Energy Audit

Edgartown Wastewater Facility

330 West Tisbury Road
P.O. Box 1205
Edgartown, MA 02539

Massachusetts Division of Energy Resources Energy Audit Program

June 30, 2008

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Executive Summary

The Edgartown WWTP was evaluated based on data gathered during site walkdowns, a review of the utility bills and discussions with administration officials. The Energy Usage Summary is provided below:

Building Energy Usage - (MMBtu) *November '06 to October '07*					
	#2 Fuel Oil	LPG	Kerosene	Electricity	Total
WWTP	638	227	48	3,554	4,466
Morgan Way Pump Station	0	0	0	2	2
Dunham Road Pump Station	0	0	0	55	55
Dock StreetPump Station	0	0	0	98	98
Chase Street Pump Station	0	0	0	0	0
Total	638	227	48	3,708	4,621

There are a number of energy conservation measures that have been identified through the audit process, which include system modifications and operational changes. The specific ECMs that are recommended are provided in the table on the following page, along with the associated costs and savings.

The Commonwealth of Massachusetts is dedicated to promoting clean energy as an alternative to traditional sources of energy. As such, 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 table is also provided which lists the specific projects that may be appropriate for various clean energy technologies.

Energy Conservation Measures Summary

ECM #	Description	Cost	Utility Funding	Site Annual Usage						Usage Savings					Annual Cost Savings					Payback (years)
				Electrical		Fuel Oil	LPG	Kerosene	Total	Electrical	Fuel Oil	LPG	Kerosene	Total	Electrical	Fuel Oil	LPG	Kerosene	Total	
				kWh	Avg. kW	MMBtu	MMBtu	MMBtu	MMBtu	kWh	MMBtu	MMBtu	MMBtu	MMBtu	Dollars					
1	Container Room Infrared Heating	$8,864	$0	1,041,493	203	638	227	48	4,467	0	46	0	0	46	$0	$1,564	$0	$0	$1,564	5.7
2	Septage Building Infrared Heating	$13,343	$0	1,041,493	203	638	227	48	4,467	0	0	54	0	54	$0	$0	$1,852	$0	$1,852	7.2
3	Pretreatment Building Heat Pump	$19,222	$250	1,041,493	203	638	227	48	4,467	24,077	0	0	0	82	$3,764	$0	$0	$0	$3,764	5.1
4	Lab Building Heat Pump	$6,453	$250	1,041,493	203	638	227	48	4,467	14,856	0	0	0	51	$2,322	$0	$0	$0	$2,322	2.8
5	Odor Control 15 HP Blower Motor	$993	$0	1,041,493	203	638	227	48	4,467	873	0	0	0	3	$136	$0	$0	$0	$136	7.3
6	Sludge Holding Tank 15 HP Blower Motors	$1,986	$0	1,041,493	203	638	227	48	4,467	2,550	0	0	0	9	$398	$0	$0	$0	$398	5.0
7	Sludge Holding Tank 25 HP Blower Motor	$2,070	$0	1,041,493	203	638	227	48	4,467	2,092	0	0	0	7	$326	$0	$0	$0	$326	6.3
8	Odor Control System Modulation	$5,536	$0	1,041,493	203	638	227	48	4,467	47,219	0	0	0	161	$7,366	$0	$0	$0	$7,366	0.8
Total		**$58,467**	**$500**	**1,041,493**	**N/A**	**638**	**227**	**48**	**4,467**	**91,667**	**46**	**54**	**0**	**413**	**$14,312**	**$1,564**	**$1,852**	**$0**	**$17,728**	**3.3**

Note: Electrical savings/increases were calculated using a loaded rate, which combined usage and demand into a single rate

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Financing Summary		
Description	**Total Project Cost**	**Utility Funding**
Edgartown WWTP	$58,467	$500
Total	**$58,467**	**$500**

Clean Energy Opportunities	
Building	**Opportunity Description**
Pretreatment Building	Installation of water-source heat pumps to heat the upper level of the Pretreatment Building. **Action Item: See ECM #3**
Laboratory Building	Installation of water-source heat pumps to heat the Laboratory building. **Action Item: See ECM #4**
WWTP Site	Installation of a wind turbine to help power existing loads. The site has ample space and sustained winds and is an ideal candidate for a wind turbine. Site management has already begun to pursue this option and other wind turbines have already been successfully sited on the island. **Action Item: Proceed based on results of MTC feasibility study.**
WWTP Site	Installation of solar photovoltaic (PV) cells on select roofs of site buildings. Most of the site buildings have pitched roofs, some of which have a southern orientation with potential for a PV installation. Generally speaking, there is little shading from surrounding trees, but a more detailed feasibility assessment would be required to evaluate each individual roof. **Action Item: Prepare Solar PV Site Selection Survey and submit to DOER.**

Table of Contents

Introduction

Through the Energy Audit Program (EAP) offered by the Commonwealth of Massachusetts, Division 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 (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.

Facility Description

Wastewater Facility

The Edgartown Wastewater Facility, which is located at 330 West Tisbury Road, underwent a large scale upgrade in 1995 and has a design flow rate and average flow rate of 0.75 MGD and 0.35 MGD respectively. The facility serves about 700 customers and employs an advanced wastewater treatment process, which includes a pretreatment building, primary clarifiers, activated sludge process with separate anoxic and aerobic basins (i.e., modified Ludzack-Ettinger process), secondary clarifiers, ultraviolet disinfection, rapid infiltration basins for effluent disposal into Martha's Vineyard's sole source aquifer, sludge processing facilities, and an odor control collection and treatment system. The plant produces approximately 0.43 dry tons of biosolids per day, which is the result of a filter press dewatering process. The effluent is discharged into the beds at a rate of between 4.0 and 5.0 gpd/sf.

Figure 1: Wastewater Treatment Plant

The design of the aforementioned odor control system was based on peak daily summer flow conditions. The system is designed for a chemical oxidation demand of 40-ppm H_2S, with a capacity of 13,000 cfm and a reaction time of 25 seconds. In order to minimize the plume that can be visible when treated air leaves the stack, a dilution damper is installed between the vessels and the fan. When the exhaust fan is operating at high speed, the fan pulls 13,000 cfm through the vessels and an additional 13,000 cfm of fresh air to dilute the treated gas when exiting the stack. While the system has been effective in reducing the number of complaints from area residents, it consumes a relatively large amount of energy, accounting for upwards of one-quarter to one-third of the facility's total electrical consumption.

The primary building is the Operations Building, which is a single story building that contains administrative offices and the previously mentioned filter press process. Additional buildings that were part of the field audit include the Lab Building, Pre-Treatment Building, Post-Treatment Building, Septage Building and Garage. There are also a number of off-site pump stations (i.e., Chase Street, Morgan Way, Dunham Road, and Dock Street) that are part of the collection system. While the individual pump stations were not visited, their electrical consumption will be considered within the overall audit, based on the availability of data. There is a 400 kW emergency generator located at the main facility and smaller generators local to the pump stations, but based on discussions with administrative personnel, these units are already enrolled in a demand response program.

The hydronic heating system in the Operations Building includes a Burnham, Model V-906, oil fired boiler with a gross output of 664 MBH and two ¾ hp Taco circulation pumps. The Post Treatment Building has a Burnham, Model V-903, oil fired boiler with a gross output of 311 MBH, but it appears oversized given the heat load for the building. The Septage building and Garage are heated by propane and kerosene respectively and the other out buildings are heated by electrical resistance units.

Energy Usage Analysis

The WWTP was the primary focus of the audit; however, energy consumption data for various pump stations was included in the energy review. The WWTP consumes an assortment of fuel types, including #2 Fuel Oil, Propane, Kerosene and Electricity. The specific energy usage breakdown by location is provided in the following tables in the form of purchased units, MMBtu and costs. The energy cost data includes current market rates for fuel oil, propane and kerosene, but historical pricing for electricity.

Building Energy Usage - (Purchase Units)
November '06 to October '07

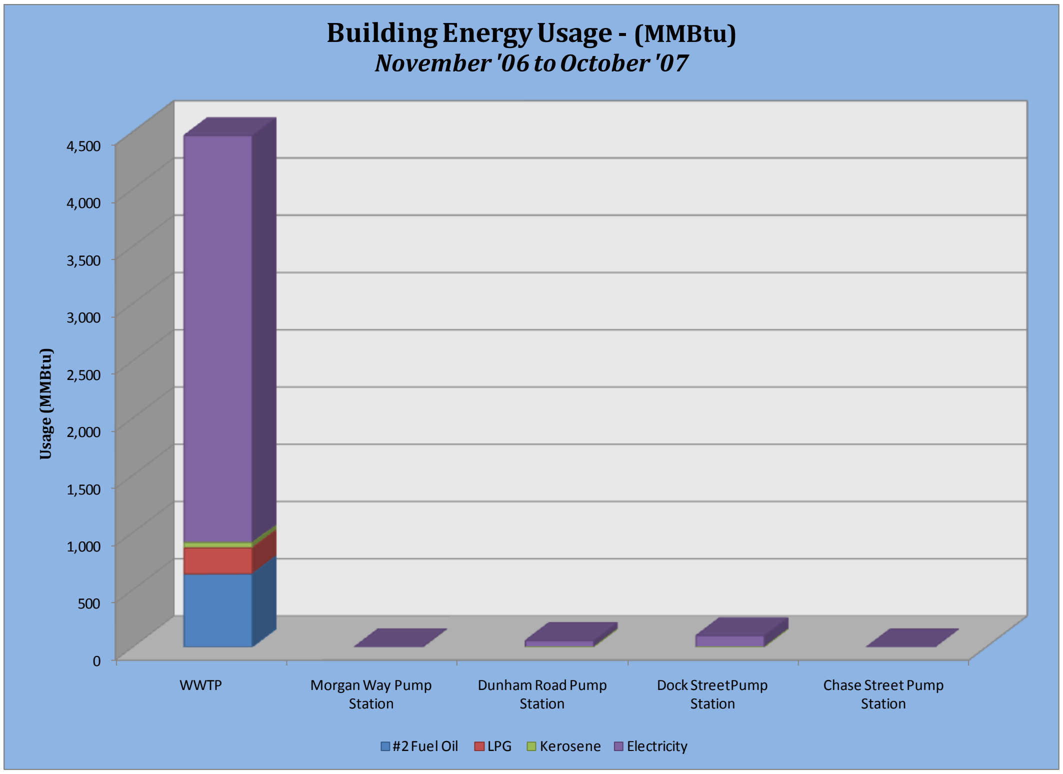
	#2 Fuel Oil (gal)	LPG (gal)	Kerosene (gal)	Elec. Usage (kWh)	Elec. Demand (kW)
WWTP	4,588	2,482	356	1,041,493	203.3
Morgan Way Pump Station	0	0	0	445	1,339.1
Dunham Road Pump Station	0	0	0	16,069	3.5
Dock Street Pump Station	0	0	0	28,723	10.8
Chase Street Pump Station	0	0	0	40,626	0.0
Total	4,588	2,482	356	1,127,356	N/A

