ARCTIC ENERGY ALLIANCE

Inuvik Wood Pellet Infrastructure Study

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

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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

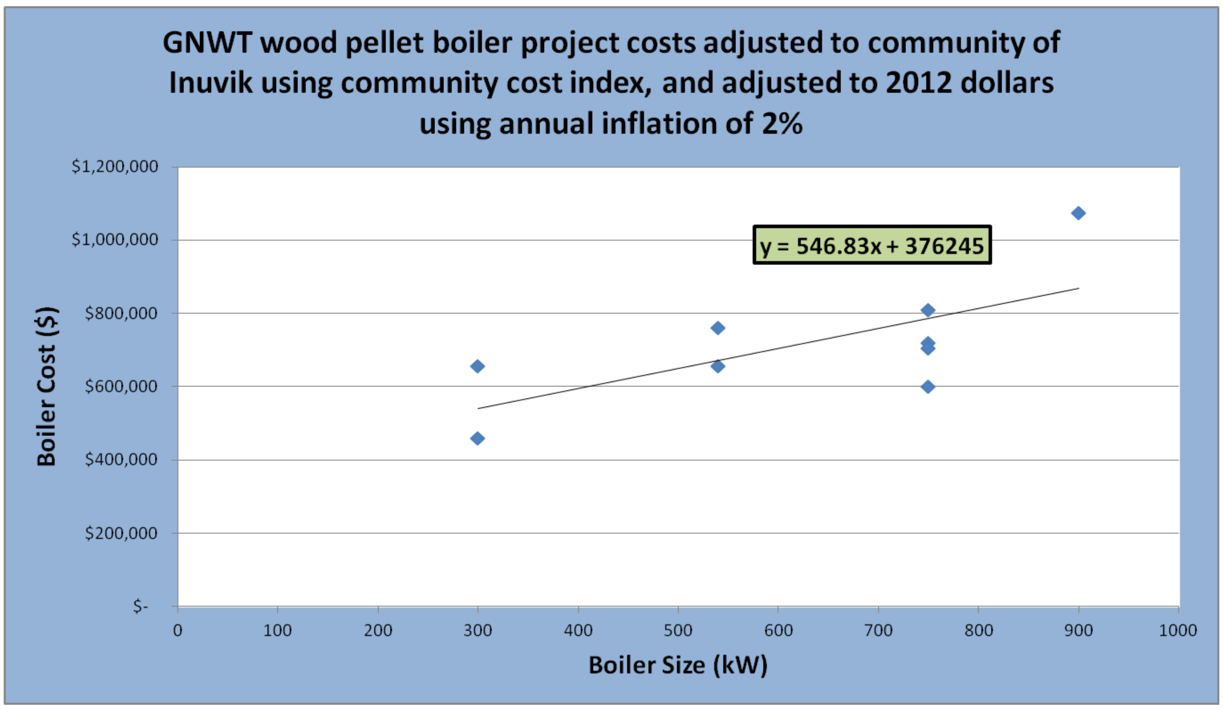
The sensitivity analysis indicates that the estimated paybacks are quite sensitive to the assumed cost of bulk delivery. If customers could receive this service at a price of 20% less ($390 / tonne), the estimated paybacks become quite interesting, ranging from about 4.8 to 7.5 years.

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 B: OVERVIEW OF PELLET HEATING SYSTEMS

Forest covers 33.3 million hectares of land in the NWT which represents 28 percent of the Canadian boreal forest. Historically, firewood was one of the primary energy sources in much of the NWT. With the gradual development of permanent settlements, fossil fuels eventually replaced wood as a primary source of heat. However, due to rising fuel costs and concerns about the release of greenhouse gas emissions, there is now an interest in finding alternatives to fossil fuels, such as wood and wood pellets.

In recent years, 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, housing complexes etc. 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 BC and Alberta. Government and private business representatives have examined the possibility of producing wood pellets in the NWT, however, it appears that local wood pellet production will not be cost-competitive with southern suppliers until the NWT wood pellet market reaches the 30,000 tonne level per year, which is roughly double its current size. The GNWT released the NWT Biomass Energy Strategy in 2010 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 BC and 3 plants in Alberta with a total 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.

Wood Pellet Appliances

Wood pellets can be burned in pellet stoves, boilers and furnaces. This section presents how these appliances work, the differences between them and some advantages and disadvantages of each.

Wood Pellet Stoves- Residential

Wood pellet stoves are used to heat one room or area without being connected to a central heating system. They are normally located in a well-used room and are designed to be decorative and to provide heat by radiation and/or convection. From the outside they look similar to wood stoves, although the fire inside looks slightly different.

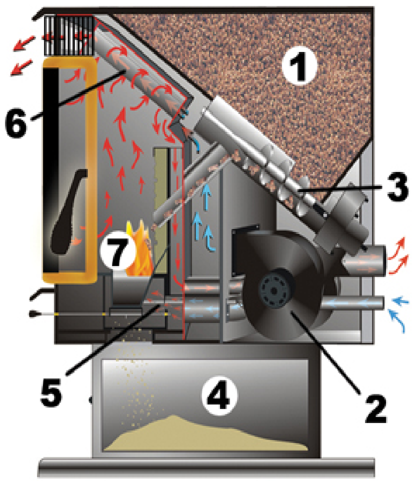


Figure B-1: A typical top-fed stove (Hearth & Home Technologies n.d.)

- Wood pellets are stored in a hopper (1)
- They are fed by an electric auger (3) into the burn grate (7) at a rate determined by the temperature control
- An automatic igniter (5) starts the fire
- Fire heats the air in heat exchange tubes (6) and a convection fan (2) blows this heated air into the room where a stove is situated
- The ash pan (4) below the burn grate collects the residue.

Stove design differs between manufactures but follows the same principles: electricity turns an auger, which moves pellets at a steady rate into the burn area. Clean air is heated indirectly by the fire and is blown out from the stove to heat the room. As the stove heats up, it also warms the room by radiating its heat.

Regulatory and insurance issues

Wood pellet stove installations must meet all the relevant codes and standards, and permits from your Local Authority may be required. Always check with your Local Authority for up-to-date information and to obtain relevant permits before starting a project.

Permits- Permits are issued by the GNWT Department of Public Works and Services (PWS) or by your Local Authority, depending on the permit. You must apply for and receive all necessary permits before starting work. When you're planning your installation schedule, make sure you leave enough time for all of your permits to be issued and any waiting periods to pass before the installation is begun. (It can take more than 3 weeks for a permit to be issued).

Inspections- If an electrical permit is necessary, electrical inspections are required when the work is roughed in and when it's finished. Your electrician will inform PWS when the work has reached the stage where it needs to be inspected. Some Local Authorities will conduct inspections based on the permits they issue. See your Local Authority for details.

Insurance- Installing a pellet stove can affect your home insurance. Once you have an idea of the stove you want and how you want it installed, call your insurance broker to make sure there won't be any problems or special conditions that you must meet. Each company has its own requirements, which vary depending on the size, age, construction, etc of your home. Some points regarding insurance requirements which might apply are:

- All of the insurance companies we've heard from to date require that stoves be ULC certified.
- Some insurance companies require that your stove be installed by a professional or that it be inspected by a Wood Energy Technology Transfer (WETT) Certified Inspector. It may be difficult to get a WETT Certified Inspector outside of regional centres in the NWT. If you need an inspection, book one before installation. To see a list of WETT certified professionals, go to www.wettinc.ca/search.html.
- Some insurance companies require copies of your inspection reports. Keep all the paperwork in a safe place. When you want to sell your house, it will be easier to sell if you have kept the paperwork and instruction manual for the stove.
- A stove which uses more than 80 bags of pellets per year is often considered a primary heating system and falls into the same insurance category as furnaces and boilers.

