Energy Technical Assistance & Planning
For New Hampshire Communities
Funded by the ARRA Energy Efficiency Conservation Block Grant

**TO:** **Burton Reynolds, New Boston, New Hampshire**

**FROM:** **Steven Weisman, Peregrine Energy Group, Inc., and Henry Harvey, P.E.**

**DATE:** **April 29, 2011**

**RE:** **Energy Efficiency Improvements for New Boston Town Buildings**

Peregrine Energy Group toured the New Boston municipal facilities on March 30, 2011. We met with Burton Reynolds, Town Administrator for New Boston. Also present was Jillian Harris, planner with New Hampshire's Southern Regional Planning Commission.

The purpose of the visit was to provide an initial high level energy assessment of town buildings. This work has been funded by the New Hampshire Office of Energy and Planning's Energy Technical Assistance and Planning program ("ETAP") to address the town's interests and needs with respect to energy efficiency improvement and capital upgrades. This memorandum summarizes our initial observations and recommendations.

We find that the energy consumption index of the Town's buildings in Btu per square foot of floor area is typical of other municipal facilities in the state. That being said, these buildings generally have ample opportunity to save energy cost-effectively.

In general, we suggest that energy upgrades be incorporated into master planning and major renovations of all the town facilities. The budgets for these energy improvements are often more easily secured in the context of approvals for larger expenditures, particularly when they can be bonded.

## Energy Use

Electricity is supplied by the Public Service Company of New Hampshire at a recent average cost of 15¢ per kiloWatt-hour. Number 2 heating oil is delivered by local suppliers. The oil cost has been $2.29 per gallon recently. See Table 1 below.

**Table 1 – 2009-2011 Annual Utility Use and Energy Density**

| Building | Square feet | Electricity (kWh) | Oil Use (gallons) | Total Annual Utility Cost | Electric kBtu/SF(1) | Oil kBtu/SF | Total kBtu/SF |
|---|---|---|---|---|---|---|---|
| Town Hall | 6,720 | 41,052 | 2,878 | $12,892 | 21 | 60 | 81 |
| Wason | 2,958 | 4,687 | 2,122 | $4,859 | 5 | 100 | 105 |
| Central Fire | 5,728 | no data | 2,069 | $4,859 | | 50 | 50 |

[1] Thousand Btu per square foot of gross floor area. ENERGYSTAR reports that values can range from 30 kBtu/Sf to 340 kBtu/SF.

The energy use indices for the Town Hall are based on the area of the main office floor, and the second floor, which is largely unoccupied. It does not include the dirt-floored basement. The Town Hall is in the mid range for the municipal office buildings we have looked at in New Hampshire, but this still indicates a building with substantial opportunity to be more efficient. The Wason building has a remarkably high oil use, probably due to the compromised thermal envelope discussed below. The oil usage is the average of the 2008-09 and 2009-10 heating seasons. If the building was used as a library during that period, then usage may drop now that it has been converted to the historical society. The Fire Station has high but not unusual oil use.

## Town Hall

The New Boston Town Hall is a former meeting house built in 1889, with a finished area of 6,720 square feet, and a gross area of about 10,000 square feet including the basement, but not the attic. The basement has a dirt floor and a low ceiling. It is a two story wood framed structure with the town offices on the first floor, a meeting space and an office on the second floor, and a basement containing the mechanical equipment. The meeting hall is only used a couple of times per month. Architect David Ely guided us on a tour of this building. He also prepared an energy efficiency report that was used as the basis of an application for an EECBG grant.

The post and beam framing provide a wall cavity of approximately six inches. The walls are at least partially insulated with blown-in cellulose, however there are also large void areas evident from the attic. The large floored attic is unused, and has 6-7 inches of cellulose insulation. There is a clock tower with associated shaft and openings for cables. The slate roof has been recently repaired. The foundation is rubble with granite blocks. There is a dirt floor in the basement, except for a small room of poured concrete for the boilers. All of the first floor and four of the second floor windows are double hung, double glazed vinyl replacement windows. The glazing has a low-emissivity coating, for a U value of .41, according to Mr. Ely's report. Due to the large size of the second floor windows, a fixed light was installed over the double hung window in

each opening. The remaining second floor windows are original single glazed wood windows with pulley weights, and exterior storm panels.