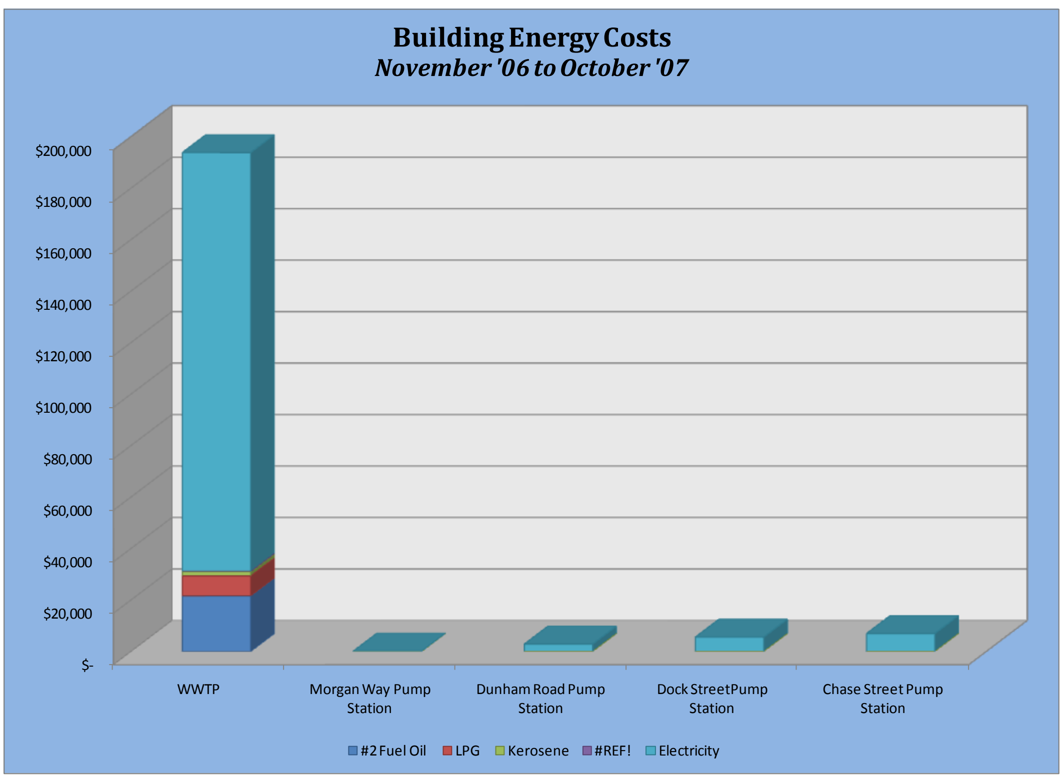
Building Energy Usage - (MMBtu)
November '06 to October '07

	#2 Fuel Oil	LPG	Kerosene	Electricity	Total
WWTP	638	227	48	3,554	4,466
Morgan Way Pump Station	0	0	0	2	2
Dunham Road Pump Station	0	0	0	55	55
Dock StreetPump Station	0	0	0	98	98
Chase Street Pump Station	0	0	0	0	0
Total	638	227	48	3,708	4,621

Building Energy Costs
Typical Year

	#2 Fuel Oil	LPG	Kerosene	Electricity	Total
WWTP	$ 21,609	$ 7,744	$ 1,691	$ 162,760	$ 193,804
Morgan Way Pump Station	$ -	$ -	$ -	$ 122	$ 122
Dunham Road Pump Station	$ -	$ -	$ -	$ 2,869	$ 2,869
Dock StreetPump Station	$ -	$ -	$ -	$ 5,592	$ 5,592
Chase Street Pump Station	$ -	$ -	$ -	$ 6,941	$ 6,941
Total	$ 21,609	$ 7,744	$ 1,691	$ 178,284	$ 209,328


Building Energy Usage - (MMBtu)
November '06 to October '07
Usage (MMBtu)
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
WWTP
Morgan Way Pump Station
Dunham Road Pump Station
Dock StreetPump Station
Chase Street Pump Station
#2 Fuel Oil
LPG
Kerosene
Electricity


Building Energy Costs
November '06 to October '07
$200,000
$180,000
$160,000
$140,000
$120,000
$100,000
$80,000
$60,000
$40,000
$20,000
$-
WWTP
Morgan Way Pump Station
Dunham Road Pump Station
Dock StreetPump Station
Chase Street Pump Station
#2 Fuel Oil
LPG
Kerosene
#REF!
Electricity

Energy Conservation Measures

The Energy Conservation Measures (ECMs) in this section are recommended based on available information at the time of the audit. Equipment specifications and associated costs are provided for budgetary planning purposes only. Detailed equipment sizing, code compliance and system design should be performed prior to final equipment selection and procurement.

ECM-1: Operations Building – Container Room Infrared Heating

Description

The container room, which is located in the Operations Building, is heated as a result of natural air exchange from the press room and the pipe runs in the room are already heat traced. However, this could be improved by closing the garage door between the two rooms and heating the container room with overhead infrared heating. Propane-fired ceiling mounted units would utilize the radiation method of heat transfer to more efficiently heat the space. Based on the walkthrough, it is estimated that the container room contributes approximately 30% of the total heat load of the Operations Building[1] or 113.4 MBH of the adjusted[2] total building heat load[3].

As designed, the heating distribution system is an inefficient use of energy for the high bay application in the container room. The heat tends to be stratified with the warmest areas being nearer the ceiling. Additionally, the frequent air changes, due to the opening of the garages doors, require the continuous heating of large amounts of outdoor air.

A more efficient means of heating the space would be to install an infrared radiant heating system for these areas. Radiant heating is very well suited for large air spaces with high ceilings, because rather than heating the air the heating element transmits heat through electromagnetic radiation to the floor and other objects within the space. This allows the heat to be delivered in a much more targeted manner and thus provides a more efficient mechanism for transferring the heat to where it is needed[4]. An additional benefit is that individual units can be turned off if so desired and any fluid piping could be protected from freezing in portions of the space that are not used regularly by using heat tracing. While the radiant method of heat transfer does not heat the air directly, the air is heated indirectly by the convective heat transfer between the ambient air and the objects in the room. The end result is that radiant heating will provide a given level of comfort at a reduced ambient air temperature as compared to non-radiant heating systems.

The specific equipment considered for this application is a low intensity, gas-fired, tube style unit, such as the HL2 Series, DET3 Series, or LD Series offered by Detroit Radiant. These units are typically specified by length, BTU rating, single stage or two stage and material of construction. The units can be used with either natural gas or propane and require connections to the outside for venting and combustion air.

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[1] This would need to be verified and refined with a detailed heat load analysis.
[2] Space load assumed to be 30% of building load and then increased by 50% to adjust for design conditions
[3] Appendix I: Estimated Heat Load Profile for Operations Building and Container Room
[4] Appendix II: Technical Report on the Advantages of Two-Stage Infrared Heating

With an estimated space design heat load of 113.4 MBH approximately two (2), two-stage, 30 ft long tube style units, rated for 50,000 Btu/hr each, would be sufficient to heat the container room. Each unit would be controlled by its own thermostat.

Ultimately, prior to implementing the recommended heating improvements, a detailed heat load analysis should be performed to allow for precise sizing of the necessary equipment.

Operation

- It is important that the infrared heating system is operated in full compliance with the manufacturer's recommendations, including sufficient clearance from combustible materials. An additional benefit of this technology is that units associated with unused portions of the room can be turned off. Only using units when and where they are needed could dramatically reduce the level of energy consumption.

Initial Cost Estimate

The total project cost is estimated to be $8,864[5]

Annual Savings Estimate and Payback

Fuel oil costs based on a unit price of $4.71 per gallon results in a total annual fuel cost of $21,609 with the current configuration. Changing to infrared radiant heating can reduce the heat usage by approximately 25% to 50% per year according to manufacturer studies[6]. As previously assumed, the area that would be upgraded to infrared radiant heating currently accounts for approximately 30% of the building heat.

Therefore the estimated savings were calculated as follows:

Infrared Radiant Heating: (Container Room Heat Load) x (Usage Reduction) x (Fuel Cost)

Infrared Radiant Heating: (153.1 MMBtu) x (30%) x ($34.06/MMBtu) = $1,564

Total Savings: $1,564

Simple payback is $8,864 / $1,564 = 5.7 years

[5] Appendix III: Operations Building – Container Room Infrared Heating Costs (Source Data: RSMeans CostWorks 1st Qtr 2008 Pricing)
[6] Appendix IV: Radiant Heat Savings

<u>ECM-2: Septage Building Infrared Heating</u>

Description

The Septage Building is currently heated by propane-fired overhead unit heaters. However, this could be improved by utilizing overhead propane-fired infrared heating. Based on FY2007 propane usage, the estimated design heat load for the Septage Building[7] is 134 MBH, which is 50% greater than the estimated heat load of 89.5 MBH.

As designed, the heating distribution system is an inefficient use of energy for the high bay application. The heat tends to be stratified with the warmest areas being nearer the ceiling. Additionally, the frequent air changes, due to the opening of the garages doors, require the continuous heating of large amounts of outdoor air.

A more efficient means of heating the space would be to install an infrared radiant heating system for these areas. Radiant heating is very well suited for large air spaces with high ceilings, because rather than heating the air the heating element transmits heat through electromagnetic radiation to the floor and other objects within the space. This allows the heat to be delivered in a much more targeted manner and thus provides a more efficient mechanism for transferring the heat to where it is needed[8]. An additional benefit is that individual units can be turned off if so desired and any fluid piping could be protected from freezing in portions of the space that are not used regularly by using heat tracing. While the radiant method of heat transfer does not heat the air directly, the air is heated indirectly by the convective heat transfer between the ambient air and the objects in the room. The end result is that radiant heating will provide a given level of comfort at a reduced ambient air temperature as compared to non-radiant heating systems.

The specific equipment considered for this application is a low intensity, gas-fired, tube style unit, such as the HL2 Series, DET3 Series, or LD Series offered by Detroit Radiant. These units are typically specified by length, BTU rating, single stage or two stage and material of construction. The units can be used with either natural gas or propane and require connections to the outside for venting and combustion air.

With an estimated space design heat load of 134 MBH approximately three (3), two-stage, 30 ft long tube style units, rated for 50,000 Btu/hr each, would be sufficient to heat the container room. Each unit would be controlled by its own thermostat.

Ultimately, prior to implementing the recommended heating improvements, a detailed heat load analysis should be performed to allow for precise sizing of the necessary equipment.

Operation

- It is important that the infrared heating system is operated in full compliance with the manufacturer's recommendations, including sufficient clearance from combustible materials. An additional benefit of this technology is that units associated with the unused portions of the building can be turned off. Only using units when and where they are needed could dramatically reduce the level of energy consumption.

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[7] Appendix V: Estimated Heat Load Profile for Septage Building
[8] Appendix II: Technical Report on the Advantages of Two-Stage Infrared Heating

Initial Cost Estimate

The total project cost is estimated to be $13,343[9]

Annual Savings Estimate and Payback

Propane costs based on a unit price of $3.12 per gallon results in a total annual fuel cost of $7,744 with the current configuration. Changing to infrared radiant heating can reduce the heat usage by approximately 25% to 50% per year according to manufacturer studies[10] and therefore a 30% usage savings was conservatively assumed.

Therefore the estimated savings were calculated as follows:

Infrared Radiant Heating: (Septage Building Heat Load) x (Usage Reduction) x (Fuel Cost)

Infrared Radiant Heating: (181.2 MMBtu) x (30%) x ($34.06/MMBtu) = $1,852

Total Savings: $1,852

Simple payback is $13,343 / $1,852 = 7.2 years

[9] Appendix VI: Septage Building Infrared Heating Costs (Source Data: RSMeans CostWorks – 1st Qtr 2008 Pricing)
[10] Appendix IV: Radiant Heat Savings

ECM-3: Pretreatment Building – Water-to-Air Heat Pump

Description

The Pretreatment Building is currently heated by electrical resistance unit heaters. Given that service water (clean effluent) could be made available, a better alternative for providing heat would be to install a water-to-air heat pump. Heat pumps are a proven technology and one that has been used at other wastewater treatment plants with great success for a number of years. An initial sizing analysis[11] was prepared to determine the feasibility of installing a water-to-air heat pump and it is estimated that two units with a 4.0 ton heating capacity should be adequate. It is important to note that detailed building plans were not readily available, so gross assumptions regarding room volume, wall areas and building envelope characteristics were made. The heat load analysis should be revised once the detailed building plans become available.

