Appendices

Acknowledgements

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Executive Summary

The Meeting the One Tonne Challenge on Annapolis Farms Project was developed by Clean Annapolis River Project (CARP) in the fall and winter of 2003 in response to the issuance of the One Tonne Challenge, and the consequent focus that greenhouse gas emission reduction was given by the Canadian Government. Implementation of the project began in February 2004, upon receipt of funding from Environment Canada's Eco Action Community Funding Program. The goal of the project was to work with farmers in the Annapolis River watershed toward reducing greenhouse gas (GHG) emissions generated from their operations. A general audit of each participating farms' practices in relation to production of GHG's was conducted using the Annapolis Atmosfarm Workbook. From the audit, GHG emission reduction plans were developed for each site. These plans were implemented in partnership with the participants, with limited funding provided by CARP.
Another aspect of this project was planting of trees as "carbon sinks". This was carried out by CARP staff throughout the spring, summer and fall of 2004. All trees were donated by J.D. Irving Limited.

A wide variety of activities were undertaken to achieve the goals of the project. Each participating farm presented a unique situation that required an approach tailored to suit its individual needs. Projects undertaken included: replacing standard incandescent lighting with energy efficient alternatives; installing timers in barns to reduce energy waste from lighting; replacing oversized, poorly insulated hot water tanks with appropriately sized and better insulated models; fitting hot water tanks with insulation to reduce standby heat losses; installing pipe insulation on exposed water lines of two circulating, heated watering systems in mink barns; installing a heat recovery unit to utilize heat taken from milk in a milk cooling system; and installing a programmable thermostat in a heated area within a stable to help reduce energy used for heating operations.

The following is a list of accomplishments realised through implementing the Meeting the One Tonne Challenge on Annapolis Farms Project:

- 16 Annapolis Atmosfarm workbooks distributed
- 16 farms reviewed their practices in relation to GHG emission production
- 14 farms participated In GHG emission reduction projects
- Energy efficient lighting Installed In six barns
- Timers Installed on two lighting systems
- Two refrigeration systems operating on R-12 (freon) refrigerant replaced with units operating on R-404a
- One inefficient chest freezer used for storing beef replaced with a much more efficient model
- Two oversized, inefficient water heaters replaced with smaller, more efficient models
- 13 hot water tanks fitted with insulating wrap
- One programmable thermostat installed In storage/office space of a stable
- One milk heat recovery system installed
- One time reduction of GHG from refrigeration systems totalling 19 tonnes CO_2
- Annual reduction of GHG from local agricultural operations totalling 27.1 tonnes CO_2 per year
- 6,600 trees planted as carbon sequestration initiative

Introduction

This report will summarise Clean Annapolis River Project's Meeting the One Tonne Challenge on Annapolis Farms Project that was developed in the fall and winter of 2003, and implemented from February to November of 2004. It will provide detail on the reasoning for the project and its development, its realisation, and the results obtained from its implementation.

Background

The Clean Annapolis River Project, founded in March of 1990, is a charitable organization whose goal is to *work with communities and organizations to foster the conservation, restoration and sustainable use of freshwater and marine ecosystems of the Annapolis watershed.* CARP's activities cover a wide range of environmental assessment, education and action projects. Some of the projects that CARP has initiated include volunteer air and water quality monitoring, private stewardship and conservation planning, and fish habitat restoration. CARP has been a participant in the Atlantic Coastal Action Program (ACAP) since 1991, and has been honoured with several regional and international awards for its efforts.

The Annapolis River watershed is a highly agricultural area with a wide diversity of farming practices yielding a large variety of products. Because of the potential for agricultural operations of any kind to contribute to greenhouse gas emissions, there is much potential in this area to reduce the contributions of greenhouse gasses from agriculture.

CARP developed the Meeting the One Tonne Challenge on Annapolis Farms Project as an initiative to help local farmers reduce the greenhouse gas emissions generated from their operations. The project focused primarily on reducing energy consumption on farms, providing benefits to both farmers and the environment. Farmers were able to reduce their power bills, and lessen the greenhouse gas emissions produced through the generation of electricity.

Funding for the project was obtained through EcoAction, an Environment Canada funding program for community based environmental Initiatives. This program requires that the applicant provide a minimum of 50% of the total project cost in matching funds or in-kind contributions. CARP sought to generate in-kind contributions to match EcoAction funding through donations of time and labour from project participants, cost sharing with participants on individual projects, seeking donations of time and expertise from various parties having experience and knowledge that was valuable to the project, and by seeking a donation of trees to be planted for carbon sequestration from J.D. Irving limited.

Methodology

The goal of the Meeting the One Tonne Challenge on Annapolis Farms project was to work with farmers within the Annapolis watershed toward reducing greenhouse gas emissions from agricultural operations in the area. In order to achieve this goal, the participation of several farmers willing to work toward this goal was crucial. Farmers were recruited for the project through several avenues. A press release was issued early on in the project inviting interested parties to participate, CARP's Executive Director, Stephen Hawboldt, brought the project to the attention of the Annapolis County Federation of Agriculture while attending their Annual General Meeting, and farm owners were contacted by phone and offered the opportunity to participate.

Potential participants were given GHG information packages consisting of the Annapolis Atmosfarm Workbook containing a series of fact sheets related specifically to GHG's and agriculture, and the Government of Canada information package titled "Climate Change: Are You Doing Your Bit?". The goals of the project were described to participants in one-on-one sessions in which instructions were given for reviewing their practices in relation to GHG emissions using the Annapolis Atmosfarm Workbook.

Upon completion of the workbooks, meetings were scheduled with the participants to discuss their results and identify priorities for each individual site. Goals were established and researched in order to identify specific measures that could be taken to reduce GHG emissions in each case. Specific plans for each site were developed in partnership with the participants and evaluated in terms of effectiveness in reaching the project's objectives. Accepted projects were partially funded, for an amount dependant on overall project expenses.

During the course of implementing each GHG emission reduction initiative, estimates of the annual reductions In GHG emissions as CO_2 were performed. This was done in order to evaluate the effectiveness of each initiative, and the overall success of the project. Energy savings in kilowatt-hours were calculated for each initiative, giving a figure used to estimate the reduction in GHG from the reduced consumption of electricity. The number of kilowatt-hours of electricity saved was multiplied by a factor representing the total GHG emissions as CO_2 per Kilowatt-hour of electricity generated for the Province of Nova Scotia. The value used was 0.78 kg CO_2 per kilowatt-hour. This factor was taken from the Annapolis Atmosfarm Outreach Pilot Project report.

Another aspect of the project was the planting of trees as a carbon sequestration initiative. A donation of shrub willow, red pine, white spruce and red spruce totalling 6,600 trees was contributed to the project by J.D. Irving Limited. These trees were planted at various sites within the watershed as opportunities arose. Each participant was offered the opportunity to have trees planted on their property, and as a result, many planting sites were on participating farms. Other planting sites had to be sought due to lack of available sites on participating farms, however. The town of Annapolis Royal agreed to having willows planted along a newly dug drainage ditch within the town marsh, and one private land owner (Jessie Bird) agreed to having pines planted alongside a hayfield on their property. The trees were planted throughout the project by CARP staff.

