Inuvik Wood Pellet Infrastructure Study

Prepared for: Environment and Natural Resources, Government of the Northwest Territories

September 2012

EXECUTIVE SUMMARY

The Town of Inuvik has been reliant on natural gas for the bulk of its electrical generation and space heating needs since 1999. Inuvik Gas is the owner and operator of a natural gas distribution system that provides natural gas to end-use residential, commercial, institutional (including Government) and municipal customers located within the town boundaries. In February 2012, Inuvik Gas advised the public that, due to problems with water in the wells that supply Inuvik, approximately 1.2 years of natural gas supply remained. Immediate efforts to switch to diesel electricity generation and oil-fired space heating were implemented by the Government of the Northwest Territories (GNWT) where possible to help extend the remaining natural gas supply.

It is expected that Inuvik Gas will provide synthetic natural gas to the residential and general service customers on the distribution system. While this will help further conserve natural gas reserves, residential and general service customers will experience significant increases in their annual heating costs as a result.

This study focuses primarily on the potential use of biomass (wood pellets) to help meet Inuvik's immediate and longer-term space heating requirements. Wood pellet heating, whether for individual homes and businesses or through a district heating system, is already well established in other NWT communities such as Yellowknife, Hay River, Fort Smith, Behchoko and Fort Simpson. The main overall purpose is to determine if there is a business case for using wood pellets as a source of heating in Inuvik.

This study looked at wood pellets supplied to Inuvik in three (3) formats: i) 18-kg bags, ii) bulk delivered through an in-town delivery service and, iii) bulk stored on site and ordered directly from the mill and stored on the building site. As of September 2012, bagged pellets are the only form available, at a cost of $10/bag ($555/tonne). It is estimated that an in-town delivery service could provide pellets for $550/tonne or less, depending on the penetration rate. It is estimated that bulk pellets could be trucked to Inuvik for about $485/tonne. Barging would also be possible, and may provide a great price incentive, but as the logistic issues have not yet been resolved, prices with barging have not been used as an option here.

The price of wood pellets has been demonstrated to be lower per GJ than any other option currently available to residents in Inuvik, but the high capital costs involved for conversion may negate the lower fuel cost.

The main findings of the economic analysis were:

- Of the potential customers in Inuvik, the large commercial and institutional customers have the shortest payback periods for installing pellet appliances. Their higher heating requirements help to quickly offset the fixed capital investment required and result in compelling paybacks of 3-10 years on the investment.
- Pellet stoves installed in residences appears to be the second most interesting group due to the low initial capital costs. The payback is not overly sensitive to changes in capital cost but is quite sensitive to changing pellet price. If 50% of a typical house's heating requirements are met by a pellet stove, a payback in the realm of 7 years is likely. Covering more of the heating load would result in a faster payback.
- Those customers installing residential or small commercial boilers or furnaces have the least economic incentive to convert to pellet heating. These customers have high capital costs and

may require expensive engineering drawings and pellet storage systems but still require an in-town delivery of pellets, making savings less. Unless there are significant reductions in conversion costs, there does not appear to be any economic incentive for this group.

It should be noted that the findings contained in this study are intended to provide residential homeowners, building owners and businesses with a general understanding of the merits and costs associated with wood pellet heating relative to other potential energy supply options in Inuvik. Any specific decision by a homeowner or facility owner to convert to wood pellet heating should be taken carefully based on site-specific technical and economic investigations and analyses.

It should also be noted that this study was published as a draft in September 2012 and reviewed and released in March 2013 and although fuel prices have changed slightly they were not updated in the analysis portion of the report.

The recommendations stemming from this report are aimed at creating a 5 year action plan to integrate pellets into the Inuvik fuel supply market. In summary, a minimum target pellet penetration of 5% of the existing heating load is recommended for year 1 (225 tonnes), 15% penetration (700 tonnes) for year 3 and 25% penetration for year 5 (1100 tonnes).

In order to realise these targets, specific recommendations are given for each sector including residential, small commercial, large commercial/institutional and pellet transportation and storage. A full list of recommendations is available in the recommendations section at the end of the report.

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1 INTRODUCTION

Located above the Arctic Circle on the Mackenzie River delta, the Town of Inuvik has a population of about 3,500 people and is accessible by air, road and marine transport. Since its inception in the late 1950's, government services, tourism, transportation, the military and oil and gas development have all been important drivers for the local economy. Today, Inuvik is the regional government centre and transportation hub for the western Arctic.

Historically, Inuvik's energy needs were met mostly by fossil fuels, with water, sewer and high-temperature heating services being provided through an above-ground utilidor system. In 1999, a natural gas distribution system was completed. Approximately 90% of the homes in Inuvik, commercial facilities, GNWT buildings, as well as the power generating plant, were converted to natural gas.

Expected to supply Inuvik's energy needs for at least 20 years and a contract in place until 2014, the Ikhil wells have experienced water problems which have reduced their lifespan; with one of the two wells shutting down completely in November 2010. To help conserve the remaining natural gas, the largest gas user in Inuvik (about 40% of the load) - the Northwest Territories Power Corporation (NTPC) - converted its power plant back to diesel fuel and the Government of the Northwest Territories (GNWT) and the Town temporarily converted all facilities with dual-fuel capability back to oil-fired heating. Reducing natural gas consumption by NTPC, the GNWT and the Town has allowed the remaining gas reserves to be used for residential and general service customers.

While there are other potential natural gas reserves in the area that could be utilized, the challenge is in bringing the natural gas to Inuvik in a way that is affordable. In the shorter-term, Inuvik Gas is offering a synthetic natural gas option. Synthetic natural gas is a mixture of propane and air that can be delivered to customers using the existing natural gas distribution system which burns just like natural gas.

All rate payers are expected to experience significant increases in their heating bills costs due to the higher cost of synthetic natural gas compared to natural gas (currently $19.30 / GJ). A price of $40/GJ for synthetic natural gas has been used in the report as an approximate average cost for simplicity's sake. Details were not known at the time of writing and are expected to fluctuate with the price of propane. Two Public Utilities Board (PUB) decisions deal with the pricing of synthetic natural gas in Inuvik:

- Rate 1- Residential Service & Rate 2- General Service: In accordance with Decision 29-2012 of the PUB released on December 6, 2012 the new rate will include a gas distribution charge of $8.27 plus the Landed Cost of Propane. As of February 4, 2013, the rate for customers will be #35.44/GJ which includes the $8.27/GJ distribution charge and $27.17/GJ propane and truck transport cost (Inuvik Gas Ltd., 2013).
- Rate 3- Government Service (GNWT & NWTHC): In accordance with Decision 18-2012 of the PUB released on August 17, 2012, the new rate will be $41/GJ.

Wood pellets may offer customers in Inuvik an economic alternative for heating. Wood pellet heating, is becoming increasingly popular in communities throughout the southern NWT (i.e. Yellowknife, Behchoko, Fort Smith, Hay River, Fort Simpson) and is starting to make inroads in communities not connected to the all-weather highway system (i.e. Norman Wells).

1.1 Purpose and objectives of the study

The purpose of this study is to determine if there is a business case for using wood pellets as a source of heating in Inuvik. The principal audience for this report is government policy makers with relevance for

homeowners, building owners and businesses looking for sufficient information on the pros and cons of wood pellet heating to make informed decisions about whether to convert their heating systems and what the estimated capital costs and annual heating costs may be compared to other potential options.

The specific objectives of this study are to:

- Identify and summarize the building heating loads in Inuvik that could potentially be converted to wood pellet heating;
- Describe the various makes, models and sizes of pellet heating systems available on the market and determine typical procurement times, installation costs, pellet supply logistics etc. involved in getting this technology installed in Inuvik;
- Determine supply chain options for getting pellets to Inuvik;
- Provide a summary of the economic costs of implementing viable wood pellet heating solutions compared to the synthetic natural gas option, including the sensitivity to different penetration scenarios.

It should be noted that the findings contained in this study are intended to provide residential homeowners, building owners and businesses with a general understanding of the merits and costs associated with wood pellet heating relative to other potential energy supply options in Inuvik. Any specific decision by a homeowner or facility owner to convert to wood pellet heating should be taken carefully based on site-specific technical and economic investigations and analyses.

