Energy Audit

Sudbury Flynn Building

278 Old Sudbury Road
Sudbury, MA 01776

Prepared for:
Massachusetts Department of Energy Resources
Energy Audit Program

Prepared by:
Russell Friend PE
Facility Energy Consultants, LLC
800 Purchase Street, Suite 314
New Bedford, MA 02740

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Executive Summary

The Massachusetts Department of Energy Resources contracted with Facility Energy Consultants, LLC, (FEC) to conduct an energy audit of the subject property, Sudbury Flynn Building, located at 278 Old Sudbury Road, Sudbury, Massachusetts 01776. The audit consisted of a building evaluation aimed at 1) assessing the overall energy usage efficiency of the building and its on-site systems, 2) identifying potential energy areas of improvement in these systems based on a maximum of a 15 year payback period, and 3) where applicable, proposing “clean energy” alternatives to the current systems where future energy savings could be realized. Included as part of the audit was a review of the building’s construction features, its historical energy costs, discussions with the local utilities concerning the property’s energy usage, and discussions with the prime energy equipment suppliers/manufactures for the purpose of determining more efficient alternatives. The energy audit site visit was performed on June 17, 2009.

1.1 General Description of Building

The Sudbury Flynn Building is a two-story building with a basement which reportedly contains 15,916 interior square feet. The building was reportedly originally constructed around 1900. A subsequent addition was completed around 1960. The basement space houses the mechanical room, a maintenance office and shop, and a finished computer training room. The first and second floors are all office spaces that house town government offices.

The Flynn building has recently received a lighting audit through NSTAR’s retrofit program. Lighting was not considered as part of this audit.

Mr. Jim Kelly served as the on-site representative for the energy audit.

1.2 ECM Table

FEC has identified 4 Energy Conservation Measures (ECMs) for this property. The following table summarizes these ECMs in terms of description, the initial investment required to implement these ECMs and their impact on energy and cost savings.

Proposed ECMs			Effect on connected electrical load (kW)	Annual Energy Usage								Annual Reduction in Greenhouse Gas (CO_2) Emissions (Tons)	Annual Savings
#	Description	Installed Cost		Existing			Savings with ECM			% Reduction			
				KWh	MMBTU		KWh	MMBTU					
					Primary Fuel	Backup Fuel		Primary Fuel	Backup Fuel	KWh	MMBTU		
1	On-Demand Water Heaters	$ 1,400	-0.257	170755	3.84		-616	3.84		-0.4%	100.0%	-0.06	$ 189
2	Insulate Water Pipes	$ 900			635.4			15.7			2.5%	0.83	$ 236
3	Increase Radiator Output	$ 4,050	1.8	170755	635.4		4320	-18.72		2.5%	-2.9%	0.84	$ 410
4	Replace Refrigerators	$ 1,500	0.1402	2200			1228			55.8%		0.52	$ 196
	Total:	$ 7,850		170755	635.4		4932	0.82		2.9%	0.1%	2.13	$ 1,032

1.3 Financial Summary

If these ECMs are implemented, the Sudbury Flynn Building can potentially save approximately $1,032 per year with an investment of $7,850.

1.4 Clean Tech

There currently does not appear to be clean technology opportunities available at the Sudbury Flynn Building; however, it is believed that the Flynn Building could be the benefactor of a solar PV system that potentially could be installed on the adjacent Noyes Elementary roof.

2 Introduction

Through the Energy Audit Program (EAP) offered by the Commonwealth of Massachusetts, Department of Energy Resources (DOER), technical assistance is provided to cities, towns, regional school districts and wastewater districts to identify capital improvements to reduce energy costs.

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, support performance contracting or justify a municipal bond funded improvement program. EAP 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 buildings and associated systems and equipment, including both process systems and building systems. The major areas covered in the audit included the building envelope, electrical systems, HVAC systems, lighting systems and operational and maintenance procedures. Another element of the audit is 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.

