REVIEW OF ENERGY MANAGEMENT OPPORTUNITIES IN CITY OF YELLOWKNIFE FACILITIES

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Executive Summary

The Arctic Energy Alliance was commissioned by the City of Yellowknife in September 2005 to review the recommendations arising from previous energy audits of City facilities in 1999 & 2000 with the appropriate facility managers and prepare a list of energy management opportunities that could be implemented in each facility. This review was also to identify any energy reduction measures that have already been implemented and any additional potential measures that were not included in the 1999 and 2000 reports. Finally, this review included the preparation of estimates of the energy, cost and greenhouse gas (GHG) savings that could be achieved by implementing the energy management opportunities identified during the reviews with the facility managers.

At the time that this report was prepared, information was not available to estimate the energy, energy cost and greenhouse gas savings associated with eighteen of the energy management opportunities that were identified by the facility managers as being feasible to implement. For the twenty opportunities that could be assessed, the potential annual energy savings are just under 883,000 megajoules and the estimated annual energy cost savings are $30,109.

The preparation of detailed capital cost estimates for the energy management opportunities was not included in the scope of work for this study. However, detailed capital cost estimates will ultimately be required for budgeting purposes and to prioritize the implementation of the opportunities. Also, the assumptions used to estimate the energy, energy cost and greenhouse gas savings should be reviewed and updated as required.

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1.0 Introduction

1.1 Background

In 1999, the City of Yellowknife commissioned Joule-Tech of Yellowknife to undertake preliminary energy audits of twelve City of Yellowknife facilities. The purpose of the energy audits was to identify major energy-consuming equipment and systems in each facility, energy reduction measures that had already been implemented, and potential measures that could be considered for future implementation.

In 2000, the City of Yellowknife commissioned Yellowknife firm Ferguson Simek Clark (now FSC) to review the preliminary energy audits completed by Joule-Tech to ascertain the potential savings associated with the potential measures identified in the Joule-Tech report and to identify any additional measures that would yield cost-effective savings in energy costs.

1.2 Statement of Work

The Arctic Energy Alliance was commissioned by the City of Yellowknife in September 2005 to review the recommendations arising from the 1999 & 2000 energy audits with the appropriate facility managers to develop a list of energy management opportunities that could be implemented in each facility. This review was also to identify any energy reduction measures that have already been implemented and any additional potential measures that were not included in the Joule-Tech and FSC reports. Finally, this review included the preparation of estimates of the energy, cost and greenhouse gas savings that could be achieved by implementing the energy management opportunities identified during the reviews with the facility managers.

The facilities that were included in the preliminary energy audits are:

1. Lift Station No. 1
2. Lift Station No. 5
3. Pumphouse No. 1
4. Pumphouse No. 2
5. Pumphouse No. 3
6. Pumphouse No. 4
7. Community Arena
8. Ruth Inch Memorial Pool
9. City Hall
10. Fire Station No. 1
11. Baling Facility
12. Public Works Garage

1.3 Report Organization

Section 2 of this report presents the results of reviews with City of Yellowknife facility managers to determine the feasibility of implementing energy management opportunities identified in the preliminary energy audits and other opportunities that have been identified since the preliminary energy audits.

Section 3 presents the estimated reductions in energy consumption and greenhouse gases associated with the energy management opportunities that appear to be feasible to implement.

2.0 Review of Energy Management Opportunities

Interviews were conducted with City of Yellowknife facility managers during November 2005 to determine:

- If any of the energy management opportunities identified in the 1999 and 2000 energy audits had been implemented;
- If it would be feasible to implement any of the other energy management opportunities identified in the 1999 and 2000 energy audits; and
- If any additional energy management opportunities have been identified since the 1999 and 2000 energy audits.

Additional information to assess the feasibility of implementing the energy management opportunities and to estimate the associated energy and greenhouse gas reductions was provided by facility managers after the initial interviews through phone calls and e-mails.

The energy management opportunities identified in each facility during the 1999 and 2000 energy audits are listed below along with the results of interviews and follow-up correspondence with the respective facility managers.

2.1 Lift Station No. 1

The 1999 and 2000 energy audits identified the following potential measures to reduce energy usage at Lift Station No. 1:

- Replacing standard efficiency pump motors with energy-efficient motors.
- Replacing F40/T12 fluorescent lamps and magnetic ballasts with F32/T8 lamps and electronic ballasts.
- Using timers to control the high pressure sodium (HPS) fixtures in the interior of the building or replacing the fixtures with locally-switched F32/T8 fixtures. Although HPS lighting is typically more efficient than fluorescent lighting, any gains in efficiency are more than offset by the fact that the HPS are operated continuously due to the length of time it takes for them to achieve full light output.

- Relocating the furnace thermostat to the wet well area of the building and reducing the thermostat setpoint to 5^o C. as it is understood that the purpose of the furnace is to prevent freezing in this part of the building.

Present-day energy management opportunities for Lift Station No. 1 were reviewed with Dennis Althouse, Works Superintendent. This review indicated that:

- Energy efficient motors are specified when existing motors are replaced.
- Consideration should be given to replacing the T12 fluorescent fixtures and high pressure sodium fixtures with T8 fluorescent fixtures.
- Consideration should be given to replacing the HPS fixtures with T8 fluorescent fixtures so that the fixtures can be manually turned on and off as required. (The use of a timer is not recommended.)
- The furnace fan motors operate continuously to improve temperature regulation. Consideration should be given to replacing the fan motors with energy-efficient, two-speed motors.

2.2 Lift Station No. 5

The 1999 and 2000 energy audits identified the following potential measures to reduce energy usage at Lift Station No. 5:

- Replacing standard efficiency pump motors with energy-efficient motors.
- Replacing T12 fluorescent lamps and magnetic ballasts with T8 lamps and electronic ballasts.
- Replacing the continuously operating HPS fixtures in the interior of the building with locally-switched T8 fluorescent fixtures.
- Reducing the furnace thermostat setpoint to 5^o C.

Present-day energy management opportunities for Lift Station No. 5 were reviewed with Dennis Althouse, Works Superintendent. This review indicated that:

- Energy efficient motors are specified when existing motors are replaced.

- Consideration should be given to replacing the T12 fluorescent fixtures and HPS fixtures with T8 fluorescent fixtures.
- Consideration should be given to replacing the HPS fixtures with T8 fluorescent fixtures so that the fixtures can be manually turned on and off as required. (The use of a timer is not recommended.)
- The furnace fan motor operates continuously to improve temperature regulation. Consideration should be given to replacing the fan motor with an energy-efficient, two-speed motor.
- Space temperatures can be reduced from 15 ^{0}C to 12 ^{0}C without presenting the risk of freezing in any part of the facility.

