Adoption Of Wood Pellets In The Prince George, BC Market: Perceptions And Opportunities

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ABSTRACT

A limited supply of non-renewable energy (e.g. oil and natural gas), coupled with environmental, economic, social and geopolitical consequences have encouraged society to search for new energy alternatives. The use of wood pellets as a bioenergy alternative is one of the options available.

The first part of this paper was exploratory research on the state of the wood pellet, its associated technology, and a review of local and international wood pellet markets. The objective is to provide an overview and identify some of the key factors influencing wood pellet markets. It was found that the consumer market in Canada is primarily residential, market penetration is low, and the key drivers of the market are the supply side players. Canada was found to be a net exporter of wood pellets the majority being shipped to markets in the US and Europe.

The second part of this study examined residential wood pellet systems within an adoption and diffusion of innovations framework. A survey of potential adopters in Prince George, BC measures their perceptions of wood pellets and explores the factors that influence their decision to adopt or not adopt this technology. It was found that the local wood pellet market has a number of barriers to overcome including technological lock-in with traditional systems and promotion and communication challenges. Opportunities were identified including the perception that wood pellets systems are economical and environmentally friendly.

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Chapter One – Introduction

A limited supply of non-renewable energy (e.g. oil and natural gas) coupled with environmental, economic, social and geopolitical consequences has encouraged society to search for new energy alternatives. The use of wood pellets as a bioenergy alternative is one of the options available. In Canada, the use of wood pellets has primarily been in the residential home heating market in the form of wood pellet stoves/fireplaces. Minimal research has been completed to date on wood pellet markets in Canada.

The first part of this paper is exploratory research on the state of the wood pellet, its associated technology, and a review of local and international wood pellet markets. The objective is to provide an overview and identify some of the key factors influencing wood pellet markets.

The second focus of this paper is to develop a better understanding of the perceptions of wood pellets and to explore factors that influence a consumers decision to adopt or not adopt this technology. A literature review on adoption and diffusion theories was conducted and was used to develop an appropriate survey that could measure consumers' perceptions of wood pellets. The survey was conducted on residents living within the city of Prince George, BC. This city was selected due to its unique proximity to a large number of existing and planned wood pellet manufacturing plants. Furthermore, the market penetration of wood pellets in the Prince George market has been relatively low. The majority of the wood pellets produced in this area are not used locally but rather are exported to the US or other international markets.

1.1 Study Objectives

Very little is known about consumers' perceptions of wood pellet systems and about why some people adopt the technology and others do not. This could be valuable information for the future growth of this industry in Canada. The overall objective of this study is to complete exploratory research on the state of the wood pellet industry, to develop a better understanding of the perceptions of wood pellets, and to explore factors that influence consumers' decision to either adopt or not adopt this technology. The following research questions were established early on in the development of this project and will be answered in this study:

1) What is the current state of wood pellet technology in Canada?
2) What is the current state of the local, North American and International wood pellet markets?
3) What is the local (Prince George) perception of wood pellets?
4) Are there any theories available to help explain the factors and characteristics that influence a consumers decision to adopt or not adopt wood pellets?
5) What are the barriers and opportunities for the local wood pellet market?
6) What possible strategies can be used to overcome these barriers and/or take advantages of opportunities in the local wood pellet market?

1.2 Research Scope

The wood pellet industry consists of sourcing of wood fibre (supply), processing (manufacturing), and consumption (marketing and end use). This study will be primarily interested in understanding consumers and the consumption process; i.e. the consumer end of the value chain.

It is beyond the scope of this project to evaluate all of the scientific and economic literature that supports or refutes all of the intricate scientific, environmental, and economic factors (e.g. cost/benefit analysis or CO_2 emission studies) for either the wood pellet itself or in comparison to other more traditional heating systems (e.g. natural gas, electricity, oil). It is noted in the literature that this type of research is significant, as it can provide benefits to producers, policy makers, and consumers. However, it poses a number of challenges, including the fact that wood pellet use is relatively new and there is limited data and knowledge in the marketplace (Gustavsson et al. 2005).

In the survey section of this study the geographic scope is the city of Prince George, BC. One of the reasons this city was chosen is its close proximity to a large number of existing and planned wood pellet manufacturing plants. The second reason is that the areas forests are currently under attack by the Mountain Pine Beetle. The current forecasts by the BC Forest Service predict that the Mountain Pine Beetle infestation will kill not less than 80% of the volume of pine forest across British Columbia (Eng 2005). This outbreak has led to a significant increase in the amount of timber being harvested in the area. The BC Provincial Government has made it a priority to obtain some value from

this timber before it becomes un-merchantable. The result is local wood pellet manufacturing plants are expanding their production capacity and new wood pellet plants are being planned for the area. There are other important factors that make the wood pellet industry a "hot topic" for this area including; volatile North American energy markets, energy security issues, international energy agreements (Kyoto), and climatic conditions. The use of bioenergy fuels (e.g. wood pellets) as an alternative to fossil fuels is gaining momentum, and worldwide use has increased substantially in the last decade (Gustavsson et al. 2005).

1.3 Potential Beneficiaries

The target beneficiaries of this study include wood pellet manufacturers, wood pellet retailers, wood pellet appliance manufacturers, wood pellet appliance retailers, wood pellet marketing associations, forest industry companies, and government. It is also the intention of this study to provide some useful information to the general public and to those who may be interested in learning more about wood pellets. The information contained within this report should also benefit other researchers in developing a better understanding of wood pellet markets.

Chapter Two - Background

2.1 Bioenergy

Rapid socio-technological innovations during the last century have given rise to abundant and reasonably low cost fossil fuel energy sources. Canada has an abundant variety of natural fossil fuels, including oil, natural gas, and coal. Unfortunately, the use of fossil fuels is causing serious environmental problems such as global warming, ozone layer depletion, air and water pollution, and hazardous waste deposition. The cost to purchase fossil fuels on the world market has increased significantly in the last five years (Statistics Canada 2005). A Statistics Canada report (2005) reported that "Canadian use of fossil fuels for energy production increased for the third year in a row in 2004…Canada consumed 7,690 10^{12} (petajoules) of energy...BC is the fastest growing province in energy consumption" (Statistics Canada 2005, 1).

There is also increasing concern that worldwide fossil fuel use will not be sustainable and there has been increasing pressure to find new sources of energy. Many options have been explored, and some have been successful including: wind energy, hydropower, solar energy, geothermal energy, nuclear energy, and bioenergy.

One of the renewable options is the use of biomass. Biomass is all of the plant and animal matter that is on the Earth's surface. The harvesting of biomass such as crops, trees or dung and using it to create energy such as heat or electricity is called bioenergy. Bioenergy could be used to directly replace fossil fuels. There has been a considerable

amount of research into the options available for the direct substitution of wood for fossil fuel and into the use of wood as a sustainable "carbon neutral" alternative. Advanced technologies now allow for wood and wood waste to be used to produce heat and energy economically.

2.2 The Wood Pellet

Wood pellets (or sometimes referred to as pellet fuel) are a densified form of dried compressed wood residue, primarily made from sawdust, shavings and fines that are a by-product of the wood processing industry (fig. 2.1).

Figure 2.1. Portrait of Wood Pellets. Source: Bruton, released into the public domain.

Wood pellets are uniform in size and content and, as a result, offer substantial advantages over cordwood burning or hog-fuel burning (bark, saw-dust, and/or shavings).

In addition, the particulate and gaseous emissions from wood pellet appliances are extremely low and their burning efficiency is very high (Pellet Fuels Institute 2006). The literature suggests a number of environmental advantages to the use of wood pellets, which include:

1) Renewable - wood can be continuously replenished, and is therefore sustainable
2) Low carbon emissions - there is only minimal amount of net carbon (CO_2) production (~5%), the major greenhouse gas, from wood combustion, since the CO_2 generated during combustion is equal to that consumed during the life-cycle of the tree
3) Minimal metals and sulfur - wood fuel has a minimal amount of heavy metals and sulfur, and therefore does not lead to acid rain
4) Minimal ash - the particulate emissions from wood fuel can be controllable by emission control devices

Other advantages of wood pellet heating systems include that they have: been subjected to lower price fluctuations than fossil fuels, are easy to transport and store (more convenient than logs), are becoming increasingly standardized and treated more like a commodity, have improved in automation, and now have higher combustion efficiencies (Gustavsson et al. 2005). In comparison to other wood biofuels such as firewood, wood chips and wood waste material, wood pellets have an increased weight to volume ratio versus chips (3:1) and sawdust waste (5:1), which provides a significant cost savings in shipping costs and storage (Ince et al. 1984; Aruna et al. 1997).