1.2 Scope of Work

The findings and recommendations contained in this report were obtained based on the following steps:

Step 1: Background and description of options available for residential and commercial buildings – the first step of the study was to give a background to wood pellet heating and describes the current customer base in Inuvik, how wood pellet heating is being used in the rest of the NWT, and the different wood pellet appliance options for residential and commercial use.

Step 2: Pellet supply options – the second step in this study was to describe the pellet supply methods to Inuvik and the estimated landed pellet price for each of the different delivery methods.

Step 3: Review of heating loads and boiler identification and sizing – the third step of the study was to estimate the heating loads for all commercial buildings in Inuvik and to determine the heating load of a typical Inuvik residence. Where data were available, the actual heating loads were used. For other buildings, the heating loads were estimated based on the approximate square footage of the building and a typical benchmark energy usage for that type of building. For the purposes of the study, five (5) categories of heating loads were used to represent the range of actual residential, commercial and institutional heating loads that exist in Inuvik. Once the inventory was complete, estimated heating loads were adjusted slightly to ensure the total heating inventory matched natural gas sales by Inuvik Gas. Prices for pellet appliances were estimated for each heating category.

Step 4: Economic analysis – the findings from the steps above were utilized to construct numerous examples of different types and sizes of pellet heating systems that could realistically be installed in various buildings in Inuvik. For each example, the capital and operating costs and annual heating demand was estimated and used to determine the economic viability, specifically the estimated annual heating cost savings and simple payback on the capital investment. A sensitivity analysis including changing pellet prices and capital costs was conducted.

2 BACKGROUND

2.1 Inuvik Gas Customers

Since 1999, Inuvik Gas has been supplying natural gas to meet approximately 90% of Inuvik's space heating and electricity generation requirements. As of early 2012, Inuvik Gas was supplying natural gas to approximately 925 commercial and residential customers at a rate of $19.30 / GJ.

2.2 Wood Pellet Heating in the NWT

The use of wood pellets for space heating of homes and buildings has been slowly increasing in several NWT communities. Since 2006, the Department of Public Works and Services has converted approximately twenty GNWT facilities to wood pellet heating. In turn, this has served as the catalyst for the development of wood pellet markets in Yellowknife, Behchoko, Fort Smith, Hay River and Fort Simpson.

Wood pellets are compressed, uniformly sized and are usually manufactured using by-products from the forestry industry such as woodchips and sawdust. Wood pellets are easy to transport and store and are suitable to use in a wide range of heating applications as well as for power generation.

Wood pellet heating can offer several advantages over other energy sources including:

- Typically lower heating costs (compared to oil or propane heating);
- Highly efficient heating technologies;
- Non-toxic (spills do not cause environmental damage);
- Clean-burning, renewable source of energy; and,
- Carbon-neutral (when burned, pellets release the same amount of carbon as trees absorb when they grow).

Wood pellet heating is becoming quite common in the NWT, North America and Europe for both residential use and for larger buildings (i.e. 5,000 to 50,000 square feet) such as office buildings, government facilities, schools, hospitals, and housing complexes that use centralized hot water heating systems. In Europe, wood pellets have been used for much longer, and with such success that annual wood pellet consumption is currently about 12 million tonnes and is forecast to reach 25 million tonnes or more by 2020.

As of 2011, the NWT's total annual wood pellet consumption was estimated to be in the range of 12,000 – 15,000 tonnes, all of which is currently being supplied from British Columbia and Alberta. Government and private business representatives have examined the possibility of producing wood pellets in the NWT. The GNWT released the NWT Biomass Energy Strategy in 2012 (Government of the Northwest Territories, 2012) with the overall goal being to establish conditions to enable biomass energy to become an integral part of the energy mix in the NWT.

As of 2012, there are 42 wood pellet manufacturing plants in operation in Canada with a total capacity to produce about 3 million tonnes of wood pellets annually (Canadian Biomass Magazine, 2012). Of these, there are 13 plants located in British Columbia and 3 plants in Alberta with a total combined production capacity of about 2.1 million tonnes per year. The western Canadian wood pellet plants serve domestic markets as well as markets in Europe and Asia.

2.3 Commercial and residential Wood Pellet Heating

Wood pellet heating technologies are available for a wide range of applications. Different types of systems common in the NWT include:

- Wood pellet stoves
- Wood pellet furnaces
- Wood pellet boilers
- Wood pellet district heating systems

The differences between these pellet systems are covered in detail in Appendix B.

Commercial-scale systems are different from smaller residential systems in that they typically incorporate automated feed and control systems. Details of the components in a commercial system are included in Appendix B.

2.4 General System Size Considerations

The sizing of a biomass boiler is a complex task even for an experienced building services engineer, and it will be different for every individual project site and boiler. Generally, there are many issues that need to be considered when deciding on the most suitable biomass system for any site.

See Appendix B for more details on the considerations one must take when sizing pellet boilers.

3 PELLET SUPPLY, STORAGE, HANDLING AND PRICING FOR INUVIK

Wood pellets are packaged, transported and handled in three different forms:

Individual 18 kg bags - for the residential pellet stove market, wood pellets are typically sold in retail stores in 18 kilogram (40 pound) plastic bags which are designed to be easily handled by one person for filling the stove hopper. Individual bags are transported to retail outlets (or consumers) on wooden pallets that usually hold between 50 and 65 bags.

One tonne bags - for larger residential or small commercial pellet heating systems, pellet mills often use one tonne bags, referred to as "Super Sacks" to sell pellets. A Super Sack can be transported on a pallet or moved directly by forklift (the bags have strap handles). Often shipping is more expensive as less weight can be transported in a truck when compared with bulk or 18kg bags due to their arrangement in the truck. They have been left out of the analysis as their transportation price was higher than for the other methods and logistics more difficult.

Bulk supply **-** the third way to purchase pellets is in loose bulk form. Depending on the mill location, some mills have a rail connection to ship pellets by grain cars to ports for transport via ship to overseas markets. For the NWT, bulk pellets are shipped in grain trucks and transferred to on-site storage silos using standard grain handling equipment (auger, gravity-feed or pneumatic systems). With minimal handling and no packaging, bulk pellet prices are the lowest per tonne.

Customers can receive shipments directly from the mill if they have enough storage capacity or via an in-town delivery service if one is set up. With in-town delivery, pellets are delivered directly through the use of special pneumatic or auger delivery trucks much like in-town oil delivery trucks. This service is very common in Europe and currently available to customers in Yellowknife and Norman Wells.

Safety and handling

Safe handling should be carried out for all forms, including:

- The generation of dust during delivery and handling of pellets should be avoided. Dust may create an explosion hazard. To avoid the inhalation of dust or ash, face masks should be worn by operators.
- Sources of heat (including light and electrical fittings) should be kept away from pellet storage. Wood pellets are flammable, but are inert under normal conditions. Flames should not be present during loading and discharge of pellet fuels, and non-smoking rules should be applied.
- Pellets are designed to have sufficient strength to be delivered and stored, while remaining easy to break down during combustion. However, repeated handling will cause the pellets to break down to sawdust. Most boiler systems can handle a significant proportion of sawdust but, for optimal efficiency, handling should be minimized.
- Special care should be taken to ensure the pellets do not get wet which will cause them to disintegrate.

3.1 Pellet Supply to Inuvik

The type of pellet storage and handling equipment used for a pellet heating system typically depends on several factors including:

- the size of the pellet heating system being installed;

- the land area available for pellet storage near a facility;
- the heating requirements of the building and
- the nature of the pellet supply arrangements that exist to serve the community.

To date, a comprehensive pellet supply chain has not yet been established to serve Inuvik so it is not possible to say with certainty exactly how such a supply might be set up and what the retail or bulk price may be to a customer for a tonne of pellets. Small 18-kg bags are currently available at local retailers for $10 and $12/bag.

