# CAPE ELIZABETH POOL IMPROVEMENTS PROPOSAL

## CAPE ELIZABETH SCHOOLS PROJECT A

EGN 304 – SPRING 2016 – DR. MOST

PREPARED BY:
KYLE BROWN, BRIAN GODSEY, BEN GOMES, NATHAN LAREAU AND LOREN LILLY

PREPARED FOR:
GREG MARLES, DIRECTOR OF FACILITIES, CAPE ELIZABETH HIGHSCHOOL

# EXECUTIVE SUMMARY

This report evaluates the economic feasibility of implementing solar thermal arrays at the Cape Elizabeth High School, to heat the pool and spa. This evaluation shows whether or not installing solar arrays on the High School, will have a payback period less than 15 years. The two forms of arrays to be evaluated are solar thermal and solar photovoltaic.

The first type of array to be analyzed is the solar thermal. This array would be used not only to heat the pool but also the spa. For sizing the solar thermal type of array, it was determined that 64 flat plate solar thermal collectors would be needed. This would cost roughly $375,000. While most of the payback periods were calculated to be past 15 years, the net present worth calculation showed that the system should make money in the long term.

The second type of array is solar photovoltaic. The specific size was not chosen because the electricity needs greatly exceed any size that could fit on the location. Also, the photovoltaic cells would be expected to have a payback of around 20 years. However, if the school switches to time of day pricing, the payback could be lower. Electricity costs are highest during the middle of the day and cheapest at night. This is ideal for photovoltaics because they only produce electricity during the day, which is when pricing would be the highest. Nevertheless, we still wouldn't recommend this array because the lifetime of the solar cells wouldn't most likely provide a profit.

The evaluation of solar thermal and solar photovoltaic produced a clear conclusion. We would recommend solar thermal collectors to heat the swimming pool. The risk would be a 20-year payback period, and the reward could be a payback period of around 10 years and a lifetime present worth profit of over $200,000.

## PROJECT GOALS

The main goal of this project is to explore the economic feasibility of installing solar arrays on the community pool located at Cape Elizabeth High School. The first type of array to be explored is a solar thermal array that would be used to hear the pool and spa at Cape Elizabeth High School. The second array to be explored is a solar photovoltaic array to provide assistance in providing the pool systems electricity needs. The only economic constraint of the arrays will be payback period. This project will also explore means of payment and potential renewable energy rebates.

## RESEARCH

Many resources were used and compared throughout research for this project. The primary resource was Professional Engineer Fortunat C. Mueller from Revision Energy of Portland, Maine. Revision Energy was able to provide information from its previous exploration of the site. Revision provided information on system sizing and system pricing to use for economic analysis.

Secondary uses were used to confirm information from Revision Energy as well as supplemental information needed for analysis, such as historic pricing and expected inflation. Dr. Jim Masi and Dr. Daniel Martinez of USM were able to provide general information and advice on the project via their ESP 313 Renewable Energies course. The professors' knowledge of the subject allowed for guidance throughout the project.

National Renewable Energy Laboratory was used for information on photovoltaic sizing and production data. NREL's PV Watts calculator was used to determine the production of photovoltaics in the proposed location. RETScreen was used in a limited fashion to help confirm the sizing numbers from PV Watts and Revision Energy.

Research on tax credits and power purchase agreements came from multiple sites including Revision Energy and NREL. All other information received (usage and engineering drawings etc.) came from Cape Elizabeth High School.

## ANALYSIS AND METHODOLOGY

The main economic constraint of the project is payback period. It is desired that the payback period be between 7 and 10 years but a maximum of 15 years may be acceptable. As a secondary analysis net present worth will also be calculated for each system. Each system is expected to last 25 years, therefor the net present worth calculations will be done using this value. However due to the unobstructed location of these panels it would be expected that the panels would last longer because a lack of physical hazards such as trees. For every year that the panels go past the 25 year mark the net present worth increases.

Due to the volatile nature of energy prices and the inability to 100% accurately forecast outputs from these systems, payback period was calculated for multiple different scenarios. For solar thermal payback was calculated at today's current price with 0%, 5% and 10% increases. The increase needed for a 15-year payback was also calculated for reference for what rates would be needed for the maximum accepted payback. Payback was also calculated with the price of oil at $4.11. The maximum price at which it reached in 2008. This value shows that payback period is directly dependent on the volatility of fossil fuels. For solar photovoltaic only the 0%, 5% and 10% increases were explored along with the 15-year payback rate.

For sizing solar thermal it was determined that 64 flat plate solar thermal collectors would be needed. This would cost roughly $375,000. For solar photovoltaic a specific size was not chosen because the electricity needs greatly exceed any size that could fit on the location. Therefor it was decided that calculations would be done on a per kW basis so that it could be applicable to whatever size desired. The price used was $3700 per kW installed.

Because Cape Elizabeth High School is a public entity they would normally not be able to advantage of tax credits. However, it was found that power purchase agreements can be made. These agreements allow a separate entity to purchase the arrays and sell the energy to the school at a discounted price. After a certain period of time the school can buy the array for a discounted price, or potentially for free. This would allow for the school to take advantage of the 30% tax credit available to everyone else who makes a renewable energy purchase.

Because the potential PPA agreement could vary, all calculations were done as if the school was purchasing the system up front with the assumption that the PPA agreement would have minimal markup.

## RESULTS

Below are the tables of results for the solar thermal collectors. With pricing as is it would take 21 years for the array to pay itself off. While the price of fossil fuels is relatively unpredictable, it could be assumed that the price of oil will increase. The last values show that a 40% increase in price would give a 15-year payback. Once payback is reached, everything after is profit.

| Cost of System | Rebate | Price After Rebate | Annual Gallons of Oil Saved |
|---|---|---|---|
| $375,000 | 0.3 | $262,500 | 12000 |

Current (Worst Case)

| Price of Oil/Gallon | Annual Savings | Payback Period | NPW |
|---|---|---|---|
| $1.50 | $18,000.00 | 20.8 | -$8,389.52 |

Best Case

| Price of Oil/Gallon | Annual Savings | Payback Period | NPW |
|---|---|---|---|
| $4.11 | $49,320.00 | 7.6 | $412,012.71 |

*$4.11 is the highest recorded price of oil/gallon in July 2008

https://www.americanprogress.org/issues/green/news/2011/04/28/9456/oil-roulette/

5% Icrease

| Price of Oil/Gallon | Annual Savings | Payback Period | NPW |
|---|---|---|---|
| $1.58 | $18,900.00 | 19.8 | $3,691.00 |