Site Descriptions and Project Details

Barteaux

This farm is located in Moschelle. It is primarily a fruit-producing farm growing a range of produce including apples, peaches, strawberries, raspberries and blueberries. Some beef is produced, as well as other produce on a limited basis. Many of the operations carried out on this farm use a limited amount of energy. One exception was in the cold storage of fruit between harvest and sale. The cold storage system at this site was quite old, and likely oversized for its intended purpose. It also operated on R-12 refrigerant, or freon, which has a very high global warming potential (GWP) and is an ozone depleting substance. It was decided that replacing this unit with a more modern one operating on R-404a would be the best course of action at this site. R-404a has a much lower GWP than R-12, and is not an ozone depleting substance. It was also decided by the owners that a new, better insulated, cold storage space should be built to accommodate the new unit. The additional insulation is expected to save energy by reducing the cooling unit run-time, though the amount cannot be reasonably estimated. A very significant one-time reduction in greenhouse gasses was achieved by switching to the new refrigerant. This measure also eliminated the use of ozone depleting substances at this site.

The following lists the goals achieved at this site:

- Greenhouse gas information package distributed to owner
- Greenhouse gas emissions review completed for the operation
- Cold storage system updated to a more efficient system
- One time GHG reduction of 9.5 tonnes CO_2

Bent

This farm is located in Clarence. It is a large, and relatively sophisticated dairy operation. Many operations on this farm are mechanized making this farm a fairly significant energy consumer. Because of this, the operator had already taken some steps toward reducing energy usage. A new barn was being built during the course of this project, and the owner agreed to use this new building as a demonstration site for this project. Two demonstrative projects were chosen for this new construction. These were energy efficient lighting and water heating. High efficiency metal halide lights were chosen to meet required light levels with a minimum of energy usage. These lights, though more expensive to purchase, are far more efficient than the standard incandescent lighting that would have been installed otherwise. In regard to water heating, a unit appropriately sized to meet hot water demand was chosen to minimize energy wasted from heating unnecessary volumes of water. This was then insulated further with double layered, reflective bubble wrap insulation with an insulation value of R-10. The increase in insulation value is estimated to reduce standby heat loss from the water heater by approximately 75%.

(Bent Continued)
The following lists the goals achieved at this site:

- Greenhouse gas information package distributed to owner
- Greenhouse gas emissions review completed for the operation
- High efficiency lighting installed in barn
- Properly sized water heater installed in barn
- Water heater fitted with insulating wrap
- Potential annual GHG emissions reduced by 1.5 tonnes CO_2

Brown
This farm is located in Upper Clements. It is a medium sized beef operation. This operation was, until recently, a dairy operation. Because of the change, energy use has been much reduced. Dairy operations require a substantial amount of hot water for equipment cleaning, and because of this are equipped with relatively large hot water heating apparatus as compared to the average beef operation, which in some cases have none. The two barns on this farm were each equipped with hot water heaters that were oversized compared to the demand for hot water. These had been in place since before 1993, at which time hot water heater manufacturers began to improve the insulation in their storage tanks to reduce standby heat loss. This situation presented an opportunity to reduce energy use for hot water heating on this farm substantially. The old hot water heaters were replaced with newer, more efficient models that were sized according to demand. Additional insulation, in the form of double layered, reflective bubble wrap insulation with an insulation value of R-10 was added to these to reduce standby heat loss further. The increase in insulation value is estimated to reduce standby heat loss from each water heater by approximately 75%.

The following lists the goals achieved at this site:

- Greenhouse gas information package distributed to owner
- Greenhouse gas emissions review completed for the operation
- Two oversized water heaters replaced with properly sized units
- New water heaters fitted with insulating wrap
- Annual GHG emissions reduced by 0.8 tonnes CO_2

Bruce
This farm is located in Centrelea. It is an organic operation that produces mostly beef and lamb. The majority of operations on this farm require very little energy. One exception was in the storage of frozen beef prior to sale. This was done using a very old, large household chest-freezer. It was determined that a new chest freezer with the same capacity would consume much less electricity than the existing one. A more efficient model was purchased to replace the existing freezer. Another initiative that was taken at this site was to replace an electric fencer that operated on standard household power with a photovoltaic fence energizer. The resultant energy savings from this initiative were less than what was hoped initially. The primary benefit derived from this initiative was in encouraging the use of alternative energy sources. In this case, the owner is now researching the possibility of using a wind turbine to generate a portion of the energy required for farm operations. This was supported during the course of the project through providing the participant with information and resources to help him with this goal.

Bruce Continued)

The following lists the goals achieved at this site:

- Greenhouse gas information package distributed to owner
- Greenhouse gas emissions review completed for the operation
- AC electric fencer replaced with photovoltaic unit
- Inefficient meat freezer replaced with energy efficient model
- Annual GHG emissions reduced by 0.5 tonnes CO_2

Cook

This Farm is located in Clarence. It is a medium sized dairy operation. The lighting in the dairy barn at this site was already high efficiency metal halide type lamps. However, these lights were typically left on all day. This was not required, and in fact not recommended practice in a dairy barn. In response to this, a timer was installed to regulate the lighting schedule. This showed significant reductions in energy consumption from lighting.
Another approach taken at this site was to fit the electric water heater in the barn with reflective, bubble wrap insulation with an insulating value of R-10. The increase in insulation value is estimated to reduce standby heat loss from the water heater by approximately 75%.

The following lists the goals achieved at this site:

- Greenhouse gas information package distributed to owner
- Greenhouse gas emissions review completed for the operation
- Timer installed to control barn lights
- Water heater fitted with insulating wrap
- Annual GHG emissions reduced by 2.3 tonnes CO_2

DeNuke

This Farm is located in Granville Beach. It is a small dairy operation. The dairy barn on this farm was lit with standard, 100-watt incandescent lights. These lights are very inefficient in terms of light emission for the amount of energy used. These were replaced with a combination of tubular, and compact fluorescent lights, which are far more efficient than the lights that were in use previously. Using tubular fluorescent lighting, it was possible to increase light levels in the centre of the barn to recommended levels for optimum milk production while reducing the energy consumption significantly. The remainder of the barn lighting was replaced with compact fluorescent lights. Light levels essentially remained the same in these areas, and energy consumption was reduced.

Another approach taken at this site was to fit the electric water heater in the barn with reflective, bubble wrap insulation with an insulating value of R-10. The increase in insulation value is estimated to reduce standby heat loss from the water heater by approximately 75%.

DeNuke Continued)
The following lists the goals achieved at this site:

- Greenhouse gas information package distributed to owner
- Greenhouse gas emissions review completed for the operation
- Incandescent lighting replaced with energy efficient fluorescent lighting in barn
- Water heater fitted with insulating wrap
- Annual GHG emissions reduced by 2.1 tonnes CO_2

Hillier
This site is located in East Torbrook. It is a medium sized mink ranching operation. This operation uses a circulating, heated watering system through which water circulates from a hot water tank, through the building, and returns to be reheated. Upon installation of this system, the owner noted a very significant increase in energy consumption from his operation. A reasonable explanation for this was that heat loss as the water passed through uninsulated water lines in the unheated barn was lowering the temperature of the water that returned through the system to the water heater. Because of this, the water heater was using significant amounts of electricity to achieve the temperature rise required before recirculation. It was found that there was approximately 750 feet of uninsulated water line that could be insulated. This was done using self-adhesive foam pipe insulation. Because of the number of variables involved in a system such as this, and the inability to compare energy use before and after insulating the pipes within the timeline of this project, no estimation of the effect implementing this project could be made. The savings, however, will very likely be significant.
Another approach taken at this site was to fit the three 40 gallon electric water heaters used in the system described above with reflective, bubble wrap insulation with an insulating value of R-10. The increase in insulation value is estimated to reduce standby heat loss from each water heater by approximately 75%.

