employ a Town Commissioning Agent

As surveys were being conducted, many examples of uncontrolled operation were viewed. Installed equipment was being operated with little or no knowledge of design intent or specifications. Training on new equipment has been limited. Personnel to focus upon efficient building operations are absent in some facilities. This method of facility energy management is not only energy wasteful but also uncomfortable for occupants.

This ECO recommends that the town hires a qualified full or part time individual (employee or contractor) to address these facility operation issues. This individual would not only commission the town facilities with the goal as underlined below in the DOE definition, but also:

1. Create (or purchase) and maintain a Town Operations and Maintenance System that would attend to all traditional O&M activities.
2. Establish a Preventative Maintenance practice wherein PMs are addressed in accordance with product specifications.
3. Standardize equipment throughout the town to reduce maintenance inventory and confusion.
4. Communicate with equipment vendors as far as learning how to operate and maintain installed equipment efficiently.
5. Act on behalf of the Town on new construction and renovation projects.
6. Establish baseline energy consumption data for all facilities and track usage going forward.
7. Establish energy goals and implementation plans to achieve these levels.
8. Work closely with Unitil to take full advantage of energy initiatives and incentives.
9. Study emerging technologies and alternative energy ideas for potential application.
10. Stay abreast of state energy programs, LEED and Advanced Building certifications, MTC grants, and other such programs.

This individual should start ASAP.
From the DOE website on Commissioning:

Building commissioning is the process of ensuring that building systems and equipment are designed, installed, tested, and capable of being operated and maintained according to the owner’s operational needs.

Building commissioning is a key part of designing and building high-performance buildings because it ensures that the money spent on controls, sensors, and equipment will be paid back over time through energy-efficient building operation. The investment in commissioning an energy-efficient building is a small part of the overall project, yet the paybacks can be large.

Commissioning can certify that a new building begins at optimal productivity and improves the likelihood that the building will maintain this level of performance.

Commissioning can restore an existing building to its designed productivity levels and can ensure that building renovations and equipment upgrades function as designed.

Commissioning activities start with the hiring of a commissioning authority or individual and continue from project development, after project completion, and continuously as buildings are utilized.
**ECO – A2 Building Operator Certification Training**

This report recommends sending facility operators to the next offering of the BOC.

The Building Operator Certification (BOC) is a nationally recognized training and certification program for building operators offering improved job skills and more comfortable, energy-efficient facilities. It addresses all facets of building O&M.

Note: Incentive may be available from Unitil

**ECO – A3 Infrared Survey of all Buildings**

All facilities appear to be in need of shell measures such as insulation, windows, and weatherization. The first step in this process is determining where the greatest heat loss takes place. This ECO recommends an Infrared survey of all facilities using town owned IR cameras.

What will an infrared scan show?

An IR scan will point out areas of heat loss, thus indicating where insulation and air sealing are required. In the IR shot shown at right, it is easy to see the extreme heat loss taking place from the basement wall. As a result of this imagery, the facility operator can insulate the basement wall and reduce the heat loss.

Incidentally, this effort would yield best results when it is very cold outside and the heat is on inside the facility or when it is hot outside and the air conditioning is at maximum.
ECO – A4  Energy Star Building Analysis

As demonstrated in this report for a sample of buildings, the US EPA offers a free benchmarking tool that compares energy usage in buildings. This report recommends benchmarking all City buildings.

ECO – A5  FEMP O&M Best Practices Guide

The FEMP O&M Best Practices Guide is a free resource that provides excellent direction on maintenance of all commercial facilities. This report recommends the printing and adoption of this guide for all City buildings.

This guide can be found at www.eere.energy.gov/femp/pdfs/omguide_complete.pdf
Currently, all facility operations and maintenance are directed by Town managers. This system is working very well however, two potential issues of concern loom on the horizon:

1. **Staff Turnover.** Retirements may be in the near future and as each key facility operator departs, so goes the wealth of knowledge needed to keep the various buildings running.

2. **The advancing age of the facilities.** Even the newest of the larger buildings are aging. As buildings age, the level of routine and preventative maintenance activity needs to steadily increase to keep pace with the rate of age-related breakdowns. For the purposes of this report, maintenance will be divided into three general categories: routine such as cleaning, preventative such as equipment tune ups, and unscheduled such as “stop what you’re doing and go replace the broken thermostat in Joe’s office.” If the routine and PM work does not increase with the age of the building, the frequency and severity of unscheduled maintenance will escalate. Should this occur, the maintenance staff will be forced to forego the vital PM activity in lieu of the demanding unscheduled work. The result of this condition sometimes referred to as “maintenance by fire fighting,” is facility systems decaying and failing at an increased rate. This of course is costly and wasteful.

This study recommends (at a minimum) the immediate purchase and data population of a Preventative Maintenance System.

If funding is available, the system could be part of a total facility system or Building Management System (BMS) which would handle:

- Work Order issuance, tracking, and management
- Preventative Maintenance
- Inventory Control
- Utility tracking and management
- Energy Management System
- Capital planning

Such a system, a BMS would provide complete control of all facilities and the multitude of building support functions contained within. This is expensive and in the future. While a BMS is in the future, the need is immediate for a Preventative Maintenance system. Without regular PM’s, the effectiveness and efficiency of the various chillers and boilers will begin to degrade immediately leading to expensive repairs and replacements in the near future.
One PM system to examine is produced by www.schooldude.com/. This easy to use system, originally designed for use by school building operators, has expanded to service all types of facilities, including municipal buildings. It has components connecting all major components of O&M and is recommended for consideration.

Typically, the major components of a PM system would contain features such as:

- **Maintenance work order issuance and tracking on a regular schedule.** Details of routine maintenance would be listed on daily work orders. Items such as cleaning, proper handling of potentially hazardous cleaning materials, checking operation of vent fans, replacing burn-out lamps and ballast, etc. would all be included in any PM system chosen.

- **Inventory verification and update in conjunction with the scheduling of work orders.** Updated parts, costs, and material lists would be added to and maintained on the PM system. Inventory would be maintained by automatically issuing reorder slips for items used.

- **Provides "reminder" services via coordination with existing calendars.** This generally operates off "run-time" set points which yield work orders for equipment after a given number of run hours. These set points are available from the equipment specifications and tracked by completed work orders.

- **Coordinates with existing maintenance/payroll/inventory control formats.** All PM systems connect to purchasing, accounting, and payroll.

- **Reminders to address steam traps, changing filters, and seasonal maintenance.** All PM systems have a module for seasonal work such as storm window maintenance, cooling and heating system "tune-ups and check-ups," filter changes, etc.

Benefits from a PM system would include:

- **Elimination of reliance upon one source of direction.**
- **Ease of tracking total PM costs by building component system.**
- **Extends the life of equipment and building assets.**
- **Improves building comfort.**
- **Reduces the O&M costs (vs not performing PM tasks).**
- **An excellent memory!**

It takes at least two full years to create a useful, populated data base of PMs for an O&M staff to utilize. The time to start is ASAP.