Facility Energy Consultants, LLC, (FEC) is pleased to submit this Energy Audit for the subject property. Our services have been performed in accordance with the scope of services and terms and conditions in FEC's contract with the Massachusetts Department of Energy Resources dated January 26. 2009.

The conclusions, recommendations, and financial implications presented in this report are based on a brief review of available drawings, interviews with key personnel who have a working knowledge of this property, our site observations, and our experience on similar projects. Observations were made by a trained professional or professionals but there may be energy conservation opportunities at the facility that were not readily accessible, not visible or which were inadvertently overlooked. Additional energy conservation measures may develop with time that were not evident at the time of this audit.

Recommendations presented in this report are conceptual in nature and are not intended to serve as a scope of work for implementation. Additional assessment and preparation of construction drawings may be required in order to develop a formal scope of work and to develop actual implementation budgets.

Opinions of probable capital costs are intended only to provide an order of magnitude or scale of the recommendations and were prepared, without developing a formal scope of work. The Opinions of Probable Costs were based on a combination of sources including published sources of cost data such as R.S. Means, discussions with the site contact(s) and others identified in this report and our experience with other projects. Actual costs will be dependant upon many factors that are beyond FEC's control including but not limited to the quality of the type and design of the remedy/replacement, quality of the materials and installation, manufacturer and type of equipment or system selected, field conditions, the extent of work performed at any one time, whether items are purchased individually or under a master purchase contract, and other factors. Additionally, bids for work can vary widely (e.g., 50-percent to 200-percent of the mean bid). If any of the opinions of probable capital costs presented herein are considered critical in making decisions about the Subject Property, FEC recommends that formal scopes of work be developed and quotations be obtained from contractors or suppliers, prior to making a final decision on the property.

3 Facility Description

The Sudbury Flynn Building, which reportedly contains 15.916 interior square feet, is a two-story building with a basement. The building was reportedly originally constructed around 1900. A subsequent addition was completed around 1960. The basement space houses the mechanical room, a maintenance office and shop, and a finished computer training room. The first and second floors are all office spaces that house town government offices.

The building is typically open from 8:00 am to 4:00 pm Monday-Friday. The estimate is that the building is at least occupied for around 2,400-hours per year. A total of approximately forty town employees have offices within this building.

The building is of brick in the basement and is assumed to be wood framed above grade. The roof is pitched and flat with slate over the pitched areas and single-ply membrane over the flat roof. The windows are double-pane insulated. There are multiple entrances with both wood and insulated steel doors. Most entrance doors open to staircases leading to the second floor with additional sets of doors leading to the interior areas at the top and bottom of the steps. Original arched windows located in the staircases have not been upgraded remain single-paned.

Heating is provided by a P-K Thermific near-condensing hot water natural gas-fired boiler rated at 1,200, 000 BTUH input and 1,020,00 BTU output. Two three-HP circulator pumps deliver hot water to radiators and cabinet heaters located throughout the building.

The basement spaces are heated with a perimeter hot water radiant loop. Heating control in some spaces is by a hand-operated ball valve on the radiators. A one-ton window unit is located in the maintenance space in the basement. Otherwise the basement is not air conditioned.

The first and second floors are also heated with a radiant hot water perimeter loop in each office space. Actuators on the radiators in these spaces are controlled thermostatically. There were complaints from some of the staff about uncomfortable conditions in the winter in certain locations. Many 1500 watt electric space heaters were evidence of the uncomfortable conditions. Window and through-the-wall air conditioners serve most of the office spaces. An interior server room and an information services room are served by 1.5 ton split system A/C units.

The heating system's control functions include outside air boiler controls, programmable circulation pump control and individual thermostatic zone control of radiator valves in each of the spaces.

Domestic hot water is supplied to the offices by a 30-gallon electric water heater located in the basement. This system serves four restroom spaces and a kitchen area in the building.

The interior lighting of commonly used spaces is primarily T12 lighting with magnetic ballasts. The lighting is scheduled for an upgrade.