2.3 Pumphouse No. 1

The 1999 and 2000 energy audits identified the following potential measures to reduce energy usage at Pumphouse No. 1:

- Replacing standard efficiency pump motors with energy-efficient motors.
- Replacing T12 fluorescent lamps and magnetic ballasts with T8 lamps and electronic ballasts.
- Installing occupancy sensors to control fluorescent lighting in intermittently-use areas of the building.
- Replacing the electrical room air conditioner with a thermostatically controlled exhaust fan.

Present-day energy management opportunities for Pumphouse No. 1 were reviewed with Dennis Althouse, Works Superintendent. This review indicated that:

- Energy efficient motors are specified when existing motors are replaced.
- Replacement of the T12 fluorescent fixtures may not be cost-effective as the facility is scheduled for replacement in five years.
- Few areas of the building are suitable for occupancy sensor control of the lighting systems.

2.4 Pumphouse No. 2

The 1999 and 2000 energy audits identified the following potential measures to reduce energy usage at Pumphouse No. 2:

- Replacing standard efficiency pump motors with energy-efficient motors.
- Replacing T12 fluorescent lamps and magnetic ballasts with T8 lamps and electronic ballasts.
- Reducing the space heating thermostat setpoints to 5^{o} C.

Present-day energy management opportunities for Pumphouse No. 2 were reviewed with Dennis Althouse, Works Superintendent. This review indicated that the space temperature setpoint has been reduced to 12 ^{0}C instead of the recommended 5^{0}C due to concerns for potential freezing in parts of the facility. Additional investments in energy-efficient improvements at this facility may not be cost-effective as this facility will be redundant in five years when Pumphouse No. 1 is replaced.

2.5 Pumphouse No. 3

The 1999 and 2000 energy audits identified the following potential measures to reduce energy usage at Pumphouse No. 3:

- Replacing standard efficiency pump motors with energy-efficient motors.
- Replacing T12 fluorescent lamps and magnetic ballasts with T8 lamps and electronic ballasts.
- Reducing the space heating thermostat setpoints to 5^{o} C.
- Replacing the incandescent lamp at the entrance to the building with a high pressure sodium fixture.

Present-day energy management opportunities for Pumphouse No. 3 were reviewed with Dennis Althouse, Works Superintendent. This review indicated that:

- Energy efficient motors are specified when existing motors are replaced.

- Consideration should be given to replacing the T12 fluorescent fixtures with T8 fluorescent fixtures.
- The furnace fan motor operates continuously to improve temperature regulation. Consideration should be given to replacing the fan motor with an energy-efficient, two-speed motor.
- Space temperatures can be safely reduced to 10 ^{0}C.
- The 150-watt incandescent fixture on the exterior of the facility has been replaced with a 70-watt high pressure sodium fixture.

2.6 Pumphouse No. 4

The 1999 and 2000 energy audits identified the following potential measures to reduce energy usage at Pumphouse No. 4:

- Replacing standard efficiency pump motors with energy-efficient motors.
- Replacing T12 fluorescent lamps and magnetic ballasts with T8 lamps and electronic ballasts and installing local switches so the fixtures are only used when the building is occupied.
- Replacing the continuously operating high pressure sodium fixtures in the interior of the building with locally-switched T8 fluorescent fixtures.
- Reducing the space heating thermostat setpoint to 5^o C.

Present-day energy management opportunities for Pumphouse No. 4 were reviewed with Dennis Althouse, Works Superintendent. This review indicated that:

- Energy efficient motors are specified when existing motors are replaced.
- Consideration should be given to replacing the T12 fluorescent fixtures with T8 fluorescent fixtures.
- Space temperatures can be safely reduced to 10 ^{0}C.

2.7 Community Arena

The 1999 and 2000 energy audits identified the following potential measures to reduce energy usage at the Community Arena:

- Replacing standard efficiency electric motors with energy-efficient motors.

- Recovering and re-using heat rejected by the ice-making compressors.
- Eliminating the simultaneous operation of the compressors to reduce electrical demand charges.
- Reducing the operating hours for metal halide fixtures over the ice surface by switching the fixtures off when the ice surface is not being used or maintained.
- Replacing the showerheads in the change rooms with low-flow showerheads and installing controls to automatically shut off the flow after a specified length of time.
- Replacing the remaining T12 fluorescent lamps and magnetic ballasts with T8 lamps and electronic ballasts.
- Installing additional occupancy sensors to control fluorescent lighting in intermittently-use areas of the building.
- Replacing incandescent lamps at the main entrance with high pressure sodium fixtures.
- Replacing the non-functioning time clock that overrides the photocells controls for the outdoor lighting.
- Installing occupancy sensors to control change room ventilation systems.
- Converting the ice-making equipment to use ammonia instead of R22 refrigerant.

Present-day energy management opportunities for the Community Arena were reviewed with Andrew Morton, Community Services Facility Manager. This review indicated that:

- Energy efficient motors are specified when existing motors are replaced.
- Consideration is being given to recovering heat rejected by the ice-making equipment to provide space heating for the bleacher area.
- It may be feasible to eliminate the simultaneous operation of the ice-making compressors.
- It may be feasible to provide reduced lighting levels over the ice surface for some activities and to switch the lighting off between activities.

- Showerheads in the change rooms should be replaced with low-flow showerheads and infrared sensors or timers.
- The remaining T12 fluorescent fixtures should be replaced with T8 fixtures or retrofitted with T8 lamps and electronic ballasts.
- Additional occupancy sensors should be installed to control the fluorescent lighting in intermittently used areas of the facility.
- The incandescent fixtures at the main entrance should be replaced with high pressure sodium fixtures.
- The timeclock for the outdoor lighting should be repaired or replaced if this has not already been done.
- Timeclock control of the air handling unit serving the change rooms may have been restored in November, 2005.
- Consideration should be given to using occupancy sensors to limit the operation of the change room exhaust fans.
- Consideration is being given to changing from a freon-based refrigerant to ammonia.
- A reflective ceiling was to be installed over the ice surface in 2005. Confirmation of this work was not available at the time of writing of this report.

