Old Crow Residential Energy Efficiency Project

Recommendations for Energy Efficiency Improvements in Targeted Residential Buildings

Prepared for the Vuntut Gwitchin First Nation
by the Pembina Institute

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Devon

Old Crow
Home Of The
Vuntut Gwitchin

Pembina Institute
for Appropriate Development

About the Pembina Institute

The Pembina Institute is an independent, citizen-based organization involved in environmental education, research, public policy development, and client-confidential environmental consulting services. Its mandate is to develop and promote policies and practices that lead to environmental protection, resource conservation, and environmentally sound and sustainable energy and resource management. The mission of the Pembina Institute is to implement holistic and practical solutions for a sustainable world. Incorporated in 1985, the Institute's head office is in Drayton Valley, Alberta, with offices in Ottawa and Calgary and satellite offices in Edmonton, Vancouver, and other locations across Canada.

The Pembina Institute's Community Eco-Solutions Program aims to facilitate the planning and implementation of end-use energy efficiency, low-impact renewable energy, and green hydrogen energy in Canadian communities. The Pembina Institute supports community energy planning efforts and provides technical and business expertise on sustainable energy options to client communities including support for engaging project investors.

For more information on the Pembina Institute's work, and details of the capabilities and services offered, please visit our website at http://www.pembina.org or contact us at:

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Report Summary

In mid-2000, Vuntut Gwitchin First Nation (VGFN) contacted the Pembina Institute to develop a project that focuses on residential energy efficiency, given that housing development was considered the leading priority of the community at that time and that several cost-effective opportunities to improve residential energy efficiency were apparent.

The Old Crow Residential Energy Efficiency project commenced early in the summer of 2001. Devon Energy Canada provided funding to address two of the projects numerous objectives:

1. Identify the priority homes for energy efficiency renovations; and
2. Audit the energy use of those homes and develop recommendations for improvements.

The following overall economic, social, and environmental objectives were identified for the project:

- Improve the efficiency of energy use in a number of community homes for heating, hot water, ventilation, appliances, and lighting.
- Improve the quality of housing stock and home comfort and quality of life for occupants in some of the older homes in the community by renovating them to new standards; and do so at much lower cost than constructing a new building.
- Reduce energy-related operating costs for residents or VGFN, freeing up funds to invest in new housing or other community priorities.
- Reduce local consumption of wood heating fuel and relieve pressure on limited supplies of local wood fuel to help conserve this valuable resource.
- Reduce environmental impacts of energy use such as local air emissions and greenhouse gases caused by burning oil or wood fuel to supply the energy.
- Create a small economic development opportunity and employment income from labour involved in energy efficiency renovation activities.
- Develop local skills and expertise in energy efficient housing renovations and energy management.

The long-term objective of this project would be to integrate energy efficiency into the existing VGFN housing program with a permanent coordinator and skilled trades people. Also, this project aimed to maximize collaboration with Yukon Housing Corporation and the Canada Mortgage and Housing Corporation through their existing programs for energy efficiency.

This report offers an analysis of these two components of the overall Energy Efficiency project.

Priority Home Listing

Four homes in Old Crow were selected for renovation, from a total of 16 that were audited (including six in one building — the six-plex). Wilkinson Consulting on behalf of Yukon Housing audited these for this project using the method as described in the *EnerGuide for Houses* (see Appendix A). The results of these audits are listed in Appendix B.

The homes ultimately suggested for upgrades as referred to in this report are:

Resident Name	Unit Number
Nukon	705
Netro	755
Moses	765
Safe House	850

Analysis of Energy Efficiency Options

This report analyses a variety of recommendations, including the installation or upgrade of

- bathroom and kitchen venting
- heat recovery ventilation system
- triple-pane windows
- awnings
- insulation
- metal-insulated doors
- wood and oil stove heating
- interior air circulation (Hi-Velocity unit)
- solar heating incorporated with the Hi-Velocity or a radiator system
- thermal mass
- weather stripping and caulking
- setback thermostat
- solar hot water heating
- energy efficient lighting
- liquid pump replacement
- appliance replacement

These installations and upgrades stand to improve living conditions in the homes in three ways:

- Better air ventilation in the living space using vent fans, Hi-Velocity system, or heat recovery ventilation unit will lessen indoor air moisture build-up and some temperature stratification (as measured from room to room and from ceiling to floor).
- Better insulation (windows, doors, Icynene insulating foam) will reduce drafts and improve heat retention.
- New technology (advanced combustion wood stoves, solar options, lighting) will reduce energy consumption, and the production of greenhouse gas emissions and the overall level of pollution in the community throughout the year, particularly during the heating season.

The analyses in this report address issues related to financial cost and payback, energy savings, and greenhouse gas emissions reductions. Of the options assessed in this manner it is recommended to

- *install specified kitchen or bathroom venting at a minimum.* Though not an economically directed measure, this option offers major venting advantages, contributing to the improvement of air quality in the home. With this option it is advised to include the humidistat controller to ensure the fan system is operating at its best.
- *install a heat recovery unit (HRV) only if the home undergoes significant "tightening" due to renovations.*
- *install triple-pane windows without a Low-E coating or protective laminate pane, upon need for replacement only.*
- *install appropriately designed awnings for homes that have air conditioning.* This would reduce the air conditioning load and therefore the electricity load. Installing awnings in other homes would also be of benefit keeping homes cooler in the summer.
- *install Icynene insulating foam to the outside of the buildings to be renovated.* This will greatly increase the comfort level in the home, with fewer drafts, greater heat retention, and less of a temperature differential throughout the rooms in the house. Icynene is selected, as it is a fire retardant, a proven product, and offers air tightness and high insulation qualities.

- *install metal insulated doors*. Though the payback may be limited, cold drafts from door areas would be reduced, and the door installation would contribute to improving the overall insulation value of the home.
- *install advanced combustion wood stoves*. Though they entail a long payback period (four to eight years), their use would reduce the annual firewood home heating requirements, and potentially reduce air pollution levels realized during the heating season.
- *upgrade to the use of a high-efficiency oil heater*. If an inefficient wood stove is being replaced, the options are to consider a more efficient wood stove as indicated in this report, or an efficient oil heater. The use of an oil heater would contribute to the reduction of demand upon the local wood supply, and potentially reduce air pollution levels realized during the heating season.
- *install thermal mass as convenient in the home*. This is potentially inexpensive, and requires no maintenance.
- *install weather stripping and caulking as required around windows and doors*. This is low in cost and generates an immediate benefit for the homeowner.
- *install a setback thermostat on any heating appliances;* or set up a routine to set back the thermostat depending upon occupancy heating demands. The cost is minimal or zero depending upon the option chosen and a significant energy reduction could result.
- *install a carbon monoxide detector*. Theses are inexpensive and could save a life. They will however require battery replacement annually if the hard-wired model is not used.
- *upgrade to compact screw-in type fluorescent light bulbs (CFLs)*. Installing the CFLs is a very economical option and significantly reduces the electricity load related to the use of lights, which is provided by a diesel-fired power generation system.
- *install a high efficiency liquids pump when it is determined that replacement is required.* This will reduce energy consumption, generate a potential payback, and may improve operating reliability.
- *replace old inefficient appliances with new energy efficient appliances as specified by the EnerGuide for Equipment Appliance Directory*. Replacement of existing appliances may be warranted in some situations when the old appliance has excessive energy demands, regardless of the waste management issues of disposing existing ones.
- *complete an Energy Guide for Houses B Audit and install monitoring equipment and collect accurate energy consumption data on houses before and after renovations take place that could be used to* direct future investments in housing.

It is tentatively recommended to

- *install an electrical space heating system in the house if wind power is introduced into the community*. This could be achieved through the installation of electric baseboard heaters in each room or a Hi-Velocity unit with ductwork. The Hi-Velocity unit has already been successfully introduced in two units in Old Crow (new Yukon Housing Corporation units).

Solar Option Comments

All solar energy options are eligible for a Renewable Energy Deployment Initiative grant that is applied to the expense of the solar portion of the system installed. Through our preliminary assessment, the solar energy options show viability with the inclusion of that 40% capital cost grant. All solar options need to be studied in more detail to determine their value as installed in a specific application in Old Crow. Solar energy options reduce the need for electricity for hot water and oil or wood for space heating if established in that manner. Many solar thermal options have already been installed in the North and have been proved to be reliable.

Closing Comments

These recommendations are evaluated from a point of view external to the community of Old Crow. Further, the analyses only address economic, energy, and greenhouse gas emissions characteristics. We recognize this aspect of the report, and respectfully submit these suggestions regarding residential energy efficiency to Old Crow as such. These recommendations do not take into consideration the values of the community of Old Crow or its individuals. Only the community members of Old Crow can determine which options would be of interest and of value.

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1 Introduction

1.1 The Community

Old Crow is the most northerly community in the Yukon, and the only community in that territory that can't be reached by road. It is located within the Arctic Circle at the confluence of the Crow and Porcupine Rivers, about 800 kilometres north of Whitehorse. Commercial access is gained to the town primarily by air. The small town is home to a relatively stable population of about 300 aboriginal people known as the Vuntut Gwitchin, meaning "People of the Lakes."[1] Another 500 Vuntut Gwitchin First Nation (VGFN) members are estimated to live outside the immediate community.[2,3] The range of the VGFN extends into northwestern Northwest Territories and northern Alaska.[4]

The livelihood of the Vuntut Gwitchin revolves around trapping, hunting, and fishing. For generations, the Vuntut Gwitchin have relied on Porcupine Caribou as their main source of meat as well as leather; the caribou hide is used to make boots, moccasins, mitts, traditional outfits, and other decorative items.

People in Old Crow enjoy long summer days and experience the short days of winter living in either a home built of logs or one that is framed. In addition to the residential buildings, the town has a First Nations Administration Building, highway maintenance buildings, a school, airport terminal, Northern store, RCMP detachment, nursing station, bed and breakfast accommodations, youth centre, Parks Canada office, and a community centre, among other buildings.

1.2 The Pembina Institute

The Pembina Institute for Appropriate Development has experience assessing energy options for northern communities, and in particular has been involved in various discussions related to the development of

[1] The population of Old Crow varied between 260 and 300 through the 1990s. About 90 percent of the population are members of the Vuntut Gwitchin First Nation. Url: http://www.yukoncommunities.yk.ca/oldcrow.html. Accessed 24 January, 2002.
[2] Yukon Chamber of Commerce. 2002. Community of Old Crow. Url: http://www.yukoncommunities.yk.ca/oldcrow.html. 24 January, 2002
[3] E-mail communication. Sandra Newman, Councilor, Vuntut Gwitchin First Nation. 8 May, 2002.
[4] Vuntut Gwitchin First Nation. Url: http://www.oldcrow.yk.net/index2.htm. 22 January, 2002

renewable energy and energy efficiency options in the Yukon Territory. This work has addressed several economic, social and environmental aspects of energy. In addition, the Pembina Institute has completed an initial assessment of various energy management options for Old Crow including district energy, energy efficiency, and wind generation power.[5] A feasibility study was completed for district heating and is currently being considered by two investors. In addition, wind power is being seriously considered by the community as an option to supplement diesel electrical supplies.

1.3 The Project

In early 2000, housing development was the leading priority within the VGFN community. At that time it had become apparent that there existed several cost-effective opportunities to improve residential energy efficiency and, at the same time, basic living conditions. The community contacted the Pembina Institute with a request to develop a project that would identify, recommend and implement energy efficiency improvements in residences where they were most needed.

The Pembina Institute developed a project proposal to identify those homes most in need of energy efficiency renovations, survey the range of potential upgrades and make recommendations as to the most appropriate choices, oversee the renovations, and monitor and report on benefits of the completed work.

The following overall economic, social, and environmental objectives were identified for the project:

- Improve the efficiency of energy use in a number of community homes for heating, hot water, ventilation, appliances, and lighting.
- Improve the quality of housing stock and home comfort and quality of life for occupants in some of the older homes in the community by renovating them to new standards; and do so at much lower cost than constructing a new building.
- Reduce energy-related operating costs for residents or VGFN, freeing up funds to invest in new housing or other community priorities.
- Reduce local consumption of wood heating fuel and relieve pressure on limited supplies of local wood fuel to help conserve this valuable resource.
- Reduce environmental impacts of energy use such as local air emissions and greenhouse gases caused by burning oil or wood fuel to supply the energy.
- Create a small economic development opportunity and employment income from labour involved in energy efficiency renovation activities.
- Develop local skills and expertise in energy efficient housing renovations and energy management.

The long-term objective of this project would be to integrate energy efficiency into the existing VGFN housing program with a permanent coordinator and skilled trades people. Also, this project aimed to maximize collaboration with Yukon Housing Corporation and the Canada Mortgage and Housing Corporation through their existing programs for energy efficiency (e.g., Residential Energy Management Program, EnergyGuide for Houses, Furnace Retrofit Program, Home Repair Program, and others).

The proposal was circulated to several prospective funders; in the spring of 2001 Devon Energy Canada (previously Anderson Exploration) agreed to sponsor the project. Devon is one of the leading developers of oil and natural gas in northern Yukon and considers it among their priorities to invest in the communities in the vicinity of their operations.

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[5] Pape, Andrew; Macintosh, Robert. 31 January, 2000. Old Crow Clean Energy and Energy Conservation Opportunities - Summary of Exploratory Discussions and Preliminary Community Visit – December 13-14th, 1999. The Pembina Institute

The Old Crow Residential Energy Efficiency project commenced early in the summer of 2001 with the following objectives:

- Identify the priority homes for energy efficiency renovations.
- Audit the energy use of those homes and develop recommendations for improvements.
- Secure financing for the renovations.
- Provide technical training for local trades people to do the renovations.
- Undertake the renovations.
- Monitor and report on the benefits of the renovations.

The funding from Devon Energy Canada was offered to accomplish the first two of these objectives, and the results of that work are presented here. The Pembina Institute then developed a second proposal to secure funding for the remaining objectives. This was submitted by VGFN to the Aboriginal and Northern Climate Change Program.[6]

The Yukon Housing Corporation and the VGFN are together proceeding in providing technical training for local trades people to carry out the renovations. A detailed four-day training workshop was delivered in the community in late April 2002. This was organized by Yukon Housing and delivered by Wayne Wilkinson. It encompassed the following topics:

- Overview of the R-2000 housing program
- Building Science and Indoor Air Quality
- Overview of the R-2000 Building Envelope Standard
- Overview of Mechanical Systems – Heating, and Domestic Hot Water
- Overview of Mechanical Systems – Ventilation
- Examination of Participants' Learnings

15 individuals from the community participated in the training program and 13 of them wrote and passed the exam, including several builders, the housing manager and other interested parties[7]. Thus, Old Crow currently has a large number of skilled energy efficiency practitioners that can proceed with housing renovations that meet high-energy efficiency standards. See Appendix F for an outline of the workshop content.

[6] Support for this program is offered by the Government of Canada through: Natural Resources Canada, and Indian Northern Affairs Canada. Url: http://www.climatechange.gc.ca/english/action_plan/na_b15.shtml. 5 June, 2002

[7] Barbara Abel, Wesley V. Smith, Lawrence D. Charlie, Ronald Leonard Frost, Jim Montgomery, Douglas Frost, Robert Netro, Ken R. Nukon, Warren Smith, Billy Gill-Scarff, Douglas W. Charlie, Peter K. Frost, Ann M. Blake.

2 Report Objectives and Overview

This report presents the results of achieving the first two objectives of the Old Crow Residential Energy Efficiency Project:

- Identify the priority homes for energy efficiency renovations.
- Audit the energy use of those homes and develop recommendations for improvements.

It begins with some general descriptions of the specific sources of energy used in homes in Old Crow (Section 3).

It then provides an overview of the residential buildings in Old Crow (Section 4), and the process used to select those residences in need of retrofitting (Section 5).

Energy audits of the homes selected for potential renovation by VGFN were done by Wilkinson Consulting for Yukon Housing Corporation, the delivery agent for the EnerGuide for Houses program in the Yukon. The EnerGuide for Houses program was developed and is partly funded by Natural Resources Canada (Federal Govemment). Information on the EnerGuide evaluation is in Appendix A, and results of the audits are presented in Appendix B.

Based on the results of the audits, the Pembina Institute identified key opportunities for energy efficiency improvements (Section 6) and made specific renovation recommendations (Section 7) for the four community homes selected for retrofit. These opportunities included installation of heating, hot water, ventilation, lighting systems and appliances.

The Pembina Institute has also undertaken to determine the capital investment required, energy savings, and emissions reductions for each upgrade suggested (Section 7).

A very short section considers the option of monitoring to add value to the overall project (section 8), and summaries of the environmental and employment aspects of following through with energy efficient renovations are included in section 9.

Section 10 incorporates a number of tables to compare economic, energy, and greenhouse gas emissions factors, and generates some discussion around the conclusions derived from the research.

Three levels of recommendations are proposed in Section 11: initiatives that are highly recommended, moderately recommended, and those that are discussed further.

Analysing the "Whole House" concept (determining how the implementation of one initiative would affect another) is not specifically addressed in this report. It is mentioned as required throughout the report but Section 12 takes the time to reiterate the significance of this concept.

Section 13 addresses the issues and concerns of having individuals outside of the Community of Old Crow evaluate the initiatives proposed.

3 Energy Supply

Old Crow experiences two climate extremes each year, one of perpetual light in the summer, and the other of extensive darkness in the winter. In 1997, weather reports showed the average daily temperature in January was –34.2°C, while in July the daily average was 14.5°C. Daily averages are based on a 24-hour day, so daytime temperatures are somewhat higher. The record high in 1997 was 27°C, and the record low was –52°C. Annual precipitation in 1997 totalled 273.3 mm. This included 160.8 mm of rain and 158.8 cm of snow.[8]

In spite of the inaccessibility of Old Crow, and the expense of bringing in products by airplane, a number of appliances and fixtures are brought into the community that are used to generate heat and use electricity in the home. The houses in Old Crow are typically equipped with space and water heating amenities, and various household appliances. Space heating is commonly provided by wood stoves and oil heaters, with electric baseboards to provide backup heating near water pipes. An electric water heater typically provides water heating, and appliances are powered by electricity.

Descriptions of the specific sources of energy used in homes in Old Crow follow below.

3.1 Biomass

Wood is typically brought into Old Crow from the surrounding areas on an individual, as needed basis. As the community is located near the tree line, trees cut for fuel may take from 100 to 200 years to regenerate;[9] regeneration times are significantly shorter (roughly 85 years) in more southerly areas.[10] As a result of such extensive regeneration times, the wood supply is getting scarcer around the Old Crow community, and travelling distances to replenish wood supplies are steadily increasing. Currently, "good" wood supplies can be found roughly 18 km out of town.[11] Due to the need to continually travel further and further to find such supplies, there is some interest in considering alternatives to wood use, or to finding ways to use wood more efficiently as a fuel source.

Establishing the cost of wood is very subjective, as the supply is gathered as required on an individual basis throughout the year. The source is currently free but there are tangible costs associated with gathering the supply. Old Crow community members who do not cut their own firewood are paying up to $250 per cord.[12] A typical household burns between 6 and 9 cords per season.[13, 14]

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[8] Yukon Chamber of Commerce. 2002. Community of Old Crow. Url: http://www.yukoncommunities.yk.ca/oldcrow.html. 24 January, 2002

[9] Url: http://www.fs.fed.us/database/feis/plants/tree/picmar/fire_effects.html. 25 January, 2002 (Reference no.10 - Black, R. Alan; Bliss, L. C. 1980. Reproductive ecology of Picea mariana [Black Spruce – ed.] (Mill.) BSP., at tree line near Inuvik, Northwest Territories, Canada. Ecological Monographs. 50(3): 331-354. [8413])

[10] Forest Practices Branch. 1999. Guidelines for Developing Stand Density Management Regimes. British Columbia Ministry of Forests. Url: http://www.for.gov.bc.ca/hfp/pubs/stand_density_mgt/sdm-21.htm. 25 January, 2002.

[11] Personal communication. Rae Moses of Old Crow, Yukon. Prior to 25 January, 2002

[12] Personal communication. Rae Moses of Old Crow, Yukon. 29 November, 2001

[13] Pape, Andrew; Macintosh, Robert. 31 January, 2000. Old Crow Clean Energy and Energy Conservation Opportunities - Summary of Exploratory Discussions and Preliminary Community Visit – December 13-14th, 1999. The Pembina Institute

[14] Personal communication. Rae Moses, of Old Crow, used roughly 9 cords in year 2000. Yukon. 29 November, 2001.

3.2 Heating Oil

Heating oil sold in Old Crow costs approximately $1.50/litre.[15] The oil is used typically for space heating and water heating in institutional buildings.

3.3 Gasoline

Vehicles that are used to transport wood supplies are typically powered with gasoline (snowmobiles in winter, one-half ton trucks in the summer). Gasoline costs $1.50/litre in Old Crow.[16] The higher cost for two-cycle oil used in snow machines that haul wood in winter is not factored into any calculations in this report.

3.4 Electricity — Diesel

Electricity is presently supplied by a diesel-fired power generating station operated by Yukon Electrical Company Ltd. (YECL). The power plant has three diesel engines with a capacity of 170 kW, 330 kW, and 600 kW each. The peak demand in Old Crow is approximately 430 kW in the wintertime.[17] Like heating oil and gasoline, diesel is brought into the community by plane. Diesel fuel and handling costs are reflected in the electricity price that is administered by YECL. The rate for electricity for non-government single unit residential service is calculated as follows:[18]

- $11.90/month basic customer, and minimum monthly charge
- $0.0986/kWh for the first 1000 kWh
- $0.2577/kWh for all kWh in excess of 1000 kWh/month
- Additional charges include:
    - 7% GST,
    - a fuel cost adjustment rider of $0.005924/kWh, and
    - rate stabilization fund adjustments that include:
        - a discount of 22.2835% on the customer charge,
        - a discount of 33.8000% on the first block of energy, and
        - an increase of 27.9239% for the second block of energy (over 1000 kWh/month); this charge is not applied during the winter billing period (1 October – 31 March).