Operation

- It is important that the water supply filter/strainer is blowdown on a regular basis.

Initial Cost Estimate

The total installed cost[12] is estimated to be approximately $8,737 per unit, plus an additional 10% for running a water source to the unit, which results in a total of $9,611 per unit. For two units, the total installed costs would be $19,222.

Annual Savings Estimate and Payback

Based on the initial sizing analysis, previously referenced, the annual savings are estimated to be $3,764.

An incentive of $125 per unit is available from National Grid, assuming all customer qualifications and equipment specifications are met. Incentives are subject to National Grid approval.

Simple payback is $19,222 / $3,764 = 5.1 years

[11] Appendix VI: Pretreatment Building Heat Pump Analysis
[12] RSMeans CostWorks, 2008 – 1st Quarter Pricing

ECM-4: Lab Building – Water-to-Air Heat Pump

Description

The Lab Building is currently heated by electrical resistance unit heaters. Given that service water (clean effluent) could be made available, a better alternative for providing heat would be to install a water-to-air heat pump. Heat pumps are a proven technology and one that has been used at other wastewater treatment plants with great success for a number of years. An initial sizing analysis[13] was prepared to determine the feasibility of installing a water-to-air heat pump and it is estimated that two units with a 2.5 ton heating capacity should be adequate. It is important to note that detailed building plans were not readily available, so gross assumptions regarding room volume, wall areas and building envelope characteristics were made. The heat load analysis should be revised once the detailed building plans become available.

Operation

- It is important that the water supply filter/strainer is blowdown on a regular basis.

Initial Cost Estimate

The total installed cost[14] is estimated to be approximately $2,933 per unit, plus an additional 10% for running a water source to the unit, which results in a total of $3,226 per unit. For two units, the total installed costs would be $6,453.

Annual Savings Estimate and Payback

Based on the initial sizing analysis, previously referenced, the annual savings are estimated to be $2,322.

An incentive of $125 per unit is available from National Grid, assuming all customer qualifications and equipment specifications are met. Incentives are subject to National Grid approval.

Simple payback is $6,453 / $2,322 = 2.8 years

[13] Appendix VIII: Lab Building Heat Pump Analysis
[14] RSMeans CostWorks, 2008 – 1st Quarter Pricing

ECM-5: Odor Control 15 HP Blower Motor

Description

The Odor Control System includes five motors; 1-25 hp motor, 1-15 hp motor and 3-5 hp motors. The 15 hp motor is a standard efficiency motor and operates an estimated 2,000 hours per year. Standard efficiency motors of this size are approximately 88.8% efficient. New premium efficiency models for this size and type of motor have an average efficiency[15] of 93.1%. Therefore, it is recommended that the existing motors be replaced with a NEMA "Premium Efficiency" motor.

Operation

- No operational changes are associated with this change.

Initial Cost Estimate

The total initial installed cost is estimated to be $993 for a replacement premium efficiency 15 hp motor.

Annual Savings Estimate and Payback

kWh Saved = 0.746 x 15 HP x 75% LF x [(1/Efficiency$_{Standard}$) – (1/Efficiency$_{Premium}$)] x Operating Hours

kWh Saved = 0.746 x 15 HP x 75% LF x [(1/0.888) – (1/0.931)] x 2,000 hours

kWh Saved = 873 kWh

Energy Savings[16] = 873 kWh x $0.156/kWh = $136.19

Simple payback is $993 / $136 = 7.3 years

[15] Appendix IX: MotorMaster+ 4.0 Motor Analysis
[16] Actual rates are based on peak, off-peak, shoulder, Low-A and Low-B charges, so for simplicity a blended total cost per kWh was used for this ECM.

ECM-6: Sludge Holding Tank (SHT #1 and #3) 15 HP Blower Motors

Description

The sludge holding tanks have three blowers that provide aeration; 2-15 hp motors and 1-25 hp motor. Only one of the blowers is operated at any given time and blower operation is rotated in order to levelize unit runtime. Based on input from plant personnel, the two 15 hp motors are standard efficiency motors and are each operated an estimated 2,920 hours per year. Standard efficiency motors of this size are approximately 88.8% efficient. New premium efficiency models for this size and type of motor have an average efficiency[17] of 93.1%. Therefore, it is recommended that the existing motors be replaced with NEMA "Premium Efficiency" motors.

Operation

- No operational changes are associated with this change.

Initial Cost Estimate

The total initial installed cost is estimated to be $1,986 for two replacement premium efficiency 15 hp motors.

Annual Savings Estimate and Payback

kWh Saved = 0.746 x 15 HP x 75% LF x [(1/Efficiency$_{Standard}$) – (1/Efficiency$_{Premium}$)] x Operating Hours

kWh Saved = 0.746 x 15 HP x 75% LF x [(1/0.888) – (1/0.931)] x 2,920 hours

kWh Saved = 1,275 kWh per motor or 2,550 kWh for two motors

Energy Savings[18] = 2,550 kWh x $0.156/kWh = $397.80

Simple payback is $1,986 / $398 = 5.0 years

[17] Appendix X: MotorMaster+ 4.0 Motor Analysis
[18] Actual rates are based on peak, off-peak, shoulder, Low-A and Low-B charges, so for simplicity a blended total cost per kWh was used for this ECM.

ECM-7: Sludge Holding Tank (SHT #2) 25 HP Blower Motor

Description

The sludge holding tanks have three blowers that provide aeration; 2-15 hp motors and 1-25 hp motor. Only one of the blowers is operated at any given time and blower operation is rotated in order to levelize unit runtime. Based on input from plant personnel, the 25 hp motor is a standard efficiency motor and is operated an estimated 2,920 hours per year. Standard efficiency motors of this size are approximately 89.5% efficient. New premium efficiency models for this size and type of motor have an average efficiency[19] of 93.8%. Therefore, it is recommended that the existing motors be replaced with a NEMA "Premium Efficiency" motor.

Operation

- No operational changes are associated with this change.

Initial Cost Estimate

The total initial installed cost is estimated to be $2,070 for a replacement premium efficiency 25 hp motors.

Annual Savings Estimate and Payback

kWh Saved = 0.746 x 25 HP x 75% LF x [(1/Efficiency$_{\text{Standard}}$) – (1/Efficiency$_{\text{Premium}}$)] x Operating Hours

kWh Saved = 0.746 x 25 HP x 75% LF x [(1/0.895) – (1/0.938)] x 2,920 hours

kWh Saved = 2,092 kWh

Energy Savings[20] = 2,092 kWh x $0.156/kWh = $326.35

Simple payback is $2,070 / $326 = 6.3 years

[19] Appendix XI: MotorMaster+ 4.0 Motor Analysis

[20] Actual rates are based on peak, off-peak, shoulder, Low-A and Low-B charges, so for simplicity a blended total cost per kWh was used for this ECM.

ECM-8: Odor Control System Modulation

Description

The Odor Control System was designed to remove odorous compounds from the various processes of the treatment plant. The two stage mist scrubber uses fine droplets of a chemical solution to absorb and oxidize odorous compounds. While it is possible to measure hydrogen sulfide (H_2S) levels in the outlet gas stream, it may not be entirely representative of the perceived odor level or strength.

The Odor Control System includes five motors; 1-25 hp motor, 1-15 hp motor and 3-5 hp motors. All of the motors, except for the 15 hp motor, operate 24 hours per day for the entire year. The 15 hp motor is only operated when the press room is processing, which is an estimated 2,000 hours per year. Based on feedback from plant personnel, each of the three 5 hp motors need to operate continuously at full speed in order to maintain an adequate negative pressure to prevent odors from escaping.

Consideration should be given to the possibility of slightly reducing the speed of the 25 hp motor during the off-season. The existing motor is a two-speed motor, but the lower speed is inadequate in maintaining odors below acceptable levels. However, if the motor was equipped with a variable frequency drive (VFD) then operations personnel would be able to control the speed much more precisely. Therefore, it is recommended that the 25 hp motor be equipped with a VFD and during the off-season operated at 80% of the current speed[21]. With some experimentation, it may be possible to operate it at even slower speeds.

Operation

- No operational changes are associated with this change except for periodic adjustments to motor frequencies for seasonal changeovers.

Initial Cost Estimate

The estimated installed cost[22] to equip the 25 hp motor with a VFD is estimated to be $5,536.

Annual Savings Estimate and Payback

Energy Savings[23] = 47,219 kWh x $0.156/kWh = $7,366

Simple payback is $5,536 / $7,366 = 0.8 years

[21] Appendix XII: Odor Control System Modulation
[22] RSMeans CostWorks, 2008 – 1st Quarter Pricing
[23] Actual rates are based on peak, off-peak, shoulder, Low-A and Low-B charges, so for simplicity a blended total cost per kWh was used for this ECM.

Clean Energy Opportunities

The Commonwealth of Massachusetts is dedicated to promoting clean energy as an alternative to traditional sources of energy. As such, 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 Energy

Through the Commonwealth Solar Program[24], 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	$3.25	$2.50	$2.00	$1.50
PLUS: Additions to Base Incentives				
Massachusetts Manufactured System	$0.25	$0.25	$0.25	$0.25
Public Building	$0.50	$0.50	$0.25	$0.25

Wind and Hydroelectric

The Massachusetts Technology Collaborative[25] (MTC) is a quasi-public agency and is the state's development agency for renewable energy. MTC offers a number of programs, including those that provide funding for wind and hydroelectric projects. The two primary programs are the Small Renewables Initiative (SRI) and the Large Onsite Renewables Initiative (LORI). The SRI provides rebates for the installation of wind and small hydroelectric projects that are up to 10 kW. Annual funding is approximately $3.6 million and is provided on a "first come – first served" basis.

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

[24] Web site: www.commonwealthsolar.org
[25] Web site: www.masstech.org

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.

Wood Pellet Fueled Heating

On a periodic basis, the DOER accepts grant applications for wood pellet fueled heating systems[26], 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.

Clean Energy Projects for Edgartown WWTP

Based on the walkthrough that was performed as part of this audit, Edgartown WWTP has a number of *Clean Energy* opportunities that could be pursued further. If a decision is made to move forward on any of these projects, then the granting authority should be contacted for the respective program, as previously described. The typical process requires the submittal of an initial application. Once a preliminary approval is obtained, a more detailed technical assessment is performed to determine the specific costs and potential payback of the project. Often times the granting authority will provide some level of funding to support this phase of the project. If there are any questions or further guidance required, please contact Mr. Scott Durkee at DOER: (617) 727-4732 ext. 40156.

Clean Energy Opportunities	
Building	**Opportunity Description**
Pretreatment Building	Installation of water-source heat pumps to heat the upper level of the Pretreatment Building. **Action Item: See ECM #3**
Laboratory Building	Installation of water-source heat pumps to heat the Laboratory building. **Action Item: See ECM #4**
WWTP Site	Installation of a wind turbine to help power existing loads. The site has ample space and sustained winds and is an ideal candidate for a wind turbine. Site management has already begun to pursue this option and other wind turbines have already been successfully sited on the island. **Action Item: Proceed based on results of MTC feasibility study.**
WWTP Site	Installation of solar photovoltaic (PV) cells on select roofs of site buildings. Most of the site buildings have pitched roofs, some of which have a southern orientation with potential for a PV installation. Generally speaking, there is little shading from surrounding trees, but a more detailed feasibility assessment would be required to evaluate each individual roof. **Action Item: Prepare Solar PV Site Selection Survey and submit to DOER.**

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

Other Considerations

- Portfolio Manager[27] is an interactive energy management tool, provided under the U.S. Environmental Protection Agency's (EPA) Energy Star program that allows organizations the ability to track and assess energy and water consumption across an entire portfolio of buildings in a secure online environment. Portfolio Manager can help set investment priorities, identify under-performing buildings, verify efficiency improvements and allow organizations to receive EPA recognition for superior energy performance.

