Energy Audit

for the

Shutesbury Elementary School

Town of Shutesbury

Massachusetts

Massachusetts Department of Energy Resources

April 2009

Prepared by

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1. EXECUTIVE SUMMARY

An energy audit was performed on the Shutesbury Elementary School located at 23 West Pelham Road in the Town of Shutesbury as part of the Energy Audit Program sponsored by the Massachusetts Department of Energy Resources (DOER). The audit consisted of a building evaluation aimed at 1) assessing the overall energy efficiency of the building and its on-site systems, 2) identifying potential areas of improvement in the building and systems based on a maximum of a 15 year payback period, and 3) where appropriate, proposing alternatives to the conventional systems.

The energy audit of the Shutesbury Elementary School was part of a multi-site audit within the Town of Shutesbury. A town wide summary, under separate cover, compiles recommendations for all of the buildings and sites included in the audit project.

Several Energy Conservation Measures (ECMs) have been identified for this property. The table on the following page summarizes these ECMs in terms of description, the initial investment required to implement these ECMs, their impact on energy and cost savings and the simple payback in terms of years.

For the Shutesbury Elementary School, the options have a combined savings of 13% on fuel and 4% on electricity. The total cost of upgrades is just over $45,000, with an average payback of 7.1 years.

Several renewable energy types were considered for this site. An onsite pellet boiler system is recommended for further consideration.

Energy Conservation Measures Summary Table

Elementary School			Annual Energy Savings				Annual Cost Savings			
			Electrical		Fuels	Energy	Electrical	Fuels	Total	
ECM#	Description	ECM Cost	kWh	kW	Oil Gal.	Total MMBTU	$	$	$	Simple Payback ECM Cost/ Savings (years)
CSs	Control System	$9,150	0	0.0	951	131.9	$ -	$ 2,282	$ 2,282	4.0
BEs	Building Envelope	$15,006	0	0.0	430	59.6	$ -	$ 1,032	$ 1,032	14.5
OSs	Occupancy Sensors	$1,427	1,369	0.0	0	4.7	$ 130	$ -	$ 130	11.0
MCs	Motor Controls	$19,447	8,600	0.0	869	149.8	$ 817	$ 2,085	$ 2,902	6.7
	TOTAL	$45,030	9,970	0.0	2249.4	346.0	$ 947	$ 5,398	$ 6,346	7.1

Total Building Energy Usage	232,000	0	17,060	3158.1	$22,040	$ 40,944	$ 62,984
Savings Reduction (%)	4%	N/A	13%	11%	4%	13%	10%

2. INTRODUCTION

Through the Energy Audit Program (EAP) offered by the Commonwealth of Massachusetts, Department of Energy Resources (DOER), technical assistance is provided for all buildings owned and operated by cities, towns, regional school districts and wastewater districts to identify capital improvements to reduce energy costs. The technical assistance provided by DOER includes an initial benchmarking of buildings and structures included in the application. Based on the results of the benchmarking, a detailed energy audit may be performed as well as a variety of feasibility studies to evaluate the potential to incorporate renewable energy sources. This comprehensive assistance provides communities with the knowledge needed to reduce energy consumption and associated financial resources.

The purpose of this audit report is to provide the program participant with a list of energy conservation projects, their costs and estimated energy savings. This information may be used to support a future application to DOER's Energy Conservation Improvement Program (ECIP), support performance contracting or justify a municipal bond funded improvement program. ECIP is a state funded grant program that provides funds for energy conserving capital improvements.

The approach taken in this audit included a thorough walk-through of the building(s) and associated systems and equipment, including both process systems and building systems. The major areas covered in the audit included the building envelope, process systems, electrical systems, HVAC systems, lighting systems and operational and maintenance procedures. A major element of the audit also included an initial interview and ongoing consultation with operational and maintenance personnel, as well as building occupants. This approach is critical to the quality of the audit process, since the input of building personnel is invaluable to the effort to obtain accurate information required for the audit.

CET's energy auditor Bill Lafley and Precision Decisions' licensed professional engineer Chris Vreeland performed the onsite audit, developed the recommendations and wrote the audit report. Personnel from the municipality provided site-specific information in advance of the audits as well as observations during the site walkthrough.

The recommendations within this report are based on one year of submitted usage data, a site review and preliminary evaluation. The energy savings and energy production figures are projected estimates based on conceptual project upgrades, information gathered at the site, and from the historical utility information provided. The actual savings may vary from these estimates due to a variety of factors. The figures used for the cost of recommended upgrades are 'opinions of probable cost' and are intended to be used for feasibility purposes only. The recommended measures should proceed to detailed design and further re-evaluation followed by competitive bidding per the Massachusetts Procurement Guidelines. The resulting responses to the bid should be used for budget approval purposes. For more information see: *Office of the Inspector General, Municipal, County, District, and Local Authority Procurement of Supplies, Services, and Real Property, Publication No. CR-1520-170-200-09/06-IGO.*

3. FACILITY DESCRIPTION

The Shutesbury Elementary School is a 32,000 square foot, 1 story building located at 23 West Pelham Road. The original building was constructed in 1972 and a large addition was added in 1992. Primary occupancy occurs during the school year with approximately 160 students and 45 staff present 8 AM – 3 PM; with occasional meetings and events in the evenings and on weekends.

The building has fourteen classrooms, one conference room, a library, gym, kitchen and various mechanical and storage rooms.

Building Envelope

The building is constructed of masonry block. The roof is pitched with asphalt shingles. There are several ridge lines to the roof. A 2.5 kW solar system was installed on one south facing roof in 2007.

The walls in the building have foam insulation in the block spaces.

The ceiling has 2 layers of 6 inch fiberglass batt insulation; the insulation is secured in the joist bays above the suspended ceiling of the addition and is laid on the old flat ceiling of the original building. There is polyethylene sheeting stapled to the bottom of the joists in the addition and there is a vented attic space above. The building is on a slab on grade. The interior office areas of the building are primarily finished with drywall, vinyl tile or carpet and suspended acoustic ceiling tiles. The attic area is unfinished. All of the windows in the building are double pane.

There are six entrances into the building. The main front and rear entrances into the building are storefront window/door assemblies. Three of the other doors are steel insulated doors. The remaining door is a wood double door.

Lighting

The lighting in the building is shown in the table below:

Area	Type	Length	Wattage	Control
Rooms	T8 -2 lamp	4’	38	Occ Sens
Gym	T5-6lamp	4’	214	Manual
Halls	Utube-T8	2’ x 2’	57	Manual
Exit Lights	LED		1.5	24/7

Exterior lighting is provided by high intensity light fixtures attached to the buildings. The exterior lighting is controlled by a mechanical timer. There is one light in the main parking area. It has one metal halide lamp mounted to it that is controlled by a mechanical timer programmed to turn on at 4 PM and off at 10 PM

Heating System

The building is heated by a two pipe hydronic system. Two oil-fired Weil McLain boilers; each rated at 810,000 BTUH, heat the water circulated through the system. The tested efficiency of one boiler was 77.6%. The other boiler was being repaired at the time of the audit. The heating and ventilating system has a direct digital control system. It is programmed for 65 F from 7:30 AM – 3 PM and 58 F from 3 PM – 7:30 AM.

Hot Water System

Potable water is received from a well. There are six restrooms in the building. The fixtures are low flow water efficient fixtures. Potable hot water is generated by one direct-fired water heater rated at 75,000 BTUH. There are 1/4 HP circulators on the hot water distribution; there is no timer or control for the circulators. There are uninsulated sections of hot water piping.