2.8 Ruth Inch Memorial Pool

The 1999 and 2000 energy audits identified the following potential measures to reduce energy usage at the Ruth Inch Memorial Pool:

- Replacing standard efficiency electric motors with energy-efficient motors.
- Replacing incandescent exit sign lamps with LED lamps.
- Installing a timer to eliminate the operation of the DHW circulating pump during unoccupied periods.
- Installing a pool cover to reduce evaporative heat losses from the main swimming pool during unoccupied periods.
- Installing timers and humidistats to reduce the operation of the ventilation and exhaust air systems during unoccupied periods.

- Installing a temperature controller to de-energize the block heater outlets when the outdoor temperature is at or above –20° C.
- Installing low volume, electronic flush valves on water closets and urinals.

Present-day energy management opportunities for the Ruth Inch Memorial Pool were reviewed with Brian Kelln, Community Services Facility Manager. This review indicated that:

- Energy efficient motors are specified when existing motors are replaced.
- Incandescent exit sign lamps have been replaced with LED lamps during the past four years with the majority of lamps having been replaced three years ago.
- Plans are presently being developed to upgrade the domestic hot water circulation system including the reinsulation of the distribution piping. It does not appear that the upgrade will include a timer for the circulating pump.
- The hot tub is presently covered for five hours each day and there are no plans to cover the swimming pool as it is believed that any cost savings would be offset by additional staffing costs.
- The ventilation systems were upgraded in 2002/2003 to include outdoor air controls. However, the ventilation system is not shut down at night as it is the only source of space heating for the facility.
- Block heater outlets are presently controlled by timers that energize the outlets from 10:00 - 13:00, 16:00 – 18:00 and 22:00 – 24:00 each day. There are no plans to use temperature controls.
- Low volume toilets were installed in 2000. There are no plans to install electronic flush valves.
- The feasibility of using infrared shower controls is presently being investigated.
- Vestibules were installed at three entrances to the facility between 2002 and 2005.

- A feasibility study to determine the potential for using a Solarwall® system to reduce energy consumption and costs for ventilation air heating was previously prepared by the Arctic Energy Alliance. This study should be reviewed and updated to reassess this opportunity.

2.9 City Hall

The 1999 and 2000 energy audits identified the following potential measures to reduce energy usage at the City Hall:

- Replacing standard efficiency electric motors with energy-efficient motors.
- Installing occupancy sensors to control lighting in intermittently used areas of the building.
- Installing timers and temperature controllers to limit the operation of the block heater outlets.
- Installing wiring to permit the use of outdoor receptacles on pole-mounted HID fixtures to be operated independently.
- Reducing space temperatures during unoccupied periods.
- Installing a timer or DDC controls to eliminate the operation of the DHW circulating pump during unoccupied periods.
- Eliminating simultaneous heating and cooling by shutting down the boilers during summer.
- Installing variable volume controls for the main ventilation system.
- Shutting down one of the boilers.

Present-day energy management opportunities for the City Hall were reviewed with Andrew Morton, Community Services Facility Manager. This review indicated that:

- Energy efficient motors are specified when existing motors are replaced.
- Occupancy sensors should be installed to control the lighting systems in intermittently used areas of the building.
- The recommendation to reduce space temperatures at night and on weekends has been implemented.

- The domestic hot water circulating pump should be turned off at night and on weekends.
- The recommendation to shut down the boilers during summer was implemented in 2004.
- The feasibility of using variable volume controls on the main ventilation system should be investigated.
- Shutting down one of the boilers is not feasible as both boilers are required during cold weather.
- Consideration is being given to upgrading some or all of the windows in the building beginning in 2006.
- The wooden exterior doors for the mechanical room should be replaced with insulated metal doors.

2.10 Fire Station No. 1

The 1999 and 2000 energy audits identified the following potential measures to reduce energy usage at Fire Station No. 1:

- Replacing standard efficiency electric motors with energy-efficient motors.
- Replacing incandescent exit sign lamps with LED lamps.
- Installing timers and temperature controllers to limit the operation of the outdoor block heater outlets.
- Replacing T12 fluorescent lamps and magnetic ballasts with T8 lamps and electronic ballasts.
- Reducing space temperatures to 15^{o} C. in the apparatus bay and hose tower.

Present-day energy management opportunities for Fire Station No. 1 were reviewed with Darcy Hernblad, Deputy Fire Chief. This review indicated that:

- Energy efficient motors will be specified when existing motors have to be replaced.
- Incandescent exit sign lamps were replaced with LED lamps in November 2005.

- Outdoor block heater outlets are controlled by timers and are energized from 04:00 – 06:00 and 16:00 – 18:00 each day. Temperature controllers are not used.
- Block heater outlets in the apparatus bay are energized on a rotating basis such that only two of the outlets are energized at any given time.
- T12 fluorescent lamps and magnetic ballasts should be replaced with T8 or T5 lamps and electronic ballasts.
- Space temperatures in the apparatus bay and hose tower were reduced in November 2005.
- Since 1999, the overhead doors have been closed manually reducing the amount of time that the doors are open by approximately 10 minutes each day.
- An annual maintenance program for the overhead doors (including replacement of the weatherstripping as required) was implemented in 2004. Consideration is presently being given to replacing the overhead doors in 2006/2007.
- The original double-glazed, wood frame windows have been replaced with argon-filled, PVC frame windows during the period of 2002 to 2005.

2.11 Baling Facility

The 1999 and 2000 energy audits identified the following potential measures to reduce energy usage at the Baling Facility:

- Replacing standard electric motors with energy-efficient motors.
- Replacing incandescent exit sign lamps with LED lamps.
- Installing or repairing controls to eliminate the continuous operation of the stack blower on No. 2 make-up air unit (MU-2).
- Reducing space temperatures during unoccupied periods in areas served by the forced-air furnace.
- Installing timers or occupancy sensors to eliminate unnecessary operation of exhaust fans in the lunchroom and change rooms.

- Replacing outdoor incandescent fixtures over entrances with high pressure sodium fixtures.
- Relocating the high pressure sodium fixtures in the front bay so they are not obscured when the overhead doors are open.
- Replacing T12 fluorescent lamps and magnetic ballasts with T8 lamps and electronic ballasts.
- Installing local switches to eliminate the continuous operation of the fluorescent fixtures in the shop area.

