
Middleborough Town Hall



Functional / Energy Assessment and Preliminary Strategic Energy Plan

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EXECUTIVE SUMMARY

The Middleborough Town Hall has excellent opportunities to improve energy efficiency, while at the same time providing a more comfortable working environment for employees and the public. Gas used for space heating in the Town Hall is 3 to 5 times per square foot more than one would expect for a building of this type and use. In addition, electrical use is 20% higher in the summer than is accounted for by the equipment installed in the building. This energy analysis identifies the causes of the energy losses, suggests mechanisms to fix the problems, and could provide over \$11,000 per year in savings for this one building alone (Table 1). The repairs to the energy systems are not costly and would see a payback of one year or less, with continued savings every year.

Table 1: Opportunities for Energy Savings

Project	Cost	Annual Savings	Payback (years)
Setback temperature on second floor	\$4,000	\$3,900	1.0
Shut off backup circulator pump	\$0	\$1,300	instant
HVAC Air System Controls Measures	\$5,200	\$5,500	0.95
Re-calibrate controls, set-points, dampers			
Optimize ventilation rates			
Right-size VAV box airflow			
Seal leaks between ballroom and attic (without setback for 2 nd floor)	\$500	\$1,500	0.33
Seal leaks between ballroom and attic (in addition to setback for Second Floor)	See above	\$400	1.25

Energy saving opportunities are as follows:

- ❖ **Setback the temperature on the second floor.** It is unnecessary to heat the ballroom during the winter when it is not in use. The pipes can be protected from freezing by replacing the water with propylene glycol. The space will not be too cold because it will get some heat rising from the first floor.
- ❖ **Shut off the backup circulator pump for the heating system.** Running the extra pump increases pipe noise, increases pipe erosion, imbalances heat delivery to individual radiators, and uses an unnecessary 7,900 kWh of electricity per year.
- ❖ **Recalibrate controls.** Heating and cooling systems run continuously during the winter and summer, respectively. The system needs to be set up so that the heat is turned down and the air conditioning is turned off when the building is not in use. The bathroom exhaust fans, which exhaust a lot of air, also need to be shut off when the building is not occupied. The current HVAC and control systems are not easy for non-technical personnel to operate, therefore an employee with technical skills needs to be identified and trained to monitor the systems for proper operation.

- ❖ **Fix the return air and outside air dampers.** Because of the slipping dampers, excess outside air is brought into the building where it must be heated or cooled. In the winter, the cold air coming through the air return was found cascading over employees or in one case over the thermostat, leading to an overheated room.
- ❖ **Optimize Ventilation rates.** The building is usually lightly occupied and being old, it is not tightly sealed. The excess air currently brought in through the ventilation system must be heated or cooled and is not necessary for healthy indoor air quality.
- ❖ **Right-size VAV box air flow rates.** Too much air is flowing through the VAV boxes for the current occupancy level and use, leading to spaces that are seriously overcooled in the summer. This wastes energy and makes it uncomfortable for employees working in the building.
- ❖ **Seal air leaks between the ballroom and the attic.** The large opening between the ballroom and the attic leak a considerable amount of warm air into the attic where it is lost through the roof.

SITE OVERVIEW

2.1 Introduction

The town hall energy systems were reviewed on 8/25/09 by two members of the Middleborough Green Energy Committee and a representative of the Middleborough Gas and Electric. We toured the building, looked at mechanical and lighting systems, and interviewed occupants about system functionality throughout the year. We then inspected mechanical components and drawings/plans for the construction of the systems. A second site and systems inspection was performed in February 2010 by two members of the Middleborough Green Energy Committee to review system operations during the heating season.

