# V. Appendix A.: Town of Stoughton Energy Audit – Prism Energy Services

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# TOWN OF STOUGHTON

## PRELIMINARY ANALYSIS

## AND

## RECOMMENDATIONS OF POTENTIAL

## ENERGY CONSERVATION MEASURES

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# TOWN OF STOUGHTON

# ENERGY CONSERVATION MEASURES

# PRELIMINARY ANALYSIS AND RECOMMENDATIONS

## CEDAR HILL GOLF COURSE: 1137 Park Street, Stoughton, MA 02072

**1- Lighting:**

See Line by line lighting audit in pdf file (Separate file)

**2- Programmable Thermostat**

The current electric baseboard unit used in the men's bathroom for heating is controlled manually. It is set at one position unless one person adjusts it. It is left at a high temperature during the heating season, with no automatic control. We propose to install one programmable thermostat in the men's bathroom to setback the temperature from the electric baseboard during the time the facility is unoccupied (Nights during the heating season).

**3- Low Flow sink Aerators.**

Existing bathroom faucets have a high flow which can be reduced by installing aerators.

We propose to install aerators on each faucet to reduce the GPM per faucet (Where aerators can fit)

**4- Kitchen Hood Control**

The kitchen ventilation is achieved by a make-up air unit which supplies 100% outside air to the kitchen. This air is then exhausted through the hood to insure no fume is returned into the facility. The make-up air units and the exhaust fan are constant volume. The air supplied to the kitchen needs to be conditioned (cooled or heated depending on the season and setpoints). The kitchen is open in the morning and closes late in the evening. We propose to add controls and variable frequency drives on the make-up air unit and on the exhaust fans motors to modulate based on the smoke and the temperature inside the hood. In addition, a schedule to shut off the make-up air unit and the exhaust fan when the kitchen closes will be put in place to save energy. When the temperature in the hood rises or the amount of smoke increases, the supply and exhaust fans will ramp-up their speed to exhaust the fumes quickly and reduce the temperature in the hood. They will ramp down when the temperature or the smoke in the hood decrease.

**5- Demand Control Ventilation**

The ventilation system of the main space is made through the air handing unit which brings in fresh air at a constant volume during the day. During some occupied hours, the space occupancy is very low, while during other hours the space occupancy is high.

We propose to regulate the amount of fresh air introduced inside the building based on the occupancy of the space. CO2 sensor will be installed to track and monitor the space occupancy and allow the control system to modulate the dampers based on the need of fresh air inside the building.

**6- Install VFD on the RTU**

There is one rooftop units serving the facility for cooling and heating some space. We propose to add a control kit with a variable frequency drive to ramp up the motor speed or ramp it down based on meeting the temperature setpoints inside the space, to reduce the electric load on the motors.

## COUNCIL ON AGING/SENIOR CENTER

**1- Lighting:**

See Line by line lighting audit in pdf file (Separate file)

## CLAPP LIBRARY/HISTORICAL SOCIETY

**1- Boiler Replacement**

Clapp Library is heated by a hot water 600 MBH boiler which was installed almost 40 years ago. The boiler is old and inefficient. The supply hot water temperature is constant during the heating season, with no capability for hot water reset based on outdoor temperature.

We propose to replace the existing boiler with two 300 MBH condensing boilers (or one 600 MBH condensing boiler) with capability to reset the heating water temperature based on the outdoor air temperature and modulate the boilers based on the building thermal load needs.

**2- Programmable Thermostats**

The building space temperature is controlled by manual thermostats which are set at one temperature, with no automatic setback. The building is open only two days a week during the day. We propose to install programmable thermostats to control all the spaces and setback the temperature at night and during unoccupied hours.

## DPW GARAGE & TRUCK MAINTENANCE GARAGE

**1- Lighting:**

See Line by line lighting audit in pdf file (Separate file)

**2- Maintenance Garage& Mechanical Bay Programmable Thermostats**

The Maintenance Garage& Mechanical Bay are heated by rooftop units and fan coil units. The space temperature is controlled by manual thermostats which are set at one temperature only with no automatic setback. These facilities are open during the day only, from 7:00 am to 3:00 pm, Monday through Friday, and very occasionally late in the day or early in the morning when there is snow storms. We propose to install programmable thermostats to control all the fan coil units, rooftop units, and setback the temperature in the spaces they serve during unoccupied hours.

## DPW OFFICE AND STORAGE GARAGES

**1- Lighting:**

See Line by line lighting audit in pdf file (Separate file)

**2- Main Entrance FCU Programmable Thermostat**

The main entrance of the DPW Office is heated by a fan coil unit which is controlled by a manual thermostat, with no option for automatic setback. The building is occupied from 7:00 am to 3:00 pm, M-F. We propose to install a programmable thermostat to control the fan coil unit and setback the temperature at night and during unoccupied hours.

## FIRE STATION 2

**1- Lighting:**

See Line by line lighting audit in pdf file (Separate file)

**2- Low-Flow Sink Aerators**

Existing bathroom faucets have a high flow which can be reduced by installing aerators. We propose to install aerators on each faucet to reduce the GPM per faucet (Where aerators can fit)

**3- Dorm Programmable Thermostats – Heating**

The dormitory space temperature is controlled by a manual thermostat set at one temperature with no automatic setback option. The space is sometime overheated while unoccupied. We propose to install a programmable thermostats to control the space temperature and setback the temperature during unoccupied hours.

**4- Dorm Programmable Thermostats – Cooling**

The dormitory space temperature is controlled by a manual thermostat set at one temperature with no automatic setback option. The space is set at a low temperature during unoccupied hours. We propose to install a programmable thermostats to control all the space temperature and set forward the temperature during unoccupied hours.

**5- Garage Bay - Programmable Thermostats**

The garage bay is heated by gas-fired fan coil units which maintain a comfortable temperature in the bay. The temperature control in the bay is manual, with no option for automatic setback.

We propose to install programmable thermostats to control each gas-fired fan coil unit and setback the space temperature during unoccupied hours (Nights)

## FIRE STATION 1

**1- Lighting:**

See Line by line lighting audit in pdf file (Separate file)

**2- Replace Heating Hot Water Boiler**

The existing heating hot water boiler for Fire station 1 was installed more than forty years ago. It is a gas fired 1.3 MBH boiler. It is old, inefficient and at the end of its useful life. We propose to install 1.2 MBH high efficiency condensing boiler – 92% (or 4 – 300 MBH condensing boilers) with controls for hot water reset based on outdoor air temperature.

**3- Add Centralized Cooling**

The dormitory is cooled by five AC window units, while the common area is cooled by two AC Window units. There is no option for temperature control for the AC window units. Each of them is manually controlled. The AC Window units are inefficient with poor temperature control. We propose to replace the AC window AC units in the dormitory (Five) with two 3 ton heat pumps and add automatic control for temperature setback. We propose to replace the AC window AC units in the common area (two) with one 3 ton heat pump and add automatic control for temperature setback.