3.2 Cost to Purchase Pellets at the Mill

Bulk pellets are normally quoted in metric tonne (1000 kg or 2204 lbs) and bagged pellets are quoted in short ton (907kg or 2000 lbs). For consistency, the prices quoted by various pellet mills are shown here in metric tonnes:

- 18 kg bags – $144 - $215 per tonne
- Bulk supply – $110 - $140 per tonne loose (poured into a container or truck)

Appendix C gives details on prices from the various mills.

3.3 Cost to Transport Pellets to Inuvik

There are twelve (12) pellet mills that are within 3100 to 2600 km of Inuvik, the closest of which are located in Burns Lake, BC.

For the purposes of transportation, wood pellets are essentially identical to grain and can potentially be shipped to and throughout the NWT by truck, rail or barge. Based on the experience gained with pellet supply arrangements in other NWT communities, it seems that the most economical means of transporting pellets is by truck, at least for those communities connected to all-weather roads.

Trucking pellets to Inuvik

The most common method of trucking pellets in bulk is using Super B-train grain trucks (i.e. an 8-axle configuration with two trailers being pulled by one truck). Different methods can be employed to load and unload the trucks including gravity feed, augers or pneumatic (forced air) systems.

A B-train can hold 43 metric tonnes of bulk pellets, 40 tonnes of palletized 18-kg bags (either 44 pallets of 50 bags or 34 pallets of 65 bags) or 32 tonnes of super sacks (1 tonne bags). In the winter the trucks are not loaded to their maximum to allow for some room for additional weight due to snow build up. A B-train will hold less (likely 40-41 tonnes) in the winter.

Given the long distances between the various mills and Inuvik (3100 to 2600 km), there will be challenges to overcome in transporting pellets by truck while respecting NWT transportation regulations. More details on the specifics of trucking costs are available in Appendix C.

Transportation costs for pellets trucked to Inuvik are in the following range:

- 18 kg bags – $343 to $406 / tonne
- Bulk – $325 to $345 / tonne

More details on the specifics of trucking costs are available in Appendix C.

Barging pellets to Inuvik

2 barging companies have been identified that could ship wood pellets to Inuvik- the Northern Transportation Company Limited (NTCL) and Island Tug and Barge.

NTCL is currently servicing Inuvik via the Mackenzie River only from Hay River. 4 trips were scheduled to Inuvik during the 2012 season. NTCL used to have a barging service from British Columbia's west coast due to large demand from one client but this service was offered in 2009 and 2010 only. Island Tug and Barge is the only barging company that has been identified that will do the Pacific coast to Inuvik/Tuktoyaktuk run. No information at the time of reporting was available from this company.

The following were identified as possible options for moving pellets up the Mackenzie River:

- Loading full B-trains (bulk or bags)
- Loading sea-cans (bulk or bags)
- Loading silos directly on the barges (bulk)
- Enclosed housing on barges (bulk)
- Loading full pallets (bags)
- Shallow draft barges (bulk)

In a study done recently on the potential of using wood pellets in Tuktoyaktuk, NT (currently unpublished, 2013) it was determined that the barging option that makes the most sense economically would be to ship an entire barge of containerized pellets (1000 tonnes) down the Mackenzie River by adding an extra barge to an existing trip. This would include modifying 20 foot containers (20 tonne pellet capacity) to serve as both shipping and storage containers. It has been estimated that the cost of pellet purchase, transportation and storage by this method would be approximately $275/tonne. However this option is one that requires large volumes of pellets to be delivered all at once and is not a realistic solution initially until volumes are up in Inuvik.

The other water based route would be to bring them around the coast to Tuktoyaktuk by ship or barge. As Tuktoyaktuk's port is too shallow for ships, they would have to be brought in either by barge or 'lightered' in from the big ship by barge to the port in Tuktoyaktuk. They would then need to be trucked to Inuvik via the winter road or barged to Inuvik.

See Appendix C for a breakdown of costs associated with barging pellets to Inuvik.

Unless shipping arrangements for large quantities of bulk pellets could be established or better barge transport rates negotiated, it appears that transporting pellets by truck is the most likely option currently available for Inuvik at the moment but barging holds promise.

3.4 Estimated Retail Prices for Pellets in Inuvik

To complete the economic analysis, it is necessary to estimate the retail price that pellets would sell for in Inuvik under each potential delivery option (18-kg bags, in-town distribution and direct bulk supply).

18-kg Bags

At the time of report writing, local businesses in Inuvik were selling 18-kg bags. They are currently available in Inuvik for $10- $12/bag. This equates to $555/tonne and $670/tonne. See Appendix C for the details.

For the purposes of the economic analysis it is assumed that an 18-kg bag of pellets would sell for a retail price of $10 per bag or $555 per tonne.

Bulk Pellet Distribution within Town

For larger residential customers and commercial customers that would consume between 5 and 100 tonnes of pellets per year, the most convenient method of pellet supply would be through in-town delivery of bulk pellets from a local pellet distributor.

The local distributor would establish a storage facility and purchase pellets in bulk. It is assumed that a weigh-scale type of pneumatic truck would be used in order to deliver accurate and flexible quantities of pellets. This is the type of service currently available to customers in Yellowknife served by Arctic Green Energy ($325/tonne as of September 2012) and in Norman Wells, served by Green Energy NWT Inc. ($490/tonne as of September 2012). On the customer's side, all that is needed is some accessible on-site storage capacity (silos are available in a wide range of sizes) and a pellet auger system to move pellets from the storage silo to the pellet hopper.

Based on an analysis completed of the total space heating load in Inuvik (see section 4), it was determined that the customers that would potentially use the in-town pellet delivery service represent about 25% (i.e. 87,000 GJ) of the total annual consumption of gas for space heating (i.e. 350,000 GJ).

To determine what the cost per tonne of pellets may be for in-town delivery, the following estimates were developed:

- **Infrastructure Costs** – the capital costs to purchase land, do site preparations, install storage capacity, buy a pneumatic delivery truck (with a weigh scale kit) and other associated costs were estimated to be $200,000;
- **Fixed Operating Costs** – the annual fixed operating costs, including equipment maintenance, taxes, electricity, labour, insurances etc were estimated to be $20,000;
- **Variable Annual Expenses** – operating expenses that would vary with the amount of pellets sold include bulk pellet purchases, transportation costs, carrying charges on pellets in storage, delivery labour and fuel for the truck. As these expenses vary with the total amount of pellets sold, it was necessary to consider market penetration assumptions;
- **Market Penetration Assumptions** – to be conservative, it was assumed that the in-town pellet distributor would be able to obtain up to 20% of the 87,000 GJ available heating market by the 3rd year. The penetration was assumed to be 5% in Year 1 (225 tonnes of pellets), 10% in Year 2 (450 tonnes) and 20% in Year 3 (900 tonnes).

Using these estimates and assumptions, and allowing for inflation and a 10% profit margin, it was calculated that the price to the customer for in-town delivery of pellets would be about $550 / tonne. This is the price that was used for these customers in the economic analysis. See Appendix D for a break-down of the costs used for the in-town delivery system.

If a 50% penetration were achieved, or if some GNWT buildings were to use this service, a pellet price of $530/tonne would be required, before taxes and depreciation, to achieve a 10% profit margin.

Direct Bulk Supply

For larger commercial and institutional customers that would consume more than 100 tonnes of pellets per year, the best pellet delivery option would be to order pellets in bulk supply directly from a pellet mill using a B-train truck (i.e. 43 tonnes per delivery). Adding the pellet purchase price and transportation costs, the delivered cost for bulk pellets would be $485/tonne. See Appendix C for details.

For the purposes of the economic analysis shown in section 5, it was assumed a larger commercial or institutional customer would receive bulk pellet deliveries at a cost of $485 / tonne.

4 INUVIK HEATING LOADS AND PELLET HEATING SYSTEM CONSIDERATIONS

Inuvik Gas is currently supplying about 350,000 GJ of natural gas per year to meet the space heating requirements of approximately 926 commercial and residential customers in Inuvik.

This section of the report presents the results of the analysis completed to determine whether wood pellet heating is an economically viable option for meeting some, or all, of the space heating load currently served by natural gas.