The following lists the goals achieved at this site:

- Greenhouse gas information package distributed to owner
- Greenhouse gas emissions review completed for the operation
- Pipe insulation installed on 750′ of water line
- Three water heaters fitted with insulating wrap
- Annual GHG emissions reduced by 1.5 tonnes CO_2

Hudson

This farm is located in Port Wade. It is a small beef-producing farm that uses very little energy for its operation. One potential GHG emission reduction initiative was identified for this farm. This was to size tractor implements, primarily ploughs, according to tractor size and power.
The plough currently being used is a single furrow unit, which means that many passes must be made through a field when ploughing. The tractors used at this site are capable of pulling two or three-furrow ploughs with very little increase in fuel consumption per pass. Switching to a two or three-furrow plough would allow ploughing to be achieved in far fewer passes.

(Hudson Continued)
This would decrease fuel consumption per operation significantly. The purchase of a plough was not eligible for funding, and no other projects were identified for this site. The participant remains interested in changing his methods as his finances permit.

The following lists the goals achieved at this site:

- Greenhouse gas information package distributed to owner
- Greenhouse gas emissions review completed for the operation

Jackson
This farm is located in Clarence. It is a small dairy operation. The dairy barn on this farm was lit with standard, 100-watt incandescent lights. These lights are very inefficient in terms of light emission for the amount of energy used. These were replaced with a combination of tubular, and compact fluorescent lights, which are far more efficient than the lights that were in use previously. Using tubular fluorescent lighting, it was possible to increase light levels in the centre of the barn to recommended levels for optimum milk production while reducing the energy consumption significantly. The remainder of the barn lighting was replaced with compact fluorescent lights. Light levels essentially remained the same in these areas, and energy consumption was reduced.
Another approach taken at this site was to fit the electric water heater in the barn with reflective, bubble wrap insulation with an insulating value of R-10. The increase in insulation value is estimated to reduce standby heat loss from the water heater by approximately 75%.

The following lists the goals achieved at this site:

- Greenhouse gas information package distributed to owner
- Greenhouse gas emissions review completed for the operation
- Incandescent lighting replaced with energy efficient fluorescent lighting in barn
- Water heater fitted with insulating wrap
- Annual GHG emissions reduced by 2.4 tonnes CO_2

Lawrence
This farm is located in Clarence. It is both a dairy and a beef producing operation. Some energy saving measures had already been taken by the owner of this operation including high efficiency lighting, and pre-cooling of the milk prior to entering the refrigerated milk tank. An opportunity arose to install a heat recovery unit that had previously been purchased by the owner with a pre-owned lot of other dairy equipment. This system is designed to accept water that is passed through a plate cooler, drawing heat from the milk before it enters the refrigerated storage tank. The water that now holds the heat from the milk is then stored in the heat recovery unit. The refrigeration tank then cools the milk further. The refrigeration line containing heat-bearing refrigerant passes through the heat recovery unit's storage tank, allowing the heat generated by this system to be passed on to the water stored in the heat recovery unit.

(Lawrence Continued)
The twice-heated water then enters the electric water heater, where additional heat is added if necessary. Because of the heat recovered from the milk cooling process, however, much less energy is required to bring the water up to the temperature required for the equipment washing cycle that occurs immediately after the milk is removed from the refrigeration tank. The cost of installing this system had prevented it from being used despite the potential savings it would show. A refrigeration technician was hired to install the system. The energy savings from this type of system can be estimated using volume of milk production and average volume of heated water used by the operation. These savings are quite significant.
Another approach taken at this site was to fit the electric water heater in the barn with reflective, bubble wrap insulation with an insulating value of R-10. The increase in insulation value is estimated to reduce standby heat loss from the water heater by approximately 75%.

The following lists the goals achieved at this site:

- Greenhouse gas information package distributed to owner
- Greenhouse gas emissions review completed for the operation
- Heat recovery unit installed in milking system
- Water heater fitted with insulating wrap
- Annual GHG emissions reduced by 4.9 tonnes CO_2

Lilly
This farm is located in Paradise. This site is a medium sized mink ranch, as well as a small beef producing operation. The mink barns on this farm use a circulating, heated watering system to provide water for the mink. This system cycles heated water through pipes to every individual cage, then back to the water heater in order to maintain high enough water temperatures to prevent the water from freezing in the pipes. Because the water is circulated through several hundred feet of water line in an unheated building, there is a very large amount of heat loss with this system. In response to this, it was decided that any water line that could be insulated would be fitted with foam pipe insulation. Much of the waterline could not be insulated due to proximity to the cages, and problems with the mink chewing the insulating material off. There was, however, 250 feet of exposed waterline that could be insulated without problems. Another approach taken at this site was to fit the 40-gallon oil fired water heater in the barn with reflective, bubble wrap insulation with an insulating value of R-10. The increase in insulation value is estimated to reduce standby heat loss from the water heater by approximately 75%. These measures should show a significant reduction in consumption of fuel for water heating, though there are too many variables to provide any reasonable estimate as to how much.

The following lists the goals achieved at this site:

- Greenhouse gas information package distributed to owner
- Greenhouse gas emissions review completed for the operation
- Pipe insulation installed on 250′ of water line
- Oil fired water heater fitted with insulating wrap

MacHattie

This farm is located in Brooklyn. It is a small beef producing operation. The barn on this farm was lit with standard 100-watt incandescent light bulbs. These lights are very inefficient in terms of light emission for the amount of energy used. New lighting, in the form of high efficiency compact fluorescent lights was installed. This showed a significant reduction in energy use for lighting at this site.

The following lists the goals achieved at this site:

- Greenhouse gas information package distributed to owner
- Greenhouse gas emissions review completed for the operation
- Incandescent lighting replaced with energy efficient fluorescent lighting in barn
- Annual GHG emissions reduced by 0.7 tonnes CO_2

Noble

This farm is located in Wilmot. It is a medium sized dairy operation. The dairy barn on this farm was lit with standard, 100-watt incandescent lights. These lights are very inefficient in terms of light emission for the amount of energy used. These were replaced with a combination of tubular, and compact fluorescent lights, which are far more efficient than the lights that were in use previously. Using tubular fluorescent lighting, it was possible to increase light levels in the centre of the barn to recommended levels for optimum milk production while reducing the energy consumption significantly. The remainder of the barn lighting was replaced with compact fluorescent lights. Light levels essentially remained the same in these areas, and energy consumption was reduced. In addition to the change in light source, a timer was installed to control the lighting schedule. This was done in response to the fact that the lights were habitually left on all day. This was not required, and in fact not recommended practice in a dairy barn. This showed very significant additional reductions in energy consumption.

Another approach taken at this site was to fit the 70-gallon electric water heater in the barn with reflective, bubble wrap insulation with an insulating value of R-10. The increase in insulation value is estimated to reduce standby heat loss from the water heater by approximately 75%.