**4- Main Common Area Programmable Thermostats:**

The main common area is heated with hot water baseboard units. During the heating season, the temperature is so high in the space that the occupants keep the door open to keep the temperature comfortable. There is a manual thermostat which seems not to work properly. We propose to install a programmable thermostat to allow better temperature control of the space and set back the temperature during unoccupied hours.

**5- Fire Station 1 Garage Bay - Programmable Thermostats**

The garage bay is heated by gas-fired fan coil units which maintain a comfortable temperature in the bay. The temperature control in the bay is manual, with no option for automatic setback.

We propose to install programmable thermostats to control each gas-fired fan coil unit and setback the space temperature during unoccupied hours (Nights)

**PUBLIC LIBRARY**

**1- Lighting:**

See Line by line lighting audit in pdf file (Separate file)

**2- Replace Heating Hot Water Boiler**

The existing heating hot water boiler at the public library is probably original to the building construction in 1969. It is a gas fired hot water boiler, rated at 582 MBH input (80% efficiency). It is old, inefficient and at the end of its useful life. We propose to replace it with a new 600 MBH high efficiency condensing boiler – 92% (or 2 – 300 MBH condensing boilers) with controls for hot water reset based on outdoor air temperature.

**3- Weatherization**

This measure consists of weather-stripping and air sealing main entrance doors which have gaps between their double doors, letting in cold or hot air which need to be conditioned unnecessarily.

**4- Demand Control Ventilation**

The ventilation system of the main space in the library is performed through the air handing units which brings in fresh air at a constant volume during the day. During some occupied hours, the space occupancy is very low, while during other hours the space occupancy is high.

We propose to regulate the amount of fresh air introduced inside the building based on the occupancy of the space served by each individual air handling unit. CO2 sensor will be installed to track and monitor the space occupancy and allow the control system to modulate the dampers based on the need of fresh air inside the building.

**5- Install VFD on Chilled Water Pumps**

There are two chilled water pumps which alternate to circulate chilled water to various AHU coils during the cooling season. These pumps are constant flow. Modulating the speed (The load) of the pumps based on the chilled demand will reduce the energy consumed by these pumps. We propose to install two 5 HP VFD (One on each pump) and set them to vary their speed based on the building cooling demand.

**6- Install VFD on Heating Hot Water Pumps**

There are two heating hot water pumps which alternate to circulate hot water to various AHU coils during the heating season. These pumps are constant flow. Modulating the speed (the load) of the pumps based on the building heating load will reduce the energy consumed by these pumps.

We propose to install two 3 HP VFD (One on each pump) and set them to vary their speed based on the building cooling demand.

**7- Chiller Compressors Replacement**

The existing chiller which serves the library is old and inefficient, with a very high kW/ton delivered. We propose to replace the chiller compressors with more efficient ones which use less kW/Ton and connect them to the existing condenser and evaporator loops.

**8- Install VFDs on AHUs**

AHUs which are used to ventilate, heat and cool various area of the library are constant volume. We propose to install variable frequency drives on each of the AHU fan motor to modulate the speed of the fan motors based on the temperature in the space to save electric energy.

## PRATTS COURT WATER TREATMENT

**1- Lighting:**

See Line by line lighting audit in pdf file (Separate file)

**2- Programmable Thermostats**

The building space temperature is controlled by multiple manual thermostats which are set at different temperature with no automatic setback. The building is open from 7:00 am to 3:00 pm M-F. We propose to install programmable thermostats to control all the spaces and setback the temperature at night and during unoccupied hours.

**3- Variable Frequency Drives on Drinking Water Pumps**

There are two drinking water pumps at Pratts Court. One is 60 HP with no VFD and another one is 15 HP. They operate during the day only, for eight hours per day. They are constant volume pumps. We propose to add VFDs on these two pumps to modulate their speed based on the demand.

**4- PLC Upgrades**

The two pumps at Pratts Court are not on the SCADA system. We propose to add them on the Control network and run them automatically all year round based on the demand, with the capability of manual control when needed by the operators.

## PUMP STATION #1

**1- Variable Frequency Drives on Drinking Water Pumps**

There is one drinking water pump at Pump Station #1. The pump motor size is 100 HP with no VFD. We propose to install one 100 HP variable frequency drive on the pump motor.

## PUMP STATION #3

1- **PLC Control on three 40 HP pump motors**

There are three 40 HP pump motors with VFDs. Only one pump can run at a time. We propose to modify the pumps operation by upgrading their control to operate two pumps at a time, a lower speed. This type of operation will lower the overall energy consumption from pump station #3.

## PUMP STATION #5

1- **VFD On Pump #5**

There is one drinking water pump at Pump Station #5. The pump motor size is 60 HP with no VFD. We propose to install one 60 HP variable frequency drive on the pump motor

## GODDARD WELL

1- **VFD On Pump #7**

There is one drinking water pump at Pump Station #7 (Goddard Well). The pump motor size is 20 HP with no VFD. We propose to install one 20 HP variable frequency drive on the pump motor

## SEWER PUMPS VFDs

There are three sewer pump motors with no VFD. Each motor is 25 HP. We propose to install three 25 HP variable frequency drive on the pump motors.

## POLICE STATION:

1- **Low-Flow Sink Aerators**

Existing Men's and Women's bathroom faucets have a high flow which can be reduced by installing aerators. We propose to install aerators on each faucet to reduce the GPM per faucet (Where aerators can fit).

2- **Cooling System Upgrade**

The existing Cooling system consists of ten split systems located on the roof of the building. The installed cooling load totals 27 tons. Each unit has a dedicated space. In recent years, the units have not been delivering enough cooling and portable cooling units have been added to the various spaces. We propose to install two (2) 20 ton condensing units to boost the cooling need of the facility and improve the efficiency of the cooling system. Energy will be saved from the efficiency of the system and by a better control of each zone served by the rooftop units.

**3- Demand Control Ventilation**

There are ten (10) zones with constant volume air system. Although the police station is open 24/7, some areas can be unoccupied for a long period. We proposed to add CO2 sensors on each zone and add controls on the ventilation system to modulate the fresh air supply based on the zone occupancy. This control system will allow to save energy, while maintaining comfort level, in zones which are not occupied all the time.

## ROBERT O'DONNELL MIDDLE SCHOOL

**1- Weatherization**

There are three double door serving as entrance to the middle school. These doors have gaps which allow air infiltration. The air entering the space needs to be air conditioned, costing a lot of money to the school. We propose to add air sealing and weather-strip the double doors to reduce the amount of air infiltration into the building.

**2- New Hot Water Heater**

Domestic hot water used by the school is produced by the heating boilers located in the mechanical room of the school. Water is stored in an oversized domestic hot water tank, with lots of heat losses. The boilers need to run when the school is in section, even when there is no need for heating. This type of heating hot water is inefficient.