10% Increase

| Price of Oil/Gallon | Annual Savings | Payback Period | NPW |
|---|---|---|---|
| $1.65 | $19,800.00 | 18.9 | $15,771.53 |

39.3% Increase

| Price of Oil/Gallon | Annual Savings | Payback Period | NPW |
|---|---|---|---|
| $2.09 | $25,080.00 | 15.0 | $86,643.93 |

Below are the tables of results for the photovoltaic array. While the same price increase can be expected with electricity as with oil, electricity is generally less volatile. Therefor the 46% increase in electricity costs is much less likely than the 40% increase in cost of oil.

| Size (kW) | Cost of System per kWH | Rebate | Price After Rebate | Annual kWh Produced |
|---|---|---|---|---|
| 1 | 3700 | 0.3 | 2590 | 1400 |

Current (Worst Case)

| Cost per kWh | Annual Savings | Payback Period | NPW (25 Years) |
|---|---|---|---|
| $0.120 | $168.00 | 22.0 | $350.27 |

5% Increase

| Cost per kWh | Annual Savings | Payback Period | NPW (25 Years) |
|---|---|---|---|
| $0.126 | $176.40 | 21.0 | $463.02 |

10% Increase

| Cost per kWh | Annual Savings | Payback Period | NPW (25 Years) |
|---|---|---|---|
| $0.132 | $184.80 | 20.0 | $575.77 |

46.7% Increase

| Cost per kWh | Annual Savings | Payback Period | NPW (25 Years) |
|---|---|---|---|
| $0.176 | $246.40 | 15.0 | $1,402.62 |

## CONCLUSIONS AND RECOMMENDATIONS

While most of the payback periods were calculated to be past 15 years, the net present worth calculations show that each system should make money in the long term. What the tables do not show is that these payback periods are directly dependent on energy prices which are difficult to predict. However, at the moment the price of oil would be considered very low. It would be a safe bet to say that oil will increase in price and potentially significantly. Therefor we would recommend solar thermal collectors to heat the swimming pool. The risk would be a 20-year payback period, and the reward could be a payback period around 10 years and a lifetime present worth profit over $200,000.

As a secondary and much cheaper option we would also like to propose DIY solar thermal. There are many open source designs for solar thermal collectors. They all have a similar structure of an insulated region within a reflective box that contains a black bladder that holds water. This water then absorbs light and heats up the water. These homemade collectors could be made by students as a part of science classes. This project would provide many opportunities for the students. Students would get introduced to the STEM field, specifically engineering, renewable energies, and manufacturing. The only part that would need to be paid to an outside company is the pumping and integration system which is roughly a third of the cost. This would drastically reduce costs. This could lower the payback period. The only downfall would be a less efficient system and potential maintenance issues. This could reduce the lifetime of the system and therefor the net present worth.

For electricity costs, prices have slowly increased over the years. A massive increase would not be expected. This would mean that the photovoltaic cells would be expected to have a payback around 20 years no matter what. However, if the school switches to time of day pricing the payback could be lower. With time of day pricing, electricity costs are high during midday and cheaper at night. This is ideal for photovoltaics because they only produce electricity during the day, which pricing would be the highest. This would help maximize savings during this period. However, this project has much more risk than solar thermal. But we would still recommend this project because the lifetime of the solar cells would most likely provide a profit.

The one factor not calculated in the above study was the reduction in emissions. Solar thermal panels take 2 years to save as much emissions as produced by making them and photovoltaics take about 3 years. This means that each array has 20+ years of "emission profit". However, the value of this emission reduction cannot be quantified because of variations in opinion. While it cannot be calculated we believe it should be significantly factored into the decision.

# Microturbine Generation
# Final Report

Cape Elizabeth Group B

Engineering Economics
EGN 304
Dr. Ivan Most

Greg Marles

Luke Levesque
Jacob Keniston
Matt Gordon
Tom Henley
Tim Libby

April 22, 2016

## Abstract:

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## Project background:

Our group was tasked with running economic analysis methods to determine the feasibility of installing a co-regeneration microturbine at Cape Elizabeth High school. Throughout this project we had regular conversations with facilities management personnel at the high school to obtain relevant information and to keep the high school informed as to our progress.

To fully complete our analysis we researched microturbines and their applications to better understand the numbers we were calculating. After having learned as much as we felt necessary to fully understand our task we began to reach out for information including but not limited to annual energy use and the costs related to it. With the data provided by our contacts at the high school we ran a variety of economic tests to determine if it was worth the time, money, and effort for the school.

## What is a Microturbine:

A microturbine is a small combustion device that can be used to provide both heat and electricity. The process of making electricity normally generates a significant amount of heat. This heat is often discarded and unused. A micro turbine is designed to contain the heat created and allow the heat to be used for other purposes while still allowing access to a spinning shaft to connect a generator for electrical generation.

There are two main types of microturbines. A simple cycle turbine mixes compressed air and fuel. This mixture is combusted and expands through a turbine. This expanding air is the main source of energy that is used to spin the turbine shaft. The combusted air is then released from the turbine, where it can be used to heat external devices. This is the main advantage of a cogeneration system. This heat would normally be lost to the atmosphere instead of being used to lower heating costs.