Installation

Basic preparatory work for installation includes installing heat and ember protection for the floor, and possibly wall and ceiling shielding for the stove, flue and any components which pass through walls or ceilings. The installation itself includes putting the stove in place, installing the venting equipment including flue pipe, combustion air intake, wall vent, chimney, flue collar, etc, as necessary, making any electrical connections.

Operation and Maintenance

Pellet stoves must be filled from weekly to daily depending on how much they're used, the ash pan needs to be emptied regularly (usually weekly), and basic cleaning is required (from weekly to monthly). Regular (normally annual) thorough cleaning of the chimney and stove components is necessary to ensure safe and efficient operation. Stoves should be maintained regularly to prevent breakdowns, ensure the appliance has a long life and to ensure it burns well – reducing fuel consumption and environmental pollution.

Pellet Storage

Pellets must be kept dry. If they get damp, they start to crumble and won't burn. Don't use wet or crumbled pellets because they can cause many problems, from jammed augers to overheated stoves. Bags of pellets often have holes in them so they must be kept covered or in a weather tight container if stored outside. Ravens will pick through plastic to the pellets, exposing them to snow or rain. Putting plywood over the bags seems to stop them, but indoor storage is better. One standard 18kg (40 lb) bag of pellets is about $0.028m^3$ (1 cubic foot).

Wood pellet stoves vs wood stoves

Advantages of Pellet Stoves

- Automatic fuelling – don't have to add and turn logs.
- Can be controlled by a thermostat to keep the temperature stable automatically
- Fire starts at the push of a button – no setting the fire or chopping kindling.
- Only need to fill hopper once or twice a day.
- Don't need to open fire box, so embers don't fly out.
- Pellets are cleaner than logs – fill the hopper from the bag, no wood splinters or bark on the floor.
- Less ash than with a log fire.

- Less risk of chimney fires and accidental fires than with logs.
- Don't need to chop wood, spend money on gas, chainsaw, etc.

Disadvantages of Pellet Stoves

- Must use pellets – can't burn logs in wood pellet appliances.
- Pellet stoves currently available don't work without electricity. It is possible to install back-up power to run your stove, but it is expensive.
- Pellets are usually more expensive than chopped wood per unit of heat produced.

Wood Pellet Boilers and Furnaces- Residential

Wood pellet boilers and furnaces are used to heat a whole house and sometimes the domestic hot water too. They are normally put out of sight, in a utility room and heat the house through a central heating system. Boilers and furnaces are larger than stoves and have larger hoppers to store more pellets.

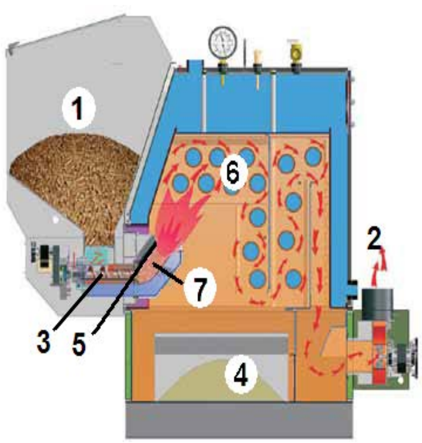


Figure B-2: A typical residential pellet boiler (Hearth & Home Technologies 2012)

- Pellets are stored in a hopper (1). Here it is built into the boiler. Some models use an external hopper.
- Pellets are fed by an electric auger (3) into the burn pot (7) at a rate determined by the temperature control.
- An automatic igniter (5) starts the fire.
- Fire heats the liquid in heat exchange tubes (6) and the exhaust gases (2) are vented to the outside. Here they are vented through a wall or a flue through the ceiling.
- The ash pan (4) below the combustion chamber collects the residue.

The design and features of furnaces and boilers varies from company-to-company and model-to-model. Boilers heat a liquid (commonly a mixture of glycol and water) which travels through pipes in a house. Heat is transferred from the liquid to a room through a heat exchanger such as radiators, baseboard fin heaters or heating coils. A boiler can also be used to heat your domestic hot water (DHW). Furnaces heat air that is circulated around the house through heating ducts. A boiler with a fan-coil heat exchanger can also be used for forced-air heating.

Regulatory and insurance issues

Regulations- Boiler and furnace installations must meet the relevant codes and standards, and permits from your Local Authority may be required. Always check with your Local Authority for up-to-date information and to obtain relevant permits before starting a project. The contractor you hire to install your system should ensure it meets all regulations and take care of all the necessary permits and inspections, but it’s your responsibility to make sure it has been done.

Permits- Permits are issued by GNWT Department of Public Works and Services or by your Local Authority, depending on the permit. You must apply for and receive all necessary permits before starting work on the installation. When planning your installation schedule, make sure you leave enough time for all of your permits to be issued and any waiting periods to pass before the installation is begun.

Inspections- Electrical inspections are required when the work is roughed in and when it’s finished. Your electrician will inform PWS when an inspection is necessary. Some Local Authorities will conduct inspections based on the permits they issue. Further information is provided in Appendix A. See your local authority for details.

Insurance- Installing a pellet boiler/furnace will affect your home insurance. It is very likely that your premiums will increase. Once you have an idea of the installation you want, contact your insurance provider to ensure there won’t be any problems and they don’t have any special conditions. Each company has its own requirements, which vary depending on the age, construction, etc of your home. Some points regarding insurance requirements which might apply are:

- All of the insurance companies we've heard from to date require that furnaces/boilers be certified to CSA B366.1.
- Some insurance companies require that your appliance be installed by a professional or that it be inspected by a WETT Certified Inspector. It may be difficult to get a WETT certified inspector outside of regional centres. Go to http://www.wettinc.ca/search.html to see a list.
- Some insurance companies require copies of your permit applications and/or inspection reports. Keep all the paperwork in a safe place. When you want to sell your house, it will be easier to sell if you have kept all the paperwork for the heating system along with the instruction manual.
- Most insurance companies require that you keep your old heating system installed as a backup. Even if it isn't required, having a backup system will often result in a smaller premium increase. If you can't leave the old system in, it might be possible to install an inexpensive electric heating system as a backup. You should be able to get a backup electrical system for less than $2,000. However, you will need a 200A electrical service to the house. If you're building a new house, requesting this with your initial power request will save time and money.
- Some insurance companies require that wood pellet boilers/furnaces be located outside the home in an accessory building, and some require that that building be located at least 50 feet from any other building, fuel tank, or other combustible.
- Some companies require that the wood furnace/boiler have a natural draft so there must be a 1.2 to 1.5 m (4 or 5 foot) vertical section of flue pipe. This is to prevent a backdraft if the power goes out or if there's a strong wind blowing outside

Installation

There are several components to the installation of your wood pellet boiler or furnace. The pellet storage must be built (unless it is built-in), heat and ember shielding around the appliance must be installed if necessary, the venting system must be installed, and the system must be connected to the heating ducts (furnace) or pipes (boiler). Talk to your installer about the details.