We propose to replace the hot water tank and the domestic hot water heating system with a small size domestic hot water heater for better efficiency

**3- Kitchen Hood Control**

The kitchen ventilation is achieved by a two unit ventilators which supplies 100% outside air to the kitchen. This air is then exhausted through the hood to insure no fume is returned into the facility. The make-up air units (unit ventilators) and the exhaust fan are constant volume. The air supplied to the kitchen needs to be conditioned (heated depending on the season and setpoints). The kitchen is open in the morning and closes late in the evening. We propose to add controls and variable frequency drives on the unit ventilators motors unit and on the exhaust fans motor to modulate based on the smoke and the temperature inside the hood. In addition, a schedule to shut off the make-up air unit and the exhaust fan when the kitchen closes will be put in place to save energy. When the temperature in the hood rises or the amount of smoke increases, the supply and exhaust fans will ramp-up their speed to exhaust the fumes quickly and reduce the temperature in the hood. They will ramp down when the temperature or the smoke in the hood decrease.

**4- VFDs on HW Pumps**

There are two hot water pump motors with no VFD. We propose to add two 3 HP VFD on the two heating hot water pump motors and modulate their speed based on the thermal loads of the spaces they serve.

**5- Energy Management System**

The existing HVAC control system consists of a combination of old pneumatic controls and a timer for equipment operation and scheduling. These controls are antiquated, lack flexibility and accuracy. We propose to add a DDC control system as an overlay to the existing pneumatic system. The DDC System will allow the building operators to perform a building wide scheduling of HVAC equipment operation, and reset heating hot water based on outdoor air temperature.

**6- Demand Control Ventilation**

There are approximately fifty (50) unit ventilators serving classrooms. We propose to add CO2 sensors on each unit ventilator and modulate the fresh air introduced into the classrooms based on the occupancy of the space. This will reduce the amount of cold air needed to be heated during the heating season while saving energy at the same time.

## GIBBONS ELEMENTARY

**1- Burner Electronic Controls**

The existing burners have mechanical cam controls on boilers which were installed in 1979. We propose to install electronic controls on the burners to adjust their operation pattern based on the thermal load.

**2- VFD on gym AHUs in the Mechanical Room**

The Gym AHU motor in the mechanical has no variable frequency drives. We propose to install one 3 HP VFD to modulate the fan motor speed based on the temperature inside the gym.

**3- Energy Management System**

The existing HVAC control system consists of a combination of old pneumatic controls timers for equipment operation and scheduling. These controls are antiquated, lack flexibility and accuracy.

During the heating season, when the outdoor temperature is 30 degrees F or below, the heating is overridden and all the HVAC units (Pumps, boilers, UVs) run constantly, including during the unoccupied hours. We propose to add a DDC control system as an overlay to the existing pneumatic system. The DDC System will allow the building operators to perform a building wide scheduling of HVAC equipment operation, and reset heating hot water based on outdoor air temperature. They will also have a better monitoring system which will reduce the run hours on the boilers and the heating systems.

**4- Demand Control Ventilation**

Gibbons Elementary School has approximately 25 unit ventilators serving classrooms. We propose to add CO2 sensors on each unit ventilator and modulate the fresh air introduced into the classrooms based on the occupancy of the space. This will reduce the amount of cold air needed to be heated during the heating season while saving energy at the same time.

## JOSEPH R. DAWE ELEMENTARY

### 1- Energy Management System

The existing HVAC control system consists of a combination of old pneumatic controls timers for equipment operation and scheduling. These controls are antiquated, lack flexibility and accuracy. The custodian performs most of the operations manually. We propose to add a DDC control system as an overlay to the existing pneumatic system. The DDC System will allow the building operators to perform a building wide scheduling of HVAC equipment operation, and reset heating hot water based on outdoor air temperature. They will also have a better monitoring system which will reduce the run hours on the boilers and the heating systems.

### 2- Burner Electronic Controls

The existing burners have mechanical cam controls on boilers which were installed in 1979. We propose to install electronic controls on the burners to adjust their operation pattern based on the thermal load.

### 3- Programmable Thermostats

One section of the school is cooled by four (4) split systems, ranging from 2 tons to five tons (Total of 11 ton). The space they served are controlled with manual thermostats, with no option for automatic set forward. These spaces are occupied six to eight hours per day only, M-F. We propose to add programmable thermostats to setback the temperature in these spaces during unoccupied hours to save energy and extend the life of the split systems.

### 4- Kitchen Equipment Conversion

The kitchen equipment run on electricity, including the stoves (four). We propose to convert the existing stoves to natural gas fires stoves since natural gas is available at the school.

## WEST ELEMENTARY SCHOOL

### 1- Kitchen Hood Control

The kitchen ventilation is achieved by a 5 HP make-up air which supplies 100% outside air to the kitchen. This air is then exhausted through the hood to insure no fume is returned into the facility. The make-up air unit and the exhaust fan are constant volume. The air supplied to the kitchen needs to be conditioned (heated depending on the season and setpoints). The kitchen is open in the morning and closes late in the afternoon. We propose to add controls and variable frequency drives on the make-up air unit motor unit and on the exhaust fan motor to modulate based on the smoke and the temperature inside the hood. In addition, a schedule to shut off the make-up air unit and the exhaust fan when the kitchen closes will be put in place to save energy. When the temperature in the hood rises or the amount of smoke increases, the supply and exhaust fans will ramp-up their speed to exhaust the fumes quickly and reduce the temperature in the hood. They will ramp down when the temperature or the smoke in the hood decrease.

**2- Energy Management System**

The existing HVAC control system at West School consists of a combination of old pneumatic controls timers for equipment operation and scheduling. These controls are antiquated, lack flexibility and accuracy. A set of manual clocks with pneumatic sensors are complex to operate and the custodians get confused on how the system works. We propose to add a DDC control system as an overlay to the existing pneumatic system. The DDC System will allow the building operators to perform a building wide scheduling of HVAC equipment operation, and automatically reset the heating system (Steam boilers and main steam valves) based on outdoor air temperature. They will also have a better monitoring system which will reduce the run hours on the boilers and the heating systems.

**3- Variable Frequency Drives on Gym AHUs**

The Gymnasium is ventilated by two 3 HP air handling units with steam heating coils. The AHUs are constant volume. We propose to add a VFD on each AHU to allow the fan motors to vary based on the temperature in the space.

**4- Steam Traps Replacement**

The building is heated with steam. There is at least one steam trap on each heating unit and one steam trap on the distribution lines. They are not regularly serviced. The practice is to replace them at the same time once in five years. They have not been replaced for a long period. We propose to replace them at the same time, with an accuracy of reducing the energy consumption by a minimum of 3%.

## HELEN H. HANSON ELEMENTARY:

**1- Energy Management System**

The existing HVAC control system at Hanson Elementary School consists of a combination of old pneumatic controls timers for equipment operation and scheduling. These controls are antiquated, old and inaccurate. During the heating season, when the outdoor temperature is 30 degrees F or below, the heating is overridden and all the HVAC units (Pumps, boilers, UVs) run constantly, including during the unoccupied hours. We propose to add a DDC control system as an overlay to the existing pneumatic system. The DDC System will allow the building operators to perform a building wide scheduling of HVAC equipment operation, and reset heating hot water based on outdoor air temperature. They will also have a better monitoring system which will reduce the run hours on the boilers and the heating systems.