Computers, Appliances & Other Plug Loads

The site also has the following major plug loads:

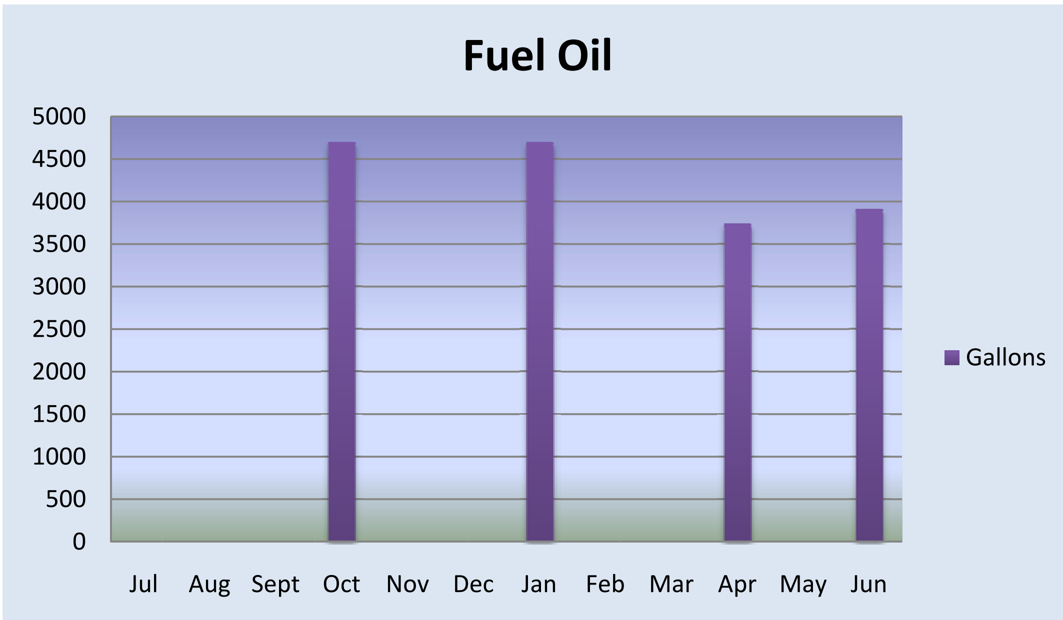
74 computer stations
2 photo copiers
1 fax machines
4 portable refrigerators
1 refrigerator
1 electric range
toaster ovens
1 water cooler

Energy Profiles

The site uses oil and electricity.

Fuel Oil

The Shutesbury Elementary School used 17,060 gallons of #2 fuel in FY07.



The most recent bill for the Town of Shutesbury has a rate of $ 2.40 per gallon with potentially higher costs in the near future.

A rate of $ 2.40 per gallon was used for savings estimates in this report.

Electrical

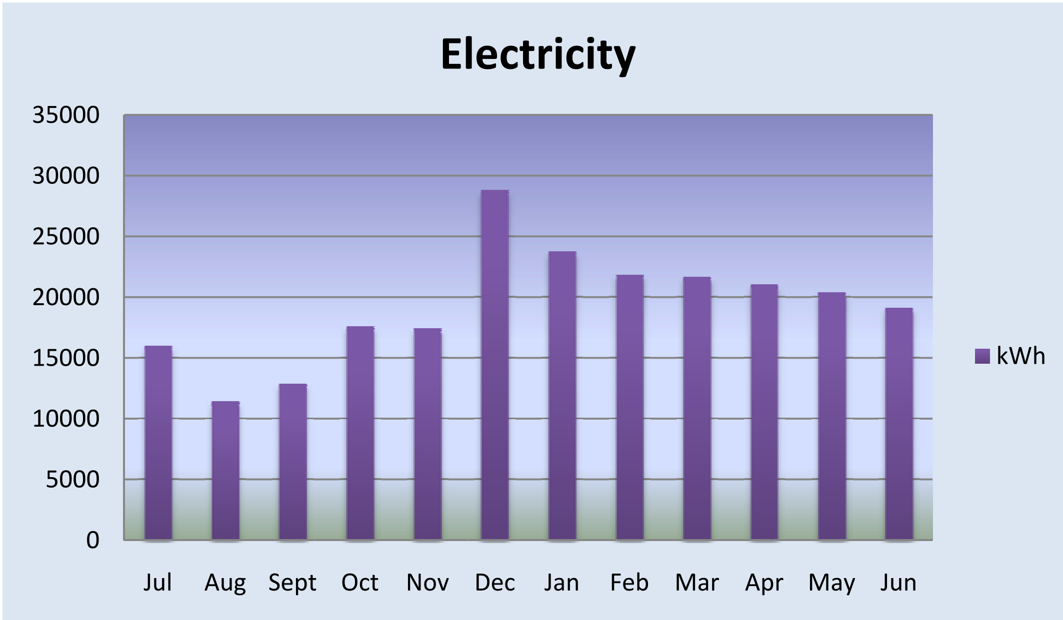
Electricity is provided by National Grid (NGrid). Electricity is billed under the G1 rate. For the fourth quarter of 2007 these rates were as follows:

Rates		
Delivery Services		
Transmission Charges		
Energy Charge		$0.013850 kWh
Demand Charge		$0.000000 kW
Distribution Charge		
Customer Charge		$16.31 flat monthly
Energy Charge		$0.002400 kWh
Demand Charge		$6.320000 kW
Transition Charges		
Energy Charge		$0.001970 kWh
Demand Charge		$0.300000 kW
Energy Conservation Charge		$0.002500 kWh
Renewable Energy Charge		$0.000500 kWh
Supplier Services		
Generation Charge		0.0741 kWh
Total rate for Energy Usage (kWh)		$0.095320
Total rate for Energy Demand (kW)		$6.620000
This results in the following:		
Average Monthly Usage	19,300 kWh	$1,839.68
Average Monthly Demand	62 kW	$410.44

Rates of $0.095 per kWh and $6.62 per kW were used for savings estimates in this report.

The monthly demand varied from 33 kW to 69 kW; this variability is normal for this site.

The electric usage for FY07 at the Shutesbury Elementary School was 232,000 kWh.



The electrical usage is steady throughout the year, with minor variations corresponding with the use of air conditioning in summer and heating (a small portion of which is electrical) in the winter. The majority of the electrical usage (approx 18,300 kWh/month) is therefore not related to heating or cooling. This baseline usage would be for lighting, appliances and other plug loads (computers, copiers, etc).

The spike in December is unexplained and was not replicated in FY 2008. If this reoccurs in the future, it should be investigated to determine the cause.

4. ENERGY CONSERVATION MEASURES

For the Shutesbury Elementary School the following energy conservation measures were evaluated:

Control system upgrades
Building envelope improvements
Occupancy sensors for lighting
Motor control(s) for fans and/or pumps

For each ECM detailed below, there is a corresponding appendix that further details the quantitative assumptions, projections and opinions of cost for the measure. The name of each appendix corresponds with each ECM section (i.e. ECM LU1 would be found in Appendix LU).

ECM CS1 – Heating Controls Upgrade

Currently the temperature is setback from 65 to 58° F for the unoccupied periods; this is a fairly aggressive setback; but a deeper setback (such as 55 F of even lower) could be considered for extended periods when the school is unoccupied. One issue with lower setbacks is that the building is too cold for after hour activities (sporting events, meetings, etc).

The current control system is accessible only via the boiler room control panel. The system can be upgraded to allow for multiple points off access: through the school network computers and for making changes from an internet connection. The setpoint screens would be upgraded to allow for easy access for a layperson to be able to adjust temperature. Programming changes would allow for temperature setpoints at different times of the day. Energy savings would be possible by implementing lower temperature setbacks during extended unoccupied times (such as weekends and vacations). Additionally, the remote access would allow for the system to be switched to the unoccupied mode from a remote computer when there is a snow day. The heating schedule would be accessible to the administration so that they could program the various zones to match the after school calendar each week and also make changes for last minute needs.