Present-day energy management opportunities for the Baling Facility were reviewed with Dennis Althouse, Works Superintendent. This review indicated that:

- Energy efficient motors are specified when existing motors are replaced.
- Incandescent exit sign lamps should be replaced with LED lamps.
- A programmable thermostat should be installed to automatically reduce space temperatures in the control room and lunchroom. Also, consideration should be given to replacing the furnace fan motor with an energy-efficient, two-speed motor as the fan runs continuously to help regulate space temperatures.
- The incandescent fixtures at the exterior of the man doors have been replaced with 50-watt high pressure sodium fixtures.
- Consideration should be given to controlling the lighting and the exhaust fans in the lunchroom and change rooms with occupancy sensors and to using an interval timer to control the fan in the janitor room.
- Consideration should be given to replacing the T12 fluorescent fixtures with T8 fixtures.
- Consideration should be given to providing local switches for the fluorescent fixtures in the shop area.

2.12 Public Works Garage

The 1999 and 2000 energy audits identified the following potential measures to reduce energy usage at the Public Works Garage:

- Reducing space temperatures during unoccupied periods.
- Replacing T12 fluorescent lamps and magnetic ballasts in the paint booth and warehouse with T8 lamps and electronic ballasts.
- Installing occupancy sensors to control lighting in intermittently used areas such as the paint booth, offices and lunchrooms.
- Installing timers and temperature controllers to limit the operation of the outdoor block heater outlets.
- Installing a waste oil furnace.

Present-day energy management opportunities for the Public Works Garage were reviewed with Dennis Althouse, Works Superintendent. This review indicated that:

- Reducing space temperatures during unoccupied periods is not feasible because the building is poorly insulated and the heating system does not have the capacity to restore temperatures to normal levels during cold weather.
- Controls have been installed to duty cycle the block heater outlets at one hour intervals when the temperature is between –5 ^{0}C. and –15 ^{0}C. and to provide continuous power to the outlets at temperatures below –15 ^{0}C.
- Consideration should be given to using a waste oil heater to offset space heating requirements in the mechanic's shop.

3.0 Estimated Energy and Greenhouse Gas Reductions

The estimated energy and greenhouse gas reductions associated with the energy management opportunities that have been identified for potential implementation in each facility are shown below. Estimated heating fuel cost savings and greenhouse gas reductions were arrived at using the following average 2005-2006 energy prices and CO_2 emission factors provided by the City of Yellowknife:

Heating Oil @ $0.7572/Litre & 2.73 kg/Litre
Propane @ $0.6820/Litre & 1.5 kg/Litre

Electrical power costs and savings are based on May 2006 rates (including GST) of $0.1554/kWh and $8.1606/kVA/month. CO_2 reductions associated with electrical savings were arrived at using the factor of 0.041 kg/kWh provided by the City of Yellowknife Community Energy Planning Committee.

3.1 Lift Station No. 1

3.1.1 Lighting System Upgrade

The existing fluorescent fixtures in this facility are fitted with T12 fluorescent lamps and magnetic ballasts. There are four 2-lamp fixtures and two 1-lamp fixtures that operate approximately 130 hours per year (0.5 hours/day x 260 days/year).

Retrofitting these fixtures or replacing them with new fixtures fitted with T8 lamps and electronic ballasts will reduce the energy consumption for each fixture by about 23%. Due to the limited operating hours for these fixtures, the payback on the investment in new or upgraded fixtures may be unacceptably long[1], but there may be other advantages in terms of consistency in the type of lighting systems used throughout the various facilities owned and operated by the City.

[1] In the absence of detailed capital cost estimates, the determination of actual payback periods is not possible.

There are also four 150-watt and two 100-watt HPS fixtures in the wet well area of the building. These fixtures operate continuously (8760 hr/yr) due to the extended warm-up period when the fixtures are switched off between daily inspections. Replacing these fixtures with T8 fluorescent fixtures would eliminate the warm-up period allowing the fixtures to be switched off between daily inspections thereby reducing the annual operating hours to 130 hours per year (see above). To yield the equivalent amount of light, the four 150-watt HPS fixtures would have to be replaced with twenty-two 1-lamp T8 fixtures (or eleven 2-lamp fixtures) and the two 100-watt HPS fixtures would have to be replaced with six 1-lamp T8 fixtures (or three 2-lamp fixtures).

Implementing these improvements would yield estimated annual energy, energy cost and greenhouse gas savings of:

Energy:	**8,837**	**KWh**
Demand:	**0.3**	**kVA (per month)**
Costs:	**$1,398**	
CO_2:	**362.3**	**kg**

3.1.2 Furnace Fan Motor Upgrade

According to information provided by Public Works staff in May 2006, there are two furnaces in the facility and each furnace has a ½ HP fan motor that operates continuously to help maintain space temperatures and prevent the accumulation of harmful gases in the facility. Replacing the furnace fan motors with 2-speed, energy-efficient electronically commutated (ECM) motors would yield estimated annual energy, energy cost and greenhouse gas savings of:

Energy:	**13,385**	**kWh**
Demand:	**1.5**	**kVA (per month)**
Costs:	**$2,230**	
CO_2:	**548.8**	**kg**

3.2 Lift Station No. 5

3.2.1 Lighting System Upgrade

The existing fluorescent fixtures in this facility are fitted with T12 fluorescent lamps and magnetic ballasts. There are ten 2-lamp fixtures that operate approximately 130 hours per year (0.5 hours/day x 260 days/year).

Retrofitting these fixtures or replacing them with new fixtures fitted with T8 lamps and electronic ballasts will reduce the energy consumption for each fixture by about 23%. Due to the limited operating hours for these fixtures, the payback on the investment in new or upgraded fixtures will be quite long, but there may be other advantages in terms of consistency in the type of lighting systems used throughout the various facilities owned and operated by the City.

There are four 150-watt HPS fixtures in the dry well and one 150-watt HPS fixture in the wet well. These fixtures operate continuously (8760 hr/yr) due to the extended warm-up period when the fixtures are switched off between daily inspections. Replacing these fixtures with T8 fluorescent fixtures would eliminate the warm-up period allowing the fixtures to be switched off between daily inspections thereby reducing the annual operating hours to 130 hours per year (see above). To yield the equivalent amount of light, the four 150-watt HPS fixtures in the dry well would have to be replaced with twenty-two 1-lamp T8 fixtures (or eleven 2-lamp fixtures) and the 150-watt HPS fixture in the wet well would have to be replaced with six 1-lamp T8 fixtures (or three 2-lamp fixtures).