**2- Burners Electronic Control**

The existing burners have mechanical cam controls on boilers which were installed in 1986. We propose to install electronic controls on the burners to adjust their operation pattern based on the thermal load.

**3- Variable Frequency Drives on Hot Water Pumps**

There are four heating hot water pumps serving four different zones of the school. Two pumps are <1.5 HP and two pumps are 3 HP each. We propose to add VFDs on these two large pumps to vary the hot water flow in the spaces they serve based on the thermal load demand.

**4- Demand Control Ventilation**

There are approximately 24 unit ventilators serving classrooms. We propose to add CO2 sensors on each unit ventilator and modulate the fresh air introduced into the classrooms based on the occupancy of the space. This will reduce the amount of cold air needed to be heated during the heating season while saving energy at the same time.

## SOUTH ELEMENTARY SCHOOL

**1- Burners Control**

The existing burners have mechanical cam controls on boilers which were installed in 1986. We propose to install electronic controls on the burners to adjust their operation pattern based on the thermal load.

**2- VFD on Hot Water Pumps**

Two heating hot water pumps are used for circulating heating hot water. Their motors have no VFD. Each motor is 3 HP size. We propose to add two 3 HP VFD on each of the two heating hot water pump motors and modulate their speed based on the thermal loads of the spaces they serve.

**3- Energy Management System**

The existing HVAC control system at South Elementary School consists of a combination of old pneumatic controls timers for equipment operation and scheduling. These controls are antiquated, old and inaccurate. During the heating season, when the outdoor temperature is 30 degrees F or below, the heating is overridden and all the HVAC units (Pumps, boilers, UVs, fan motors) run constantly, including during the unoccupied hours, until the outdoor air temperature is above 30 degrees F again. This type of building operation is expensive and can be improved without freezing hot water pipes, as feared by the building operators. We propose to add a DDC control system as an overlay to the existing pneumatic system. The DDC System will allow the building operators to perform a building wide scheduling of HVAC equipment operation, and reset heating hot water based on outdoor air temperature. They will also have a better monitoring system which will reduce the run hours on the boilers and the heating systems

**4- Programmable Thermostats**

The Teachers Room, the Conference room and the library have manual thermostats controlling the temperature in the space. We propose to replace them and install programmable thermostats to allow temperature setback at night and on weekends when the spaces are not occupied.

## E.A. JONES ELEMENTARY SCHOOL

### 1- Pipe Insulation

There are 25 feet 4"steam pipes on boiler #2 which are bare and uninsulated, resulting in significant heat losses. We propose to insulate these bare pipes with appropriate fiber glass to reduce heat losses and improve the boilers efficiency.

### 2- Energy Management System

The existing HVAC control system at Jones Elementary School consists of a combination of old pneumatic controls timers for equipment operation and scheduling. These controls are antiquated, inaccurate and complicated to operate. We propose to add a DDC control system as an overlay to the existing pneumatic system. The DDC System will allow the building operators to perform a building wide scheduling of HVAC equipment operation, and automatically reset the heating system (Steam boilers and main steam valves) based on outdoor air temperature. They will also have a better monitoring system which will reduce the run hours on the boilers and the heating systems.

### 3- Burners Electronic Control

The existing burners for the steam boilers have mechanical cam controls which were installed at least a few decades ago. We propose to install electronic controls on the burners to adjust their operation pattern based on the thermal load.

### 4- Steam Traps Replacement

The building is heated with steam. There is at least one steam trap on each heating unit and one steam trap on the distribution lines. They are not regularly serviced. The practice is to replace them at the same time once in five years. They have not been replaced for a long period. We propose to replace them at the same time, with an accuracy of reducing the energy consumption by a minimum of 3%.

## HIGH SCHOOL

### 1- Install VFDs on Air Handling units

AHUs which are used to ventilate, heat and cool various area of the high school are constant volume. They are located in the gymnasium, cafeteria, locker rooms and some classrooms and large spaces. We propose to install variable frequency drives on each of the AHU fan motor to modulate the speed of the fan motor based on the temperature in the space to save electric energy.

### 2- DDC Overlay on Pneumatic controls

The existing HVAC control system at the high school consists of a combination of old pneumatic controls timers for equipment operation and scheduling. These controls are antiquated, inaccurate and often very complex to operate. We propose to add a DDC control system as an overlay to the existing pneumatic system. The DDC System will allow the building operators to perform a building wide recalibration of the sensors and pneumatic devices and be able to view their performance on a screen at the same time.

**3- HVAC Scheduling – Start/ Stop**

This measure consists of upgrading the existing pneumatic controls to allow a strict scheduling of HVAC equipment. Currently, scheduling of large equipment is performed individually by mechanical timers, while other HVAC equipment (EF, UVs) are not scheduled. A DDC control system (Front end) combined to overlay on pneumatic controls will allow to turn off HVAC equipment based on a schedule set by the building operators.

**4- Heating Hot Water Temperature Reset**

This measure consists of varying the heating hot water temperature based on outdoor air temperature, rather than maintaining a constant water temperature for the heating hot water. This measure saves a significant amount of energy when the temperature outside is above freezing.

**5- Main Steam Valve Control**

One side of the high school is heated with steam. We propose to control the steam flow from the boilers based on outdoor air temperature by matching the space temperature needs with the lengths the main steam valve is open/closed during unoccupied hours when no AHUs with steam coils are in use. This measure allows to reduce the load on the steam boilers, especially during mild weather to avoid space overheating.

**6- Pipes and Valves Insulation**

The building has many areas where the insulation of the heating pipes has deteriorating, exposing bare pipes. In addition, big size steam valves radiate a lot of heat in the mechanical rooms. This measure will consist of insulating heating hot water pipes in the mechanical rooms where the insulation has deteriorated, insulation of steam pipes with fiber glass insulation material, and putting insulation blankets around large steam valves.

**7- Kitchen Hood Control**

The kitchen ventilation is achieved by one make up air unit which supplies 100% outside air to the kitchen. This air is then exhausted through the hood to insure no fume is returned into the facility. The make-up air unit and the exhaust fan are constant volume. The air supplied to the kitchen needs to be conditioned (heated depending on the season and set points). The kitchen is open in the morning and closes late in the evening. We propose to add controls and variable frequency drives on the air make up air fan motor and on the exhaust fans motor to modulate based on the smoke and the temperature inside the hood. In addition, a schedule to shut off the make-up air unit and the exhaust fan when the kitchen closes will be put in place to save energy. When the temperature in the hood rises or the amount of smoke increases, the supply and exhaust fans will ramp-up their speed to exhaust the fumes quickly and reduce the temperature in the hood. They will ramp down when the temperature or the smoke in the hood decrease.

**8- Boiler Burners Control**

The high school heating system consists of four 6,300 MBH boilers located in two mechanical rooms. There are two boilers in each mechanical room. One boiler in each mechanical room is used to handle the thermal load during the heating season, while the other one is in standby mode.