The interior areas are finished with drywall and plaster. Floors are typically the original hard wood flooring with some carpeting and tiled spaces. Ceilings typically use dropped panels, although the ceilings are still nine feet above in most spaces.

4 Energy Usage Analysis and Benchmarking

4.1 Usage Analysis

The following table summarizes the basic energy rates and FY08 energy cost expenditure data that formed the basis for many of the calculations in this report.

Utility	Provider	Rates	FY08 Expenditures
Electric	NSTAR	$ 0.163/kWh	$27,787.00
Gas	NGRID	$1.87/therm	$11,872.00
#2 Oil	NA	NA	NA
Water & Sewer		NA	NA
Propane Gas		NA	NA
TOTALS			**$ 39,659.00**

The following table lists the building's area and its total energy and cost indices. The total energy index is a measure of energy intensity, or annual energy usage per square foot of building area. Similarly, the energy cost index is a measure of annual energy costs per square foot of building area.

Heated Area (SF)	Total Annual Cost Of Energy ($)	Energy Cost Index $/SF-Year	Total Energy Index (KBTU/SF-YR)
15,916	$ 39,659	$2.49	77

4.2 Benchmarking in Energy Star

Benchmarking has been employed in order to make determinations of the relative energy efficiency of this facility. FEC, in cooperation with the Massachusetts Department of Energy Resources, is using the Portfolio Manager tool developed by the Federal EPA. The Portfolio Manager tool allows the input of historic utility data of a facility to be compared to normalized data of a large database of buildings of its peers.

Energy Star has compiled a database of some facility types sufficient to allow energy use comparisons.

The energy use metric (energy intensity) of KBTU/SF/yr was used as a general guide to determine the efficiency of this facility. Sudbury Flynn Building's energy intensity is 77 KBTU/SF/YR with an energy cost of $2.49 per square foot. Both of these figures are high. Based on this, it was determined that this facility should be audited for potential energy savings measures.

After adjustment of some building assumptions, this building rated in the 63rd percentile for energy efficiency against Energy Star's Office Building database.

The results generated by Portfolio Manager related to this facility are displayed below in section 4.3.

4.3 Statement of Energy Performance

Energy Performance Comparison

	Evaluation Periods		Comparisons		
Performance Metrics	**Current** (Ending Date 06/30/2008)	**Baseline** (Ending Date 06/30/2008)	**Rating of 75**	**Target**	**National Average**
Energy Performance Rating	63	63	75	N/A	50
Energy Intensity					
Site (kBtu/ft2)	77	77	66	N/A	89
Source (kBtu/ft2)	164	164	141	N/A	191
Energy Cost					
$/year	$ 39,658.00	$ 39,658.00	$ 34,165.06	N/A	$ 46,192.53
$/ft2/year	$ 2.49	$ 2.49	$ 2.15	N/A	$ 2.90
Greenhouse Gas Emissions					
$MtCO_2e$/year	106	106	91	N/A	123
$kgCO_2e$/ft2/year	7	7	6	N/A	8

5 Energy Conservation Measures

FEC has identified 4 Energy Conservation Measures (ECMs) for this property. The following table summarizes these ECMs in terms of description, the initial investment required to implement these ECMs and their impact on energy and cost savings.

Proposed ECMs			Effect on connected electrical load (kW)	Annual Energy Usage								Annual Reduction in Greenhouse Gas (CO_2) Emissions (Tons)	Annual Savings
				Existing			Savings with ECM			% Reduction			
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If these ECMs are implemented, the Sudbury Flynn Building can potentially save approximately $1,032 per year with an investment of $7,850.

5.1 ECM Discussion

FEC has identified 5 Recommended Energy Conservation Measures (ECMs) for this property. The following paragraphs describe each of these ECMs along with the initial annual energy savings and payback period for each ECM.