Wood pellets are produced at a pellet mill where the raw material is dried, compressed and formed into small eraser sized bits. The production of wood pellets typically involves 6 stages:

1) Hogging and grinding – raw material is "hogged" into a small and uniform size
2) Drying – the wood dust is dried to a specific moisture level using wood or natural gas in a rotary drum dryer
3) Pellet Formation – wood dust is converted into pellets using a pellet mill. Usually no additives are added, as the lignin in the wood acts as the binding agent
4) Cooling – pellets are cooled to allow the lignin to set
5) Fines separation – residual fines are separated and returned to the process
6) Bagging – pellets are bagged immediately or stored in a silo to reduce the chance of exposure to moisture

In the North American market there are two grades of pellet fuel available: standard and premium grades. The primary difference between these two grades is that a standard grade contains a higher level of inorganic ash than the premium grade. A standard grade pellet has up to a 3% ash content, whereas a premium grade would have less than 1%. A typical premium grade wood pellet has the characteristics outlined in Appendix 1. These sorts of wood pellets make up about 95% of the pellet production in North America (Pellet Fuels Institute 2006). The heat value of wood pellets range from 8,500 - 8,900 BTU (5.5 - 5.6 MWh/metric ton). Pellet manufacturers are encouraged to label their product, and quality test regularly to ensure the protection of consumers. The

North American industry has developed standards, through the Pellet Fuels Institute, to create a product that is consistent in content, density, size, and quality. The standards place the responsibility for testing on the pellet mills, and the Pellet Fuels Institute recommends that manufacturers conduct both internal and independent laboratory testing of their product on a regular basis. The required standards for wood pellets are the following: (Pellet Fuels Institute 2006)

1) Density – product must have consistent hardness and energy content (minimum of 639 kg/m^3)
2) Dimensions – length must be 1 ½" maximum and diameter of ¼" x 5 1/16" to ensure predictable fuel amounts as well as to prevent jamming
3) Fines – there must be a limited amount of sawdust from pellet breakdown, to avoid dust while loading and to reduce problems with pellet flow (should be below 0.50%)
4) Chlorides – pellets must have a limited salt content (no more than 300 parts per million to avoid stove and vent rusting
5) Ash content – this is an important factor in maintenance frequency, should be minimized (should not exceed 0.30%)

European standards vary between countries and are not consistent with North American standards. The quality of wood pellets in Europe has been improving in recent years as part of an effort to improve their image, market competitiveness, and durability in handing as well for reliability and convenience (Gustavsson et al. 2005). In Sweden,

for example, the ash content of wood pellets has been reduced from 10% in the 1980's to about 0.5% in 2002 (Dahlstrom 2002). Examples of countries with known standards include Austria, Germany, Sweden, and Finland (Gustavsson et al. 2005).

2.3 Combustion Technology

Wood pellets are typically used in a number of different residential type appliances such as wood pellet stoves, furnaces, etc., to produce heat or they can be used in larger sized cogeneration or boiler systems to produce both heat, and/or electricity. The users of wood pellets can be categorized into three areas based on the requirements of the consumer targeted (each will be described below). These three categories are:

1) Residential wood pellet appliances (e.g. stove, furnaces, boilers, and BBQ's)
2) District heating systems
3) Industrial cogeneration and boiler systems

Residential Wood Pellet Appliances

The most common residential wood pellet appliance in Canada is a pellet stove/fireplace. This product is an automatic combustor that uses both wood pellets and electricity for operating and a flue for leading flue gasses out. An informal internet survey of wood pellet stove manufacturing companies indicates that a number of different models are available. These include freestanding stoves and models that can be inserted into an existing open fireplace. Typically a wood pellet stove is light and does not require a massive base. An advantage of pellet stoves is their easiness of use, small amount of

ash production, adjustability of output, and ability to rapidly heat the space required (Alakangas and Paju 2002). Residential wood pellet furnaces and boilers (for heating and hot water heating, respectively) are also available on the market. However, both of these systems are not very popular in Canada. A wood pellet appliance is capable of generating between 10,000 and 500,000 BTU of heat and can heat an entire house if properly installed (BC Pellet Fuel Manufacturers Association 2006). The most recent introduction to the market is the wood pellet barbeque.

District Heating Systems

District heating systems provide heat energy to multiple consumers from a single heat source. These systems can also be coupled with the cogeneration of electricity. A wood fuelled heating plants size is measured by its heat output, typically measured in megawatts (MW). A small district heating system (0.025 MW to 0.150 MW) would be suitable for a single building, garage, barn, or small greenhouse. A medium sized heating plant would have a heat output of approximately 1 to 4 MW, and would typically be used in a school, or a larger complex such as a university, a factory or in a small town system. Larger systems would fall into the large-scale district heating (or cogeneration) category, which will be discussed in the next section. A typical district heating plant produces thermal energy which is transferred as hot water or steam through an insulated steel or plastic pipe (National Research Council 1985). The thermal energy is distributed to the end user where the heat is extracted and circulated into a buildings interior environment. After the heat has been extracted the water is then returned to the production plant for reheating. This type of system will often supply domestic hot water, thus eliminating the

need for a hot water tank. Fossil fuels have traditionally been the source of energy for district heating systems (Mackenzie-Kennedy 1979). The majority of district heating systems rely on multiple fuel sources to be more viable. Fuel sources could include: municipal solid waste, waste heat from electrical or industrial processes, and other renewable sources such as geothermal, straw, and wood biomass. In 1997, it was estimated there were over 6,000 district heating systems in North America (Schweig 1997). These systems are commonly found in building complexes such as universities, schools, hospitals, jails, and government buildings, etc. (Metro Toronto Opportunities Investigation Group 1995). Market penetration of these systems in Canada is low, with approximately 50 cities using them, most notably: Charlottetown, PEI; Toronto, ON; Ouje-Bougoumou, PQ; and Grassy Narrows, ON (Schweig 1997). There was no literature available to confirm whether any of these operations were using wood pellets.

Industrial Cogeneration and Boiler Systems

Cogeneration describes the process whereby simultaneous production of power/electricity, hot water, and/or steam occurs from one fuel. In the 1980's the relatively low natural gas prices made the development of cogeneration plants attractive. In fact, gas-fired cogeneration was the main reason for the decline in conventional power plant construction that occurred in North America during the 1980's. Cogeneration is considered to be an environmentally friendly method of producing electricity (power) steam and/or hot water at the same time, in one process, with one fuel. Cogeneration plants can often reach energy efficiencies of up to 90%, and depending on the technology used and the system it is replacing, there can be fuel savings in the range of 10-40%

(Madlener and Wickart 2004). The typical fuels used in cogeneration systems are natural gas, fuel oil, propane, and renewable energy such as bio-waste and wood or wood waste. It is common for forest product manufacturing facilities to install cogeneration plants as an efficient way to provide power and thermal energy to meet on-site requirements and as a way to use their wood waste.

An industrial boiler is a large closed vessel in which water or another type of fluid is heated under pressure. This hot fluid is then circulated for use in other processes. Boilers can utilize combustible industrial by-products, gases, liquids or solids. These large industrial boilers can also use heat energy from some other separate combustion process, such as heat recovery boilers from different processes. A boiler plant most often forms just a small part of a larger process. A hot water boiler plant could produce heat for use in a district heating system. Alternatively, a steam boiler would produce steam for some industrial process or for power production.

Usually cogeneration systems and industrial boilers are large ranging in size from a few megawatts to as high as 300 MW plus (based on electrical output). These larger systems would most often be found in prisons, hospitals, large factories, or in a more extensive city system. For example, in Stockholm, Sweden more than 60% of the city's heat demand is met by an expansive district heating system and in some central areas of the city the share increases to nearly 90%. This system is run by a number of different cogeneration systems and boiler plants. One of these plants has three 100 MW boilers, one of which, operates almost exclusively on wood pellets and was the first biomass-

fired, cogeneration power plant in the Stockholm area. In 1999 there were about 6,310 wood power plants in the US that were capable of exceeding 15MW (Bergmann and Zerbe 2004). However, it appears that none of these use wood pellets as a source of fuel.

Chapter Three - Market Analysis

3.1 Prince George Market

In 2005 there were five wood pellet manufacturing facilities located in British Columbia (BC Pellet Fuel Manufacturers Association 2006). Three of these five operations were located in and around the Prince George area. These include a mill within the city of Prince George (Pacific Bioenergy), one in Quesnel (Pinnacle Pellet), and one in Vanderhoof (Premium Pellet), with a combined annual capacity of approximately 550,000 tons of wood pellets. These mills do supply local retailers and "walk-up" customers as part of their business. However, their production capacities far exceed the requirements of the local market and therefore they are involved in exporting wood pellets to the larger US and international market place.

The development of new wood pellet manufacturing facilities is occurring in the Prince George area. In July 2005, CH. Anderson and Associates of Vancouver, BC and TallOil of Stockholm, Sweden announced a proposed $100 million project to build four new pellet fuel plants in the BC interior (Harris 2005). The goal of this project was to build pellet plants to meet the needs of European demand for renewable energy and was developed based on the pine beetle damaged forests and abundantly available low cost fibre source. The CEO of TallOil, Henrik Lundberg, is quoted as saying "increased demand for renewable energy is being driven in Europe by green incentives and national energy policy is supporting the business case for manufacturing wood pellets in BC" (Harris 2005, 1). The first two pellet plants are planned for Quesnel and Vanderhoof and the locations for the remaining two plants have not yet been determined.