The changes made on this site during the course of the project were some of the most successful, showing a much higher reduction in greenhouse gas emissions than all other sites.

The following lists the goals achieved at this site:

- Greenhouse gas information package distributed to owner
- Greenhouse gas emissions review completed for the operation
- Incandescent lighting replaced with energy efficient fluorescent lighting in barn
- Timer installed to control lighting in barn
- Water heater fitted with insulating wrap
- Annual GHG emissions reduced by 7.9 tonnes CO_2

Taylor

This site is located in Lawrencetown. It is a large cranberry growing operation. During harvest, cranberries were stored in a cold storage facility that was refrigerated with an old refrigeration unit operating on R-12 (freon) refrigerant. The insulating panels in the cold storage room were poorly sealed, reducing the efficiency of the system. In response to these issues two actions were taken. The first was to replace the existing refrigeration unit with a more modern one operating on R-404a refrigerant. R-404a has a significantly lower global warming potential than R-12, and is not an ozone depleting substance. In order to better seal the cold storage space, all seams between insulation panels were taped. In addition, the door to the cold storage room was fitted with a plastic door strip. This is basically a plastic curtain designed to minimize temperature rise while the door is open. These measures should increase the overall efficiency of the system. While the reduction of energy requirements achieved by sealing the cold storage room are not readily estimable, they are expected to be significant. A very significant one-time reduction in greenhouse gasses was achieved by switching to the new refrigerant. This measure also eliminated the use of ozone depleting substances at this site.

The following lists the goals achieved at this site:

- Greenhouse gas information package distributed to owner
- Greenhouse gas emissions review completed for the operation
- Cold storage system updated to a more efficient system
- Seams of insulating panels in cold room taped
- Door to cold room fitted with plastic door strip
- One time GHG reduction of 9.5 tonnes CO_2

Tracy

This site, located in Clarence, is a horse stable and riding ring. Lights are needed in the stable area for long periods during the day. The lighting used was in the form of thirteen standard 60-watt incandescent bulbs. These were replaced with 13-watt compact fluorescent bulbs showing a significant energy savings.
There is a small, heated storage/ office space within the stable area, where an electric water heater is located. Very little heat is required in this area outside of the riding ring's operating hours. A minimal amount of heat, sufficient to prevent the water lines from freezing, is adequate for at least 8 out of 24 hours. To minimize energy used to heat this space, a programmable thermostat allowing precise temperature control for various times of the day was installed. In addition to this, the 40-gallon water heater tank was fitted with reflective bubble wrap insulation with an insulation value of R-10 in order to cut down on standby heat loss. The increase in insulation value is estimated to reduce standby heat loss from the water heater by approximately 75%.

The following lists the goals achieved at this site:

- Greenhouse gas information package distributed to owner
- Greenhouse gas emissions review completed for the operation
- Incandescent lighting replaced with energy efficient fluorescent lighting in stable
- Programmable thermostat installed in heated storage/office space
- Water heater fitted with insulating wrap
- Annual GHG emissions reduced by 2.5 tonnes CO_2

Troop

This farm is located in Belleisle. It is a small beef-producing farm that uses very little energy for its operation. No potential GHG emission reduction initiatives could be identified for this site.

The following lists the goals achieved at this site:

- Greenhouse gas information package distributed to owner
- Greenhouse gas emissions review completed for the operation

Tree Planting

6600 trees, donated by J.D. Irving Limited, were planted throughout the course of the project as a carbon sequestration Initiative. The trees were a variety of shrub willow, red pine, white spruce, and red spruce. These were planted at various sites throughout the watershed.

The following is a list of sites and the number of trees planted at each site:

- Annapolis Royal Marsh (Annapolis Royal): 2,000 trees
- Barteaux Property (Moschelle): 710 trees
- Bird Property (Port Royal): 400 trees
- Bishop Property (Round Hill): 560 trees
- Bruce Property (Centrelea): 430 trees
- Hudson Property (Port Wade): 1,100 trees
- Lilly Property (Paradise): 150 trees
- Troop Property (Belleisle): 1,250 trees

Summary of Accomplishments

The Meeting the One Tonne Challenge on Annapolis Farms Project was implemented with encouraging results. More participants were accommodated than was expected to be possible at the onset, resulting in a wide range of projects and very significant reductions in greenhouse gas emissions.

The following is a list of accomplishments realised through implementing the Meeting the One Tonne Challenge on Annapolis Farms Project:

- 16 Annapolis Atmosfarm workbooks distributed
- 16 farms reviewed their practices in relation to GHG emission production
- 14 farms participated In GHG emission reduction projects
- Energy efficient lighting installed in six barns
- Timers installed on two lighting systems
- Two refrigeration systems operating on R-12 (freon) refrigerant replaced with units operating on R-404a
- One inefficient chest freezer used for storing beef replaced with a much more efficient model
- Two oversized, inefficient water heaters replaced with smaller, more efficient models
- 13 hot water tanks fitted with insulating wrap
- One programmable thermostat installed in storage/office space of a stable
- One milk heat recovery system installed
- One time reduction of GHG from refrigeration systems totalling 19 tonnes CO_2
- Annual reduction of GHG from local agricultural operations totalling 27.1 tonnes CO_2 per year
- 6,600 trees planted as carbon sequestration initiative

Conclusions and Recommendations

It can be concluded from the results achieved through implementing this project that community based initiatives to reduce greenhouse gas emissions can be quite successful. It has been demonstrated that members of the agricultural community are willing to work with organizations such as CARP to adopt more sustainable practices, and that there is much potential for reducing environmental impacts from agriculture by doing so. It is recommended that projects of this nature continue to receive consideration.

The fact that financial support for greenhouse gas emission reduction projects was offered to farmers through this project helped greatly in achieving the goals that were set. Many initiatives that were taken proved quite expensive up front, which would have, in many cases, discouraged farmers from implementing them.

One limiting factor that was encountered during the course of this project was time. This project was planned and implemented through some of the busiest time of year for farmers. A longer planning period beginning in the fall is recommended. The capacity to support implementation of projects through the winter should be built into similar projects as well.

Appendix A

Barteaux- Calculations

Barteaux- Calculations

Cold Storage

Previous system: 7 lbs of R-12 (Global Warming Potential 8,500 x CO_2[1])
New system: 10 lbs R-404a (Global Warming Potential 3,850 x CO_2[1])

Total GHG as CO_2 In previous system:

$$\frac{7 \text{ lbs} \times 8{,}500}{2.2 \text{ lbs/kg}} = 27{,}045.5 \text{ kg as } CO_2$$

Total GHG as CO_2 In new system:

$$\frac{10 \text{ lbs} \times 3{,}850}{2.2 \text{ lbs/kg}} = 17{,}500 \text{ kg as } CO_2$$

Total one-time rduction In GHG as CO_2:

27,045.5 - 17,500
= 9,545.5 kg as CO_2
= 9.5 tonnes as CO_2

[1] Value taken from Environment Canada, Environmental Protection Branch, Ontario Region fact sheet : "Halocarbon Management Strategy for Federal Facilities", 1999

Appendix B

Bent- Calculations

Allen Bent – Calculations

Lighting

PROPOSED SYSTEM (METAL HALIDE 175W BULBS):
4hrs/day X 2 bulbs X 175w X 7days/week X 52 weeks = 509.6kwh/yr