5.1.1 Install On-Demand Water Heaters

Existing water heater

An electric 30 gallon centrally located water heater is used to provide domestic hot water to the building's restrooms and kitchenette. There is no circulation on this supply, so as the hot water is demanded from a faucet far from the water heater it takes some time for this water to warm up. The hot water supply pipes are not insulated. One drawback from this system is convenience. Since most of the demand is for short periods of hand washing, the wait time for hot water is inconvenient. From an energy perspective, energy is lost to the distribution piping and its surroundings each time hot water is called for and there are inherent stand-by losses with the water heater. In addition, the cost of electric heat is more expensive than that provided by natural gas.

One solution could be to convert this unit to natural gas for cost savings. Another would be to install small electric on-demand water heaters at each of the points of demand. This would eliminate the wait time and the sources of system inefficiency.

Recommendation: It is recommended to install on-demand hot water heaters beneath the sinks at each point of use. A 2.5 gallon unit is suggested for each sink location and a 6 gallon unit is recommended for the kitchenette.

Cost to implement	$1,400.00	Est. annual cost savings	$189.00	Payback period	7.4 years

5.1.2 Install Insulation Hot Water Piping

Uninsulated hot water piping

Hot water piping in the area around the boiler was observed to be missing insulation. These pipes are in semi-unconditioned spaces. Most of the heat that is dissipated through these uninsulated pipes will not contribute to building heat.

Recommendation: Hot water piping should be insulated - particularly if it runs through spaces that are not conditioned as the heat lost does not contribute to building heating. It is recommended that uninsulated hot water piping be insulated.

Cost to implement	$900.00	Est. annual cost savings	$236.00	Payback period	3.8 years

5.1.3 Increase Radiator Output

One of many existing electric space heaters

Some of the office workers are uncomfortably cold in the winter. In order to maintain comfort, they use electric space heaters. Electric heat is expensive. It would be more cost effective to use the central hot water loop to provide additional heating to cold spaces in the building.

Airflow across a radiator can increase its output. Small fan units can be added to or near radiators to increase their heat output. Even more heat can be generated by installing a cabinet heater on the steam or water loop. The only electric required for these type heaters is the electric to run the small fan motor.

Recommendation: It is recommended that small fan units be located in cold areas of the office in lieu of electric space heaters.

Cost to implement	$4,050	Est. annual cost savings	$410.00	Payback period	9.9 years

5.1.4 Replace inefficient Refrigerator

Existing

Two older model refrigerators, a staff room refrigerator and a refrigerator in the basement are in use in the Flynn building. More energy efficient refrigerators are available.

Recommendation: It is recommended to replace the existing refrigerator with an Energy Star rated equivalent that uses 470 kWh per year or less.

Cost to implement	$ 700.00	Est. annual cost savings	$ 86	Payback period	8.1 years

5.2 Other ECMs Considered

The building has over fifteen window unit air conditioners, a two split system air conditioner to cool each of the spaces. Each window unit and split system is on its own thermostat. A sampling of Energy Efficiency Ratios (EER) of these units was shown to be between 7.1 and 10.7 EER with most of the lower EERs attributed to the larger window and though-the-wall units.

Due to the nature of the building, each space has a variable cooling demand. According to the building representative, the Information Services room no longer has a heating requirement as the internal heat output of electrical equipment keeps this space in continuous cooling mode.

In addition to the unique cooling demands and inefficiency of the existing system, the many window units detract from the appearance of the building.

An air conditioning technology that has a long track record outside of the United States and that is gaining acceptance here is a Variable Refrigerant Volume (VRV) System. This system uses a central condensing unit to supply variable volume of refrigerant to each of many small indoor units each supplying cooling to each of the spaces. The benefits are two-fold. First, it is easy to retrofit into an existing structure and its efficiencies can range between 13 and 14 EER. Window units could be removed and individual space zone control would be maintained.

Initial calculations for this system show annual energy savings around $4,000 per year. However, since this system is an engineered system and installation costs are difficult to determine, this was not included as an ECM. It is expected that the cost of a fully installed system may be $80,000 or more. Based on this, the system's justification would need to be based on more than just energy efficiency. Maintenance cost reduction, window and wall unit replacement costs, and aesthetic enhancement combined with energy efficiency would likely make this a sensible solution for the Flynn Building.