In February 2006, Canadian Forest Products Ltd. announced its intention to build a wood pellet mill in Houston, BC (Appendix 2). This pellet plant would be a joint venture between Canadian Forest Products Ltd., Pinnacle Pellet, and the Moricetown Band. Pellet production is expected to begin in the fall of 2006. The press release notes that "wood pellets produced at this facility will be suitable for both industrial and home heating consumption and will be sold into a combination of the North American, Asian, and European markets" (Canfor News Release 2006, 1). All of this production capacity will create an oversupply of wood pellets in the Canadian market and therefore wood pellet manufacturers will increasingly look to the export markets to meet their sales requirements.

In preliminary discussions with local wood pellet manufacturers, it was noted that it was not in their company's best interest to ship wood pellets to US or offshore markets as it requires a stronger sales effort, an efficient supply chain, currency exchange issues, and other associated risks. It appears that they would like to see growth in the local wood pellet market.

As is the case with the entire North American market, the primary use of wood pellets in Prince George is for residential use in the form of wood pellet stoves/fireplaces. The local wood pellet market competes primarily with natural gas and electricity heating systems. A site visit to a total of 19 potential wood pellet and appliance retailers was conducted in March of 2006. A total of 9 retailers were identified that sold either wood pellets or wood stoves or both. The data collected was only on the retail price being

offered for the wood pellets and wood stoves. This information was used to produce a price comparison for these products (table 3.1)

Table 3.1. Survey Results on Pricing of Wood Pellets and Wood Stoves, in Prince George, BC (2006 data)

	Low	High	*n*	Mean
Wood Pellets				
40 lb bag	$2.99	$4.79	6	$3.79
Bulk (per ton)	$136	$175	5	$149
Wood Stoves/Fireplaces	$1,799	$4,500+	6	

It was found that wood pellets were sold in either a 40 lb. bag or in bulk. A bulk purchase involved buying a skid of wood pellets weighing approximately one metric ton. A total of 6 wood pellet appliance retailers were identified in Prince George. The wood pellet appliance retailers all reported strong sales of the wood pellet stoves/fireplaces. Only one company was identified as having a wood pellet furnace in stock and could order a wood pellet hot water heater if a buyer was interested. It is important to note that other wood pellet or wood appliance retailers could have been missed in this short survey.

In Prince George, there were no district heating or industrial cogeneration operations using wood pellets. In October 2005 the City of Prince George passed a by-law to allow the city to develop a $9.3 million biomass district heating system (Nielsen 2005). The project would involve connecting 18 downtown core buildings. It is not clear as to whether wood pellets have been considered as a fuel source for this project.

3.2 North American Market

In 2005 there were over 60 wood pellet mills in North America, 20 located in Canada and 40 in the US (Pellet Fuel Institute 2006). The largest pellet producing regions in North America are located on either coast, with very little production elsewhere. In North America the majority of wood pellet manufacturing companies have been established specifically for the purpose of pellet production. Wood pellet producing plants range in production rates of 0.75 to 15 ton per hour. The research indicates that these variations are based primarily on the size of the operation but also depends on the species of wood used. The plants using softwoods generally have a higher production rate than those using hardwoods. Industry experts believe that between 1990-1992 hardwood productivity was 50% less than softwood (UMBERA 2000). However, significant gains were made by 1994 when it was estimated that the hardwood output was reduced to about 25% less than softwood (UMBERA 2000).

Wood pellet use in North America is almost exclusively consumed as a residential heating supplement, the majority (95%) being used in pellet stoves/fireplaces (Pellet Fuels Institute 2006). There are very few homeowners using furnaces or boilers for wood pellets. In North America the sales of wood pellet fuel directly follows the demand curve produced by the number of residential wood pellet stoves sold (table 3.2 and fig. 3.1).

Table 3.2. US Hearth Appliance Shipments 2005. Source: Kaiser and Johnson 2006

US Hearth Appliance Shipments 2005 (units)	
Cordwood	561,596
Gas	2,141,165
Electric	380,000
Pellet	118,490
Total	3,201,251

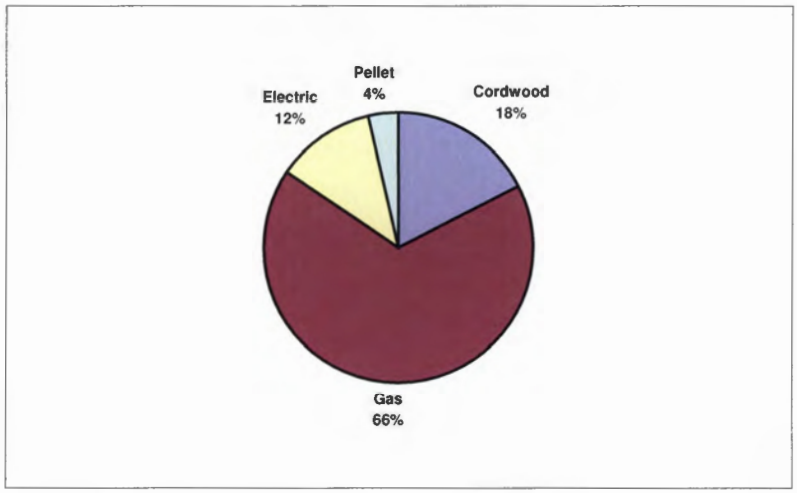


Figure 3.1. US Hearth Appliance Shipments Percentages (2005). Source: Kaiser and Johnson 2006.

The sales of wood pellet stoves in North America rapidly increased in the early 1990's and leveled off in the late 1990's when the industry was under pressure from natural gas. The market has improved steadily in recent years. It is hard to determine how many pellet stoves/fireplaces exist in North America due to the fact that good statistics are not available. However, it is estimated that the residential North American wood pellet market accounts for about 956,000 tons of production and sales (Natucka 2005). The average households yearly consumption of pellets is 2 tons, so on average there are 450,000-500,000 pellet stoves in operation in North America (Natucka 2005).

Wood pellet production has been increasing steadily in the last five years (fig. 3.2) with the largest increase occurring in Canada.

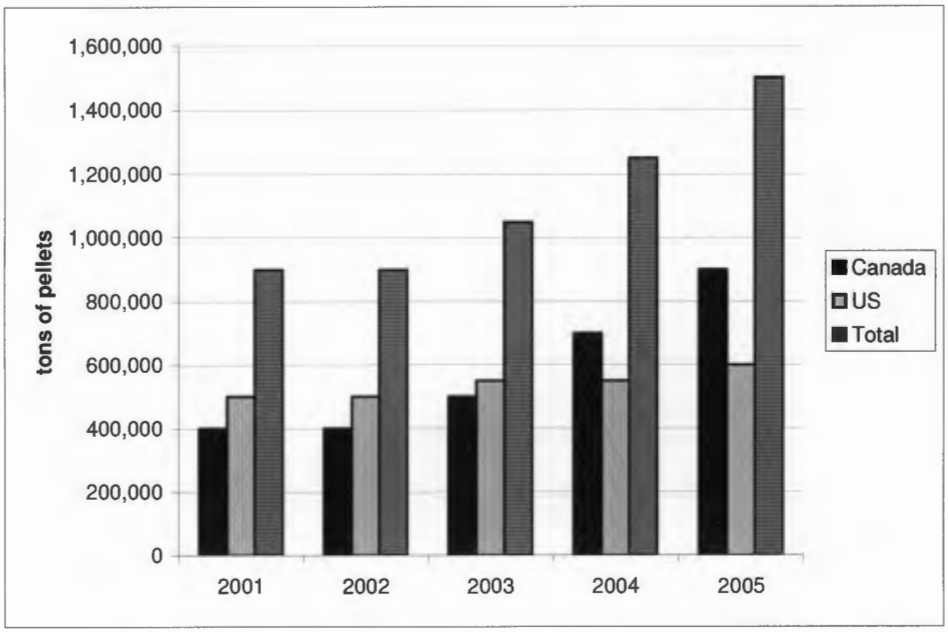


Figure 3.2. Canada vs. US Pellet Production (2001-2005). Source: Natucka 2005.

In 2005 Canada produced about 55% or 915,000 tons of the total North American production (Natucka 2005). The Canadian export market shows the most growth in pellet production over the last few years and was expected to ship 582,000 tons during 2005. Research indicates that the majority of future wood pellet production is expected to come from Western Canada based primarily on the large availability of timber supply and reduced fibre cost (based on the Mountain Pine Beetle epidemic) (Natucka 2005). Total North American wood pellet production for 2006 is projected to be 1,653,500 tons (Natucka 2005).

The wood pellet industry in North America competes with all other energy options including electricity, oil, and natural gas, etc. In North America the use of wood pellets, as an alternative heat and energy source, has been relatively slow to be adopted. It is estimated that only 0.025% of US residential heat uses pellet fuel (UMBERA 2000). American wood pellet producers rely solely on the domestic market, as it is not economically viable for them to do business in the export market based on raw material cost and fibre availability (Natucka 2005).

3.3 International Markets

The wood pellet market in continental Europe is by the far the largest producer and user with total production capacity of approximately 5.1 million tons annually (table 3.3).