The boilers burners are mechanically controlled. We propose to retrofit them and have them electronically controlled. At the same time, we propose to track the excessive amount of air in the stack, add VFDs on the boiler supply air motors and modulate the speed of the motors based on the O2 level in the exhaust. This strategy maintains an almost constant O2 level in the stack while reducing the amount of energy needed to heat cold air brought into the combustion chamber of the boiler.

**9- Steam Traps Replacement**

One side of the building is heated with steam. There is at least one steam trap on each heating unit and one steam trap on each distribution line. They are not regularly serviced. The last time these traps were replaced was almost ten years ago. The practice is to replace them at the same time once every five to seven years. We propose to replace all of them at the same time, with an accuracy of reducing the energy consumption by a minimum of 3%.

## STOUGHTON ENERGY AUDITS

| Building Name and/or Location | Projected Annual Electricity Savings (kWh) | Projected Annual Gas Savings (Therms) | Total Annual Electricity Usage without Street/Traffic Lights or High School (kWh) | Total Annual Gas Usage without High School (Therms) | Projected Annual Propane Savings (Gallons) | Projected Annual Cost Savings | ESTIMATED Total Project Cost | Estimated Incentives | ESTIMATED Total Cost After incentives | Estimated Payback After Incentives (years) |
|---|---|---|---|---|---|---|---|---|---|---|
| **TOTALS** | **907,108** | **105,247** | **5,091,868** | **512,972** | **40** | **265,622** | **2,690,751** | **329,239** | **2,361,512** | **8.9** |
| **CEDAR HILL GOLF COURSE: 1137 Park Street, Stoughton, MA 02072** | | | 55,884 | | | | | | | |
| Lighting | 3,985 | | | | | **$655** | **$6,740** | $1,920 | **$4,820** | **7.4** |
| Programmable Thermostat - Men's Bathroom | 1,995 | | | | | **$328** | **$1,200** | $499 | **$701** | **2.1** |
| Low-Flow Sink Aerators | | 83 | | | | **$91** | **$700** | $83 | **$617** | **6.8** |
| Kitchen Hood Control | 3,219 | 1,641 | | | | **$2,334** | **$32,000** | $2,446 | **$29,554** | **12.7** |
| Demand Control Ventilation | 1,515 | 420 | | | | **$711** | **$7,800** | $799 | **$7,001** | **9.8** |
| VFD on RTU | 5,366 | | | | | **$882** | **$11,000** | $1,342 | **$9,659** | **10.9** |
| **COUNCIL ON AGING/SENIOR CENTER: 110 Rockland Street, Stoughton, MA 02072** | | | 68,640 | | | | | | | |
| Lighting | 12,825 | | | | | **$2,108** | **$27,591** | $4,165 | **$23,426** | **11.1** |
| **CLAPP LIBRARY/HISTORICAL SOCIETY: 6 Park Street, Stoughton, MA 02072** | | | 8,256 | | | | | | | |
| Boiler Replacement | | 848 | | | | **$933** | **$48,000** | $4,000 | **$44,000** | **47.2** |
| Programmable Thermostats | | 680 | | | | **$748** | **$3,300** | $680 | **$2,620** | **3.5** |
| **DPW Truck Maint. Garage, Account Number 7546051019: 950 Central Street, Stoughton, MA 02072** | | | 100,488 | | | | | | | |
| Lighting | 42,256 | | | | | **$6,947** | **$68,840** | $12,765 | **$56,075** | **8.1** |
| Maintenance Garage& Mechanical Bay Programmable Thermostats | 10,660 | 4,199 | | | | **$6,371** | **$19,700** | $6,864 | **$12,836** | **2.0** |
| **DPW Office and Storage Garages, Account Number 8793859013: 950 Central Street, Stoughton, MA 02072** | | | 41,148 | | | | | | | |
| Lighting | 19,221 | | | | | **$3,160** | **$41,510** | $10,600 | **$30,910** | **9.8** |
| Main Entrance FCU Programmable Thermostat | | 98 | | | | **$108** | **$700** | $98 | **$602** | **5.6** |
| **FIRE STATION 2: 1550 Central Street, Stoughton, MA 02072** | | | 110,496 | | | | | | | |
| Lighting | 22,402 | | | | | **$3,683** | **$44,063** | $4,200 | **$39,863** | **10.8** |
| Low-Flow Sink Aerators | | 178 | | | | **$196** | **$800** | $178 | **$622** | **3.2** |
| Dorm Programmable Thermostats - Heating | | 141 | | | | **$155** | **$1,200** | $141 | **$1,059** | **6.8** |
| Dorm Programmable Thermostats - Cooling | 2,236 | | | | | **$368** | **$3,100** | $559 | **$2,541** | **6.9** |
| Garage Bay - Programmable Thermostats | | 2,122 | | | | **$2,334** | **$5,400** | $2,122 | **$3,278** | **1.4** |
| **FIRE STATION 1: 30 Freeman Street, Stoughton, MA 02072** | | | 104,172 | | | | | | | |
| Lighting | 14,356 | | | | | **$2,360** | **$18,668** | $840 | **$17,828** | **7.6** |
| Replace Boiler | | 1,826 | | | | **$2,009** | **$97,500** | $8,000 | **$89,500** | **44.6** |
| Add Centralized Cooling | 9,274 | | | | | **$1,525** | **$45,000** | $2,319 | **$42,682** | **28.0** |
| Main Common Area Programmable Thermostats | | 354 | | | | **$389** | **$2,100** | $354 | **$1,746** | **4.5** |
| Garage Bay - Programmable Thermostats | | 5,658 | | | | **$6,224** | **$14,700** | $5,658 | **$9,042** | **1.5** |
| **LIBRARY: 84 Park Street, Stoughton, MA 02072** | | | 191,940 | | | | | | | |
| Lighting | 46,175 | | | | | **$7,591** | **$98,629** | $12,205 | **$86,424** | **11.4** |
| Boiler Replacement | | 1,118 | | | | **$1,230** | **$92,000** | $1,118 | **$90,882** | **73.9** |
| Weatherization | 220 | 189 | | | | **$244** | **$1,200** | $244 | **$956** | **3.9** |
| DCV | 3,349 | 383 | | | | **$972** | **$11,000** | $1,220 | **$9,780** | **10.1** |
| VFDs on Chilled Water Pumps | 5,981 | | | | | **$983** | **$12,000** | $1,495 | **$10,505** | **10.7** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| VFDs on Hot Water Pumps | 3,198 | | | | | **$526** | **$12,000** | $800 | **$11,201** | **21.3** |
| Chiller Compressors Replacement | 12,000 | | | | | **$1,973** | **$63,000** | $3,000 | **$60,000** | **30.4** |
| VFDs on AHUs | 16,678 | | | | | **$2,742** | **$27,000** | $4,170 | **$22,831** | **8.3** |
| **PRATTS COURT WATER TREATMENT: Pratts Court, Stoughton, MA 02072** | | | 133,320 | | | | | | | |
| Lighting | 12,597 | | | | | **$2,071** | **$23,209** | $1,640 | **$21,569** | **10.4** |
| Programmable Thermostats | | 328 | | | 40 | **$453** | **$4,900** | $328 | **$4,572** | **10.1** |
| VFDs on 60 HP and 15 HP Pump Motor | 47,772 | | | | | **$7,854** | **$48,000** | $11,700 | **$36,300** | **4.6** |
| PLC Controls Upgrade | 7,000 | | | | | **$1,151** | **$11,000** | $1,750 | **$9,250** | **8.0** |
| **PUMP STATION #1: 1740 Central Street, Stoughton, MA 02072** | | | | | | | | | | |