Operation and Maintenance

Pellet boilers/furnaces need more care than oil, propane, gas or electric ones, but the care varies – some need daily attention. The hopper may need loading daily, or it may be automated. The ash pan must be emptied and tubes cleaned regularly (often monthly). Annual maintenance must be performed by a knowledgeable person. Boilers and furnaces should be maintained regularly to prevent breakdowns, ensure the appliance has a long life and to ensure it burns well – reducing fuel consumption and environmental pollution. See your manual for maintenance details. You should keep a servicing log – a record of what has been done to the appliance, when and by whom. You might want to sign maintenance and servicing contract with a trained certified heating contractor covering periodic servicing and condition-based maintenance. Arranging for a follow-up visit by the installer about 1 month after installation is a good idea as it provides the opportunity for the appliance to be fine tuned and provides a chance for you to ask any questions you have. You should report any faults immediately so they can be rectified to prevent damage.

Pellet storage

Pellets must be kept dry. If they get damp, they start to crumble and won't burn. Don't use wet or crumbled pellets because they can cause many problems, from jammed augers to overheated stoves. Bags of pellets often have holes in them so they must be kept covered or in a weather tight container if stored outside. Ravens will pick through plastic to the pellets, exposing them to snow or rain. Putting plywood over the bags seems to stop them, but indoor storage is better. One standard 18kg (40 lb) bag of pellets is about 0.028m^3 (1 cubic foot).

If you're storing bulk (loose) pellets, a minimum storage may be required for in-town delivery services, if available. There may be by-laws that specify that the building/tank shouldn't be in front of your house. Don't block access for services such as water and sewage, or your fire escape routes. Bulk storage bins, whether inside or outside, should be sealed and fitted with a vent with a filter to stop dust flying out when it is filled.

Wood pellet boilers/furnaces vs oil or propane

Advantages of Wood Pellet Boilers/Furnaces

- Pellets usually cost much less than oil or propane per unit of heat produced.
- Burning pellets produces fewer GHG emissions than burning oil or propane.
- Spilled or leaking pellets are easier, safer and much cheaper to clean up than oil or propane.

Disadvantages of Wood Pellet Boilers/Furnaces

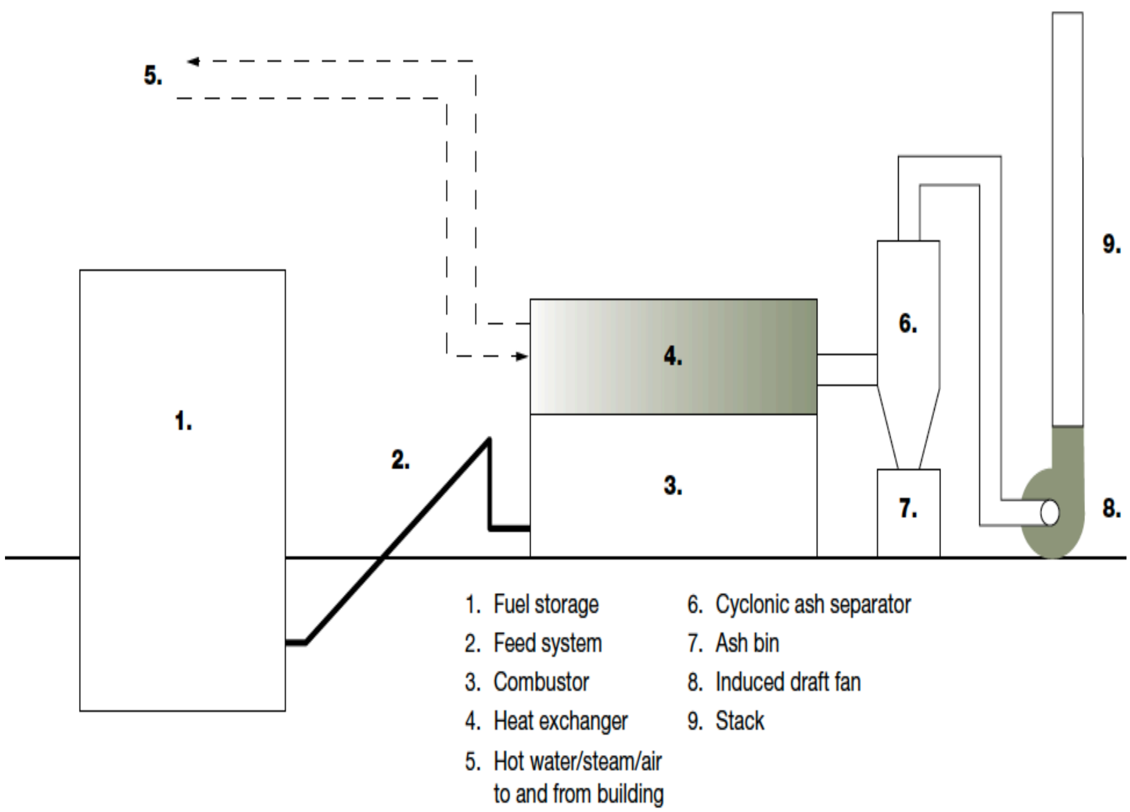
- Pellet appliances are more expensive than oil or propane appliances.
- Maintenance such as ash removal and cleaning must be performed regularly (usually by the homeowner).
- Pellet container must be filled regularly unless you have bulk storage with an automatic feed (currently only available in Yellowknife).

Wood Pellet Boilers- Commercial

Commercial-scale systems are different from smaller residential systems in that they typically incorporate automated feed and control systems and require emissions control equipment to ensure that emissions regulations are met. If the combustor generates steam or hot water, it is often called a "boiler." If it generates hot air, it is called a "furnace."

Commercial biomass combustion systems have several distinct components, each of which is needed for the entire system to operate properly.

Figure B-3: Commercial Wood Pellet Heating System Components



1. **Fuel Storage-** The fuel storage bin should be sized to provide sufficient fuel for the maximum possible interval between wood deliveries. The bin should be designed for easy loading of the fuel. Often, the storage bin can be installed inside the building to allow for easier unloading of the fuel. Another alternative is a storage silo. The storage bin should be structurally sound and accommodate the requirements for specified biomass fuels.
2. **Fuel Feed System-** The fuel feed system is one of the more problem-prone elements of the facility and should be designed and operated carefully. Typically, fuel is drawn from the bottom of the bin using a moving floor or screw conveyor. The fuel is then moved to a metering device, where it is fed into the combustor in a controlled manner. Burn back protection devices should be incorporated into the system to prevent a fire from ever escaping the combustor and traveling back to the storage bin.
3. **Combustor-** The combustor is the enclosed chamber where the fuel is burned by heating it and

adding oxygen (air) in the right amount and proportion. Many different combustor designs are available, but they all serve to combine the fuel with air in a hot environment so that the fuel combusts completely.