4.1 Heat Content and Commodity Pricing

One tonne of wood pellets provides about 19.3 gigajoules (GJ) of heat energy which, in turn, is equivalent to the heat energy available from about 500 litres of heating oil. A typical oil or wood pellet appliance burns at about 80% efficiency.

4.2 Heating Loads of Inuvik Buildings

The first step in determining the viability of wood pellet heating involved an analysis of the space heating requirements for all residential and non-residential buildings in Inuvik. This was achieved by compiling an inventory of all non-residential buildings, multi-unit residential (i.e. apartments) buildings and housing with its own heating system (i.e. detached houses and row houses). For each building or facility, publicly available information was gathered on the type of building, the total floor area and the type of fuel used for heating (i.e. natural gas or heating oil).

Using information on typical space heating requirements by building type (i.e. retail, office, school, warehouse, garage, row house, apartment etc.), the estimated floor area and the number of heating degree days per year in Inuvik, calculations were performed to determine the estimated peak heating load (in kilowatts) and the estimated annual heating requirement (in gigajoules) for all of the buildings in the inventory. Actual heating data was used where available.

4.2.1 Inuvik Heating Load Analysis - By Type of Building

The main focus of this study is on the potential use of pellet heating systems in non-residential buildings in Inuvik.

Key observations derived from this analysis are as follows:

- The total estimated peak heating load for all buildings in the inventory is **26,200** kW. Of this, approximately 24,500 kW is natural gas-fired and 1,700 kW is oil-fired;
- The total annual space heating requirement for Inuvik for 2012 for buildings connected to natural gas is approximately **335,000 GJ**;
- Non-residential space heating requirements are about **230,000 GJ or 68%** of Inuvik's total gas-fired space heating needs;
- Residential space heating requirements are about **105,000 GJ or 32%** of Inuvik's total gas-fired space heating needs;
- Total annual space heating by oil is approximately **25,000** GJ, of which about 14,000 GJ is for housing. The remaining heating oil consumption is mostly for garages and warehouses.

An analysis of the estimated heating loads in Inuvik, by type of building is included in Appendix E.

4.2.2 Inuvik Heating Load Analysis – By Individual Building

For readers interested in reviewing the information compiled for each individual building, a summary of the entire inventory, organized by street address, is provided in Appendix E.

4.2.3 Inuvik Heating Load Categories

To be able to properly match the range of residential and building heating loads in Inuvik with the different types and sizes of pellet heating systems on the market, and the different pellet delivery options, five categories were created to represent typical heating load scenarios. The heating load scenarios are based on their peak load rather than their annual load. For each building type the building's annual load was estimated based on its area and building type. As some building types have uses other than heating for the gas, the peak heating load to annual load ratio varies. As boilers are sized by their peak load, peak loads (normally stated in kW) are used here as category labels.

At present, synthetic natural gas is available, supplied through the existing natural gas distribution system. Discussions are in place to have liquefied natural gas in Inuvik which would also be supplied through the distribution system. For this analysis it is assumed that there will be some form of fuel distributed to the residents to provide back-up or peak heating requirements. It is recommended that residents have a back-up plan should the distribution system not be available in the future.

Category 1: Residential (<30 kW peak) – the first category is a residential house using a wood pellet stove, and whose peak heating load is less than 30 kW . It is assumed that 50% of the annual heating load would be met by the wood pellet stove, with the remaining load heating being provided by the town's main delivered gas system (synthetic natural gas, liquid natural gas, etc.). The residence would use less than five (5) tonnes of pellets per year which would be supplied in 18-kg bags.

Category 2: Residential / Small Commercial (10–60 kW peak) – the second category is a larger residential house or small commercial building with a peak heating load between 10 and 60 kW that would be heated using pellet furnace or boiler installed in a mechanical room or small outdoor building. It is assumed that the pellet heating system would be sized to meet 50% of the peak load and would cover 90% of the annual heating requirement, with the remaining heating being provided by town's delivered gas system (synthetic natural gas, liquid natural gas, etc.). These buildings would use less than forty (40) tonnes of pellets per year which would be supplied via in-town bulk delivery.

Category 3: Multi-Residential / Small Commercial (60–150 kW peak) – the third category is a multi-residential building (such as an apartment) or a small commercial building with a peak heating load between 60 and 150 kW that would be heated using pellet furnace or boiler installed in a mechanical room or small outdoor building. It is assumed that the pellet heating system would be sized to meet 50% of the peak load and would cover 90% of the annual heating requirement, with the remaining heating being provided by the town's delivered gas system (synthetic natural gas, liquid natural gas, etc.). These buildings would use less than one hundred (100) tonnes of pellets per year which would be supplied via in-town bulk delivery. These systems would require engineering drawings.

Category 4: Small Commercial / Institutional (150–300 kW peak) – the fourth category represents small commercial or institutional buildings with a peak heating load between 150 and 300 kW that would be heated using a pellet boiler installed in a mechanical room or in an outdoor shed. It is assumed that the pellet heating system would be sized to meet 50% of the peak load and would cover 90% of the annual heating requirement, with the remaining heating being provided by the town's delivered gas system (synthetic natural gas, liquid natural gas, etc.). These buildings would use less than two hundred (200) tonnes of pellets per year which would be supplied directly from the mill to the customer using bulk delivery. These systems would require engineering drawings.

Category 5: Large Commercial / Institutional (>300 kW peak) – the last category represents large commercial or institutional buildings with a peak heating load greater than 300 kW that would be heated using a containerized boiler. It is assumed that the pellet heating system would be sized to meet 50% of the peak load and would cover 90% of the annual heating requirement, with the remaining heating being provided by the town's delivered gas system (synthetic natural gas, liquid natural gas, etc.). These buildings would use more than two hundred (200) tonnes of pellets per year which would be supplied directly from the mill to the customer using bulk delivery. These systems would require engineering drawings.

These five categories were used as the basis for the economic analysis.

4.3 Pellet Heating System Sizing and Identification

The second step in the analysis involved a survey of various heating system suppliers to determine the different types of pellet heating systems available on the market capable of meeting the building heating requirements and peak loads that exist in Inuvik (i.e. from 10 to 2,000 kW).

At the outset, it is important to recognize that, while there are many different biomass heating systems on the market, particularly in Europe, not all suppliers are willing and capable of serving Inuvik. In this regard, key factors to consider include:

- The fact that the installation of biomass heating systems in Canada is still in its infancy. As a result, the majority of pellet heating system suppliers have not yet established a Canadian sales and distribution network;
- Even fewer suppliers are capable of ensuring adequate service and maintenance support in Inuvik; and
- Any pellet heating system installed in Canada must meet Canadian certification standards.

These factors were used to help determine which systems and suppliers represented realistic options for Inuvik.

4.3.1 Pellet Heating Systems – Availability and Pricing

Using the information on the building energy requirements and peak loads in Inuvik and the optimum sizing approach previously described, a survey of pellet heating system manufacturers and suppliers was conducted to determine the most suitable systems available, and estimate the capital costs to purchase, transport and install the systems in Inuvik.

Price estimates were received from several sources for each category. Shipping and installation costs varied greatly and due to a number of prevailing factors, most of which are project-specific, make it difficult to estimate these costs in a general way. The main factors for projects in Inuvik include:

- The purchase price of suitable system components (as specified above), by scale, quality, configuration and features.
- Construction requirements for boiler room and fuel storage, depending on availability of sufficient space.
- Requirements of electrical and mechanical construction (including plumbing)
- General site conditions (including accessibility).

The noticeable differences in shipping costs are primarily defined by transport distances, and individual marketing calculations.

5 ECONOMIC ANALYSIS OF PELLET HEATING SYSTEMS FOR INUVIK

This section of the report explains and summarizes the analyses completed to estimate the annual pellet heating costs and simple paybacks that may occur if buildings in Inuvik are converted to pellet heating.

The following key assumptions were used to create five different heating ranges which cover all of the individual building heating loads in Inuvik.