It is recommended that all computers be configured to go into sleep mode after a predetermined time period set by the library staff. Instructions for installing this feature on any computer are available from the following Energy Star website:

http://www.energystar.gov/index.cfm?c=power_mgt.pr_power_mgt_implementation_res#tech_assistance

This low to no cost ECM can save up to $60 per year per computer in a typical office setting. Because this is potentially a no-cost ECM and because the computer use patterns are unknown, this was not considered as an ECM.

6 Operational and Maintenance Analysis

The quality of the maintenance and operation of the facility's energy systems 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 property. These actions, which have been divided into specific and general recommendations, will insure that the energy conservation measures identified in this report will remain effective. The following general recommendations should be continued or implemented.

Building Envelope

1. Caulking and weather stripping is functional and effective.
2. Holes are patched in the building envelope.
3. Cracked or fogged windowpanes are repaired.
4. Automatic door closing mechanisms are functional.
5. Interior vestibule doors are closed.

Heating and Cooling

6. Temperature settings are reduced in unoccupied areas and set points are seasonally adjusted.
7. Equipment is inspected for worn or damaged parts.
8. Heating is uniform throughout the designated areas.
9. Evaporator and condenser coils in AC equipment are clean.

Domestic Hot Water

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

Lighting

13. Only energy efficient replacement lamps are used and in-stock.
14. Lighting fixture reflective surfaces and translucent covers are clean.
15. Walls are clean and bright.
16. Timers and/or photocells are operating correctly on exterior lighting.

Miscellaneous

17. Refrigerator and freezer doors close and seal correctly.
18. Office/computer equipment is either in the “sleep” or off mode when not used.

7 Clean Technology 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

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 "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.

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, underfloor 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 especially with summer locker room or kitchen usage, fire stations, and public housing facilities. On a periodic basis, the DOER accepts grant applications for solar hot water systems.

[1] Web site: www.commonwealthsolar.org

Solar at Sudbury Flynn Building

Solar PV mounted to the roof of the Sudbury Flynn Building is not recommended; however, the adjacent roof of the Noyes School appears to be at the right orientation and with a clear sky. This configuration may allow the Noyes School to be a good candidate for a solar PV array. Since the school is not in operation during the summer when a solar array can be most beneficial, FEC is recommending consideration of tying the Flynn Building to the array so that summertime peak loads may be offset by the array at a time when the school's loads are low. This may allow a Noyes School solar array to be cost effective.

The current domestic hot water demand is relatively low. For this reason, a solar hot water feasibility study is not recommended for this facility.

Wind

The Massachusetts Renewable Energy Trust's (MRET) Commonwealth Wind initiative will provide an overarching framework to expand investments for wind energy installations in Massachusetts and help the Commonwealth meet Governor Deval Patrick's 2000 MW by 2020 wind goals as well as the Renewable Portfolio Standard (RPS). MRET will formally launch Commonwealth Wind during the summer of 2009 and additional details on the program will be available then. The three types of projects listed below would qualify for technical and/or financial assistance:

- Commercial scale projects that primarily serve wholesale markets
- Community-scale projects in the 100 kW to approximately2 MW range where the project sponsor and primary beneficiary is a private company or organization, a municipality, or a government agency, and
- Small-scale projects under 100 kW serving residential, small commercial or institutional buildings.

Wind at Sudbury Flynn Building

Based on the wind map of Massachusetts provided by the U.S. Department of Energy, Sudbury is located in a Class 1 or 2 wind region. A Class 1 wind is defined as wind power rated at 0-200 watts/square meter at a height of 50 feet. Class 2 wind is defined as wind power rated at 200 to 300 watts/square meter. These are the lowest wind power designation and regions with a Class 1 and 2 designations are typically not recommended for wind energy projects. A Massachusetts wind resource map can be found at the following web site: http://www.windpoweringamerica.gov/maps_template.asp?stateab=ma

Wood Pellet Fueled Heating

On a periodic basis, the DOER accepts grant applications for wood pellet fueled heating systems[2], 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.