It is important to acknowledge that although many new schools have the wide-ranging functionality for their control systems as described above, often the systems are not utilized to their full extent. This may be due in part to the extra administrative time required each week for setting up the schedule, or from a simple lack of training. *Therefore, the level of time commitment should be understood and the appropriate personnel assigned and properly trained during the initial system commissioning.*

The estimated energy savings is 951gallons of oil resulting in an annual savings of $2,282. The estimated cost of the measure is $9,150 yielding a simple payback of 4 years. This upgrade is recommended at this time.

Note: A setback to 55° F (or lower) should be performed in increments to ascertain if there are any heating coils or other piping that experience freeze-up at the issues with the lower temperatures. If issues are encountered, then they should be remedied by resizing and/or insulating the equipment in question. Only then should the incremental temperature reductions resume.

ECM BE1 – Air Sealing

Above the suspended ceilings of the offices and classrooms in the new section of the building there are several penetrations through the plastic vapor barrier that should be sealed. Air movement through the plastic sheeting into the fiberglass batt insulation is not only a direct heat loss, but also degrades the R-value of the insulation. The penetrations around ducts, wires, etc. should be sealed with tape; tape, caulk and fire rated spray foam should be used for sealing along the edges of steel beams and the perimeter of the walls. It is estimated that these improvements will reduce the air changes in the building by .25 air changes per hour. The reduction in summer cooling was not factored into the analysis due to the low level of A/C usage. The estimated energy savings is 430 gallons of oil resulting in an annual savings of $1,030. The estimated cost of the measure is $15,000 yielding a simple payback of 14.5 years. This upgrade is recommended at this time.

ECM OS1 & OS2 – Install Occupancy Sensors

The gym and hallway lights are on continuously while the building is occupied. Installing occupancy sensors to turn off the gym lights and half (every other fixture) of the hallway lights would turn the lights out for the number of hours that there is no activity in these areas. It is estimated that by using occupancy controls, the lights would be off an additional 2 hours per day. The estimated energy savings is 1369 kWh/year resulting in an annual savings of $130. The estimated cost of the measure is $1,427 yielding a simple payback of 11 years. This upgrade is recommended at this time.

ECM MC1 & MC2 – Fan Motor Controls & VFDs

The main ventilation systems for the school operate at single speeds and have no occupancy controls (other than time control during occupied hours). Most of the school is ventilated through one main air handling unit with a 20 HP circulation fan and an 8 HP fresh air fan with damper controls. It is recommended that both of these fans be operated with variable speed drives. A CO_2 sensor and related DDC programming should be used to optimize fresh air for this system. The two air handling units in the gym should also be retrofit to operate on CO_2 controls. This has both electrical savings and heating savings (from reducing the amount of makeup air that must be conditioned). The estimated energy savings is 7624 kWh/year and 742 gallons of oil resulting in an annual savings of $2,506. The estimated cost of the measure is $18,642 yielding a simple payback of 7.4 years. This upgrade is recommended at this time.

ECM MC3 – Timer on Hot Water Circulator Pump

There are circulator pumps on the domestic hot water system that serve the bathrooms, kitchen and janitorial sinks. The circulator pumps operate continuously to maintain hot water to these areas. A 7-day, programmable timer can be installed to operate the pumps during occupied hours. The estimated energy savings is 976 kWh/year and 126 gallons of oil resulting in an annual savings of $395. The estimated cost of the measure is $805 yielding a simple payback of 2 years. This upgrade is recommended at this time.

5. OPERATIONAL ANALYSIS

The quality of the maintenance and operation of the energy systems for a building has a direct effect on its overall energy efficiency. Energy efficiency needs to be a consideration when implementing facility modifications, equipment replacements, and general corrective actions. The following is a list of activities that should be performed as part of the routine maintenance program for the site. These actions, which have been divided into specific and general recommendations, will help improve energy conservation and support the measures identified in this report.

Specific Recommendations

The Shutesbury Elementary School has a documented operational and maintenance plan where energy efficiency is a recognized priority. The head custodian, Walter, had a relatively high competence of HVAC systems; he has reportedly retired (in the time since the site audit was conducted). Finding a replacement candidate with this level of HVAC knowledge may be difficult; therefore, an increased level of contracted support may be needed. Part of the training and orientation of the new staff should include a formal course on HVAC maintenance management as well as specific training on the software and DDC system used at the site. It is recommended that the existing HVAC preventative maintenance contract be continued.

The one boiler that was measured had an efficiency of 77.6%, which is relatively low for a boiler of this vintage. Readings should be taken on both boilers. If the readings are not over 80% (within 2% of the original nameplate efficiency) then a burner upgrade or other maintenance should be performed.

The hot water feed to the rinse sink in the kitchen should have a check valve (code requirement). This prevents the hot water from circulating back into the cold water line (thermosyphon); this happens when the faucets are left on at the rinse station. Similarly, check valves should be installed on janitorial sinks to prevent the same issue.

General Recommendations

The following general recommendations and tasks should be continued or implemented (where applicable):

Building Envelope

1. Caulking and weather stripping is functional and effective.
2. Holes are patched and sealed in the building envelope.
3. Cracked windowpanes are repaired.
4. Window air conditioners are removed prior to the heating season.
5. Automatic door closing mechanisms are functional.
6. Interior vestibule doors are closed.

7. Storm windows are closed in the fall and throughout heating season.
8. Screens are removed on south facing windows during heating season.
9. Maintain gutters, manage roof runoff and perimeter surface water.

Heating and Cooling

10. The pilot lights on furnaces are turned off in the summer.
11. The burners are clean and fuel/air ratios are optimized.
12. Heat exchange surfaces of furnaces are clean and free of scale.
13. Utilize existing setback thermostats. Reduce the set point of the setback from 62 F to 55 F. Extend hours as needed to reach occupied set point at start of workday.
14. Reduce temperature settings in unoccupied areas and set points are seasonally adjusted.
15. Control valves and dampers are fully functional.
16. Pneumatic control systems are checked for air leaks, and corrected if needed.
17. Equipment is inspected for worn or damaged parts.
18. Ductwork is sealed.
19. Hot air registers, and return air ductwork are clean and unobstructed.
20. Air dampers are operating correctly.
21. Heating is uniform throughout the designated areas.
22. Evaporator and condenser coils in AC equipment are clean.
23. Air filters are clean and replaced as needed.

Domestic Hot Water

24. Domestic hot water heater temperature is set to the minimum temperature required.
25. All hot water piping is insulated and not leaking.
26. Tank-type water heaters are flushed as required.

Lighting

27. Turn off lights in rooms when there is enough natural lighting.
28. Use single (compact fluorescent) desk lamps in offices and turn off overhead lights if applicable.
29. Over-lit areas are managed by bi-level switching or photocell controls.
30. Only energy efficient replacement lamps are used and in-stock.
31. Lighting fixture reflective surfaces and translucent covers are clean.
32. Walls are clean and bright.
33. Timers and/or photocells are operating correctly on exterior lighting.

Miscellaneous

34. Use energy saver mode on monitors, and hibernate mode on computers.
35. Use energy saver mode on all copiers, fax machines, etc.
36. Turn off/shutdown all office equipment at night.
37. Refrigerator and freezer doors close and seal correctly.
38. Reduce number of refrigerators. (Combine smaller ‘private’ refrigerators into one single larger unit for the building).
39. Set refrigerator(s) on energy saver mode and/or adjust to medium temperature setting.
40. Set freezer(s) on lowest energy (highest temp) mode when not getting used.
41. Kitchen/bathroom exhaust fans are only used when needed.

42. Office/ computer equipment is either in the “sleep” or off mode when not used.
43. Conduct all recommended equipment specific preventive maintenance tasks.
44. Verify that peak demand on the building/equipment has not changed significantly since the original building commissioning or the most recent retro-commissioning.
45. Replacement equipment (pumps, compressors, etc) are not over/undersized for the particular application.
46. Replacement equipment should be energy conserving and/or high premium devices (compare life cycle costs, not first costs).