4. **Heat Exchanger (Boiler)-** The heat exchanger removes the heat from the combustion gases and places it in the air or water that is used for space heating or other needs. Heat exchangers can be a common location for deposits and buildup of ash (fouling), which must be controlled if thermal efficiency is to remain high. Many modern technologies include automatic pneumatic cleaning systems.
5. **Ash Handling System-** Combustion ash is removed at several locations within the combustor. Bottom ash is the heavier ash material that falls through the grate to the bottom of the combustor. It is removed manually or with the aid of a screw auger. Top ash is lighter ash that settles in other parts of the combustor. Top ash is also often removed from the combustor using a screw auger. Fly ash is the lightest; it is carried out of the combustor along with the exhaust gases. Fly ash must be separated from the exhaust gases by the pollution control system, and it is then deposited into a bin. Ash from a biomass combustor can be put into a landfill or used as a fertilizer or soil amendment.
6. **Pollution Control Devices-** Larger combustors require some sort of additional treatment to reduce the amount of pollution in the stack gas. Devices for treatment include cyclonic separators, bag houses, electrostatic precipitators, and scrubbers. Cyclonic separators are standard on almost all biomass combustors and are the only pollution control needed on many devices. These separators use centrifugal force in rotating airflow to separate ash particles from the combustor's flue gas. They are simple to operate and are very reliable. Ash is deposited in a container at the base of the separator, where it can be collected and discarded.

   If the concentration of particles in the flue gas is still too high, it may be necessary to use a "bag house." This is a large enclosure containing filters shaped like bags. The flue gas is forced through the filters, which trap particles and prevent them from being released into the air. A "backflow" cleaning cycle is used to clean the filters and collect the ash. Electrostatic precipitators may also be used to collect particles. These consist of large, electrically charged plates that apply an electric field to the flue gas and draw out charged particles.

   Lastly, scrubbers may be used, in which a liquid spray (often water) is used to "wash" chemicals (e.g., $SO2$) and particles out of the flue gas. These devices are often costly and are usually only necessary in extremely sensitive environments.
7. **Stack-** The stack is the final pathway for flue gases to the outside. An electric fan, called an "induced draft fan," is usually used to maintain a steady flow rate of flue gas. If the temperature of the flue gas is low enough, moisture will condense out of the gas and deposit on the flue walls.

   This "condensate" liquid is acidic and can cause accelerated corrosion of the flue components. Care should be taken to either keep the flue gas temperature high enough to prevent condensation or ensure that all flue components are sufficiently resistant to corrosion.
8. **Auxiliary Heating System-** Biomass combustors work best when they are operating at or near full capacity. When the heat requirement is very low, the combustor is not able to maintain the proper thermal environment for combustion, leading to smoky stack gas and low thermal efficiency. This problem can occur during spring or fall, when heat requirements for a building are smaller.

The combustor's "turndown ratio" is the minimum heat output (relative to full load) that can be maintained while still providing good performance.

The most common approach to dealing with this problem is to use a small "auxiliary boiler" that provides heat only when the requirement for heat drops below the biomass system's turndown ratio (often about 20 percent of full load). Facilities that switch over from natural gas, electricity, or fuel oil systems often keep their old equipment to use for auxiliary heat.

9. **Boiler House-** Both the boiler room as such and the fuel storage very much depend on the system size and its fuel requirements. A number of biomass system manufacturers offer a "ready to operate" solution, where the boiler system is preinstalled in a container. The containerized package boilers are pre-installed in modified shipping containers. This reduces the cost of on-site construction to a minimum.

   For each project, it is important to evaluate whether the site has sufficient space to accommodate a containerized system solution, as well as a separate Boiler House construction.

10. **Control System-** The control system (not shown in Figure B-3) measures the operating parameters of the heating system, adjusting it as necessary to ensure smooth, high-efficiency, safe operation. Digital controllers and monitoring systems are standard components for large systems, and they allow operators to assess the combustor's performance in detail.

Regulatory and insurance issues

Boiler and furnace installations must meet the relevant codes and standards, and permits from your Local Authority may be required. Always check with your Local Authority for up-to-date information and to obtain relevant permits before starting a project. The project manager you hire to install your system should ensure it meets all regulations and take care of all the necessary permits and inspections, but it's your responsibility to make sure it has been done. You will need an engineer since one of the requirements for all commercial installations is for stamped engineering drawings to be submitted to the Fire Marshal's Office and approved before work starts.

Permits

Permits are issued by GNWT Department of Public Works and Services or by your Local Authority, depending on the permit. You must apply for and receive all necessary permits before starting work on the installation. When planning your installation schedule, make sure you leave enough time for all of your permits to be issued and any waiting periods to pass before the installation is begun.

- Office of the Fire Marshal Approval – A complete design package must be completed, stamped by a Professional Engineer (NWT), submitted to the Office of the Fire Marshal for review and approved by them before the installation starts.
- Electrical Permit – Furnaces/boilers require an electrical connection so an electrical permit is necessary. Your electrician should apply for a permit from PWS at the GNWT.
- Boiler Permit - Pellet boilers with "closed" (pressurized) systems require a boiler permit, while boilers with open systems don't. Your installer should apply for a permit from PWS at the GNWT.
- Mechanical, Development and Building Permits – These may be necessary, depending on your community.

Inspections

- Design Engineer – The design engineer who stamped the plans approved by the Fire Marshal's Office must provide a letter of verification for the entire system.
- Fire Marshal's Office – The Fire Marshal's Office needs to inspect and approve the entire installation.
- Electrical Inspections - Electrical inspections are required when the work is roughed in and when it's finished. Your electrician will inform PWS when an inspection is necessary.
- Mechanical Inspections – A boiler inspection by the Inspection Section of PWS may be required. Your installer will inform PWS when an inspection is necessary.
- Local Authority Inspections - Some Local Authorities will conduct inspections based on the permits they issue. See your Local Authority for details.

Installation

There are several components to the installation of your wood pellet boiler or furnace. The pellet storage must be built (unless it is built-in), heat and ember shielding around the appliance must be installed if necessary, the venting system must be installed, and the system must be connected to the heating ducts (furnace) or pipes (boiler). Talk to your installer about the details.

Operation and Maintenance

Pellet boilers/furnaces need more care than oil, propane, gas or electric ones, but the care varies – some need daily attention. The hopper may need loading daily, or it may be automated. The ash pan must be emptied and tubes cleaned regularly (often monthly). Annual maintenance must be performed by a knowledgeable person. Boilers and furnaces should be maintained regularly to prevent breakdowns, ensure the appliance has a long life and to ensure it burns well – reducing fuel consumption and environmental pollution. See your manual for maintenance details. You should keep a servicing log – a record of what has been done to the appliance, when and by whom. You might want to sign maintenance and servicing contract with a trained certified heating contractor covering periodic servicing and condition-based maintenance. Arranging for a follow-up visit by the installer about 1 month after installation is a good idea as it provides the opportunity for the appliance to be fine tuned and provides a chance for you to ask any questions you have. You should report any faults immediately so they can be rectified to prevent damage.

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Pellets must be kept dry. If they get damp, they start to crumble and won't burn. Don't use wet or crumbled pellets because they can cause many problems, from jammed augers to overheated stoves. Bags of pellets often have holes in them so they must be kept covered or in a weather tight container if stored outside. Ravens will pick through plastic to the pellets, exposing them to snow or rain. Putting plywood over the bags seems to stop them, but indoor storage is better. One standard 18kg (40 lb) bag of pellets is about $0.028m^3$ (1 cubic foot).