  The utility information for the buildings included in this audit for Edgartown WWTP have been entered into Portfolio Manager. With this record established, it is recommended that the information be updated on a periodic basis and utilized in making future decisions related to energy conservation.

- MotorMaster+ is a tool provided by the U.S. Department of Energy. It is an energy-efficient motor selection and management software tool and includes a catalog of over 20,000 AC motors. This tool features motor inventory management tools, maintenance log tracking, efficiency analysis, savings evaluation, energy accounting, and environmental reporting capabilities. It is recommended that this tool be utilized to manage the entire inventory of motors.

- The PostTreatment Building is a good candidate for "rightsizing" of the heating system. Given the removal of some of the equipment in the building and the residual heat from the air compressors in the bottom level, a more detailed heat load analysis would be required in order to correctly rightsize the heating system.

- The electricity supply for Edgartown WWTP is currently covered under a negotiated contract with Conedison Solutions. The next time the contract comes open for competitive bidding, it is recommended that the Hampshire Council of Governments (COG) be included on the bidders list. Hampshire COG is a not-for-profit organization that offers two rate plans as described below:
  - Basic Service: Under this plan, Hampshire COG supplies electricity at the same rate as the utility. At the end of the fiscal year, any profit is rebated in a lump sum payment to each member of the program, based on their portion of the total revenue.
  - Real-Time Pricing: Under this program, Hampshire COG supplies electricity, based on the real-time pricing posted by ISO New England, plus a small fee to cover overhead costs. For users without an interval meter, the usage is based on the load profile of the entire group. For users with an interval meter, the pricing is based on their actual usage.

[27] http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager

Conclusion

The Edgartown WWTP was evaluated based on data gathered during site walkdowns, a review of the utility bills and discussions with administration officials. The Energy Usage Summary is provided below:

Building Energy Usage - (MMBtu) *November '06 to October '07*					
	#2 Fuel Oil	**LPG**	**Kerosene**	**Electricity**	**Total**
WWTP	638	227	48	3,554	4,466
Morgan Way Pump Station	0	0	0	2	2
Dunham Road Pump Station	0	0	0	55	55
Dock StreetPump Station	0	0	0	98	98
Chase Street Pump Station	0	0	0	0	0
Total	638	227	48	3,708	4,621

There are a number of energy conservation measures that have been identified through the audit process, which include system modifications and operational changes. The specific ECMs that are recommended are provided in the following table along with the associated cost and savings:

Energy Conservation Measures Summary							
ECM #	**Description**	**Cost**	**Utility Funding**	**Site Annual Usage (MMBTU)**	**Usage Savings (MMBTU)**	**Annual Savings**	**Payback (years)**
1	Container Room Infrared Heating	$8,864	$0	4,466	46	$1,564	5.7
2	Septage Building Infrared Heating	$13,343	$0	4,466	54	$1,852	7.2
3	Pretreatment Building Heat Pump	$19,222	$250	4,466	0	$3,764	5.1
4	Lab Building Heat Pump	$6,453	$250	4,466	0	$2,322	2.8
5	Odor Control 15 HP Blower Motor	$993	$0	4,466	3	$136	7.3
6	Sludge Holding Tank 15 HP Blower Motors	$1,986	$0	4,466	9	$398	5.0
7	Sludge Holding Tank 25 HP Blower Motor	$2,070	$0	4,466	7	$326	6.3
8	Odor Control System Modulation	$5,536	$0	4,466	161	$7,366	0.8
Total		**$58,467**	**$500**	**35,728**	**280**	**$17,728**	**3.3**

Appendices

Appendix I:	Estimated Heat Load Profile for Operations Building and Container Room
Appendix II:	Technical Report on the Advantages of Two-Stage Infrared Heating
Appendix III:	Operations Building – Container Room Infrared Heating Costs
Appendix IV:	Radiant Heat Savings
Appendix V:	Estimated Heat Load Profile for Septage Building
Appendix VI:	Septage Building Infrared Heating Costs
Appendix VII:	Pretreatment Building Heat Pump Analysis
Appendix VIII:	Lab Building Heat Pump Analysis
Appendix IX:	MotorMaster+ 4.0 Motor Analysis
Appendix X:	MotorMaster+ 4.0 Motor Analysis
Appendix XI:	MotorMaster+ 4.0 Motor Analysis
Appendix XII:	Odor Control System Modulation

Appendix I

Estimated Heat Load

for

Operations Building and Container Room

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Operations Building - Existing Heat Load Profile

Assumed Heat Load: 252,000 Btu/hr

OA Bin	Total Annual Hours	Estimated Heating Load (Btu/hr)	Energy Use (MMBtu)
97	5		
92	42		
87	122		
82	277		
77	431		
72	630		
67	724		
62	743		
57	717	12,600	9.03
52	675	22,680	15.31
47	657	45,360	29.80
42	697	68,040	47.42
37	749	90,720	67.95
32	797	113,400	90.38
27	565	136,080	76.89
22	363	158,760	57.63
17	249	181,440	45.18
12	156	204,120	31.84
7	88	226,800	19.96
2	41	252,000	10.33
-3	19	252,000	4.79
-8	10	252,000	2.52
-13	4	252,000	1.01
-18	1	252,000	0.25
Total	**8,762**	**N/A**	**510.3**

Design Heat Load: 378,000

1. Binned Data: Boston/Logan, MA, Average Year (1967 to 1996)
2. Typical #2 Fuel Oil Usage: 4,588 gallons or 638 MMBtu
3. Efficiency of Existing Heating System: 80%
4. Annual Heating Energy Required by Building: (638 MMBtu x 80%) = 510.4 MMBtu

Operations Building - Container Room Heat Load Profile

Assumed Heat Load: 75,600 Btu/hr

OA Bin	Total Annual Hours	Estimated Heating Load (Btu/hr)	Energy Use (MMBtu)
97	5		
92	42		
87	122		
82	277		
77	431		
72	630		
67	724		
62	743		
57	717	3,780	2.71
52	675	6,804	4.59
47	657	13,608	8.94
42	697	20,412	14.23
37	749	27,216	20.38
32	797	34,020	27.11
27	565	40,824	23.07
22	363	47,628	17.29
17	249	54,432	13.55
12	156	61,236	9.55
7	88	68,040	5.99
2	41	75,600	3.10
-3	19	75,600	1.44
-8	10	75,600	0.76
-13	4	75,600	0.30
-18	1	75,600	0.08
Total	**8,762**	**N/A**	**153.1**

Design Heat Load: 113,400

1. Binned Data: Boston/Logan, MA, Average Year (1967 to 1996)

Appendix II

Technical Report on the Advantages of Two-Stage Infrared Heating

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TECHNICAL REPORT

RE-VERBER-RAY®
DETROIT RADIANT PRODUCTS COMPANY

SUMMARY OF AN INDEPENDENT STUDY DOCUMENTING THE ADVANTAGES OF TWO-STAGE INFRA-RED HEATING

INTRODUCTION:

DETROIT RADIANT PRODUCTS COMPANY developed and introduced the RE-VERBER-RAY Two-Stage *HL Series* (high-low) in early 1993. A study was undertaken to objectively document the benefits of two-stage infra-red heating. In cooperation with its' Canadian associate company, Brant Radiant Heaters, Ltd., Detroit Radiant contacted RDM Engineering and requested that a documented study be compiled. In October 1993 RDM Engineering, an independent research firm, engaged a test that documented and demonstrated the benefits of the *HL Series*.

The patented design of the *HL Series* features a "calculated input differential" which allows the heater to operate in a "high-fire" or a "low-fire" mode. The differential between the two levels of operation is 30%. ASHRAE weather records show that an average of 90% of the degree hours within the USA can be satisfied by operations in "low-fire." Only 10% of degree hours will require operation in the "high-fire" mode. What this means is that this heater will adjust to the environment, producing the most comfortable and economical infra-red heat available. The building will be comfortably heated during a moderately cold day, yet the heaters are capable of satisfying the design heating capacity on the coldest of winter days. The test facility was carefully selected to reflect not only typical industrial building construction, but also a commitment by management and staff that consistent work patterns would be maintained during the test period. A detailed heat loss study of the test facility prior to the start of the test period documented a total building heat loss of 200,000 BTU/H.

The inside of the test site, representing a typical industrial building and showing the RE-VERBER-RAY Two-Stage *HL Series*. This heating system objectively documented a minimum of 12% additional energy savings - and a 35% reduction in "On and Off Cycles" - when compared to a single input system.

THE TEST SITE:

The test site selected in October 1993 to objectively document the benefits of the RE-VERBER-RAY Two-Stage *HL Series* by an independent research firm.

[Installation Details - **Ceiling:** 20' high, R20 insulation, steel interior sheathing and fiberglass, tar and gravel roof. **Walls:** 8" concrete block, non-insulated. **Doors:** Two 3' x 8' exterior doors, one 10' x 12' overhead. **Windows:** none. **Use:** HVAC contractor, equipment repair and storage.]

TEST PROCEDURE:

Two 100/65 MBTU/H *HL Series* were installed along with Honeywell T775-A1019 controllers.

For this "real world" test, the heaters operated on alternate days one of two ways: [1] On "two-stage," whereby the heaters were either "off," or allowed to switch automatically between the "low-fire" (65 MBTU/H) and the "high-fire" mode (100 MBTU/H) or; [2] On "single stage," whereby the heaters were either "off" or running in "high-fire" mode (100 MBTU/H), simulating a single stage unit.

The two alternate operating possibilities of "low" and "high," as noted above, were switched on a controlled 24-hour cycle, with the level of heat output based on actual building heating demand. This methodology provided the necessary controls to objectively compare the two alternative heating methods.

HL SERIES

State-of-the-art, two-stage gas-fired infra-red heater

RESULTS: As the findings below will attest, the RE-VERBER-RAY *HL Series* has proven cost-saving benefits over single-stage infra-red heaters. Documented fuel savings, reductions in on/off cycles, faster recoveries and increased comfort levels are some of the benefits that one can expect by using the *HL Series*.

THE FINDINGS:

The test period ran from October 15, 1993, to April 15, 1994 (184 days or 1/2 year). During this time, the “single-stage” portion of the test (where the heaters ran only at 100 MBTU/H) and the “two-stage” portion of the test (where the heaters were allowed to switch between 65 MBTU/H and 100 MBTU/H based on heating demand) were each in operation for 92 days. The average outside temperature for the “high” portion was -2.3ºC (28ºF) and for the “two-stage” portion -1.3ºC (29.5ºF).

The first of the RE-VERBER-RAY *HL Series* units had an average cycle time of 39.5 minutes on “high,” and 78.1 minutes on “low,” again demonstrating longer heater operation on “low fire.” On the second unit, the number of on/off cycles was reduced by 36.5%.

Natural gas consumption was reduced using the “low” operation for the two *HL Series* units by 12% during the six-month period - **a savings of 23,018 cubic feet of natural gas.**

CONCLUSION:

The RE-VERBER-RAY Two-Stage *HL Series* has been shown to be a more efficient heating system than standard single-stage infra-red heaters.