PREVIOUSLY INTENDED LIGHTING (INCANDESCENT 100W BULBS)
4hrs/day X 13 bulbs X 100w X 7days/week X 52 weeks = 1,892.8kwh/yr

POTENTIAL ENERGY SAVINGS
1,892.8kwh – 509.6kwh = 1,383.2kwh/yr

Annual CO_2 Emissions Savings
1,383.2kwh X 0.78kg of CO_2/kwh = 1,078.9kg of CO_2

Water Heater

19 gallon, post-1993 model
Insulation: Reflective bubble wrap (R-value 10)
Standby Heat Loss: 74 watts/hour[1]

Annual standby heat loss (no insulation) = 74 watts x 24 hours x 365 days
= 648.2 kwh/yr

Annual standby heat loss after insulation = 25% of heat loss without insulation[2]
= 648.2 kwh/yr x 0.25
= 162.1 kwh/yr

Annual savings = annual heat loss (no insulation) – annual heat loss (with insulation)
= 648.2 kwh/yr – 162.1 kwh/yr
= 486.2 kwh/yr

Annual reduction in greenhouse gas emissions (Kg as CO_2)
= 486.2 kwh/yr x 0.78 kg/kwh
= 379.2 kg/yr

Total Annual Reduction in GHG Emissions
= 1,078.9 kg/yr + 379.2kg/yr
= 1,458.1 kg/yr as CO_2
= 1.5 tonnes/year as CO_2

[1]GSW inc. Technical Support
[2]Hal Dobbelsteyn, Department of Energy, Halifax

Appendix C

Brown- Calculations

Brown - Calculations

40-Gallon GSW Inc Water Heater

- Installed 1990
- 2 X 3,000watt element
- [1]Standby heat loss for this period = 100w/hr
- [2]Elements heats 12.2gallon/hr
- Total water usage for David Brown – 5gallons/day

Water Heating for Standby Losses

100w/hr X 24hrs/day X 7days/week X 30weeks/yr = 504kwh/yr

Water Heating for Water Replaced

5 gallons/day / 12.2gallons/hr = 0.41hr/day
0.41hr/day X 3,000w X 7days/week X 30weeks/yr = 258.3kwh/yr

Total = 504kwh/yr + 258.3kwh/yr = 762.3kwh/yr

60-Gallon John Wood

- Installed 1990
- 2 X 4,500watt elements
- [1]Standby loss for this period = 120w/hr
- [2]Elements heats 12.2gallon/hr

Water Heating for Standby Losses

120w/hr X 24hrs/day X 7days/week X 30weeks/yr = 604.8kwh/yr

Water Heating for Water Replaced

0.41hr/day X 4,500w X 7days/week X 30weeks/yr = 387.5kwh/yr

Total = 604.8kwh/yr + 387.5kwh/yr = 992.3kwh/yr

Combined Systems

762.3kwh/yr + 992.3kwh/yr = 1,754.6kwh/yr

[1] Hal Dobelstyn Department of Energy
[2] GSW Inc. Technical Support

19 gallon Space Saver by GSW Inc Water Heaters

- 1 X 3,000watt element
- [3]Standby Loss = 74w/hr

Water Heating for Standby Losses
74w/hr X 24hrs/day X 7days/week X 30weeks/yr = 373.0kwh/yr

Water Heating for Water Replaced
0.41hrs/day X 3,000w X 7days/week X 30weeks/yr = 258.3kwh/yr

Total = 373.0kwh/yr + 258.3kwh/yr = 631.3kwh/yr

Combined for two systems
Standby loss: 373.0kwh/yr X 2= 746kwh
Replacement: 258.3kwh/yr X 2= 516.6kwh

Additional Insulation
According to Department of Energy – Additional Insulation with an R rating of 10 or more will reduce standby heat loss by 75%, regardless of the system

Energy consumption of new system = Standby Loss X 0.25+ Replacement
=746kwh/yr X 0.25 + 516.6kwh/yr
= **703.1kwh/yr**

Energy Savings

(Total energy consumption of combined existing systems) - (Total energy consumption of new system)
1,754kwh/yr – 703.1kwh/yr = **1050.9kwh/yr**

Greenhouse Gas Emission Reductions

1050.9kwh/yr X 0.78kg CO_2 = 819.7kg CO_2/yr
=0.8 tonnes/year as CO_2

[1]Hal Dobbelsteyn, Department of Energy, Halifax
[2]GSW Inc. Technical Support

[3] GSW Inc . Technical Support

Appendix D

Bruce- Calculations

Bruce- Calculations

Fencer

110 Volt
0.1 Amps
11 watts
Operated approx 180 days/yr

Annual energy consumption of fencer:
11watts X 24Hrs X 180 days = 47,520 watts/yr = 47.5 kwh/yr

GHG emission reduction achieved by replacing AC fencer with photovoltaic fencer:
47.5 kwh/yr X 0.78 kg of CO_2/kg = **37.1kg of CO_2**

Freezer

Previous Freezer:
115 Volts
3.5 Amps
402.5 watts
Run time: 8 hrs/day
Energy consumption = 402.5 watts x 8hrs x 365 days = **1,175.3 kwh/yr**

Replacement Freezer:
Energy consumption: 569 kwh/yr [1]

Energy savings
1,175.3 kwh/yr - 569 kwh/yr = **606.3 kwh/yr**

Annual reduction In GHG emissions:
606.3 kwh/yr x 0.78 kg/kwh as CO_2
=**472.9 kg/yr as CO_2**

Total Annual GHG Emission Reductions

472.9 kg/yr + 37.1 kg/yr = 510 kg/yr as CO_2
= **0.5 tonnes/ year as CO_2**

Appendix E

Cook- Calculations

Cook- Calculations

Light Timer

Lighting System: 5 x 175 metal halide lamps
Previous Lighting Schedule: 14 hours/ day
Lighting Schedule With Timer: 8 hours/ day

Energy use with previous lighting schedule:

5 x 175 watts x 14 hours x 365 days
= 4471.3 kwh/yr

Energy use with timed schedule:

5 x 175 watts x 8 hours x 365 days
= 2,555 kwh/yr

Annual energy savings from timed schedule:

4471.3 - 2,555 = 1,916.3 kwh/yr

Annual GHG emission reductions:

1,916.3 kwh/yr x 0.78 kg/yr as CO_2
= 1,494.7 kg/yr as CO_2

Water Heater

70 gallon, pre-1993 model
Insulation: Reflective bubble wrap (R-value 10)
Standby Heat Loss: 150 watts/hour[1]

Annual standby heat loss (no insulation) = 150 watts x 24 hours x 365 days
= 1,314 kwh/yr

Annual standby heat loss after insulation = 25% of heat loss without insulation[2]

= 1,314 kwh/yr x 0.25
= 328.5 kwh/yr

Annual savings = annual heat loss (no insulation) – annual heat loss (with insulation)
= 1,314 kwh/yr – 328.5 kwh/yr
= 985.5 kwh/yr

Annual reduction in greenhouse gas emissions (Kg as CO_2)
= 985.5 kwh/yr x 0.78 kg/kwh
= 768.7 kg/yr