6. CLEAN ENERGY OPPORTUNITIES

The Commonwealth of Massachusetts is dedicated to promoting clean energy as an alternative to traditional sources of energy. As such, the DOER and other agencies have developed a number of programs to promote the use of clean energy sources by potentially providing technical assistance and/or financial incentives based on project feasibility. A brief discussion of the various programs is provided below, along with specific projects that may be appropriate for the respective technologies.

Solar Photovoltaics

Through the Commonwealth Solar Program [1] , rebates are offered to encourage the installation of solar photovoltaic (PV) power by homeowners, businesses and municipalities. The rebate program is designed to help defray the costs that are associated with the installation of eligible systems from 20% - 60%. Rebate applications have been available since January 23, 2008. Incentives are greater for projects on public buildings and those that incorporate products manufactured in Massachusetts. The rebates are available for systems that will be directly owned by the applicant, as well as those financed through a third-party ownership model that takes advantage of federal and state tax credits. A total of $68 million is available over the next four years. The following table provides the initial rebate levels:

Non-Residential Rebates for Incremental Capacity ($/Watt)				
Incremental Capacity	**First: 1 to 25 kW**	**Next: > 25 to 100 kW**	**Next: > 100 kW to 200 kW**	**Next: > 200 kW to 500 kW**
Base Incentive	$3.15	$3.00	$2.00	$1.40
PLUS: Additions to Base Incentives				
Massachusetts Manufactured System	$0.15	$0.15	$0.15	$0.15
Public Building	$1.00	$1.00	$1.00	$1.00

Third-Party PV Financing Resources

MTC and DOER encourage applicants to explore various options for financing their PV project. One such option is known as Third-Party Financing. With Third-Party Financing, the PV system is owned and operated by an entity that is separate from the building owner or the PV installer. The Third-Party Financing entity has sufficient financial capital to pay for the entire installation and to maintain and operate the system over its lifetime. In return, the building owner, or

1 Web site: www.commonwealthsolar.org

"host" site, signs a long term contract agreeing to purchase all the power produced by the PV system.

Third-Party Financing is a way to install a large PV array with little or no up-front capital expense from the building owner or "host" site. This type of financing may be most applicable to entities such as non-profits or public buildings. The Third-Party PV Owner can utilize the substantial tax incentives available for PV projects, along with rebates and other incentives, plus the sale of the electricity from the PV array to finance the PV project. Third party financing for municipal PV systems is just taking hold in Massachusetts. At this time, the sites of primary interest are buildings with large flat roofs that can accommodate at least 100 KW of solar.

Solar Hot Water

The State supports the use of solar hot water systems and the payback periods are generally attractive for buildings with high water usage. Systems are generally composed of solar thermal collectors, a fluid system to move the heat from the collector to its point of usage, and a reservoir or tank for heat storage and subsequent use. The systems may be used to heat water for home or business use, for swimming pools, radiant floor heating or as an energy input for space heating and cooling and industrial applications. Attractive applications for town buildings and facilities may include municipal pools, schools with full year hot water usage (summer locker room and/or kitchen usage), fire stations, and public housing facilities. On a periodic basis, the DOER accepts grant applications for solar hot water systems. A maximum of $50,000 per project is available for installation; however, applicants may propose greater grant requests, which will be considered based on the merits of the project and available funding.

Wind and Hydroelectric

Through the Large Onsite Renewables Initiative (LORI) [2], rebates are offered to encourage the installation of wind and hydroelectric for homeowners, businesses and municipalities. The rebate program is designed to help defray a portion of the costs that are associated with the installation of eligible systems.

The LORI awards grants for feasibility studies and design and construction projects for projects that are greater than 10 kW. Feasibility grants are capped at $40,000 with an applicant cost share of 15%. Design grants are capped at the lesser of $125,000 or 75% of actual cost and construction grants are capped at the lesser of $275,000 or 75% of actual costs.

Ownership of existing water diversions or dams with large flows or heads is generally needed for a viable hydroelectric projects. Land with average annual wind speeds of 14 mph or greater are needed for a viable wind project; this is more common along coastlines and at higher elevations (>1800 ft) and along ridge lines. Various types of permits are generally required for both types of projects.

2 Web site: www.masstech.org/renewableenergy/large_renewables.htm

Wood Pellet Fueled Heating

On a periodic basis, the DOER accepts grant applications for wood pellet fueled heating systems [3], which burn pellets made from renewable sources of energy such as compacted sawdust, wood chips, bark and agricultural crop waste. Funding is available to cities, towns, regional school districts, as well as water and wastewater districts. A maximum of $50,000 per project is available for installation; however, applicants may propose greater grant requests, which will be considered based on the merits of the project and available funding. A total of $525,000 is available for this program. The grantee is responsible for repaying 30% of the funds granted within one year of the completed installation.

District Energy

A district energy system consists of a central plant that produces steam, hot water or chilled water to provide space heating, domestic hot water heating, and air conditioning. Modern systems typically rely on hot water distribution rather than steam. The district energy is delivered through a network of pre-insulated buried pipes to a clustered community of commercial, industrial and residential customers. As a result, individual buildings don't need their own boilers, furnaces and cooling systems. Applications for towns can include a cluster (2 or more) of town buildings, school buildings located proximate to each other. The development of small district energy systems serving public buildings can provide an anchor for the expansion of the system into town centers to serve privately owned buildings. Using biomass as a fuel source for the district system enables the rapid displacement of fossil fuels used for building heating and appreciable reductions in town greenhouse gas emissions. Funding is available for towns that can demonstrate good district energy applications to perform feasibility studies of district energy systems that primarily serve town buildings.

3 http://www.mass.gov/Eoca/docs/doer/pub_info/doer_pellet_guidebook.pdf

Clean Energy Assessment

The Shutesbury Elementary School was assessed for solar, wind, hydroelectric and biomass.

Solar Hot Water and Photovoltaics

This site was accessed for solar in 2007. By coincidence this was also performed by Precision Decisions LLC. A 2.5 kW solar photovoltaics project was recommended for the site and was installed in 2007. Additional solar photovoltaics could be installed at the site. However, there is not enough unshaded area to be considered for a third party system (100 kW or larger).

The roof could accommodate a small solar hot water system. However, the limited hot water usage of an elementary school combined with the drop in usage during the summer makes it a poor candidate for solar hot water.

Wind and Hydroelectric

This site is in a poor wind area therefore it is not a viable site for a wind turbine.

There is no river or stream located at this site; it cannot be considered for hydroelectric either.

7. BIOMASS HEATING

Background

Biomass boiler systems are similar in construction to an oil-fired boiler but with a large storage bin for the fuel and one or two conveyors to feed the fuel into the burner. Typically the system is sized for a portion of the heat load and the conventional system is used in conjunction to meet the higher heat loads (during the coldest periods). In most cases the conventional system is capable of supplying the entire heat load in the event the biomass boiler is not functioning or in the event of a lack of biomass fuel. While very large biomass boilers have been used for decades in large industry (such as pulp and paper) moderate sized boilers are not commonplace. This results in a limited number of manufacturers and qualified repair technicians. The supply of biomass fuel is also not well developed in all regions. Biomass primarily comes in three different forms: cord wood, chips, and pellets. Significant space is needed for the storage of the biomass as well as vehicle access for unloading of the fuel.

Concerns Associated with Biomass Fuels

- **Burning biomass usually takes more operator attention then burning conventional fuels.** A biomass system can be shut down if an oversized chip jams the fuel handling equipment. Operators need to watch for jamming and shutdowns, which are more frequent than with oil or gas systems. (See "The Importance of the System Operator" on page 57.)