| VFD on 100 HP Pump Motor | 68,838 | | | | | **$11,317** | **$55,000** | $12,500 | **$42,500** | **3.8** |
| **PUMP STATION #3: King Street, Stoughton, MA 02072** | | | 78,000 | | | | | | | |
| PLC Controls on three 40 HP VFDs | 18,895 | | | | | **$3,106** | **$13,000** | $4,724 | **$8,276** | **2.7** |
| **PUMP STATION #5: Plain Street, Stoughton, MA 02072** | | | 196,188 | | | | | | | |
| VFD on 60 HP Pump Motor | 67,831 | | | | | **$11,151** | **$45,300** | $8,250 | **$37,050** | **3.3** |
| **GODDARD WELL: 909 Summer Street, Stoughton, MA 02072** | | | 80,292 | | | | | | | |
| VFD on 20 HP Pump Motor | 20,871 | | | | | **$3,431** | **$19,000** | $3,900 | **$15,100** | **4.4** |
| **THREE SEWER PUMPS - Stoughton, MA 02072** | | | | | | | | | | |
| VFD on three 25 HP pump motors | 34,959 | | | | | **$5,747** | **$37,500** | $13,950 | **$23,550** | **4.1** |
| **POLICE STATION: 26 Rose Street, Stoughton, MA 02072** | | | 221,940 | | | | | | | |
| Low-Flow Sink Aerators | | 208 | | | | **$229** | **$600** | $208 | **$392** | **1.7** |
| Cooling System Upgrade | 26,000 | | | | | **$4,274** | **$72,000** | | **$72,000** | **16.8** |
| Demand Control Ventilation | 6,612 | 1,259 | | | | **$2,472** | **$18,000** | $2,912 | **$15,088** | **6.1** |
| **ROBERT O'DONNELL MIDDLE SCHOOL: 211 Cushing Street, Stoughton, MA 02072** | | | 527,244 | 95,598 | | | | | | |
| Weatherization | 401 | 453 | | | | **$564** | **$3,800** | $553 | **$3,247** | **5.8** |
| New Hot Water Heater (DHW) | | 1,995 | | | | **$2,195** | **$37,000** | $1,995 | **$35,005** | **16.0** |
| Kitchen Hood Controls | 4,507 | 1,597 | | | | **$2,498** | **$35,000** | $2,724 | **$32,276** | **12.9** |
| VFDs on HW Pumps | 7,987 | | | | | **$1,313** | **$18,000** | $2,000 | **$16,000** | **12.2** |
| EMS | 3,491 | 787 | | | | **$1,440** | **$27,000** | $1,660 | **$25,340** | **17.6** |
| Demand Control Ventilation | | 2,520 | | | | **$2,772** | **$52,000** | $2,520 | **$49,480** | **17.8** |
| **GIBBONS ELEMENTARY: 235 Morton Street, Stoughton, MA 02072** | | | 211,488 | 35,884 | | | | | | |
| Burner Electronic Control | | 1,140 | | | | **$1,254** | **$16,000** | $1,140 | **$14,860** | **11.9** |
| VFD on gym AHUs and Mech Room | 10,569 | | | | | **$1,738** | **$27,000** | $3,000 | **$24,000** | **13.8** |
| EMS | 5,479 | 5,616 | | | | **$7,078** | **$69,000** | $6,986 | **$62,014** | **8.8** |
| Demand Control Ventilation | | 1,057 | | | | **$1,163** | **$28,000** | $1,057 | **$26,943** | **23.2** |
| **JOSEPH R. DAWE ELEMENTARY: 131 Pine Street, Stoughton, MA 02072** | | | 237,132 | 47,759 | | | | | | |
| EMS | | 1,064 | | | | **$1,801** | **$22,500** | $1,064 | **$21,436** | **11.9** |
| Burners Automatic Control | | 655 | | | | **$721** | **$9,800** | $655 | **$9,145** | **12.7** |
| Programmable Thermostats | 16,885 | | | | | **$2,776** | **$7,200** | $4,221 | **$2,979** | **1.1** |
| Kitchen Equipment Conversion | 14,400 | -517 | | | | **$1,799** | **$28,000** | $3,600 | **$24,400** | **13.6** |
| **WEST ELEMENTARY: 1322 Central Street, Stoughton, MA 02072** | | | 240,828 | 63,211 | | | | | | |
| Kitchen Hood Control | 7,404 | 798 | | | | **$2,095** | **$35,000** | $2,649 | **$32,351** | **15.4** |
| EMS | 3,162 | 9,809 | | | | **$11,310** | **$97,000** | $10,599 | **$86,401** | **7.6** |
| Add VFD on the Gym AHU (2 -3 hp VFDs) | 10,285 | | | | | **$1,691** | **$20,000** | $2,000 | **$18,000** | **10.6** |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Steam Traps Replacement | | 1,880 | | | | **$2,068** | **$26,000** | $1,880 | **$24,120** | **11.7** |
| **HELEN H. HANSON ELEMENTARY: 1800 Central Street, Stoughton, MA 02072** | | | 162,624 | 37,850 | | | | | | |
| EMS | 7,889 | 6,619 | | | | **$8,578** | **$87,000** | $8,591 | **$78,409** | **9.1** |
| Burner Electronic Control | | 1,700 | | | | **$1,870** | **$20,000** | $1,700 | **$18,300** | **9.8** |
| VFDs on HW Pumps | 7,987 | | | | | **$1,313** | **$18,000** | $2,000 | **$16,000** | **12.2** |
| Demand Control Ventilation | | 861 | | | | **$947** | **$22,000** | $861 | **$21,139** | **22.3** |
| **SOUTH ELEMENTARY SCHOOL: 171 Ash Street, Stoughton, MA 02072** | | | 153,612 | 32,965 | | | | | | |
| Burner Electronic Control | | 1,100 | | | | **$1,210** | **$20,000** | $1,100 | **$18,900** | **15.6** |
| VFDs on two Hot Water Pumps | 12,138 | | | | | **$1,995** | **$18,000** | $2,000 | **$16,000** | **8.0** |
| EMS | 10,744 | 5,994 | | | | **$8,360** | **$97,000** | $8,680 | **$88,320** | **10.6** |
| Programmable Thermostats | 433 | 292 | | | | **$392** | **$3,600** | $400 | **$3,200** | **8.2** |
| **E.A. JONES ELEMENTARY: 137 Walnut Street, Stoughton, MA 02072** | | | 147,180 | 42,409 | | | | | | |
| Boiler 2 Pipe Insulation | | 293 | | | | **$322** | **$2,600** | $293 | **$2,308** | **7.2** |
| EMS | 2,161 | 6,596 | | | | **$7,611** | **$83,000** | $7,136 | **$75,864** | **10.0** |
| Burner Electronic Control | | 585 | | | | **$644** | **$20,000** | $585 | **$19,415** | **30.2** |
| Steam Traps Replacement | | 1,170 | | | | **$1,287** | **$22,000** | $1,170 | **$20,830** | **16.2** |
| **HIGH SCHOOL: 234 Pearl Street, MA 02072** | | | | | | | | | | |
| VFDs on Fan Motors | 14,700 | | | | | **$2,417** | **$24,000** | $3,675 | **$20,325** | **8.4** |
| DDC Overlay on Pneumatic Controls | 36,000 | 2,000 | | | | **$8,118** | **$98,000** | $11,000 | **$87,000** | **10.7** |
| Demand Control Ventilation | | 4,600 | | | | **$5,060** | **$78,000** | $4,600 | **$73,400** | **14.5** |
| HVAC Start/Stop Scheduling | 165,000 | 4,200 | | | | **$31,746** | **$99,000** | $45,450 | **$53,550** | **1.7** |
| Heating HW temperature Reset | | 2,000 | | | | **$2,200** | **$34,000** | $2,000 | **$32,000** | **14.5** |
| Steam Main Valve Control | | 6,100 | | | | **$6,710** | **$74,000** | $6,100 | **$67,900** | **10.1** |
| Pipes Insulation | | 1,700 | | | | **$1,870** | **$7,300** | $1,700 | **$5,600** | **3.0** |
| Kitchen Hood Control | 9,000 | 1,150 | | | | **$2,745** | **$29,000** | $3,400 | **$25,600** | **9.3** |
| Boiler Burners Controls | 8,200 | 5,600 | | | | **$7,508** | **$87,000** | $7,650 | **$79,350** | **10.6** |
| Steam Traps Replacement | | 2,100 | | | | **$2,310** | **$23,000** | $2,100 | **$20,900** | **9.0** |