Total Annual Reduction in GHG Emissions

= 1,494.7 kg/yr + 768.7 kg/yr
= 2,263.4 kg/yr as CO_2
= 2.3 tonnes/year as CO_2

[1]GSW inc. Technical Support
[2]Hal Dobbelsteyn, Department of Energy, Halifax

Appendix F

DeNuke- Calculations

Carl DeNuke - Calculations

Lighting

Winter Months (Nov. to Apr. – 26 weeks)

Side-Lighting

Savings: Replace 10 X100w with 12 X 20w = 760w savings

760w X 9hrs/day X 7days/week X 26 weeks = 1,244.9kwh/yr

Center-Lighting

Savings: replace 4 X 100w with 6 X 60w = 40w savings

40w X 14hrs/day X 7days/week X 26 weeks = 101.9kwh/yr

Summer Months (May. to Oct. – 26 weeks)

Both Lighting Used- 3hrs/day

(760w + 40w) X 3hrs/day X 7days/week X 26 weeks = 436.8kwh/yr

Milk Room

Savings: replace 2 X 60w with 2 X 20w = 2 X 40w savings

2 X 40w X 10hrs/day X 7days/week X 52 weeks = 291.2kwh/yr

Annual Energy Savings:

1,244.9kwh/yr + 101.9kwh/yr + 436.8kwh/yr + 291.2kwh/yr = 2,074.8kwh/yr

Annual CO_2 Savings:

2,074.8kwh/yr X 0.78kg of CO_2/kwh = 1,618.3kg of CO_2/yr

Water Heater

40 gallon, pre-1993 model

Insulation: Reflective bubble wrap (R-value 10)

Standby Heat Loss: 100 watts/hour[1]

Annual standby heat loss (no insulation) = 100 watts x 24 hours x 365 days

= 876 kwh/yr

Annual standby heat loss after insulation = 25% of heat loss without insulation[2]

= 876 kwh/yr x 0.25

= 219 kwh/yr

Annual savings = annual heat loss (no insulation) – annual heat loss (with insulation)

= 876 kwh/yr – 219 kwh/yr

= 657 kwh/yr

Annual reduction in greenhouse gas emissions (Kg as CO_2)

= 657 kwh/yr x 0.78 kg/kwh

= 512.5 kg/yr

Total Annual Reduction in GHG Emissions

= 1,618.3 kg/yr + 512.5 kg/yr

= 2,130.8 kg/yr as CO_2

= 2.1 tonnes/year as CO_2

[1]GSW inc. Technical Support

[2]Hal Dobbelsteyn, Department of Energy, Halifax

Appendix G

Hillier- Calculations

Hillier- Calculations

Water Heater

3 x 40 gallon, post-1993 model

Insulation: Reflective bubble wrap (R-value 10)

Standby Heat Loss: 96 watts/hour[1]

Annual standby heat loss (no insulation) = 3 x 96 watts x 24 hours x 365 days

= 2,523 kwh/yr

Annual standby heat loss after insulation = 25% of heat loss without insulation[2]

= 2,523 kwh/yr x 0.25

= 630.8 kwh/yr

Annual savings = annual heat loss (no insulation) – annual heat loss (with insulation)

= 2,523 kwh/yr – 630.8 kwh/yr

= 1,892.2 kwh/yr

Annual reduction in greenhouse gas emissions (Kg as CO_2)

= 1,892.2 kwh/yr x 0.78 kg/kwh

= 1,475.9 kg/yr

= 1.5 tonnes/ year as CO_2

[1]GSW inc. Technical Support

[2]Hal Dobbelsteyn, Department of Energy, Halifax

Appendix H

Jackson- Calculations

Alan Jackson – Calculations

Lighting

Winter Months
(Nov. to Apr. – 26 weeks)

Side Lightning
Savings: Replace 12 X 100w with 12 X 20w = 12 X 80w savings
12 X 80w X 9hrs/day X 7days/week X 26 weeks = 1,572.5kwh/yr

Center Lighting
Savings: Replace 6 X 100w with 6 X 60w = 6 X 40w savings
6 X 40w X 16hrs/day X 7days/week X 26 weeks = 698.9kwh/yr

Summer Months
(May. – Oct. – 26 weeks)

Center Lightning Only
Savings: replace 6 X 100w with 6 X 60w = 6 X 40w savings
6 X 40w X 3 hrs/day X 7days/week X 26 weeks = 131.0kwh/yr

Annual Energy Savings:
1,572.5kwh/yr + 698.9kwh/yr + 131.0kwh/yr = 2,402.4kwh/yr

Annual CO_2 Savings:
2,402.4kwh/yr X 0.78kg of CO_2/kwh = 1,873.9kg of CO_2 /yr

Water Heater

40 gallon, post-1993 model

Insulation: Reflective bubble wrap (R-value 10)

Standby Heat Loss: 96 watts/hour[1]

Annual standby heat loss (no insulation) = 96 watts x 24 hours x 365 days

= 841 kwh/yr

Annual standby heat loss after insulation = 25% of heat loss without insulation[2]

= 841 kwh/yr x 0.25

= 210.3 kwh/yr

Annual savings = annual heat loss (no insulation) – annual heat loss (with insulation)

= 841 kwh/yr – 210.3 kwh/yr

= 630.8 kwh/yr

Annual reduction in greenhouse gas emissions (Kg as CO_2)

= 630.8 kwh/yr x 0.78 kg/kwh

= 492 kg/yr

Total Annual Reduction in GHG Emissions

= 1,873.9 kg/yr + 492kg/yr

= 2,365.9 kg/yr as CO_2

= 2.4 tonnes/year as CO_2

[1]GSW inc. Technical Support

[2]Hal Dobbelsteyn, Department of Energy, Halifax

Appendix I

Lawrence- Calculations

Lawrence- Calculations

Milk Heat Recovery

Volume of milk produced per day: 750L
Volume of heated water used per day: 300L

Estimate for energy savings was obtained using the following chart:

Potential energy (dollar) savings by transferring milk heat to water - based on daily milk production and warmed water usage.