- **In contrast to other fuels, biomass fuel is variable in quality. It may require more vigilance and effort from the owner to ensure the desired fuel quality.** Fuel quality can vary with the time of year and the species of wood being chipped. Chip suppliers may become lax about the size characteristics of the fuel they provide and about keeping the fuel from getting wet when it rains or snows.

- **It may require time and effort to set up a stable biomass fuel supply network in a region where one is not in place.** Most marketable biomass in the Northeast is sold to paper mills and electric generating plants. It may be difficult to get biomass suppliers to meet the needs of institutions such as schools and hospitals that are used to the level of customer service that oil dealers provide.

- **Biomass does not burn as cleanly as natural gas. The public may be worried about a new biomass installation because of the reputation of wood burning as being "dirty".**

  Public education about modern wood-chip heating is critically important for the success of any project. The public's perception of wood-burning is often based on home wood stove experience, with little or no understanding of the new generation of wood-chip systems.

- **Some biomass systems require more main-tenance than systems using conventional fuels.**

  While the best biomass installations have no higher maintenance costs and personnel needs than facilities that burn oil or gas, some biomass system owners have experienced increase maintenance costs for either operator time or parts replacement and repairs.

Source: Wood Chip Heating Guide: A Guide For Institutional and Commercial Biomass Installations, Timothy M. Maker, 2004

Biomass Boiler Assessment

The existing boiler room has 2 medium boilers. For most conditions the building can be heated by one boiler, conveniently allowing for one boiler to be down for maintenance. The boilers are in fairly good condition but do require periodic maintenance. One of the boilers could be removed to make room for some of the equipment associated with a biomass boiler. Biomass boiler systems do not operate with the same level of up-time and reliability as a new conventional boiler. Therefore, if this option is considered the other boiler would need to be very well maintained and replaced once its reliability is in question. This is probably not the best option.

The other alternative is to build a room adjacent to the boiler room for the biomass boiler. This can add enough additional cost to make the project financially unattractive. However, there is not enough space available in the existing boiler rooms or any existing space adjacent to the boiler room that could be converted. In some cases small prepackaged, skid-mounted systems come built with equipment enclosures and they do not require any building space.

The sizing of the biomass boiler is typically smaller than the heat load so as to allow the boiler to be able to run at full load throughout most of the heating season. The supplemental boiler (in this case one of the existing boilers), is fired periodically. This operating scheme is especially true for chip boilers as they have limited turn-down capabilities. This type of sizing scenario also allows for smaller initial capital costs. Even with a smaller biomass boiler, significant reductions in annual fossil fuel usage are possible. This is because the biomass system is operated as the primary (aka lead) boiler and meets most, if not all, of the heating demand during the entire moderate heating season (Sept-Nov, March-May). During the cold heating season (Dec-Feb) the biomass boiler still acts as the lead boiler and meets much of the heat load with only periodic operation needed from the oil-fired boiler(s).

A series of biomass boiler sizes were modeled to determine the best size based on the lowest life cycle cost. The result of this analysis was that a system size of between 250,000-350,000 BTUs was the most appropriate. This will have the net result of offsetting approximately 55-65% of the annual oil consumption.

This size system is too small for a financially viable chip handling system and boiler. Increased use of chip boilers, in time, may allow for smaller chips systems to be manufacturer cost competitively.

Note: Most biomass projects experience lower operating time on the biomass fuel during the first year while site personnel become familiar with the system's operation. This can be improved, to some degree, with an aggressive training and commissioning plan.

Fuel Storage and Handling

Biomass storage can occupy a considerable amount of space. The logistics of storage and delivery of biomass fuel will often determine the feasibility of a site.

Pellets

Pellet storage is typically the most compact. Pellets are stored in a silo; the silo can be located inside or outside depending on the amount of available space. Filling of the silo is relatively simple since the delivery truck is usually equipped to air convey the pellets (*see photos*). Given the site layout the most likely location for the pellet storage would be adjacent to the boiler room to the north of the proposed biomass boiler. One silo would serve to store 15-25 tons of pellets. This amount of storage is recommended based on the projected fuel usage and to economize around delivery capacity. The silo would need to be constructed so that it is easily removed if a boiler replacement needs to be performed.

Note: Fire protection of the structure adjacent to the solid fuel storage area would also need to be considered.

Cord Wood

Biomass systems utilizing cord wood require significantly more storage space and manual labor (even for the large units with semi-automated feeders). There is not enough area adjacent to the boiler room to store a significant amount of cord wood; therefore double handling of the fuel would be required. Providers of cord wood could offer offsite storage with periodic delivery for an additional fee. At the municipal level, cord wood biomass is typically an option only when at least a portion of the fuel is considered free; i.e., the wood is already being handled as part of the operation (such as at a DPW facility for a town that has to perform a lot of tree clearing for road and site maintenance).

Wood Chips

Wood chip storage takes moderately more room than pellets due to the bulk density of the fuel and the handling equipment required to convey the chips to the boiler. Self-unloading tractor trailers (aka live-bottom trailers) are typically used to deliver chips. The access needed for these trucks is considerable due to their length and the need to back up squarely to the storage area (as opposed to pellet deliveries which can unload at a variety or orientations). Another alternative is to use a dump body trailer. For this application the chip storage must be below the elevation of the trailer (usually below grade).

The existing road access to the proposed biomass boiler area, even if modified, is too restrictive to allow for complete access for a full size live bottom trailer. In order to create the necessary access the parking area would need to be reconfigured and potentially expanded, and the adjacent property would likely need to be accessed (with an easement or land acquisition). Any of these upgrades would add enough cost to the project to make it financially unviable.

The equipment used for delivery of chips is limited since the applications historically involved larger sites with access to full size vehicles. It is possible that, as the biomass chip market penetrates smaller markets, equipment will be developed to services more congested sites. Therefore, if this project does not get considered for a few years, chip delivery should be reevaluated as the economics of chips is often more attractive than pellets for a building load of this size.

Supply of Biomass

The supply of biomass fuel is a major consideration.

Wood pellets are currently available through a variety of distributors. Most of these get their supply from one manufacturer in Jaffery, New Hampshire. At times the demand of wood pellets exceeds the regional supply and additional pellets are shipped from Canada, or from as far away as the west coast. When this happens the cost can increase considerably. With the unprecedented increase in oil costs in 2008, the demand for pellets increased dramatically. This also caused significant pellet purchasing ahead of the heating season. The result was increases in pellet prices to $250-$300 per ton; this was nearly double the price of pellets in 2004. While oil prices have retreated considerably since their peak in July 2008, pellet prices have not come down through the winter of 2009. Additional manufacturing capacity has been coming online to meet the increased demand. However, much of the raw material for pellets comes from sawmill waste. With construction activity at decade lows, pellet manufacturers have to travel a larger radius to find material; also the qualification process to become a source of raw material takes time. The prices of pellets should moderate in the next year with additional raw material qualified, additional capacity on line, and growth in the demand for pellets slowing due to lower oil prices. However, with all the uncertainty in the economy coupled with volatile oil prices, pellet prices may be mercurial. *See project recommendations section for more discussion on pricing of pellets and project viability.*

Cord wood is readily available in western Massachusetts due to the extensive wooded areas. Supply and distribution is well developed due to the prevalent use of residential woodstoves. Contacts can be established to provide a fixed annual amount of wood from firewood suppliers; storage could also be considered.

Currently there is ample wood chip supply in western Massachusetts; however, there is limited, to no, distribution currently available for customers heating with biomass chips. Typically the first installation of a large biomass system in a region creates the need for the distribution. As the project approaches its final phase one or more entrepreneurial distribution companies is identified who make the investment for the truck/trailer to service this and future needs. Several installations in Vermont are serviced by local supplies and could likely service Shutesbury if a local supplier does not materialize. *Since the layout of the school was not conducive to chip delivery this was not investigated further for this assessment.*

Other Considerations

Several other criteria are considered in determining the type of biomass fuel.