Implementing these improvements would yield estimated annual energy, energy cost and greenhouse gas savings of:

Energy:	**7,708 kWh**
Demand:	**0.2 kVA (per month)**
Costs:	**$1,218**
CO_2:	**316.0 kg**

3.2.2 Furnace Fan Motor Upgrade

According to information provided by Public Works staff in May 2006, there is one furnace in the facility with a 1/3 HP fan motor that operates continuously to help maintain space temperatures evenly and prevent the accumulation of harmful gases in the facility. Replacing the furnace fan motor with a 2-speed, energy-efficient electronically commutated (ECM) motor would yield estimated annual energy, energy cost and greenhouse gas savings of:

Energy:	**2,234 kWh**
Demand:	**0.3 kVA (per month)**
Costs:	**$372**
CO_2:	**91.6 kg**

3.2.3 Space Temperature Reduction

The space temperature in Lift Station No. 5 is presently maintained in the range of 15 – 20 ^{0}C, but Public Works concurs that the temperature could be reduced to 12 ^{0}C. Fuel consumption data for the Lift Station were not provided for this study so it is not possible to determine the actual amount of heating oil that would be saved by reducing the space temperature. However, a study published by the National Research Council suggests that heating oil consumption will be reduced by about 2% for each degree Celsius reduction in space temperatures. Therefore, this measure could reduce heating oil consumption and costs and greenhouse gas emissions by up to 16%.

3.3 Pumphouse No. 1

As noted in Section 2, this facility is scheduled for replacement in five years, so investments in energy efficiency improvements may not be cost-effective.

3.4 Pumphouse No. 2

As noted in Section 2, investments in energy-efficient improvements at this facility may not be cost-effective as this facility will be redundant in five years when Pumphouse No. 1 is replaced.

3.5 Pumphouse No. 3

3.5.1 Lighting System Upgrade

According to the 1999/2000 energy audits, there are eight 2-lamp T12 fluorescent fixtures that operate approximately 130 hours per year (0.5 hours/day x 260 days/year). Information provided by Public Works in May 2006 indicates that there is an additional 8-foot fixture fitted with four lamps so there is the equivalent of ten 2-lamp fixtures in the facility.

Retrofitting these fixtures or replacing them with new fixtures fitted with T8 lamps and electronic ballasts will reduce the energy consumption for each fixture by about 23%. Due to the limited operating hours for these fixtures, the payback on the investment in new or upgraded fixtures will be quite long, but there may be other advantages in terms of consistency in the type of lighting systems used throughout the various facilities owned and operated by the City.

Upgrading the fluorescent fixtures in this facility would yield estimated annual energy, energy cost and greenhouse gas savings of:

Energy:	**25 kWh**
Demand:	**0.2 kVA (per month)**
Costs:	**$22**
CO_2:	**1.0 kg**

3.5.2 Furnace Fan Motor Upgrade

According to the 1999/2000 energy audit reports, space heating for this facility is provided by a hot water boiler. However, information provided by Public Works in May 2006 indicates that there is a furnace with a ½ HP fan motor that operates continuously to help maintain space temperatures evenly throughout the facility. The 2000 FSC audit report suggested that it may be advantageous to replace the boiler with a forced-air furnace and it is assumed that this measure has been implemented.

Replacing the furnace fan motor with a 2-speed, energy-efficient electronically commutated (ECM) motor would yield estimated annual energy, energy cost and greenhouse gas savings of:

Energy:	**3,346 KWh**
Demand:	**0.4 kVA (per month)**
Costs:	**$557**
CO_2:	**137.2 Kg**

3.5.3 Space Temperature Reduction

Details of current space temperature setpoints and fuel consumption for the pumphouse were not provided for this study, so it is not possible to determine the actual amount of heating oil that would be saved by reducing the space temperature. However, as noted previously, heating oil consumption will be reduced by about 2% for each degree Celsius reduction in space temperatures.

3.6 Pumphouse No. 4

3.6.1 Lighting System Upgrade

Information provided by Public Works in May 2006 indicates that there are three 2-lamp T12 fluorescent fixtures used for night lighting (continuous operation) and two more fixtures in the chlorine room. Details of the operating hours for the chlorine room fixtures were not provided, but it is assumed that they are only used during daily inspections or about ½ hour per day or about 130 hours per year.

Upgrading or replacing these fixtures with new fixtures fitted with T8 lamps and electronic ballasts would yield estimated annual energy, energy cost and greenhouse gas savings of:

Energy:	**340 kWh**
Demand:	**0.1 kVA (per month)**
Costs:	**$62**
CO_2:	**14.0 kg**

3.6.2 Space Temperature Reduction

As noted in Section 2, the space temperature in this facility can be safely reduced to 10 ^{0}C. Details of current space temperature setpoints and fuel consumption had not been provided when this report was prepared, so it was not possible to determine the actual amount of heating oil that would be saved by reducing the space temperature. However, as noted previously, heating oil consumption could be reduced by about 2% for each degree Celsius reduction in the space temperature.

3.7 Community Arena

3.7.1 Heat Recovery

As noted in Section 2, consideration is being given to recovering heat rejected by the ice-making equipment to provide space heating for the bleacher area. Space heating in this area is presently provided by propane-fired unit heaters. The recovered heat would probably eliminate the requirement for the unit heaters, but details of the propane consumption for the unit heaters was not provided so it is not possible to determine the quantities of propane and greenhouse gases that would be saved by this measure.

3.7.2 Single Compressor Operation

During the review of energy management opportunities for the Community Arena, it was noted that it might be possible to eliminate the simultaneous operation of the refrigeration compressors.

When this report was prepared, the feasibility of this measure had not been confirmed. However, if it is determined in the future that this measure can be implemented, the potential reduction in the peak electrical demand for the facility would be about 43 kW (according to information provided by the City in December 2005) and the potential annual savings in demand charges are about $4210 per annum. There may also be minor reductions in the energy consumption and greenhouse gas emissions associated with the compressor operation due to the fact that the operating compressor will be at or near full-load (optimum) operating conditions.

3.7.3 Variable Illumination Levels

During the review of energy management opportunities for the arena, it was determined that it might be possible to reduce the amount of lighting over the ice surface during certain activities and to switch the lighting off between activities. However, the information required to estimate the potential savings that could be achieved by these measures had not been provided at the time that this report was prepared.

3.7.4 Shower Controls

During the review of energy management opportunities for the arena, it was determined that the existing showerheads in the change rooms should be replaced with low-flow showerheads controlled by infrared sensors. However, the information required to estimate the potential savings that could be achieved by this measure had not been provided at the time that this report was prepared.