Table 3.3. Pellet Plants and Production Figures for Europe and Other Pellet Production Regions (2005-2006 data). Source: Ljungblom 2005

Country	No. Pellet Plants	Annual Production (mt.)
Europe		
Austria	15	509,000
Belarus	2	not available
Belgium	2	36,000
Bulgaria	1	not available
Czech Republic	2	11,000
Denmark	8	550,000
Estonia	5	345,000
Finland	18	446,000
France	11	202,000
Germany	20	398,000
Hungary	1	not available
Italy	36	720,000
Latvia	8	341,000
Lithuania	7	110,000
Netherlands	1	100,000
Norway	9	138,000
Poland	19	356,000
Slovakia	7	132,000
Slovenia	3	90,000
Spain	3	70,000
Sweden	32	1,261,000
Switzerland	4	60,000
United Kingdom	3	110,000
Russia	25	759,000
Total	**242**	**5,104,000**
Other		
Canada	20	915,000
United States	40	738,000
Japan	13	65,000

The largest European user and producer of wood pellets is Sweden with an annual production capacity of 1.26 million tons (Ljungblom 2005). There has been little

development of wood pellet production or consumer markets outside of North America and Europe.

Sweden is the world leader in the production and use of pellet fuels as a bioenergy alternative. Wood pellet production in Sweden started in the late 1970's with the development of a production facility in Mora, Sweden. The plant began production in November 1982. At this time there was limited knowledge on how to produce a wood pellet production facility. In the early 1990's the Swedish government introduced a tax on mineral fuel, which reduced the competitiveness of burning fossil fuels such as coal, oil or gas. Therefore, the use of biomass became a positive energy alternative. This marked the beginning of a successful wood pellet industry in Sweden. As of 2005 there were approximately 30 wood pellet production sites for wood pellets in Sweden, with an annual production of almost 1.2 million tons (Ljungblom 2005). In contrast to North America the majority of wood pellet are used in district heating or large-scale district heating (or cogeneration) plants. These large scale heating plants in Sweden are typically ones that have been converted from coal-dust firing. At present these district heating and large-scale systems are using approximately 1 million tons of wood pellets per year.

The Swedish residential market uses about 250,000 tons annually (2003 data) for use in about 37,000 residences (Mahapatra et al. 2004). In order to meet the country's demand, Sweden is a large importer of wood pellets, primarily from Canada. The future for residential pellet stove use in Sweden appears promising (Mahapatra et al. 2004). However, the research indicates that there are still some perception problems in the Swedish residential market, including a lack of knowledge of the advantages of wood

pellet systems. Consumers in Sweden also see many technical and non-technical problems in small heating units, such as storage, delivery to the customer and service. In Sweden, wood pellets for the consumer market are packed in loose bulk or big bags and purchases are usually made direct from the pellet manufacturer. However, there has been an increase in the number of pellet dealers that now deliver pellets directly to the consumers' door by bulk vehicles (Mahapatra et al. 2004).

In October 2005, the government of Sweden developed a new policy target: "the creation of the conditions necessary to break Sweden's dependence on fossil fuels by 2020" (Government Offices of Sweden 2005, 1). The policy instruments include investment grants, norms for energy use, loans with interest subsidies and information drives. The government has identified that the promotion of district heating with wood pellets is an important part of this policy. The government is also planning to spend upward of $125 million per year for research into new knowledge for a renewable society (Government Offices of Sweden 2005). District heating systems have increased rapidly in Sweden in recent years and the Swedish government is expecting this trend to continue.

The European Union (EU) has been a proponent of the use of bioenergy alternatives such as wood pellets. The EU's "White Paper on Renewable Energy Sources" proposed to double the use of renewable energy from 6% in 1997 to a target of 12% by 2010 (European Commission 1997). It was anticipated that biomass, which has a current share of about 3% of total energy consumption would make the largest contribution (Gustavsson et al. 2005). In its "Campaign for Action" the European

Commission proposed setting a target of one million biomass heated homes in the EU-15 (Austria, Belgium, Denmark, Germany, Greece, Finland, France, Ireland, Italy, Luxembourg, Portugal, Spain, Sweden, the Netherlands, and UK) during the period 1999-2003 (Gustavsson et al. 2005). This sent a positive signal to the European bioenergy market.

Due to this increased level of interest in Europe for bioenergy (e.g. wood pellets) fuel alternatives there has been a great deal of research conducted in this field.

3.4 "Thermie B" Project

In 2000 a group of European partners from Sweden, Norway, German and Austria conducted a comprehensive study know as the Thermie B project to study and encourage the development of the wood pellet markets worldwide (UMBERA 2000). The study was titled "Wood Pellets in Europe" and was financed by the European Commission, and the Austrian and Norwegian governments. In this study the authors reached a number of conclusions and recommendations to encourage the market penetration of wood pellets. The following is a brief synopsis of this studies findings.

Wood pellets have great market potential as a biomass fuel even though their current share of the heat energy market is presently small. There is great potential for this industry worldwide due to the availability of raw material, comparatively high energy density, the possibility of their use in automatic firing systems offering a high level of customer convenience. Furthermore, wood pellets have been shown to be price

competitive (versus other fuels) in some markets. The study also identified a number of barriers including, communication problems and competition between the various players make coordination a problem (UMBERA 2000). This report also cites a lack of infrastructure as a barrier to the installation of pellet fuel systems. The study noted a non-existent supply system for pellet fuel, heating systems and services, which could act to prevent consumers from purchasing wood pellet heating systems (UMBERA 2000). It was identified that social or traditional pressures of customers could be further inhibiting the growth of pellet heating systems. However, the most important factor identified was that of economics whereby both pellet fuel and non-renewable sources are similar but pellet fuel systems require a higher investment cost. The report suggests that the non-technical obstacles are likely to have the most influence on market development rather than technical barriers.

The Thermie B report also identified a number of strategies that could lead to further market penetration of wood pellet heating systems. These strategies include garnering political support for the industry, for example in reaching Kyoto targets. Another important strategy would be to develop further co-ordination, co-operation and information. The report identified the need to better develop the technology including heating systems, transport and storage (and the supply chain), pellet quality, and quality assurance. Furthermore, wood pellet manufacturers need to do a better job of marketing and advertising their product and to develop a stronger brand image among consumers (UMBERA 2000).

Chapter Four - Adoption and Diffusion Literature

In the case of the launch of a new technology it is often a puzzle as to why it takes such a long period of time to be adopted by those people who would seem most likely to benefit from its use. In fact, the vast majority of new products and services that enter the market every year fail at a considerable cost to companies (Cooper 1993; Mahajan et al. 2000). Therefore, it is of utmost importance for companies developing new products to understand why some people adopt an innovation and others do not and to understand the factors that may influence this decision. Equally important, consumer behavior researchers are interested in better understanding rates of adoption within this process. Research and theories on "adoption" and "diffusion" of innovations contribute to such understanding.

In this paper the following definitions for adoption, diffusion, and innovation will be used. Adoption refers to a decision that an individual makes to use an innovation, whereas diffusion will refer to the accumulated level of users of an innovation within a particular market (Rogers 2003). The term innovation has been defined a number of different ways, Rogers (1983, 11) defines an innovation as: "an idea, practice or object perceived as new by the individual. It matters little, as far as human behavior is concerned, whether or not an idea is objectively new as measured by the lapse of time since it's first use or discovery…if the idea seems new and different to the individual, it is an innovation".

In marketing, an innovation is considered to contribute significantly to the extent that a firm is market driven (Manu and Sriram 1996; Hurley et al. 1998). One of the most popular theoretical frameworks for analyzing adoption characteristics has been the model proposed by Rogers (1962). A number of other models and theoretical constructs have also been developed. The following chapter will look at the Rogers (1962) model and a number of others; the intention is to provide insight relevant to this paper. This research has been completed within the context of consumer adoption of tangible innovative products.

4.1 Adoption Literature Background

The roots of adoption and diffusion research extend back to Gabriel Tarde who was one of the forefathers of sociology and social psychology (Rogers 2003). Tarde observed a number of generalizations about the diffusion of innovations which he called the "laws of imitation" and which he published in a book in 1903. Tarde was the first to plot the S-shaped diffusion curve, which will be discussed further in this chapter. In 1943 two sociologists, Bruce Ryan and Neal Gross, published a seminal study titled "The Diffusion of Hybrid Seed Corn in Two Iowa Communities" which renewed interest and provided the modern genesis of present day diffusion research (Roger 2003). The Ryan and Gross study (Ryan and Gross 1943), used interviews with adopters of an innovation to examine a number of factors related to adoption. Researchers have since built on the work of Ryan and Gross to conduct studies and develop theories related to the adoption of innovations.