A recent study by the Pembina Institute demonstrates that there is the potential for wind power generation to supplement the diesel-fired supply.[19] However, as wind power is an inconsistent source of energy generation, and individuals cannot be expected to schedule their need for energy only during the times when wind-generated power is available, particularly during the winter months, diesel-fired energy generation will remain necessary. A wind-diesel hybrid system may be a power generation option to consider in the future. In addition, a micro-utility system might also be an efficiency measure initiative to consider.[20]

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[15] Ken Arnold. Personal communication, 26 January, 2002.
[16] Ibid.
[17] Pembina Institute. District Heating System Feasibility Study. August 9, 2001.
[18] Rate Schedule –1480 – Residential Service – Old Crow Diesel – Non-Government rate – Yukon Electric Limited – 24 January, 2002
[19] Andrew Pape and Robert Macintosh. 2000. *Old Crow Clean Energy and Energy Conservation Opportunities: Summary of Exploratory Discussions and Preliminary Community Visit.* December 13–14th, 1999. The Pembina Institute.
[20] Eco-NoMad. The EcoNomad™ is a complete micro-utilities infrastructure that allows for the provision of all utilities - potable water storage and purification, wastewater management and treatment, water and space heating

4 Overview of Old Crow Residential Buildings

The federal government has historically provided Old Crow residents with housing free-of-charge, including maintenance. More recently, under their self-government mandate, the VGFN has established a Housing Policy,[21] including home ownership programs that will gradually change the shape of housing in Old Crow.

Although under the Housing Policy many houses are still provided by the VGFN Government, new arrangements will permit private ownership of houses through a negotiated transfer of ownership from the VGFN government to the occupant for a price, an investment of "sweat equity" labour by occupants equivalent to 10% of the cost of the home, or payments toward a loan.

4.1 Number of Residences

A 1996 census identified 105 occupied private dwellings in Old Crow. At that time, the average value for a house averaging just fewer than two bedrooms was $46,840, while rental housing costs averaged $390 per month. A later study conducted in 1997, "Yukon Region First Nation Profiles," reported 130 housing units in the community,[22] with an average of 2.6 people per household.[23] It has recently been recorded that water is delivered to 123 houses within the town.[24]

4.2 Emissions from Housing

Reducing greenhouse gasses through the implementation of energy conservation measures is a fundamental objective of this project. To derive an estimate of the greenhouse gasses generated from the residential sector of Old Crow, the following assumptions were made:

- Residences in Old Crow = 123
- Wood stoves are used for heating and cooking in 80% of residences[25] = 98 residences

and cooling, and electrical supply - to any "off-grid" building. The patented system is housed in a standard shipping container and can be easily transported anywhere in the world. Url: http://www.economad.com/ 3 July, 2002

[21] VGFN. *Housing Policy and Programs*. 2001. Draft Copy for Discussion Purposes Only..

[22] Yukon Chamber of Commerce. 2002. Community of Old Crow. Url: http://www.yukoncommunities.yk.ca/oldcrow.html. 24 January, 2002

[23] Yukon Region First Nation Profiles. DIAND. December, 1997. Yukon Community Profiles. HRDC. October, 1999. Url: http://yukonweb.com/government/ybs/firstnations/vuntut.pdf, 24 January, 2002

[24] Personal communication. Georgi MacStephen, Manager, Community Operations, Engineering and Development Branch, Yukon Territory Government, M-4. Phone: 867-667-5195. 13 June, 2001

[25] From the list of houses surveyed by the EnerGuide House representative, 81% of the homes did not have oil heaters. In addition, from a random survey done by Rae Moses, of 13 homes in Old Crow, 100% had wood stoves (all 13 surveyed) and two of the13 had both oil heaters and a wood stove.

- Of these 98 residences, all use approximately the same amount of wood = 6 cords/year.[26]
- Of the 20% (25 residences) that use monitor oil heaters for space heating, the use of wood = 5 cords of wood/year.[27]
- The 25 residences that use oil heaters consume roughly 160 litres of heating oil/month for six months of the year.[28]
- Assuming the use of gasoline vehicles for wood collection = 240 litres gasoline/year for each 6 cords of wood and 200 litre/year for each 5 cords wood.
- Average monthly electricity use for the six summer months = 630 kWh/residence.[29]
- Average monthly electricity use for the six winter months = 1030 kWh/residence.[30]

The greenhouse gas emissions considered in this report are methane (CH_4), nitrous oxide (N_2O) and carbon dioxide (CO_2), as generated by any of the residential sources of energy use.

It is assumed that wood consumption creates net greenhouse gas emissions from combustion, given that the growth rate of trees, and hence sequestration of carbon, is significantly less than the rate of harvesting live trees. If only dead wood were used, which is a common practice in other parts of the Yukon where fire-kill timber is used (e.g., Pelly Crossing), then net emissions could be considered as zero. In some cases, there would be a net emission reduction because the decomposition of dead wood would have resulted in methane emissions, which are a more potent greenhouse gas than carbon dioxide emissions resulting from burning wood for heating.

The table below highlights the GHG emissions from the residential sector in Old Crow.

Table 1: Breakdown of Emissions for the Residential Sector in Old Crow

Energy Source	GJ/year	CH_4/year (kg)	N_2O/year (kg)	CO_2/year (kg)	Total Tonnes CO_2e/year
Wood	14,800	109	117	1,094,000	1,133
Gasoline	830	56	24	57,000	65
Oil	600	11	4	48,300	50
Electricity	4,410*	1,600	0	835,500	870
Total	20,640				2,118

**Electricity energy only. This is equivalent to roughly 13,400 GJ (roughly 364,000 litres) in diesel energy (assuming 33% energy conversion efficiency from diesel to electricity).*

[26] Established using data from survey done by Rae Moses of several residences in Old Crow.
[27] Ibid.
[28] Ibid.
[29] Ibid.
[30] Ibid.

5 Retrofit Candidates

Under the VGFN Housing Policy, significant renovation improvements are to be made to a select number of residential units each year. Candidate houses for renovation are selected by the Government Services Department of the VGFN on a basis of need. A total of approximately $45,000 is allotted for individual residential unit improvements each year. Candidates for grants are assessed on their basis of need and the amount of personal physical labour the individual receiving the grant is willing to contribute to the renovation ("sweat equity").

For the purposes of this study, under the guidance of VGFN housing personnel, four residences in Old Crow were identified as priorities for energy efficiency and building retrofits to be completed in the summer of 2002. Selection of the four was based on a number of criteria: (1) above-average heating or electrical costs; (2) high heat loss; (3) a generally sound structure but strong need for building quality improvements; (4) use of electric hot water or space heating (high cost); and/or (5) ease of retrofitting the building for energy conservation. Some of the selected houses in Old Crow have already been partly renovated; the practical retrofit measures that could be applied to any house thus depended upon its renovation history.

The four homes selected for upgrades, and twelve other units (including six units in one building), were audited by Wilkinson Consulting on behalf of the Yukon Housing Corporation using the method as described in *EnerGuide for Houses* (see Appendix A for a description of this method). The EnerGuide program applies a rating to a house of between 0 and 100, with 100 being a perfectly energy efficient home which could be heated exclusively with occupant body heat. A rating of 80 is equivalent to an R-2000 rating, the target level of energy efficiency. The Yukon Housing audit is limited to features of the house shell, windows, insulation, air ventilation, space heating and hot water and excludes an assessment of the efficiency of wood stoves. The results of these audits are listed in Appendix B. This report also made preliminary recommendations on a number of retrofit options as assessed on economic, energy reduction, and greenhouse gas emissions characteristics.

Retrofit options vary significantly from house to house, but include such measures as improved ventilation, efficient lighting, hot water tank conversion, solar heat collection, additional insulation, window replacement, water conservation, air leak sealing, and the use of high-efficiency appliances, and controllers. In addition, indoor air quality must be maintained or improved; this includes ensuring that a tightly sealed building with combustion appliances is properly vented to avoid endangering the health of the occupants. This report outlines retrofit recommendations for each of the four houses.

The four houses selected for retrofit, together with information on their existing characteristics, are presented in Table 2.

Table 2: Retrofit Candidate Characteristics

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Area (Ft^2)	710	542	724	935
EnerGuide Number[1]	78	77	74	66
Last Renovated/ Modified	1989	1989	1989	1989
Occupancy (persons)	1	1	2	0
Interior Cladding (drywall, no finish) (log – rough)	Rough	N/A	N/A	To be completely renovated by March 2002
Window Comments	N/A	Foil on window	N/A	Standard Triple glazed windows
Floor	Poor condition	N/A	N/A	N/A
Heat Supply for Interior of House	Wood stove (inefficient model) Oil (Monitor heater)	Wood stove Oil (Monitor heater)	Wood stove (old, oversized)	Wood stove
Water Heater	Electric	Electric	Electric	Electric
Interior Venting	Not connected in bathroom; not operating	N/A	Poorly installed fan	Poor bathroom fan Poor rangehood fan
Washer/Dryer	None; clothes are hung inside to dry	N/A	Apartment-sized dryer, vented into house	N/A
Air Conditioning	N/A	N/A	Yes	N/A
Lights	12[2]	12[2]	12	12[2]
Refrigerator	N/A	N/A	2	N/A
Crawlspace Under Building	N/A	Skirting only; floor should be super-insulated; landscaping needed to keep crawlspace free of blown in snow	N/A	N/A
Energy Billing History	None	None	Yes	N/A
Wood Used	6 cords/year[3]	5 cords/year[3]	9.25 cords/year[4]	6 cords/year[3]
Electricity Used	11,200 kWh/year[3]	11,200 kWh/year[3]	9,475 kWh/yr(2000) 8,005 kWh/yr(2001)	11,200 kWh/year[3]
Heating Oil Used	None	960 litres/year[3,5]	None	None
Estimated Total Energy Consumption (GJ/year)	173	188	224	173
Electricity ($/year)	$1,133	$1,133	$1,037	$1,133
Wood ($/year @ $250/cord)	$1,500	$1,250	$2,313	$1,500
Oil ($/year)	0	$960	0	0
Gasoline for wood ($/year)	0	0	0	0
Total Estimated Energy Cost ($/year in 2001)	$2,633	$3,823	$3,350	$2,633
Renovations	None	None	External additions made	Completed April, 2002

Table 2: Retrofit Candidate Characteristics (continued)

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Interest of Homeowner in Conservation	N/A	N/A	Keenly interested in efficiency upgrades	N/A
Unique Situations	None	None	None	Building may be moved; increased energy use and moisture production anticipated
Wood Supply	Not covered – no stockpiling	N/A	N/A	N/A
Quality of Insulation in Building	N/A	N/A	N/A	Good insulation package
Quality of Vapour Barrier in Building	N/A	N/A	Polythene on exterior wall	N/A

[1]Established by Yukon Housing
[2] Assume all same as Rae Moses
[3] Estimated from survey
[4] Old Crow average is 6 cords/year
[5] Conservative estimate compared to Dan Gagnier's data, which estimated 200 litres/month when no one was home (six months of the year) = 1200 litres/year

Figures 1 through 4 depict each of the houses selected for renovation. These photographs were taken in May 2001.

Figure 1: Nukon (705)

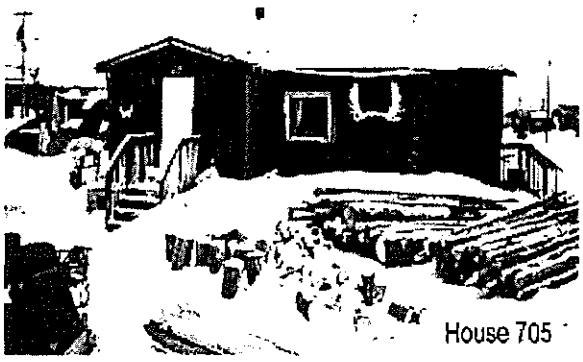
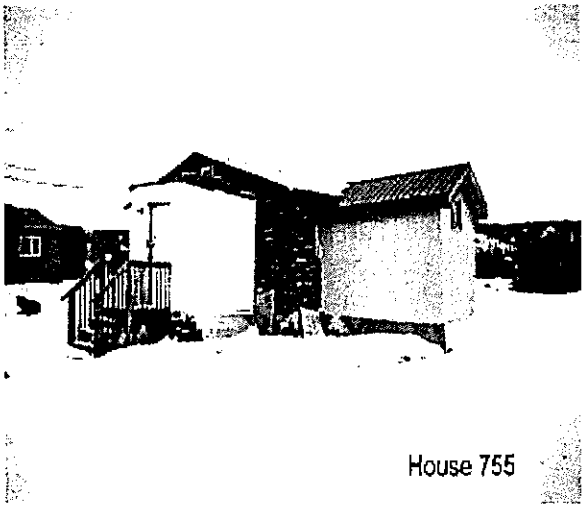


Figure 2: Netro (755)



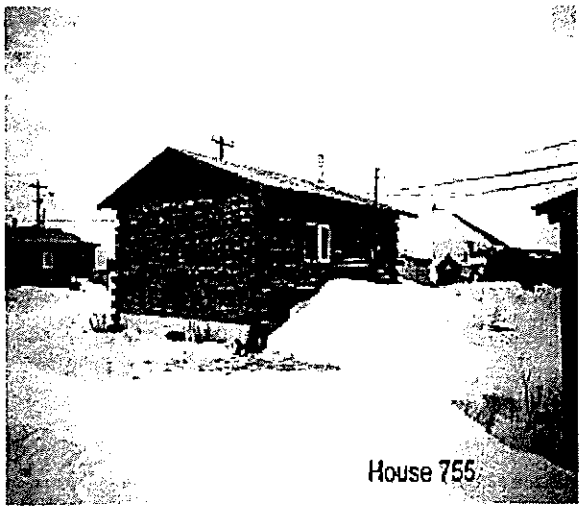


Figure 3: Moses (765)

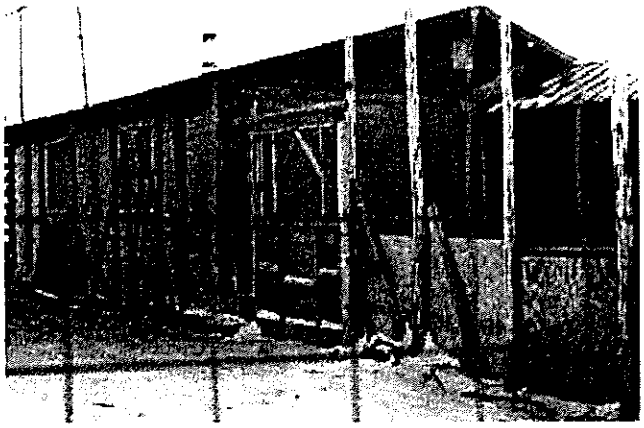
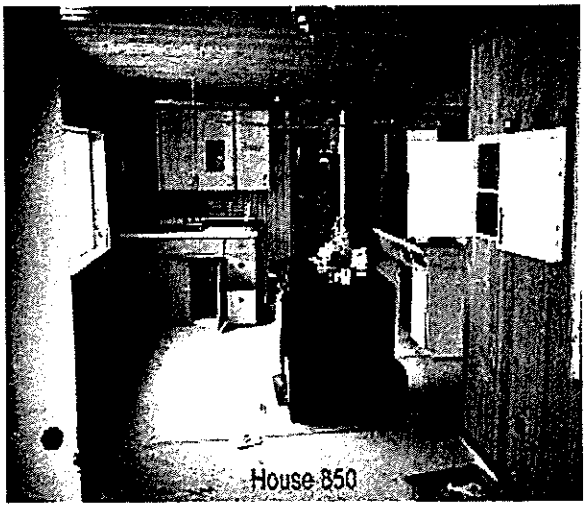


Figure 4: Safe House (850) – pre-retrofit photos



5.1 Community Survey

Rae Moses voluntarily surveyed 13 units in Old Crow. A summary of his findings is presented in Appendix C. It is uncertain whether the data observed in this small number of houses are representative of the conditions prevalent in other houses throughout the community. However, the summary results indicate a disconcerting trend of drafts and condensation. These are key indicators of ventilation, installation, and insulation problems.

6 Retrofit Options

This chapter provides an overview of potential energy efficiency options for residences in Old Crow and describes the potential benefits of each retrofit option.

Options highlighted in this chapter have been selected on the basis of their feasibility: simplicity in operation, application in other northern and remote communities, and history of past success. The list of selected options is not, however, an exhaustive one. All options listed offer a good opportunity to reduce energy consumption, energy costs, and related emissions, and to improve indoor air quality conditions. To ensure success, the resident must be committed to any retrofit initiative proposed, and thus full consultation with residents on specific energy efficiency proposals is essential.

Chapter 7 highlights the results of the energy, financial and greenhouse gas reduction potential analyses of each of the retrofit options.

6.1 Ventilation

When a house is equipped with increased insulation and vapour barriers, the bathroom fan and alternative interior air evacuative ducting options become important in ventilation. A well-designed ventilation system will maintain good air quality inside the home while also ensuring that other energy efficient components can function properly, thus enhancing the overall comfort level within the home.

6.1.1 Existing Ventilation

In almost every unit audited in Old Crow, the existing ventilation system was inoperative, corrupted (disconnected), or inadequately installed (e.g., flex hose ducting was often inappropriately substituted for smooth walled ducting, thus restricting the flow of air). Ventilation fans in place were typically inexpensive ($16.99[31] for hardware only), noisy and not designed to be installed in a wall. They were definitely not intended to provide adequate ventilation for an entire house.

A proper bathroom fan set has a 90–cubic-feet-per-minute (CFM) suction, 1.5 to 2.5 Sone (sound rating) squirrel-cage type fan, that is controlled with a dehumidistat (see below), and a 15-minute timer. The fan should be vented to the exterior with smooth metal ducting and, if ducted through an unheated space, should be insulated to avoid condensation and related problems (wall stains, wood structure degradation, icing). An efficient fan draws about 13 Watts (W) while older, inefficient models might draw about 30 W. While installing a new, efficient fan is only a small improvement in energy use reduction, it is still an improvement. Given that the new fan will operate more quietly, it is more likely to be used as well.

Mounted just outside the bathroom, the dehumidistat will switch the bathroom fan on and off during the heating season, automatically controlling air quality throughout the home. The dehumidistat should be set to ensure that the fan is automatically turned on to eject overly humid air to the outdoors and draw fresh air in through normal drafts.[32] Dehumidistats and timers cost approximately $20 each.[33] These are standard under the national building code.

[31] VGFN materials list – #850 Safe House

[32] Central Mortgage Housing Corporation is going to recommend house humidity not exceed 35%. – Personal communication, Communication with Craig Olsen of Olsen's Resource Consulting. Whitehorse, Yukon. May, 2002

[33] Personal communication. Thomas Marek. January, 2002.

Although this bathroom fan design could also act as a whole house ventilator, an additional, separate, kitchen range hood ventilation option could be considered to enhance the air handling system of the cooking space.

6.1.2 Heat Recovery Ventilator (HRV)

A heat recovery ventilator (HRV) is designed to provide continuous or timed ventilation throughout a house, and to recover the heat carried in the exhausted stale air. It is a balanced-type ventilation system, meaning it both removes and replaces equal volumes of air from the house. Unlike a bathroom fan or clothes dryer, no pressure imbalances occur in the house because of the operation of the HRV, which improves energy efficiency, comfort and safety. The HRV alone will not cause combustion appliance backdrafting (for example, will not suck wood stove fumes back into the house), nor increase vapour transmission into the structure and insulation of the house. When appropriately designed, it provides ventilation without generating cold drafts.

An HRV recovers 60 to 75% of the heat in the exhaust air leaving the house, and returns this heat to the home. Some HRVs will recover moisture from the exhaust stream as well, helping to maintain indoor humidity levels in cold, dry climates. An HRV can usually be located in a closet or utility room, making for a quiet ventilation system. The sound generated from the operation of a properly installed HRV won't be noticed in most areas of the house. The HRV could replace several bath and utility room fans with a single system that may run continuously or intermittently. An HRV allows a tight, well insulated home to maintain a minimal 2–4°F inside temperature difference between the floor and ceiling, providing exceptional comfort. The HRV is not the only solution to the elimination of air stratification and cold spots in the home. It is one component that works together with other options, such as triple pane windows, insulated doors, insulation and airtight vapour barrier installation, to contribute to the overall air quality of the home.

HRVs typically use about 100 to 200 Watts per hour of electrical energy. Controls include timers for scheduled ventilation, demand switches for high-speed ventilation of bathrooms, utility rooms and kitchens (although a range hood is still needed), humidistats to control moisture levels in the home and various gas sensors. HRVs require their own duct system, except for some installations where the forced air system and HRV share some ducts. HRV ducts are usually 6" to 8", and require sealing and insulation (like any good duct system) when outside the thermal envelope.

HRVs are generally used only in homes that have a ventilation rate of fewer than 0.35 air changes per hour and that would therefore require mechanical ventilation.[34] The tightest house of those recommended for renovation in 2002 has an hourly air change rate of 3.8. In this case, an HRV would not be considered as a renovation option unless there were plans to insulate and "tightened up" the house considerably by installing a new vapour barrier.

In addition, experience with application of HRVs in the North is limited. There is some concern that an HRV may not be able to handle the humidity at design temperature. It is assumed that this can be remedied by incorporated a simple heat exchanger design modification. Energy use reductions are potentially derived from the total displacement of wood and oil fuel use. It is not clear from existing data what the financial and energy savings might be.