3.7.5 Fluorescent Lighting Upgrade

During the review of energy management opportunities for the arena, it was noted that some of the fluorescent fixtures are still fitted with T12 lamps and magnetic ballasts. Details of the numbers of fixtures and operating hours were not available when this report was prepared so it was not possible to estimate the potential reductions in energy consumption, costs and greenhouse gas emissions that would be achieved by upgrading these fixtures to T8 lamps and electronic ballasts. However, as noted previously in this report, the energy consumption and greenhouse gas emissions would be reduced by about 23% for each fixture that was upgraded.

3.7.6 Occupancy Sensors for Lighting Systems

During the review of energy management opportunities for the Community Arena, it was determined that the energy consumption and greenhouse gas emissions associated with the lighting systems in some areas of the building (eg. change rooms and washrooms) could be reduced by using occupancy sensors to automatically switch the lighting off when the areas are not occupied. The magnitude of the savings depends on the number of fixtures that could be controlled in this manner and the reductions in the operating hours for these fixtures. As this information had not been provided at the time that this report was prepared, it was not possible to quantify the energy and greenhouse gas emissions reductions associated with this measure.

3.7.7 Outdoor Incandescent Lighting Upgrade

During the review of energy management opportunities for this facility, it was determined that the three 100-watt incandescent fixtures at the main entrance to the building should be replaced with energy-efficient HPS fixtures.

Replacing these fixtures with 35-watt HPS fixtures would yield energy, energy cost and greenhouse gas savings of:

Energy:	**591 KWh**
Demand:	**0.1 kVA (per month)**
Costs:	**$105**
CO_2:	**24.2 Kg**

These fixtures were originally controlled by a photocell in conjunction with a timeclock, but the timeclock was not functioning during the 1999 Joule-Tech audit. The savings shown above assume that the timeclock has not been repaired.

3.7.8 Outdoor Lighting Controls

As noted above, outdoor lighting at the arena was originally controlled by a photocell in conjunction with a timeclock, but the timeclock was not functioning during the 1999 Joule-Tech audit. At the time that this report was prepared, it had not been confirmed if the timeclock had been repaired or replaced and details of the timeclock settings were not provided so it was not possible to estimate the potential savings that would be achieved by using a timeclock in conjunction with the photocell controls.

3.7.9 Occupancy Sensors for Exhaust Fans

During the review of energy management opportunities for the arena, it was noted that timeclock control of the ventilation system and exhaust fans for the changerooms was restored in November 2005. It was also noted that additional energy savings could be achieved by using occupancy sensors to limit the operation of the exhaust fans to times when the changerooms are actually being used. However, the information required to estimate the savings that would be achieved by this measure had not been provided when this report was prepared.

3.7.10 Refrigerant Conversion

During the review of energy management opportunities, it was noted that switching from the current freon-based refrigerant used by the ice-making equipment to an ammonia-based refrigerant could reduce the energy usage and greenhouse gas emissions for ice-making. Estimates of the potential savings were to have been provided by the compressor manufacturer, but this information was not available when this report was prepared.

3.8 Ruth Inch Memorial Pool

3.8.1 Infrared Shower Controls

During the review of energy management opportunities for this facility, it was noted that plans are underway to replace the manual shower controls with infrared controls to automatically shut off the water when the showers are vacated. According to information provided by the facility manager, this measure is expected to reduce shower water consumption by about 2 gallons per shower for a total savings of 350,000 gallons or 1,591,100 litres per year based on usage rates of 500 showers per day, 350 days per year.

Assuming an average incoming water temperature of 4 ^{0}C., an average shower temperature of 40 ^{0}C. and a seasonal boiler efficiency of 75%, the estimated annual reductions in heating oil consumption, energy costs and greenhouse gas emissions are:

Heating Oil:	**9,136**	**Litres**
Costs:	**$6,918**	
CO_2:	**24,941.3**	**Kg**

3.8.2 Ventilation Air Preheat System (Solarwall)

During the review of energy management opportunities, it was noted that an earlier analysis of the potential savings that could be achieved by using a Solarwall® ventilation air preheat system determined that the payback period on the investment would be unacceptably long. However, heating oil prices have risen considerably since the original analysis and it would be worthwhile to review and update the original analysis. At the time that this report was prepared, details of the ventilation rates and heat loads were not available so the analysis could not be updated.

3.9 City Hall

3.9.1 Occupancy Sensor Lighting Controls

During the review of energy management opportunities for City Hall, it was noted that the energy usage and greenhouse gas emissions associated with the operation of the lighting systems could be reduced by using occupancy sensors to automatically control the lighting in intermittently-used areas of the building. At the time that this report was prepared, details of the potential reductions in operating hours in each of these areas had not been provided so it was not possible to accurately estimate the energy, energy cost and greenhouse gas reductions. However, to demonstrate the potential magnitude of the savings, if the lighting system usage in each area identified by the facility manager as potentially benefiting from occupancy sensor control was reduced by 2 hours per day, 260 days per year, the annual savings would be:

Energy:	**3,804 kWh**
Demand:	**0.0 kVA (per month)**
Costs:	**$591**
CO_2:	**156.0 kg**

3.9.2 Domestic Hot Water Circulating Pump Timer

During the review of energy management opportunities, it was determined that it would be feasible to shut down the domestic hot water circulating pump between the hours of 23:00 and 07:00, Monday to Friday each week and from 23:00 on Friday to 07:00 on Monday, each week. The estimated annual reductions in energy consumption, energy costs and greenhouse gas emissions that would be achieved by this measure are:

Energy:	**567 kWh**
Demand:	**0.0 kVA (per month)**
Costs:	**$88**
CO_2:	**23.2 kg**

3.9.3 Variable Volume Ventilation System

The 2000 FSC Energy Audit Report concluded that the potential annual cost savings would not justify an investment in modifying the main City Hall ventilation system from constant volume to variable volume, it was determined during the review of energy management opportunities that, due to recent increases in fuel and power costs, this opportunity should be re-examined.

Using current fuel and power prices and the estimated heating oil and electrical power savings identified in the FSC report, this measure would yield annual reductions in energy consumption, energy costs and greenhouse gas reductions of:

Electricity:	**51,387 kWh**
Heating Oil:	**2000 Litres**
Costs:	**$9,500**
CO_2:	**7566.9 kg**

3.9.4 Window Upgrade

During the review of energy management opportunities, it was noted that consideration was being given to begin upgrading the windows in the building in 2006. At the time that this report was prepared, specifications for the existing and proposed windows had not been provided so it was not possible to estimate the potential reductions in energy consumption, energy costs and greenhouse gas emissions associated with this measure.