2.2 Historical Energy Use

Figure 1 – 2009 Electricity

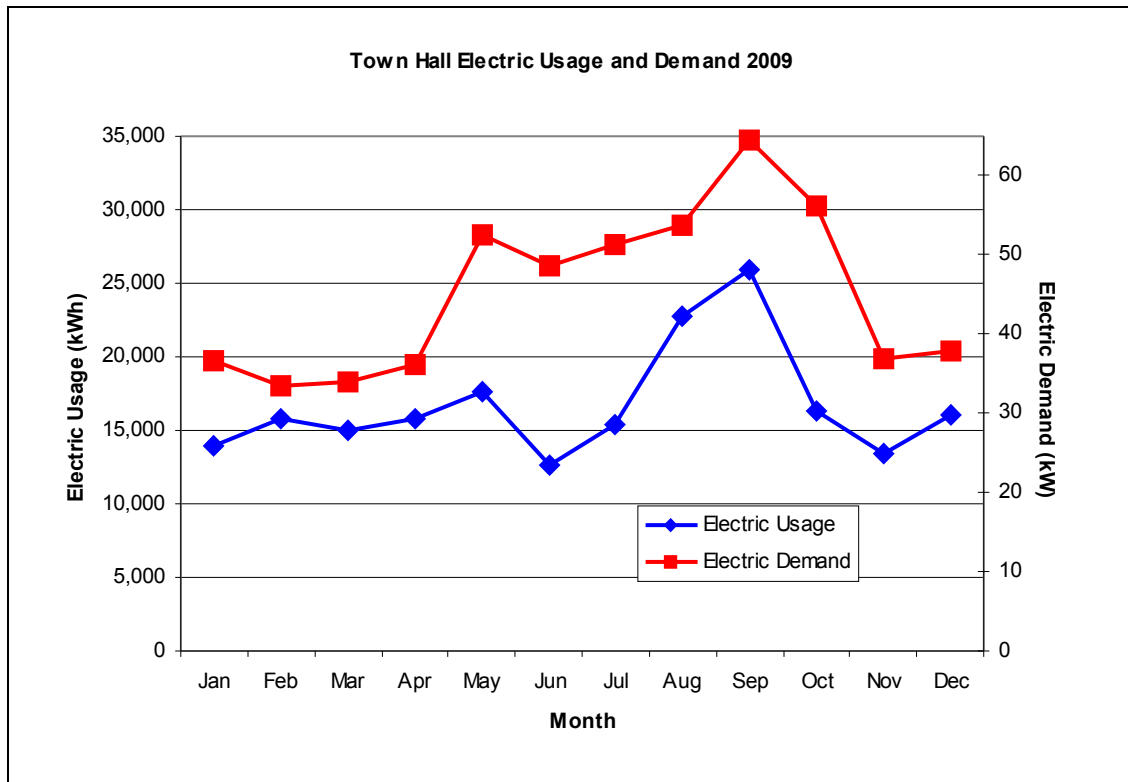
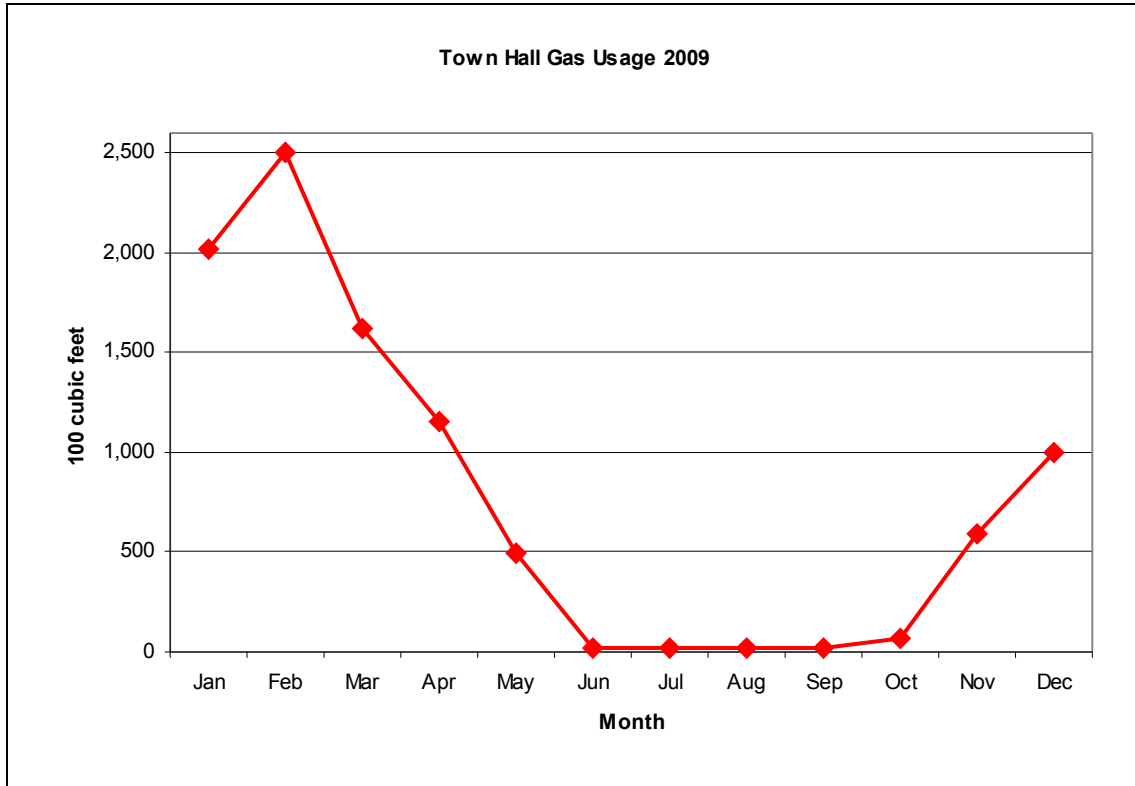