The heating plant consists of two hot water boilers fueled on oil, installed in 2005. Each boiler is rated for 208,000 Btu per hour capacity. There are two circulator pumps delivering hot water to baseboard radiation on the first and second floors. Thermostatic radiator valves control the temperature in each room. Supply and return pipes in the basement are uninsulated.

There is at present no ventilation system in the building, other than the operable windows. Old vents in the wall of the meeting room are unused. The building has efficient T8 fluorescent lights with electronic ballasts.

We recommend the following energy efficiency measures. Many of these are discussed in greater detail in the Energy Efficiency Report for the Town of New Boston prepared by Mr. Ely.

Note that for the Town Hall and other buildings, we recommend various air sealing measures. Air sealing will save energy cost effectively, and many of the buildings have large air leaks providing an excess of air movement. Nevertheless, each building should be checked for adequate ventilation before and after air sealing. If a building does not meet ASHRAE Standard 62-2010 for ventilation, it should have mechanical ventilation installed that brings it up to that standard.

## Savings Opportunities

The simplest ways to save energy and increase comfort in the Town Hall are better boiler controls, insulating the heat distribution piping, and upgrading the thermal envelope.

### Table 2 -- Summary of Energy Reduction Opportunities for the Town Hall

| | Description | Approximate Implementation Cost | Utility Incentive Available[1] | Other Benefits[2] | Potential Utility Savings Electric kWh/yr | Potential Utility Savings Oil Gallons/yr | Annual Cost Avoidance | Simple Payback Yr |
|---|---|---|---|---|---|---|---|---|
| 1 | Install boiler controls | $3,840 | | | | 230 | $ 500 | 7-8 |
| 2 | Insulate hot water pipes | $3,600 | | | | 132 | $ 300 | 10-14 |
| 3 | IR scan walls, insulate voids | $2,600 | | A | | 121 | $ 300 | 8-10 |
| 4 | Air seal & insulate attic | $6,432 | | A | | 414 | $ 900 | 6-8 |
| 5 | Air seal basement & insulate perimeter | $3,660 | | A | | 238 | $ 500 | 6-8 |
| 6 | Update lighting to super T8 | $2,400 | $400 | D | 2,538 | | $ 400 | 4-6 |
| | | | | | | | | |
| | ***Estimated Program*** | ***$22,532*** | ***$400*** | | ***2,538*** | ***1,135*** | ***$2,900*** | ***7.6*** |

***Notes***
*(1) Subject to Utility Incentive Policy and Screening Analysis*
*(2) A - Better Comfort; B - Improved Reliability; C - Reduced Maintenance; D - Enhanced Appearance*

***Current Utility Budget:*** ***$12,892 /yr***
***Percent Reduction:*** ***22%***

### *1. Install boiler controls.*

The boilers were observed delivering hot water at 210°F on a mild day. Also the thermostatic radiator valves that control temperature in the rooms have no provision for a night setback. Both issues can be addressed with a boiler controller such as Tekmar or Heat Timer. These controls can regulate hot water supply temperature on a schedule so it is near 180°F in very cold weather, and closer to 140°F on milder days, reducing the heat loss in the pipes, and enhancing control in the rooms. In addition, the controller can have programmable unoccupied periods. The boiler availability will be limited, depending on

outdoor conditions, to reduce the building temperature when it is vacant at night and on weekends, and bring it back up to 70°F for morning occupancy.

**<u>Next steps</u>: Obtain quotes from mechanical and/or controls contractors to install a controller with the indicated capabilities.**

2. ***Insulate hot water pipes.***

Long runs of copper hot water pipe in the basement are uninsulated, compromising the delivery of heat to the occupied spaces. While some heating of the basement is desirable to prevent freeze-ups, this is more than necessary. This can be implemented in conjunction with measure 5 below to make sure the basement stays warm.