3.9.5 Mechanical Room Exterior Door Upgrade

During the review of energy management opportunities, it was noted that consideration was being given to begin upgrading the mechanical room exterior doors. At the time that this report was prepared, specifications for the existing and proposed doors had not been provided so it was not possible to estimate the potential reductions in energy consumption, costs and greenhouse gas emissions associated with this measure.

3.10 Fire Station No. 1

3.10.1 Fluorescent Lighting System Upgrade

During the review of energy management opportunities for Fire Station No. 1, it was noted that the fluorescent lighting fixtures are fitted with T12 lamps and magnetic ballasts. During the 1999/2000 energy audits, the apparatus bay lighting operated continuously, but it is now turned off at night. The hours that the lights are switched off were not ascertained prior to the preparation of this report, but assuming they are switched off from 22:00 each evening until 06:00 each morning, the operating hours for the apparatus bay lighting are 5840 hours per year. According to the 2000 FSC energy audit report, the remaining fluorescent fixtures in the Fire Station operate an average of 8 hours per day, 365 days per year.

According to the 1999 Joule-Tech energy audit report, there are seventy 2-lamp fixtures in the apparatus bay and ninety-two 2-lamp fixtures and sixteen 1-lamp fixtures in other parts of the facility. Based on the operating hours shown in the paragraph above, replacing or upgrading these fixtures to T8 lamps and electronic ballasts would reduce annual energy consumption, energy costs and greenhouse gas emissions by:

Energy:	**13,712 kWh**
Demand:	**3.4 kVA (per month)**
Costs:	**$2,460**
CO_2:	**562.2 kg**

3.10.2 Overhead Door Upgrade

During the review of energy management opportunities, it was noted that consideration is being given to upgrading the overhead doors in 2007. According to information provided by the Deputy Fire Chief, the existing doors have a thermal resistance of R-14 (RSI 2.47) and the proposed new doors would have a thermal resistance of R-3.7 (RSI 0.65). Therefore, heat losses through the new doors would be considerably greater than through the existing doors so no reductions in energy consumption, energy costs and greenhouse gas emissions would be achieved by this measure.

3.11 Baling Facility

3.11.1 LED Exit Sign Lamps

During the review of energy management opportunities for the Baling Facility, it was confirmed that the exit signs in this facility are still fitted with 25-watt incandescent lamps. Replacing these lamps with 1.5-watt LED lamps would reduce annual energy consumption, energy costs and greenhouse gas emissions by:

Energy:	**2,059 KWh**
Demand:	**0.2 kVA (per month)**
Costs:	**$343**
CO_2:	**84.4 Kg**

3.11.2 Programmable Space Heating Thermostats

During the review of energy management opportunities, it was determined that space temperatures in the lunchroom, change rooms and control room could be reduced during unoccupied periods. Details of the fuel consumption and operating hours for the furnace serving had not been provided when this report was prepared so it was not possible to determine the potential reductions in energy consumption, energy costs and greenhouse gas emissions.

In any case, space temperatures in these parts of the facility are currently maintained at about 23 ^{0}C. According to various published reports, heating fuel consumption in a typical building will be reduced by 1% to 2% for each degree Celsius of temperature at night and on weekends. Assuming that the temperature in the control room, change rooms and lunchroom can be reduced to 16 ^{0}C. during unoccupied periods and using the intermediate value of 1.5% for the fuel savings, using a programmable thermostat to automatically reduce temperatures during unoccupied periods will reduce heating oil consumption, costs and greenhouse gas emissions by at least 10%.

3.11.3 Furnace Fan Motor Upgrade

The fan motor in the furnace serving the lunchroom, change rooms and control room runs continuously to maintain uniform temperatures throughout these parts of the facility. During the review of energy management opportunities, it was determined that the fan motor should be replaced with a 2-speed, energy efficient ECM motor.

The annual reductions in energy consumption, energy costs and greenhouse gas emissions that would be achieved by this measure are:

Energy:	**3,346 KWh**
Demand:	**0.4 kVA (per month)**
Costs:	**$557**
CO_2:	**137.2 Kg**

3.11.4 Occupancy Sensor Lighting Controls

During the review of energy management opportunities, it was determined that occupancy sensors could be used to automatically turn off the lighting in the lunchroom, hallway and change rooms when these areas are not occupied. Details of the potential reductions in the operating hours for these lighting systems were not provided for this study so it is assumed that the lighting presently operates continuously between 08:00 and 18:00, 260 days per year (2600 hours per year) and that using occupancy sensors would reduce the operating hours to an average of 3 hours per day for a potential reduction in operating hours of about 780 hours per year.

Based on these estimates, the potential annual reductions in energy consumption, energy costs and greenhouse gas emissions are:

Energy:	**1,445 kWh**
Demand:	**0.0 kVA (per month)**
Costs:	**$224**
CO_2:	**59.2 kg**

Note: The estimated savings assume that the existing T12 lamps and magnetic ballasts will be replaced with T8 lamps and electronic ballasts (see Section 3.11.6).

3.11.5 Occupancy Sensor/Timer Exhaust Fan Controls

During the review of energy management opportunities, it was noted that the exhaust fans serving the lunchroom and change rooms operate continuously. Assuming that these fans are only required to operate about two hours per day, 260 days per year, using occupancy sensors to control the fans would yield estimated annual reductions in energy consumption, energy costs and greenhouse gas emissions of:

Electricity:	**1236 kWh**
Heating Oil:	**3445 Litres**
Costs:	**$2800**
CO_2:	**9456.6 kg**

3.11.6 Fluorescent Lighting System Upgrade

During the review of energy management opportunities, it was confirmed that the existing fluorescent lighting fixtures in this facility are fitted with T12 lamps and magnetic ballasts and that they should be replaced or upgraded with T8 lamps and electronic ballasts. The annual reductions in energy consumption, energy costs and greenhouse gas emissions that would be achieved by this measure are:

Energy:	**1,030 kWh**
Demand:	**0.8 kVA (per month)**
Costs:	**$239**
CO_2:	**42.2 kg**

Note: The estimated savings assume that the energy management opportunities described in Sections 3.11.5 and 3.11.7 will be implemented.