Figure 2 – 2009 Gas



The town hall building used 200,760 kWh of electricity in 2009 and had a peak demand of 64.5 kW during the month of August. Gas is used primarily for space heating during the winter and gas use was 9,827 therms for the year. The average electric cost was \$0.17/kWhr and the average gas cost was \$18.00 per MMBTU or \$1.80 per Therm. The preliminary analysis for the energy efficiency measures uses these rates.

We reviewed the electricity usage and billing history for the site and made the following observations:

- Gas use spikes heavily during the winter as one would suspect since the gas is used almost exclusively for space heating
- Gas use for space heating is between 3 to 5 times as much per square foot (approximately 475,000 BTU per gross building square foot) as one would expect for a

building of this type and use. If one excludes the ballroom, which purportedly is not heated, then gas use per square foot would compare even more unfavorably to commercial standards.

- The electric demand is consistent with the equipment installed in the building with the exception of a demand spike that was 20 percent higher in August or early September and another spike in September/October that was 7.5 percent higher than the typical summer demand for the building.
- It appears that lighting only uses 20-30,000 kWh per year and it is not clear where the other 170,000 kWh in electricity is going. The HVAC system fans should run approximately 800 hours per year, which would use 3,000 kWh. This leaves a large amount of electricity use that could only be accounted for if the building is cooled and ventilated continuously throughout the summer. This has been confirmed with several weekend and holiday visits during the summer.

2.3 Facility Description

The Town Hall is a two story building with a basement and was constructed in 1871. The facility underwent extensive renovations in 1999-2000. At that time, the facade was re-done, thermal glazing was installed in the historic windows, the electrical systems and lighting were upgraded, and central air conditioning and ventilation was added. The hot water finned-tube heating system had some minor modifications done at this time. The interior walls, ceilings, and floors were renovated or refurbished as well. The building has a total of approximately 14,000 square feet over two floors plus a full basement. The basement consists of storage and a large office/room for the IT department. The first floor houses town offices, the selectmen's meeting room, a small meeting room, a break room, and restrooms. The second floor is comprised of a large ballroom and a stage area. Typically there are 13 people working in the building on a regular basis. During business hours, 1-15 members of the public are in the building to conduct town business. At times, various rooms (especially the selectman's meeting room) can be heavily occupied for town meetings.

2.4 ENERGY SYSTEMS

2.4.1 LIGHTING

Offices are illuminated with T-8 linear fluorescent light fixtures. The halls have old style incandescent fixtures with hard-wired retrofit compact fluorescent lamps. The ballroom has a combination of metal halide downlights, chandeliers with incandescent lamps on dimmers, and wall sconces with fluorescent lamps.

2.4.2 Mechanical Systems

Cooling for the facility is provided by an air-cooled packaged chiller which is located outside in a mechanical systems pit along with the condensing unit for the IT room split cooling system and the backup generators. Heating for the first floor is provided by baseboard hot water radiators. HVAC for the IT room is provided by a stand-alone Liebert air handler that has direct expansion (DX) cooling. The second floor ballroom is heated only, with no mechanical cooling ducted to the space. The heating is provided by perimeter radiators, with hot water coming from the main boiler. The boiler provides hot water for the second floor radiators, for the re-heat coils in VAV boxes, to a pre-heat coil in the main air handler, and to the perimeter finned-tube heating radiators in the first floor offices.

Controls for the HVAC systems are independent for the ventilation/cooling system versus the perimeter radiator heating system. There is no communication between the two control systems and they can, therefore, fight each other if the boiler and air conditioner are both operational at the same time.