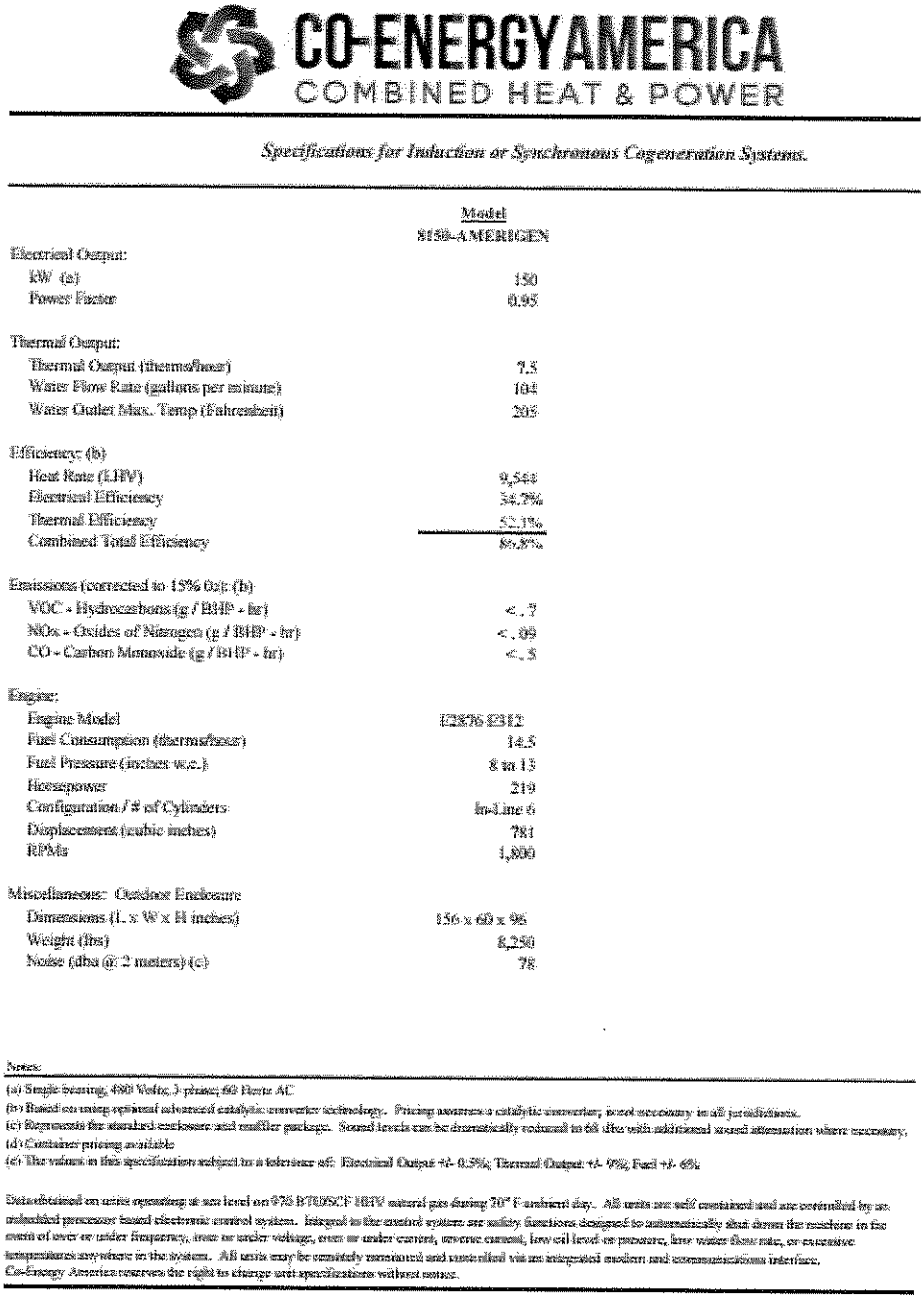
The second type of turbine is called a recuperated turbine. This device is very similar to a simple cycle turbine except a small amount of the exhaust is routed into a heat exchanger. This warm exhaust is used to heat up the incoming air into the turbine. The heated incoming air requires less fuel to reach the temperature level needed in the inlet of the turbine. This process reduces the amount of fuel needed and increases efficiency. Although recuperated systems have a higher electricity to heat ratio, the added advantage of better efficiency is often desired.

ADD MORE

## Co-Energy America 150 KW Cogeneration System:

The system we have chosen for our design is the 150KW unit made by Co-Energy America. This system is appropriately sized to provide the needed heat and electrical power, while not being too large to still operate at full capacity. This system is capable of providing 150KW of electrical power to the existing electrical system at 480V with a power factor of .95. The system has an electrical efficiency of 34.7% and a thermal efficiency of 52.1% for a combined efficiency of 86.8%.

This cogeneration device is not however a microturbine. This device uses an inline 6 cylinder natural gas engine. This engine turns at 1800 RPM and produces 219 horsepower. Although a microturbine is not used the principle of cogeneration is still used. The spinning shaft from the engine is used to turn a generator that provides electrical power. The heat produced by the engine can then be used to provide thermal energy to external devices such as heaters for the facility. The data sheet for the device is shown below.



CO-ENERGYAMERICA
COMBINED HEAT & POWER

*Specifications for Induction or Synchronous Cogeneration Systems.*

| | Model<br>8150-AMERIGEN |
|---|---|
| Electrical Output: | |
| KW (a) | 150 |
| Power Factor | 0.95 |
| Thermal Output: | |
| Thermal Output (therms/hour) | 7.5 |
| Water Flow Rate (gallons per minute) | 104 |
| Water Outlet Max. Temp (Fahrenheit) | 205 |
| Efficiency: (b) | |
| Heat Rate (LHV) | 9,544 |
| Electrical Efficiency | 34.7% |
| Thermal Efficiency | 52.1% |
| Combined Total Efficiency | 86.8% |
| Emissions (corrected to 15% O2): (b) | |
| VOC - Hydrocarbons (g / BHP - hr) | <. 7 |
| NOx - Oxides of Nitrogen (g / BHP - hr) | <. 09 |
| CO - Carbon Monoxide (g / BHP - hr) | <. 3 |
| Engine: | |
| Engine Model | E2876 E312 |
| Fuel Consumption (therms/hour) | 14.5 |
| Fuel Pressure (inches w.c.) | 8 to 13 |
| Horsepower | 219 |
| Configuration / # of Cylinders | In-Line 6 |
| Displacement (cubic inches) | 781 |
| RPMs | 1,800 |
| Miscellaneous: Outdoor Enclosure | |
| Dimensions (L x W x H inches) | 156 x 60 x 96 |
| Weight (lbs) | 8,250 |
| Noise (dba @ 2 meters) (c) | 78 |

Notes:

(a) Single bearing, 480 Volts, 3 phase, 60 Hertz AC
(b) Based on using optional advanced catalytic converter technology. Pricing assumes a catalytic converter; is not necessary in all jurisdictions.
(c) Represents the standard enclosure and muffler package. Sound levels can be dramatically reduced to 68 dba with additional sound attenuation where necessary.
(d) Container pricing available
(e) The values in this specification subject to a tolerance of: Electrical Output +/- 0.5%; Thermal Output +/- 9%; Fuel +/- 6%