Heating Range Scenarios & Key Assumptions Used for Economic Analysis

	Heating Ranges	System Type	Peak Heat Load	System Size Required	Tonnes of Pellets Required Per Year	Pellet Delivery Method	Retail Price of Pellets (estimate)
1	Residential (Pellet stoves)	Stove	<30 kW	10 – 15 kW	<5	Bags	$10.00 /bag ($555 /tonne)
2	Residential (Boilers) / Small commercial	Furnace/ Boiler installed in mechanical room	15-60 kW	18 – 30 kW	<40	In-town bulk delivery	$550 /tonne
3	Multi-Residential /Commercial	Furnace/ Boiler installed in mechanical room	60-150 kW	30 - 75 kW	<100	In-town bulk delivery	$550 /tonne
4	Commercial / Institutional	Containerized boiler	150-300 kW	75 - 150 kW	<200	Bulk delivery direct from mill	$485 /tonne
5	Large Commercial / Institutional	Containerized boiler	>300 kW	>150 kW	>200	Bulk delivery direct from mill	$485 /tonne

An explanation of the economic analysis and the results obtained for each heating range are provided below.

5.1 Residential Pellet Stoves - Heating Range #1

There are several dealers of pellet stoves and residential sized pellet boilers and furnaces in the larger communities in the NWT (i.e. Yellowknife, Hay River, Fort Smith). There are several contractors in Inuvik currently selling and installing pellet stoves. The pellet stoves range in size from about 9 to 21 kW.

Numerous different brands of stoves are available on the market. The system purchase prices in the south of the NWT range from about $2,250 up to $3,300 depending on the supplier and size of the stove. The installation costs can vary greatly.

For a typical residence in Inuvik, it is assumed that 50% of the heating requirement would be met by pellets and the remaining 50% met by synthetic gas.

Based on recent pellet stove purchase and installation costs for Yellowknife and Hay River, the following assumptions were used for the economic analysis of a pellet stove installation in Inuvik:

- Estimated capital cost in Inuvik: $7,000 ($5,000 materials, $2,000 installation); and,
- Cost of pellets = $10.00/bag ($555/tonne).

The results for the base case economic analysis are shown in Table 5.1A below:

Table 5.1A: Results for Residential Pellet Stove Conversion – Base Case

Building	Estimated Annual Heating (GJ)	Estimated System Size	Estimated Total Cost to Convert	Estimated Annual Heating Cost (50% pellets, 50% gas)	Estimated Annual Heating Cost (100% synthetic gas)	Estimated Annual Heating Cost Savings	Estimated Simple Payback on Conversion (years)
Residence	170 GJ	15 kW	$7,000	$5,800	$6,800	$1000	7.3

Based on these assumptions, a wood pellet stove would result in estimated annual heating cost savings of $1000. The simple payback on the estimated $7,000 conversion cost would be 7 years.

To test the sensitivity of the key assumptions, the capital conversion costs were adjusted upwards by 20%. As the assumed pellet pricing is the most sensitive variable in the analysis, the pellet pricing was adjusted downwards and upwards by 20%. The results of the sensitivity analysis are shown in Table 5.1B below:

Table 5.1B: Results for Residential Pellet Stove Conversion – Sensitivity Analysis

Building Type	Estimated Annual Heating	Estimated Total Cost to Convert	Estimated Simple Paybacks			
			Base Case	20% Increase in Conversion Costs	20% Decrease in Pellet Pricing ($8/bag)	20% Increase in Pellet pricing ($12/bag)
Residence	170 GJ	$7,000	7.3	8.8	4.9	15.0

In conclusion, the estimated payback is not overly sensitive to changes in the capital cost. A 20% increase in the estimated conversion cost generates about a 20% increase in the payback period. Similarly, if a residential pellet stove can be installed in Inuvik for less than $7,000, there will be a corresponding drop in the amount of time needed to recoup the initial investment through annual energy savings.

The results above do indicate that the economic viability of a pellet stove conversion is highly sensitive to the actual retail price of bagged pellets. The base case assumption of $10 per bag is considered to be

realistic as one retailer in Inuvik is currently selling bagged pellets at this price. If cheaper shipping arrangements were obtained in order to bring the price of bagged pellets down by 20%, the payback period for recovery of the pellet stove conversion costs would drop to about 5 years, which would be much more attractive to a residential homeowner.

The payback will also improve if more than 50% of the annual heating is met by pellet heating.

5.2 Residential & Small Commercial - Heating Range #2 (15 to 60 kW peak)

For residential customers or small commercial buildings with a peak heating loads of less than 60 kW, their yearly consumption of pellets will range anywhere from about 5 to 40 tonnes, depending on the size of the building and other factors. For these customers, it is impractical to take delivery of an entire B-train of pellets (43 tonnes) directly as this would require an amount of storage in excess of a year's supply. It is assumed that these customers will be served by an "in-town" local pellet distributor.

For small-scale pellet heating systems, purchase cost estimates from suppliers ranged from $6,800 to more than $100,000 depending on the supplier and size of the system. Shipping and installation can add additional costs ranging from $11,000 to about $23,500, depending on circumstances. In total, the installed costs can range anywhere from about $17,000 (for an 18 kW system) to more than $125,000 (for a 75 kW system).

The assumptions used in the economic analysis for the buildings in this heating range were as follows:

- Heating systems are installed inside the building- no costs were included for exterior containers;
- The pellet system installed is sized at 50% - 60% of the building peak heating load. From this, it is assumed that 90% of the building's annual heating requirements are met by pellets and that 10% is met by synthetic gas;
- The estimated total capital cost to convert a building to pellet heating includes the system purchase price, transportation costs, installation costs, engineering and the cost of minimal pellet storage capacity:
    - Silo cost = $6,500
    - Installation = $10,000
    - Boiler cost = $8,000-$11,500
    - Shipping = $3,000
    - Engineering:
        - Residential = $0
        - Commercial = $30,000
- Annual maintenance costs:
    - Residential = $500
    - Commercial = $1,500
- In-town pellet supply provided at a cost of $550/ tonne; and,
- The estimated cost for synthetic natural gas is $40 / GJ.

The results for the base case economic analysis are shown in Table 5.2A below for two residences and several small commercial buildings:

Table 5.2A: Results for Pellet Heating System Conversions in 15 - 60 kW peak Range – Base Case

Building	Estimated Annual Heating (GJ)	Estimated System Size	Estimated Total Cost to Convert	Estimated Annual Heating Cost (90% pellets, 10% gas)	Estimated Annual Heating Cost (100% synthetic gas)	Estimated Net Annual Heating Cost Savings	Estimated Simple Payback on Conversion (years)
Residence 1	170 GJ	18 kW	$25,700	$5,000	$6,800	$1,300	20.4
Residence 2	340 GJ	18 kW	$25,700	$10,100	$13,600	$3,000	8.5
Building 1	519 GJ	18 kW	$55,700	$15,400	$20,800	$3,900	14.4
Building 2	674 GJ	33 kW	$58,400	$20,000	$27,000	$5,500	10.7
Building 3	766 GJ	33 kW	$58,400	$22,700	$30,600	$6,400	9.1

For the residential installations, the estimated total cost to convert to pellet heating is quite high (relative to the size of the system being installed) and results in estimated simple paybacks between 8.5 and 20 years. For the three commercial buildings, the estimated simple paybacks ranged from about 9.1 to 14.4 years. If lower costs for installation and engineering (for the commercial buildings) could be achieved, the estimated paybacks would improve somewhat.

To test the sensitivity of the key assumptions and results obtained, the capital costs were adjusted upwards by 20% and the pellet pricing was decreased and increased by 20%. The results of the sensitivity analysis are shown in Table 5.2B below:

Table 5.2B: Results for Pellet Heating System Conversions 15–60 kW peak Range – Sensitivity Analysis

Building Type	Estimated Annual Heating	Estimated Total Cost to Convert	Estimated Simple Paybacks			
			Base Case	20% Increase in Conversion Costs	20% Decrease in Pellet Pricing	20% Increase in Pellet pricing
Residence 1	170 GJ	$25,700	20.4	24.5	12.1	66.3
Residence 2	340 GJ	$25,700	8.5	10.2	5.4	20.1
Building 1	519 GJ	$55,700	14.4	17.3	8.5	46.0
Building 2	674 GJ	$58,400	10.7	12.8	6.5	28.9
Building 3	766 GJ	$58,400	9.1	10.9	5.6	23.4

The sensitivity analysis indicates that the estimated paybacks are quite sensitive to the assumed cost of in-town pellet delivery. If customers could receive this service at a price of $445 / tonne or less, then the estimated paybacks improve considerably to a range of 5.4 to 12 years.