If you're storing bulk (loose) pellets, a minimum storage may be required for in-town delivery services, if available. You will need to build or install some kind of container or tank to hold the pellets. Check local by-laws when planning your storage. Don't block access for services such as water and sewage, or fire escape routes.

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.

Unlike conventional fossil fuel boilers, a biomass boiler cannot be sized by simply applying a factor to the peak heat load of the site. Instead, the size of a biomass heating system should be based on the diurnal and annual heat load profile of the site and the type of heating circuits that will be supplied by the boiler. It is important that these heat demand profiles are accurately modeled at the start of every single project site evaluation. Quick assumptions made at an early stage can easily lead to incorrectly sized biomass heating systems being installed, therefore it is important to quantify the heat demands accurately at the beginning.

Based upon the site specific heat energy requirements, the system efficiency is a cost, maintenance and feedstock-regulating factor. Appropriate sizing is important to achieve good levels of utilization, to ensure performance profiles are suitable for the biomass system, and to enable effective integration with the existing heating systems. Biomass boilers do not operate very efficiently if constantly called on to “relight”. To avoid this, some systems incorporate a buffer tank which has the effect of reducing the number of times the boiler is called on to relight and which can provide an instant source of hot water on demand.

In the transition periods during spring and fall, the heat load will typically be approximately 20-40% of the boiler nominal output, resulting in less efficient and less than ideal operating conditions. During the summer period, the heat load of the building will typically be a small fraction of the peak heat load, since only the hot water supply will be maintained. This operating method is not often used as it reduces the efficiency (typically 20-30% lower than that of the nominal output) and has an increased negative effect on the environment. The alternative to the deteriorated summer operation is to combine the installation with a hot well or buffer storage tank and/or a conventional toping up/backup furnace system.

The nominal thermal capacity of a biomass energy system is determined by the energy requirement of each individual user building or building cluster. The detailed heat load calculations define the energy system’s size and scale, which in turn affects all prevailing circumstances, particularly the biomass fuel requirements and maintenance time frames.

In boiler size planning, a distinction must be made between base load and peak load for economic reasons. Usually, one or more biomass boilers cover the base load heat requirement while the peak load boilers are usually fired with fossil fuels, like natural gas or heating oil. The distinction between base load and peak load is necessary to achieve a high number of full-load operating hours of the biomass system in order to decrease the total heat generation and maintenance costs and increase the system efficiency. There are different approaches for sizing a biomass system.

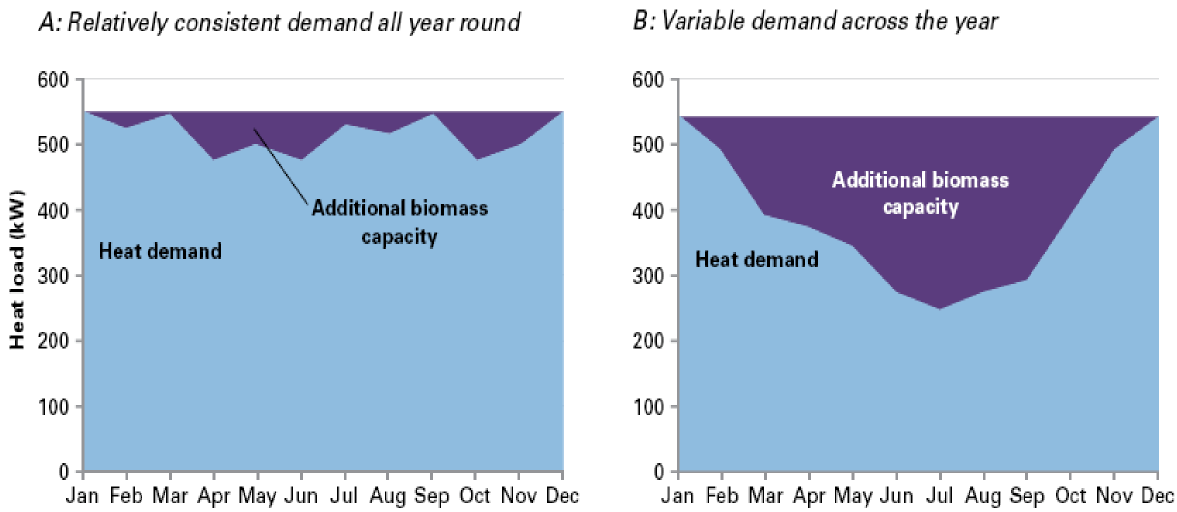
Base Load Sizing

Base-load sizing is an approach where the biomass plant is sized to meet only the base load of the heating demand profile. There are very few instances where this type of sizing would be used in the NWT as summer base loads are extremely low. Base-load sizing in the NWT would typically mean the biomass plant would only contribute a very small proportion of the annual heat demand at the site, and base-load sizing in this case would be sub optimal.

Peak Load Sizing

Peak-load sizing is an approach where the biomass plant is sized with the capability to provide the peak heat load and all of the annual heat requirements at the site (see Figure below). The key consideration for peak-load sizing is the over capacity of the plant (shaded purple).

Figure B-4: Peak-Load System Sizing



Example A shows where peak-load sizing is likely to be close to optimal. The heat load remains relatively consistent throughout the year and thus the biomass plant will have little need for modulation below the maximum rated output and will also have high utilization (or capacity factor), and only a small amount of plant capacity will not be utilized (shaded purple).

Example B has relatively long periods when the load required at site is significantly lower than the capacity of the biomass plant, thus leading to a greater under utilization (shaded purple) – in this instance peak-load sizing would be sub optimal.

Optimum Sizing

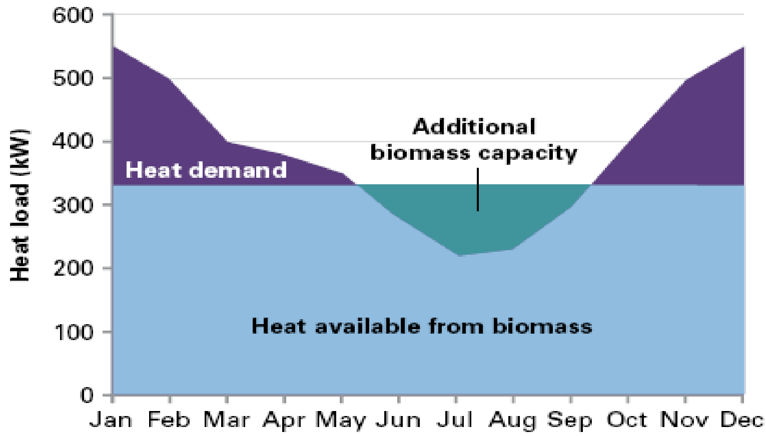
The optimum plant sizing approach tries to achieve a balance between CAPEX (Capital Expenditure) investment and operational costs. It aims to combine the benefits of:

- Base-load sizing – minimizing total CAPEX and CAPEX per ton of CO_2 saved.
- Peak-load sizing – maximizing the fossil fuel displacement and hence increasing CO_2 savings.

Figure 4 below shows an example of a typical seasonal heating load profile.