The first floor and parts of the basement are cooled and ventilated with air from the main air handler. This air handler feeds into a variable air volume (VAV) distribution system. A variable air volume system is meant to provide a small amount of air for cooling and ventilation when load in the space is low (i.e. low occupancy) and increase the airflows when loads in the space are high (i.e. high occupancy). There are re-heat coils in the VAV box that are intended to re-heat the air to maintain proper space temperature in case the minimum air flow settings are greater than the amount of air required for cooling the space at any given time. In this facility however, the boiler is turned off for the summer and from a combination of low loads and high airflow, the spaces get over-cooled. Since this system was designed with a minimum occupancy that is much greater than is realized, even the minimum airflow rates are almost always higher than are needed for cooling and the spaces get over-cooled. It appears that attempts have been made in the past to re-set the supply air temperatures at the air handler in order to prevent over-cooling of the spaces. This may help prevent some over-cooling, but it causes high relative humidity levels in the facility. High relative humidity causes a whole host of indoor air quality issues in addition to being uncomfortable from being “clammy”, and the high humidity increases the sensitivity to common odors (such as cleaners, smoke and “mustiness” of the facility and stored items).

The design of this system, combined with the high summer humidity, requires that the air handler provide air that is no warmer than 55 degrees to the VAV boxes. It is up to the VAV box controls (combined with hot water from the boiler), to vary the flow and reheat the air when required to maintain a comfortable space temperature for each space. This is a fairly energy intensive type of system if it is operated as designed. The apparent change in the operating strategy of shutting the boiler off during the summer, combined with the air flow rates being oversized for the present use of the space, leads to operations that significantly overcool the building or create high indoor humidity levels.

It is suspected that the controls for the VAV air system were never commissioned and as such never really functioned properly. In addition, it appears that service personnel (HVAC contractors) were brought in from time-to-time to do “repairs” to the system; however they were not familiar with the system design/equipment/controls and control troubleshooting/programming. As is typical with this type of attempted “fix”, they likely did

manual adjustments to VAV box dampers which further defeats the ability of the controls to operate the system as conditions change.

2.5 Additional Observations on the Mechanical Systems

Air side HVAC systems were set up for maximum occupancy levels in each of the spaces. Because there are no provisions for sensing occupancy (CO2 based ventilation control) the system provides enough ventilation and cooling capacity for 2-10 times the typical occupancy level of the spaces. This excess ventilation is both costly and creates a dysfunctional system operation as the system typically overcools the spaces. In addition, since the heating system controls and cooling system controls are separate and do not communicate, one system can be trying to cool the space while the other system tries to heat it, resulting in a huge waste of energy.

Also observed during the site inspections both during the summer and winter was that the air control dampers on the air-handling unit were loose on the shaft/linkages. In the summer, this resulted in a large excess of outside air being brought into the air-handling unit, where it was cooled and passed into the building. Apparently, the exhaust/relief dampers were closed and the building was being slightly pressurized. This was confirmed for both the basement at the rear entry door and for the main level doors when they were open. When the doors were closed, this excess air found its way up the lobby/stairs and into the ballroom area which was incredibly cool for a space with no cooling system. During the winter, the natural stack-effect of the building (warm air in a building tries to rise and leak out the top and cool air comes in at the lower levels), combined with the incredibly leaky ceiling in the ballroom and stage areas, was causing cold air to be drawn in though the air handler (even though it was off), where it entered the spaces through the return air path. This air was cold and it tended to dump into ceiling plenums and out through the return air grills. In the selectman's room the return air grill for the ventilation system happens to be above the thermostat. The cold air entered the room and cascaded down the wall over the heating system thermostat. Since the cold air was hitting the heating system thermostat, the perimeter baseboard heat was on at full capacity and most of the room (except for a small area directly around the door and thermostat) was over 80 degrees.

It was mentioned by staff that the ballroom was not heated during the winter; however there are no provisions for control of the heating system or provisions for freeze prevention for the radiators in the ballroom. In addition, a visit in February of 2010 revealed that the ballroom was indeed being heated.

The following is a more detailed description of the proposed system modifications and repairs that could be implemented to save energy, reduce operating costs, and make the building more comfortable for employees.