3.11.7 Shop Lighting Switching Improvements

There are seventeen 1-lamp fixtures and one 2-lamp fixture in the shop area of the building. These fixtures operate continuously (8760 hours per year) as there is no local switch to control them. According to information provided by Public Works, these fixtures would only operate 2080 hours per year (8 hrs/day x 260 days/yr) if a local switch was provided to turn off the lights at the end of each workday. Therefore, the reduction in annual operating hours would be about 6680 hours per year and the annual reductions in energy consumption, energy costs and greenhouse gas emissions would be:

Energy:	**3,935 kWh**
Demand:	**0.0 kVA (per month)**
Costs:	**$611**
CO_2:	**161.3 kg**

Note: The estimated savings assume that the existing T12 lamps and magnetic ballasts will be replaced with T8 lamps and electronic ballasts (see Section 3.11.6).

3.12 Public Works Garage

3.12.1 Waste Oil Heater

According to information provided by the Works Superintendent, the garage generates about 1600 litres of waste oil each year. At present, this oil is given to a local business that operates a waste oil heater.

Assuming the average heat content of this waste oil is equal to or greater than that of P40/P50 heating oil, using a waste oil heater to offset space heating requirements in the Public Works would reduce heating oil purchases for the garage by 1600 litres or $1212 per annum. This measure will not reduce greenhouse gas emissions for the garage.

Heating Oil:	**1600**	**Litres**
Costs:	**$1212**	
CO_2:	**0**	**kg**

3.12.2 Occupancy Sensor Lighting Controls

During the review of energy management opportunities, it was determined that some areas in the warehouse would benefit by using occupancy sensors to automatically switch off the lighting when the areas are not occupied. At the time that this report was prepared, details of these lighting systems had not been provided so it was not possible to estimate the energy, energy cost and greenhouse gas reductions that would be achieved by implementing this measure.

3.13 Other Opportunities

During and after the meetings to review potential energy management opportunities with the various facility managers, it was noted that consideration should be given to implementing the lighting system upgrades proposed in this report at the other lift stations and pumphouses that were not included in the scope of work for this study. It was also noted that consideration should be given to using LED lamps for Christmas lighting at City Hall, the Public Works Garage and along Franklin Avenue. At the time that this report was prepared, details of these lighting systems had not been provided so it was not possible to estimate the energy, cost and greenhouse gas reductions that would be achieved by implementing these measures.

4.0 Summary and Conclusions

Table 1 summarizes the energy, energy cost and greenhouse gas savings that would be achieved by implementing the energy management opportunities in Section 3 for which information was available to determine the savings.

Table 1: Summary of Energy Management Opportunities

	Estimated Annual Savings						
	Heating Oil		Electrical Power		Totals		CO_2
Description of Opportunity	Litres	$	kWh	$	MJ	$	kg
3.1.1 Lighting System Upgrade	Nil	Nil	8,837	$1,398	31,813	$1,398	362
3.1.2 Furnace Fan Motor Upgrade	Nil	Nil	13,385	$2,230	48,186	$2,230	549
3.2.1 Lighting System Upgrade	Nil	Nil	7,708	$1,218	27,749	$1,218	316
3.2.2 Furnace Fan Motor Upgrade	Nil	Nil	2,234	$372	8,042	$372	92
3.2.3 Space Temp. Reduction	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3.5.1 Lighting System Upgrade	Nil	Nil	25	$22	90	$22	1
3.5.2 Furnace Fan Motor Upgrade	Nil	Nil	3,346	$557	12,046	$557	137
3.5.3 Space Temp. Reduction	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3.6.1 Lighting System Upgrade	Nil	Nil	340	$62	1,224	$62	14
3.6.2 Space Temp. Reduction	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3.7.1 Heat Recovery	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3.7.2 Single Compressor Operation	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3.7.3 Variable Illumination Levels	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3.7.4 Shower Controls	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3.7.5 Fluorescent Lighting Upgrade	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3.7.6 Lighting Occupancy Sensors	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3.7.7 Outdoor Lighting Upgrade	N/A	N/A	591	$105	2,128	$105	24
3.7.8 Outdoor Lighting Controls	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3.7.9 E/A Fan Occupancy Sensors	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3.7.10 Refrigerant Conversion	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3.8.1 Infrared Shower Controls	9,136	$6,918	N/A	N/A	239,830	$6,918	24,941
3.8.2 Ventilation Air Preheat	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3.9.1 Lighting Occupancy Sensors	Nil	Nil	3,804	$591	13,694	$591	156
3.9.2 DHW Circulating Pump Timer	Nil	Nil	567	$88	2,041	$88	23
3.9.3 Variable Volume Ventilation	2,000	$1,514	51,387	$7,986	254,993	$9,500	7,567
3.9.4 Window Upgrade	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3.9.5 Exterior Door Upgrade	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3.10.1 Fluorescent Lighting Upgrade	Nil	Nil	13,712	$2,460	49,363	$2,460	562
3.10.2 Overhead Door Upgrade	Nil	Nil	Nil	Nil	Nil	Nil	Nil
3.11.1 LED Exit Sign Lamps	Nil	Nil	2,059	$343	7,412	$343	84
3.11.2 Programmable Thermostats	TBD	TBD	TBD	TBD	TBD	TBD	TBD
3.11.3 Furnace Fan Motor Upgrade	Nil	Nil	3,346	$557	12,046	$557	137
3.11.4 Lighting Occupancy Sensors	Nil	Nil	1,445	$224	5,202	$224	59
3.11.5 Exhaust Fan Controls	3,445	$2,609	1,236	$192	125,025	$2,800	9,457
3.11.6 Fluorescent Lighting Upgrade	Nil	Nil	1,030	$239	3,708	$239	42
3.11.7 Light Switching Improvements	Nil	Nil	3,935	$611	14,166	$611	161
3.12.1 Waste Oil Heater	1,600	$1,212	Nil	Nil	56,000	$1,212	Nil
3.12.2 Lighting Occupancy Sensors	TBD	TBD	TBD	TBD	TBD	TBD	TBD
Totals	16,181	$12,253	110,150	$17,857	882,945	$30,109	44,323

TBD: To Be Determined

Additional information is required to determine the energy, energy cost and greenhouse gas savings that would be achieved by several of the energy management opportunities shown in Table 8 and the additional energy management opportunities described in Section 2.13.

The preparation of detailed capital cost estimates for the energy management opportunities described in this report was not included in the scope of work for this study. However, cost estimates will ultimately be required for budgeting purposes and to prioritize the projects. Also, the assumptions used to estimate the energy, energy cost and greenhouse gas savings should be reviewed and updated as required.