A minimum savings of 12% in energy usage was documented using the *HL Series*. This is in comparison to single-stage infra-red heaters. Other benefits that this study revealed were:

35% reduction in on/off cycles, resulting in improved employee comfort (see figures 1 and 2).

Improved product life due to the reduction in on/off cycles.

Overall improved operating efficiency, reducing carbon dioxide emissions.

Faster recoveries. Energy is not wasted reheating the exchangers when “high-fire” is called for.

Design benefits. The *HL Series* allows you to design your building in accordance with “worst case” design temperature. Realistically, this rarely occurs and the heater will make the appropriate adjustments.

Figure 1

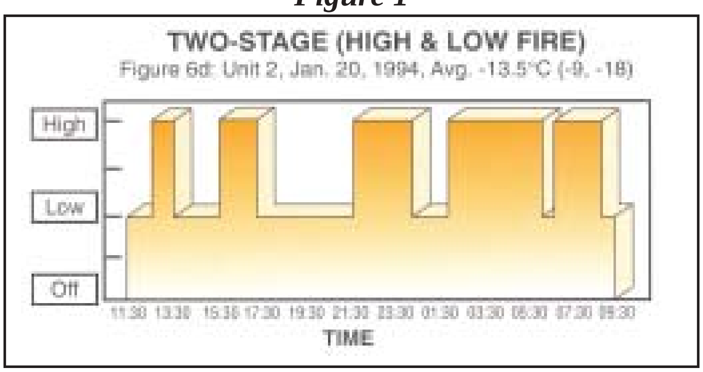
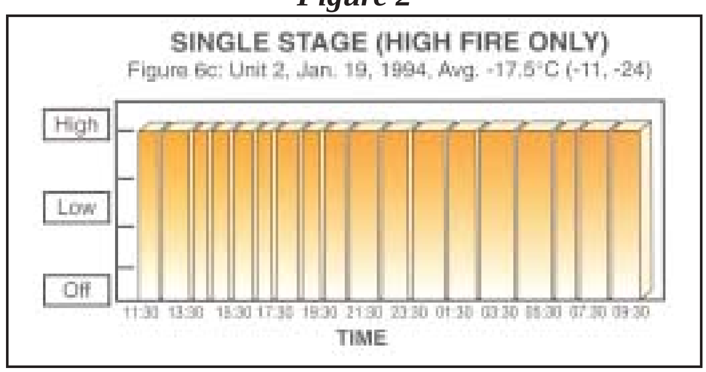


Figure 2



These two graphs, reproduced with permission from the RDM Engineering Report, dramatically demonstrate the operating differences between the two-stage and single-stage input infra-red alternatives.

RDM ENGINEERING

Over the past 12 years, Guelph, Ontario based R.D. Mac Donald, P.E., and RDM Engineering have researched and produced a number of scientific, technical and informational papers on the subject of energy efficiency, as well as tested and reported on other energy matters for a wide variety of clients. Serving as an Energy Advisor and Energy Specialist to government, major utilities and private sector clients, Mr. Mac Donald and RDM Engineering remain actively involved in a broad spectrum of energy matters, including their recent testing and reporting on the RE-VERBER-RAY Two-Stage, High-Low *HL Series* detailed in this Technical Report.

Printed by Detroit Radiant Products based on an independent test report prepared by RDM Engineering. Form# HLTR-5M-10/04(OP)

Appendix III

Operations Building
Container Room Infrared Heating Costs

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Operations Building - Container Room Infrared Heating

Data Release : Year 2008 Quarter 1

Qty	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Total	Total O&P	Ext. Total O&P
2	Infra-red unit, gas fired, unvented, electric ignition, input, 100% shutoff, 50 MBH, excludes piping and wiring	Q5	2	8	Ea.	$ 609.39	$ 258.28	$ 867.67	$ 1,096.37	$ 2,192.74
100	Pipe, steel, black, threaded, 1" diameter, schedule 40, Spec. A-53, includes coupling and clevis hanger assembly sized for covering, 10' OC	1 Plum	53	0.151	L.F.	$ 3.57	$ 5.30	$ 8.87	$ 12.64	$ 1,264.00
20	Pipe, steel, black, threaded, 3/4" diameter, schedule 40, Spec. A-53, includes coupling and clevis hanger assembly sized for covering, 10' OC	1 Plum	61	0.131	L.F.	$ 2.43	$ 4.62	$ 7.05	$ 10.26	$ 205.20
5	Elbow, 90 Deg., steel, cast iron, black, straight, threaded, standard weight, 1"	1 Plum	13	0.615	Ea.	$ 4.48	$ 21.91	$ 26.39	$ 40.62	$ 203.10
5	Elbow, 90 Deg., steel, cast iron, black, straight, threaded, standard weight, 3/4"	1 Plum	14	0.571	Ea.	$ 3.22	$ 20.13	$ 23.35	$ 36.66	$ 183.30
2	Tee, steel, cast iron, black, straight, threaded, standard weight, 1"	1 Plum	8	1	Ea.	$ 4.99	$ 35.16	$ 40.15	$ 63.59	$ 127.18
2	Tee, steel, cast iron, black, straight, threaded, standard weight, 3/4"	1 Plum	9	0.889	Ea.	$ 5.60	$ 31.08	$ 36.68	$ 57.63	$ 115.26
4	Valves, steel, cast, gate, flanged, 150 lb., 2"	1 Plum	8	1	Ea.	$ 654.69	$ 35.16	$ 689.85	$ 774.00	$ 3,096.00
1	Engineering Services					$ -	$ -	$ -	$ -	$ 1,477.36
									Total	**$ 8,864.14**

Appendix IV

Radiant Heat Savings

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CHAPTER 15

INFRARED RADIANT HEATING

RADIANT principles discussed in this chapter apply to equipment with radiant source temperatures ranging from below room temperature to 5000°F. Radiant source temperatures are categorized into four groups as follows:

- Low temperature
- Low intensity
- Medium intensity
- High intensity

Low-temperature or panel heating and cooling systems have source temperatures up to 300ºF. Typical low-temperature sources are the ceiling and/or floor of the conditioned space. The source of energy for this application can be electrical resistance wire or film element, hot water, or warm air. Low-temperature radiant heating is used in residential applications and in office, commercial, or industrial buildings. These systems are often applied in conjunction with variable air volume (VAV)systems. Chapter 6 has further information on low-temperature (panel heating and cooling) systems.

Low-intensity source temperatures range from 300 to 1200ºF. A typical low-intensity heater is mounted on the ceiling. It may be constructed of a 4 in. steel tube 20 to 30 ft long. A gas burner inserted into the end of the tube raises the tube temperature, and, because most units are equipped with a reflector, the radiant energy emitted is directed down to the conditioned space.

Medium-intensity source temperatures range from 1200 to 1800ºF. Typical sources include porous matrix, gas-fired infrared or metal sheathed, electric units.

High-intensity radiant source temperatures range from 1800 to 5000ºF. A typical high-intensity unit is an electrical reflector lamp with resistor temperatures of 4050ºF.

Low-, medium-, and high-intensity infrared heaters are frequently applied in aircraft hangars, factories, warehouses, foundries, greenhouses, and gymnasiums. They are applied to such open areasas loading docks, racetrack stands, under marquees, outdoor restaurants, and around swimming pools. Infrared heaters are also used for snow control, condensation control, and industrial process heating. Reflectors are frequently used to control the distribution of radiation in specific patterns.

When infrared is used, the environment is characterized by:

l. A high-temperature directional radiant field created by the infrared heaters
2. A low-temperature radiant field consisting of the walls and/or enclosing surfaces
3. Ambient air temperatures often lower than those found with conventional convective heaters.

Convection heat loss from the radiantly heated floor, sealed objects, and the radiant heat source increases the ambient temperature. Ultimately, the combined action of these factors determines occupant comfort and thermal acceptability of the environment.

The preparation of this chapter is assigned to TC6.5, Radiant Space Heating and Cooling.

ENERGY CONSERVATION

Infrared heating units are effective for spot heating. However, because of efficient performance, they are also used for total heating of large areas and entire buildings (Buckley 1989). Radiant heaters transfer energy directly to solid objects. Little energy is lost during transmission because air is a poor absorber of infrared energy. Since an intermediate transfer medium (such as air or water) is not needed, fans or pumps are not required.

As infrared energy warms floors and objects, they, in turn, release heat to the air by convection. Reradiation to surrounding objects also contributes to the comfort in the area. An energy saving advantage is that radiant heat can be turned off when it is not needed; when it is turned on again, it is effective in minutes.

Human comfort is determined by the average of mean radiant and dry-bulb temperatures. With radiant heating, the dry-bulb temperature may be kept lower for a given comfort levelthan with other forms of heating (ASHRAE 1981).As a result, the heat lost to ventilating air and via conduction through the shell of the structure is proportionally smaller, as is energy consumption. Infiltration, which is a function of temperature, is also reduced.

In some situations, radiant heating savesenergy by reducing the temperature stratification from the equipment to the floor.

Buckley and Seel (1987) compared energy savings of infrared heating with other types of heating systems. A New York State report (1973) identified annual fuel savings as high as 50%. Recognizing the reduced fuel requirement for these applications, Buckley (1988) notes that it is common for manufacturers of radiant equipment to recommend installation of equipment with a rated output that is 80 to 85% of the heat loss calculated by methods described in Chapter 25 of the 1989ASHRAE *Handbook-Fundamentals.*

INFRARED ENERGY GENERATORS

Gas Infrared

Modern gas-fired infrared heaters burn gas to heat a specific radiating surface. The surface is heated by direct flame contact or with combustion gases. Studies bythe Gas Research Board of London (1944), Plyler (1948),and Haslam *et al.* (1925) reveal that only 10 to 20% of the energy produced by open combustion of a gase-ous fuel is infrared radiant energy, whereas wavelength span can be controlled by design. The specific radiating surface of a properly designed unit increases radiant release efficiency and directs radiation toward the load. Heaters are available in the following types (see Table 1 for characteristics):

Indirect infrared radiation units (Figures la, Ib, and Ie) are internally fired and have the radiating surface between the hot gases and load. Combustion takes place within the radiating elements, which operate with surface temperatures up to 1200ºF. The

EVALUATION OF INFRA-RED vs. FORCED AIR HEATING

A Summary of ASHRAE Research Project Number 4643. Printed by Detroit Radiant Products

A study determining the effectiveness (23% fuel savings and improved comfort levels) of a two-stage heating system and how it meets heat requirements more efficiently vs. forced air heating systems.

R.D. MacDonald, P.Eng., Member ASHRAE; M.E. Armstrong, P.Eng., K.G. Boyd, P.Eng. - Appreciation for technical support and funding from Union Gas, Chatham, ON and Brant Radiant Heaters Ltd., Paris, ON.

DESCRIPTION:

A three-year study was conducted at a commercial facility with frequent overhead door openings. Participant installed both a forced-air unit heater (FA) and a tube-type infrared heater (IR). Units were operated by a common thermostat, with a manual override switch, to allow for either forced air or infrared operation. This evaluation method allowed for an accurate side-by-side evaluation of the different heating systems.

Exterior

Interior

PROCEDURES & METHODS:

- Measure temperatures at 10 minute intervals, outside and a variety of inside and slab locations.
- Measure gas usage daily at designated times, conduct regular interview with staff on comfort.
- Predetermined operating cycles for forced air and infrared heater (i.e. alternate weeks, etc.).