RECOMMENDATIONS FOR OPERATIONAL AND EFFICIENCY IMPROVEMENTS

3.1 Plug Loads and Office Equipment

During the course of the audit visits and at other times when in the Town Hall, informal surveys of the various office equipment showed that most of the equipment was either turned off or was in a “sleep” or low power mode. Notable exceptions to this were the copy machines/printers. Nearly all computers, networked printers, and networked printer/copiers have low power modes that can be automatically programmed on internal timers or when the device has not been used for a set period of time. The low power mode can be set to automatically re-start when a print job is sent to it or when someone makes a copy. Some of the more advanced networked copier/printers have more than one level of low power mode that can “awaken” the device at faster or slower rates.

3.2 Lighting Systems

Since the bulk of the lighting systems that are used frequently already use compact fluorescent and fairly efficient T-8 lighting technologies, there is not much that can or should be done with regards to further upgrades for efficiency. The incandescent lamps on dimmers in the chandeliers for the ballroom are used infrequently and as such, the newer cold-cathode dimmable fluorescent or LED technologies would have a very long payback and are not recommended at this time. For the most part, it appears that the local control (wall switches) for the lighting are properly located and used, thus no motion sensor-based switching technologies are recommended at this time.

3.3 HVAC - Heating Systems

3.3.1 Setback Temperature on the Second Floor

Site personnel indicated that the ballroom was not heated in the winter. Inspections of the heating system and controls showed no active setback controls or freeze protection control for the radiators. During the site inspections in February and March, the ballroom heat was indeed operating and the ballroom and stage area were comfortable even though there are significant

air leaks above the ballroom in the ceiling of the stage area, and the chandelier cupolas leak a significant amount of heated air into the attic of the building.

A few approaches can be taken to minimize the heating of the ballroom and stage areas during the winter while minimizing the risk of freezing any radiators or pipes. One option is to use controls and sensors at select locations on the piping and radiators of the ballroom to monitor for low temperatures and run the heat to stay well above freezing. A second option would be to add a circulator to the piping for the second floor to create a tertiary loop and monitor the return water temperature at this one location. This temperature would be used to control the amount of hot boiler water that is injected into the tertiary loop to minimize the heating further than method one above. A third option would be to replace the water in the boiler/heating loop with a propylene glycol and water solution to prevent the piping from freezing down to a temperature of 10 degrees Fahrenheit. This method would reduce the energy use by the largest amount. The ballroom will still not be extremely cold as most of the heat loss from the first floor will be through the ceiling and up into the ballroom.

Another area of significant heat loss was the Janitor off of the lobby area by Nickerson Avenue. This room was significantly over-heated (approaching sauna temperatures) due to a control problem with the system. According to the custodian, this has been this way since he was working in the building.

3.3.1.1 Savings Analysis

Based on the above information and additional assumptions on heat loss rate increase through the first floor ceiling to a colder third floor, method 3 above (freeze protecting the piping with propylene glycol) could reduce the building gas use by approximately 2,200 therms per year which is worth \$3,900 per year. This represents approximately 23 percent of the gas cost for the facility. Using one of the first two methods discussed above would likely save between \$2,000 and \$3,000 per year depending on how aggressive the setback temperature is or how successful the monitoring locations chosen work.

3.3.1.2 Implementation

Control strategy for freeze protection: not recommended given that town buildings do not have a high success rate in maintaining control functionality

Propylene glycol: approximately \$5.00 net per gallon at a 30/70 percent solution (protection down to 7 degrees F) Assume roughly 500 gallons, for a total cost of \$2,500.

Controls: Additional work needs to be done on the faulty controls for the heating system to allow setback in the ballroom and prevent overheating in locations such as the janitor's office. Repair and setup of the heating controls is estimated to cost \$1,500.

3.3.2 Circulator pumps

Although the heating system has two circulator pumps, one primary and one backup, we found that both pumps were running simultaneously. The consequences of running both pumps at once include pipe noise, pipe erosion, imbalanced heat delivery to the individual radiators, and extra electric use (5 hp ~ 3.0 Bhp). The estimated electric use for 3000 hrs/yr is approximately 7,900 kWh. This amount of electricity is worth approximately \$1,300 per year.

3.3.2.1 Implementation

Simply shut off the second pump, and if desired, modify the controls so that the second pump starts automatically if the first pump stops for some reason.