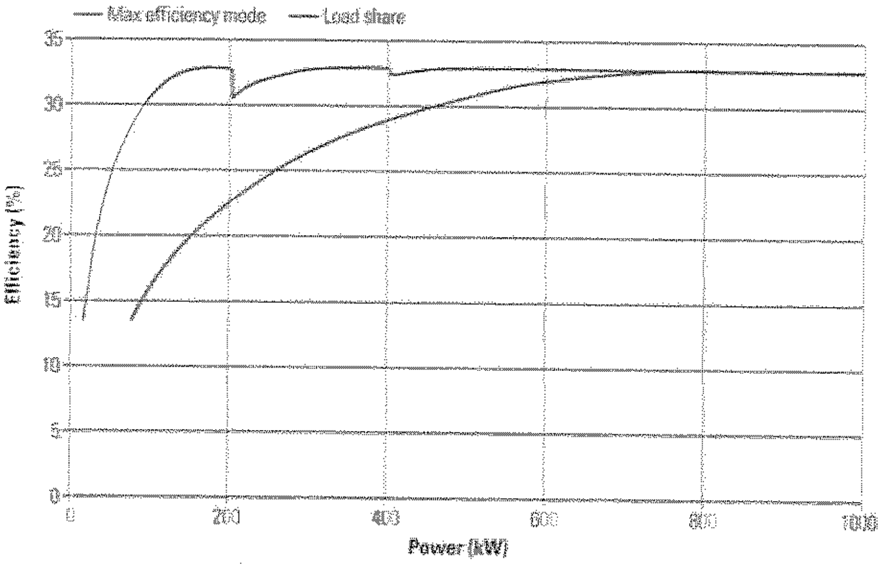
Data obtained on units operating at sea level on 970 BTU/SCF HHV natural gas during 70° F ambient day. All units are self contained and are controlled by an embedded processor based electronic control system. Integral to the control system are safety functions designed to automatically shut down the machine in the event of over or under frequency, over or under voltage, over or under current, reverse current, low oil level or pressure, low water flow rate, or excessive temperatures anywhere in the system. All units may be remotely monitored and controlled via an integrated modem and communications interface. Co-Energy America reserves the right to change unit specifications without notice.

This cogeneration system, although not a microturbine, is more feasible because of the very high efficiency. It is very common for microturbines to have an electrical efficiency of 20-35%. This means that heat recovery is essential when running the device. Without recovering and using the exhaust heat, the device is simply not efficient enough to justify its use. However, turning on and off a microturbine is not desired as it is often difficult and time consuming. This cogeneration device operates at the high end of the typical microturbine efficiency range while also allowing the user to turn on and off the device quickly and easily.

## Fueling Options:

The most common practice for microturbine generators is to power them using natural gas. This is used because it is cheaper than oil, and runs at a much higher efficiency than propane. The current offer we found for natural gas is $0.85 per gallon compared to the $1.489 that Cape Elizabeth High School is locked in for next year. This efficiency usually ranges between the high twenties to low thirty percentiles. A recuperated microturbine system allows for a higher efficiency though. A plot of the efficiency of a natural gas powered microturbine based off load can be seen in Figure 1 below.

Figure 1



(powermag.com)

One major conflict to using natural gas as a power source is that Cape Elizabeth does not currently have access to natural gas. In order to gain access to natural gas, Cape Elizabeth would need to run a pipeline for Portland. It has been estimated that this pipeline would cost the town approximately 1.3 million dollars. When conferencing with Greg Marles, he stated and our economic analysis concurs, that unless oil prices rise to $3.00 per gallon or more, the numbers just don't make sense to spend the money to get natural gas to Cape Elizabeth. With the price of oil moving down from the $2.08 per gallon that they paid this year to only $1.48 per gallon next year, they should see a sizeable cost savings considering they consume between 52,000 and 56,000 gallons per year. This works out to around $33,600.00 savings over the previous year.

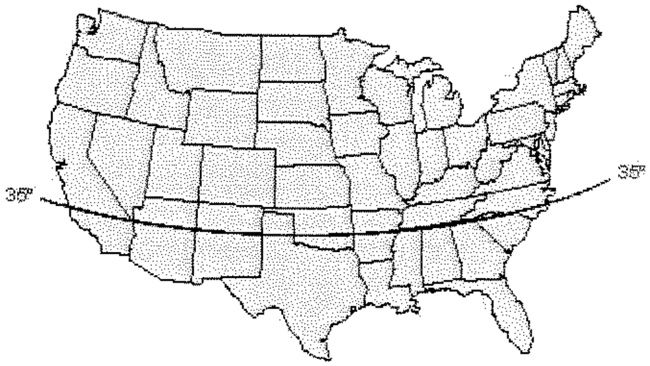
Having said all of this, natural gas is the most common form of fuel for microturbine systems today. When speaking with Rob McMenimon, a representative from CoEnergy America, he stated that everything lines up in Cape Elizabeth for a microturbine system to be installed except for the fact that they lacked access to natural gas. Other companies such as Vergent Power and Siemens, yielded similar results. As of now, the only systems we can gather significant data on are natural gas powered systems. For these reasons, we have decided to push forward with our economic analysis, assuming Cape Elizabeth gains access to natural gas.

Due to the lack of access to natural gas in Cape Elizabeth, the option of powering a turbine with propane was investigated. Currently, Capstone leads the way in propane powered microturbines. They are still in the prototype stage when using propane as the main source of power for these systems. They have currently explored the 30kW and 60kW systems using their C30 model (capstoneturbine.com). These tests were successes but they had their shortcomings along the way. Multiple failure options such as clogged fuel filters, dealing with freezing temperatures, and electronic pump failures made running the microturbine system with consistency a problem.

To power a microturbine system with propane, special equipment is needed. The first thing that they would need is a storage tank. Now, Cape Elizabeth High School already has a propane tank that they use to heat their pool with. They have a single 1,000 gallon tank with two 100 gallon tanks for a total of 1,200 gallons of storage capacity. The next piece needed is a liquid pump, which moves the liquid propane from the storage tank. The size of the pump depends on the system at hand, for it must meet the volumetric flow rate and pressure requirements of the microturbine system.

For the next component of the system there are a few different options. Microturbines can only run on vaporized propane. If the liquid propane reaches the microturbine system, the system will not fire. Some possible options include heating the tank so that the liquid propane turns to gas. This would need the interior of the tank to be above the vaporization temperature of propane which is around -44 °F when in a storage container. The other option is to include a vaporizer. The vaporizer will be placed after the liquid pump which will provide approximately 800Btu per gallon of heat to the entering propane (propanecouncil.org). Any place above the 35th parallel is recommended to use a vaporizer system, due to the colder climate. A map of the 35th parallel in the United States can be seen in Figure 2 below.