[34] The Energy Outlet. February, 2002. Heat Recovery Ventilators. Url: http://energyoutlet.com/res/hrv/. 18 February 2002

6.1.3 Ventilation Upgrade Summary

Bathroom Fan: ~70 cfm 'low Sone' with dehumidistat, 15-minute timer and duct kit

- Cost: $400 (estimated)[35] Some components can be obtained for less in Whitehorse (e.g., individual timer and dehumidistats: $20–30 each; Panasonic 50 cubic feet per minute (CFM) bathroom fan: $150)[36]
- Optional additional consideration: Dual blower (max 250 cfm) variable speed range exhaust: $400 (estimated)[37]
- Includes all wiring and duct kit
- Maintenance: assumed to be negligible

Heat Recovery Unit (HRV):[38]

- Cost: $2,500
- Installation with travel and accommodation: $2,000 + $1,000
- Fan: 1/12 horsepower
- Weight: 50 pounds
- Size: roughly 2 ft x 2 ft x 30 inches
- Maintenance: $50/year[39]

Table 3: Bathroom Ventilation

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Bathroom Ventilation Upgrade Opportunity?	Yes	Yes	Yes	Yes
Hardware Cost	$400.00	$400.00	$400.00	$400.00
Shipping*	$52.00	$52.00	$52.00	$52.00
Installation cost	$200.00	$200.00	$200.00	$200.00
Maintenance	N/A	N/A	N/A	N/A
Total Gross Cost	$652.00	$652.00	$652.00	$652.00

*$0.65/lb[40] 40 lb load[41] +26.00 to Whitehorse[42]

[35] Personal communication. Thomas Marek. January, 2002.
[36] Personal communication. Communication with Craig Olsen of Olsen's Resource Consulting. Whitehorse, Yukon. May, 2002 May, 2002.
[37] Personal communication. Thomas Marek. January, 2002.
[38] Personal communication. Wilf Sheuer. Pro Star Mechanical Technologies Ltd. Victoria B.C. Phone: 250-383-4558. 22 February, 2002.
[39] Estimated. Gary Woloshyniuk. 3 March, 2002
[40] Telephone quotation from Air North - Dec.3/01 Whitehorse to Old Crow.
[41] Estimate by Gary Woloshyniuk. January, 2002
[42] Estimate by Gary Woloshyniuk. January, 2002

Table 4: Kitchen Ventilation

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Kitchen Ventilation Upgrade Opportunity?*	Yes	Yes	Yes	Yes
Hardware Cost	$400.00	$400.00	$400.00	$400.00
Shipping**	$52.00	$52.00	$52.00	$52.00
Installation Cost	$200.00	$200.00	$200.00	$200.00
Maintenance	N/A	N/A	N/A	N/A
Total Gross Cost	$652.00	$652.00	$652.00	$652.00

*Only the bathroom upgrade is considered, as it will provide adequate ventilation for the units. Though no energy will be saved with this installation, it will put to use that which is already wasted on existing fan systems that do not perform adequately.
**$0.65/lb[43] 40 lb load[44] +26.00 to Whitehorse[45]

Table 5: Heat Recovery Ventilation (HRV) Unit

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Heat Recovery Ventilator	Yes, if house is tightened up	Yes, if house is tightened up	Yes, if house is tightened up	Yes, if house is tightened up
Hardware Cost	$2,500.00	$2,500.00	$2,500.00	$2,500.00
Shipping*	$32.50	$32.50	$32.50	$32.50
Installation Cost**	$3,000.00	$3,000.00	$3,000.00	$3,000.00
Maintenance cost/year	$25.00	$25.00	$25.00	$25.00
Total Gross Cost	$5,532.00	$5,532.00	$5,532.00	$5,532.00

***$0.65/lb[46] 40 lb load[47] +26.00 to Whitehorse[48]
**Includes travel

6.2 Windows[49]

Within Old Crow, there is roughly a 50% split in sales of double- and triple-glazed windows. Very little low-emittance (Low-E)[50] window product is sold. Between six and nine window units are replaced in Old Crow each month due to vandalism.

Considering basic triple-pane windows as the current standard, the upgrade to consider could be the triple-pane window with the Low-E coating, Argon gas[51] between the panes, and warm-edge spacer bars

[43] Telephone quotation from Air North - Dec.3/01 Whitehorse to Old Crow.
[44] Estimate by Gary Woloshyniuk. January, 2002
[45] Estimate by Gary Woloshyniuk. January, 2002
[46] Telephone quotation from Air North - Dec.3/01 Whitehorse to Old Crow.
[47] Estimate by Gary Woloshyniuk. January, 2002
[48] Estimate by Gary Woloshyniuk. January, 2002
[49] Telephone conversation with Dave Renyk, Sales Manager, Northern Windows, Nov. 27/01. Phone: 867-667-7332. 28 January, 2002
[50] Low-remittance (Low-E) coating. Microscopically thin, virtually invisible, metal or metallic oxide layers deposited on a window or skylight glazing surface primarily to reduce the heat conductivity (U) -factor by suppressing radiative heat flow. A typical type of Low-E coating is transparent to the solar spectrum (visible light and short-wave infrared radiation) and reflective of long-wave infrared radiation. This coating improves both the heating and cooling season performance of a window.
[51] In a sealed glass insulating unit, air currents between the two panes of glass carry heat to the top of the unit and settle into cold pools at the bottom. Filling the space with a less conductive, more viscous, or slow-moving gas such

between all panes. The Low-E option reflects radiant heat back into the living space during the winter, and prevents radiant heat from coming in during the summer. It may also increase the heating load in some cases by reducing solar gain opportunities. The Low-E coating adds a slight tint to the glass, and, in rooms housing plants that require direct sunlight, has the potential to slightly inhibit plant growth. In addition, Low-E installations may reduce the overall amount of light entering the residence. The reduction in light entering the house in the winter months could have an adverse psychological effect upon the residents (Seasonal Affective Disorder). The Argon gas is meant to provide extra insulation value between the panes, but has been found to leak out after a number of years.

The Argon gas and Low-E options add about 10% to the cost of the standard triple-pane window; the average pay back time for the premium is roughly three years as a result of energy savings (reflective of Whitehorse energy costs) on a new installation. This payback would also apply to upgrading from a plain double-pane to a plain triple-pane window.

If window breakage is an issue, it may be cost-effective to add a protective Lexan pane to the installed windows. Lexan is a proved window product that is indestructible and transparent. Excessive abuse will result in scratches being left on the surface, and eventually the unit will have to be replaced. The installation of Lexan may also generate a safety concern. In the case of an emergency situation, such as a fire in the home, a Lexan window could prevent access into and out of the house. Two options exist to install Lexan protection:

- buying a window that has a special sill to accommodate the extra Lexan pane: or,
- screwing a Lexan sheet to the exterior of the window sill (cheaper of the two options).

An option to consider in place of Lexan is a laminated pane product that could be installed as the outer pane of a triple-pane window. It shatters as a car windshield does when broken. It would prevent extensive penetration and keep the glass from being broadcast over an excessive area, but would still require replacement once broken. The cost of this option is the same as that for a Lexan sheet.

Protection consideration could offer a financial payback over time considering replacement costs (labour) and the energy loss implications of exposing the interior of the house to outside temperatures of -40°C while replacing a broken window.[52] The addition of the extra protective pane adds approximately a 60% price premium over basic triple-pane vinyl, while improving performance in both heating (R) value (the equivalent of another pane) and vandalism resistance value.

If a protective pane is to be installed, it should be added as a separate sash attached with screws to the triple-pane vinyl frame. Keeping the protective pane a short distance away from the triple-glass panes allows for some deflection in the outer pane upon impact, without breaking the underlying panes in the triple-pane window system. It would not make sense to install a protective pane within the triple-pane window system itself. If a Lexan pane were installed as the outer pane within a triple-pane system and were hit excessively, the deflection in the Lexan could be enough to break the underlying panes. The same could be said of the laminate pane. If any of the panes were to be broken, the whole frame would have to be replaced. The only benefit to installing a protective pane within the triple-window system would be to reduce the time of exposure to the outside environment that would likely occur if no protective panes were installed.

The triple-pane window is a better insulator than double pane, and has the potential to reduce condensation problems commonly realized in homes built in the North.

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as argon minimizes the convection currents within the space, conduction through the gas is reduced, and the overall transfer of heat between the inside and outside is reduced.

[52] The design temperature for Old Crow is -51°C. Personal communication Thomas Marek. 23 January, 2002.

6.2.1 Window Upgrade Summary

- 3′ x 4′ standard triple glazed, vinyl casement $450
- Low-E and Argon cost adder $45
- Extra Lexan/laminated pane cost adder $270
- Five window replacements per residence
- Lexan or laminated pane could be considered as an option depending upon the level of concern related to vandalism. It is suggested in this case to represent the conservative case.
- Window supplies can be obtained out of Whitehorse. Installation classes are offered annually, free-of-charge, by the window sales company in Whitehorse.
- Energy savings realized from the installation of upgraded windows in Old Crow residences were calculated assuming Whitehorse weather conditions. No consideration was given to weather differences between Whitehorse (base reference: average of 2106 degree days winter total) and Old Crow (study base: average of 4719 degree days winter total[53]) (see Chapter 7). Therefore, the benefits are actually underestimated, furthering the case for window upgrade.

Table 6: Window Upgrade

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Triple-Pane Window Upgrade Opportunity?	Yes	Yes	Yes	Yes
Hardware Cost	$2,250.00	$2,250.00	$2,250.00	$2,250.00
Shipping*	$325.00	$325.00	$325.00	$325.00
Installation Cost	$600.00	$600.00	$600.00	$600.00
Maintenance	Replacement?	Replacement?	Replacement?	Replacement?
Total Gross Cost	$3,175.00	$3,175.00	$3,175.00	$3,175.00

*$0.65/lb 100 lb load each window

6.3 Awnings

Installed on windows facing the sun during the day, window awnings could generate an energy reduction benefit to those housing units with air conditioning systems installed, as is noted in the survey. In homes without air conditioning, awnings would increase the comfort level of the occupants by keeping the home cooler in the summer by shading the windows. Awnings must be designed to withstand the local climate conditions of Old Crow. There is a potential opportunity to design and make awnings locally, from local products (e.g., woven willow). Commercial awnings can cost up to $500 each.[54]

6.3.1 Awning Upgrade Summary

- Fixed, as opposed to flexible (roll up), awnings: $500
- Two awnings per house

[53] Freezing degree days – Each day of winter, receives a score based on the number of degrees below zero to which the temperature falls that day. For example, if the temperature is –10°C., the score for that day is –10°C. ref: Burn, Chris. 2002. Danger: Thin ice ahead. Environment Canada, Pacific and Yukon Region. Url: http://www.taiga.net/yourYukon/col155.html. 28 January, 2002.

[54] Paul & Jenine Baker Snowdrift Awnings, Dec4/01

Table 7: Awning Installation

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Awning Upgrade Opportunity?	Yes	Yes	Yes	Yes
Hardware Cost	$1,000.00	$1,000.00	$1,000.00	$1,000.00
Shipping*	$32.50	$32.50	$32.50	$32.50
Installation Cost	$100.00	$100.00	$100.00	$100.00
Maintenance	Replacement as required	Replacement as required	Replacement as required	Replacement as required
Total Gross Cost	$1,132.50	$1,132.50	$1,132.50	$1,132.50

*$0.65/lb 25 lb[55] load each awning

6.4 Insulation and Vapour Barrier

To retain an adequate level of comfort in the house, insulation must be installed effectively in a number of areas in the home including the walls and ceiling, around water tanks (hot and cold storage), and under the main floor (above the crawlspace between the floor and the earth). To perform properly, insulation must be accompanied by an effectively installed air and vapour barrier. Inadequate vapour barrier "detailing" allows air to penetrate the walls, significantly reducing the performance of installed insulation, especially that of fibreglass batt insulation. Air leaks comprise roughly 40% to 50% of the heat lost from buildings in the North.[56]

Insulation is rated in terms of thermal resistance, called R-value, which indicates the resistance to heat flow. The higher the R-value is, the greater is the insulating effectiveness. The R-value of thermal insulation depends on the type of material, its thickness, and its density. Installing more insulation in the home increases the R-value.

The effectiveness of an insulated wall or ceiling also depends on how and where the insulation is installed. For example, insulation that is compressed will not perform up to its full rated R-value. Also, the overall R-value of a wall or ceiling will be somewhat different from the R-value of the insulation itself because some heat flows around the insulation through studs and joists. For example, the overall R-value of a wall with insulation between wood studs is less than the R-value of the insulation itself because the wood provides a thermal short circuit around the insulation. The installation of both insulation and the vapour barrier is critical to their proper functioning as a unit.

There are various types of insulation to consider for building construction and retrofit situations. Each has its own advantages and disadvantages.

Fibreglass Batt

Fibreglass is the most commonly installed insulating material. It does not require trained personnel to install, but it requires strict attention to the detailed work related to ensuring a properly installed vapour barrier. It is the least expensive of the insulating options suggested here. The buildings in Old Crow are typically insulated with fibreglass batts in the walls and ceilings. The heating R-value[57] of batt insulation is 3.2 per inch of thickness.

[55] Personal communication. Vern. Edmonton Tent and Awning 2000 Inc.. Phone : 780-420-1405. 28 January, 2002
[56] Personal communication. Potter, Kirk. Energy North, Whitehorse, Yukon. Phone: 250-746-6664. 5 December, 2001.
[57]

Blown in Cellulose [58]

Cellulose is an insulation made out of recycled newsprint, and other paper fibres, with a fire retardant added. The short cellular wood fibres of the material fill all voids and cavities for a tight fit. It has roughly 12.5% more insulating capacity per inch than that of fibreglass batts, and it requires a standard vapour barrier installation in its application. This product is blown in to achieve high densities that will resist air leaks at joints. Rodents do not favour cellulose making it ideal for applications where they pose a problem. It may not be the best choice for retrofit situations, as it is not possible, for example, to determine how well the walls are filled. However in an attic upgrade situation, this insulation option may prove to be very effective. The heating R-value of cellulose blown insulation is 3.6 per inch of thickness. Installation of this type of insulation requires trained personnel. Installation also requires electrical blower equipment using 220 volts at 40 amps.

Icynene [59]

Icynene insulation is a water-based, environmentally friendly foam that is sprayed or poured in place and then expands. It contains no formaldehyde, chlorofluorocarbons or hydrochlorofluorocarbons. Unlike conventional insulation products, Icynene fills the entire wall, ceiling, crawlspace or floor cavity to form an impenetrable, airtight, insulated building envelope. It is a light-density foam that expands 100 times its initial volume in seconds to form a soft, flexible insulation, with roughly 25% more insulating capacity than that offered by fibreglass batts. The heating R-value of Icynene insulation is roughly 4 per inch of thickness.

This product provides superior control of air leaks and sound, and reduces condensation in walls, attics and floors. It lets moisture pass through at a very slow rate but does require some type of vapour retarder such as a vapour barrier on the outside. It maintains indoor air quality by preventing the growth of mould and mildew and, as such, is used by people who have extreme chemical sensitivities. It will not melt in a fire situation, and will not fuel combustion. Trained personnel are required to install this product. Installation also requires equipment using 220 volts at 40 amps.

Waltite [60]

Waltite is a high-density cellular plastic, applied by spraying, that forms a continuous, monolithic barrier applicable for most building insulation needs. It has one of the highest insulating values per inch of any insulating material available, is an effective air and vapour barrier, and will not absorb water. It also increases the strength of the material upon which it is applied, while providing roughly twice the insulating value per inch of thickness as that of fibreglass batts. Waltite requires less framing material in retrofit situations than that of cellulose and Icynene. The heating R-value of Waltite insulation is roughly 6.4 per inch of thickness.

Waltite will burn and requires a thermal barrier. Also, it uses HCFCs as a blowing agent in its manufacture, which are greenhouse gases, thus reversing the climate benefits of saving energy in the first place. Spray-installation of this two-part foam type of insulation requires trained personnel. Installation also requires equipment using 220 volts at 40 amps.

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[58] Personal communication. Potter, Kirk. Energy North, Whitehorse, Yukon. Phone: 250-746-6664. 5 December, 2001.

[59] Personal communication. Potter, Kirk. Energy North, Whitehorse, Yukon. Phone: 250-746-6664. 5 December, 2001.

[60] Personal communication. Potter, Kirk. Energy North, Whitehorse, Yukon. Phone: 250-746-6664. 5 December, 2001.

The premium cost for cellulose and foam insulation (Waltite and Icynene) over fibreglass batts run from 25%–45%, depending upon the product chosen, but an insulation improvement in performance of roughly 40% may be realized. This is also combined with other savings, for example in labour costs spent addressing vapour barrier concerns.

Crawlspace under floors should be super-insulated to prevent cold floors in the winter and well ventilated so as not to melt permafrost.

Water tanks and pipes inside the home should also be insulated. With an insulated tank, hot water will remain hot longer with less energy input requirements over time, and the home will not be faced with an instantly large heating demand when the potable water storage tank is filled with cold water during routine water deliveries. Further detailed tank insulation effects are not considered in this insulation assessment.

6.4.1 Insulation Summary

For the purposes of the analysis in the next chapter, building insulation values are assumed to be doubled in each house, respectively cutting the annual building heat demand in half. This assumes that the air barrier is also improved while the insulation is upgraded. If the air barrier is not improved, doubling the insulation value will not necessarily reduce heat demand by one-half. All exterior surfaces are assumed to be insulated: ceiling, walls and floor. Kirk Potter, of Energy North Construction Inc. in Whitehorse, has applied all forms of insulation listed in this section and found them to operate successfully in many regions in the North.[61] Details on the insulating products and a related joint-venture proposal for installation are provided in Appendix E.

- **Fibreglass batt**: This are not considered an option as the houses to be renovated typically are prone to drafts and vapour barrier problems.
- **Cellulose**: This is not considered effective in resolving poorly air sealed vapour barriers. It is more commonly used in conventional, straightforward projects. It settles over time and must be installed to tight specifications to achieve the desired R-value.
- **Icynene**: Icynene will be considered in that it may resolve some living quality problems in the home, is environmentally benign and acts as a fire retardant.
- **Waltite**: This option will be considered in that it may resolve some living quality problems in the home. There is however some reservation in fully backing this product as HCFCs are used in its manufacture and it is not fire retardant.
- All framing required would be supplied by First Nations. These costs are not reflected in the estimates. Generally the insulation installer has noted that exterior installations cost less than interior installations and are less of an intrusion on the occupants.
- On exterior applications, installing an additional vapour barrier (First Nations responsibility) would not be required if using a foam insulation option. The existing vapour barrier in the house, combined with the sealing properties of the foam, would suffice both as an air and vapour barrier. For interior installations it would be the responsibility of the First Nations group to properly install a new vapour barrier. The foam would act as an adequate air barrier.
- The cost of labour to strap and side an exterior-applied foam insulation installation would be roughly $2,100.[62] This is included in the analysis.

[61] Personal communication. Kirk Potter. Energy North Inc. 18 February, 2002.
[62] Personal communication with Kirk Potter, Energy North. 6 June, 2002. Estimate only - at roughly $2 per square foot including materials.

- To reduce fire risk (Waltite foam insulation application), a paint called "Safe Coat" can be applied to the interior of a newly insulated house. This product has the unique property of reducing fire risk by absorbing oxygen that might fuel a fire. It has been known to extinguish fires on its own. It is a non-toxic product. The price per gallon is $65–90. A gallon will cover roughly 150 square feet of surface area. The average 700-square-foot house would need approximately $400 worth of paint (6 gallons). This cost is not included in the analysis.

Table 8: Insulation and Vapour Barrier

Unit*	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Insulation Upgrade opportunity?	Not a candidate according to EnerGuide audit	Yes	Yes	Yes
Insulation: Icynene	$15,905.00	$12,764.00	$15,308.00	$18,200.00
Insulation: Waltite	$17,258.00	$14,538.00	$17,506.00	$20,880.00
Shipping Icynene**	$419.85	$344.42	$426.74	$520.32
Shipping Waltite**	$1,172.61	$961.94	$1,191.86	$1,453.22
Other Costs	$682.00	$560.00	$693.00	$845.00
Total Cost: Icynene	$16,197.00	$13,668.00	$16,428.00	$19,566.00
Total Cost: Waltite	$19,112.00	$16,059.00	$19,391.00	$23,178.00

*All labour is included in the price for the insulation only - quoted by the insulation retailer.
**$0.65/lb, 1700lbs for Icynene and 4600 lbs for Waltite.

6.5 Doors

Metal insulated doors provide a higher degree of insulation and security than do traditional wooden entrance doors. The R-value of the door is zero once it is opened, and of some value once it is closed. Weighing all the factors — speed of installation, strength-to-weight ratios, thermal efficiency, quality and consistency of material — along with reduced energy costs, a steel door will provide significant energy savings over a conventionally constructed one.

6.5.1 Door Replacement Summary

- A wooden, hollow-core, 1 ¾" thick door has an Rvalue of 2.17.
- The recommended option is a metal, insulated, 2" or greater in thickness, urethane core door with an insulating value of R15.[63] The calculations done for this option allow for the installation of two exit doorways in the house design.
- Northerm Windows sells the "Arctic Combo" door unit that includes a metal-insulated interior door and an outward swinging, insulated, exterior storm door for $750–850.[64]

[63] Colorado Energy Org. 2002. R-Value Table, Insulation Values for Selected Materials. Url: http://coloradoenergy.org/procorner/stuff/r-values.htm. 28 January, 2002.
[64] Phone communication with Dave Renyk at Northerm, in Whitehorse. 4 June, 2002. Interior door with window: $850. Interior door with no window: $750. Exterior storm door for both options is ½ window screen.

Table 9: Door Upgrade

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Door Upgrade Opportunity?	Yes	Yes	Not a candidate according to EnerGuide audit	Yes
Metal Door Combo Cost	$1,500.00	$1,500.00	$1,500.00	$1,500.00
Shipping Door* (80 lbs)	$104.00	$104.00	$104.00	$104.00
Installation Costs (local labour 1/2 day/door)	$240.00	$240.00	$240.00	$240.00
Maintenance	N/A	N/A	N/A	N/A
Total Gross Cost	$1,844.00	$1,844.00	$1,844.00	$1,844.00

*$0.65/lb

6.6 Space Heating

Four types of space heating options are considered for homes in Old Crow; three are already in common use. The most common, and perhaps the least expensive financially, is wood. There are also some oil space heaters in the community (e.g., Monitor heater), and at least one electric baseboard heater in every house to provide backup heat and prevent water freezing problems. A unique option to consider adding to this list is the "Hi-Velocity" heater. It utilizes heat taken from a hot water tank, such as the existing electric tanks in the community, and distributes it throughout the living space more effectively than would be realized by convection and radiant heat distribution from a stove. Heat for the Hot water tank can be provided by electricity, oil, or solar thermal collection.