3.4 HVAC - Air Side Systems

3.4.1 Repair, Re-calibrate, and Re-set schedules for HVAC control System

Based on the historical electrical use, it was suspected that the HVAC cooling system runs continuously during the summer months. Numerous inspections of the facility during the evenings and weekends in late summer in 2009 and late spring/early summer 2010 proved that this is indeed the case. The system needs to be set up so that the controls will properly start and stop the air conditioning system in the proper sequence. Then town personnel need to be trained to monitor the cooling system for proper operation and alert service personnel if the system is outside program parameters.

On 8/25/09, it was noticed that cool air was going up the stairs, and the ballroom, which has no cooling, was relatively cool. Cool air does not typically rise. Return air and outside air damper linkages on the main air handler were slipping, and the dampers were not in calibration with each other, nor were they necessarily open or closed when they were supposed to be. It was observed that because of the slippage in the dampers, excess outside air was being brought in, thus increasing the load on the air handler for no useful reason, and this excess air was being pushed up into the ballroom.

A winter visit in February 2010 confirmed that there were problems with the dampers because in the winter cold air was cascading out of some of the HVAC return grills. This creates a very

uncomfortable situation for people working in the vicinity of these grills, and in one case, the air was flowing over the thermostat in the selectman's meeting room, causing the perimeter baseboard heat to overheat the room. With these dampers not secured, and with the leaky as ceiling in the ballroom, a considerable amount of warm air escapes through to the attic and out of the building, with cold air replacing it at the lower level through the un-secured HVAC system.

The driving force of this air moving through the building in the winter is due to the density difference between the inside air and the outside air caused by the difference in temperature. With the building as leaky as it is above the ballroom, combined with dampers that are open (also door & window cracks, open doors etc.), the air can move into the building, warm up, and then exit the top of the building. The nature of the "stack effect" is such that as it gets colder outside the density differences get larger, which drives even more air through the building. The control linkages on the main air handler need to be tightened and calibrated by a qualified HVAC technician who is familiar with this type and brand of control system and can perform the necessary repairs and operational checks to ensure the system is operating as required for functionality and efficiency.

Because the Town Hall is typically very lightly occupied for its size, coupled with the fact that the building is not very tight and the building is fitted with user-operable windows, it is recommended that the air-side HVAC system (air handler) be set up to not actively bring in extra outside air for ventilation except for periods when there is heavy occupancy (Selectman's meetings) or when outside air can be directly used for cooling the building (without using the chiller) for an air-side economizer cycle.

In addition to scheduling the main HVAC system to turn on and off, the central bathroom exhaust system needs to be operated on a similar schedule. It was confirmed that the bathroom exhaust system does operate continuously even when there are no occupants in the building nights and weekends. There are they four bathrooms and a total of 1600 cfm of exhaust (a lot). We confirmed that the fans run continuously; they should be shut off when the building is not occupied.

3.4.1.1 Savings Analysis

Scheduling the operation of the HVAC system to coincide with expected building occupancy will require that the system be used no more than 13 hours per day for 5 days per week (65 hours) and be off for the remaining time (103 hours). Shutting off the main air handler when the building is unoccupied would save approximately 14,000 kWh annually. This amount of energy is worth \$2,400 per year.

For the loose HVAC damper/linkage problem, It is very difficult to estimate exactly how much extra air is being brought into the building under differing operating modes since there appears to be a “warm up” mode in the controls that may or may not move the dampers at all (a warm-up mode would close the outside air dampers before normal occupancy to reduce the active ventilation load on the system when warming up or cooling down the building before the normal occupancy of the building). Also, for the heating season, when the air handler is turned off, the amount of air passing through the open dampers and up through the building through the “stack-effect” of the building changes with both outside and inside temperature swings.

Savings for repairing and recalibrating the damper linkages will be based on reducing the amount of outside air going through the building that would have to be cooled or heated. Savings for heating was calculated using an 8760-hour spreadsheet analysis tool using a building balance point of 63 F outdoor temperature, TMY (typical meteorological year) weather data, and an average of 400 cfm of excess ventilation (approximately 4 percent of the air handler design flow). The extra heating lost due to this leakage is approximately 78 million BTU which takes approximately 975 therms of gas using an 80 percent efficient boiler. This much gas costs the town \$1,750 per year. This does not include the effect of overheating the selectman’s room due to the cold air cascading over the thermostat nor does it include the electricity used for space heaters that people use under their desks to counteract the cold air entering the ceiling plenum (return air path) and cascading out of the ceiling return air registers.