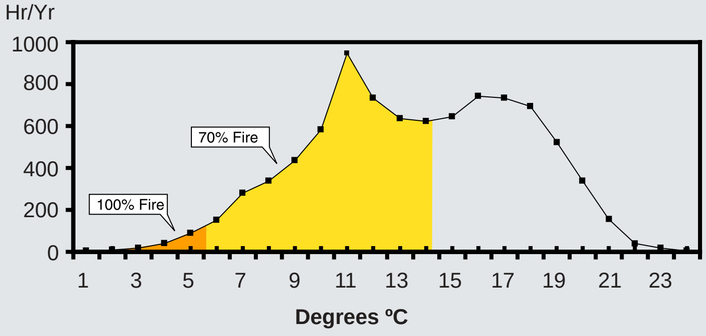


Figure 1- Hours per year of High Fire and Low Fire Operation.

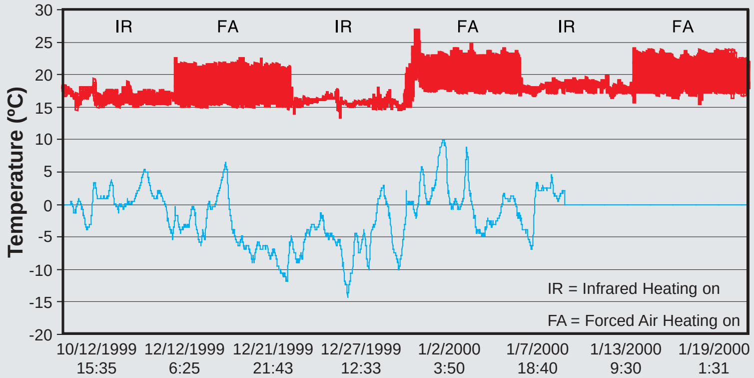
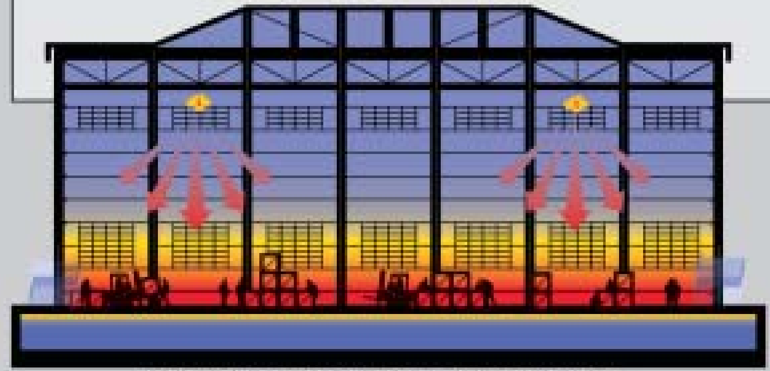
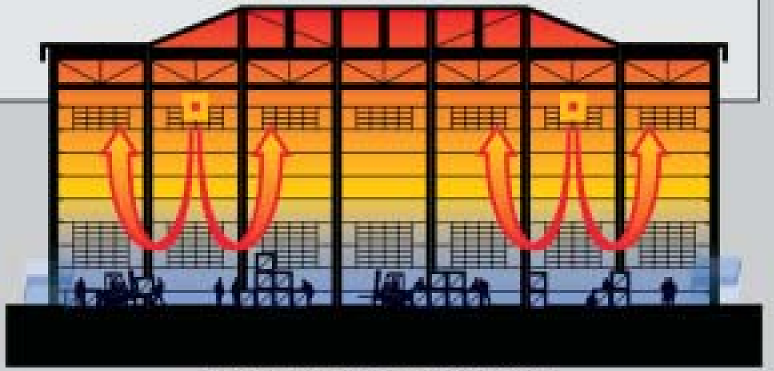


Figure 2 - Infrared vs. Forced Air Temperature Cycling



INFRARED TWO-STAGE HEATING SYSTEM



FORCED AIR HEATING SYSTEM

TESTS:

TEST 1 - (10-1-99 to 2-17-00) **-** Target Set Point -17ºC.

- The method of testing was established using the system and verifying the controls.
- Systems operated equally at 1-2 week alternating intervals during the heating season.
- Energy savings comparing FA and IR proved minimal.

TEST 3 - (10-16-00 to 4-12-01).

Set Point - IR=14ºC & FA=17ºC; Actual Avg. Temp.- IR 21.2ºC & FA 18.9ºC.

- Systems operated during the heating season at 1 week alternating intervals.
- Infra-red savings measured 23.0% (note average higher temperature for IR).

TEST 2 - (2-18-00 to 4-28-00).

Set Point - IR=16ºC & FA=19ºC; Actual Avg. Temp.- IR 13.2ºC & FA 17.7ºC.

- Systems operated during the heating season at 1 week alternating intervals.
- IR savings measured 19.5%, savings influenced by the lower set-point of IR.

TEST 4 - (12-15-01 to 3-25-02).

Avg. Actual 'Delta T' to OAT was 31.3ºC and 21.8ºC.

- IR and FA systems cycled weekly 2000-2001.
- IR only 2001-2001.
- Saved 25.4% with continuous infra-red vs. weekly interval infra-red vs. forced air.

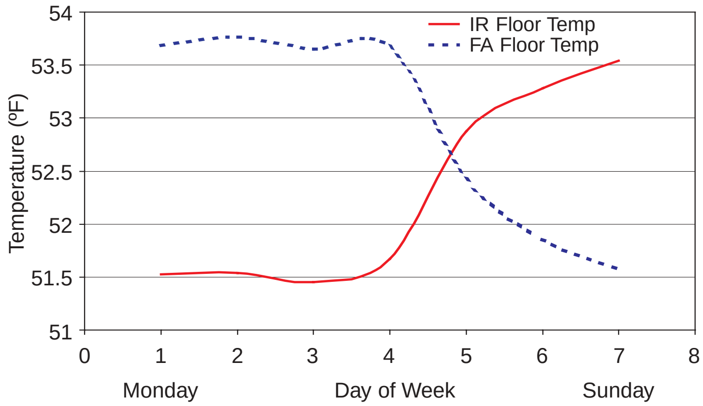


Figure 3- Slab Temperature Changes of FA and IR.

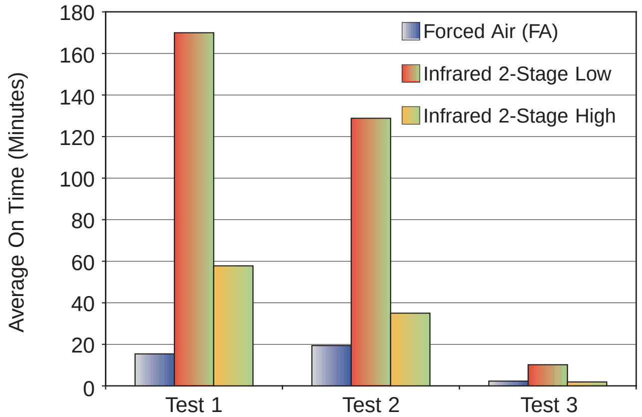


Figure 4- Average IR Low/High vs. FA Opening Time.

CONCLUSIONS:

1. Infra-Red heating saved up to 23% over a conventional Forced Air heating system.
2. The thermal flywheel effect in the slab contributes to energy use efficiency.
3. A weekly cycle of Forced Air vs. Infra-red is not a useful method of evaluating potential in either system due to the flywheel effect.
4. Two stage Infra-Red heat system ran on low fire longer than Forced Air per on-cycle; plus only used high fire 8-23% of the total on-time for heating.

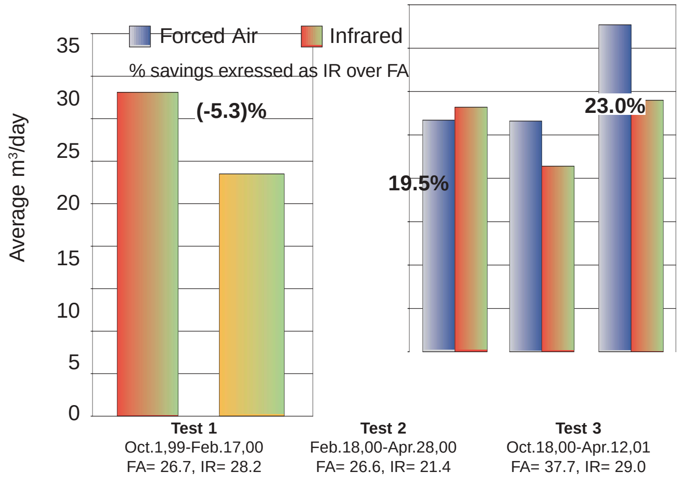
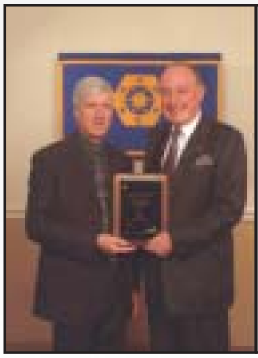


Figure 5- Forced Air vs. Infra-red Energy Usage.



In June 2004, the AHR Committee presented its' distinguished "Paper of the Year Award" to Agviro, Inc. for their work on this study.

ABOUT AGVIRO, INC.:

Based in Guelph, Ontario Ronald D. MacDonald PhD and Agviro, Inc. (formerly RDM Engineering) have researched and produced a number of scientific, technical and information papers on the subject of energy efficiency, as well as tested and reported on other energy matters for a wide variety of clients. Serving as an Energy Advisor and Energy Specialist to government, major utilities and private sector clients, Mr. MacDonald and Agviro, Inc. remain actively involved in a broad spectrum of energy matters, including their recent testing and reporting on the benefits of two-stage infra-red heaters as outlined in the summary of this award winning, ASHRAE Accredited Study.

Printed by Detroit Radiant Products based on an independent test report prepared by Agviro, Inc.
Form# LBAHR-5M-10/04 (OP)

Appendix V

Estimated Heat Load Profile
For
Septage Building

BOWMAN
ENGINEERING, INC.™

Septage Building - Existing Heat Load Profile

Assumed Heat Load: 89,500 Btu/hr

OA Bin	Total Annual Hours	Estimated Heating Load (Btu/hr)	Energy Use (MMBtu)
97	5		
92	42		
87	122		
82	277		
77	431		
72	630		
67	724		
62	743		
57	717	4,475	3.21
52	675	8,055	5.44
47	657	16,110	10.58
42	697	24,165	16.84
37	749	32,220	24.13
32	797	40,275	32.10
27	565	48,330	27.31
22	363	56,385	20.47
17	249	64,440	16.05
12	156	72,495	11.31
7	88	80,550	7.09
2	41	89,500	3.67
-3	19	89,500	1.70
-8	10	89,500	0.90
-13	4	89,500	0.36
-18	1	89,500	0.09
Total	**8,762**	**N/A**	**181.2**

Design Heat Load: 134,250

1. Binned Data: Boston/Logan, MA, Average Year (1967 to 1996)
2. Typical LPG Usage: 2,482 gallons or 227 MMBtu
3. Efficiency of Existing Heating System: 80%
4. Annual Heating Energy Required by Building: (227 MMBtu x 80%) = 181.6 MMBtu