**<u>Next steps</u>: Hire a commercial piping insulation contractor.**

3. ***Thermographic scan of walls and insulation of voids.***

The walls have some cellulose insulation blown into the framing cavities. This is visible from the attic. Empty areas are also visible. It is impossible to know exactly how much wall area is actually insulated without thermal vision, i.e. an infrared (IR) camera. We recommend an IR scan of the walls to identify voids. The thermographic pictures should be accompanied by visual photographs which can be given to an insulation contractor, so he can fill the voids efficiently. All empty areas should be filled with dense-pack cellulose. We recommend a blower door test at the same time as the IR scan to identify and document major air leakage sites. If there are areas with fiberglass batt insulation, it will be difficult to install dense-pack cellulose over the fiberglass, and the fiberglass itself does not provide an effective air barrier. One remedy for this situation, discussed by Mr. Ely, is to remove the clapboard siding, upgrade insulation, install an air barrier, and replace the siding. This adds to the cost but provides a premium job. While that is the best practice, it is also true than many thousands of homes have been insulated with cellulose in the walls, without full-scale removal of siding, and have benefited greatly.

**<u>Next steps</u>: Have an IR scan and blower door test on the Town Hall (this contractor does not have to prepare another energy audit and report – the deliverables should be IR and visual photographs, blower door results, and a very brief written statement summarizing the major findings). Use the results to obtain insulation quotes.**

4. ***Air seal and insulate attic.***

The attic has some insulation, but the amount is suboptimal for the climate. The attic floor of an older building generally has large sites for air leakage. We recommend sealing open shafts, removing existing insulation and sealing all penetrations for piping, wiring, ducts, flues, structural framing, and at the attic hatch. This should include partition top plates, and an air seal at the eaves, continuous with the top of the walls, both for savings and ice dam mitigation. This work will require that many of the attic floor boards be removed. Leakage sites associated with the clock tower are challenging to seal but should also be addressed. After air sealing, replace the existing insulation, and top off to R50 level with cellulose. In

order to preserve a usable attic space, it may be necessary to remove the attic floor boards, deepen the joist cavity by installing a set of joists on top of and at right angles to the existing joists, and replacing the flooring. This carpentry work will add to the cost of the job.

**<u>Next steps</u>: Finalize the plan for the attic floor joists, how to insulate around the clock tower, and other details. Some instructions for the contractors should be developed, at a minimum a description of the scope of work, if not a full specification. Obtain quotes for this work.**

5. ***Air seal basement and insulate basement perimeter.***

The granite block and fieldstone foundation has almost no insulating value, and the rim joist area of the basement is a large source of air leakage. We recommend installation of two inches of high density polyurethane foam at the perimeter, including the rim joist area, and extending over and below the granite blocks. At the same time, major leakage sites between the basement and the occupied space above should also be sealed (pipe and wiring penetrations, etc.). The doors at the rear end of the basement should be upgraded and weatherstripped if necessary, and that section of basement wall should be insulated and made airtight.

**<u>Next steps</u>: Develop a written scope of work for potential bidders, including the type, thickness, and extent of the insulation, and areas to be addressed for air sealing, weatherstripping, etc. Obtain quotes.**

6. ***Upgrade lighting.***

The Town Hall has T8 fluorescent lamps with electronic ballasts, already quite efficient. However lighting technology progresses rapidly, and it is possible to change out T8 lights to "super T8" lights with more efficient ballasts and reflectors, and lower wattage lamps. In many cases over-lit areas can have the total power significantly reduced while still providing fully adequate illumination. We recommend an audit and proposal by qualified lighting contractor(s).

**<u>Next steps</u>: Invite lighting contractors to visit the site and submit proposals.**

## Additional Measures for Town Hall

***Replace boilers with condensing propane-fired.*** Condensing boilers can achieve much higher efficiency than the non-condensing models currently in place, and this should be considered for the future. However the control and envelope measures listed above will be more cost-effective, and this would require installation of propane tanks, and commitment to purchasing propane which can be more expensive on a Btu basis than oil.