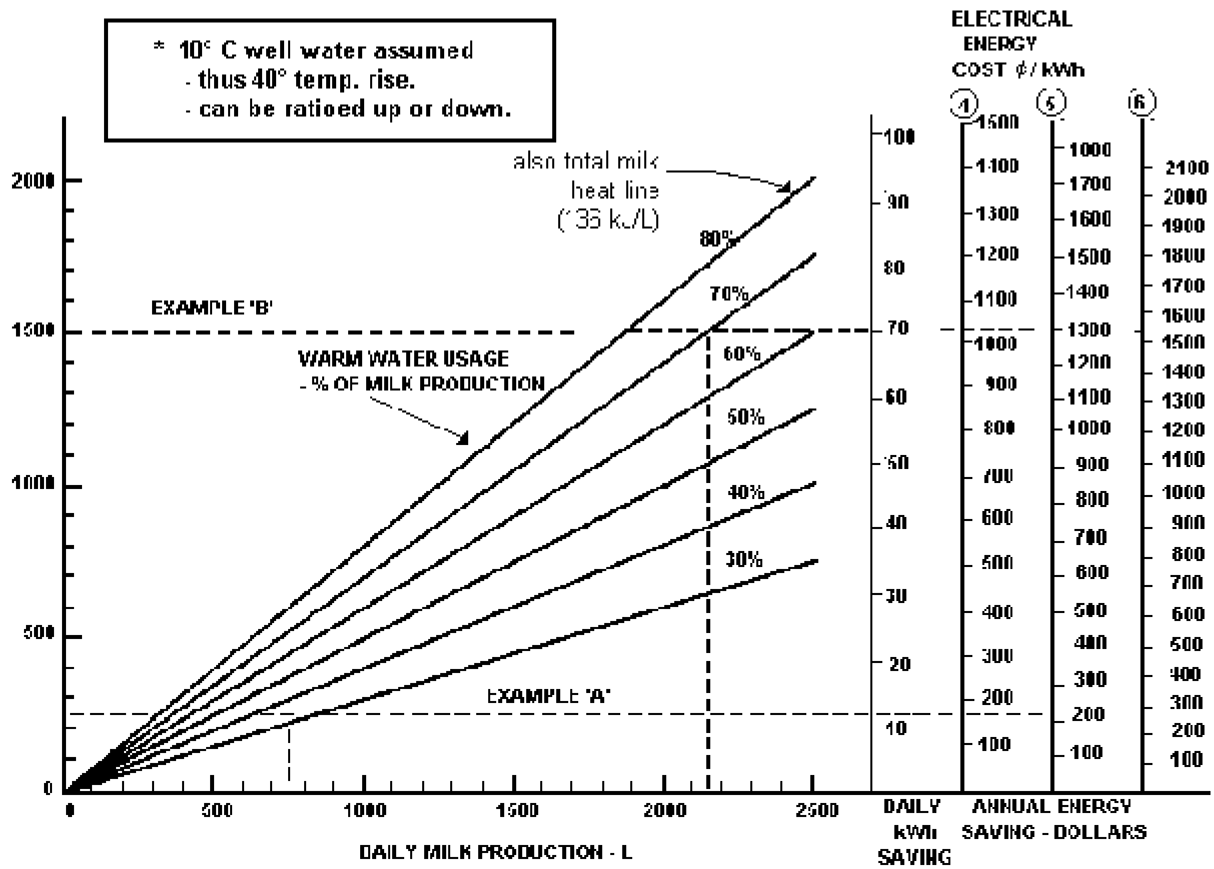

Figure illustrates by examples the range of opportunity for capital recovery of heat recovery equipment for most dairy operations in Ontario.

Taken From: Ontario Ministry of Agriculture and Food Factsheet "Heat Recovery From Milk Cooling Systems", R.G. Winfield, Energy Engineer, Agriculture Energy Centre, Feb. 1988, Rev. Sept. 1996
http://www.gov.on.ca/OMAFRA/english/livestock/dairy/facts/88-032.htm

Milk Heat Recovery cont'd

Using the preceding chart and the volumes of milk produced and hot water used, It can be estimated that the Installation of the milk heat recovery system will reduce consumption of electricity for water heating by **15 kwh per day**.

Annual energy savings from milk heat recovery:
15 kwh/day x 365 days/ year = **5,475 kwh/yr**

Annual GHG emission reductions from milk heat recovery:
5,475 kwh/yr x 0.78 kg/kwh as CO_2
= **4,270.5 kg/yr as CO_2**

Water Heater

70 gallon, post-1993 model

Insulation: Reflective bubble wrap (R-value 10)

Standby Heat Loss: 115 watts/hour[1]

Annual standby heat loss (no insulation) = 115 watts x 24 hours x 365 days

= 1007.4 kwh/yr

Annual standby heat loss after insulation = 25% of heat loss without insulation[2]

= 1,007.4 kwh/yr x 0.25

= 251.9 kwh/yr

Annual savings = annual heat loss (no insulation) – annual heat loss (with insulation)

= 1,007.4 kwh/yr – 251.9 kwh/yr

= 755.6 kwh/yr

Annual reduction in greenhouse gas emissions (Kg as CO_2)

= 755.6 kwh/yr x 0.78 kg/kwh

= 589.4 kg/yr

Total Annual Reduction in GHG Emissions

= 4,270.5 kg/yr + 589.4 kg/yr

= 4859.9 kg/yr as CO_2

= 4.9 tonnes/year as CO_2

[1]GSW inc. Technical Support

[2]Hal Dobbelsteyn, Department of Energy, Halifax

Appendix J

MacHattie- Calculations

MacHattie- Calculations

Lighting

Calving Time (Jan. to Apr.)
Calf Area - 24hrs/day X 1 bulb X 80w X 7days/week X 17 weeks = 228.5kwh
Hay Barn – 3hrs/day X 9bulbs X 80w X 7days/week X 17 weeks = 257.0kwh
Cow Barn – 2hrs/day X 660w(12bulbs) X 7days/week X 17 weeks = 157.1kwh
Total = 642.6kwh

Feedlot Time (Sept. to Nov.)
Calf Area – 0hrs/day = 0kwh
Hay Barn – 1.5hrs/day X 9bulbs X 80w X 7days/week X 13 weeks = 98.3kwh
Cow Barn – 1.5hrs/day X 660w X 7days/week X 13 weeks = 90.1kwh
Total = 188.4kwh

Quiet Time (May to Sept.)
Calf Area – 0hrs/day = 0kwh
Hay Barn – 1.5hrs/day X 9bulbs X 80w X 7days/week X 22 weeks = 166.3kwh
Cow Barn – 1hrs/day X 660w X 7days/week X 22 weeks = 101.6kwh
Total = 267.9kwh

Annual Total Savings:
642.6kwh + 188.4kwh + 267.9kwh
= 937.9 kwh/yr

1,098.9kwh/yr

Annual GHG Emission Reductions:
937.9 kwh/yr X 0.78kg of CO_2/kwh = 731.6 kg of CO_2/yr
= 0.7 tonnes/year as CO_2

Appendix K

Noble- Calculations

Robert Noble – Calculations

Winter Months
(Nov. to Apr. – 26 weeks)

Center and Side-Lighting:
Savings: Replace 21 X 100w for 24hrs/day with 14 X 20w and 7 X 60w for 16hrs/day = 39,200whrs/day savings
39,200whrs/day X 7days/week X 26week = 7,134.4kwh/yr

Summer Months
(May- Oct. – 26 weeks)

Center and Side-Lighting
1,400w X 5hrs/day X 7days/week X 26 weeks = 1,274kwh/yr

Milk Room (year round)
Savings: replace 4 X 100w with 4 X 20w = 4 X 80w savings
4 X 80w X 8hrs/day X 7days/week X 52 weeks = 931.8kwh/yr

Annual EnergySavings:
7,134.4kwh/yr + 1,274kwh/yr + 931.8kwh/yr = 9,340.2kwh/yr

Annual CO_2 Savings:
9,340.2kwh/yr X 0.78kg of CO_2/kwh = 7,285.4kg of CO_2/yr

Water Heater

70 gallon, post-1993 model

Insulation: Reflective bubble wrap (R-value 10)

Standby Heat Loss: 115 watts/hour[1]

Annual standby heat loss (no insulation) = 115 watts x 24 hours x 365 days

= 1007.4 kwh/yr

Annual standby heat loss after insulation = 25% of heat loss without insulation[2]

= 1,007.4 kwh/yr x 0.25

= 251.9 kwh/yr

Annual savings = annual heat loss (no insulation) – annual heat loss (with insulation)

= 1,007.4 kwh/yr – 251.9 kwh/yr

= 755.6 kwh/yr

Annual reduction in greenhouse gas emissions (Kg as CO_2)