6.6.1 Baseboard Heat

If baseboards heaters are to be installed in water tank areas or anywhere else in the home, a separately wired, inexpensive gas diaphragm-type thermostat should be used. It provides accurate and responsive heat control and as a result generates significant energy savings. Recommended controller models of this type include White Rogers — model 1A85W633, and Honeywell — model T4398A1013. The controllers themselves can also be replaced on existing baseboards to achieve energy savings with minimal retrofit costs. The controller, installation labour and wiring add up to roughly $150. Baseboard heating could be considered as a supplement in other areas of the home in the event wind energy production is developed in Old Crow.

6.6.2 Wood Heating

Many of the wood stoves used in the homes audited appear to be of an inefficient type and would not be compatible with the design standards of an energy efficient home. Experience in the field has shown that efficiencies from wood stoves don't get much higher than 60% unless extreme measures are taken by using excess air blowers for primary and secondary air in a commercial setting. Units of this nature might attain slightly more than 70% efficiency.[65] The wood stoves in Old Crow are estimated to be 50% efficient in their operation. These could be upgraded to stoves that have the potential to reach a 70% efficiency rating.

Smaller wood heating appliances could be used to realize improved efficiency (e.g., Jotul unit). These units are better sized to the demands for heat noted in Old Crow, cost less, incur lower shipping charges,

[65] Personal communication. Wilf Scheuer, Pro Star Mechanical Technologies Ltd. Phone 250-383-4558. 22 February, 2002.

and take less space in the home than larger units. The only drawback is that the smaller units hold less fuel and need to be stoked with smaller pieces more frequently than do larger units. However, the total amount of wood used would also be reduced (negating the requirement for more frequent refuelling) if other retrofits are done that significantly improve the thermal energy efficiency and air tightness of the home. The energy retention and storage potential of the retrofits would also reduce the need to keep a fire going constantly.

"Catalytic" wood stoves are also available. In such units, a catalyst, similar to the catalytic converter in a car, burns unburned fuel (smoke) from the fire before it exits through the flue. A catalyst will start burning smoke coming from the fire when it has reached a temperature of between 350°F and 600°F. Stoves with a catalyst burn more efficiently than those without, but they do require more maintenance. This usually includes replacing the catalyst every few years. Catalytic combustors may decrease emissions and increase overall fuel efficiency by 25–30%; the proper operation of a catalyst depends entirely on what goes into the firebox. Of particular importance to maintaining effective operation is having a dry wood supply for fuel. Users of catalytic stoves must focus their efforts on drying wood for a least a year before burning it in their stove.

New catalytic wood stoves and inserts advertise efficiencies of 70–80%. Catalytic combustors last from one to ten years, depending on the stove, the fuel used, and how often the stove is used. The catalytic cell is removable and replaceable and costs between $75 and $160.[66]

Though the efficiency of the catalytic-combustion-supported wood stove is higher than normal, new advanced combustion technology is now on the market that can match the efficiency of the catalytic option with less concern about the catalytic components. Manufacturers are now moving away from the catalytic design option and getting more involved with new, more robust advanced combustion technology. Advanced technology wood appliances ensure secondary combustion of flue gasses, and produce more heat than older conventional stoves, reducing the volumes of wood needed for seasonal heating.

Old units should only be replaced with newer stoves if they are due to be replaced in any case.

Features to consider in the stoves are the efficiencies as well as construction. Cast iron units retain their heat longer than do steel stoves, however, cast units are also more susceptible to damage from abuse (shipping and heavy use concerns). Having a stovetop cooking surface area should also be of concern to individuals if the stove is used for this purpose as well as space heating.

While modern wood stoves are designed to achieve high efficiency, stove operators need to understand their operation. Achieving a highly efficient fire requires the use of dry wood. Green wood contains moisture that must first be evaporated before it can burn. Burning wood with high moisture content creates low-temperature fires in the stove that increases the rate of creosote build up in the chimney. In order to avoid chimney fires that develop because of this, a chimney needs to be cleaned frequently (at least once a month). It is noted that in Old Crow the use of green wood is common.

Some training would be of value to those interested in learning about the proper handling of wood. Less fuel wood would be required over the season as a result.

[66] Energy Efficiency and Renewable Energy Network (EREN). May, 2001. Catalytic Combustors in Wood Burning Appliances. US Department of Energy. Url: http://www.eren.doe.gov/consumerinfo/refbriefs/bb5.html. 1 March, 2002.

As outlined in Chapter 3, wood supplies in Old Crow are limited and will become scarce in the short-term due to the extremely low growth rate of trees in the area. As such, any efforts to expand the use of wood should be discouraged.

6.6.2.1 Wood Heater Upgrade Summary

- Though the catalytic data is provided for information, it is not a recommended option, primarily because the wood used for stoves in Old Crow is quite often green. This would soon render the catalytic components inoperative and the stove inefficient. Manufacturers are moving away from this design to the new advanced combustion option. Blaze King catalytic stoves can be bought in Whitehorse for about $2,500.
- Stoves to be considered for purchase should meet EPA (Environmental Protection Agency (of the USA)) or CSA B415.1 (Canadian equivalent to EPA standard) standards. These would use 30% less wood and produce 90% less smoke compared to non-standard older stove designs.[67] In addition, for all existing and new wood stove installations, an effort should be made to ensure optimal chimney design specifications are followed (e.g., to ensure the chimney is of a specified diameter and reaches a minimum height above the crown of the roof).
- It is estimated that an increase in efficiency of 10% (improving the 50% efficient package with one operating at near 60% efficiency) could be realized with the installation of more efficient wood stoves. A 20 % improvement (assessed in this report) could be realized replacing an old inefficient wood stove with a catalytic or advanced combustion stove.
- The Jotul is actually rated at an operating efficiency of 71% according to US EPA specifications. A further increase of roughly 10% would be realized with the installation of a catalytic wood stove package (advertised in literature as 70–80% efficient). The Jotul Wood Heater (model F602CB) is a small stove, excellent for cooking, and of cast iron construction.
- Other stove models to consider are the Regency, Osburn and Pacific Energy. These come in various sizes, are reasonably efficient in operation (estimated in high 60% range; Pacific Energy advertises a 70% efficiency rating for its product), EPA-approved, use advanced combustion technology and are of steel construction. The Osburn and Pacific Energy models also double as an efficient cook top. The price and weight of these stoves are all comparable to the Jotul.
- A new wood heater should only be installed where the existing heater is being considered for replacement.

Table 10: Wood Stove Upgrade – Normal and Catalytic

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Cost for High Efficiency Stove Package with Chimney Upgrade	$2,200.00	$2,200.00	$2,200.00	$2,200.00
Ship unit (250 lb)	$250.00	$250.00	$250.00	$250.00
Installation Costs (local labour 1 day)	$240.00	$240.00	$240.00	$240.00
Maintenance **	$25.00	$25.00	$25.00	$25.00
Total Gross Cost Wood Stove 70% efficiency	$2,600.00	$2,600.00	$2,600.00	$2,600.00

*$0.65/lb

** Expressed as minimal – assumed value of personal time commitment only no materials

[67] Communication with Craig Olsen of Olsen's Resource Consulting. Whitehorse, Yukon. May, 2002. May, 2002.

6.6.3 Oil Heating

Some residences in Old Crow have oil heaters installed. These units (commonly either a Monitor or Toyotama model) are of a relatively efficient design, typically upward of 85%. Opportunities for improvement in this area would be in the maintenance of the heaters to ensure heat exchanger efficiency and blower operation are maintained. Because oil heater installations don't accommodate an air circulation duct system, they do not circulate warm air throughout the home effectively.

The most effective mechanism for improving energy efficiency with oil heaters is to train the home occupant to use the "set-back" control on existing heaters which lowers the setpoint temperature at night or during periods when the house is not occupied.

6.6.4 Hot Water for Space Heating – Hi-Velocity System Retrofit

A small, "Hi-Velocity" (product name) hot water space heating system could be used as an alternative to wood or oil heating, using electricity as the primary source of energy with pre-heating from solar sources during the spring, summer, and fall for any space heating needs. Under this type of system, heat is taken from a regular hot water tank of 80–100 gallons (replacing the existing, small hot water tanks to accommodate the extra heating load) and is distributed throughout the house through forced air ductwork (retrofit installation) running through the attic space. The unit does not have to be located centrally, but can be located to suit system requirements. The ducts are small, compact, and easily hidden, with the vent outlets working as effectively with ceiling, floor, or sidewall discharge. Such Hi-Velocity systems are very efficient, compact, versatile in operation, and easy to install. Units have successfully been installed as far north as Yellowknife.[68]

Electricity would be used to heat the water for the space-heating load, to drive a water pump (1/4 horsepower), and to run a motor that drives the forced-air fan (1/2 horsepower).

Electricity in Old Crow is currently provided by diesel engines. Operating the Hi-Velocity heating apparatus would be less efficient than burning oil in a monitor heater because of the losses in generating power at the engines, distributing it to residences, and converting it to thermal energy within the hot water tank. In addition, the extra cost of operating the Hi-Velocity unit on electricity under the present rate structure would render this option uneconomical.

Nevertheless, almost all houses in Old Crow presently use electricity to heat water. Installing an oil-fired hot water system to act as a combined water and space heating system would require extra venting and create insulation sealing and oil storage concerns. The electricity supply already in place is relatively easy to tap in to, and is a clean source of end-use power (indoor air quality consideration). If wind power were to be introduced into the community (one of the options being considered by the Vuntut Development Corporation[69]), and the wind power resource were to be maximized during winter heating months, then electrical space heating options such as the Hi-Velocity unit could permit residents to use wind power for space heating. Still, electrical baseboard heaters in each room would be more cost-effective.

The Hi-Velocity unit can also incorporate heat input from solar thermal collectors (see below), tied in to heat recovery ventilation (HRV) systems, and can incorporate cooling systems if desired. Adding heat to the water tank from a centrally located wood stove (which incorporates a water heat exchanger) would be possible but not easy, requiring a pump, control, plumbing to the tank, and an extra heat exchanger in the

[68] Energy Savings Products Limited. February, 2002. Company Product and Overview - Installations and Applications. Url: http://www.hi-velocity.com/en/company/history.htm. 21 February, 2002.
[69] See Yukon Energy Corporation. *Old Crow Wind Resource Assessment.* 2001.

hot water tank. This approach is not recommended, as it would increase the overall consumption of wood energy.

Oil-fired "Hi-Velocity" systems are already in use in two newly built Yukon Housing Corporation staff duplexes located close to the school in Old Crow. These "Hi-Velocity" systems are set up with a fan coil unit from an oil-fired hot water tank. Upon installation there were some control problems with the system related to power bumps on the electricity power system knocking out the controllers and resulting in freeze-ups. But now that these have been resolved, the systems are working very well. These units are installed in very energy-efficient dwellings with a very well installed insulation package.[70]

Overall, the Hi-Velocity unit is only considered technically appropriate if it is combined with both a wind electricity source and a solar thermal pre-heater at the house, and if the house is already renovated to incorporate advanced insulation standards. Even in such a case, this is not to say that it would be economically efficient.

6.6.4.1 Hot Water for Space Heating –Hi-Velocity System Retrofit Summary

- Application of a "Hi-Velocity" hot water to forced air heating unit.
- The winter electricity consumption of a residence in Old Crow is over 1,000 kWh per month, which would move residents into a higher rate class (see Section 3.4). Unless electricity is supplied under a different rate, this option is not considered financially viable.
- This option is only considered appropriate in homes where significant insulation and air and vapour barrier upgrades have been implemented. It would also be ideal if wind power were introduced into the community. Other options would be to combine the unit with solar thermal pre-heating, and an HRV. To confirm the financial feasibility, using a Hi-Velocity hot water forced-air, space-heating unit should be compared against using electrical baseboard heaters that use wind power, and also against the use of low-cost "radiators" that use solar thermal energy for space heating.

Table 11: Hi-Velocity Hot Water Air Flow Unit

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Appropriateness of Upgrade?	Maybe - if wind power introduced and combined with solar thermal	Maybe - if wind power introduced and combined with solar thermal	Maybe - if wind power introduced and combined with solar thermal	Maybe - if wind power introduced and combined with solar thermal
Hi–Velocity Cost	$5,800.00	$5,800.00	$5,800.00	$5,800.00
Shipping* (200 lbs) **to Whitehorse** **to Old Crow**	 $500.00 $130.00	 $500.00 $130.00	 $500.00 $130.00	 $500.00 $130.00
Installation Costs (local labour 1 day)	$240.00	$240.00	$240.00	$240.00
Other Training (local labour training 1 week) $4000 total	$1,000.00	$1,000.00	$1,000.00	$1,000.00
Maintenance (assumed value of personal time commitment only, no materials) $/year	$25.00	$25.00	$25.00	$25.00
Total Gross Cost	$7,670.00	$7,670.00	$7,670.00	$7,670.00

*$0.65/lb

[70] Personal communication. Allyn Lyon. Yukon Housing Authority. 31 May, 2002

6.6.5 Solar Energy

Though not currently used in Old Crow, thermal solar energy collection for space and water heating purposes is an option being used in various locations in the North. Particularly of note are those that have been installed in Whitehorse in a large downtown apartment, an RV park that uses it for its shower facilities, and several homes. These systems are proved and have worked well to date.[71] Active solar hot water collectors could be integrated into existing hot water systems that would also supplement space heating. A number of solar collection system combinations are reviewed in this report.

Photovoltaic electricity generation modules can also be used to generate electricity from exposure to the sun. Although these are not considered in this report, they could be used in Old Crow during months of adequate sunlight to supplement diesel power supplies using emerging "grid-intertie" technologies.

6.6.5.1 Hot Water for Space Heating - Solar Supplement[72]

Solar energy is abundant in Old Crow during the summer months (i.e., the sun doesn't go below the horizon in June and July), continues through to November and is available again beginning in April. The sun could provide a source of thermal energy through "collectors" that concentrate and collect solar energy. These collectors transfer the solar heat gained to an antifreeze fluid that can be used to heat water within a standard hot water tank. The solar energy can "pre-heat" the tank, while electricity can provide backup for periods when solar energy is not available. Solar energy can be used for domestic hot water and space heating purposes. The design is such that the heat exchanger doesn't allow antifreeze contamination of the domestic hot water system.

If solar heat were to supplement space heating, the simplest interconnection would be to use a solar/electric combination hot water tank. The 80–100 gallon "combo tank" has an internal heat exchanger and a 5–6 kW electric element incorporated at the top where the hot water is drawn from. Using a combo tank would require replacement of an existing electric hot water tank. It would also be possible to install a separate solar pre-heat tank leaving the existing electric tank in place. This would take up more space and would not be ideal if space is a concern.

Hot water is available at all times due to the electrical backup, but the solar heat contribution would always provide a proportion of the hot water needs. A "Solar Fraction" of 26% has been demonstrated in Inuvik for water heating alone, meaning that 26% of the total annual hot water needs were provided for by solar energy.

Data indicate that a solar collector would function quite well in Old Crow, capturing heat throughout the summer season and portions of the "shoulder seasons" of spring and fall. Up to roughly 16 GJ of heat can be collected over the year using "HelioTech" double-glazed solar collector panels.[73] This heat would be used to displace existing heat demand in the house in a roughly 50%-split going to space heating and water heating respectively.

For space heating, distribution could be achieved by using baseboard radiators close to the hot water tank with copper water pipes running through them or by a "Hi-Velocity" unit as described above.

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[71] Personal Contact. Bill Kendrick, Solterra Energy Services Co. Whitehorse, Yukon Territory. Telephone: (867) 668-7119. 28 June, 2002

[72] For more information, see *Solar Water Heating Systems – a Buyers Guide* at http://www.nrcan.gc.ca/es/erb/reed/

[73] Personal communication. Matthew Salkeld. EnergyWise Technologies, British Columbia, Email: msalkeld@interchange.ubc.ca

Thermal solar collectors are currently eligible for a 40% capital cost rebate through the Renewable Energy Deployment Initiative offered by Natural Resources Canada.

6.6.5.2 Hot Water for Space Heating - Solar Supplement Summary

- Heat from the solar collectors could be used to supplement space and water heating.
- The Hi-Velocity hot water system and ductwork package is not included in the evaluation as it is more expensive than baseboard option: $14,565 vs. $7,670.
- A baseboard radiator could provide an alternative heat distribution model to the Hi-Velocity system.
- Extensive training, supervision and manual preparation are included with the solar portion of this option.
- The hot water tank should be insulated. There is no calculation for the estimated savings realized from reducing heat loss from the tank. The cost for insulating the tank is about $85.

Table 12: Solar Water and Space Heating – Radiator Package

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Solar Heating Upgrade Opportunity?	Yes	Yes	Yes	Yes
Cost Solar Package	$2,770.00	$2,770.00	$2,770.00	$2,770.00
Shipping* Solar	$630.00	$630.00	$630.00	$630.00
Other Installation Costs – tank, piping, labour (estimate 2 days to install), travel accommodation and training	$8,100.00	$8,100.00	$8,100.00	$8,100.00
Maintenance Solar $/year	$100.00	$100.00	$100.00	$100.00
Optional Baseboard Radiator Distribution if Hi-Velocity is not Used (Includes Labour)	$2,000.00	$2,000.00	$2,000.00	$2,000.00
Total Gross Cost Including Radiator	$13,500.00	$13,500.00	$13,500.00	$13,500.00
REDI Grant Allotment 40%	($5,400.00)	($5,400.00)	($5,400.00)	($5,400.00)
Net Cost	$8,100.00	$8,100.00	$8,100.00	$8,100.00

*$0.65/lb

6.6.6 Thermal Mass

Installing "extra" thermal mass of any type in the home – for example doubling the gyprock panel layout on the inside walls, or even bringing large rocks inside the home — would help increase the heat storage capacity of the home. Such a mass would reduce the demand for space heating requirements typically experienced when trying to compensate for colder temperature swings outside the home. It could also help in situations where homes have small stoves that can run out of fuel overnight. No specific recommendations are made in this respect. Though this concept becomes of less concern if a house is properly insulated and sealed, thermal mass storage is always a good design concept to incorporate.

6.6.7 Draft Proofing

Adding weather stripping, or caulking as required to the doors and windows in the home, will reduce energy lost in the winter in the home due to cold drafts coming from the doors and windows. Energy savings are not calculated for this initiative as there are various improvements that could be made to any one house. However this initiative is noted as one that is low in capital cost and labour, and reaps immediate benefits for the homeowner.

6.6.8 Setback Thermostat

Operating energy-efficient equipment in a well-insulated house requires some degree of fine-tuning to make sure everything is optimized all the time. The setback thermostat could be used for this purpose for a variety of heating systems. Some heating systems, such as oil monitor heaters, include this feature.

The thermostat would be set to control the heat source to make sure it was only running at those times in keeping with the occupant's lifestyle — making the home warm when the person wakes up and allowing it to cool to a set lower limit in the person's scheduled absence. A setback thermostat cost in the order of $75. Energy savings would be significant in situations where individuals don't turn down their heat when they leave for extended periods of time. It is not clear what the payback duration or savings actually might be. It is likely safe to say that, if used in the way described above, the thermostat would have a relatively short payback period. Of note is that if people switch from a wood stove to an oil-fired Monitor heater, they might have a tendency to run the Monitor hotter than effectively necessary, to create the same heat sensation offered by the woodstove. This is an educational issue that needs to be addressed. Running the Monitor at a high temperature may be okay while people are in the home, but it should be turned down to a minimum when no one is home. Setback thermostats have no ability to control heat output from wood stoves.

6.6.9 Carbon Monoxide Detector

Carbon monoxide (CO) is one of the components produced from incomplete combustion. Exposure to excessive levels of CO is unhealthy and can prove to be lethal. All combustion appliances are capable of producing this gas as a result of normal operation. In many cases the venting design of the appliance safely carries such emissions out of the house. However, these evacuation systems don't always work, and occasionally get damaged, preventing the gasses from properly venting outside the house. A carbon monoxide (CO) detector should be installed in all houses with oil space heaters or wood stoves to guard against such concerns. Detectors warn the occupants of impending unsafe carbon monoxide indoor air quality levels in time for them to safely vacate the premises.

Senco Sensors (http://www.sencosensors.com/) and Kidde Nighthawk (http://www.airspill.com/) make CO detection monitors. The best units are run on an electrical supply and cost roughly $70. With installation a CO monitor might cost up to $175.[74] Battery-powered units are also available for about the same cost, but would not incur installation costs. A battery-powered unit would need to be checked annually for proper operation (replacement of battery and system check).

It has been noted that the air quality in general in Old Crow is not good in the heating season. A lot of smoke odours and particulates are in the air at this time and the prevailing winds blow the contaminants throughout the entire community, creating worsening conditions the further downwind you go. This may be due to the use of green wood that tends to burn slow and generate a lot of smoke in wood stoves. There

[74] Estimated $100 for installation. Gary Woloshyniuk

may be other air quality concerns in the community that need to be addressed.[75] There are no recommendations regarding overall air quality in the community offered in this report. This is mentioned with the implication that air quality in the home may be affected by exterior conditions as well as those inside.

6.7 Solar Water Heating

Indoor plumbing is a relatively recent innovation in the community, predominantly installed as an "add-on" feature in the renovation of older residences. A standard electric hot water tank is used to heat water in the bulk of the houses surveyed in Old Crow. Electric hot water heating can be supplemented by a solar thermal system as explained in the space heating section under "Solar Heating." A solar domestic hot water system using electricity as back up would be a fairly simple proposition, using a "combo tank" with an internal heat exchanger and electric element. This would mean replacing an existing electric hot water tank with a combo tank. It would also be possible to install a separate solar pre-heat tank leaving the existing electric tank in place. This would take up more space and would not be ideal if the loss of floor space is a concern.