Appendix VI

Septage Building Infrared Heating Costs

BOWMAN
ENGINEERING, INC.™

Septage Building Infrared Heating

Data Release : Year 2008 Quarter 1

Qty	Description	Crew	Daily Output	Labor Hours	Unit	Material	Labor	Total	Total O&P	Ext. Total O&P
3	Infra-red unit, gas fired, unvented, electric ignition, input, 100% shutoff, 50 MBH, excludes piping and wiring	Q5	2	8	Ea.	$ 609.39	$ 258.28	$ 867.67	$ 1,096.37	$ 3,289.11
150	Pipe, steel, black, threaded, 1" diameter, schedule 40, Spec. A-53, includes coupling and clevis hanger assembly sized for covering, 10' OC	1 Plum	53	0.151	L.F.	$ 3.57	$ 5.30	$ 8.87	$ 12.64	$ 1,896.00
30	Pipe, steel, black, threaded, 3/4" diameter, schedule 40, Spec. A-53, includes coupling and clevis hanger assembly sized for covering, 10' OC	1 Plum	61	0.131	L.F.	$ 2.43	$ 4.62	$ 7.05	$ 10.26	$ 307.80
8	Elbow, 90 Deg., steel, cast iron, black, straight, threaded, standard weight, 1"	1 Plum	13	0.615	Ea.	$ 4.48	$ 21.91	$ 26.39	$ 40.62	$ 324.96
8	Elbow, 90 Deg., steel, cast iron, black, straight, threaded, standard weight, 3/4"	1 Plum	14	0.571	Ea.	$ 3.22	$ 20.13	$ 23.35	$ 36.66	$ 293.28
3	Tee, steel, cast iron, black, straight, threaded, standard weight, 1"	1 Plum	8	1	Ea.	$ 4.99	$ 35.16	$ 40.15	$ 63.59	$ 190.77
3	Tee, steel, cast iron, black, straight, threaded, standard weight, 3/4"	1 Plum	9	0.889	Ea.	$ 5.60	$ 31.08	$ 36.68	$ 57.63	$ 172.89
6	Valves, steel, cast, gate, flanged, 150 lb., 2"	1 Plum	8	1	Ea.	$ 654.69	$ 35.16	$ 689.85	$ 774.00	$ 4,644.00
1	Engineering Services					$ -	$ -	$ -	$ -	$ 2,223.76
									Total	**$13,342.57**

Appendix VII

Pretreatment Building
Heat Pump Analysis

BOWMAN
ENGINEERING, INC.™

Report Prepared By:

Bowman Engineering, Inc.
P.O. Box 410
Greenfield, MA 01302
Phone: (413) 303-0238 Fax: (413) 604-0139

For:

Edgartown WWTP - Pretreatment Building
330 West Tisbury Road
P.O. Box 1205
Edgartown, MA 02539

Design Conditions: New Bedford; Latitude: 41; Time 10:00 AM

Indoor:

Summer temperature:	75
Winter temperature:	55
Relative humidity:	50

Outdoor:

Summer temperature:	82
Winter temperature:	9
Summer grains of moisture:	97
Daily temperature range:	19

Building Component	Sensible Gain (BTUH)	Latent Gain (BTUH)	Total Heat Gain (BTUH)	Total Heat Loss (BTUH)
Infiltration	0	33,660	33,660	75,900
Walls	948	0	948	10,325
Door Leakage	0	1,616	1,616	6,881
Ceilings	30	0	30	3,312
Doors	0	0	0	2,061
Floors	720	0	720	720
Miscellaneous	0	0	0	0
Lights	0	0	0	0
Ventilation	0	0	0	0
People	0	0	0	0
Duct	0	0	0	0
Skylights	0	0	0	0
Partitions	0	0	0	0
Windows	0	0	0	0
Whole Building - All Components	**1,698**	**35,276**	**36,974 (3 tons)**	**99,199**

Edgartown WWTP Pretreatment Bldg - Heat Load Profile

Assumed Heat Load: 66,133 Btu/hr

OA Bin	Total Annual Hours	Estimated Heating Load (Btu/hr)	Energy Use (MMBtu)
97	8		
92	44		
87	121		
82	247		
77	422		
72	688		
67	804		
62	787		
57	777	3,307	2.57
52	766	5,952	4.56
47	760	11,904	9.05
42	832	17,856	14.86
37	788	23,808	18.76
32	668	29,760	19.88
27	441	35,712	15.75
22	284	41,664	11.83
17	181	47,616	8.62
12	88	53,567	4.71
7	37	59,519	2.20
2	13	66,133	0.86
-3	2	66,133	0.13
-8	0	66,133	0.00
-13	0	66,133	0.00
-18	0	66,133	0.00
	8,758		**113.8**

Design Heat Load: **99,199**

1. Binned Data: Boston/Logan, MA, Average Year (1967 to 1996)
2. Efficiency of Electrical Resistance Heating Unit(s): 100%

Edgartown WWTP Pretreatment Bldg - Heating Analysis

	Existing		Recommended	
Description	Unit Heaters		Water-to-Air Heat Pump	
Fuel Type	Electricity (kWh)		Electricity (kWh)	
Energy Delivered (MMBtu)		113.8		113.8
Adjustment Factor for Design Heat Load		1.5		1.5
Unit Efficiency or COP		100.0%		3.6
Design Usage (MMBtu)		170.7		47.4
Typical Usage (MMBtu)		113.8		31.6
Typical Usage (kWh)		33,337		9,260
Energy Costs ($/MMBtu)	$	45.80	$	45.80
Total Energy Costs	$	5,211.09	$	1,447.53
Total Savings			**$**	**3,763.57**

Appendix VIII

Lab Building
Heat Pump Analysis

BOWMAN
ENGINEERING, INC.™

Report Prepared By:

Bowman Engineering, Inc.
P.O. Box 410
Greenfield, MA 01302
Phone: (413) 303-0238 Fax: (413) 604-0139

For: Edgartown WWTP - Lab Building
330 West Tisbury Road
P.O. Box 1205
Edgartown, MA 02539

Design Conditions: New Bedford; Latitude: 41; Time 10:00 AM

Indoor:		**Outdoor:**	
Summer temperature:	75	Summer temperature:	82
Winter temperature:	55	Winter temperature:	9
Relative humidity:	50	Summer grains of moisture:	97
		Daily temperature range:	19

Building Component	**Sensible Gain (BTUH)**	**Latent Gain (BTUH)**	**Total Heat Gain (BTUH)**	**Total Heat Loss (BTUH)**
Infiltration	0	11,220	11,220	25,300
Walls	946	0	946	24,196
Ceilings	0	0	0	8,832
Floors	2,880	0	2,880	2,880
Miscellaneous	0	0	0	0
Lights	0	0	0	0
Ventilation	0	0	0	0
People	0	0	0	0
Duct	0	0	0	0
Skylights	0	0	0	0
Partitions	0	0	0	0
Door Leakage	0	0	0	0
Doors	0	0	0	0
Windows	0	0	0	0
Whole Building - All Components	**3,826**	**11,220**	**15,046 (1.5 tons)**	**61,208**

Edgartown WWTP Lab Bldg - Heat Load Profile

Assumed Heat Load: 40,805 Btu/hr

OA Bin	Total Annual Hours	Estimated Heating Load (Btu/hr)	Energy Use (MMBtu)
97	8		
92	44		
87	121		
82	247		
77	422		
72	688		
67	804		
62	787		
57	777	2,040	1.59
52	766	3,672	2.81
47	760	7,345	5.58
42	832	11,017	9.17
37	788	14,690	11.58
32	668	18,362	12.27
27	441	22,035	9.72
22	284	25,707	7.30
17	181	29,380	5.32
12	88	33,052	2.91
7	37	36,725	1.36
2	13	40,805	0.53
-3	2	40,805	0.08
-8	0	40,805	0.00
-13	0	40,805	0.00
-18	0	40,805	0.00
	8,758		**70.2**

Design Heat Load: **61,208**

1. Binned Data: Boston/Logan, MA, Average Year (1967 to 1996)
2. Efficiency of Electrical Resistance Heating Unit(s): 100%

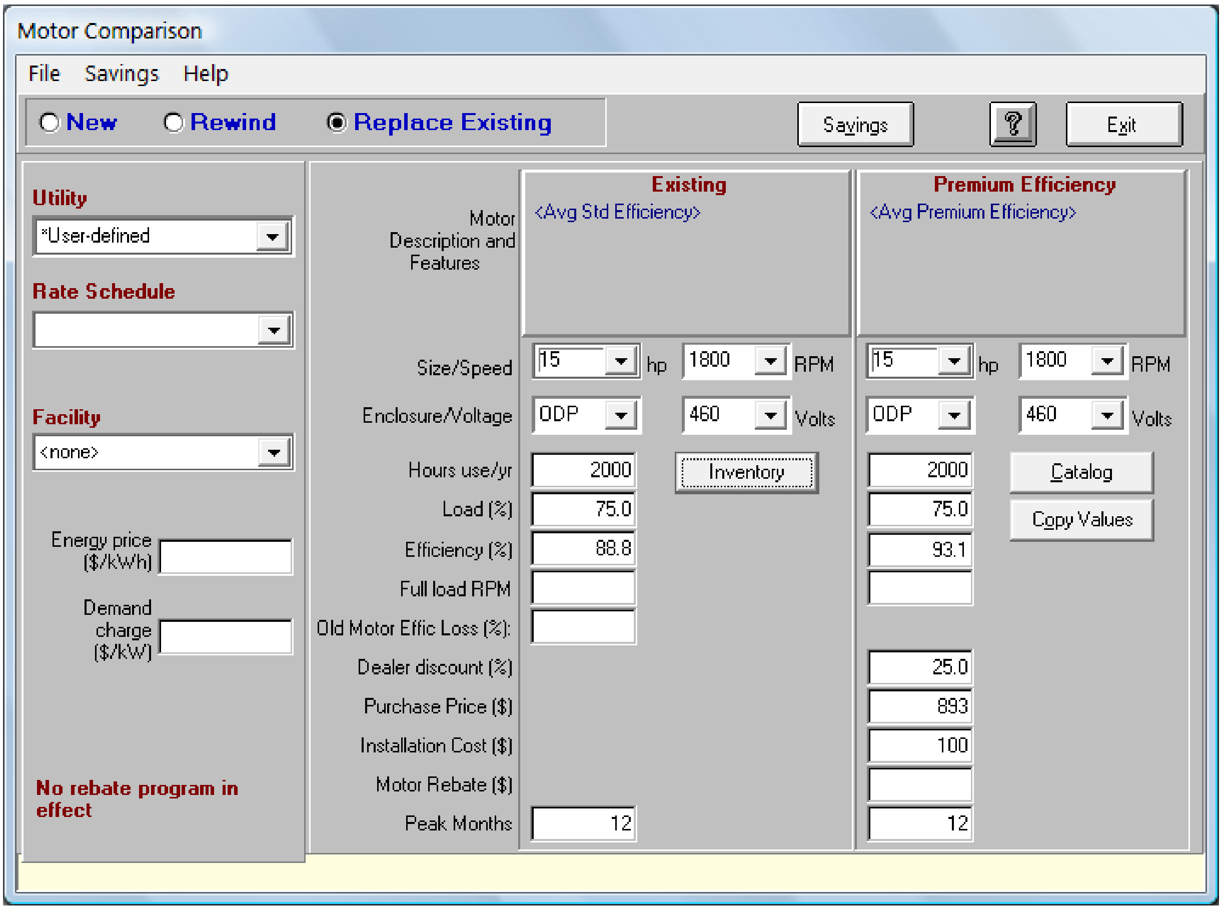
Edgartown WWTP Lab Bldg - Heating Analysis

	Existing	Recommended
Description	Unit Heaters	Water-to-Air Heat Pump
Fuel Type	Electricity (kWh)	Electricity (kWh)
Energy Delivered (MMBtu)	70.2	70.2
Adjustment Factor for Design Heat Load	1.5	1.5
Unit Efficiency or COP	100.0%	3.6
Design Usage (MMBtu)	105.3	29.3
Typical Usage (MMBtu)	70.2	19.5
Typical Usage (kWh)	20,570	5,714
Energy Costs ($/MMBtu)	$ 45.80	$ 45.80
Total Energy Costs	$ 3,215.36	$ 893.16
Total Savings		**$ 2,322.20**