It can be seen that the amount of the heat load offset by the biomass system (shaded blue) is increased compared to the base-load sizing example, but the additional unused plant capacity (shaded green) is reduced compared with the peak-load sizing example. This allows the biomass system to run at a relatively high level of utilization and displaces a significant amount of the heat load that would otherwise be delivered by natural gas.

Figure B-5: Optimum System Sizing



In this situation the additional loads, which the biomass system does not meet (such as instantaneous demand, peak heating requirements or during start-up from cold) are met by the natural gas backup system. As a general rule of thumb, sizing the biomass plant in this scenario at between 50- 70% of the peak load can in fact deliver 80-90% of the annual heat demand for the site.

Once the site heat load profiles have been calculated, an evaluation can be made of whether the load profile will benefit from thermal storage. Sites with variable heat loads will offer the opportunity to reduce the size of biomass boiler relative to peak loads, allow the boiler to operate more continuously, reduce boiler cycling and increase seasonal efficiency.

Optimum sizing could also be achieved by using more than one boiler. The smallest boiler would be used at low loads and subsequent boilers can be turned on when the demand is higher.

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APPENDIX C: PELLET PRICES IN INUVIK

Table C-1: Pellet prices per tonne quoted at the mill (Aug/Sept 2012)

Mill	Location	Distance to Inuvik (km)	18 kg bags ($/tonne)	Bulk ($/tonne)
Pinnacle Pellet Burns Lake	Burns Lake, BC	2617	$160/tonne (SPF) $215/tonne (Fir)	$140/tonne
Pinnacle Pellet Meadowbank	Strathnaver, BC	2917		
Pinnacle Pellet Quesnel	Quesnel, BC	2960		
Pinnacle Pellet Williams Lake	Williams Lake, BC	3071		
Pinnacle/Canfor Houston Pellet	Houston, BC	2538		
Foothills Forest Products	Grande Cache, AB	2946	$156/tonne	$110/tonne
La Crete Sawmills	La Crete, AB	3081	$144/tonne	$115.50/tonne
Vanderwell Contractors	Slave Lake, AB	3016	$153/tonne	$130/tonne

12 pellet mills are within about 3000km driving distance from Inuvik.

- Pacific Bioenergy in Prince George, BC is not currently taking orders for local sales
- Premium Pellet in Vanderhoof, BC and Vanderhoof Specialty Wood Products in Vanderhoof, BC were both contacted but no response to inquiries into pellet prices.
- Tahtsa Pellets Limited in Burns Lake, BC is not making pellets at this moment

Trucking

Table C-2: Transportation costs (Aug/Sept 2012) for trucking pellets to Inuvik

Company	Transportation method	Pellet format	Cost at Mill	Cost transportation mill to Inuvik	Total
Pinnacle Pellets	Truck- B-train	Bagged (18 kg)	$160/tonne	$405/tonne	**$565/tonne**
Pinnacle Pellets	Truck- B train	Bulk	$140/tonne	$345/tonne	**$485/tonne**

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).

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. Specifically, the maximum driving time allowed is 15 hours per day up to a total limit of 70 hours driving time within a 7-day period.

Trucking wood pellets to Inuvik would be the same as trucking any commodity to Inuvik. Two potential options were identified for trucking pellets to Inuvik:

1. No storage facility on route – the trip would be done in 1 pass from the mill to Inuvik. As an example, starting in Prince George, BC and using available sleeping facilities in Watson Lake and at the junction of the Klondike and Dempster Highway, it may be possible to complete a trip within 3 days. Alternatively, a sleeper truck could be used with the driver sleeping en route. In order to not exceed the maximum of 70 driving hours in a 7-day period, it would appear that a rest period would be needed in Inuvik before the return leg could be undertaken.
2. Relay points without storage- Relay points would be used with drivers driving shorter routes to and from designated points. They would simply drop a full trailer at the relay point and bring back an empty trailer with no loading or unloading of goods. Another driver would pick up the full trailer and take it to the next relay point. There would likely be relay points in Watson Lake or Whitehorse.
3. Relay point with storage facility in Watson Lake or Whitehorse – another option would be the establishment of a dry storage facility in Watson Lake (or Whitehorse). This would allow trips to be broken into smaller segments but would entail additional costs for the facility, equipment for unloading and loading trucks and sleeping arrangements for drivers.

Trucking costs from one of Pinnacle's mills to Inuvik (5 are within about 3000km from Inuvik).

1. Bagged pellets: $405/tonne for transportation, $160/tonne for pellets. These would be a B-train holding 44 pallets with 50 bags each. Total = $565/tonne bagged
2. Bulk pellets: $345/tonne transportation, $140/tonne for pellets. These would be dry hopper bottom bulk carriers, and could hold 43 tonnes. Total = $465-$485/tonne bulk

Barging

Table C-3: Transportation costs (Aug/Sept 2012) for barging pellets to Inuvik

Company	Transportation method	Pellet format	Cost of purchase and transport to Hay River	Cost transportation Hay River to Inuvik	Other costs	Total
NTCL	Barge- B-trains bulk	Bulk (43 tonnes)	$148/tonne	$935/tonne	-	**$1083/tonne**
NTCL	Barge- B-trains bagged	18 kg bags (40 tonnes)	$179/tonne	$1006/tonne	-	**$1185/tonne**
NTCL	Barge- pallets of bags	1 pallet of 50 x 18 kg bags (45 tonnes)	$179/tonne	$286/tonne	-	**$465/tonne**
NTCL	Barge- containerized bulk	50 sea-cans (1000 tonnes)	$148/tonne	$75/tonne	**$50+ /tonne**	**$273/tonne**

NTCL has priced out 3 methods for barging wood pellets from Hay River to Inuvik

1. Barge full B-train (50,000 kg) of bulk or bagged pellets. Cost Hay River – Inuvik – Hay River is $36,500 + 5% fuel surcharge and taxes. A B-train can hold 43 tonnes of bulk or about 40 tonnes palleted bags (44x 50 bag skids). The price is thus $935/tonne bulk or $1006/tonne bagged from Hay River. Purchase and shipping cost bulk pellets from La Crete (the closest mill to Hay River) to Hay River is $148/tonne bulk, $179/tonne bagged. Total cost = $1083/tonne bulk, $1185/tonne bagged.

2. Barging pallets of bagged pellets. The price is $13,000 for 50 pallets (of 50 bags each) Hay River – Inuvik. The price is $260/pallet or $286/tonne. Purchase and shipping cost of bagged pellets from La Crete (the closest mill to Hay River) to Hay River is $179/tonne bagged. Total cost = $465/tonne bagged.

3. Barging an entire barge of containerized pellets (1000 tonnes at a time) 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, there is may be additional handling now required on both ends- filling the sea cans in Hay River or having special transportation from the mill, and in Inuvik getting the pellets into the storage systems.

   It would also be possible to use the sea-cans as silos and fill the sea-cans at the mill, transport them as is on the barge and then move them directly to the site where they will be used;

reducing the handling required. This would require purchasing the sea-cans, modifying them to include built-in augers and then shipping them back to be re-used.