Table 13: Solar Water Heating Only

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Solar Heating Upgrade Opportunity?	Yes	Yes	Yes	Yes
Cost Solar Package	$1,850.00	$1,850.00	$1,850.00	$1,850.00
Shipping* Solar	$630.00	$630.00	$630.00	$630.00
Other Installation Costs – tank, piping, labour (estimate 2 days to install), travel accommodation and training	$7,550.00	$7,550.00	$7,550.00	$7,550.00
Maintenance Solar $/year	$100.00	$100.00	$100.00	$100.00
Total Gross Cost Including Radiator	$10,033.00	$10,033.00	$10,033.00	$10,033.00
REDI Grant Allotment 40%	($4,013.00)	($4,013.00)	($4,013.00)	($4,013.00)
Net Cost	$6,020.00	$6,020.00	$6,020.00	$6,020.00

*$0.65/lb

6.8 Lighting

In winter months in particular, lighting can be a major consumer of electrical energy. Compact fluorescents (CFL) are an ideal alternative lighting option to incandescent bulbs. A 15-Watt CFL adequately provides the equivalent light output of a 60-Watt incandescent bulb for one-quarter of the electricity. In addition, CFLs have a significantly longer life — 10 times that of an incandescent bulb.

[75] Email communication. Thomas Marek. 25 April, 2002. AIM600 sensors had also been available until recently when the company manufacturing these units got bought out. The new company no longer makes residential CO detection equipment.

Before switching to alternate lighting types such as CFLs in a remote location like Old Crow, a decision has to be made as to what type of product to stock in the community. A commitment has to be made to carry the product locally. In order for a conversion program to be successful, people will have to be committed to using them.

There are two system options to choose from when considering using CFLs: screw-in bulbs and hardwired fixtures that replace the screw in incandescent mounts. Screw-in CFLs easily replace existing incandescent bulbs provided that shades and fixtures are of a compatible size. Tight fixtures may not accommodate the large base or length of a CFL light. Screw-in CFLs are now mass-produced and available at a reasonable cost. Hard-wiring special CFL fixtures with unique bulb types ensures the use of less expensive bulbs, but requires a guaranteed supply from a local distributor and up-front electrician costs to install the fixtures.

In comparison to the CFL, basic incandescent fixtures like the ones installed in Safe House are less expensive, but provide poor lighting, are inefficient, and have a short life. Nevertheless, each bulb has its place. CFLs reduce energy consumption when replacing traditional incandescent bulb use, but they should not be used in outside applications due to potential vandalism and cold conditions. While incandescent bulbs may be ideal for outside applications, installing a motion sensor light control system in place of the traditional socket mount should be considered to further reduce energy consumption. A reduction in energy consumption of roughly 50% could be expected when using CFLs and external motion control sensor systems on incandescent systems.

Another option to consider in daily use is that of task lighting. This is lighting such as a desk lamp that only lights the area being worked in. It is not intended to light entire rooms. Smaller areas are lit, so less energy is required of the "task light", whether using CFLs, incandescent bulbs, or other light sources (e.g., halogen).

6.8.1 Interior Lighting

As a general rule, it is inappropriate to utilize energy-efficient ballasted lighting (e.g., CFLs) bulbs where lights are frequently switched on and off, for example by a motion detector, or in bathrooms. Premature failure related to constant short "on–off" cycling will negate any energy savings. It is recommended to keep incandescent bulbs in areas that are frequently switched, and CFLs in all other areas, like kitchens, dining rooms and hallways.

Hardwired compact fixtures can be purchased for roughly $45. These fixtures only accept the compact fixture lamp replacements. These bulbs cost less than the screw-in CFL because they do not contain their own ballast. An advantage of this type of installation from an energy-efficiency perspective is that when burned out, this bulb can only be replaced when broken by the same type of bulb, while a screw-in CFL might possibly be replaced with an incandescent bulb.

Good screw-in CFLs can be delivered in bulk to major centres for about $15 each, but the price is quite dependent upon the distributor used. IKEA CFL products appear to be the least expensive option to date in the North. Based on an order of 1000 bulbs delivered into Whitehorse, the cost would be roughly $13.50 each[76].

[76] Communication with Craig Olsen of Olsen's Resource Consulting, Whitehorse, Yukon. May, August 2002

6.8.2 Exterior Lighting

CFLs should not be used in exterior applications. The cold weather can have a detrimental affect on the ballast operation.[77] If energy-efficient exterior lighting is desired, low-pressure sodium is the most energy-efficient option to consider. It retains a long operating life, but the broadcast colour is very yellow. Though this makes it hard to distinguish colours under such lighting conditions, the sodium lamps are very reliable and present a "warmer" feel in winter. If this outdoor lighting option is unacceptable, an incandescent bulb set up on a motion or timer system will reduce exterior lighting energy consumption and provide adequate traditional lighting.

6.8.2.1 Lighting Summary

- CFL screw-in type: Their ease of installation makes them readily acceptable in the marketplace and appropriate for application in Old Crow. Under the proper operating conditions the initial higher capital cost will be regained from reduced electricity consumption and a longer bulb life than will be realized from the incandescent option. For simplicity, it is recommended that all bulbs be replaced with screw-in compact fluorescents on a maintenance-replacement basis.
- CFL fixture type: These could be recommended for larger homes, or where the occupants are more prone to going from room to room to do different tasks. As a hardwired installation and relying heavily upon suppliers for unique stock, this option is harder for the market to accept. These are not recommended for installation.

Table 14: Lighting

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Lights Upgrade Opportunity?	Yes	Yes	Yes	Yes
Cost of 6 CFL Screw-in Bulbs (half of 12 total house lights)	$90.00	$90.00	$90.00	$90.00
Shipping*: CFL Screw (6 = 5 lb)	$3.25	$3.25	$3.25	$3.25
Maintenance	Replacement as required	Replacement as required	Replacement as required	Replacement as required
Total Gross Cost CFL Screw Bulbs	$93.25	$93.25	$93.25	$93.25

*$0.65/lb

6.9 Water/Sewage

There may be an advantage to installing a smaller pump capable of producing a higher pressure for the water supply on new installations. There would be minimal if any additional cost involved as the pump is a replacement item and not additional. The smaller pump would use less power and be less prone to cycling, improving operating efficiency.

6.10 Appliances

When new appliances are purchased for the community the appliance with the best available energy efficient technology at the time should be given top priority in the purchasing decision. This decision should be made based on the remaining life expectancy of the appliance as well as energy (and water)

[77] the Panasonic CFL has an instant-on operating mode down to –30C. Communication with Craig Olsen of Olsen's Resource Consulting, Whitehorse, Yukon. May, 2002

consumption of the older appliance compared to a new Energy Star® rated appliance. In the case of several major household appliances (especially refrigerators and clothes washers) the gains in energy efficiency and consequent cost savings can pay back the cost of the appliances in as little as five or six years.[78]

Although disposal issues are significant in Old Crow because of the remoteness of the community, stockpiling decommissioned appliances (including removal of refrigerants by a certified extractor) is an option until such time as reasonable backhaul rates are available. There may be advantages to bringing in a new appliance and disposing of an older model even if it is still functioning. For example, a study conducted in July 2001 by the Yukon Bureau Statistics indicates that roughly 25% of homes in Yukon diesel-electric communities have refrigerators that are at least ten years old. Energy consumption of these older fridges could be as much as three times that of a new Energy Star® rated fridge. From an energy use perspective, this could mean annual operating cost savings of $130 (1,300 kWh) per year or more (from $170 per year down to $40 per year).[79]Each appliance to be considered for replacement should be assessed accordingly as appliance technology has advanced significantly in some areas over the last few years (as with refrigerators and washing machines) and not in others. For more information on energy-efficient appliances, see the Office of Energy Efficiency website (www.oee.nrcan.gc.ca) and click on "Appliances".

It is also worthy to note once again that, with diesel electric power generation operating at low efficiencies, any reduction in electricity demand will also be of benefit to reducing power production-related emissions.

6.11 Building Envelope

Air leaks in housing, especially those contributing to infiltration, are of particular concern in extreme cold climates. They result in significant energy losses, have the potential to degrade building appearance and structure, and result in an uncomfortable environment for occupants. EnerGuide pressure testing results and the opinion of Yukon Housing Corporation suggest that the houses retrofitted previously in Old Crow were not performing up to the retrofit specifications. Better installation of the vapour barrier would significantly have reduced the infiltration problems that exist in the homes tested. The bulk of these problems will be handled through the proper installation of the windows, doors, and insulation as specified in this report. However, it is critical that building contractors are trained in appropriate energy-efficient building envelope techniques.

[78] Written communication. Janne Hicklin, Energy Efficiency Program Coordinator, Energy Solutions Centre Whitehorse, Yukon. 1 June, 2002.
[79] Written communication. Janne Hicklin, Energy Efficiency Program Coordinator, Energy Solutions Centre Whitehorse, Yukon. 1 June, 2002.

7 Analysis of Proposed Retrofits

7.1 Costs of Retrofits

The following table outlines the costs of the retrofit options highlighted above. Where the word, "Yes," is included it implies that this option could be considered. Where the work, "No," is listed, it implies that the house already has this option in place, and is not in need of the retrofit or upgrade.

Table 15: Summary of Retrofit Costs

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Bathroom Ventilation	Yes	Yes	Yes	Yes
Total Gross Cost	$652.00	$652.00	$652.00	$652.00
Kitchen Ventilation	Yes	Yes	Yes	Yes
Total Gross Cost	$652.00	$652.00	$652.00	$652.00
Heat Recovery Ventilator	Yes	Yes	Yes	Yes
Total Gross Cost	$5,532.00	$5,532.00	$5,532.00	$5,532.00
Triple Pane Windows	Yes	Yes	Yes	Yes
Total Gross Cost	$3,175.00	$3,175.00	$3,175.00	$3,175.00
Awning Upgrade	Yes	Yes	Yes	Yes
Total Gross Cost	$1,132.50	$1,132.50	$1,132.50	$1,132.50
Insulation Upgrade	No	Yes	Yes	Yes
Total Gross Cost Icynene	$16,200.00	$13,700.00	$16,400.00	$19,600.00
Door Upgrade	Yes	Yes	No	Yes
Total Gross Cost	$1,844.00	$1,844.00	$1,844.00	$1,844.00
Wood Heater Upgrade	Yes	Yes	Yes	Yes
Total Gross Cost Cat. Wood Stove 70% eff.	$2,600.00	$2,600.00	$2,600.00	$2,600.00
Hot Water Space Heating Electricity - Hi-Vel Retrofit	Yes	Yes	Yes	Yes
Hot Water Space Heating– Electric - Hi-Vel Retrofit Total Gross Cost	$7,670.00	$7,670.00	$7,670.00	$7,670.00
Hot Water Space Heating - Solar Supplement - - Radiator Retrofit	Yes	Yes	Yes	Yes
Total Cost Hot Water Space Heating - Solar - Radiator Retrofit (with REDI Grant)	$8,100.00	$8,100.00	$8,100.00	$8,100.00
Hot Water Only – Solar Supplement	Yes	Yes	Yes	Yes
Total Cost	$6,020.00	$6,020.00	$6,020.00	$6,020.00
Lights Upgrade	Yes	Yes	Yes	Yes
Total Gross Cost CFL screw bulbs	$93.25	$93.25	$93.25	$93.25

7.2 Anticipated Energy Savings

The following table provides an estimate of the energy savings from each of the potential retrofits. These figures were based on the energy consumption of each home characteristics of which are outlined in Table 2.

Table 16: Summary of Anticipated Energy Savings

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Bathroom Ventilation	Yes	Yes	Yes	Yes
Energy Saved	None (replace existing)	None (replace existing)	None (replace existing)	None (replace existing)
Kitchen Ventilation	Yes	Yes	Yes	Yes
Energy Saved (15.4 watt draw[80])	Would double existing fan power use.	Would double existing fan power use.	Would double existing fan power use.	Would double existing fan power use.
Heat Recovery Ventilator	Yes	Yes	Yes	Yes
Energy Saved GJ/year[81]	Not calculated	Not calculated	Not calculated	Not calculated
Triple Pane Window	Yes	Yes	Yes	Yes
Energy Saved GJ/year	3.5	3.8	4.8	2.5
Awning Upgrade	Yes	Yes	Yes	Yes
Electricity Energy Saved GJ/year	None	None	9.7	None
Insulation Upgrade	No	Yes	Yes	Yes
Total Energy Saved wood/gasoline/oil GJ/year**	74	66	102	66
Door Upgrade	Yes	Yes	No	Yes
Total Energy Saved wood gasoline heating oil GJ/year**	2.1	2.3	2.9	1.5
Wood Heater	Yes	Yes	Yes	Yes
Total Energy Reduction (wood + gasoline) using Catalytic or Advanced Technology Wood Stove (70% eff. GJ/year)	29.7	35.6	54.9	35.6
Hot Water Space Heating– Electricity - Hi-Velocity System Retrofit – only if house were to be totally upgraded with insulation	Yes	Yes	Yes	Yes
Energy Reductions – depends on availability of wind power, GJ/year	Unknown	Unknown	Unknown	Unknown

[80] Steam and Sauna Connection. Url: http://steamsaun.com/fans.htm. 28 January, 2002

[81] Personal communication. Wilf Sheuer. Pro Star Mechanical Technologies Ltd. Victoria B.C. Phone: 250-383-4558. 22 February, 2002.

Table 16: Summary of Anticipated Energy Savings – (continued)

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Hot Water Space Heating – Solar Supplement – Radiator Retrofit	Yes	Yes	Yes	Yes
Energy of reduced electricity (diesel GJ), wood, and/or oil, GJ/year	Up to 27	Up to 27	Up to 27	Up to 27
Hot Water Only – Solar Supplement	Yes	Yes	Yes	Yes
Electricity Energy Displaced GJ/year -	5	5	5	5
Lights Upgrade opportunity	Yes	Yes	Yes	Yes
Electricity Energy displaced GJ/year	1.75	1.75	1.75	1.75

7.3 Anticipated Financial Savings

The following table outlines an estimate of financial savings from each energy efficiency option. These were based on the current electrical, oil, and wood prices as outlined in Chapter 3.

Normally, where wood is the primary heat source, the electrical heating load will be nominal and the bill for electricity will fall within the lower threshold of costs per kilowatt hour (kWh) on the YECL electrical rates. However, when electricity is used for heating, it is possible that the demand will be large enough to push the electricity cost into the next higher bracket that is more than double the rate of the lower one as outlined in Section 3.4 above. Calculations in this study arbitrarily apply the lower rate bracket of less than 1,000 kWh/month to initiatives that will use electricity in the summer months, and, as each of the four houses has at least one electrical baseboard heater, the higher rate of greater than 1,000kWh/month for initiatives that will use electricity in the winter months (1 October — 31 March inclusive).

Table 17: Summary of Financial Savings

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Bathroom Ventilation	Yes	Yes	Yes	Yes
Money saved	None	None	None	None
Kitchen Ventilation	Yes	Yes	Yes	Yes
Money saved	Would double existing fan power cost	Would double existing fan power cost	Would double existing fan power cost	Would double existing fan power cost
Heat Recovery Ventilator	Yes	Yes	Yes	Yes
Money saved/year	Not determined	Not determined	Not determined	Not determined
Triple Pane Window	Yes	Yes	Yes	Yes
Money saved/year	$72.00	$54.00	$67.00	$36.00
Awning Upgrade	Yes	Yes	Yes	Yes
Money saved (electricity cooling)/year**	None	None	$107 .00	None
Insulation Upgrade	No	Yes	Yes	Yes
Total saved/year **	$1,516.00	$928.00	$1,430.00	$928.00
Door Upgrade	Yes	Yes	No	Yes
Total savings wood gasoline oil/year**	$44.00	$33.00	$41.00	$22.00
Wood Heater Upgrade	Yes	Yes	Yes	Yes
Money saved/year from catalytic/Advanced combustion wood heater wood/gasoline energy use reduction	$441.80	$530.15	$817.32	$530.15
Hot Water Space Heating – Electricity - Hi-Vel Retrofit	Yes	Yes	Yes	Yes
Energy cost savings/year in wood gasoline, oil	Not determined.	Not determined.	Not determined.	Not determined.

Table 17: Summary of Financial Savings (continued)

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Hot Water Space Heating - Solar Supplement, Radiator Retrofit	Yes	Yes	Yes	Yes
Savings/year with solar and radiator retrofit - displacing wood, gasoline, oil, electricity	$424.00	$380.00	$381.00	$380.00
Hot Water Only – Solar Supplement	Yes	Yes	Yes	Yes
Money Saved/Year Electricity	$240.00	$240.00	$240.00	$240.00
Lights Upgrade	Yes	Yes	Yes	Yes
Money Saved/Year Electricity	$126.00	$126.00	$126.00	$126.00

7.4 Financial Assessment

The following table provides a financial assessment of each retrofit option. This was done through the following procedure:

- The capital cost of each item was amortized over the individual product life using a 5% discount rate to convert the capital cost into annual payments.
- The annual operating costs were added.
- The annual energy savings were subtracted.
- The "Simple Payback" is a measure of the time it takes to repay the total capital cost of the investment using the savings realized each year. No depreciation of assets or inflation of the value of money over time is considered in this calculation.
- The "Net Present Value" (NPV) is equivalent to the total value of the investment in today's dollars, with all future costs and energy savings discounted according to the year in which they occur (i.e., savings in the long-term are considered less valuable than savings in the short-term), added together, and expressed as a single number. A positive NPV value indicates a worthwhile investment, assuming the assumptions are correct. A negative NPV value suggests the investment is not justifiable on purely financial grounds, but could be justifiable for environmental purposes.
- The "Internal Rate of Return" (IRR) is a calculation of the expected profit to be earned by undertaking the investment. It is essentially the percentage profit that one would earn for a given dollar investment. Where there is no direct financial saving, "N/A" is included in the IRR slot.

Table 18: Summary of Financial Assessment Data

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Bathroom Ventilation	Yes	Yes	Yes	Yes
Simple Payback (years)	N/A	N/A	N/A	N/A
Net Present Value	($620.95)	($620.95)	($620.95)	($620.95)
Internal Rate of Return	N/A	N/A	N/A	N/A
Kitchen Ventilation	Yes	Yes	Yes	Yes
Simple Payback (years)	N/A	N/A	N/A	N/A
Net Present Value	($620.95)	($620.95)	($620.95)	($620.95)
Internal Rate of Return	N/A	N/A	N/A	N/A
Heat Recovery Ventilator	Yes	Yes	Yes	Yes
Simple Payback (years)	Not determined	Not determined	Not determined	Not determined
Net Present Value	Not determined	Not determined	Not determined	Not determined
Internal Rate of Return	Not determined	Not determined	Not determined	Not determined
Triple Pane Window	Yes	Yes	Yes	Yes
Simple Payback (years)	44	59	47	89
Net Present Value	($2,170.00)	($2,390.00)	($2,230.00)	($2,600.00)
Internal Rate of Return	-6.6%	-8.7_	-7.1%	-11.4%
Awning Upgrade	Yes	Yes	Yes	Yes
Simple Payback (years)	N/A	N/A	10.54	N/A
Net Present Value	($1,078.57)	($1,078.57)	$196.96	($1,078.57)
Internal Rate of Return	N/A	N/A	7.07%	N/A
Insulation Upgrade Icynene	No	Yes	Yes	Yes
Simple Payback (years)	11	15	11	21
Net Present Value	$2,560.00	($2,000.00)	$1,330.00	($7,600.00)
Internal Rate of Return	6.9%	3.1%	6.0%	-0.5%

Table 18: Summary of Financial Assessment Data (continued)

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Door Upgrade	Yes	Yes	No	Yes
Simple Payback (years)	42	57	45	85
Net Present Value	($1,240.00)	($1,370.00)	($1,270.00)	($1,500.00)
Internal Rate of Return	-6.3%	-8.35%	-6.8%	-11.1%
Wood Heater Upgrade to 70%	Yes	Yes	Yes	Yes
Simple Payback (years)	6	5	3	5
Net Present Value	$2,230.00	$3,280.00	$6,690.00	$3,280.00
Internal Rate of Return	14.2%	18.0%	29.5%	18.0%
Hot Water Space Heating – Electricity - Hi-Velocity Retrofit	Yes	Yes	Yes	Yes
Simple Payback (years)	Not determined	Not determined	Not determined	Not determined
Net Present Value	Not determined	Not determined	Not determined	Not determined
Internal Rate of Return	Not determined	Not determined	Not determined	Not determined
Hot Water Space Heating - Solar Supplement – Radiator Retrofit	Yes	Yes	Yes	Yes
Simple Payback (years)	19	21	21	21
Net Present Value	($3,850.00)	($4,370.00)	(4,360.00)	($4,370.00)
Internal Rate of Return	-2.0%	-3.2%	-3.2%	-3.2%
Hot Water Only – Solar Supplement	Yes	Yes	Yes	Yes
Simple Payback (years)	25	25	25	25
Net Present Value	($3,200.00)	($3,200.00)	($3,200.00)	($3,200.00)
Internal Rate of Return	-3.09%	-3.09%	-3.09%	-3.09%
Lights Upgrade	Yes	Yes	Yes	Yes
Simple Payback (years)	0.7	0.7	0.7	0.7
Net Present Value	$870.00	$870.00	$870.00	$870.00
Internal Rate of Return	102%	102%	102%	102%

7.5 Emission Reduction

The following table outlines anticipated emission reductions. They are based on the following assumptions of resulting reductions:

- Wood displacement: 76.50 kg CO_2eq per GJ of wood energy displaced.
- Oil displacement: 83.47 kg CO_2eq per GJ of oil energy displaced.
- Electricity displacement: 197.22 kg CO_2eq per GJ of electricity displaced.
- Gasoline displacement: 78.34 kg CO_2eq per GJ of gasoline energy displaced.