Appendix IX

MotorMaster+ 4.0 Motor Analysis

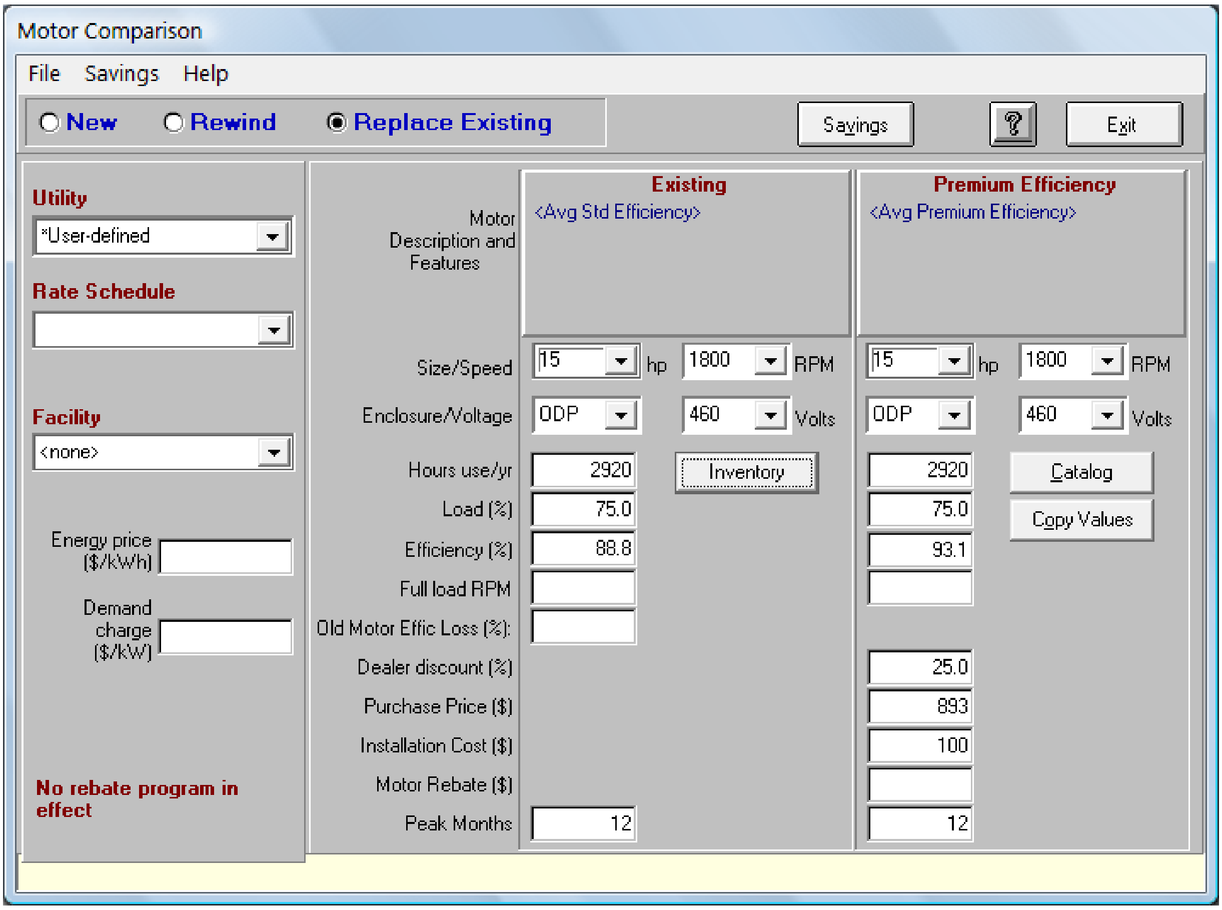
BOWMAN
ENGINEERING, INC.™


Motor Comparison
File Savings Help
New
Rewind
Replace Existing
Savings
Exit
Utility
*User-defined
Rate Schedule
Facility
<none>
Energy price ($/kWh)
Demand charge ($/kW)
No rebate program in effect
Motor Description and Features
Existing
<Avg Std Efficiency>
Premium Efficiency
<Avg Premium Efficiency>
Size/Speed
15 hp 1800 RPM
15 hp 1800 RPM
Enclosure/Voltage
ODP 460 Volts
ODP 460 Volts
Hours use/yr
2000
Inventory
2000
Catalog
Load (%)
75.0
75.0
Copy Values
Efficiency (%)
88.8
93.1
Full load RPM
Old Motor Effic Loss (%):
Dealer discount (%)
25.0
Purchase Price ($)
893
Installation Cost ($)
100
Motor Rebate ($)
Peak Months
12
12

Appendix X

MotorMaster+ 4.0 Motor Analysis

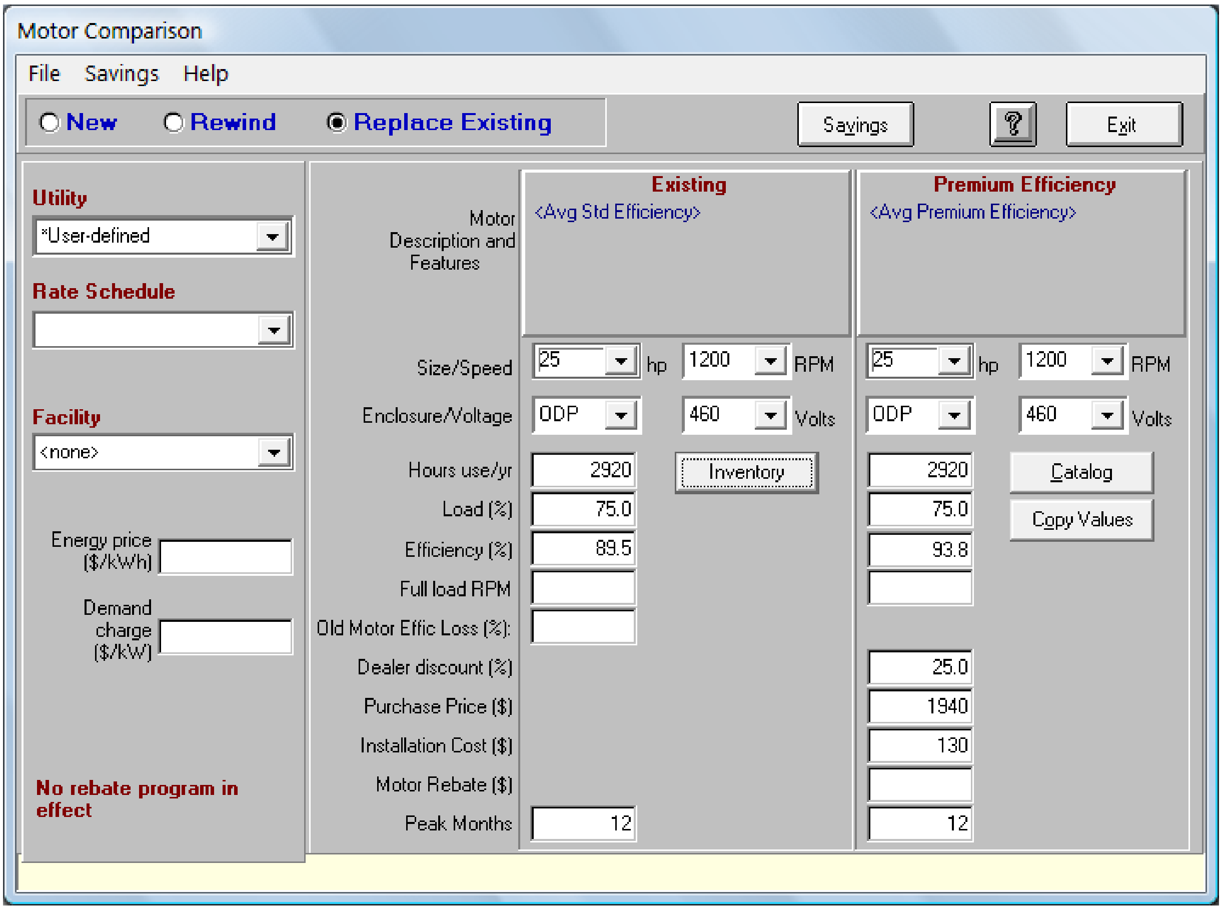
BOWMAN
ENGINEERING, INC.™


Motor Comparison
File Savings Help
New
Rewind
Replace Existing
Savings
Exit
Utility
*User-defined
Rate Schedule
Facility
<none>
Energy price ($/kWh)
Demand charge ($/kW)
No rebate program in effect
Motor Description and Features
Existing
<Avg Std Efficiency>
Premium Efficiency
<Avg Premium Efficiency>
Size/Speed
15 hp 1800 RPM
15 hp 1800 RPM
Enclosure/Voltage
ODP 460 Volts
ODP 460 Volts
Hours use/yr
2920
Inventory
2920
Catalog
Load (%)
75.0
75.0
Copy Values
Efficiency (%)
88.8
93.1
Full load RPM
Old Motor Effic Loss (%):
Dealer discount (%)
25.0
Purchase Price ($)
893
Installation Cost ($)
100
Motor Rebate ($)
Peak Months
12
12

Appendix XI

MotorMaster+ 4.0 Motor Analysis

BOWMAN
ENGINEERING, INC.™


Motor Comparison
File Savings Help
New Rewind Replace Existing
Savings
Exit
Utility
*User-defined
Rate Schedule
Facility
<none>
Energy price ($/kWh)
Demand charge ($/kW)
No rebate program in effect
Motor Description and Features
Existing
<Avg Std Efficiency>
Premium Efficiency
<Avg Premium Efficiency>
Size/Speed
25 hp 1200 RPM
Enclosure/Voltage
ODP 460 Volts
Hours use/yr
2920
Inventory
Catalog
Copy Values
Load (%)
75.0
Efficiency (%)
89.5
93.8
Full load RPM
Old Motor Effic Loss (%):
Dealer discount (%)
25.0
Purchase Price ($)
1940
Installation Cost ($)
130
Motor Rebate ($)
Peak Months
12

Appendix XII

Odor Control System Modulation

BOWMAN
ENGINEERING, INC.™

Odor Control System - Modulation Recommendation											
		Summer				Off-Season				Electricity Savings	
				Pumping Power (kW)				Pumping Power (kW)			
Motor Size	Total Annual Hours	Seasonal Hours	Percent of Full Speed	Fixed Speed	Variable Speed	Seasonal Hours	Percent of Full Speed	Fixed Speed	Variable Speed	Energy Demand (kW)	Energy Usage (kWh)
25	8,760	2,880	100%	16.46	16.46	5880	80%	16.46	8.43	8.03	47,219
15	2,000	667	100%	9.87	9.87	1333	100%	9.87	9.87	0.00	0
5	8,760	2,880	100%	3.29	3.29	5880	100%	3.29	3.29	0.00	0
5	8,760	2,880	100%	3.29	3.29	5880	100%	3.29	3.29	0.00	0
5	8,760	2,880	100%	3.29	3.29	5880	100%	3.29	3.29	0.00	0
55	**37,040**	**6,427**		**29.62**	**29.62**	**13,093**		**29.62**	**21.59**	**8.03**	**47,219**

1. Motor Load Factor Assumed: 75%
2. Motor Efficiency Assumed: 85%
3. Motor Input (kW) = (HP * 0.746*0.75)/0.85