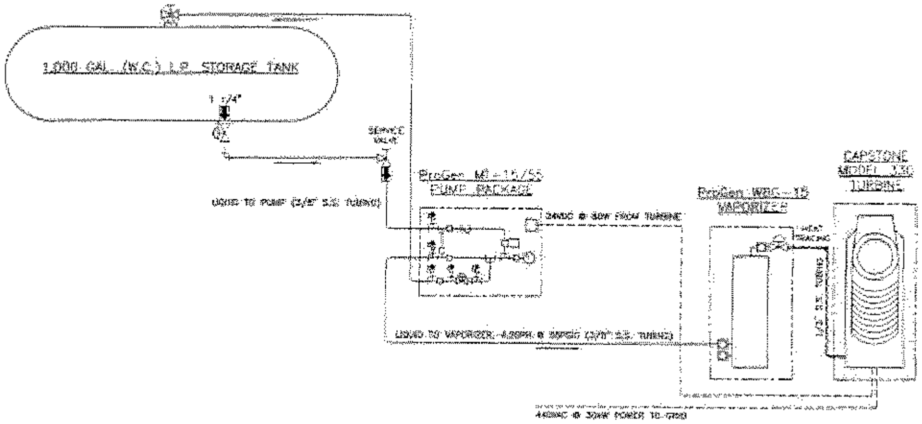
Figure 2



(propanecouncil.org)

Finally, the system must also include a regulator to regulate the pressure of the propane. This will insure that the propane does not condense when in the vapor line. The vapor line must also include heat tracing for maintenance purposes. This can be used as a diagnostic to make sure the microturbine is getting the correct fuel source. A complete schematic of a propane powered microturbine system can be seen in Figure 3.

Figure 3



(propanecouncil.org)

Currently, Cape Elizabeth High School is able to purchase propane for $1.589 per gallon. The 1,000 gallon tank that they are using to store propane to heat their pool would work for this project but they currently have that in use. Propane fueled microturbine systems are also still in their prototype stages. Because of this, it would be nearly impossible to find a company willing to install this system. The cold weather also causes problems when working with propane and the associated equipment. It would need extensive maintenance checks as well. Because of these factors, we suggest going with the natural gas model if and only if Cape Elizabeth gains access to natural gas.

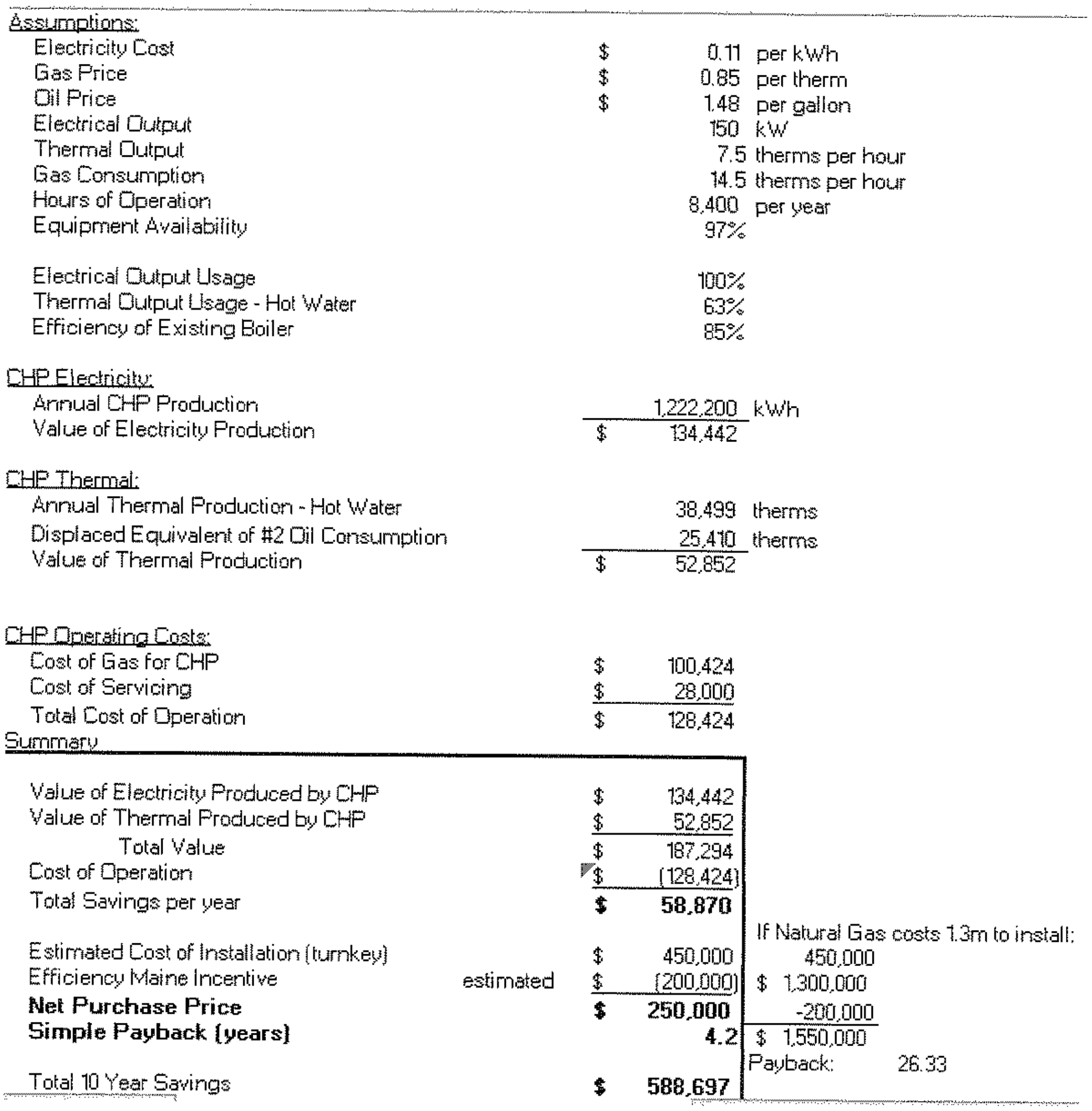
Analysis:

For our analysis we consulted with Building Facilities Engineering Company, Siemens, Vergent Power Solutions, and Co-Energy America. Building Facilities Engineering Copany is an HVAC company in Beverly, MA. They assisted us in giving us the background info we needed in order to understand how the current system works.

Siemens is a company focussing on energy efficient automation solutions. They helped us in connecting us to a specialist in the microturbine field, Vergent Power Solutions. Vergent Power Solutions then lead us onto Capstones website while they gave us valuable insight into how to go about choosing a system. The last company we spoke with was Co-Energy America which we got there info through Building Facilities Engineering. They are a company that focusses on cogeneration systems and they have done a large amount of work up here in Maine. They assisted us in the bulk of the analysis. As stated earlier in this report, once we consulted with all these professionals it was decided that Natural Gas is really the most cost effect means of fueling. Therefore, our analysis is based on the assumption that the oil prices rise and Natural Gas is used for fueling.