Savings for cooling energy were calculated using an 8760-hour spreadsheet analysis tool only accounting for system operation between 6:00 a.m. and 7:00 p.m. weekdays (assuming that the controls are fixed and re-programmed to run only when the building is scheduled to be occupied). The analysis used a balance point of 68 F drybulb outdoor temperature to account for some of the moisture removal requirements of warmer humid air and some fan energy. The extra ventilation due to the slipped damper actuator linkages above the design levels is approximately 38 million BTU’s of cooling or 3,200 ton-hours of cooling. With an air-cooled chiller efficiency of approximately 1.4 kWh per ton-hour delivered, this cooling energy requires 4,500 kWh which is worth \$750 per year.

The total savings from fixing and recalibrating the dampers and linkages for both heating and cooling is \$2,500 (\$1,750 + \$750) per year. When combining the savings from scheduling the HVAC system off during unoccupied hours with the savings from the damper linkage problems, the overall savings becomes \$4,900 per year (\$2,500 + \$2,400). There may be some additional savings during the winter as some people use small electric space heaters to counteract the cold drafts from the HVAC system leaking cold air due to the loose damper linkages. As

mentioned earlier, these loose damper linkages contribute to significant comfort issues during the winter.

3.4.1.2 Implementation

Implementation of this portion of the controls measure requires a repair and re-calibration of the damper actuators, linkages, and a final check of the controls for proper sequence and operation. These minor repairs and checks/calibrations should be able to be performed by a qualified technician (one who is familiar with this type and brand of control system) within a 4 to 8 hour period and thus should cost less than \$1,200 for minor parts and labor.

3.4.2 Optimize ventilation rates to reflect actual occupancy

Since the building is lightly occupied most of the time and the building is not very tight, there is little need to use the building cooling system to provide ventilation in excess of the natural leakage of the facility. The only exception to this is when there is a heavily attended selectman's meeting. For these events, there can be a control override to bring in more outside air if desired. Typical moderate density office occupancy levels are between 100 to 150 square feet per person. As a comparison, this facility typically has 13 people occupying approximately 8,000 square feet of space or over 600 square feet per person.

The air handler should be set up to provide no more than 700 cfm of outside air with no local/general exhaust at the air handler. Most of this extra makeup air will be exhausted through the toilet exhaust system with a small remainder to keep the building from developing a negative pressure. Even this amount of ventilation will accommodate a building occupancy of 45 people with no credit taken for any of the ventilation provided by the natural leakage of the building.

3.4.2.1 Savings Analysis

Savings for cooling and fan energy was calculated using an 8760-hour spreadsheet analysis tool only accounting for system operation between 6:00 a.m. and 5:00 p.m. weekdays. The analysis used a balance point of 68 F drybulb outdoor temperature to account for some of the moisture removal requirements of warmer humid air and some fan energy. The extra ventilation (this does not including the grossly excessive ventilation due to the slipped damper actuator linkages) above the design levels (based on a much higher building occupancy level) is approximately 30 million BTU's of cooling or 2,500 ton-hours of cooling. With an air-cooled chiller efficiency of approximately 1.4 kWh per ton-hour, this cooling energy requires 3,500 kWh which is worth \$600 per year.

3.4.2.2 Implementation

Implementation of this measure requires a re-balance of the toilet exhaust system as well as setting the minimum intake air for typical occupancy at the 700 cfm level. The setting of the air handler outside air flow at this level will take no more effort than setting the damper as required after fixing the loose linkages as part of the repair measure above.

3.4.3 Right-size VAV Box Air Flow for Current Space Use

In cooling mode, when air enters a room from the HVAC system, it passes through several diffusers that are designed to diffuse the cold air into the room air evenly to ensure proper mixing. If the airflow through the diffusers is too high, it is noisy. If they flow rate is too low, the air does not mix, it instead falls like a waterfall onto the employee who happens to sit underneath or near the diffuser. The cold air also pools at the floor and does not mix properly with the room air.

To improve the functionality and the efficiency of the town hall cooling and ventilation system, the air flows need to be “right-sized” for the current minimum and maximum occupancies of each space. This would entail re-programming and rebalancing the diffusers, replacing or blocking off some of the diffusers to keep the air-flow rates between the minimum and maximum recommended levels for that size and style of diffuser. The system also needs to be checked to make sure that the controls and VAV box work properly together and vary the damper position, flows, and re-heat coil control valve position.