Considerable research has been done from a socio-demographic and psychographic perspective of attributes of individuals in an attempt to identify individuals who exhibit innovative behavior and are therefore likely to be early adopters (Midgely and Dowling 1978). It was soon realized that if these early adopters could be identified this would be an important target market in which to base marketing campaigns for new products. These studies have attempted to link the adoption characteristics with the cognitive style of an individual known as their innate innovativeness. The results of this research has been mixed, with Foxall and Bhate (1993) claiming that this concept of innate innovativeness is too simplistic on its own, and the propensity to adopt may be influenced by the product content and levels of involvement. There have been a number of other studies that have evaluated adoption behavior based on socio-economic and demographic factors. It has been suggested that there are a number of personal characteristics that could be important predictors of consumers' adoption of an innovation. Studies have suggested that early adopters often have higher levels of income, are highly educated, and are of a higher social status (LaBay and Kinnear 1981 Lockett and Littler 1997). However, the consensus is that although these personal attributes play an important role in adoption behavior it is the perceived attributes of the innovation itself that are the more powerful predictor of adoption (LeBay and Kinnear 1981; Holak 1988; Lockett and Littler 1997; Rogers 2003).

In marketing adoption and diffusion studies, the highly regarded Bass Model has received a great deal of attention (Bass 1969). The original Bass Model was developed to predict the uptake of consumer products based on various advertising campaigns and how

these influence the diffusion process over time and how contagion and saturation effects form the S-shaped diffusion curve. The Bass Model quantifies the introduction of new technologies depending on the up-take by innovators and imitators by estimating the introduction and acceptance rate variables (Bass 1969). This model is still widely used today for forecasting sales of new products and services. The Bass Model is also used to determine optimal product/service pricing and to analyze marketing-mix effects.

The most well know and widely used adoption and diffusion theories have been developed by Everett Rogers. Rogers book *Diffusion of Innovations* was first published in 1962 and is now in its 5th edition (Rogers 2003). His theories are perhaps the simplest model for understanding the adoption pattern of innovations. Rogers (2003) four main diffusion theories are: innovation decision process, individual innovativeness, rate of adoption, and perceived attributes. All four of these theories will be discussed in further detail below.

The theories that Rogers (2003) proposed are known as epidemic models, where the driving force is the spread of information through the meeting between an adopter and a non-adopter. Whereby the non-adopter learns about the innovation and because of this adopts the innovation – like the spread of a disease. There are other models that attempt to give a more defined prediction by looking at factors not present in these epidemic models, including such concepts as change of cost over time, product differentiation, interdependence between technologies, continuing incremental change, critical mass, network and compatibility standards, price and marketing mix issues.

4.2 Epidemic Models

One of the central themes of most discussions of new products (innovations) is the apparent slow speed in which consumers adopt the product or idea. If this innovation is a real improvement over an existing technology then why do some people adopt it later than others? The literature does not provide a clear answer to this question. However, there are a couple of points on which there is consensus. The first is that all potential users never adopt new innovations at the same time, evidenced by the fact, widespread diffusion of new innovations can take anywhere from five to fifty years to be adopted, depending on the innovation (Mansfield 1961). The second point is that the diffusion of an innovation follows a predictable temporal pattern, in the form of a sigmoid shape known as the S-shaped diffusion curve (fig. 4.1): the diffusion rates first rise and then fall over time, leading to a period of relatively rapid adoption which is between an early period of slow take up and a late period of slow approach to satiation (Rogers 2003).

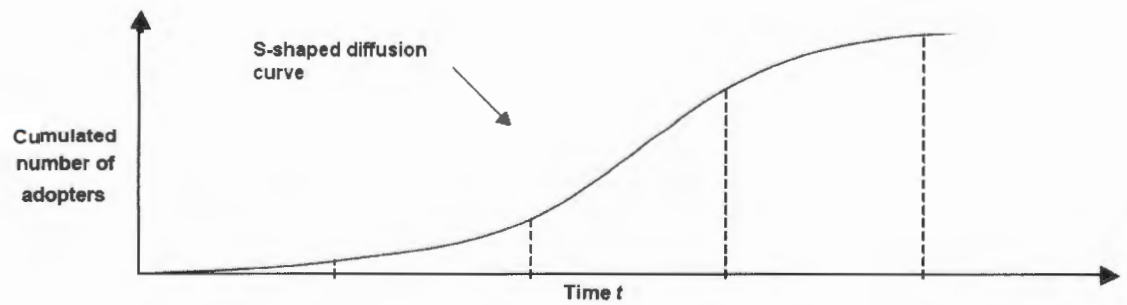


Figure 4.1. S-Shaped Diffusion Curve. Source: Rogers 2003.

In epidemic models, potential adopters start by having little or no information about a new technology and therefore are unable to adopt it. As diffusion proceeds, the

adopters via their day-to-day interactions will influence the non-adopters, just as one may contract a disease by contact with an infected person. The result is that the number of adopters grows and as the dissemination of the information speeds up, the diffusion will increase. However, once the number of adopters exceeds the number of non-adopters, the speed of diffusion decreases. An important factor is that the probability of coming in contact with an adopter is not the same for every technology. This is dependent on a number of characteristics of an innovation such as profitability, risks and the size of investment required to adopt (Mansfield 1961). Epidemic models have been criticized in that they assume that everyone has an equal chance of becoming "infected", which some researchers conclude violates common sense (Davies 1979; Stoneman 1983).

4.3 Rogers Epidemic Models

As mentioned previously the four main diffusion theories proposed by Rogers in his book *Diffusion of Innovation* (Rogers 1962) are: the innovation decision process, individual innovativeness, rate of adoption, and perceived attributes. In the following section each one of these theories will be more thoroughly described.

The Innovation Decision Process

Rogers (2003) describes the innovation decision process as one in which an individual passes from first knowledge of an innovation to forming an attitude about the innovation, to deciding whether to adopt or reject, to implementation of the new idea, to confirmation of the decision. Rogers (2003) attributes this behavior to essentially dealing with the uncertainty that is involved in deciding about a new alternative as compared to

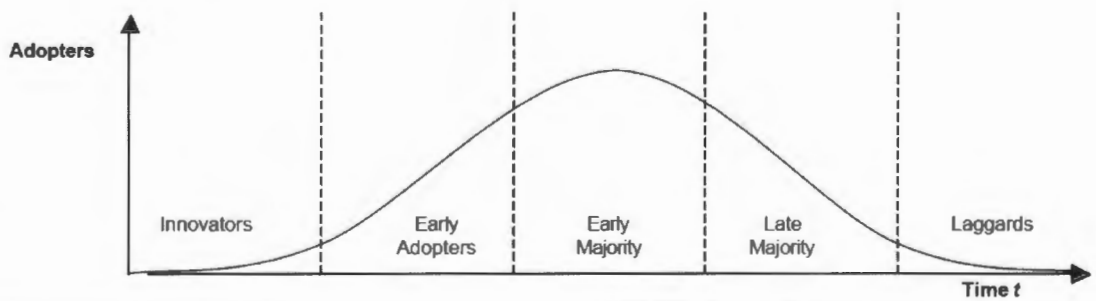
one previously in existence. The decision as to whether to adopt or not occurs somewhere between the initiation (knowledge) stage and the implementation stage (Rogers 2003). The referring stages are:

1) Knowledge - occurs when a individual becomes aware of an innovations existence and begins to develop an understanding of its basic functions
2) Persuasion - occurs when an individual forms an attitude, favorable or unfavorable, towards an innovation
3) Decision - occurs when an individual starts towards the process of deciding whether or not to adopt the innovation
4) Implementation - occurs when an individual actually starts using an innovation
5) Confirmation - occurs when an individual seeks re-affirmation for the innovation decision already made

Individual Innovativeness

Roger categorized certain features that characterize adopters' attitudes towards innovativeness and their position along the S-shaped diffusion curve. Rogers (1983, 242) defined innovativeness as "the degree to which and individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system". Rogers' five categories of adopters (fig. 4.2) and their definitions are: (Rogers 2003)

1) Innovators – the first to adopt, are the first 2.5%, are venturesome, risk-takers, have an ability to understand and apply complex technical knowledge, can cope with a high degree of uncertainty
2) Early Adopters – follow the innovators, are the next 13.5%, are successful, respected by peers, look to early adopters for advice and information, often serve as a role-model for many other members of the social system
3) Early Majority – make up the next 34%, deliberate some time before adopting a new idea, important link in the diffusion process, follow with deliberate willingness in adopting innovation, but seldom lead
4) Late Majority – make up the next 34%, skeptical, cautious, feel increasing network pressure from peers, do not adopt until others have done so, scarce resource means
5) Laggards – are the last 16%, have limited resources to adopt, are isolated, are traditional, suspicious of innovations, limited resources, must be certain that a new idea will not fail before they will adopt



% Adopters	2.5	13.5	34.0	34.0	16.0

Figure 4.2. Rogers Five Adopter Categories. Source: Rogers 2003.

Rogers (2003) is quick to point out that these five adopt categories are "ideal types" and are only conceptualizations bases on observations of reality and were designed to make comparisons possible.