# VI. Appendix B: Town of Stoughton Streetlight Retrofit Proposal – Speclines

Project Name:

**Stoughton Green Cobra LED Street Light Conversion ROI NGRID TARIFF demo**

Client:

**Town of Stoughton**

Prepared By: Ben

Date: 23-Mar-15

*Note: These are estimated savings only. Annual and monthly savings are based on a number of variables and assumptions that could change over time. The actual savings derived for the project may be higher or lower. Spec-lines does not imply a warranty of performance or savings as calculated and shown within this program and document.*

## System Energy Cost Summary

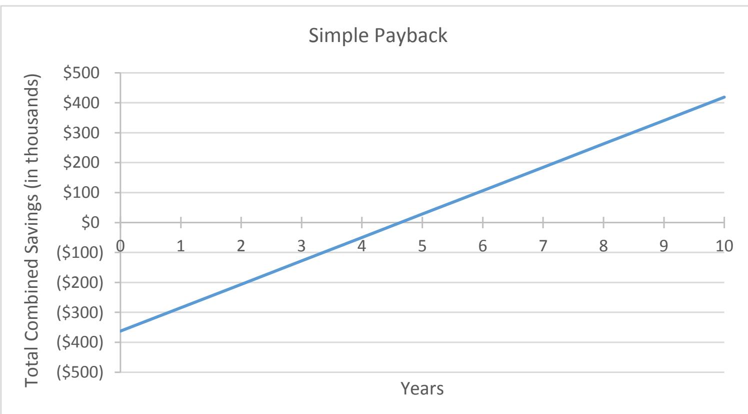
| | Total Initial Cost | Total Number of Fixtures | Total System kW | Annual kWh | Cost of Energy per kWh | kWh Inflation Rate (%/yr) | First Year Energy Cost |
|---|---|---|---|---|---|---|---|
| **Proposed Spec-lines LED** | $362,511 | 2,123 | 78.26 | 326,767 | $0.140 | 2.00% | $45,747 |
| **Existing HID Fixtures** | N/A | 2,123 | 211.92 | 884,898 | $0.140 | 2.00% | $123,886 |

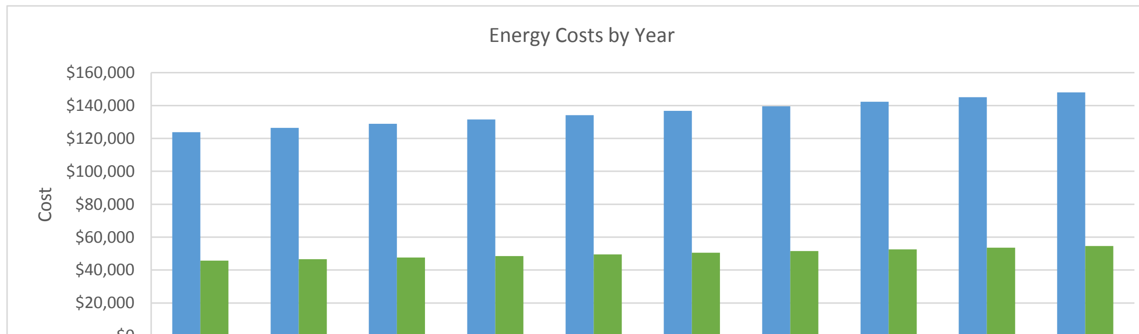
## Payback Analysis: Energy Savings

| First Year Energy Savings | Cost of Waiting (monthly) | Simple Payback (years) | IRR (%) |
|---|---|---|---|
| $78,138 | $6,512 | 4.64 | 23% |

## Sample Financing

| | Project Cost | Interest Rate | Payment ($/yr) | Total Project Cost After Repayment |
|---|---|---|---|---|
| **No Financing** | $362,511 | -- | -- | $362,511 |
| **5 year Term** | $362,511 | 3.00% | $79,156 | $395,779 |
| **10 year Term** | $362,511 | 3.00% | $42,497 | $424,973 |




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| HID System | $123,886 | $126,363 | $128,891 | $131,469 | $134,098 | $136,780 | $139,516 | $142,306 | $145,152 | $148,055 |
| LED System | $45,747 | $46,662 | $47,596 | $48,547 | $49,518 | $50,509 | $51,519 | $52,549 | $53,600 | $54,672 |

| | |
|---|---|
| **ENERGY USE REDUCED BY** | **63%** |
| **10 YEAR SAVINGS** | **$855,594** |
| **RETURN ON INVESTMENT** | **4 years + 7 months** |

By converting to LED, this project will save 558,132 kWh per year.