A second phase of “right-sizing” the system could be undertaken to further reduce energy use and maintenance for the facility. The second phase would be to add ductwork and an additional VAV Box to provide cooling for the IT Room and shut down (and mothball) the extremely oversized Liebert cooling system that is dedicated to the IT room.

3.4.3.1 Scope of Work & modification details

The chiller has 4 levels of capacity control with the 4 compressors. Check to make sure the lower settings do not end up short cycling the compressors. If necessary, the operating deadband for the start/stop of compressors can be widened (the deadband is typically from 42 to 44 degrees; a wider deadband can be from 41 to 46 degrees).

VAV box settings & balance for diffusers:

VAV Box	Area Served	Orig. Min/Max	New Min/Max	Notes & Details

V-1	Assessor's Office	250/825	150/600	Rebalance diffuser for back office to lower cfm setting.
V-2	Assessor's Office	230/780	200/500	
V-3	Selectman's Room	540/1800	450/1800	
V-4	Administrative Office	360/1200	200/800	Block off ducts to 2 diffusers in interior of room and move remaining 2 diffusers approximately 4 feet further from outside wall
V-5	Town Manager	200/670	150/500	Block off duct to wall register SR-1 near interior of room
V-6	Stairs/Entry Nickerson	270/900	250/800	
V-7	Meeting Room	240/810	140/580	
V-8	Lavatories	320/1070	250/800	
V-9	Front Stairs	180/600	120/500	
V-10	Basement	750/2500	750/2500	Reduce balance on EF2 from 1600 cfm to 600 cfm

- Notes 1) provide additional programming to allow box to fully close if minimum flow setting still over shoots setpoint a.k.a. "Shutoff VAV"
- 2) Rebalance diffusers at same ratio as above new flow settings with exception of areas where diffusers are to be "blocked off"

3.4.3.2 Savings Analysis

The primary benefits from this measure is to be able to deliver drier air to the spaces during the summer, while at the same time preventing overcooling of the spaces. The drier air delivery will help prevent the high humidity conditions that are conducive to mold and mildew growth. The energy savings from this component will be from a reduced airflow and reduced overcooling of the spaces and has been factored into the savings analysis for the previous measure.

3.4.3.3 Implementation

To re-check (and repair as necessary) the VAV box controls, re-balance the minimum and maximum flows, and block off selected diffusers, should take a two-person team of qualified technicians less than two days to complete. Depending on how many parts are required for repair, the cost to perform the above scope of work should be less than \$4,000 for an overall HVAC control system repair/recalibrate//optimize cost of approximately \$5,200.

3.5 Building Envelope

3.5.1 Seal air leaks between Ballroom and attic

There are a significant number of sizable openings above the ballroom and stage area into the attic. These openings leak a considerable amount of warm air into the attic where it is then lost through the roof. See pictures below:



Vents above Chandeliers

The picture below shows one of the numerous holes through the original lath and plaster ceiling as well as a chase for some sort of stage curtain/prop or line access that is both open and missing some trim that would provide a better air-seal around the chase.





These openings, combined with a heated second floor, contribute to the excessive heat loss and heating energy used for the town hall. Even if the measure for setting back the heat for the ballroom was implemented, the savings from sealing these large gaps would be worthwhile.

3.5.1.1 Savings Analysis

For the ballroom heated as it presently is, the savings from sealing up these large leaks would be approximately \$1,500 per year. If the measure to freeze-protect the boiler water system is implemented, the savings would be approximately \$400 per year, on top of the \$2-3,000 savings from turning off the heating in the ballroom when not in use.

3.5.1.2 Implementation

Implementation of this measure can be done in a very basic fashion or as a major repair/renovation to the ceiling in the stage area. The very basic fashion for patching the holes consists of using approximately 25 square feet of 6-mil plastic film, a staple gun, approximately 6 to 8 cans of expanding foam insulation, and a few hours of labor. Sealing the cupolas above

the chandeliers could be as simple as removing the nails someone installed to keep the sliding door on the top of the cupola open and shutting the sliding doors, or it could consist of fabricating new operable covers with better seals – the main thing is to get the big openings closed off.

Sealing these leaks and closing off these openings in a very basic fashion will cost less than \$500 to implement. Of course, if it were desired to renovate the ceiling or to fabricate new cupola covers, the cost would be considerably higher.