All biomass systems produce some amount of air emissions. The most concerning to the site, itself, is *particulate matter*. See the following link for more information about the different types of particulate matter and potential health effects:

http://www.epa.gov/particles/

Both cord wood and chip boilers typically produce more particulate matter than similarly sized pellet boilers. The level of particulate mater can be reduced with treatment of the exhaust stream; however, it is not required (by the DEP) for systems in the size range being considered. Often the added cost of the treatment systems makes the project financially unviable at these smaller size ranges. However, in this case treatment may be needed for both cord wood or chip systems given the proximity of the boiler room (exhaust stacks) to the many fresh air intakes to the school. A pellet system will be more likely to have low enough particulate emissions. However, this issue should be studied further as part of detailed design and included in the equipment specifications for biomass system performance. Proper operation of the biomass system and the quality and moisture content of the fuel supply also has an effect on emissions and should be included in operations training.

The amount of time required to operate and maintain a biomass system varies. Typically cord wood has the highest time commitment, followed by chips, then pellets.

Recommendations

A chip boiler is not recommended since it is not currently compatible with the relatively small heat load for the site; furthermore, the space constraints at the site do not allow for delivery and storage of wood chips. Cord wood could be considered, but operating costs, storage, handling and localized emissions are impediments to successful implementation and operation. A pellet boiler is the most appropriate biomass option for the site.

An assessment model was developed for a pellet boiler system; a copy is included in the Appendix. Some modifications would need to be made at the site to allow for access to the proposed biomass system location adjacent to the boiler room. This would include relocation of at least one of the storage sheds as well as extending the paved driveway to the boiler room. The paths around the school that are plowed in winter to serve as fire escape routes would need to be reconfigured as would some of the snow removal storage areas. An estimated cost for these items is included in the project estimate. Operation and autonomous maintenance of the pellet system is most cost effective if performed by personnel already at the site (such as custodial staff), but can also be performed by other town personnel (such as DPW maintenance). Based on discussions with the town administrator a rate of $25 per hour was used in the financial analysis for the estimated 4 hours per week for these operating costs.

The biggest unknown variable in the assessment model is the future cost of pellet fuel relative to the cost of heating oil. With the current low price of heating oil and high cost of pellets, the project actually has no payback (i.e. it costs about the same to run on oil as it does pellets). Historically this has not been the case as pellet fuel has had a net cost of about 2/3 that of oil. As opposed to current costs for these fuels, predicted values of $2.50 per gallon for oil and $200 per ton for pellets were used in the project financial analysis in the Appendix; this represents a ratio in prices that is more representative of the historical trends. However, due to the potential variability of both fuels, a range of price scenarios and their impact on the project economics were analyzed and summarized on the following page.

Over the long term, certain scenarios are highly unlikely to occur; therefore these were *not* considered:

- very high oil prices and very low pellet prices
- very low oil prices and very high pellet prices

Project Fuel Price Sensitivity Analysis					
Oil	Pellets	Payback	Oil	Pellets	Payback
$1.50	$125	21.9	$2.00	$150	12.2
$1.50	$150	39.7	$2.00	$175	17.8
$1.50	$175	40+	$2.00	$200	31.3
			$2.00	$225	40+
Oil	Pellets	Payback	Oil	Pellets	Payback
$2.50	$200	10.6	$3.00	$225	7.8
$2.50	$225	13.4	$3.00	$250	9.3
$2.50	$250	19.9	$3.00	$275	11.4
$2.50	$275	35.5	$3.00	$300	16.4
$2.50	$300	40+	$3.00	$325	22.5
Oil	Pellets	Payback	Oil	Pellets	Payback
$3.50	$275	7.1	$4.00	$300	5.8
$3.50	$300	8.3	$4.00	$325	6.5
$3.50	$325	10	$4.00	$350	7.5
$3.50	$350	12.4	$4.00	$375	8.8
$3.50	$375	18.2	$4.00	$400	10.7

Oil is price per gallon, pellets is price per ton
Payback in years and reflects 'Equity Payback' (includes fuel escalation, etc. per appendix)

Generally a project is not advised if the equity payback exceeds 15 years and it is never recommended if the equity payback exceeds the project life (in this case estimated at 25 to 40 years depending on the number of equipment rebuilds). Due to the broad distribution of the project financials, it is recommended that a pellet boiler project is not executed until the pellet market has demonstrated a better balance of supply and demand. With recent prices between $1.75-$2.00 for #2 fuel oil and $210-$240 per ton for pellets, the project would fall into a *grey* area where it is not financially viable. The sensitivity analysis demonstrates that a price increase as little as $25 per ton in certain ranges can have a dramatic effect on the project economics. If over the next 12 to 18 months prices trend toward the *green* ranges in the table, then the project should be considered. It may be prudent to move forward with much of the detailed design and permitting work immediately, so that the project is ready to execute once the market has stabilized.

Appendix CS   Control System Upgrade   Town of Shutesbury   Elementary School

Apr-09

			Base Case				Proposed				Annual Savings			Total Est.	Simple
Area	ECM#	Description	Annual Usage	Efficiency	Net Energy	Annual Cost		Efficiency	Net Energy MMBTU					Cost	Payback
			Gallons	X zone %	MBTU			X zone	MBTU		MBTU	Gallons	$		
	CS1	DDC Upgrade	16,630	78.0%	1799	$39,912		78.0%	1667		132	951	$2,282	$9,150	4.0
Total	CSs	Control System	16,630								132	951	$2,282	$9,150	4.0
Fuel Type:	Oil														
Cost:	$2.40														

Opinion of Cost

Measure	Item	Detail	UOM	Qty	Equip (ea)	Matl (lot)	Labor (hr)	Labor rate	Subtotal	Engineering	Conting	Total	Source
										12%	10%		
CS1		DDC Upgrade	ea	1	$3,000	$0	60	$75	$7,500	$900	$750	$9,150	Est

Appendix BE Building Envelope Upgrade Town of Shutesbury Elementary School

Apr-09

			Base Case				Proposed				Annual Savings			Total Est.	Simple
Area	ECM#	Description	Annual Usage	Efficiency	Net Energy	Annual Cost	Annual Usage (	Efficiency	Net Energy	Annual Cost				Cost	Payback
			Gallons		MBTU		Gallons		MBTU		MBTU	Gallons	$		
	BE1	Airsealing	17060	78.0%	1845.52009	$40,944	16630	78.0%	1799	$39,912	60	430	$1,032	$15,006	14.5
Total	BEs	Building Envelope	17,060							39,912	60	430	$1,032	$15,006	14.5
Fuel Type:	Oil														
Cost:	$2.40														

Opinion of Cost

Measure	Item	Detail	UOM	Qty	Equip (ea)	Matl (lot)	Labor (hr)	Labor rate	Subtotal	Engineering	Conting	Total	Source
										12%	10%		
BE1		Airsealing	ea	1	$0	$300	160	$75	$12,300	$1,476	$1,230	$15,006	Est
													Est
													Est
													Est
													Est

Appendix OS

Occupancy Sensors - Lighting

Town of Shutesbury

Elementary School

Apr-09

			Base Case				Proposed				Annual Savings			Total Est.	Simple
Area	ECM#	Description	Annual	Fixture	Fixture	Annual Usage	Annual Usage (	Fixture	Fixture	Annual Usage				Cost	Payback
			Hours	Quantity	Wattage	kWh	Hours	Quantity	Wattage	kWh	kW	kWh	$		
	OS1	Gym	1600	12	214	4,109	1200	12	214	3,082	0.00	1027	$98	$681	7.0
	OS2	Hallways	1600	15	57	1,368	1200	15	57	1,026		342	$32	$747	23.0
Total	OSs	Occupancy Sensors				5,477					0	1369	$130	$1,427	11.0
Power	Electric														
Cost:	$0.10	kWh	$6.62	kW											