Perceived Attributes

Rogers (2003) notes that it is important to not focus solely on the characteristics of the different adopter categories and their behaviors but it is also important to analyze the "innovation". Therefore, the question is, how do the properties of the innovation affect the rate of adoption? In Rogers (2003) theory of perceived attributes he proposes there are five features which impact the rate of adoption and that characterize innovations:

1) Relative advantage – degree to which an innovation is subjectively perceived by a potential adopter to be better than existing ideas
2) Compatibility – the degree to which an innovation is subjectively perceived to be consistent with exiting values and social norms, past experiences, and needs
3) Complexity – the degree to which an innovation is subjectively perceived to be difficult to understand and use
4) Trialability – degree to which an innovation can be experimented with on a limited basis
5) Observability – degree to which the results of an innovation are visible to others, visibility can stimulate peer discussion of an innovation and allow an innovation to achieve status symbol character

In addition to these five perceive attributes proposed by Rogers (2003) a number of studies have added a sixth feature (Ostlund 1974; LaBay and Kinnear 1981; Holak 1988; Lockett and Littler 1997):

6) Uncertainty (Risk) – if an innovation associated with a high level of uncertainty or risk the individuals will be less likely to purchase. In Rogers (2003) Gerwin identifies three types of risk:
    a. Technical uncertainty – extent to which a potential adopter finds it difficult to determine how reliable an innovation is and how well it will function
    b. Financial uncertainty – extent to which a potential adopter finds it difficult to determine if adoption of an innovation will be financially attractive
    c. Social uncertainty – extent to which it would be acceptable that conflict could occur in the potential adopters immediate environment with regards to purchase of an innovation

The six perceived innovation characteristics lay at the heart of the adoption of an innovation process (Rogers 2003). The perception that individuals have about a particular innovation effects their value assessment and their propensity to adopt a new idea (Ostlund 1974; Holak 1988; Rogers 2003). The use of these six attributes allows researchers to differentiate between whether a consumer will actively accept or reject an innovation. Furthermore, a relationship exists between these six attributes in regards to

acceptance rates and to the innovation diffusion (adoption) rate. Therefore, it would be expected that the higher the perceived relative advantage, compatibility, divisibility, and observability of an innovation, and the lower the complexity and uncertainty (risk), the shorter the diffusion time period of an innovation should be.

Rate of Adoption

Rogers (2003) rate of adoption theory describes the relative speed at which innovations are diffused over time in a pattern that resembles an S-shaped curve (fig. 4.1), as described previously. The rate of adoption is usually measured as the number of individuals who adopt an innovation over a give period of time. Rogers (2003) proposes that communication channels used to diffuse an innovation will affect the rate of adoption. A communication channel can be defined as a means to get a message from one person to another. The use of mass media channels can be effective in creating knowledge of innovations. However, interpersonal channels are even more effective in changing attitudes toward a new idea and influencing a decision to either adopt or reject a new innovation. Studies show that most individuals are likely to adopt an innovation through subjective evaluation of peers who have adopted the innovation rather than due to scientific research by experts (Rogers 2003). Intermediaries are also considered to play an important role in convincing others to adopt an innovation. These intermediaries are considered to be critical because often innovators are dissimilar to the broad mass of potential adopters and therefore may have communication or credibility problems. The two categories of intermediaries identified by Rogers (2003) are:

1) Opinion leaders – These are people who are characterized as being of a higher social status and are somewhat more innovative than their peers. They play a vital role in persuading the unconvinced majority of their peers. By accepting the innovation themselves they help to overcome the caution about the risks and costs of adoption.
2) Change Agents – These people work to expedite and broaden the range of the innovation. They work to create demand for the innovation by reducing the barriers to adoption, persuading adopters and supporting the adoption decisions being made. These individuals act as a bridge between technical experts and consumers, without having an allegiance to either group, and their ability to work effectively with both groups is critical. Rogers notes that this group is most effective when they work in partnership with opinion leaders (Rogers 2003).

4.4 Other Models

The literature review found a number of other adoption diffusion models that cross over a number of different disciplines. There were three models that were discussed briefly in studies involving bioenergy research, however, all three of these model do not appear to have the popularity of Rogers (2003) epidemic diffusion model. The three models are:

1) Equilibrium Diffusion Models – Treat the diffusion process as a sequence of equilibria that is determined by environmental changes and the technologies characteristics (Stoneman 2002). In this model the interplay between technology

suppliers and adopters play an important role, as well, heterogeneity of actors and the agents' technological expectations are significant. Unfortunately, this model typically assumes perfect information on the side of the adopters.

2) Evolutionary Diffusion Models – Uses some of the features of the equilibrium model such as perfect information among actors and heterogeneity among actors, but bases the dynamic analysis within a disequilibrium framework. In this model adopters employ a simple set of rules that are updated by trial and error. These types of model are also known as agent-based models and often require a large amount of data and mathematical tractability.

3) Social Interaction Diffusion Models – Are based on multi-agent modeling. This group of models has roots in graph theory, statistical mechanics and evolutionary game theory (Kirman 1997; Young 1999). These models are best suited for empirical estimation due to a richer mathematical structure and the functional forms used often closely match multinomial choice models in econometrics.

Chapter Five - Wood Pellet Literature

With the rapid growth of wood pellet markets worldwide there has been an increasing interest in the adoption and diffusion of wood pellet heating systems. The majority of the research using diffusion models on wood pellets has been done in Europe and is recent (e.g. Roos, et al. 1999; UMBERA 2000; Rakos and Hackstock 2001; Vinterback and Roos 2001). The consensus as outlined in a paper by Madlener and Gustavsson (2002) is that wood based heating systems still suffer from a number of barriers, which include, being labour intensive, old-fashioned and outdated, lack of public/private education, and experience among key supply side actors including: architects, planners, and installers (based on survey done on Austrian pellet heating systems installers [Jauschnegg 1982]), and lack of peer-group information in a large share of the population (e.g. Rohracher and Suschek-Berger 1997; Rosh and Kaltschmitt 1999).

In a 2002 study titled "Socio-economics of the diffusion of innovative bioenergy technologies: the case of small pellet heating systems in Austria" the authors used Rogers (2003) five classification of innovation features (this study did not consider the sixth perceived attribute – uncertainty/risk), as discussed in the previous section of this paper, and contrasted these with some socio-economic and environment features of small scale bioenergy systems (Gustavsson and Madlener 2002). The aim of the authors was to attempt to study the diffusion of innovation of small-scale wood pellet heating systems.

The following is a brief summary of their perceived attributes findings (Gustavsson and Madlener 2002).

1) Relative advantage – The most important advantage of wood pellet systems is the mitigation of greenhouse gases (substitution for fossil fuels) and the use of a domestic/local energy resource. This would require diffusion promotion policies, such as fiscal incentives, such as those provided in countries like Sweden to make them competitive with the alternatives.
2) Compatibility – Technical compatibility should not be a major issue for households that already have a central heating system installed, this is not the case for households with electric heat. As far as social compatibility (norms and values) it can be expected that small-scale bioenergy systems (SSBS) systems will have a good chance where these may be conceived to be an improvement over existing systems (log wood or chips to pellets). In some cases SSBS may be compatible to an adopters needs.
3) Complexity – Modern SSBS systems are at a disadvantage over conventional systems. Installers tend to stick with traditional system due to lack of knowledge, training and experience. However, this could be overcome by helping owners better understand their system and maintaining them on their own.
4) Trialability – Trialing SBSS systems is usually not possible. However, innovative entrepreneurs could lease to potential adopters.

5) Observability - Surveys have shown that trade fairs, exhibition and store displays play an important role to establish first contact with potential adopters and help raise public awareness (Vinterback and Roos 2001).

In addition to these points the authors noted that lack of information of actors involved in the purchase (the consumers) and the installers (e.g. architects and planners) of new heating systems appear to be a crucial barrier that they suggest needs to be resolved, especially in the initial phase of the market diffusion process.

In a 2004 paper, "Some reflections on the diffusion of pellet heating systems in Sweden", Gustavsson and Madlener teamed up with Mahapatra (Mahapatra et al. 2004). In this study, the authors noted that small-scale pellet heating systems (SSPHS) have been sold in Sweden for almost 10 years but the market penetration has been rather slow. They proposed studying the barriers of SSPHS based mainly on evolutionary economics and sociological theories of diffusion. In terms of evolutionary economics the authors applied the concept of innovation diffusion developed by Midttun and Koefoed (2003) to the development of heating technology in Sweden. Their findings based on their development of an evolutionary economic model are that institutional support has been directly linked to the development of wood pellet technology. Therefore, in the absence of policies to help internalize the external costs of fossil fuel systems, new bioenergy systems are more expensive and therefore less appealing to the consumer. Presently, the SSPHS systems are economical due to the high taxation of fossil fuels (Mahapatra et al. 2004).

In the second part of this study the authors looked at concepts from both the sociological diffusion of innovation theory and also added in some concepts from the economics literature. They noted the importance of looking at both supply and demand side factors. For supply side factors they studied product improvement and differentiation as well as information provision and supplier perception issues. On the demand side they looked at price, consumer behavior, bounded rationality and technological lock-in. As well they looked at perceived characteristics of innovation using Rogers (2003) five characteristic that determine the rate of adoption of an innovation, and finally they looked at issues of heterogeneity and spread of information. The conclusion of their study was that investment cost and fuel price were not the major issues in the diffusion of SSPHS in Sweden. The critical factors were product improvement and differentiation, information gaps about existence of SSPHS and its advantages, dissatisfaction among earlier adopters, and technological lock-in with fossil fuel based systems.