Wood Pellet Heating for Sudbury Flynn Building

Biofuels are typically attractive alternatives as a heating fuel in locations where wood pellets are available in bulk, the heating demand is sufficient to justify the investment, and when heating fuels with a greater cost than natural gas are the only alternatives. Sudbury does not meet this profile and biofuel heating is not recommended as a cost effective alternative.

[2] http://www.mass.gov/Eoca/docs/doer/pub_info/doer_pellet_guidebook.pdf

7.1 Recommended Clean Energy Projects for Sudbury Flynn Building

There currently does not appear to be clean technology opportunities available at the Sudbury Flynn Building, however, it is believed that the Flynn building could be the benefactor of a solar PV system that could be potentially installed on the adjacent Noyes Elementary roof.

8 Other Considerations

In addition to the actions recommended in Section 6 of this report, the following recommendations should also be considered.

No other recommendations have been identified.

9 Appendices

ECM Calculations

On-Demand Water Heaters					
Current Usage:	Stand-by		standing pilot	Consumption	**Total:**
Stand-by heat loss	2	deg/hr			
Volume	30.00				
Fuel Oil Rate ($/therm)	4.6			38.40	
Boiler Efficiency	100%			100%	
ccf of fuel used/yr	24.18			38.40	
Current Cost	$ 111.22			$ 176.65	$ 287.86
Consumption					
Number of occupants	30		**Capital Cost**		
Set point	110		Installed cost per unit		$ 350.00
Incoming water temp.	50		Number units required		4
Total BTU required/day	10521		Total installed cost		$ 1,400.00
Usage/day/occcupant	0.7				
Days used per year	200		Current fuel cost		$ 287.86
			Proposed fuel cost		$ 98.62
Proposed usage for electric instant water heaters			Annual Cost Savings		$ 189.25
Total kW required/day	3.082				
Total kW required/yr	616.34		**Annual Energy Savings**		
Cost of electricity $/kWh	0.16		**Capital Cost**		$ 1,400.00
Cost of energy for heaters	$ 98.62		**Simple Payback**		7.4

Insulate Water Pipes

Step 1		Obtain total cost of insulating steam and hot water pipes			
				900	$
Step 2		Transfer the following information from the Survey:			
4-45		Heat distribution type (steam or hot water):			
4-48	**a**	Linear feet of uninsulated 3/4" diameter pipe:		540	ft.
4-48	**b**	Linear feet of uninsulated 1" diameter pipe:		#REF!	ft.
4-48	**c**	Linear feet of uninsulated 1-1/2" diameter pipe:		#REF!	ft.
4-48	**d**	Linear feet of uninsulated 2" diameter pipe:		#REF!	ft.
4-48	**e**	Linear feet of uninsulated 3" diameter pipe:		100	ft.
4-48	**f**	Linear feet of uninsulated 4" diameter pipe:		#REF!	ft.
4-48	**g**	Linear feet of uninsulated 6" diameter pipe:		#REF!	ft.
5-9	**h**	Cost of heating fuel:	Gas:	1.5	$/therm
			Oil:	#REF!	$/gal
			Propane:		$/gal
Step 3		Obtain the following value from Table 1:			
Table 1		Savings factors for heat distribution type			
Table 1	**a**	3/4" diameter pipe:		0	
Table 1	**b**	1" diameter pipe:			
Table 1	**c**	1-1/2" diameter pipe:			
Table 1	**d**	2" diameter pipe:			
Table 1	**e**	3" diameter pipe:		0	
Table 1	**f**	4" diameter pipe:			
Table 1	**g**	6" diameter pipe:			