***Install pellet-fired boiler(s).*** This would permit the use of a local resource, and should provide moderate cost savings vs. oil. It would be worthwhile to get quotes for the installation of pellet boiler with storage hopper and feed system, and take note of the available bulk delivery pellet prices, to determine if this makes economic sense. Note that consumption will be appreciably

reduced if the above measures are implemented, making the case for a new boiler less compelling.

## Wason Building -- Historical Society (Old Library)

The 1927 Wason building, formerly the library, now houses the historical society collections. The conditioned area -- one floor plus a partial basement -- is approximately 3,000 square feet. The building also has open and enclosed porches overlooking the adjacent river. The building size was more than doubled by a cathedral-roofed addition on the back side. The building is not usually occupied. The thermostat was set at 60°F when observed.

The walls are concrete block with a brick façade and plastered interior (no insulation). There is a pitched roof, and an attic with fiberglass insulation, but the insulation has been jumbled and misplaced over time so it is not as effective as it could be. The older section windows are standard: single glazed double hung windows with weights and chains, and storm panels. The newer construction has large areas of double pane fixed glazing, including three patio doors.

Two furnaces in the basement of the old section provide heat. Some ducts serve floor diffusers in the front room, and a large duct runs up to the attic for the rear section. In the attic the sheet metal ducts have branches of insulated flex duct to the diffusers. The ducts are insulated with fiberglass wrap and duct tape. The furnaces burn oil, and each delivers a nominal 87,000 Btu per hour. They are ducted in parallel. There is a small electric domestic hot water heater.

Lights are generally either T8 fluorescent tubes, or compact fluorescent in can fixtures.

### Savings Opportunities

This building, at 100 kBtu per square foot for oil, is a very heavy user, especially considering that it is rarely occupied and the thermostat is set at 60°F most of the time, except during the Historical Society meetings.

1. ***Air seal attic and install insulation correctly.***

   The attic of this building has a number of features which make it difficult to insulate and air seal. For one thing, the large chases for ductwork to pass from the basement to the vented attic provide a channel for warm air to exit the building. As well, the concrete block and brick wall between the old and new construction has newer open wood framing providing more channels for air movement. The level changes around the cathedral ceiling section of the new building have large openings in the framing. There are many flex ducts to ceiling diffusers, and a lot of electrical wiring going down to the outlets. The brick walls at the perimeter have a gap between interior plaster and the bricks. All these locations make for a leaky building envelope, and combined with the jumbled fiberglass batts, this goes a long way toward explaining the high heating oil usage.

   We recommend that New Boston hire a competent air sealing contractor to move systematically through the attic, remove the fiberglass insulation, air seal all the above

mentioned leaks and others encountered, then replace the fiberglass in an orderly way. Although fiberglass is not the most effective insulation, it should work if pressed into position and held in place, after a thorough air sealing.

**<u>Next steps</u>: Write a scope of work. Diagrams and specific instructions may be necessary. Obtain quotes.**

2. ***Install a programmable thermostat.***

   The building was 63°F on the day observed, although unoccupied. A deeper setback may be possible, e.g. 55°F. With a scheduling thermostat, the temperature could be programmed for 70° when meetings or open houses take place, and the deeper setback maintained during unused periods.

   **<u>Next steps</u>: Replace existing thermostat with an appropriate programmable one.**

3. ***Improve duct wrap and seal ducts.***

   The insulation on the ducts, although mostly in place, has partly fallen away. The duct insulation is held in place with duct tape, which, ironically, does not work for that purpose (it dries out and falls off!). The ducts should have the insulating wrap removed and should be sealed with a mastic formulated for that purpose. The insulation should then be replaced and fastened with a proper tape or crimp stapler.

   **<u>Next steps</u>: Hire a commercial duct insulation contractor.**

## Fire Station

The New Boston Fire Department's Bunting Station in the center of town has three overhead doors in front, and three on the side. It was built in 1973 and has 5,700 square feet of space, including the garages, a small first floor office, and a larger second floor meeting room and kitchen. The hose drying tower is still in use. It is lightly occupied, with generally one person manning the station about 40 hours per week.