In a more recent paper "Energy systems in transition: perspectives for the diffusion of small-scale wood pellet heating technology" completed in 2005 these same researchers noted that small-scale wood pellet heating systems have started to penetrate the residential heating market in Europe and elsewhere (Gustavsson et al. 2005). The study noted that although there has been growth in the market there continues to be impediments around issues including, cost reduction, convenience and reliability, and environmental impact. The study noted that the literature repeatedly emphasizes that the non-technical aspects related to wood based heating systems are at least as important as

the technical aspects for market penetration (Gustavsson et al. 2005). A lack of information among potential adopters and also wholesale and retail sellers, politicians, engineers, architects, planners, etc., is an important barrier that still exists. The study recommends that adoption and diffusion modeling is a useful approach to study the overall market potential of a technology and the diffusion dynamics and impact of influencing variables. However, the research notes diffusion models can be limiting in that commercial data is often confidential, and public data has yet to be systematically collected in sufficient amounts. The study comments that epidemic diffusion models tend to be the least demanding for data requirements but consequently suggests that this type of model is better suited for market forecasting. The results of this study are that small-scale heating systems can be effective in meeting heat and electricity requirements and to sustainable energy policies, provided that framework conditions allow the adoption and diffusion to occur on a significant scale. The study recommends that cost and benefit calculations should also be considered since they can provide incentives for adopters and suppliers (Gustavsson et al. 2005).

Chapter Six - Hypotheses

The discussion of perceived attributes and adoption theories and the preceding review of wood pellet literature reveals that the use of adoption theories can be a relevant and effective means of developing a better understanding of the adoption of wood pellets. The perceived attribute model that Rogers (2003) proposes has been used in wood pellet research. Furthermore, this model has been used in a large number of other studies in a variety of fields including adoption of solar energy systems (LaBay and Kinnear 1981), internet grocery shopping adoption (Vrechopoulos et al. 2001; Hansen 2005), adoption of open aquaculture (Tango-Lowy and Robertson 2002) and adoption studies of online e-payment systems (Middlesex et al. 2006), to name a few. All of these studies have found the perceived attributes model proposed by Rogers (2003) to provide useful insight into consumers' behavior and propensity to adopt a new technology. In all of these studies, a consumer survey component was one of the most popular methods of data collection. Therefore, in this study the perceived attributes model will be used to help guide in the development of a survey, based on the framework outlined in figure 6.1.

Perceived Innovation Characteristics					
Relative Advantage Perceived degree of advantage of an innovation	Compatibility Perceived degree of compliance with values, experiences and needs	Complexity Perceived degree of difficulty to understand and use	Trialability Perceived degree of risk reduction by testing the innovation on limited basis	Observability Perceived degree of ability to communicate the characteristics of the innovation	Uncertainty Perceived degree of risk of an innovation (technical, financial, social)
Research Selected					
Mansfield (1993)	Holak (1988)	Rogers (2003)	Rogers (2003)	Rogers (2003)	Ostlund (1974)
Report Relationship					
Positive	Positive	Negative	Positive	Positive	Negative

Probability of Innovation Adoption

Figure 6.1. Perceived Attribute Characteristics.

Based on the perceived attributes framework, the hypotheses to be tested will be: The use of a adoption theory in the form of the perceived attribute model will provide a better understanding of the local perceptions of wood pellets and to explore factors that influence consumers' decision to either adopt or not adopt this technology.

Chapter Seven - Survey Methodology

7.1 Data Collection

The data was collected through an email survey targeted at citizens living within the city of Prince George, BC. The surveys were presented to respondents in a web-based format and were collected by an online survey company called Zoomerang (www.zooomerang.com). A distribution list of potential respondents was constructed and emails (with the web-link) were distributed in the early stages of the survey response window. A web-link to the survey site was attached to emails that were forwarded to potential respondents and further forwarded by the initial respondents. The survey was "active", i.e. online, for a period of one-week in March 2006. In comparison to print surveys, online surveys are comparable in respect to response rates, scale/construct means and inter-item reliabilities and online surveys are likely to produce fewer missing responses (Boyer et al. 2002). The survey required the respondents to answer all of the questions provided, except for two: one identifying the respondents' city of residence if it was other than Prince George, and one for any general comments on the survey. There was some concern that requiring respondents to answer the majority of questions may lead to a lower response rate, as some respondents may not feel like answering certain questions (e.g. age and household income). However, it was determined that in order to increase accuracy of the results this style would be used. The survey was short in length and was estimated it would take the average respondent under ten minutes to complete.

7.2 Measures

The survey consisted of 19 sections of questions of which some had multiple questions. A number of different question styles were used throughout the survey, which included: yes or no, open responses, multiple choice, check boxes, and Likert scales. Likert scaling is a bipolar scaling method, which measures a negative or positive response from respondents. The use of Likert scales is commonly used in adoption theory surveys (Vrechopoulos et al. 2001; Hansen 2005). In this survey a five point Likert scale was used.

The survey was designed into four parts, which would not have been easily identifiable by the respondents. The first section of the survey was to establish whether or not respondents resided within the scope of the study (residents of Prince George, BC) and also asked details about their home ownership and current heating situation. This part of the survey also determined whether or not the respondents were wood pellet adopters.

The second part of the survey was used to determine respondents' thoughts on a number of important features of a wood pellet appliance and wood pellets. Using a five point Likert scale (1=not important at all to 5=extremely important), respondents were asked to rate the features they would find to be "important" as it relates to purchasing an appliance that uses wood pellet fuel. A couple of examples include: cost (price) of the wood pellet appliance, ease of use of the wood pellet appliance, and quality of the wood pellet appliance. At the end of this section respondents were asked to comment on what would be their main reason for buying or not buying a wood pellet appliance.

The third section of this survey had questions formulated from previous perceived attribute and adoption studies and the literature review. Informal qualitative information gathering was done to help in the development of the questions used in this part of the survey. A five point Likert scale design was used to rate these questions. Table 7.1 summarizes the questions asked and the associated perceive attribute intended to be tested.

Table 7.1. Original Construct and Items

Construct	Sign	Items
Perceived Relative Advantage	+	Wood pellet systems are economical
		Wood pellet systems are environmentally friendly
Perceived Compatibility	+	Wood pellets are compatible with my lifestyle
		Wood pellet systems are old-fashioned
Perceived Complexity	-	Wood pellet systems are complex
		Wood pellet systems are labour intensive
Perceived Trialability	+	Demonstrations of product before purchase is important
		Availability of home trials before purchase is important
Perceived Observability	+	Wood pellet systems have been highly promoted
Perceived Uncertainty (risk)	-	Wood pellet systems are a risky investment
		Wood pellet systems have a positive reputation

A total of 11 items were used to measure perceived attributes, with end points rating from totally disagree to completely agree or from not important to extremely important. These main constructs (perceived attributes) were measured as follows:

- Relative advantage was measured by two items, which measure the perceived degree of advantage of wood pellet systems. Relative advantage was tested in two areas (economics and environment) which are the two most used advantages associated with wood pellet systems.

- Compatibility was measured by two items, which measure the degree to which a potential adopter perceives wood pellets to be compatible with their needs, as recommended by Rogers (2003). One of the two questions ask specifically whether or not potential adopters feel wood pellets are compatible with their lifestyles.
- Two items measured complexity, which is the degree to which a potential adopter perceives wood pellets as being relatively complex. One of the two questions asks specifically whether or not potential adopters feel wood pellet systems are complex.
- Two items measured trialability, which is the degree to which potential adopters perceive wood pellet systems to be trialable. The questions constructed for this measure used a different Likert scale than the other perceived attributes and respondents were asked to identify whether they perceived trialability to be important or not. This was determined to be the more appropriate approach to evaluating this perceived attribute.
- One item measured observability, which is the degree to which the result of adopting wood pellets is perceived to be visible to potential adopters. The questions designed for this measure asks whether or not respondents feel wood pellet systems had been highly promoted. This should give an indication as to whether or not respondents feel that the wood pellets have been highly visible to them.
- Two items were also used to measure uncertainty (risk), which is the perceived risk associated with the adoption of wood pellets for potential adopters.

One of the questions designed for this measure asked respondents whether or not they feel wood pellets are a risky investment.

The third section of this survey asked respondents a number of questions related to factors that would effect their purchasing decision and were rated from not important at all to extremely important (Likert scales). Respondents were asked, for example, whether they thought feedback from wood pellet users, or the number of wood pellet retailers, or wood pellet appliance retailers would be important or unimportant to them.

The final section collected demographic information on the respondents. This included measures such as gender, age group, education level, and household income.

Chapter Eight - Results and Discussion

8.1 Survey Results

The following section will give a brief overview of the survey results. A discussion of the results will follow in section 8.2.