In conclusion, it would appear that if slightly lower installation and engineering costs could be realized and in-town pellet delivery could be obtained at 20% less ($445 / tonne), then the larger buildings in this range (i.e. with annual heating requirements of 500 to 800 GJ) may have economic incentive to convert to pellet heating.

5.3 Multi-Residential & Commercial – Heating Range #3 (60 to 150 kW peak)

For multi-residential buildings or commercial buildings with a peak heating load between 60 and 150 kW, it is estimated that yearly consumption of pellets will range anywhere from about 40 to 100 tonnes, depending on the size of the building and use. For these customers, it is possible that they will take delivery of an entire B-train of pellets (43 tonnes) directly but this would require storage for a half to one year's supply of pellets. For boilers above 30kW installed in non-residential, or residential buildings larger than a duplex, engineered drawing are required (Department of Justice, GNWT, 2002).

For small-scale pellet heating systems, purchase cost estimates from suppliers ranged from $6,800 to more than $100,000 depending on the supplier and size of the system. Shipping and installation can add additional costs ranging from $11,000 to about $23,500, depending on circumstances. In total, the installed costs can range anywhere from about $17,000 (for an 18 kW system) to more than $125,000 (for a 75 kW system).

For the economic analysis, it is assumed that these customers will be served by an "in-town" local pellet distributor. This would only require the customers to install a minimum amount of pellet storage.

The assumptions used in the economic analysis for the buildings in this heating range were as follows:

- Heating systems are installed inside the building – no costs were included for exterior containers;
- The boiler installed is sized at 50% - 60% of the building peak heating load. From this, it is assumed that 90% of the building's annual heating requirements are met by pellets and that 10% is met by synthetic gas;
- The estimated total capital cost to convert a building to pellet heating includes the system purchase price, transportation costs, installation costs, engineering and the cost of pellet storage capacity:
    - Silo cost = $45,000
    - Installation = $20,000
    - Boiler cost = $105,000
    - Shipping = $8,500
    - Engineering = $60,000
- Annual maintenance costs of $1,500;
- In-town pellet supply provided at a cost of $550/ tonne; and,
- The estimated cost for synthetic natural gas is $40 / GJ.

The results for the base case economic analysis are shown in Table 5.3A below for five different sized commercial buildings:

Table 5.3A: Results for Pellet Heating System Conversions in 60 - 150 kW peak Range – Base Case

Building	Estimated Annual Heating (GJ)	Estimated System Size	Estimated Total Cost to Convert	Estimated Annual Heating Cost (90% pellets, 10% gas)	Estimated Annual Heating Cost (100% synthetic gas)	Estimated Net Annual Heating Cost Savings	Estimated Simple Payback on Conversion (years)
Building 4	1156 GJ	75 kW	$238,500	$34,300	$46,200	$10,500	22.8
Building 5	1366 GJ	75 kW	$238,500	$40,500	$54,600	$12,600	18.9
Building 6	1807 GJ	75 kW	$238,500	$53,600	$72,300	$17,200	13.9
Building 7	1618 GJ	75 kW	$238,500	$48,000	$64,700	$15,300	15.6
Building 8	1975 GJ	75 kW	$238,500	$58,600	$79,000	$19,000	12.6

For the commercial buildings in this heating range, the estimated net annual heating cost savings ranged between $10,000 and $19,000. However, due to the high estimated capital costs for system purchase, installation and engineering, the estimated simple paybacks range from about 12.5 to 22.8 years. Again, if these systems can be installed for less than estimated in this study, the estimated paybacks would improve somewhat.

To test the sensitivity of the key assumptions and results obtained, the capital costs were adjusted upwards by 20% and the pellet pricing was decreased and increased by 20%. The results of the sensitivity analysis are shown in Table 5.3B below:

Table 5.3B: Results for Pellet Heating System Conversions 15– 60 kW peak Range – Sensitivity Analysis

Building Type	Estimated Annual Heating	Estimated Total Cost to Convert	Estimated Simple Paybacks			
			Base Case	20% Increase in Conversion Costs	20% Decrease in Pellet Pricing	20% Increase in Pellet pricing
Building 4	1156 GJ	$238,500	22.8	27.3	14.6	52.6
Building 5	1366 GJ	$238,500	18.9	22.6	12.1	42.3
Building 6	1807 GJ	$238,500	13.9	16.6	9.0	30.1
Building 7	1618 GJ	$238,500	15.6	18.8	10.1	34.3
Building 8	1975 GJ	$238,500	12.6	15.1	8.2	27.1

The sensitivity analysis indicates that the estimated paybacks are quite sensitive to the assumed cost of in-town pellet delivery. If customers could receive this service at a pellet price 20% lower ($445 / tonne), then the estimated paybacks improve somewhat to a range of 8.2 to 14.5 years, however, there would still be little economic incentive to convert to pellet heating.

In conclusion, it would appear that for buildings in this heating range, the high capital cost to convert are substantial relative to the annual savings on heating costs that would result. Unless significant reductions in the conversion costs could be achieved, there does not appear to be an economic incentive to convert to pellet heating.

5.4 Commercial & Institutional – Heating Range #4 (150 to 300 kW peak)

For commercial or institutional buildings with a peak heating load between 150 and 300 kW, their yearly consumption of pellets will be 100- 200 tonnes which would be supplied directly to the customer using bulk delivery. This would require that sufficient on-site storage capacity be provided to take delivery of a full B-train (i.e. 43 tonnes).

As the scale of biomass combustion systems increases, the individual prices set by the various suppliers start to become significantly different (despite the fact that some suppliers, in part, offer the same products).

General price differences between system manufacturers are most often due to substantial differences in quality, design and configuration of the heating systems. There are noticeable price differences between the different systems which are primarily due to the important fact that some systems are approved under the American Society of Mechanical Engineers (ASME) standard whereas some are not.

The assumptions used in the economic analysis for the buildings in this heating range were as follows:

- Heating systems are installed outside the building in a container;
- The boiler installed is sized at 50% - 60% of the building peak heating load. From this, it is assumed that 90% of the building's annual heating requirements are met by pellets and that 10% is met by synthetic gas;
- The estimated total capital cost to convert a building to pellet heating includes the system purchase price, transportation costs, installation costs, engineering and the cost of pellet storage capacity:
    - Silo cost = $45,000
    - Installation = $20,000
    - Boiler cost = $105,000
    - Container = $40,000
    - Shipping = $8,500
    - Engineering = $60,000
- Annual maintenance costs of $3,000;
- Bulk pellet delivery provided at a cost of $485/ tonne; and,
- The estimated cost for synthetic natural gas is $40 / GJ.

The results for the base case economic analysis are shown in Table 5.4A below for four different sized commercial and institutional buildings:

Table 5.4A: Results for Pellet Heating System Conversions in 150 – 300 kW peak Range – Base Case

Building	Estimated Annual Heating (GJ)	Estimated System Size	Estimated Total Cost to Convert	Estimated Annual Heating Cost (90% pellets, 10% gas)	Estimated Annual Heating Cost (100% synthetic gas)	Estimated Net Annual Heating Cost Savings	Estimated Simple Payback on Conversion (years)
Building 9	2387 GJ	150 kW	$253,500	$63,500	$95,500	$28,900	10.3
Building 10	3225 GJ	150 kW	$253,500	$85,800	$129,000	$40,200	7.5
Building 11	3560 GJ	150 kW	$253,500	$94,800	$142,400	$44,600	6.7
Building 12	3655 GJ	150 kW	$253,500	$97,300	$146,200	$45,900	6.5

For the buildings in this heating range, the estimated net annual heating cost savings ranged between about $29,000 and $46,000. These savings resulted in estimated simple payback periods ranging from 6.5 to 10.3 years.