Opinion of Cost

Measure	Item	Detail	UOM	Qty	Equip (ea)	Matl (lot)	Labor (hr)	Labor rate	Subtotal	Engineering		Conting	Total	Source
										12%		10%		
OS1	Occ Sens	Occupancy Sensor	ea	6	$58	$0	0.5	$70	$558	$67		$56	$681	Est
OS2	Occ Sens	Occupancy Sensor	ea	4	$58	$100	1	$70	$612	$73		$61	$747	Est

Appendix MC

Motor Controls

Town of Shutesbury

Elementary School

Apr-09

			Base Case				Proposed				Annual Savings			Total Est.	Simple
Area	ECM#	Description	Elec Use	Heat Loss	System	Annual Cost	Elec Use	Heat Loss	System	Annual Cost				Cost	Payback
			kWh	MMBTU	Efficiency		kWh	MMBTU	Efficiency		Gallons	kWh	$		
	MC1	Sensors	0	263.6	80%	$5,702	0	181.2	80.0%	$3,920	742	0	$1,782	$8,638	4.8
	MC2	VFDs	15248	0.0	80%	$1,449	7624	0.0	80.0%	$724	0	7624	$724	$10,004	13.8
	MC3	Circ Pump Timer	1953	28.0	80%	$791	976	14.0	80.0%	$395	126	976	$395	$805	2.0
Total	MCs	Motor Controls	17,201	292		$7,942	8,600	195		$5,040	869	8600	$2,902	$19,447	6.7
Fuel Type:	Oil	Electric													
Cost:	$2.40	$0.10													

Opinion of Cost

Measure	Item	Detail	UOM	Qty	Equip (ea)	Matl (lot)	Labor (hr)	Labor rate	Subtotal	Engineering	Conting	Total	Source
										12%	10%		
MC1	Sensors	CO2 Controls	ea	3	$400	$1,200	24	$65	$7,080	$850	$708	$8,638	Quote
MC2	VFD	VFD for 20 & 8 HP fans	ea	2	$1,500	$1,000	30	$70	$8,200	$984	$820	$10,004	Est
MC3	Timer	Circ Pump Timer	ea	3	$80	$0	2	$70	$660	$79	$66	$805	Est

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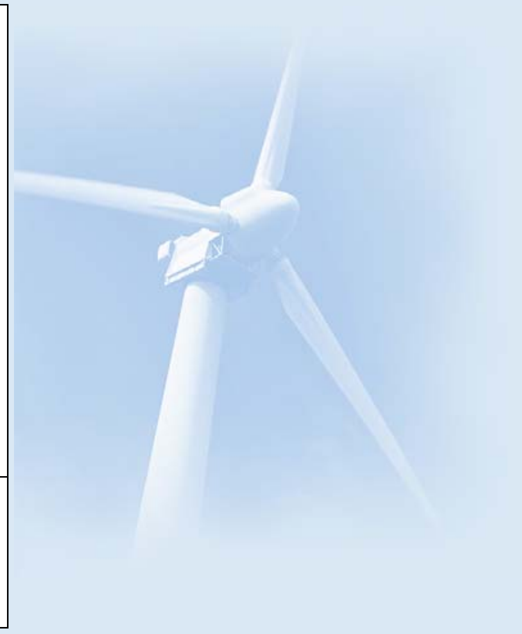
www.retscreen.net

Clean Energy Project Analysis Software

Project information

See project database

Project name	Shutesbury Elementary
Project location	Shutesbury, MA
Prepared for	DOER
Prepared by	Precision Decisions LLC
Project type	Heating
Technology	Biomass system
Analysis type	Method 2
Heating value reference	Higher heating value (HHV)
Show settings	☑
Language - Langue	English - Anglais
User manual	English - Anglais
Currency	$
Units	Imperial units



Site reference conditions

Select climate data location

Climate data location	Albany
Show data	☑

	Unit	Climate data location	Project location
Latitude	˚N	42.8	42.8
Longitude	˚E	-73.8	-73.8
Elevation	m	89	89
Heating design temperature	°C	-16.6	
Cooling design temperature	°C	29.8	
Earth temperature amplitude	°C	21.5	

Month	Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
	°C	%	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January	-5.9	71.2%	1.77	100.7	4.4	-6.8	741	0
February	-4.4	68.5%	2.64	100.7	4.5	-5.1	627	0
March	1.3	64.8%	3.62	100.6	4.8	0.4	518	0
April	8.1	61.2%	4.66	100.4	4.7	7.3	297	0
May	14.5	65.7%	5.48	100.5	4.0	14.3	109	140
June	19.2	69.7%	6.01	100.4	3.7	19.7	0	276
July	21.9	70.6%	6.05	100.5	3.4	22.1	0	369
August	20.5	74.1%	5.19	100.6	3.2	20.9	0	326
September	16.1	75.7%	4.11	100.8	3.3	16.4	57	183
October	10.0	72.4%	2.81	100.8	3.6	9.2	248	0
November	4.3	73.1%	1.71	100.7	4.2	2.9	411	0
December	-2.7	74.0%	1.41	100.7	4.3	-3.5	642	0
Annual	8.6	70.1%	3.79	100.6	4.0	8.2	3,650	1,294
Measured at (m)					10.0	0.0		

NASA UNEP GEF reeep

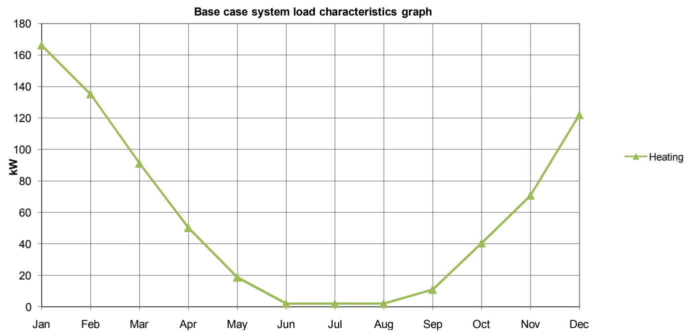
Complete Load & Network sheet

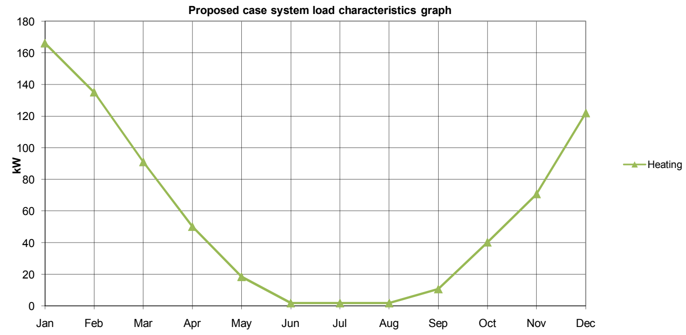
RETScreen4 2008-04-22 NRCan/CETC - Varennes

RETScreen Load & Network Design - Heating project

Heating project	Unit	
Base case heating system	Single building - space heating	
Heated floor area for building	ft²	32,000
Fuel type		Diesel (#2 oil) - gal
Seasonal efficiency	%	78%
Heating load calculation		
Heating load for building	(Btu/h)/ft²	28.0
Domestic hot water heating base demand	%	4%
Total heating	million Btu	1,858
Total peak heating load	million Btu/h	0.9
Fuel consumption - annual	gal	17,295
Fuel rate	$/gal	2.500
Fuel cost		$ 43,236
Proposed case energy efficiency measures		
End-use energy efficiency measures	%	0%
Net peak heating load	million Btu/h	0.9
Net heating	million Btu	1,858