**This savings is equal to the emissions produced by 81 cars a year!**

**Or the amount of carbon sequestered by 315 acres of U.S. forests in one year!**

**This project would remove 848,463 lbs of CO2 emissions!**

speclines
INNOVATIVE OUTDOOR LIGHTING SOLUTIONS

Project Name:
**Stoughton Green Cobra LED Street Light Conversion ROI NGRID TARIFF demo**
Client:
**Town of Stoughton**

*Note: These are estimated savings only. Annual and monthly savings are based on a number of variables and assumptions that could change over time. The actual savings derived for the project may be higher or lower. Spec-lines does not imply a warranty of performance or savings as calculated and shown within this program and document.*

kWh Inflation Rate (%/yr): 2.00%
Daily Operating Hours: 11.44

| | New Fixture | No. of Fixtures | Annual kWh | Cost per kWh | Year 1 Energy Costs | Rebate | per Fixture Costs | per Fixture Installation Costs | Total Retrofit Costs | Net Project Costs |
|---|---|---|---|---|---|---|---|---|---|---|
| A | 1-20G-350 | 1,540 | 152,723 | $0.140 | $21,381 | $91,634 | $133 | $100 | $358,820 | $267,186 |
| B | 1-20G-350 | 252 | 24,991 | $0.140 | $3,499 | $14,995 | $133 | $100 | $58,716 | $43,721 |
| C | 1-20G-580 | 102 | 10,115 | $0.140 | $1,416 | $12,138 | $133 | $100 | $23,766 | $11,628 |
| D | 1-30F-700 | 43 | 12,793 | $0.140 | $1,791 | $5,117 | $171 | $100 | $11,653 | $6,536 |
| E | 1-30F-700 | 3 | 893 | $0.140 | $125 | $536 | $171 | $100 | $813 | $277 |
| F | 2-40F-1000 | 96 | 47,602 | $0.140 | $6,664 | $17,137 | $206 | $100 | $29,376 | $12,239 |
| G | 2-100F-700 | 87 | 77,651 | $0.140 | $10,871 | $25,884 | $438 | $100 | $46,806 | $20,922 |
| H | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| I | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| J | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| **TOTAL** | | **2,123** | **326,767** | | **$45,747** | **$167,439** | | | **$529,950** | **$362,511** |

| | NEW LED SYSTEM COSTS AND INCENTIVES | | | | | EXISTING SYSTEM COSTS | | SAVINGS BY SWITCHING TO LED | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Year** | **Payment** | **Total Rebate** | **New Energy Costs** | **New Annual Costs** | **New Cumulative Costs** | **Existing Energy Costs** | **Existing Cumulative Energy Costs** | **Energy Savings (Existing - New)** | **Net Annual Savings or Costs** | **Cumulative Savings** |
| 1 | $42,497 | $167,439 | $45,747 | ($79,195) | ($79,195) | $123,886 | $123,886 | $78,138 | $203,081 | $203,081 |
| 2 | $42,497 | | $46,662 | $89,160 | $9,965 | $126,363 | $250,249 | $79,701 | $37,204 | $240,284 |
| 3 | $42,497 | | $47,596 | $90,093 | $100,058 | $128,891 | $379,140 | $81,295 | $38,798 | $279,082 |
| 4 | $42,497 | | $48,547 | $91,045 | $191,102 | $131,469 | $510,609 | $82,921 | $40,424 | $319,506 |
| 5 | $42,497 | | $49,518 | $92,016 | $283,118 | $134,098 | $644,707 | $84,580 | $42,082 | $361,588 |
| 6 | $42,497 | | $50,509 | $93,006 | $376,124 | $136,780 | $781,486 | $86,271 | $43,774 | $405,362 |
| 7 | $42,497 | | $51,519 | $94,016 | $470,140 | $139,516 | $921,002 | $87,997 | $45,499 | $450,862 |
| 8 | $42,497 | | $52,549 | $95,047 | $565,187 | $142,306 | $1,063,308 | $89,756 | $47,259 | $498,121 |
| 9 | $42,497 | | $53,600 | $96,098 | $661,285 | $145,152 | $1,208,460 | $91,552 | $49,054 | $547,175 |
| 10 | $42,497 | | $54,672 | $97,170 | $758,454 | $148,055 | $1,356,515 | $93,383 | $50,885 | $598,060 |
| 11 | $0 | | $55,766 | $55,766 | $814,220 | $151,016 | $1,507,531 | $95,250 | $95,250 | $693,311 |
| 12 | $0 | | $56,881 | $56,881 | $871,101 | $154,036 | $1,661,567 | $97,155 | $97,155 | $790,466 |
| 13 | $0 | | $58,019 | $58,019 | $929,120 | $157,117 | $1,818,684 | $99,098 | $99,098 | $889,564 |
| 14 | $0 | | $59,179 | $59,179 | $988,299 | $160,259 | $1,978,944 | $101,080 | $101,080 | $990,645 |
| 15 | $0 | | $60,363 | $60,363 | $1,048,661 | $163,465 | $2,142,408 | $103,102 | $103,102 | $1,093,747 |
| 16 | $0 | | $61,570 | $61,570 | $1,110,231 | $166,734 | $2,309,142 | $105,164 | $105,164 | $1,198,911 |
| 17 | $0 | | $62,801 | $62,801 | $1,173,033 | $170,069 | $2,479,211 | $107,267 | $107,267 | $1,306,178 |
| 18 | $0 | | $64,057 | $64,057 | $1,237,090 | $173,470 | $2,652,681 | $109,413 | $109,413 | $1,415,591 |
| 19 | $0 | | $65,338 | $65,338 | $1,302,429 | $176,939 | $2,829,620 | $111,601 | $111,601 | $1,527,192 |
| 20 | $0 | | $66,645 | $66,645 | $1,369,074 | $180,478 | $3,010,098 | $113,833 | $113,833 | $1,641,025 |
| **TOTAL** | **$424,973** | | **$1,111,540** | **$1,369,074** | | **$3,010,098** | | **$1,898,558** | **$1,641,025** | |

# VII. Appendix C: MMBTU Conversion Chart – DOER

**MMBTU Conversion Chart[7]**

***Fuel Energy Content of Common Fossil Fuels per DOE/EIA***

BTU Content of Common Energy Units – (1 million BTU equals 1 MMBTU)

- 1 kilowatt hour of electricity = 0.003412 MMBTU
- 1 therm = 0.1 MMBTU
- 1 ccf (100 cubic foot) of natural gas = 0.1028 MMBTU (based on U.S. consumption, 2007)
- 1 gallon of heating oil = 0.139 MMBTU
- 1 gallon of propane = 0.091 MMBTU
- 1 cord of wood = 20 MMBTU
- 1 gallon of gasoline = 0.124 MMBTU (based on U.S. consumption, 2007)
- 1 gallon of E100 ethanol = 0.084 MMBTU
- 1 gallon of E85 ethanol = 0.095 MMBTU
- 1 gallon of diesel fuel = 0.139 MMBTU
- 1 gallon of B100 biodiesel = 0.129 MMBTU
- 1 gallon of B20 biodiesel = 0.136 MMBTU[8]
- 1 gallon of B10 biodiesel = 0.137 MMBTU[7]
- 1 gallon of B5 biodiesel = 0.138 MMBTU[7]
- 1 barrel of residual fuel oil = 6.287 MMBTU

[7] If a conversion factor for a fuel you use is not provided, please contact DOER.

[8] Calculated Values from those of diesel and B100 biodiesel