To test the sensitivity of the key assumptions and results obtained, the capital costs were adjusted upwards by 20% and the pellet pricing was decreased and increased by 20%. The results of the sensitivity analysis are shown in Table 5.3B below:

Table 5.4B: Results for Pellet Heating System Conversions in 150– 300 kW peak Range – Sensitivity Analysis

Building Type	Estimated Annual Heating	Estimated Total Cost to Convert	Estimated Simple Paybacks			
			Base Case	20% Increase in Conversion Costs	20% Decrease in Pellet Pricing	20% Increase in Pellet pricing
Building 9	2387 GJ	$253,500	10.3	12.4	7.5	16.5
Building 10	3225 GJ	$253,500	7.5	8.9	5.5	11.7
Building 11	3560 GJ	$253,500	6.7	8.0	4.9	10.5
Building 12	3655 GJ	$253,500	6.5	7.8	4.8	10.2

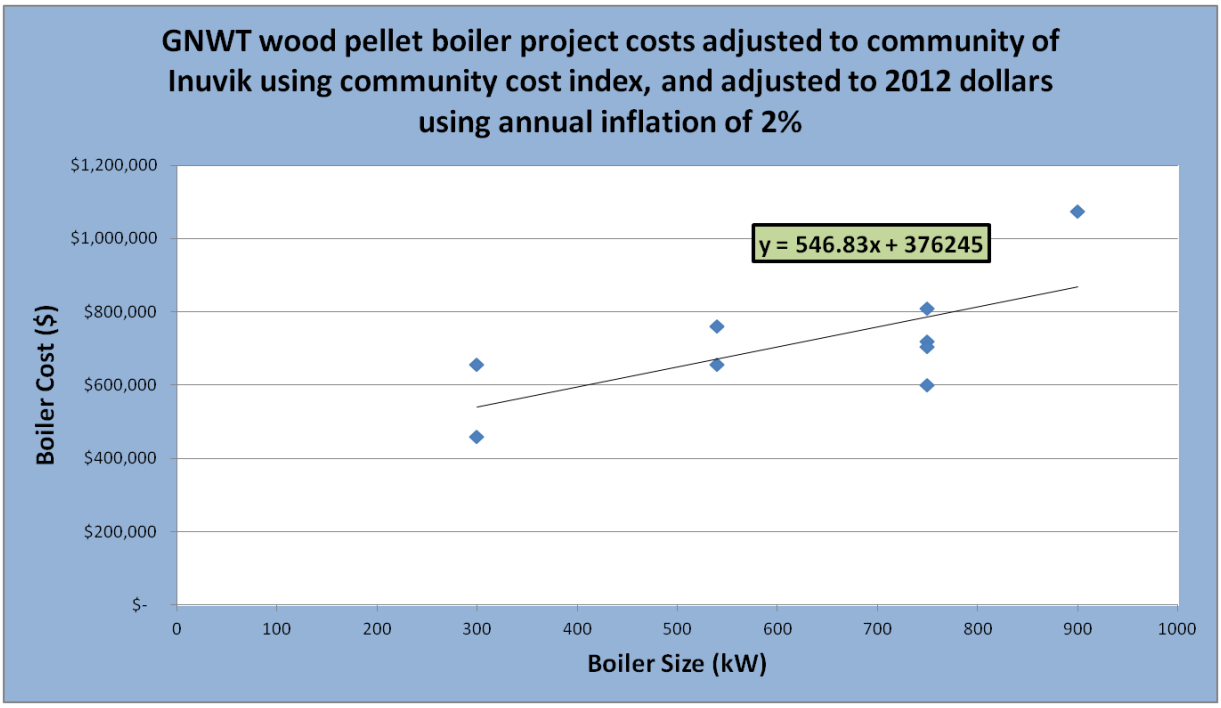
The sensitivity analysis indicates that the estimated paybacks are quite sensitive to the assumed cost of bulk delivery. If customers could receive this service at a price of 20% less ($390 / tonne), the estimated paybacks become quite interesting, ranging from about 4.8 to 7.5 years.

In conclusion, it would appear that for buildings in this heating range, the high annual heating requirements help spread the fixed capital investment required to convert to pellet heating and result in significant annual energy cost savings and reasonably compelling paybacks on the investment.

5.5 Large Commercial & Institutional – Heating Range #5 (>300 kW peak)

For large commercial or institutional buildings with a peak heating load greater than 300 kW, their yearly consumption of pellets will be more than 200 tonnes which would be supplied directly to the customer using bulk delivery. This would require that sufficient on-site storage capacity be provided to take delivery of a full B-train (i.e. 43 tonnes). To provide a safety margin, it is also assumed that each customer would install sufficient pellet storage to have at least two to three months worth of pellets on hand, in case there were ever any significant interruptions in the pellet supply chain.

For the economic analysis of large-scale pellet heating systems, an analysis of the GNWT installations was conducted. The GNWT has installed 9 pellet heating systems of 300- 900 kW size in the NWT, with a price range of $350,000 - $830,000. Using a 2% inflation rate and adjusting for community price differences, the equation shown in the chart below was created based on an installed system size of 300- 900 kW:



The assumptions used in the economic analysis for the buildings in this heating range were as follows:

- Heating systems are installed outside the building in a container;
- The boiler installed is sized at 50% - 60% of the building peak heating load. From this, it is assumed that 90% of the building's annual heating requirements are met by pellets and that 10% is met by synthetic gas;
- The estimated total capital cost to convert a building to pellet heating is derived based on the GNWT's experiences and the size of the boiler being installed;
- Annual maintenance costs of $16,250;
- Bulk pellet delivery provided at a cost of $485/ tonne; and,
- The estimated cost for synthetic natural gas is $40 / GJ.

The results for the base case economic analysis are shown in Table 5.5A below for five different sized buildings:

Table 5.5A: Results for Pellet Heating System Conversions in >300 kW peak Range – Base Case

Building	Estimated Annual Heating (GJ)	Estimated Building Peak Load	Estimated Total Cost to Convert	Estimated Annual Heating Cost (90% pellets, 10% gas)	Estimated Annual Heating Cost (100% synthetic gas)	Estimated Net Annual Heating Cost Savings	Estimated Simple Payback on Conversion (years)
Building 13	5605 GJ	425 kW	$540,000	$149,200	$224,200	$58,800	9.2
Building 14	7856 GJ	596 kW	$540,000	$209,100	$314,240	$88,900	6.1
Building 15	8909 GJ	676 kW	$671,100	$237,100	$356,360	$103,000	6.5
Building 16	14945 GJ	1133 kW	$671,100	$397,800	$597,800	$183,800	3.7
Building 17	19396 GJ	1385 kW	$769,400	$516,300	$775,840	$243,300	3.2

For the buildings in this heating range, the estimated net annual heating cost savings ranged between $58,000 and $243,000. These savings resulted in estimated simple payback periods ranging from 3.2 to 9.2 years. For the larger buildings, the annual energy savings and 3 to 4 year paybacks look quite favourable.

To test the sensitivity of the key assumptions and results obtained, the capital costs were adjusted upwards by 20% and the pellet pricing was decreased and increased by 20%. The results of the sensitivity analysis are shown in Table 5.5B:

Table 5.5B: Results for Pellet Heating System Conversions >300 kW peak Range – Sensitivity Analysis

Building Type	Estimated Annual Heating	Estimated Total Cost to Convert	Estimated Simple Paybacks			
			Base Case	20% Increase in Conversion Costs	20% Decrease in Pellet Pricing	20% Increase in Pellet pricing
Building 13	5605 GJ	$540,000	9.2	11.0	6.4	16.2
Building 14	7856 GJ	$540,000	6.1	7.3	4.3	10.1
Building 15	8909 GJ	$671,100	6.5	7.8	4.7	10.7
Building 16	14945 GJ	$671,100	3.7	4.4	2.7	5.8
Building 17	19396 GJ	$769,400	3.2	3.8	2.3	4.9

The sensitivity analysis indicates that the estimated paybacks would improve even more if customers could receive bulk pellet delivery at a price of 20% less ($390 / tonne or less), ranging from 2.3 to 6.4 years.