Table 19: Summary of kg CO_2eq/year Emissions Reductions

Unit	Nukon (705)	Netro (755)	Moses (765)	Safe House (850)
Bathroom Ventilation	Yes	Yes	Yes	Yes
Total kg CO2eq/year emissions reduction	0	0	0	0
Kitchen Ventilation	Yes	Yes	Yes	Yes
Total kg CO2eq/year emissions reduction	0	0	0	0
Heat Recovery Ventilator	Yes	Yes	Yes	Yes
Total kg CO2eq/year emissions reduction	Not calculated	Not calculated	Not calculated	Not calculated
Triple-Pane Window	Yes	Yes	Yes	Yes
Total kg CO2eq/year emissions reduction	276	294	366	195
Awning Upgrade	Yes	Yes	Yes	Yes
Total kg CO2eq/year emissions reduction	0	0	631	0
Insulation Upgrade	Yes	Yes	Yes	Yes
Total kg CO2eq/year emissions reduction	50,801	59,067	91,062	59,067
Door Upgrade	Yes	Yes	Yes	Yes
Total kg CO2eq/year emissions reduction	168	179	223	118
Wood Heater Upgrade	Yes	Yes	Yes	Yes
Total kg CO2eq/year emissions catalytic wood heater reduction	2423	2908	4483	2908

Table 20: Summary of kg CO_2eq/year Emissions Reductions (continued)

Hot Water Space Heating – Electricity - Hi-Velocity Retrofit	Yes	Yes	Yes	Yes
Total kg CO2eq/year emissions reduction	Not calculated	Not calculated	Not calculated	Not calculated
Hot Water Space Heating - Solar Supplement – Radiator Retrofit	Yes	Yes	Yes	Yes
Total kg CO2eq/year emissions reduction	1869	1858	1858	1858
Hot Water Only – Solar Supplement	Yes	Yes	Yes	Yes
Total kg CO2eq/year emissions reduction	980	980	980	980
Lights Upgrade	Yes	Yes	Yes	Yes
Total kg CO2eq/year emissions reduction	345	345	345	345

8 Monitoring

A request has been made to the VGFN Government Services Department to initiate the collection of electricity, oil bills and wood consumption data. These data will be used to establish a baseline of energy consumption for the houses in Old Crow. With this baseline in place, it will be possible to readily determine the impact upon energy consumption due to the retrofits installed.

As this database becomes established for the houses and buildings in Old Crow, It is also recommended that digital relative humidity (RH) and temperature data loggers be installed as soon as possible in all buildings documented in this report, except for the Safe House, plus one other home earmarked for retrofit in the future. In addition, the Yukon Energy Solutions Centre in Whitehorse has suggested that they could provide this monitoring equipment. These monitors would ideally be used to collect data from now until throughout the remainder of this winter, and continue to next winter. One particular data logger that could help in this respect is the HOBO H8 RH/Temp Logger along with its related mobile download device and software.[82] ACR Systems Inc (http://www.acrsystems.com) also sells data loggers. Albert Rock of Yukon is the owner of ACR and is presently operating out of a lower mainland office in Surrey, British Columbia.[83]

Table 21: Monitoring and Control Systems

Unit Description	Price and Quantities	Function
Monitoring HOBO® H8 RH/Temp Logger	US$85 each (1.63 CAN$ conversion = $140) – Need 4four units (total $640)	Measures Temperature and Relative Humidity (real time); download software required.
HOBO® H8 RH/Temp Logger Shuttle	Approximately CAN$260 –Need 1one unit	Enables one unit to download separate logs and bring to single PC for processing.
HOBO® H8 RH/Temp Logger software (Boxcar Pro 4.0)	Approximately CAN$155) – Need 1one package	Allows enhanced data management for results: graphs, displays.
ACR systems Inc logger – Smart Reader 2	CAN$919 Need one logger	Records measurements from temperature and relative humidity probe (real time); download software required.
ACR systems software for Logger	CAN$189 Need one package	Is needed to operate database and record data download from Logger to single PC for processing.
ACR systems probe	CAN$219 Need four probes (total CAN$880)	Sensor that records temperature and humidity, and transmits signal to logger.

ACR Systems Inc (http://www.acrsystems.com) also sells data loggers. Albert Rock of Yukon is the owner of ACR and he is presently operating out of a lower mainland office in Surrey, British Columbia.[84]

Infrared scanning of the buildings to be retrofitted can also provide considerable information on their level of energy efficiency performance. Before and after images of the retrofitted buildings should be

[82] Onset Computer Corporation. Url: http://www.hobologgers.com/Products/Product_Pages/HOBO_H08/3926_H08rhtemp.html. 26 January, 2002.
[83] Phone contact: Local: 1(604)-591-1128: Toll Free:+1-800-663-7845
[84] Phone contact: Local: 1(604)-591-1128: Toll Free:+1-800-663-7845

considered as a part of this project. These surveys would be used to complement the building information generated by the EnerGuide evaluations. Phil Louden[85] is familiar with such services that might be of help in the monitoring stage of this project.

- Finally, Yukon Housing Corporation will provide an EnerGuide "B" Audit free -of -charge following the completion of energy retrofits. [86] (EnerGuide "A" audits provide high-tech information that can help pinpoint repair and energy upgrade options. Follow-up "B" audits show how a home's energy efficiency has improved after the repairs and upgrades have been done.)[87]

[85] Phil Loudon. Independent –residential energy specialist. Phone 907-452-8368. Email: nrgtech@polarnet.com
[86] Phone Yukon Housing Corporation Head Office in Whitehorse: 1-800-661-0408, ask for 5759. In Whitehorse phone: 867- 667-5759 or email: ykhouse@housing.yk.ca
[87] Yukon Housing Corporation. Url: http://www.housing.yk.ca/services/hrp.html. 3 July, 2002.

9 Potential Environmental and Employment Aspects

Up to this point the report has focused on the energy and financial benefits of energy-efficiency retrofits in houses in Old Crow. There are many other aspects to consider when addressing retrofits, such as personal choice, comfort, and social infrastructure. These are factors that are beyond the scope of this report to analyze. Only the residents of Old Crow can evaluate these options. However two other characteristics related to the renovation options proposed in this report that should be addressed are potential environmental and employment impacts.

9.1 Air Emission Reductions

Emissions are generated whenever energy is used, and in Old Crow, energy is usually generated from the combustion of fossil fuels. When any fuel is combusted, a number of gaseous and particulate byproducts are generated. These can vary from being benign to toxic to humans. Through the reduction in fuel consumption, air quality can improve.

Greenhouse gasses (GHGs) trap heat in the atmosphere. This is a natural process, and has contributed to the generation of life on this planet by maintaining a temperature that supports our species and those around us. However, it has been determined that humans have been contributing to the sum of the greenhouse gasses at a rate far in excess of natural progression. This is having the effect of warming the earth at an historically untimely rate, resulting in global climate change. There are many GHGs, but when addressing combustion sources three are of particular concern: carbon dioxide, nitrous oxide and methane. The greater the volume of these gasses emitted, the more we contribute to climate change. Other emissions, though not classified as greenhouse gasses are also of concern:

- Particulate matter (PM) emissions are not classified as a GHG, but are harmful to the respiratory tract and a constituent of smog. PM emissions are usually classified into three sizes: all sizes (PM), smaller than 10 microns (PM10), and smaller than 2.5 microns (PM2.5). Simply put, the smaller the particle size, the deeper into the lungs that the particle can penetrate and, the more potential damage it can cause. Wood combustion emits significant amounts of particulate matter in all three categories.

- Carbon monoxide (CO) emissions impair the body's ability to deliver oxygen to cells. Wood and oil combustion create CO.

- Volatile organic compound (VOC) emissions contribute to ground-level ozone or "urban smog" (harmful to the respiratory tract and plant productivity; a constituent of smog) and PM formation and are emitted primarily through fossil fuel and wood combustion.

- Nitrogen oxides (NO_x) are harmful to the respiratory tract, contribute to acid deposition, and are a precursor to ground level ozone (i.e., "smog") and PM creation. They are emitted through fossil fuel combustion.

Sulphur oxides (SO_x) are harmful to the respiratory tract, contribute to acid deposition (e.g., acid rain), and are a precursor to PM creation. They are emitted through fossil fuel combustion.

9.1.1 Wood

Wood is one of the predominant fuels used in the area. It is one of the least expensive options, and has been used in the northern communities probably as long as anyone can remember. However, even with its currently limited use in Old Crow, shortfalls in the resource have begun to occur. It is noted in this report that one has to go further and further from town to get the wood appropriate for burning. The northern forest along the treeline where Old Crow is situated does not regenerate quickly and, as a result, is becoming depleted. Care in its use through more efficient combustion, or displacement with another fuel type will help prolong the life of this resource.

The aggregate equivalent weight of carbon dioxide that is produced from burning 1,000 kilograms of wood is roughly 1,550 kilograms. [88]

9.1.2 Heating Oil

Burning heating oil is much more expensive than burning wood for the same heat energy content, but it is not all that different from wood when the combustion process takes over. It contributes to the same air emissions and GHG accumulation in the atmosphere.

Heating oil produces a number of contaminants during the combustion process as does wood, but it produces 2.83 kg of CO_2 per litre combusted. [89]

9.1.3 Diesel Fuel

Electricity is produced in Old Crow by a diesel-fired reciprocating engine. This engine burns the diesel fuel and emits the emissions up the exhaust stack.

Along with particulate matter and other fossil fuel related emissions, diesel fuel oil also produces roughly 710 kg of CO_2 per 1,000 kWh of generated electricity from the combusted diesel. [90]

9.1.4 Gasoline

Stands of good wood reserves are receding further and further from the town. At this time it is roughly 18 km to the closest stand of good wood. Driving and sledding to the site likely result in the consumption of gasoline.

As with diesel, gasoline produces a wide range of fossil fuel combustion emissions as well as roughly 20 kg of CO_2 per 8.3 litres of unleaded gasoline combusted (100 km travelled).[91]

9.2 New Employment

Employment opportunities exist for those who are trained in the installation of the various energy efficiency retrofit installation options mentioned. There is minimal employment otherwise in the upkeep of the installed options - most being permanent fixtures (doors, windows, insulation) or systems that require minimal personal effort to maintain their proper performance (changing light bulbs or batteries).

Some of the contractors that can do the work described offer annual training sessions, and the insulation contractor has also expressed interest in a joint venture opportunity as a part of their potential

[88] Pembina Clearing House. Wood in incinerator. 29 January, 2002.
[89] Pembina Clearing House. Heavy oil in burner incinerator. 29 January, 2002.
[90] Pembina Clearing House. Diesel powered electricity generation. 29 January, 2002.
[91] Pembina Clearing House. The operation of a light duty gasoline powered vehicle. 29 January, 2002.

involvement in working in Old Crow (see Appendix E). In addition, it has been mentioned that a number of local people have attended the EnerGuide Workshop and have passed the exams proving their ability to fulfil various contracting obligations related to the initiatives proposed in this report.

The options presented in this report offer a variety of short-term employment opportunities for those with the appropriate skills. Table 21 provides a list of retrofit options together with the types of skills needed to install the option. Employment estimates are generated from estimates provided by the various reviewers and the writers of this report.

Table 22: Employment options — Skills Identification

Retrofit Option	Skill Sets Required	Potential Employment Per House To Be Retrofitted*
Kitchen Fan Venting	Electrical, framing, carpentry finishing	½ day
Bathroom Fan Venting	Electrical, framing, carpentry finishing	½ day
Heat Recovery Unit	Electrical, framing, carpentry finishing	1 day
Triple Pane Windows	Framing, carpentry finishing, insulation wrapping	5 windows – 2 ½ days Suggested to replace windows instead on an as needed basis.
Awnings Installation	Carpentry finishing, framing	1 day
Insulation Upgrade	Woodwork, framing, specific insulation training	3 days (outside framing of two days supplied by community and 1 day for insulation crew)
Door Upgrade	Framing	1 day – 2 doors
Wood/oil Stove Upgrade	Venting	½ day (venting only)
Install Thermal Mass	Interior renovation (Drywall installation) or heavy lifting (rock gathering and placement)	Drywall – 4 days Rock gathering – ongoing as desired
Draft Proofing	Caulking and framing	½ day
Hot Water Space Heating – Electricity Hi-Velocity Retrofit	Electrical, venting, framing	1 day
Hot Water Space Heating - Solar Supplement – Radiator Retrofit	Electrical, special technical, venting, plumbing	2 days
Hot Water Only – Solar Supplement Upgrade	Electrical, special technical, venting, plumbing	2 days
Lights Upgrade	None	No employment – self initiated
Monitoring	Special technical.	Ongoing till enough data is acquired. 1 day/week for data gathering and reporting.

* employment for one person

On a much larger scale, information on comparative employment opportunities between various sectors per dollar invested is demonstrated in Appendix G. These statistics indicate greater employment is provided per dollar invested in renewable energy initiatives and energy efficiency, than if the same number of dollars is invested, for example, in the energy development sector.

10 Conclusions and Discussion

From the various analyses, it can be noted that there are several opportunities to reduce energy consumption, costs, and emissions, and to earn a financial return on the investments required. Overall, it could be said that the costs for the renovations, even the most expensive ($19,600 for the most expensive Icynene insulation initiative), are less than the costs of constructing an entirely new building (in 1996 a home with two bedrooms had an estimated value of $46,840). The renovations will also greatly improve the air quality and personal comfort level of the residents within the homes involved.

These analyses are presented below in two sections: their competitive positions related to financial, energy and environmental aspects (Section 10.1), and their individual characteristics (Section 10.2).

10.1 Competitive Aspects of Comparison

Conclusions in this section are organized into three sections: financial, energy and environmental aspects. In each section are noted the greatest values realized from the study results.

10.1.1 Financial Aspects

A number of the options proposed for the various renovation candidates have a positive rate of return on investment, or at least a simple payback period that is realistic for a home renovation investment time frame (20 years). Details on specific results of simple payback, net present value and internal rate of return can be found in Table 17. The renovations that will reap the greatest financial returns, presented in no particular order, are as follows:

- Awning upgrade: 10-year payback
- Insulation upgrade: 11–21-year payback
- Wood heater upgrade (catalytic or advanced combustion): 3–6-year payback
- Solar heating radiator system: 19–21-year payback
- Lights: 9-month payback

10.1.2 Energy Aspects

The most significant absolute energy use reductions were realized with the following measures (see Table 16 for specific data):

- Insulation: 66–102 GJ/year
- Wood heater upgrade (catalytic or advanced combustion): 32–58 GJ/year
- Radiator heating system with solar heating and wind power: up to 27 GJ/year

10.1.3 Environmental Aspects

Those initiatives that have the greatest absolute emissions reduction potential are as follows (see Table 19 for specific data):

- Insulation: 51,000–91,062 kg CO2e /year
- Wood heater upgrade (catalytic/ advanced combustion): 2,400–4,500 kg CO2e /year
- Radiator with solar and wind: up to 1,860 kg CO2e /year

10.2 Individual Characteristics

This section provides a summary of the suitability of each of the retrofit options as well as a review of its benefits.

10.2.1 Kitchen and Bathroom Fan Venting Operation

It is evident that the fans in place are not working properly and need to be replaced on the whole. The replacement fans include a humidistat, and are designed to exhaust humid air from the home. Reduced relative humidity will reduce condensation on the windows and improve interior levels of comfort. There is no direct financial advantage to installing a fan venting system. Indirectly, the installation and effective use of this system may prevent the development of problems related to humidity build-up in the interior of the home, such as wood rot and mildew growth.

Benefits summary

- Financial benefits: Money would be "saved" by replacing existing systems being used that don't presently ventilate properly.
- GHG reduction benefits: yes
- Other benefits: important component to reduce interior humidity levels

10.2.2 Heat Recovery Unit

A heat recovery unit (HRV) would typically be used in a home that had a very tight air envelope and was well insulated. The HRV captures heat from interior air that is exhausted, and transfers a portion (65%) of the heat to the incoming air. It is not clear whether or not there is an economic advantage to the installation of such a unit; otherwise it is a very important component in a tightly designed home system.

Benefits summary

- Financial benefits: not determined
- GHG reduction benefits: not determined
- Other benefits: significantly important component of an airtight house system

10.2.3 Triple-Pane Window Replacement

These windows provide better insulating value than that offered by double-pane windows. A Low-E coating reduces the amount of light that is transmitted through the window that may have an adverse effect upon residents. The extra insulation provided by the use of Argon gas between the panes is apparently short lived, as the Argon has a tendency to leak out after a few years.

Having a protective pane of glass, installed as the outer pane within the triple-pane frame will not likely protect interior panes from damage related to impact. The whole window needs to be replaced when a glass pane is broken, whether or not a protective pane within the three-pane window is installed. A separate exterior protective pane installation may prove to be a safety hazard in case of an emergency (prevention of access into and out of the residence) and may hamper the operation of windows.

Benefits summary

- Financial benefits: very long payback period
- GHG reduction benefits: yes
- Other benefits: reduces interior condensation problems and cold drafts

10.2.4 Awning Upgrade

A proper awning installation over windows will help reduce solar heat input into the home in the summer. This would potentially reduce indoor air temperatures in the summer, reducing the demand for air conditioning in those homes that have it, and otherwise making the home more comfortable with reduced interior temperature.

Benefits summary

- Financial benefits: very long payback period for homes that use air conditioning
- GHG reduction benefits: yes, from homes that use air conditioning
- Other benefits: improvement in interior comfort level in summer

10.2.5 Insulation Upgrade

There are numerous types of insulation to use in a house. Some offer more airtight qualities and insulating value per inch of thickness than others. Foam insulation applications are more expensive than cellulose and glass fibre installations, but create an airtight seal not inherent in the application of other insulation options. Each insulation type has its own operating characteristics; some insulate better than others, they vary in their response to exposure to moisture and fire, and they require different application methods.

Table 24: Insulation Upgrade Options

Insulation	Fire resistant	Fire Retardant	Vapour Barrier	Air tight installation	Insulation cost $/ft^2	Comparative R value to Fibreglass batt
Cellulose	Yes	Yes	No	Potential	4	1.25
Icynene	Yes	Yes	No	Yes	6	1.25
Waltite	No	No	Yes	Yes	7	2

Benefits summary

- Financial benefits: payback period of from 11 to 21 years
- GHG reduction benefits: significant
- Other benefits: less draft in the house.

10.2.6 Door Upgrade

A metal insulated door has a much higher insulating value than a traditional solid wood core door.

Benefits summary

- Financial benefits: very long payback period
- GHG reduction benefits: yes
- Other benefits: no cold drafts from door area in winter

10.2.7 Space Heating

10.2.7.1 Baseboard Heat

The installation of a baseboard heater with a gas diaphragm controller will reduce electricity consumption compared to electrical controllers. This option would garner greater support upon the installation of a wind power facility in Old Crow as electricity use presently comes at a premium cost.
Benefits summary:

- Financial: not determined.
- GHG reduction benefits – not determined, but anticipated to be small
- Other Benefits – should reduce energy consumption – inexpensive option to meet specific heat source application (water tank)

10.2.7.2 Wood Heater Upgrade

A typical wood burning stove in Old Crow probably operates at an efficiency of roughly 50–55%. There are commercial catalytic and advanced combustion stoves that claim an efficiency of around 70%. Using a stove with a higher efficiency rating has the potential to reduce fuel costs, fuel used, air pollution generated during the heating season, and overall annual production of greenhouse gas emissions.

Benefits summary

- Financial benefits: relatively short payback period
- GHG reduction benefits: yes
- Other benefits: potentially extends the life of the local wood supply

10.2.7.3 Oil Heating

Existing oil heaters are determined to be efficient, and need not be replaced. The installation of oil heating should be compared to that of wood heating.

Benefits summary

- Financial benefits: not determined
- GHG reduction benefits: not determined
- Other benefits: potentially extends the life of the local wood supply by displacing wood heat with oil heat

10.2.7.4 Hot Water for Space Heating – Hi-Velocity System Retrofit

As analysed in this study, the Hi-Velocity unit would take heat from a hot water tank and distribute it throughout the home. This option would not be considered unless the home was to be retrofit with significant insulation, air and vapour barrier systems. It is presently being used very successfully to distribute the heat from oil-fired heaters in two residences in Old Crow.

Benefits summary

- Financial benefits: have not been determined
- GHG reduction benefits: have not been determined
- Other benefits: improved distribution of heat throughout the home.

10.2.7.5 Hot Water for Space Heating - Solar Supplement

As analysed in this study, the Hi-Velocity unit or a hot water radiator system would take heat from a hot water tank and distribute it throughout the home. The solar collector system would provide heat to supplement the electrically heated hot water system.

Benefits summary

- Financial benefits: simple payback period of from 19 to 21 years
- GHG reduction benefits: yes
- Other benefits: improved distribution of heat throughout the home, and use of solar energy

10.2.8 Thermal Mass

Adding thermal mass to a home will help reduce heating demand fluctuations related to sudden outdoor temperature changes.

Benefits summary

- Financial benefits: have not been determined, but the option could be very inexpensive (could put large rocks found locally around a heat source or in discrete locations)
- GHG reduction benefits: have not been determined
- Other benefits: retention of heat, simple to implement, no maintenance

10.2.9 Draft Proofing

Adding Weather stripping and caulking as needed to window and door frames will reduce air infiltration in the home.

Benefits summary

- Financial benefits: have not been determined as there is a wide variance in potential application from house to house, but the option is anticipated to be of a low cost, and energy savings are immediate.
- GHG reduction benefits: have not been determined, but there would be a reduction benefit
- Other benefits: little labour involved, simple to implement, low to no maintenance, and reduced discomfort from drafts in the home.

10.2.10 Setback Thermostat

For those homes that have controllable heat sources (electricity and oil) the setback thermostat could be an effective energy conservation device.