From pellet supply chain study done for Tuktoyaktuk (unpublished, 2013):

50 Containers barged from Hay River – Container Delivery

Cost Analysis

Bulk Pellet Price @ loading ($/t)	$148
Shipping Cost ($/t)	$75
Inuvik Container Storage ($/t/yr)	$25
Inuvik Delivery Cost ($/t)	$25
Pellet Price @ Customer ($/t)	$273

Assumes container is delivered directly to customer who has the capacity to store 20t on-site

Cost to transport full barge $75K - conversation with Scott Dryden, NTCL Oct 2012

Container storage cost - $5K to purchase / 10 years / 20t = $25/t

Inuvik delivery cost = ($60K for container truck/10 yrs + $19K/yr costs)/1000t = $25/t

In summary, it may be possible to get bulk pellets to Inuvik by barge for less than $300/tonne if volumes are high (1000 tonnes at a time). Some logistics would need to be worked out. It would be possible to barge large quantities of bagged pellets (45 tonnes at a time) for about $465/tonne.

APPENDIX D: IN-TOWN PELLET DELIVERY SERVICE IN INUVIK

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. On the customer's side, all that is needed is some 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.

As described in section 3.1.3, 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.

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
- **Fixed Operating Costs** – the annual fixed operating costs, including equipment maintenance, taxes, electricity, labour, insurances etc
- **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).

Table D-1: Fixed infrastructure costs related to an in-town pellet delivery service in Inuvik

Initial Capital Costs	Number	Cost Each	Total Cost
Grain bins (128 tonnes each)	2	$ 14,600	$ 29,200
Bin setup (bolt together bins)	4	$ 3,500	$ 14,000
Site preparation including bin pad	1	$ 10,000	$ 10,000
Land (undeveloped @ $1.10 per ft2)	40,000	$ 1.10	$ 44,000
100 amp single phase electrical service & one 20' pole with exterior light	1	$5,000	$ 5,000
Used feed truck with pneumatic delivery	1	$ 60,000	$ 60,000
New Grain auger	1	$ 11,000	$ 11,000
Weigh scale kit for truck, including installation	1	$ 1,500	$ 1,500
Shipping of truck, bins, auger	1	$ 25,000	$ 25,000
			$ 192,700

Table D-2: Fixed operating costs related to an in-town pellet delivery service in Inuvik

Fixed Annual Operational Costs	Number	Cost Each	Total Cost
Equipment maintenance (5% of original capital value)	1	$ 5,010	$ 5,010
Land taxes	1	$ 1,500	$ 1,500
Electricity (lighting, winter only)	1	$ 841	$ 841
Labour for administration	139	$ 60	$ 8,320
Business Insurance	1	$ 2,000	$ 2,000
Delivery truck registration & insurance	1	$ 3,000	$ 3,000
			$ 20,671

Table D-3: Variable Annual Expenses related to an in-town pellet delivery service in Inuvik

Cost of pellets delivered to Inuvik
Finance payments (constant)
Finance charges on pellets in storage
Delivery Labour
Fuel for delivery truck

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.

APPENDIX E: INUVIK HEATING LOADS

Table E-1: Inuvik Heating Load Analysis – Generic by Type of Building

Building Type	# of Buildings or Units	# of Gas Services	Total Area (m^2)	Total Peak Heating Load (kW)	Annual Heating (GJ Gas)	Annual Heating2 (GJ Oil)
Apartments	16	16	27,827	1,576	24,364	0
Bank	1	1	346	52	684	0
Bar / Pub	1	1	1,437	102	1,568	0
Church	4	4	2,666	155	2,036	0
Condos	1	1	595	34	519	0
Daycare	1	1	104	6	91	0
Garage	21	21	11,467	1,852	18,033	6,376
Hotel	5	5	17,317	919	13,828	0
Hospital	1	1	9,000	1,345	31,057	0
House	305	305	45,750	3,849	44,363	14,085
Library	1	1	720	108	1,425	0
Office	32	32	27,237	4,164	50,889	2,425
Medical Clinic	1	1	180	19	190	0
Pool / Recreation	1	1	6,834	725	11,183	0
Restaurant	1	1	136	10	148	0
Retail	15	15	13,165	1,635	21,544	0
School	4	4	29,203	3,036	27,879	0
Row House	79	491	46,446	4,692	61,871	0
Warehouse	24	24	12,194	1,969	23,466	2,490
TOTALS	**514**	**926**	**252,624**	**26,248**	**335,137**	**25,375**

Table E-2: Inuvik Heating Load Analysis – Individual Buildings in Inuvik- By Street Address

Disclaimer: The estimated annual heating loads and approximate peak heating loads are estimates only based on approximate building square footage and assumed building use. These values are for reference only and **should not** be used for boiler sizing.

Building Name	Number	Street or Avenue	Floor Area	Estimated Annual Heating Load (GJ)	Approximate Peak Heating Load (kW)
Alder Rowhouses (14 bldgs)		Alder Drive	7,734	10,303	781
McDonald Bros Electric Ltd	2	Arctic Street	437	930	71
4-Bay Garage		Bay Street	828	1,762	134
Bompas Apartments	52	Bompas Street	3,264	2,849	185
Midnight Sun Recreation Complex		Bompas Street	6,834	11,183	725
Bonnetplume Rowhousing		Bonnetplume Road	691	921	70
Boot Lake Apartments	12	Boot Lake Road	2,070	1,807	117
Lakeview Manor (Apartments)	20	Boot Lake Road	3,242	3,074	305
Lauron Apartments		Boot Lake Road	1,325	1,156	75
Parkview Apartments		Boot Lake Road	1,283	1,120	73
Aurora Student Housing		Breynat Street	828	723	47
Carn Road Warehouse / Garage	25	Carn Road	2,144	4,564	346
Carn Road Warehouses	25	Carn Road	890	1,894	144
Carn Road Garage (attached to office)		Carn Road	760	1,618	123
Carn Road Office (attached to garage)		Carn Road	408	807	61
Teepee Apartments	1	Council Crescent	1,846	3,655	277
Jim Koe Building	3	Council Crescent	928	1,837	139
McDonald Manor	7	Council Crescent	1,565	1,366	89
Finning Garage		Dempster Highway	704	1,499	114
The Corner Store	15	Dolphin Street	330	539	41
Dolphin Rowhouses		Dolphin Street	931	1,240	94
Duck Condos		Duck Lake Street	595	519	34

Building Name	Number	Street or Avenue	Floor Area	Estimated Annual Heating Load (GJ)	Approximate Peak Heating Load (kW)
Town Hall	2	Firth Street	1,088	2,154	163
Fire Department	2	Firth Street	400	851	65
Ice Wireless, New North Networks Ltd	74	Firth Street	278	551	42
Samuel Hearne Carpentry Shop		Firth Street	262	558	42
Samuel Hearne Shop		Firth Street	640	1,362	103
Inuvik Liquor Store	64	Franklin Road	695	1,137	86
Home Hardware Building Centre	73	Franklin Road	621	1,016	77
Qimalik Garage		Franklin Road	429	913	69
Federal Government Compound (5 bldgs)		Franklin Road	1,456	3,099	235
Franklin Road Mixed Use		Franklin Road	1,680	3,325	252
Home Building Centre		Franklin Road	421	896	68
Group 1355, Lot 17		Industrial Road	282	599	45
Group 1355, Lot 20		Industrial Road	480	1,022	77
Northern Store Warehouses		Industrial Road	458	974	74
Block 76, Lot 22 Office		Industrial Road	122	241	18
Block 76, Lot 23 Warehouse		Industrial Road	317	674	51
Arctic Builders General Contractors		Industrial Road	250	531	40
Northwind Tire		Industrial Road	221	470	36
Inuit Rowhousing		Inuit Road	3,251	4,331	328
Row Houses (14 bldgs)		Kingaluk Place	6,688	8,909	676
New Building		Kingmingya Road	300	594	45
Blackstone Building	85	Kingmingya Road	323	640	49
Training Centre / Food Bank	116	KingMingya Road	238	304	22
Kingmingya Rowhousing		KingMingya Road	411	548	42
New School		Kingmingya Road	12,000	5,922	1,759
Homeless Shelter		Kingmingya Road	362	462	30
Kugmallit GNWT Row Housing		Kugmallit Road	5,898	7,856	596