The analysis started with knowing what Cape Elizabeth currently pays for utilities. We then needed to know how much energy was going in and out of the boiler system that is currently at the school. Then the size and occupancy of the building was obtained. The next part of the spreadsheet then calculates the Combined Heat and Power value that is being added to the system for both the electricity and thermal sides. The annual operating costs, totalling $128,424, are then subtracted from the annual added value resulting in the annual net savings, $58,870. Taking into account the $200,000 Efficiency Maine incentive, the net cost of installation is $250,000 resulting in a payback period of 4.2 years. If the installation of a natural gas line, costing $1,300,000 is added in this analysis then the payback period goes up to 26.3 years.

Below is the spreadsheet used to calculate the payback that we worked with Co-Energy America to create:



| | | | | | | |
|---|---|---|---|---|---|---|
| Assumptions: | | | | | | |
| Electricity Cost | | $ | 0.11 | per kWh | | |
| Gas Price | | $ | 0.85 | per therm | | |
| Oil Price | | $ | 1.48 | per gallon | | |
| Electrical Output | | | 150 | kW | | |
| Thermal Output | | | 7.5 | therms per hour | | |
| Gas Consumption | | | 14.5 | therms per hour | | |
| Hours of Operation | | | 8,400 | per year | | |
| Equipment Availability | | | 97% | | | |
| Electrical Output Usage | | | 100% | | | |
| Thermal Output Usage - Hot Water | | | 63% | | | |
| Efficiency of Existing Boiler | | | 85% | | | |
| CHP Electricity: | | | | | | |
| Annual CHP Production | | | 1,222,200 | kWh | | |
| Value of Electricity Production | | $ | 134,442 | | | |
| CHP Thermal: | | | | | | |
| Annual Thermal Production - Hot Water | | | 38,499 | therms | | |
| Displaced Equivalent of #2 Oil Consumption | | | 25,410 | therms | | |
| Value of Thermal Production | | $ | 52,852 | | | |
| CHP Operating Costs: | | | | | | |
| Cost of Gas for CHP | | $ | 100,424 | | | |
| Cost of Servicing | | $ | 28,000 | | | |
| Total Cost of Operation | | $ | 128,424 | | | |
| Summary | | | | | | |
| Value of Electricity Produced by CHP | | $ | 134,442 | | | |
| Value of Thermal Produced by CHP | | $ | 52,852 | | | |
| Total Value | | $ | 187,294 | | | |
| Cost of Operation | | $ | (128,424) | | | |
| Total Savings per year | | **$** | **58,870** | | If Natural Gas costs 1.3m to install: | |
| Estimated Cost of Installation (turnkey) | | $ | 450,000 | | 450,000 | |
| Efficiency Maine Incentive | estimated | $ | (200,000) | | $ 1,300,000 | |
| **Net Purchase Price** | | **$** | **250,000** | | -200,000 | |
| **Simple Payback (years)** | | | **4.2** | | $ 1,550,000 | |
| | | | | | Payback: | 26.33 |
| Total 10 Year Savings | | **$** | **588,697** | | | |

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http://www.coenergyamerica.com/cogeneration/

CO-ENERGYAMERICA
COMBINED HEAT & POWER

Customer Name: Cape Elizabeth
Project Analysis: 150kW CHP

Assumptions:

| | | | |
|---|---|---|---|
| Electricity Cost | $ | 0.11 | per kWh |
| Gas Price | $ | 0.85 | per therm |
| Oil Price | $ | 1.48 | per gallon |
| Electrical Output | | 150 | kW |
| Thermal Output | | 7.5 | therms per hour |
| Gas Consumption | | 14.5 | therms per hour |
| Hours of Operation | | 8,400 | per year |
| Equipment Availability | | 97% | |
| | | | |
| Electrical Output Usage | | 100% | |
| Thermal Output Usage - Hot Water | | 63% | |
| Efficiency of Existing Boiler | | 85% | |

CHP Electricity:

| | | | |
|---|---|---|---|
| Annual CHP Production | | 1,222,200 | kWh |
| Value of Electricity Production | $ | 134,442 | |

CHP Thermal:

| | | | |
|---|---|---|---|
| Annual Thermal Production - Hot Water | | 38,499 | therms |
| Displaced Equivalent of #2 Oil Consumption | | 25,410 | therms |
| Value of Thermal Production | $ | 52,852 | |

CHP Operating Costs:

| | | |
|---|---|---|
| Cost of Gas for CHP | $ | 100,424 |
| Cost of Servicing | $ | 28,000 |
| Total Cost of Operation | $ | 128,424 |

Summary

| | | |
|---|---|---|
| Value of Electricity Produced by CHP | $ | 134,442 |
| Value of Thermal Produced by CHP | $ | 52,852 |
| Total Value | $ | 187,294 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Cost of Operation | | $ | (128,424) | | | |
| Total Savings per year | | **$** | **58,870** | | | |
| | | | | If Natural Gas costs 1. | | |
| Estimated Cost of Installation (turnkey) | | $ | 450,000 | | 450,000 | |
| Efficiency Maine Incentive | estimated | $ | (200,000) | $ | 1,300,000 | |
| **Net Purchase Price** | | **$** | **250,000** | | -200,000 | |
| **Simple Payback (years)** | | | **4.2** | $ | 1,550,000 | |
| | | | | Payback: | | 26.33 |
| Total 10 Year Savings | | **$** | **588,697** | | | |

CO-ENERGYAMERICA
COMBINED HEAT & POWER

Customer Name: Cape Elizabeth
Project Analysis: 85kW CHP

Assumptions:

| | | | |
|---|---|---|---|
| Electricity Cost | $ | 0.11 | per kWh |
| Gas Price | $ | 0.85 | per therm |
| Oil Price | $ | 1.48 | per gallon |
| Electrical Output | | 85 | kW |
| Thermal Output | | 5.0 | therms per hour |
| Gas Consumption | | 9.3 | therms per hour |
| Hours of Operation | | 8,400 | per year |
| Equipment Availability | | 97% | |
| | | | |
| Electrical Output Usage | | 100% | |
| Thermal Output Usage - Hot Water | | 66% | |
| Efficiency of Existing Boiler | | 85% | |

CHP Electricity:

| | | | |
|---|---|---|---|
| Annual CHP Production | | 692,580 | kWh |
| Value of Electricity Production | $ | 76,184 | |