Benefits summary

- Financial benefits: have not been determined but could incur no cost if the occupant would adjust the temperature requirement to match occupancy demands (when not in the home, turn the thermostat down before leaving)
- GHG reduction benefits: have not been determined
- Other benefits: the thermostat would automatically adjust for routine occupancy heat requirements

10.2.11 Carbon Monoxide Detector

Having a carbon monoxide detector in the home is a fundamental matter of safety.

Benefits summary

- Financial benefits: have not been determined
- GHG reduction benefits: not applicable
- Other benefits: could save lives, and reduce property damage

10.2.12 Hot Water Only - Solar Supplement Upgrade

The solar collector system would provide heat to supplement the electrically heated hot water system only.

Benefits summary

- Financial benefits: very long payback period of 25 years
- GHG reduction benefits: yes
- Other benefits: use of solar energy – displacement of electricity used from diesel powered generator.

10.2.13 CFL Upgrade

Screw-in compact fluorescent lights can be used in place of regular incandescent lights without affecting the light output levels. The Panasonic versions are known to operate in an "instant on" fashion, at temperatures as cold as –21°C.

Benefits summary

- Financial benefits: very short payback period of 9 months
- GHG reduction benefits: some
- Other benefits: easily installed as replacements for the spent incandescent bulbs

10.2.14 Water/Sewage

Using a more efficient liquids pump, installed in a replacement maintenance program< could reduce overall energy consumption.

Benefits summary

- Financial benefits: have not been determined
- GHG reduction benefits: have not been determined, but are estimated to be reduced
- Other benefits: could realize quieter operation, greater reliability

10.2.15 Appliances

Installing a more efficient appliance could reduce overall energy consumption.

Benefits summary

- Financial benefits: have not been determined
- GHG reduction benefits: have not been determined, but are estimated to be reduced
- Other benefits: could realize quieter operation, greater reliability – concern over landfill issues

10.2.16 Monitoring

Equipment exists to monitor the temperature and relative humidity in houses and record the information on a continuous basis. This information could be used to determine the effectiveness of the retrofit installations.

Benefits summary

This illustrates how effective the retrofits are which is critically important to the community to direct future investments in housing.

11 Recommendations

As mentioned elsewhere in this report, it is not the purpose of these recommendations to impose the values of the writers upon those who have an interest in the renovations proposed. These lists of recommendations are drawn from the various observations made elsewhere in this report.

Recommended:

- *install specified kitchen or bathroom venting at a minimum.* Though not an economically directed measure, this option offers major venting advantages, contributing to the improvement of air quality in the home through better removal of humidity from the home. With this option it is advised to include the humidistat controller to ensure the fan system is operating at its best.

- *install a heat recovery unit (HRV) only if the home undergoes significant "tightening" due to renovations.* The benefit of its use stems from its role as a significantly important component in a total, tight house design, allowing air in and out under controlled conditions. It is not recommended to install an HRV in the home under consideration if no exterior wall, floor and ceiling insulation and vapour barrier improvement options are installed.

- *install triple-pane windows without a Low-E coating or protective laminate pane, upon need for replacement only.* The coating is not recommended as it reduces light infiltration. The protective laminate pane is not recommended as it comes at a premium cost that doesn't contribute to reducing overall window replacement costs. Though the protective pane would possibly reduce energy losses from the home if the window were to be broken in the winter, this energy loss is not considered to be of significant economic value.

- *install appropriately designed awnings for homes that have air conditioning.* This would reduce the air conditioning load and therefore the electricity load. If installed in other homes, there would be no economic advantage, but the home might stay cooler in the summer than otherwise, and be more comfortable to the occupant.

- *install Icynene insulating foam to the outside of the buildings to be renovated.* This is a step up from using cellulose and ensures an airtight barrier will be formed when the installation is complete. This will greatly increase the comfort level in the home, with fewer drafts, greater heat retention, and less of a temperature differential throughout the rooms in the house. Icynene is selected as it is a fire retardant and a proved product, and offers air tightness and high insulation qualities.

- *install metal insulated doors.* Though the payback may be limited, cold drafts from door areas would be reduced, and the door installation would contribute to improving the overall insulation value of the home.

- *upgrade to the use of advanced combustion wood stoves.* Though they entail a long payback period (four to eight years), their use would reduce annual firewood home heating requirements, and potentially reduce air pollution levels realized during the heating season. Catalytic stoves are not recommended as an option as they need significant maintenance, and it appears that manufacturers are moving away from supporting the catalytic design. This upgrade should be done even if an older inefficient wood stove is not being considered for replacement in order to start reducing the demand on the local wood supply, and to improve local air quality during the heating season.

- *upgrade to the use of a high efficiency oil heater.* If an inefficient wood stove is being replaced, the options are to consider a more efficient wood stove as indicated in this report, or an efficient oil heater. The use of an oil heater would contribute to the reduction of demand upon the local wood supply.

- *install thermal mass as convenient in the home.* This is potentially inexpensive, and requires no maintenance.

- *install weather stripping or caulking as required to reduce drafts from doors and windows.* This is low in capital cost, requires little labour, and relatively no maintenance.

- *install a setback thermostat on any heating appliances*; or set up a routine to set back the thermostat depending upon occupancy heating demands. The capital cost ranges from zero to minimal depending upon the option chosen and a significant energy reduction could result.

- *install a carbon monoxide detector.* Theses are inexpensive and could save a life. These are invaluable. They will however require battery replacement annually if the hard-wired model is not used.

- *upgrade to using compact screw-in type fluorescent light bulbs.* They offer a short payback period, no difference in lighting levels as compared to incandescent bulbs and are easy to upgrade. Installing compact fluorescent lights is very economical and significantly reduces the electricity load related to the use of lights, which is provided by a diesel-fired power generation system. These should be installed as replacements for burned out incandescent bulbs.

- *install a high efficiency liquids pump when it is determined that replacement is required.* This will reduce energy consumption, generate a potential payback, and may improve operating reliability.

- *replace old inefficient appliances with new energy efficient appliances as specified by the EnerGuide for Equipment Appliance Directory.* Replacement of existing appliances may be warranted in some situations when the old appliance has excessive energy demands, regardless of the waste management issues of disposing existing ones. *Energy that is wasted throughout the useful life of some inefficient appliances before being replaced may prove to be significant.*

- *complete an EnerGuide for Houses "B" Audit, and install monitoring equipment to collect accurate energy consumption data on houses before and after renovations take place to determine the effectiveness of the renovations.* This would generate data that could be used to direct future investments in housing.

Tentatively recommended:

- *install an electrical space heating system in the house if wind power is introduced into the community.* This could be achieved through the installation of electric baseboard heaters in each room or a Hi-Velocity unit with ductwork. The Hi-Velocity unit has already been successfully introduced in two units in Old Crow (new Yukon Housing corporation units). The Hi-Velocity units are tied into oil-fired hot water tank heater venting. However, it is not recommended this be done if no exterior wall, floor and ceiling insulation and vapour barrier improvement options are installed. This option should only be considered for low-energy-use homes, as it is not clear from the existing data what the financial and energy savings might be. The benefit of its use stems from evenly distributing heat within the whole house.

11.1 Solar Option Comments

All solar energy options are eligible for a Renewable Energy Deployment Initiative (REDI)[92] grant that is applied to the expense of the solar portion of the system installed. Through our preliminary assessment, the solar energy options show viability with the inclusion of the 40% capital cost grant. Simple payback calculations, allowing no discount for inflation, indicate a payback period in the range of 20 years. All solar options should be studied in more detail to determine more accurate economic and environmental impacts as related to specific solar applications in the Old Crow environment. Solar energy options reduce the need for electricity for hot water and oil or wood for space heating if established in that manner. Both, solar thermal and photovoltaic installations have been proved to be successful in Northern climates.

12 Whole House, System Concept

This report does not aggressively address the concept of the house being comprised of a system of components that interact with one another. Only when referring to the installation of the Hi-Velocity and heat recovery units in this report does this topic arise. However, this is an important aspect to consider when thinking about following through with renovations as described in this report. In particular, a great deal of attention should be placed on incorporating effective venting as the building envelope of a house becomes more airtight as a result of installing better windows, doors, vapour barriers and insulation. In an airtight home venting becomes critical to maintaining good indoor air quality and occupant safety. The assessments in this report did not consider the interaction of installing one system with or without the other. Each individual retrofit was only evaluated upon its own merit.

13 Closing Comments

We recognize that the energy conservation initiatives in this report are evaluated from a point of view external to the community of Old Crow. Further, our assessments only address the aspects of economic, energy and greenhouse gas emissions characteristics. They do not take into consideration the values of the community of Old Crow or its individuals. We recognize this aspect of the report, and respectfully submit these suggestions regarding residential energy efficiency to Old Crow as such. We acknowledge that only the community members of Old Crow can provide the insight needed to determine which options, if any, would be of interest and of value.

[92] Canada. Renewable Energy Deployment Initiative. Url: http://www.iea.org/pubs/reviews/files/enpol98/06c-rv98.htm

Appendix A – EnerGuide Evaluation[93]

An EnerGuide for Houses evaluation is a professional energy assessment by a certified energy technician of a home's heating, hot water and ventilation systems, insulation and air leakage. An energy technician conducts a walk-through assessment of the home to evaluate it as a system. The data collected by the technician during the walk-through is entered into energy analysis and modelling software developed by Natural Resources Canada to simulate a home's energy systems and calculate its level of energy efficiency.

During the energy evaluation, the EnerGuide for Houses technician also performs a blower door test (description below) to measure the amount of uncontrolled airflow into a home and how much heat is lost to the outdoors. When the blower door test is running, the technician will guide the home residents around their house to show them the exact points where the house is leaking.

As part of the evaluation, a report is generated for the residents that lists the home's EnerGuide for Houses rating and suggests cost-effective improvements that will increase the home's energy efficiency, reduce energy bills and increase your home comfort.

Blower Door Test[94]

To perform a thorough energy efficiency analysis of a home, energy technicians use specially designed blower door test equipment to measure the home's rate of air leakage.

The blower door is a variable-speed fan mounted on an adjustable panel that can fit into any exterior door opening of the home. When the energy technician turns the fan on, the pressure inside the home is gradually reduced to allow outside air to flow into the house through unsealed openings or cracks in the house structure. Pressure gauges connected to the fan measure the rate of airflow required to keep the home at a constant pressure so the technician can calculate the home's resistance to air infiltration.

While the fan is still running, the technician will walk residents through the home to illustrate, using a smoke pencil, the exact points where the house leaks air and needs to be sealed.

Energy Performance Report[95]

Knowing where and why a client's home is wasting energy is the first step in taking action to correct any problems. An energy efficiency evaluation report pinpoints exactly which areas in the home can be

[93] Energuide for Houses. February, 2002. Get Energy Efficiency Advice for Existing Homes. Natural Resources Canada. Url: http://oee.nrcan.gc.ca/houses-maisons/english/e19.cfm. 17 February, 2002.
[94] Energuide for Houses. February, 2002. Blower Door Test. Natural Resources Canada. Url: http://oee.nrcan.gc.ca/houses-maisons/english/e31.cfm. 17 February, 2002.
[95] Energuide for Houses. February, 2002. Energy Performance Report. Url: http://oee.nrcan.gc.ca/houses-maisons/english/e49.cfm. 17 February, 2002.

improved to make the home more comfortable to live in while cutting its energy costs. If clients are going to renovate, an EnerGuide for Houses technician will suggest practical and proven efficiency improvements that can be drawn into your plans for future energy savings.

A client energy evaluation report is an important tool to use in identifying areas where to incorporate energy efficiency into their home through properly planned upgrades and renovations. In it is included:

- where the home is wasting energy and how to correct the situation
- a breakdown of the amount of energy used for space heating, water heating, lighting and appliances
- an estimate of how much energy is lost through the basement, windows, doors, main walls and ceiling and the home's mechanical ventilation system, if installed, before and after carrying out all of the recommended upgrades
- the home's current EnerGuide for Houses rating and the rating they can expect if they complete all the recommended improvements

In conjunction with the EnerGuide for Houses program, the energy analyst technician will go through the report with the client to describe the results of the blower door test, indicate where heat is being lost in the home and explain all the recommended improvements. As well, the technician will answer any questions the client may have regarding the results of the evaluation, the EnerGuide for Houses rating and what is written in the report.

EnerGuide for Houses Rating and Label[96]

Energy costs can strain your household budget. EnerGuide for Houses provides you with an objective rating of your home's energy performance to compare it with other homes in your neighbourhood and across Canada.

What is an EnerGuide for Houses Rating? The rating is a standard measure of your home's energy performance. Ratings are calculated by professional EnerGuide for Houses technicians from information collected during an on-site energy assessment of your home or from analysing the building plans for a renovation or new home.

Why Should I Have My House Rated? The rating is part of an EnerGuide for Houses evaluation established to help you improve the areas in your home that are currently wasting money and energy. The rating shows your home's present level of energy efficiency and its potential level after completing recommended upgrades. If you're looking to buy a home, the EnerGuide for Houses rating shows you its energy efficiency.

How is the Rating Determined? During the on-site walk-through of a home, the energy technician collects data on home energy systems, house construction materials and assembly to produce an estimate of your home's total energy consumption. Energy analysis software is used to compare your home to a reference house of a similar size in a similar climatic region. To factor out the influence of occupants on energy consumption, standard operating conditions are used in the calculation of the rating.

Standard Operating Conditions

- four occupants in the home
- a thermostat setting of 21°C

[96] Energuide for Houses. February, 2002. Energy Performance Report. Url: http://oee.nrcan.gc.ca/houses-maisons/english/e51.cfm. 17 February, 2002.

- total domestic hot water consumption of 225 litres per day
- lighting and appliance electricity consumption of 24 kilowatt-hours per day
- a minimum monthly average ventilation rate of 0.35 air changes per hour during the heating season

What Do the Numbers Mean? A home's energy efficiency level is rated on a percentage scale of 0 to 100. A 0 represents a home with major air leakage, no insulation and extremely high energy consumption, and a 100 represents a house that is airtight, well-insulated, sufficiently ventilated and requires no purchased energy.

A Guide to the Ratings

Type of House	EnerGuide for Houses Rating
Old house not upgraded	0 to 50
Upgraded old house	51 to 65
Energy-efficient upgraded old or typical new house	66 to 75
Energy-efficient new house	68 to 82
Highly energy-efficient new house	80 to 90
House approaching zero-purchased energy; Advanced House	91 to 100

Should I Be Concerned With a Low Rating? A low rating represents a greater potential for energy savings. No matter what rating your house receives, the energy technician will also suggest how to increase your home's energy efficiency. For example, if you have an upgraded old house, you can expect a rating between 51 and 65. If your house is rated in this range, your home is performing well for its type and year of construction. If you implement energy efficiency upgrades, you can expect the rating to increase to as high as 75.

What is an EnerGuide for Houses Label? After assessing your home or building plans, the technician prepares a report that lists your home's energy rating and the potential rating the house could obtain if upgrade renovations are made. Included with the report is an EnerGuide for Houses label that can be displayed on your furnace or electrical box to show your home's energy rating. The label displays useful information about your home's use of energy and provides you with a record of the name of your technician.

Appendix B – EnerGuide for Houses Audit Results

The following data were generated by the Yukon Housing Authority. A "yes" indicates that option should be considered as an upgrade opportunity. Those house units indicated with shading are the ones that have been selected for renovation in 2002.

Summary Energuide Home Evaluations Old Crow																
VGFN House No.	435	850	755	515	235	505	705	765	865	935	910	911	912	913	914	915
File No.	1211A 00230	*31	*32	*33	*34	*35	*36	*37	*38	*39	*40	*41	*42	*43	*44	*45
EGH Rating[1], before	77	66	77	73	77	68	78	73	78	80	70	72	72	72	72	70
EGH Rating, after	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
ACH@50pa[2], before	5.57	8.25	5.2	8.2	5.47	5.5	3.8	11	2.9	3.3	19.82	19.49	19.49	19.49	19.49	19.82
Savings Opportunities to Achieve EGH 80																
Air Leak sealing	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Attic insulation		yes	yes	yes		yes		yes	yes							
Wall insulation		yes	yes	yes				yes								
Crawlspace insulation		yes				yes		yes								
Bathroom insulation		yes	yes	yes		yes	yes	yes	yes							
Windows	yes*	yes	yes	yes		yes		yes	yes							
Doors	yes*	yes	yes	yes		yes	yes		yes							
Monitor stove		yes	yes	yes		yes		yes	yes	yes	yes	yes	yes	yes	yes	yes
DHW[3] tank	yes	yes	yes							yes	yes	yes	yes	yes	yes	yes
HRV[4]																

* option either upgrade doors or upgrade windows on north side

1. EGH Rating – EnerGuide House rating
2. ACH50 pa – Air changes per hour at 50 pascals pressure for the Blower door test.
3. DHW – Domestic Hot Water
4. HRV – Heat Recovery Ventillation

Appendix C – Old Crow Energy Survey

Results from Survey of Old Crow residences – taken by Rae Moses.

Survey Results (Rae Moses' study)

Date	01/23/02	01-02-02	01/22/02	01/13/02	01/23/02	01/23/02	01/22/02	01/22(?)/02	01/23/02	01/23/02	01/23/02	01/22/03	01/23/02	%
Number	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	
name														
home age	5 to 10	>10	>10	<5	5-10 years	>10	>10 newly renovated 1998.	<5	>10 last renovated 1984	5 to 10	<5	>10 last renovated 1989, 31 year old house.	5 to 10	
home type	prefab	log	complete reno 1992	log	Prefab	log	log	log prefab	log	prefab	log	log	prefab	
home style	3 bedroom	4 bedroom, 2 storey attic	3 bedroom	2 storey	2 bedroom Attic	2 bedroom attic	3 bedrooms	2 bedroom	2 bedroom attic	3 bedroom attic	4 bedroom, 2 story	2 bedroom	3 bedroom attic	
Current problems:														
roof			1			1			1			1	1	38.46%
windows	1	1	1		1	1	1	1	1			1	1	76.92%
doors	1	1	1		1	1	1	1	1	1		1	1	84.62%
plumbing						1						1		15.38%
open attic	1											1		15.38%
other	Floor		floors			Coment about attic?	bathroom		floors			floor	off level	

urvey Results (Rae Moses' study) cont'd

date	01/23/02	01/02/02	01/22/02	01/13/02	01/23/02	01/23/02	01/22 02	01/22(?)/02	01/23/02	01/23/02	01/23/02	01/22/03	01/23/02	%
Number	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	
Other	Plywood coming loose											Foundation		
Explanations	Ice on the wall throughout winter - Floor falling apart	Bath-room is cold. Drafts from windows and doors.	very cold floors, draft from doors/windows	"Addon" Bathroom dead air space - condensation	Doors/windows drafty - house needs levelling	Windows/doors - not to bad. Kitchen freezes up when not there.	Roof leaks, drafts from windows and doors.	drafts	Roof leaks in spring, condensation windows mould, floors - blk rot/breezy will rot?, ceiling - - blk rot?	Doors drafty	New, big house	roof leaks, floors are very cold, foundation cracking is rotten.	condensation - lots. Drafts doors/window	
People in house	5	6	5	5	1	1	4	4	3	2	4	2	4	100.00%
monitor stove														0.00%
wood stove	1	1	1	1	1	1	1		1		1	1	1	84.62%
both								1		1				15.38%
fuel/month								130litres		200				
cords wood/season	6	7	5	5	7	6	6	5	6	5	8	8	5	
wood type	green 1/2 dry 1/2	green and dry	green and dry	green 1/2 dry 1/2	green 1/2 dry 1/2	green 1/2 dry 1/2	70% green, 30% dry	green and dry	30% green 70% dry	dry 100%	green 1/2 dry 1/2	70% green, 30% dry	30% green 70% dry	
get wood	purchase	self - $450/season gas/oil	self - 125$ for season	self - $1000 (?)	self - 25$/week	self - 40 gallons fuel (gasoline?) + 6 oil (litres?)	self - 195$	Self - $175	Self	Self - 50$ - 20 litres gas, 1 ltre oil	self - 230$	Self (?) - 408	purchase	

Survey Results (Rae Moses' study) cont'd

Date	01/23/02	01/02/02	01/22/02	01/13/02	01/23/02	01/23/02	01/22/02	01/22(?)/02	01/23/02	01/23/02	01/23/02	01/22/03	01/23/02	%
Number	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	
time to get wood		30 hours	20 hours	6 hours	1.5 hours	1-2 hours	16 hours	16	2 hours/day		80	6		
cost/cord	300	300	250	300	300	300	250	250	300	300		250-300	300	
cost of fuel/litre							1.5	1.5		1.5		1.5		
Water per delivery	3/4	3/4	3/4	full - 250 gal	1/2	1/2	3/4	3/4to full - 350 gallons	full	3/4 - 250 gallons	full - 300 gallons	3/4to full - 100(?) gallons	full - 270 gallons	
ave electricity bill/month winter	250	135	200	600	50	45-50	120	80 (?)	120	yearly average 59.89	125	90	60	
ave electricity bill/month summer	20-80	80	150	250 (?)	25	25-30	100	30	100		80	80	40	
appliances:														
cook stove	1	1	1	1	1	1	1	1	1	1	1	1	1	100.00%
fridge	1	1	1	1	1	1	1	1	1	1	1	1	1	100.00%
freezer	1	1	1	1	1	1	1	1	1	1	1	1		92.31%
electric kettle	1			1		1	1		1			1	1	53.85%
water tank	1	1	1	1	1	1	1	1	1	1	1	1	1	100.00%
computer	1	1					1			1	1	1	1	53.85%
T.V.	1	1	1	1	1	1	1	1	1	1	1	1	1	100.00%
water pump	1	1	1	1	1	1	1	1	1	1	1	1	1	100.00%
coffeepot	1	1	1	1		1	1				1	1	1	69.23%
hot plate														0.00%
light bulbs	1	1	1	1	1	1	1	1	1	1	1	1	1	100.00%
radio/stereo	1	1	1	1	1	1	1	1	1	1	1	1	1	100.00%
elect blanket														0.00%
Microwave	1	1	1	1		1	1	1	1	1	1		1	84.62%
Celing fans	1	1	1		1	1	1	1	1	1	1	1		84.62%
floor lights	1				1					1		1	1	38.46%

Survey Results (Rae Moses' study) cont'd

Date	01/23/02	01/02/02	01/22/02	01/13/02	01/23/02	01/23/02	01/22/02	01/22(?)/02	01/23/02	01/23/02	01/23/02	01/22/03	01/23/02	%
Number	1002	1003	1004	1005	1006	1007	1008	1009	1010	1011	1012	1013	1014	
heaters (fans)		1				1		1			1			30.77 %
cold fans	1	1				1	1						1	38.46 %
others	washer/ dryer, (?)	washer/ dryer		washer/dryer/telephone/charger	washer/ dryer	washer	Washer/spin dryer	Washer Dryer, (?,?)	Washer Dryer, power tools	washer/ dryer	Washer/jet test (?)	Washer/ Dryer, Air conditioner	Washer	

Appendix D – Insulating Products

Insulating Products – detailed information and Joint Venture - Energy North Package.