The fire station has slab on grade construction, except for a small basement level boiler room. It has framed walls with vinyl siding and gypsum board interiors (wood paneling on the second floor). There is an attic over the large front garage that appears to be insulated with fiberglass batts, but the insulation has been disrupted by workers. The attic area is crowded with stored items, including rolls of fiberglass, and it is hard to tell if the insulation is effectively installed. The second floor ceiling has fiberglass batts laid over dropped ceiling tiles.

There are two 2005 oil-fired hot water boilers piped in parallel. The Ultimate Engineering units provide 208,000 Btu per hour hot water each to unit heaters in the garages and to perimeter baseboard on the second floor. There are two circulating pumps. Copper pipes are uninsulated; the boilers short-fire, and supply water temperature is circa 210°F. There is one thermostat in the main garage, but we were unable to locate a thermostat on for the second floor. The second floor was 76°F when we visited.

The station has T8 fluorescent lights.

## Savings Opportunities

1. ***Install boiler controls.***

   The boilers were observed delivering hot water at 210°F on a mild day. This can be addressed with a boiler controller such as Tekmar or Heat Timer. These controls can regulate hot water supply temperature on a schedule so it is near 180°F in very cold weather and closer to 140°F on milder days, reducing the heat loss in the pipes and enhancing control in the rooms.

   **<u>Next steps</u>: Obtain quotes from mechanical and/or controls contractors to install a controller with the indicated capabilities.**

2. ***Insulate hot water pipes.***

   The copper and steel hot water pipes in the boiler room are uninsulated, causing that room to be overheated and diminishing the delivery of heat to the occupied spaces. The supply and return pipes should be insulated from the boiler room to the occupied spaces (pipes running to the unit heaters in the garage do not need to be included).

   **<u>Next steps</u>: Hire a commercial piping insulation contractor.**

3. ***Install programmable thermostats and zone the second floor.***

   The second floor meeting room and kitchen were 76°F on the day observed, and no thermostat could be found.

   The second floor should be a separate zone on the heating system, so the first step is to install an electric zone valve for that area, if none exists, with a thermostat. This thermostat, as well as a replacement unit for the two in the garages on the first floor, should be programmable. With programmable thermostats, it will be possible to reduce temperatures at night and bring them back up to the desired level in the morning. When the building is cooler at night, it loses less heat to the outdoors, so that less heat has to be supplied by the boiler. (The heat that it takes to warm the building up in the morning is balanced by the heat that is released when the temperature is set back in the evening, so that's a wash.) Although building staff may do some of this manually, a programmable thermostat makes it much easier and ensures day-on-day control when staff schedules or time demands vary.

   Thermostats available include: seven day programmable (different schedule for each day of the week); 5-1-1 programmable (one schedule for weekdays, one for Saturday, and one for Sunday), and 5-2 programmable (one schedule for weekdays, and one for weekends).

   **<u>Next steps</u>: Obtain quotes to zone and install programmable thermostat for the second floor. Change out the garage thermostat and appoint someone to manage both thermostats.**

4. ***Improve attic insulation and air seal.***

Major air leaks over the garage should be sealed. One major leak was noted at a shaft with electric wires near the attic door. There may be other leaks at wiring and piping penetrations and at the wall between the garage attic and the finished second floor space. The insulation in the main part of the attic over the garage should be set properly in place. It would be best to top off the fiberglass batts with cellulose to an R50 level.

At the same time, the insulation over the second floor meeting room and kitchen should be corrected. Fiberglass batts laid on ceiling tiles is an inferior construction detail. There is no good air barrier in this case, so the insulation is not effective, and moisture problems may result. We recommend installing the insulation in the roof rafters (if there is no attic), with an air and vapor barrier as needed and vented in accord with sound building practice.

**<u>Next steps</u>: Determine the construction details over the second floor space. Develop an insulation detail, with a drawing and instructions. Solicit quotes from contractors.**