In conclusion, it would appear that for buildings in this heating range, the high annual heating requirements help spread the fixed capital investment required to convert to pellet heating and result in significant annual energy cost savings and some compelling paybacks on the investment.

5.6 Penetration scenarios

The penetration or uptake rate of conversion in Inuvik will not greatly affect the economic analysis, with the exception of those buildings using an in-town pellet delivery service. Those customers buying bagged pellets or bringing in bulk deliveries on their own will not notice a huge difference in price with different penetration scenarios. The customers using the in-town delivery service will however notice a difference in pellet price based on the penetration rate.

As described in section 3.4, a local distributor would have fixed infrastructure and fixed operating costs irrespective of how many pellets were sold. These costs will not change based on penetration and thus the higher the penetration rate, the lower these costs per tonne sold. It is estimated that 25% of Inuvik's load (or 87,000 GJ) fits into the category requiring in-town delivery. Based on a 5% year 1, 10% year 2, 20% year 3 penetration of this group, a pellet price of $550/tonne would be required to receive a 10% profit margin. If a 50% penetration were achieved, or if some GNWT buildings were to use this service, a pellet price of $530/tonne would be required to achieve a 10% profit margin.

In summary, the penetration rate doesn't change pellet price significantly for any of the pellet options.

6 CONCLUSIONS

In conclusion, residents in Inuvik will be facing a rise in their heating costs of up to 100% over the next winter. Wood pellets have made economic sense in other communities in the NWT and may be a viable option for space heating in Inuvik. Their price is demonstrated to be lower per GJ than any other option currently available to residents in Inuvik, but the high capital costs involved for conversion may negate the lower fuel cost.

Table 6.1: Comparison of heating fuels in Inuvik

Fuel Type	Unit Cost (as of September 2012)	Unit cost ($/GJ)
Natural Gas[1]	$19.30 / GJ	$19.30/ GJ
Synthetic Natural gas (Propane-Air Mix)[2]	$40.00 / GJ (est)	$40.00 / GJ (est)
Heating Fuel[1,3]	$1.77 / litre	$46.37 / GJ
Wood Pellets – bags[3,4]	$10 / bag	$28.76 / GJ
Wood Pellets – bulk delivered through in town delivery service[1,4]	$550 / tonne	$28.50 / GJ
Wood Pellets – bulk stored on site and ordered directly from mill[3,5]	$485 / tonne (est.)	$25.13 / GJ

Notes: Refer to report for details

Pellets are currently being brought into Inuvik and sold for $10/bag. Trucking seems to be the most straight-forward and practical method of bringing in bulk pellets to Inuvik but barging may present a very interesting option cost-wise, although logistically complicated. Barging B-trains of pellets to Inuvik is not currently an economically interesting option.

Of the potential groups in Inuvik, the large commercial and institutional customers have the shortest paybacks for installing pellet appliances. The higher heating requirements help spread the fixed capital investment required and result in compelling paybacks of 3-10 years on the investment.

Pellet stoves installed in residences appears to be the second most interesting group due to the low initial capital costs. The payback is not overly sensitive to changes in capital cost but is quite sensitive to changing pellet price. If 50% of a typical house's heating requirements are met by a pellet stove, paybacks in the realm of 7 years are likely. Covering more of the heating load would result in a better payback.

Those customers installing residential or small commercial boilers or furnaces have the least economic incentive to convert to pellet heating. These customers have high capital costs and may require expensive engineering drawings and pellet storage systems but still require an in-town delivery of pellets, making savings less. Unless there are significant reductions in conversion costs, there does not appear to be any economic incentive for this group.

There is a large potential for bulk or bagged pellets to be barged to Inuvik. This area needs considerable more work and time should be devoted to this area. Barging of pellets has the potential to be a large game changer in Inuvik.

7 RECOMMENDATIONS

The recommendations stemming from this report are aimed at creating a 5 year action plan to integrate pellets into the Inuvik fuel supply market. This study concludes that large commercial and institutional customers have the shortest paybacks for installing pellet appliances and that pellet stoves installed in residences appears to be the second most interesting group due to lower initial capital costs. In light of the report findings, the Arctic Energy Alliance recommends the following actions:

Year 1

Set a target for pellet penetration for year 1 of 5% of the heating load (225 tonnes of pellets).

Residential Buildings:

- The GNWT facilitates a pellet stove installation program using the trained installers from the WETT course offered in Inuvik 2012/13 to install 20 pellet stoves.
- The GNWT continues providing financial incentives to homeowners.
- The GNWT creates a program with targeted support for low income households.
- The GNWT commissions a study of houses managed by the Inuvik Housing Authority to investigate the possibility of using pellet stoves in their houses or creating mini district heating systems between houses.

Small commercial Buildings:

- The GNWT provides external funding to convert a commercial or institutional building as part of a visible demonstration project.
- The GNWT continues providing financial incentives for converting buildings to pellet heating and facilitates projects to have a 5-7 year payback. Financial incentives for the purchase of pellet heating systems are indispensable for pellet heating system market start up in this group.
- The GNWT hosts a biomass fair in the early spring bringing government, manufacturers, suppliers, installers and interested clients together.
- The GNWT's Public Works and Services conducts a design study for a small wood pellet district heating system centered around a GNWT building.

Large commercial & Institutional Buildings:

- The GNWT's Public Works and Services converts a large GNWT building to pellet heating and installs on-site storage as part of a visible demonstration project.
- The GNWT continues providing financial incentives for the installation of pellet heating systems.

Pellet Transportation & Storage:

- The GNWT makes pellets available with a private supplier to ensure that a minimum of 200 tonnes of bagged pellets are available in town next winter (enough for ~ 50 stoves).
- The GNWT works with a supplier to deliver a B-train of bulk pellets to Inuvik.
- The GNWT's Petroleum Products Division investigates transportation of pellets by barge.

Years 2 & 3

Set a target for pellet penetration for year 3 of 15% of the heating load (700 tonnes of pellets).

Residential Buildings:

- The GNWT conducts a pellet installation program using the trained installers from the WETT course offered in Inuvik 2012/13 to install another 20 pellet stoves per year.
- The GNWT offers another WETT certification course for installers.
- The GNWT continues providing financial incentives to homeowners.
- The Inuvik Housing Authority implements the recommended measures from study in year 1.

Small commercial Buildings:

- The GNWT continues providing financial incentives for converting buildings to pellet heating.
- The GNWT monitors the economic and greenhouse gas savings on the demonstration project and the GNWT publishes a case study or report on this installation.
- The GNWT's Public Works and Services installs a small district heating system on 3-10 buildings in town based on recommendations from study in year 1.

Large commercial & Institutional Buildings:

- The GNWT continues providing financial incentives for converting buildings to pellet heating.
- NTPC and the GNWT commission a design study for the feasibility of a wood pellet cogeneration plant.

Pellet Transportation & Storage:

- The GNWT facilitates work with a private supplier to conduct a trial run shipment of pellets using a modified 20t sea-can which would act as both transportation vessel and onsite storage facility.
- The GNWT develops a business case for barging wood pellets based on the findings of the barge transportation study conducted in year 1 and tests it out.

Years 4 & 5

Set a target for pellet penetration for year 5 of 25% of the heating load (1100 tonnes of pellets).

Residential Buildings:

- The GNWT provides ongoing support for residential pellet stove installations.
- The GNWT facilitates expansion of pellet demand in other communities by supporting a 10 wood pellet stove per year installation program in Aklavik, Fort McPherson and/or Tuktoyaktuk.

Small commercial Buildings:

- The GNWT provides ongoing support and monitoring of small district heating systems and small commercial installations.
- The GNWT incentivizes an in-town bulk pellet delivery business.
- The GNWT designs a targeted program to assist small businesses to convert to pellet heating.

Large commercial & Institutional Buildings:

- NTPC and the GNWT build a wood pellet cogeneration plant.
- The GNWT expands wood pellet district heating systems.

Pellet Transportation & Storage:

- The GNWT's Petroleum Products Division works with a supplier to get pellets delivered through the region and potentially down the Mackenzie River from Fort Simpson to the Sahtu communities en route to Inuvik.

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APPENDIX A: REFERENCES

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