Building Name	Number	Street or Avenue	Floor Area	Estimated Annual Heating Load (GJ)	Approximate Peak Heating Load (kW)
Kugmallit / Inuit Rowhousing		Kugmallit Road	2,605	3,470	263
Ambulance Garage & Offices		Kugmallit Road	698	1,381	105
Aurora College Main Building		Loucheux Road	15,197	19,396	1,385
Food Bank		Loucheux Road	379	807	61
Loucheux Apartment		Loucheux Road	1,408	1,229	80
Ingamo Hall	20	Mackenzie Road	778	901	117
Lighthouse Community Church	40	Mackenzie Road	942	720	55
First Bible Baptist Church	47	Mackenzie Road	322	246	19
Northwestel Building	52	Mackenzie Road	667	1,557	173
Aurora College Learning Centre	54	Mackenzie Road	810	1,602	122
L.F. Semmler Building	56	Mackenzie Road	1,560	3,088	234
Beckett Business Centre	75	Mackenzie Road	280	458	35
Polar Bed & Breakfast	75	Mackenzie Road	220	180	12
Café Gallery & News Stand Bldg	84	Mackenzie Road	650	1,064	81
Library	100	Mackenzie Road	720	1,425	108
Youth Centre	103	Mackenzie Road	228	291	19
The Roost Restaurant	106	Mackenzie Road	136	148	10
IRC Office Building	107	Mackenzie Road	3,348	6,627	503
Midtown Market	108	Mackenzie Road	289.6	474	36
Northern Images	115	Mackenzie Road	274	448	34
The Trapper Pub	124	Mackenzie Road	1,437	1,568	102
Professional Building	125	Mackenzie Road	1,710	2,798	212
Eskimo Inn	133	Mackenzie Road	4,442	3,634	236
CIBC Building	134	Mackenzie Road	346	684	52
Mack Travel Building	155	Mackenzie Road	2,832	5,605	425
Northmart	160	Mackenzie Road	4,126	6,753	512

Building Name	Number	Street or Avenue	Floor Area	Estimated Annual Heating Load (GJ)	Approximate Peak Heating Load (kW)
AOGS Office Building	162	Mackenzie Road	678	1,343	102
Strip Mall	165	Mackenzie Road	619	1,013	77
Wood 2-Story (Old Bowling Alley)	171	Mackenzie Road	1,050	1,718	130
Arctic Foods	176	Mackenzie Road	1,037	1,697	129
Catholic Church (Igloo)	180	Mackenzie Road	506	386	29
Mackenzie Hotel	185	Mackenzie Road	5,957	4,874	316
Canada Post	187	Mackenzie Road	998	1,975	150
Preschool	192	Mackenzie Road	104	91	6
Anglican Church	194	Mackenzie Road	897	685	52
Capital Suites	198	Mackenzie Road	4,768	3,560	253
Nova Inn	288	Mackenzie Road	1,931	1,580	102
Inuvialuit Communications Society	292	Mackenzie Road	530	1,049	80
Inuvik Hospital		Mackenzie Road	9,000	31,057	1,345
Western Arctic Visitor Centre		Mackenzie Road	214	350	27
Aurora Research Institute		Mackenzie Road	1,110	2,197	167
BDHSSA Residence		Mackenzie Road	1,393	1,216	79
Smartie Row Houses		Mackenzie Road	11,219	14,945	1,133
Aurora New Building		Mackenzie Road	1768	2,257	161
Govt of Canada		Mackenzie Road	446.4	884	67
Arctic Family Medical Clinic		Millen Street	180	190	19
Muskrat Warehouse		Muskrat Road	283.2	603	46
Nanuk Place Row Houses		Nanuk Place	4,954	6,599	500
Y-Group Home		Natala Drive	845	1,079	70
Acklands Grainger	23	Navy Road	1,122	2,387	181
Mackenzie Valley Construction	74	Navy Road	1,411	3,004	228
Northwind Office & Warehouse	146	Navy Road	339	722	55

Building Name	Number	Street or Avenue	Floor Area	Estimated Annual Heating Load (GJ)	Approximate Peak Heating Load (kW)
Beaufort Logistics Office		Navy Road	70	139	11
Beaufort Logistics Shop		Navy Road	629	1,338	102
Stanton Distributing		Navy Road	2,102	4,475	339
Firewalker NWT		Navy Road	558	1,189	90
Northwind Industries		Navy Road	473.6	1,008	76
Warehouse Block 64 Lot 4		Navy Road	412.8	879	67
Office Block 64 Lot 5		Navy Road	758.4	1,501	114
Warehouses		Navy Road	617.6	1,315	100
Dowland Building		Navy Road	376	800	61
Mackenzie Range Supply		Navy Road	465.6	762	58
Tundra Drilling Services Ltd		Navy Road	335	713	54
Norcan Garage / Warehouse		Ookpik Road	1,125	2,395	182
Office		Reliance Street	560	1,108	84
Billy Moore Adult Handicapped Home		Semmler Place	216	276	18
Nijaa Apartments	20	Tununuk Place	1,270	1,109	72
Tununuk Apartments	40	Tununuk Place	3,888	3,225	220
Mountainview Apartments	50	Tununuk Place	3,874	3,381	219
Unknown apartments		Tununuk Place	1,188	1,037	67
Tununuk Place 3-story Peach		Tununuk Place	1,229	1,072	70
Houses (~300 @ 147m2, 75% on natural gas)		Various	33,075	42,255	2,738
Houses (~300 @ 147m2, 25% on oil)		Various	11,025	14,085	913
PWS Trades Office	41	Veteran's Way	298	589	45
Royal Canadian Legion Branch 220	118	Veteran's Way	526	1,042	79
Northern Industrial Sales Ltd.	135	Veteran's Way	805	1,317	100
RCMP Building		Veteran's Way	1,437	2,844	216
Bottle Depot		Veteran's Way	546	1,162	88
PWS Trades Buildings		Veteran's Way	1,214	2,585	196

Building Name	Number	Street or Avenue	Floor Area	Estimated Annual Heating Load (GJ)	Approximate Peak Heating Load (kW)
Alex Moses Greenland Bldg		Veteran's Way	301	595	45
NTPC Office		Veteran's Way	613	1,213	92
MACA OFFICES		Veteran's Way	371	539	76
New GNWT Office		Veteran's Way	600	1,188	90
Millenium Construction Office		Willow Road	275	544	41
Millenium Construction Shop		Willow Road	360	766	58
Wolverine Rowhouses		Wolverine Road	2,064	2,749	209