CHP Thermal:

| | | | |
|---|---|---|---|
| Annual Thermal Production - Hot Water | | 26,888 | therms |
| Displaced Equivalent of #2 Oil Consumption | | 17,746 | therms |
| Value of Thermal Production | $ | 36,912 | |

CHP Operating Costs:

| | | |
|---|---|---|
| Cost of Gas for CHP | $ | 64,410 |
| Cost of Servicing | $ | 28,000 |
| Total Cost of Operation | $ | 92,410 |

Summary

| | | |
|---|---|---|
| Value of Electricity Produced by CHP | $ | 76,184 |
| Value of Thermal Produced by CHP | $ | 36,912 |
| Total Value | $ | 113,096 |

|  |  |  |  |
|---|---|---|---|
| Cost of Operation |  | $ | (92,410) |
| Total Savings per year |  | $ | **20,686** |
| Estimated Cost of Installation (turnkey) |  | $ | 450,000 |
| Efficiency Maine Incentive | estimated | $ | (200,000) |
| **Net Purchase Price** |  | **$** | **250,000** |
| **Simple Payback (years)** |  |  | **12.1** |
| Total 10 Year Savings |  | **$** | **206,863** |

CO-ENERGY AMERICA
COMBINED HEAT & POWER

Customer Name: Cape Elizabeth
Project Analysis: 250kW CHP

| Assumptions: | | | |
|---|---|---|---|
| Electricity Cost | $ | 0.11 | per kWh |
| Gas Price | $ | 0.85 | per therm |
| Oil Price | $ | 1.48 | per gallon |
| Electrical Output | | 250 | kW |
| Thermal Output | | 24.5 | therms per hour |
| Gas Consumption | | 12.7 | therms per hour |
| Hours of Operation | | 8,400 | per year |
| Equipment Availability | | 97% | |
| | | | |
| Electrical Output Usage | | 100% | |
| Thermal Output Usage - Hot Water | | 53% | |
| Efficiency of Existing Boiler | | 85% | |
| **CHP Electricity:** | | | |
| Annual CHP Production | | 2,037,000 | kWh |
| Value of Electricity Production | $ | 224,070 | |
| **CHP Thermal:** | | | |
| Annual Thermal Production - Hot Water | | 105,802 | therms |
| Displaced Equivalent of #2 Oil Consumption | | 69,829 | therms |
| Value of Thermal Production | $ | 145,245 | |
| **CHP Operating Costs:** | | | |
| Cost of Gas for CHP | $ | 87,958 | |
| Cost of Servicing | $ | 28,000 | |
| Total Cost of Operation | $ | 115,958 | |

Summary

| | | |
|---|---|---|
| Value of Electricity Produced by CHP | $ | 224,070 |
| Value of Thermal Produced by CHP | $ | 145,245 |
| Total Value | $ | 369,315 |

| | | | |
|---|---|---|---|
| Cost of Operation | | $ | (115,958) |
| Total Savings per year | | **$** | **253,357** |
| | | | |
| Estimated Cost of Installation (turnkey) | | $ | 450,000 |
| Efficiency Maine Incentive | estimated | $ | (200,000) |
| **Net Purchase Price** | | **$** | **250,000** |
| **Simple Payback (years)** | | | **1.0** |
| | | | |
| Total 10 Year Savings | | **$** | **2,533,570** |

| | |
|---|---|
| Useful Life (years) | 15 |
| Cost | 250,000 |
| Depreciation Rate | 20% |
| Straight Line Method | |

| Year | Life (years | Straight Line Depr | Value | Double Declining Depriciation Value |
|---|---|---|---|---|
| 0 | 15 | 250000 | 250000 | 250000 |
| 1 | 14 | 16666.66667 | 233333.3 | 33333.33333 |
| 2 | 13 | 16666.66667 | 216666.7 | 28888.88889 |
| 3 | 12 | 16666.66667 | 200000 | 25037.03704 |
| 4 | 11 | 16666.66667 | 183333.3 | 21698.76543 |
| 5 | 10 | 16666.66667 | 166666.7 | 18805.59671 |
| 6 | 9 | 16666.66667 | 150000 | 16298.18381 |
| 7 | 8 | 16666.66667 | 133333.3 | 14125.09264 |
| 8 | 7 | 16666.66667 | 116666.7 | 12241.74695 |
| 9 | 6 | 16666.66667 | 100000 | 10609.51403 |
| 10 | 5 | 16666.66667 | 83333.33 | 9194.912156 |
| 11 | 4 | 16666.66667 | 66666.67 | 7968.923869 |
| 12 | 3 | 16666.66667 | 50000 | 6906.400686 |
| 13 | 2 | 16666.66667 | 33333.33 | 5985.547261 |
| 14 | 1 | 16666.66667 | 16666.67 | 5187.474293 |

|  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  | Gallon #2 oil = 138,000 BTU |  |  |  |
|  |  |  |  | $/kWh |  |  | $ 2.08 |  | $0.80 |  |
|  |  | Kwh | Demand | $ 0.11 |  |  | Oil | Price | Convert to therms | Price |
| 2015 | Jan | 174,600 | 502 | $ 19,206 |  |  | 2,400 | 4,992 | 3,312 | 2,650 |
|  | Feb | 183,000 | 523 | $ 20,130 |  |  |  | - | - | - |
|  | Mar | 189,600 | 504 | $ 20,856 |  |  | 5,000 | 10,400 | 6,900 | 5,520 |
|  | Apr | 165,000 | 499 | $ 18,150 |  |  | 2,614 | 5,437 | 3,607 | 2,886 |
|  | May | 148,800 | 505 | $ 16,368 |  |  |  | - | - | - |
|  | Jun | 115,800 | 410 | $ 12,738 |  |  |  | - | - | - |
|  | Jul | 88,200 | 258 | $ 9,702 |  |  |  | - | - | - |
|  | Aug | 115,800 | 463 | $ 12,738 |  |  |  | - | - | - |
|  | Sep | 168,000 | 482 | $ 18,480 |  |  | 5,225 | 10,869 | 7,211 | 5,769 |
|  | Oct | 160,800 | 502 | $ 17,688 |  |  | 5,200 | 10,816 | 7,176 | 5,741 |
|  | Nov | 187,200 | 499 | $ 20,592 |  |  | 6,823 | 14,192 | 9,416 | 7,533 |
|  | Dec | 184,200 | 501 | $ 20,262 |  |  | 7,507 | 15,615 | 10,360 | 8,288 |
| 2016 | Jan | 184,800 | 497 | $ 20,328 |  |  | 9,280 | 19,303 | 12,807 | 10,245 |
|  | Feb | 178,200 | 488 | $ 19,602 |  |  | 11,830 | 24,606 | 16,325 | 13,060 |
|  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  | Total Cost |  | $ 111,238 |  | $ 59,041 |
|  |  |  |  |  |  |  |  |  |  | Nat Gas Savings |