RETScreen Load & Network Design - Heating project





Proposed case load and energy		Heating
System peak load	million Btu/h	1
System energy	million Btu	1,858

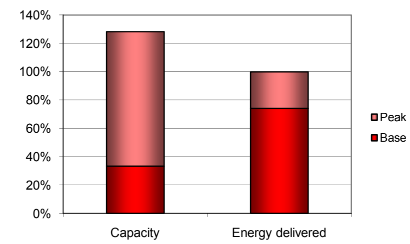
RETScreen Energy Model - Heating project

☐ Show alternative units

Proposed case heating system				
System selection		Base load system		
Base load heating system				
Technology		Biomass system		
Fuel selection method		Single fuel		
Fuel type		Wood - pellets		
Fuel rate	$/t	200.000		
Biomass system				
Capacity	million Btu/h	0.3	33.5%	See product database
Heating delivered	million Btu	1,378	74.2%	
Manufacturer		X		
Model		X		
Seasonal efficiency	%	76%		
Boiler type		Hot water		
Fuel required	million Btu/h	0.4		

Proposed case system characteristics	Unit	Estimate	%	
Heating				
Base load heating system				
Technology		Biomass system		
Capacity	million Btu/h	0.3	33.5%	
Heating delivered	million Btu	1,378	74.2%	
Peak load heating system				
Technology		Boiler		
Fuel type		Diesel (#2 oil) - gal		
Fuel rate	$/gal	2.500		
Suggested capacity	million Btu/h	0.6		
Capacity	million Btu/h	1	94.9%	
Heating delivered	million Btu	479.2	25.8%	
Manufacturer		X	See PDB	
Model		S	4 unit(s)	
Seasonal efficiency	%	78%		
Back-up heating system (optional)				
Technology				
Capacity	kW			

System design graph



Proposed case system summary	Fuel type	Fuel consumption - unit	Fuel consumption	Capacity (kW)	Energy delivered (MWh)
Heating					
Base load	Wood - pellets	t	97	88	404
Peak load	Diesel (#2 oil)	gal	4,461	249	140
			Total	**337**	**544**

RETScreen Cost Analysis - Heating project

Settings			
Method 1 (selected)	Notes/Range (selected)		
Method 2	Second currency	Notes/Range	None
	Cost allocation		

Initial costs (credits)	Unit	Quantity	Unit cost	Amount	Relative costs
Feasibility study					
Feasibility study	cost	1	$ 6,000	$ 6,000	
Sub-total:				**$ 6,000**	4.9%
Development					
Development	cost			$ -	
Sub-total:				**$ -**	0.0%
Engineering					
Engineering	cost	1	$ 24,000	$ 24,000	
Sub-total:				**$ 24,000**	19.6%
Heating system					
Base load - Biomass system	million Btu/h	0.3	$ 80,000	$ 24,000	
Peak load - Boiler	million Btu/h	0.9	$ -	$ -	
Energy efficiency measures	project			$ -	
User-defined	cost	1	$ 45,000	$ 45,000	
				$ -	
Sub-total:				**$ 69,000**	56.3%
Balance of system & miscellaneous					
Spare parts	%		$ 3,000	$ -	
Transportation	project		$ 3,500	$ -	
Training & commissioning	p-d		$ 2,500	$ -	
Shed Relocation	cost	1	$ 7,500	$ 7,500	
Contingencies	%	15.0%	$ 106,500	$ 15,975	
Interest during construction			$ 122,475	$ -	
Sub-total:		Enter number of months		**$ 23,475**	19.2%
Total initial costs				**$ 122,475**	100.0%

Annual costs (credits)	Unit	Quantity	Unit cost	Amount
O&M				
Parts & labour	project	144	$ 25	$ 3,600
User-defined	cost	1	$ 500	$ 500
Contingencies	%	10.0%	$ 4,100	$ 410
Sub-total:				**$ 4,510**
Fuel cost - proposed case				
Diesel (#2 oil)	gal	4,461	$ 2.500	$ 11,154
Wood - pellets	t	97	$ 200.000	$ 19,435
Sub-total:				**$ 30,589**

Annual savings	Unit	Quantity	Unit cost	Amount
Fuel cost - base case				
Diesel (#2 oil)	gal	17,295	$ 2.500	$ 43,236
Sub-total:				**$ 43,236**

Periodic costs (credits)	Unit	Year	Unit cost	Amount
User-defined	cost	15	$ 14,000	$ 14,000
		25	$ 28,000	$ 28,000
End of project life	cost			$ -

RETScreen Financial Analysis - Heating project

Financial parameters

General

Fuel cost escalation rate	%	5.0%
Inflation rate	%	3.0%
Discount rate	%	0.0%
Project life	yr	40

Finance

Incentives and grants	$	
Debt ratio	%	

Income tax analysis

Annual income

Electricity export income

GHG reduction income

Net GHG reduction	tCO2/yr	127
Net GHG reduction - 40 yrs	tCO2	5,081

Customer premium income (rebate)

Other income (cost)

Clean Energy (CE) production income

Project costs and savings/income summary

Initial costs			
Feasibility study	4.9%	$	6,000
Engineering	19.6%	$	24,000
Heating system	56.3%	$	69,000
Balance of system & misc.	19.2%	$	23,475
Total initial costs	**100.0%**	**$**	**122,475**
Annual costs and debt payments			
O&M		$	4,510
Fuel cost - proposed case		$	30,589
Total annual costs		**$**	**35,099**
Periodic costs (credits)			
User-defined - 15 yrs		$	14,000
		$	28,000
Annual savings and income			
Fuel cost - base case		$	43,236
Total annual savings and income		**$**	**43,236**

Financial viability

Pre-tax IRR - equity	%	11.6%
Pre-tax IRR - assets	%	11.6%
After-tax IRR - equity	%	11.6%
After-tax IRR - assets	%	11.6%
Simple payback	yr	15.1
Equity payback	yr	10.6
Net Present Value (NPV)	$	1,017,062
Annual life cycle savings	$/yr	25,427
Benefit-Cost (B-C) ratio		9.30
GHG reduction cost	$/tCO2	(200)

Yearly cash flows

Year #	Pre-tax $	After-tax $	Cumulative $
0	-122,475	-122,475	-122,475
1	8,635	8,635	-113,840
2	9,159	9,159	-104,681
3	9,713	9,713	-94,968
4	10,297	10,297	-84,671
5	10,914	10,914	-73,757
6	11,564	11,564	-62,194
7	12,250	12,250	-49,944
8	12,973	12,973	-36,971
9	13,736	13,736	-23,235
10	14,541	14,541	-8,694
11	15,389	15,389	6,695
12	16,283	16,283	22,978
13	17,226	17,226	40,204
14	18,220	18,220	58,423
15	-2,545	-2,545	55,879
16	20,371	20,371	76,249
17	21,534	21,534	97,784
18	22,760	22,760	120,544
19	24,052	24,052	144,595
20	25,412	25,412	170,007
21	26,846	26,846	196,853
22	28,356	28,356	225,209
23	29,946	29,946	255,156
24	31,622	31,622	286,777
25	-25,239	-25,239	261,538
26	35,244	35,244	296,782
27	37,201	37,201	333,984
28	39,262	39,262	373,245
29	41,431	41,431	414,676
30	9,734	9,734	424,410
31	46,120	46,120	470,530
32	48,651	48,651	519,181
33	51,316	51,316	570,497
34	54,121	54,121	624,619
35	57,074	57,074	681,692
36	60,181	60,181	741,874
37	63,452	63,452	805,325
38	66,894	66,894	872,219
39	70,516	70,516	942,735
40	74,327	74,327	1,017,062

Cumulative cash flows graph