Step 4 Estimate annual energy savings due to conduction losses:

a	3/4" diameter pipe:	2a		3a				
		0.00	x	1.25	=	0	/yr	
b	1" diameter pipe:	2b		3b				
		#REF!	x	0.00	=	#REF!	/yr	
c	1-1/2" diameter pipe:	2c		3c				
		100.00	x	1.57	=	157	/yr	
d	2" diameter pipe:	2d		3d				
		#REF!	x	0.00	=	#REF!	/yr	
e	3" diameter pipe:	2e		3e				
		100.00	x	0.00	=	0	/yr	
f	4" diameter pipe:	2f		3f				
		40.00	x	4.74	=	189.6	/yr	
g	6" diameter pipe:	2g		3g				
		#REF!	x	0.00	=	#REF!	/yr	
h	Total (add all results):					157		

Step 5 Calculate annual cost savings:

4h		2h			
157.00	x	1.50	=	235.5	$/yr

Step 6 Calculate your payback period:

1		5			
900.00	/	235.50	=	3.8	yrs

Table 1: Savings Factors for Insulating Pipes

Heat Distribution Type	Pipe Size	Fuel Type: Gas	Oil	Propane
Hot water	3/4"	1.02	0.73	1.11
	1"	1.28	0.91	1.40
	1-1/2"	2.10	1.50	2.29
	2"	2.58	1.84	2.82
	3"	3.76	2.69	4.10
	4"	4.74	3.39	5.23
	6"	6.82	4.87	7.45
Steam	3/4"	2.16	1.54	2.36
	1"	2.68	1.91	2.93
	1-1/2"	3.96	2.83	4.32
	2"	4.90	3.50	5.35
	3"	7.08	5.06	7.73
	4"	8.96	6.40	9.78
	6"	13.12	9.37	14.32

Savings factors assume pipes are hot 2,000 hours per year. Actual savings will differ in warmer and cooler climates. Derated to 1500 hrs per year for this analysis

Increase Radiator Output						
				Rates		
Electric heater wattage		1.5	kW		0.16	$/kWh
Annual run time/heater		320	hrs		1.5	$/therm
Number of heaters		9				
Annual energy consumption of heaters		4320				
Cost of electrical consumption	$	691.20				
Cost of installation of small air handlers	$	450.00	ea*	Total cost	**$**	**4,050.00**
Energy consumption of heaters		5200	BTUH			
Total Energy Consumption		187.2	therm			
Cost of additional energy consumption	$	280.80				
Annual savings = cost of electric consumption - cost of hot water =				**$**	**410.40**	
Capital cost = $150/unit and $300/unit for installation			Simpe Payback =			9.9

Replace Refrigerators

Efficiency Units

Step 1	Obtain total cost of replacing older refrigerators with high-efficiency units:				
	cost per unit:	$750		$1,500	$
Step 2	Transfer the following information from the Survey:				
4-13	**a** Total number of dwelling units in development:*			2	
4-85	**b** Average age of existing refrigerators:			20	
5-9	**c** Cost of electricity:			0.16	$/kWh
Step 3	Obtain the following value from Table 1:				
Table 1	Approximate annual energy use of each old refrigerator:			1,100	kWh/yr
Step 4	Calculate annual energy savings per refrigerator:				
		3			
		1,100	- 486	= 614	kWh/yr
Step 5	Estimate annual energy savings:				
		2a	4		
		2	x 614.00	= 1,228	kWh/yr
Step 6	Calculate annual cost savings:				
		5	2c		
		1,228	x 0.16	= $196	$/yr
Step 7	Calculate payback period:				
		1	6		
		1,500	/ 196	= 7.6	yrs

Size	Unit Cost	Make	Model	Energy Savings
15.0 CF	716	Whirlpool	ET5WSEXS	442
18.0 CF	776	Whirlpool	ET8FTEXS	486

Table 1: Energy Use of Existing Refrigerators

Age	**Energy Use**	
1970s	1400	kWh/yr
Early 1980s	1100	kWh/yr
Late 1980s	800	kWh/yr

Entered
Calculated