ENERGY NORTH
[illegible] WHITEHORSE YUKON, CANADA [illegible]
[illegible]

To: Mr. Tom Marek – Pembina Institute
Tel: (250)746-6664

From: Kirk Potter Energy North Construction Inc.

Re: Proposal for insulation in Old Crow

[illegible]

Sorry for the delay in getting this material to you. I've included a brief description of each material, its advantages and disadvantages. I've also introduced a number of alternative systems for insulating homes in Old Crow, showing the advantages and disadvantages of each system. Information for costing is also provided. Also included is a proposal for insulating interior water tanks, as we discussed, and a brief description of a possible joint venture with the First Nation.

1. MATERIALS

A. Icynene

The Icynene insulation system is a water-based, environmentally friendly sprayed or pour-in-place, expanding foam containing no formaldehyde, CFCs or HCFCs. Unlike conventional insulation products, Icynene fills the entire wall, ceiling, crawlspace or floor cavity to form an impenetrable, airtight insulated building envelope. It is a light density foam that expands 100 times its initial volume in seconds to form a soft, flexible insulation.

Icynene will provide superior control of air leakage and sound and reduces condensation in the walls, attics and floors. This superior ability reduces energy bills, helps soundproof rooms and improves indoor air quality by preventing the growth of mould and mildew. It is recognized as a very safe building product by many different organizations and is found used by people who have extreme chemical sensitivities.

More details about Icynene can be found at www.icynene.com or by contacting Energy North.

B. Walltite

Walltite is a high density spray-applied cellular plastic that forms a continuous, monolithic air barrier insulation. Walltite has one of the highest R-values per inch of any insulated material available. It is an effective air barrier, vapour barrier and will not take on water. Walltite increases the strength of the material it is being used with – i.e. wall cavities strengthen, ties framing material together. More detailed information can be provided if needed. Provided by Energy North Construction Inc.

C) Cellulose

Cellulose is an insulation made out of recycled newsprint, and other paper fibres, with a fire-retardant added. The short cellular wood fibres of the material fill all voids and cavities for a tight fit. This product is blown in to achieve high densities that will resist convective air leakage. Rodents do not favour cellulose, making it an ideal product for rural applications.

For more information, call Can-Cell Industries Inc., at 1-800-661-5031, or Energy North at 1-867-667-7414.

2) ADVANTAGES / DISADVANTAGES

All three products provide a significant improvement to energy savings compared to conventional insulation, – i.e. fibreglass and boardstock. Air leakage contributes to approximately 40% to 50% of heat loss from buildings in the north. All three of the products described above are proven effective air barriers, contributing to their superior performance over conventional insulation systems, which require other products like Tyvek or plastic to perform. The Icynene and Waltite are better air barriers than the cellulose, but if the cellulose is installed properly, it is an effective air barrier.

The Icynene and cellulose are very effective in slowing the progress of fires. The Icynene does not fuel combustion and will not melt in a fire situation, so doesn't create open cavities necessary for flame spread. Cellulose will smoulder and stay intact in a fire, giving the occupants more time to vacate the building. The Waltite will burn and requires a thermal barrier.

The Waltite will not suffer from moisture and is an approved vapour barrier. The Icynene lets moisture pass through it at a very slow rate but does require some type of vapour retarder – i.e. vapour barrier paint, plastic vapour barrier (but does not need to be sealed). Cellulose requires a conventional vapour barrier. The Waltite has the highest R-value per inch of the three materials. The cellulose and Icynene are approximately 25% higher than fibreglass and the Waltite has approximately twice the R-value as fibreglass insulation.

The Icynene insulation is probably the most affordable material for flying into Old Crow due to its high yield.

- ICYNENE—two 45-gallon drums (475 kg.) produce approx. 15,000 – 22,000 board feet of insulation.
- WALTITE – two 45-gallon drums (475 kg.) produce approx. 3,500 – 4,500 board feet of insulation
- CELLULOSE – comes in 12 kg. bags, which are approx. 3 cu. ft, and cover approx 60 – 160 board feet of area, depending upon application.

The cellulose and Icynene both carry the Environmentally Friendly logos from various government agencies: cellulose, for its recycled content, and its ability to reduce greenhouse gases; and Icynene for its ability to reduce greenhouse gases and because it has no CFCs or HCFCs. Both Icynene and cellulose are being used to achieve environmentally friendly and energy efficient buildings. Waltite reduces greenhouse gases but uses HCFCs as a blowing agent.

We have used all three products in the North over the past ten years. We have found that the Icynene and Waltite have worked extremely well in sealing air vapour barrier problems in existing building envelopes, where other insulating systems have failed. We have used these products in various projects where ice damming and condensation were causing damage to the building envelope. After using the foam insulation, we eliminated heat loss/air movement through the building envelope, thereby eliminating these problems. We have been very successful using the foam for problem vaulted ceilings, pole floors, flat ceiling spaces and poorly air-sealed vapour

barriers. The cellulose has been used in more conventional projects and has performed extremely well.
Please call for any references that you may require.

3) WALL AND ROOF DETAILS (*see attached shop drawings*)

A) Exterior retrofit

Advantages:

- Little disruption to occupants
- Keeps wall on the inside of building envelopes (provides heat sink)
- Keeps window setback in wall, which helps prevent frosting
- No loss of interior space
- Can tie roof and wall details together, to have continuous insulated building envelope

Disadvantages:

- May require hording, depending upon weather
- Exterior siding would be required
- May lose log asthetics
- May require more insulation to overcome vapour barrier situation

B) Interior retrofit

Advantages:

- Vapour seal on the inside of building envelope
- Weather would not be a factor
- If interior retrofit is happening, it would be very cost effective

Disadvantages;

- Major disruption to occupants during working hours
- Major interior retrofit

NOTES on wall and roof details:

1) In both interior and exterior retrofits, Waltite would reduce the amount of framing material needed for a retrofit and could be used with lighter framing materials (2x2s may be used) because of its ability to strengthen the wall. The Icynene and cellulose would require framing material to be well-secured to the substrate.
2) Cellulose may cause some problems on an interior retrofit for drywalling and would probably require a rain screen on the exterior retrofit.
3) The insulated blocks would be the preferred system, but horizontal and vertical framing on a log wall would be acceptable, or a framed wall would only require horizontal or vertical framing.
4) We try to leave at least ½ inch between the foam insulation and the siding, on an exterior retrofit.

From : OLDHAM PHONE No. : 530 5311 Dec. 05 2001 10:58PM P04

5) In the attic we add approx. 2 inches of Waltite, or 4 inches to 6 inches of Icynene, and build up the R-value with loosefill over top.

4) COSTING

+ FREIGHT COST/EQUIP INSTALLED COST

Walls:

Icynene – interior or exterior retrofit approx 6 inch: **$3/ sq. ft.** ~25% GREATER THAN FIBERGLASS

Waltite – same area approx 3 inches to 4 inches: **$4/ sq. ft.** ~45% GREATER

Cellulose – same area approx. 6 inches: **$2/ sq. ft.**

Ceiling:

Icynene – 4 inches to 6 inches: **$2.50 - $3/ sq. ft.**

Waltite – 2 inches to 3 inches: **$2.50 - $3/ sq. ft.**

Cellulose – R-40 approx. 10 inches (loosefill): **$1.50 / sq. ft.** – HIGHER SHIPPING/BD FT

Other costs to be covered by Vuntut Gwitchin First Nation:

- Equipment to be flown in – approx. 600 lbs. for either foam or cellulose
- Material to be flown in (see coverage above)
- Would require transportation for equipment – i.e. fourwheeler or truck
- Would require 40 amps – 220 volts
- **All framing and retrofit would be performed by First Nation. These prices only include installation of insulation**
- Room and board
- One trained technician to be flown in (would require local labourer; these costs at Energy North' expense)

5) INSULATED TANKS

$?

The holding tanks can be insulated with a 2 lb. spray foam insulation. We would recommend 2 inches of foam on these tanks and thermal barrier. The cost for this is approx. $1.50/gallon.

6) JOINT VENTURE

As mentioned before, I would like to discuss a joint venture in spray foam equipment with the Vuntut Gwitchin First Nation. Energy North would lease the foam equipment to the First Nation for a period of approximately three years, during which time we would provide training, materials, parts and technical help with the foam industry. After a three-year period, the First Nation would own the equipment and have the training and on-the-job expertise to operate a successful spray foam business for their own work and any other markets that may be interested.

I hope these notes are of help to you in your decision-making. Please do not hesitate to call me at 1-867-667-7414 if you have any questions.

Thank you,

Kirk Potter

INUVIK

JOINT VENTURE - LEASE EQUIP

- MAT'L COST + 19%
- TRAINING/AR
- MAINT

-70K OWN LEASE

From : OLDHAM PHONE No. : 538 5311 Dec. 05 2001 10:58PM P05

Page No. 5 of 7 Pages

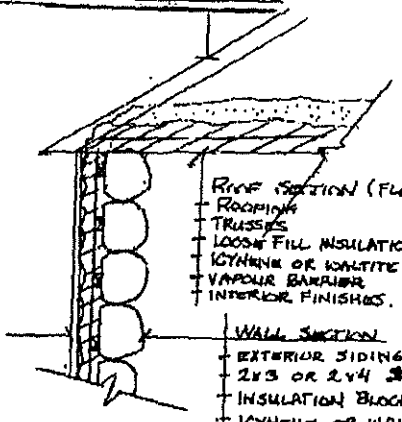
ENERGY NORTH

58 Alsek Road
WHITEHORSE, YUKON, CANADA Y1A 3K4
Tel: (867) 667-7414
Fax: (867) 667-7418

ATTENTION	TELEPHONE	DATE
ATT: TOM MARK PEMBINA INSTITUTE	250-746-6664	DEC. 2/01
ATT	JOB NAME	
	INSULATION SHOP DRAWINGS	
PROVINCE / POSTAL CODE	JOB LOCATION	
	OLD CROW, YUKON	
CITY / DATE OF PLANS		JOB TELEPHONE

WALL & ROOF DETAILS

EXTERIOR APPLICATIONS



ROOF SECTION (FLAT ATTIC SPACE)
- ROOFING
- TRUSSES
- LOOSE FILL INSULATION (SEE NOTES)(3)
- ICYNENE OR WALTITE (SEE NOTES)(1)
- VAPOUR BARRIER
- INTERIOR FINISHES.

WALL SECTION
- EXTERIOR SIDING
- 2x3 OR 2x4 STRAPPING (SEE NOTES)(2)
- INSULATION BLOCKS (SEE NOTES)(4)
- ICYNENE OR WALTITE (SEE NOTES)(1)
- LOG WALL OR FRAMED WALL
- INTERIOR FINISHES

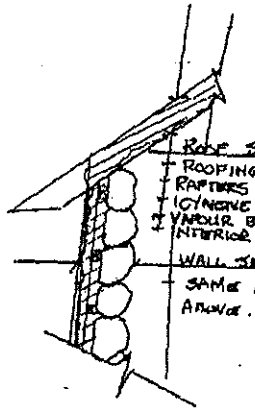
NOTES

1) ICYNENE WOULD REQUIRE APPROX. 6 INCHES OF MATERIAL. WALTITE WOULD REQUIRE 3.5 TO 4 INCHES OF MATERIAL.

2) STRAPPING WOULD BE DETERMINED BY SUPPLY AND MATERIAL USED AS INSULATION. IE. HIGH DENSITY OR WALTITE WILL ADD STRENGTH TO THE WALL SO SMALLER FRAMING MATERIAL WOULD BE REQUIR

3) LOOSE FILL INSULATION: SHOULD BE CELLULOSE BECAUSE OF PERFORMANCE

4) INSULATION BLOCKS ARE USED TO PREVENT THERMAL BRIDGING OF FRAMING MATERIAL. BOARD STOCK COULD BE USED OR BLOCK CAN BE PURCHASED. HORIZONTAL FURRING MATERIAL CAN ALSO BE USED THIS IS NOT AS EFFECTIVE AS USING INSULATION.



ROOF SECTION (SLOPED ATTIC)
- ROOFING
- RAFTERS
- ICYNENE OR WALTITE. (SEE NOTES)(5)
- VAPOUR BARRIER.
- INTERIOR FINISHES.

WALL SECTION
- SAME AS ABOVE.

5) ICYNENE OR WALTITE CAN BE INSTALLED FROM THE EXTERIOR OR INTERIOR OF SLOPE CEILING, DEPENDING ON AREA TO BE RETRO. FIT.

From : OLDHAM PHONE No. : 530 5311 Dec. 05 2001 10:59PM P05

Page No. 8 of 76 Pages

ENERGY NORTH CONSTRUCTION INC.
58 Alsek Road
WHITEHORSE, YUKON, CANADA Y1A 3K4
Tel: (867) 667-7414
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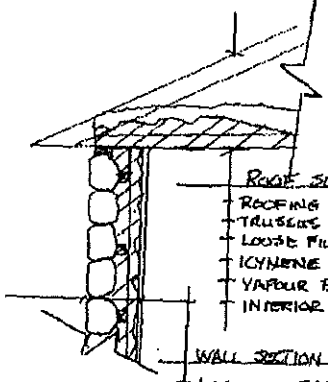
ATT: TOM MAREK
PEMBINA INSTITUTE
250-746-6664
DEC 2/01
INSULATION SHOP DRAWINGS
OLD CROW, YUKON

WALL & ROOF DETAILS

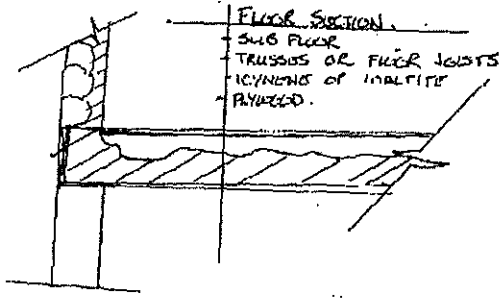
INTERIOR APPLICATION.



ROOF SECTION (FLAT ATTIC SPACE)
- ROOFING
- TRUSSES
- LOOSE FILL INSULATION (SEE NOTES)(3)
- ICYNENE OR WALTITE (SEE NOTES)(1)
- VAPOUR BARRIER
- INTERIOR FINISHES

WALL SECTION
- LOG OR FRAMED WALL.
- INSULATION BLOCKS
- 2x3 or 2x4 STRAPPING (SEE NOTES)(2)
- ICYNENE OR WALTITE (SEE NOTES)(1)
- VAPOUR BARRIER.
- INTERIOR FINISHES

FLOOR DETAIL



FLOOR SECTION.
- SUB FLOOR
- TRUSSES OR FLOOR JOISTS.
- ICYNENE or WALTITE
- PLYWOOD.

NOTE

A) FLOOR CAN BE DONE FROM UNDER SIDE BUT CAVITY ~~SHOULD~~ BE FILLED ON PERIMETER OF BUILDING TO MAKE SURE OF A CONTINUOUS AIR BARRIER.

Appendix E– Training Modules for Old Crow

R-2000 Workshop- Old Crow, Yukon
AGENDA
April 23,24,25 &26

Day 1	**Module 1: The R-2000 Program**	2002.04.23
1:00	Welcome and Registration	
	Instructor and Participant Introductions	
	Module Objectives and Teaching Techniques Review Agenda, Rules, Instructor Expectations	
	GROUP SESSION: Participant Introduction and Expectations	
2:00	What is the R2000 Program Builders Role, Certification Sub-trades Role, Certification YHC's Role Design Evaluators Role, Certification, Training R-2000 Inspectors Role, Certification, Training	
2:30	Break	
3:00 :	Introduce R2000 Technical Requirements R-2000 PICK Lists Enrolling and Certifying an R2000 Home	
	R2000 Design Evaluation and HOT2000 Simulation Electronic Data Forms	
4:30	Completion of Module 1	
Day 2	**Module 2: Building Science and IAQ**	
9:30	BUILDING SCIENCE AND THE BUILDER	
	Introduce Issues	
	Building Science Principles - Comfort - Air Movement - Heat Flows - External Design - Moisture Flows - Internal Design	
10:45	Break	
11:00	Air Barrier Systems and Materials Definitions and Standards NBC and R-2000 Vapour barrier systems Definitions and Standards NBC and R-2000 Air barriers and vapour diffusion retarders	
12:00	Lunch	
1:00	Site Visit and Blower Door Demonstration	
	Visit safe house and discuss renovations. Perform blower door test and depressurization test.	
4:30	Complete Module 2	

Day 3	**Module 3: THE R2000 BUILDING ENVELOPE**	
9:30	Module Objectives and Teaching Techniques Review Agenda, Rules, Instructor Expectations	
	GROUP SESSION: Participant Introduction and Expectations	
9:45	From the Rim Joist Down - Foundations	- Slabs
10:45	BREAK	
11:00	- Rim Joist Detailing	
12:00	Lunch	
1:00	From the Rim Joist Up - Walls - Ceiling	- Attic and Roofs - Air / Vapour Barrier Detailing
2:00	Windows and doors	
4:30	Completion of Module 3	
Day 4	**Module 4: Mechanical Systems, Heating and DHW**	
9:30	Instructor and Participant Introductions	
	Module Objectives and Teaching Techniques Review Agenda, Rules, Instructor Expectations	
	GROUP SESSION: Participant Introduction and Expectations	
9:45	Technical Requirements for Mechanical Systems	
	The Builders Role in Mechanical Systems The R-2000 Design Evaluators Role The R-2000 HVAC Inspectors Role The Installers Role, Certification, Documentation	
10:15	Heating Systems Fuel types Combo systems	Venting Types Standards
	Completion of Module 4	
10:45	BREAK	
11:00	**Module 5: Mechanical Systems, Ventilation**	
	Types of Ventilation Systems Technical Requirements for Ventilation Systems	
	The Builders Role in Mechanical Systems The R-2000 Design Evaluators Role The R-2000 HVAC Inspectors Role The Installers Role, Certification, Documentation	
	Design Requirements Installation Requirements Field Experience	
	Completion of Module 5	
12:00	Lunch	
	Module 6: Review and Exam	
1:00	Review Course Material	
	Write Exam	
	Correct and Review Exam	
4:30	Completion of Module 6	

Appendix F – Comparative Employment Opportunity Statistics

On a broader scale of analysis, employment creation benefits from energy efficiency, and renewable energy initiatives that contribute to greenhouse gas reductions and air quality improvements, have been found to provide significantly more employment opportunity than have traditional energy sector development activities that have varying environmental impacts.[97]

On average, energy efficiency investments (e.g., building retrofits) create over 35 person years of employment per million dollars invested. This is about five times as many as generated from investment in conventional energy supply (e.g., oil, gas). These employment opportunity levels are itemized in Tables 20 and 21.

One factor in the higher number of jobs per dollar invested in energy efficiency is that the activities tend to be fairly labour-intensive in terms of direct employment. The most important factor, however, is the job creation arising from the re-spending effect of energy savings.

Tables 1 and 2 illustrate the comparative employment opportunities between the sectors of renewable energy and energy efficiency and the oil industry.

Table 23: Employment Estimates per Million Dollars of Investment

Application	Jobs per $M
Rational Energy Program for Canada	47.4
Saskatchewan Residential Energy Efficiency/Cons.	15.9
Saskatchewan Commercial Energy Efficiency/Cons.	20.7
Saskatchewan Industrial Energy Efficiency/Cons.[98]	79.8
Toronto Energy and Water Efficiency	42.9
Ontario Demand Side Management	38.5
B.C. Demand Side Management	30.6
Canadian Municipal Energy Initiative	65.8
U.S. Conservation	23.5
U.S. Energy Efficiency	32.5
U.S. Energy Efficiency	27.1
U.S. Energy Efficiency and Renewable Energy	35.5
U.S. Demand Side Management	19.7
Washington State Demand Side Management	31.8
Average	**36.6**

[97] Campbell, Barbara; Dufay, Larry; and Macintosh, Rob. 31 January, 1997. Comparative Analysis of Employment from Air Emission Reduction Measures. Environment Canada – Global Air Issue Branch, The Pembina Institute for Appropriate Development

[98] The original figure provided in the source study was divided in half in order to be conservative about the dollar value of energy savings and the resultant re-spending effect.

Table 23: Employment Estimates per Million Dollars of Investment

Application	Jobs per $M
Alberta Oil	6.5
Alberta Oil Sands	14.6
Alberta Gas	4.0
Saskatchewan Oil Combined Cycle	4.1
Saskatchewan Natural Gas Electricity Generation	5.8
Alberta Large Hydro-Electric	1.4
Saskatchewan Large Hydro-Electric	8.2
B.C. Large Hydro-Electric	2.6
Saskatchewan Coal	9.3
Saskatchewan Nuclear	9.7
U.S. Oil Refining	6.1
U.S. Natural Gas	7.8
U.S. Coal Mining	14.9
Average	**7.3**