= 755.6 kwh/yr x 0.78 kg/kwh

= 589.4 kg/yr

Total Annual Reduction in GHG Emissions

= 7,285.4 kg/yr + 589.4 kg/yr

= 7,874.8 kg/yr as CO_2

= 7.9 tonnes/year as CO_2

[1]GSW inc. Technical Support

[2]Hal Dobbelsteyn, Department of Energy, Halifax

Appendix L

Taylor- Calculations

Taylor- Calculations

Cold Storage

Previous system: 7 lbs of R-12 (Global Warming Potential 8,500 x CO_2[1])
New system: 10 lbs R-404a (Global Warming Potential 3,850 x CO_2[1])

Total GHG as CO_2 In previous system:

$$\frac{(7 \text{ lbs} \times 8{,}500)}{2.2 \text{ lbs/kg}} = \mathbf{27{,}045.5 \text{ kg as } CO_2}$$

Total GHG as CO_2 In new system:

$$\frac{(10 \text{ lbs} \times 3{,}850)}{2.2 \text{ lbs/kg}} = \mathbf{17{,}500 \text{ kg as } CO_2}$$

Total one-time rduction In GHG as CO_2:

27,045.5 - 17,500
= 9,545.5 kg as CO_2
= **9.5 tonnes as CO_2**

[1] Value taken from Environment Canada, Environmental Protection Branch, Ontario Region fact sheet : "Halocarbon Management Strategy for Federal Facilities", 1999

Appendix M

Tracy- Calculations

Tracy - Calculations

Programmable Thermostat

Room dimensions: 10′ x 14′ x 8′
Area of walls: (2 x 112 ft^2) + (2 x 80 ft^2) = 384 ft^2
Area of ceiling: 140 ft^2
Area of floor: 140 ft^2
R-value of walls: 12
R-value of ceiling: 20
R-value of floor: 5
Heating season: 213 days
Assumed average outdoor temperature: 32^0F
Indoor temperature during operation: 62^0F
Indoor temperature during non-operation: 39^0F
Operating time per day: 16 hours
Non-operating time per day: 8 hours
BTU's per kwh from electric heat: 3,413 BTU/kwh[1]

Formula for calculating heat loss[2]:

$$\text{Heat loss (BTU/hr)} = \frac{(\text{area in ft}^2)\ (\text{indoor temp. }^0\text{F} - \text{outdoor temp. }^0\text{F})}{\text{R-value}\ \ \frac{t^2 \times {}^0\text{F}}{\text{BTU/hr}}}$$

Calculations:

$$\text{Heat loss (walls) during operation} = \frac{(384\ \text{ft}^2)\ (62^0\text{F}-32^0\text{F})}{12\ \text{BTU/hr}} = \mathbf{960\ BTU/hr}$$

$$\text{Heat loss (ceiling) during operation} = \frac{(140\ \text{ft}^2)\ (62^0\text{F}-32^0\text{F})}{20\ \text{BTU/hr}} = \mathbf{210\ BTU/hr}$$

$$\text{Heat loss (floor) during operation} = \frac{(140\ \text{ft}^2)\ (62^0\text{F}-32^0\text{F})}{5\ \text{BTU/hr}} = \mathbf{840\ BTU/hr}$$

$$\text{Heat loss (walls) during non-operation} = \frac{(384\ \text{ft}^2)\ (39^0\text{F}-32^0\text{F})}{12\ \text{BTU/hr}} = \mathbf{224\ BTU/hr}$$

$$\text{Heat loss (ceiling) during non-operation} = \frac{(140\ \text{ft}^2)\ (39^0\text{F}-32^0\text{F})}{20\ \text{BTU/hr}} = \mathbf{49\ BTU/hr}$$

Heat loss (floor) during non-operation = $\frac{(140\ ft^2)\ (39^0F-32^0F)}{5\ BTU/hr}$ = **196 BTU/hr**

Total rate of heat loss during operation = 960 BTU/hr + 210 BTU/hr + 840 BTU/hr
= **2,010 BTU/hr**

Total rate of heat loss during non-operation = 224 BTU/hr + 49 BTU/hr + 196 BTU/hr
= **469 BTU/hr**

Total heat loss per heating season during operation = 2010 BTU/hr x 16 hrs x 213 days
= **6,850,080 BTU/season**

Total heat loss per heating season during non-operation = 469 BTU/hr x 8 hrs x 213 days
= **799,176 BTU/season**

Combined total heat loss per heating season = 6,850,080 BTU + 799,176 BTU
= **7,649,256 BTU/season**

Heat loss per season without temperature schedule = 2010 BTU/hr x 24 hrs x 213 days
= **10,275,120 BTU/season**

Energy required per season to replace heat loss using temperature schedule =

$\frac{7,649,256\ BTU}{3,413\ BTU/kwh}$ = **2,241.2 kwh per season**

Energy required per season to replace heat loss without temperature schedule =

$\frac{10,275,120\ BTU}{3,413\ BTU/kwh}$ = **3010.6 kwh per season**

Energy savings using temperature schedule = 3010.6 kwh – 2,241.2 kwh = **769.4 kwh**

Greenhouse gas emission reduction per season using temperature schedule =

769.4 kwh x 0.78 kg of CO_2/kwh = **600.1 kg of CO_2 per heating season**

Lighting

Previous system: 13 x 60 watt incandescent
Period of use: 8 hrs/ day year round
Replacement: 13 x 13 watt compact fluorescent

Energy use before changes:

13 x 60 watts x 8 hrs x 365 days
= 2,277.6 kwh/yr

Energy use after changes:

13 x 13 watts x 8 hrs x 365 days
= 493.5 kwh/yr

Energy savings:

2,277.6 – 493.5 = 1,784.1 kwh/year

Annual reduction in GHG emissions:

1,784.1 kwh/year x 0.78 kg/kwh as CO_2
= 1,391.6 kg/year as CO_2

Water Heater

40 gallon, post-1993 model

Insulation: Reflective bubble wrap (R-value 10)

Standby Heat Loss: 96 watts/hour[3]

Annual standby heat loss (no insulation) = 96 watts x 24 hours x 365 days

= 841 kwh/yr

Annual standby heat loss after insulation = 25% of heat loss without insulation[4]

= 841 kwh/yr x 0.25

= **210.3 kwh/yr**

Annual savings = annual heat loss (no insulation) – annual heat loss (with insulation)

= 841 kwh/yr – 210.3 kwh/yr

= **630.8 kwh/yr**

Annual reduction in greenhouse gas emissions (Kg as CO_2)

= 630.8 kwh/yr x 0.78 kg/kwh

= **492 kg/yr**

Total Annual GHG Emission Reductions

= 600.1 kg/yr + 1,391.6 kg/yr + 492 kg/yr
= 2,483.7 kg/yr
= **2.5 tonnes/ year as CO_2**

[1] Value taken from Natural Resources Canada, Office of Energy Efficiency fact sheet "Heating With Electricity",2004
http://oee.nrcan.gc.ca/publications/infosource/pub/home/heating_with_electricity.cfm

[2]Equation taken from Georgia State University, Department of Physics and Astronomy: HyperPhysics fact sheet "Calculating Home Heating Energy", 2004
http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/heatloss.html

[3]GSW inc. Technical Support

[4]Hal Dobbelsteyn, Department of Energy, Halifax