| | | | | |
|---|---|---|---|---|
| Gallon Propane = 91,000 BTU | | | | |
| | | $ 2.00 | | |
| Propane | Convert to therms | | Total Therms Used | |
| | | | | |
| | | | | |
| | - | | 3,312 | |
| | - | | - | |
| | - | | 6,900 | |
| | - | | 3,607 | |
| | - | | - | |
| 668 | 608 | 1,215 | 608 | |
| | - | - | - | |
| | - | - | - | |
| 49 | 44 | 89 | 7,255 | |
| 1,862 | 1,695 | 3,390 | 8,871 | |
| 1,092 | 994 | 1,987 | 10,410 | |
| 114 | 104 | 208 | 10,464 | |
| 722 | 657 | 1,313 | 13,463 | |
| 267 | 243 | 487 | 16,568 | |
| | | | | |
| | | $ 8,688 | | $ 119,926 |
| | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Co-Energy America | | | | | | | | | | | | |
| 85kW Amerigen | | | | | | | | | | | | |
| therms in | 9.3 | | | | | | | | | | | |
| therms out | 5 | | | | | | | | | | | |
| monthly run hrs | 679 | 8148 | Hrs/ yr | | | | | | | | | |
| monthly therms in | 6,315 | | | | | | | | | | | |
| monthly therms out | 3,395 | | | | | | | | | | | |
| GAS- Ngrid | | | | | | | | | | | | |
| | March | Apri | May | June | July | Aug | Sept | Oct | Nov | Dec | Jan | Feb |
| bill | | | | | | | | | | | | |
| usage (therms) | 6,900 | 3,607 | - | - | - | - | 7,211 | 7,176 | 9,416 | 10,360 | 12,807 | 16,325 |
| Assume 100% is used for HW/ Heating | 6,900 | 3,607 | - | - | - | - | 7,211 | 7,176 | 9,416 | 10,360 | 12,807 | 16,325 |
| 85kW Amerigen | | | | | | | | | | | | |
| over/ (under) | (3,505) | (212) | 3,395 | 3,395 | 3,395 | 3,395 | (3,816) | (3,781) | (6,021) | (6,965) | (9,412) | (12,930) |
| Boiler Efficiency @ 85% | 5,865 | 3,066 | - | - | - | - | 6,129 | 6,100 | 8,004 | 8,806 | 10,886 | 13,876 |
| 85kW thermal usage % | 100% | 90% | 0% | 0% | 0% | 0% | 100% | 100% | 100% | 100% | 100% | 100% |
| average | 66% | | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Co-Energy America | | | | | | | | | | | | |
| 85kW Amerigen | | | | | | | | | | | | |
| therms in | 14.5 | | | | | | | | | | | |
| therms out | 7.5 | | | | | | | | | | | |
| monthly run hrs | 679 | 8148 | Hrs/yr | | | | | | | | | |
| monthly therms in | 9,846 | | | | | | | | | | | |
| monthly therms out | 5,093 | | | | | | | | | | | |
| GAS- Ngrid | | | | | | | | | | | | |
| | March | April | May | June | July | Aug | Sept | Oct | Nov | Dec | Jan | Feb |
| bill | | | | | | | | | | | | |
| usage (therms) | 6,900 | 3,607 | - | - | - | - | 7,211 | 7,176 | 9,416 | 10,360 | 12,807 | 16,325 |
| Assume 100% is used for HW/Heating | 6,900 | 3,607 | - | - | - | - | 7,211 | 7,176 | 9,416 | 10,360 | 12,807 | 16,325 |
| 85kW Amerigen | | | | | | | | | | | | |
| over/(under) | (1,808) | 1,485 | 5,093 | 5,093 | 5,093 | 5,093 | (2,118) | (2,084) | (4,324) | (5,267) | (7,714) | (11,233) |
| Boiler Efficiency @ 85% | 5,865 | 3,066 | - | - | - | - | 6,129 | 6,100 | 8,004 | 8,806 | 10,886 | 13,876 |
| 85kW thermal usage % | 100% | 60% | 0% | 0% | 0% | 0% | 100% | 100% | 100% | 100% | 100% | 100% |
| average | 63% | | | | | | | | | | | |

|  |  |  |  |  |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Co-Energy America |  |  |  |  |  |  |  |  |  |  |  |  |
| 85kW Amerigen |  |  |  |  |  |  |  |  |  |  |  |  |
| therms in | 24.5 |  |  |  |  |  |  |  |  |  |  |  |
| therms out | 12.7 |  |  |  |  |  |  |  |  |  |  |  |
| monthly run hrs | 679 | 8148 | Hrs/ yr |  |  |  |  |  |  |  |  |  |
| monthly therms in | 16,636 |  |  |  |  |  |  |  |  |  |  |  |
| monthly therms out | 8,623 |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| GAS- Ngrid |  |  |  |  |  |  |  |  |  |  |  |  |
|  | March | April | May | June | July | Aug | Sept | Oct | Nov | Dec | Jan | Feb |
| bill |  |  |  |  |  |  |  |  |  |  |  |  |
| usage (therms) | 6,900 | 3,607 | - | - | - | - | 7,211 | 7,176 | 9,416 | 10,360 | 12,807 | 16,325 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| Assume 100% is used for HW/ Heating | 6,900 | 3,607 | - | - | - | - | 7,211 | 7,176 | 9,416 | 10,360 | 12,807 | 16,325 |
| 85kW Amerigen |  |  |  |  |  |  |  |  |  |  |  |  |
| over/ (under) | 1,723 | 5,016 | 8,623 | 8,623 | 8,623 | 8,623 | 1,412 | 1,447 | (793) | (1,736) | (4,184) | (7,702) |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| Boiler Efficiency @ 85% | 5,865 | 3,066 | - | - | - | - | 6,129 | 6,100 | 8,004 | 8,806 | 10,886 | 13,876 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
| 85kW thermal usage % | 68% | 36% | 0% | 0% | 0% | 0% | 71% | 71% | 93% | 100% | 100% | 100% |
| average | 53% |  |  |  |  |  |  |  |  |  |  |  |