The first question asked respondents to consent to the use of their answers for the purpose outlined in the introduction to the survey. The consent approval rate was 100%. The total number of surveys completed was 57. It was estimated that 150 individuals received this survey and therefore, the response rate was around 38%. From a total of 57 responses, 47 (82%) individuals had their primary residences located in the city of Prince George. The other 10 respondents (18%) were outside the geographic scope of this study and these results were eliminated from the analysis.

The majority of respondents (92%) owned their own house. The remaining respondents owned a townhouse, condo or apartment (2%), were renters of a house (2%), were renters of townhouse, condo or apartment (2%) or had other living arrangements (2%). There were no respondents that lived at home (fig. 8.1).

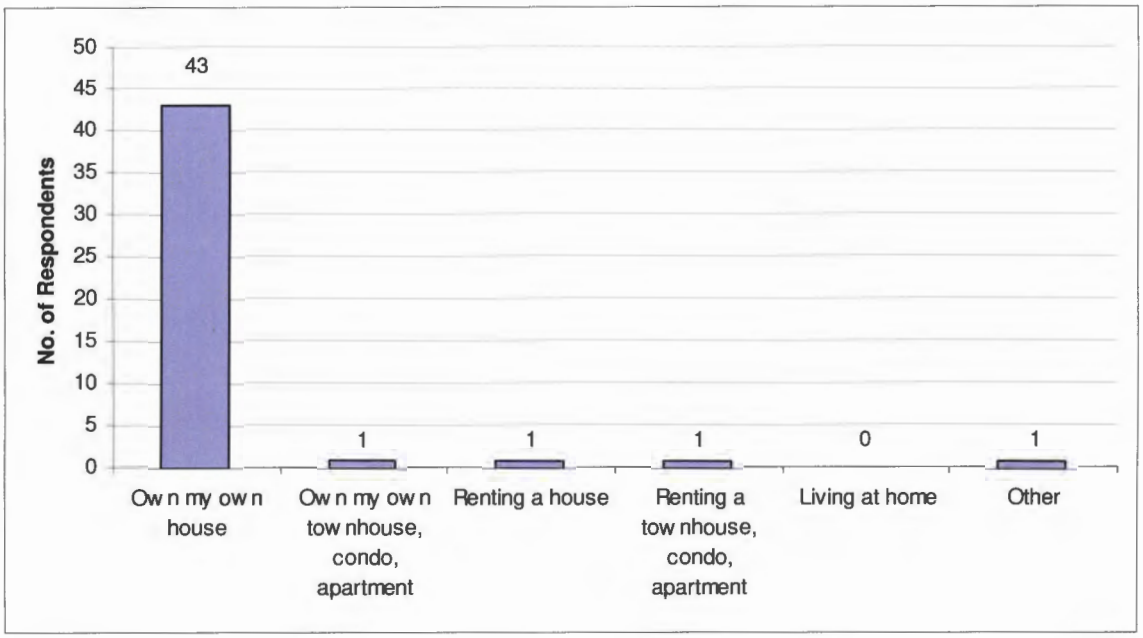


Figure 8.1. Residential Situation of Respondents (n=47).

The primary home heating fuel source of respondents was overwhelmingly natural gas (98%) and the only other fuel source identified was electricity (2%). Unfortunately, this survey did not include any respondents whose primary home heating source was wood pellets.

The majority of respondents did not have intentions to purchase a wood pellet appliance (83%) although there were seven respondents that were planning to purchase a wood pellet appliance in 1-5 years (15%) and one respondent was planning to a purchase sometime after 5 years.

The first set of Likert scale questions asked respondents to rate, in importance, a number of features of wood pellet appliances. All of the results for each question were

then averaged. The most important feature identified was the cost and availability of wood pellet fuel (fig. 8.2). The quality of the wood pellet appliance, the ease of its use, and the availability of reputable wood pellet appliance installers followed in importance. The least important feature was the availability of government incentives to help cover the purchasing cost of a wood pellet appliance.

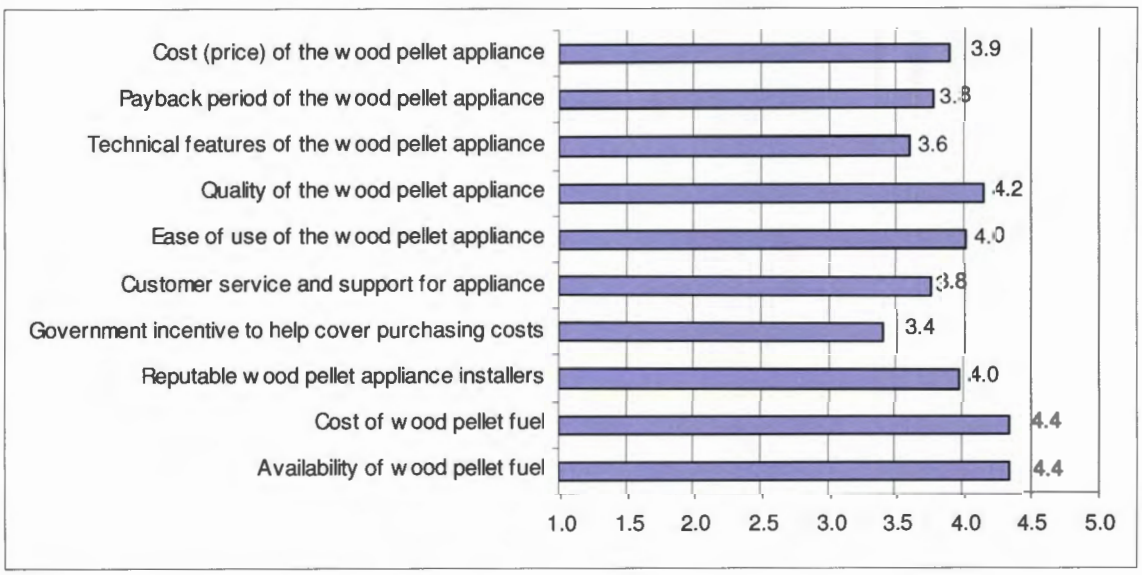


Figure 8.2. Evaluation of Wood Pellet Appliance Features by Respondents (average) (Likert Scale: 1 – not at all important and 5 – extremely important).

The survey then asked respondents to identify their main reason for buying or not buying a wood pellet appliance. This was an open-ended question and as such there were wide ranging answers. However, there were a number of general themes to the answers and these were categorized under a number of headings. The main headings used for the reason not to buy a wood pellet appliance include: cost, environment (negative), not enough knowledge, unknown risk, inconvenience, and no reason to switch (satisfied with current heating system). Figure 8.3 displays the results.

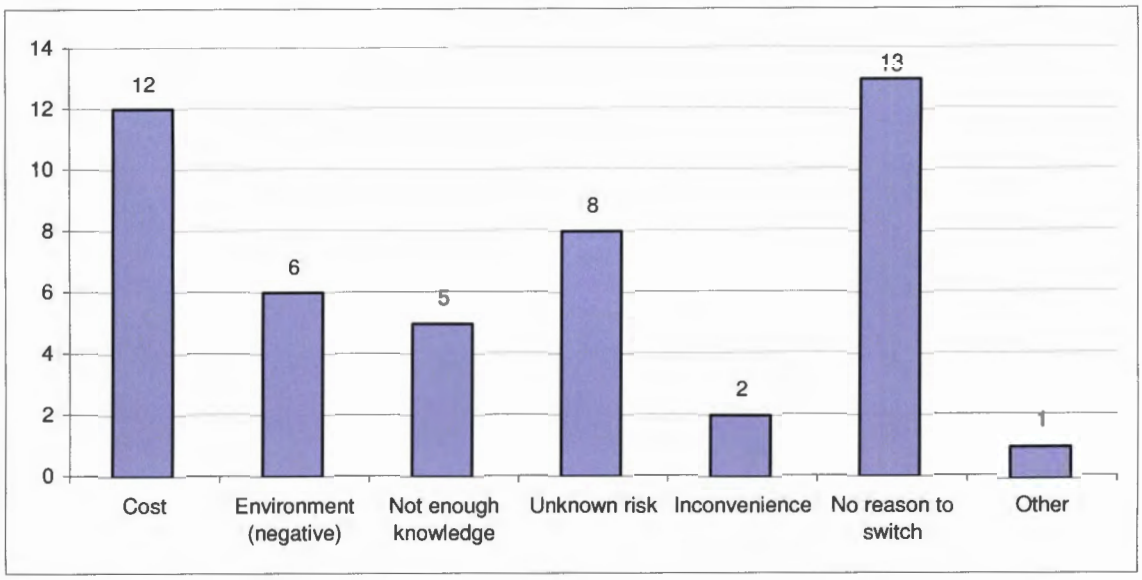


Figure 8.3. Evaluation of Respondents Reasons for Not Purchasing a Wood Pellet Appliance (n=47).

The two most popular reasons for not purchasing a wood pellet appliance were respondents did not have a reason to switch from their current heating systems and they had concerns with the costs associated with a wood pellet system. The respondents' individual answers to this question can be found in Appendix 3 (question 8 – individual responses).

There was also a wide variation in the responses given as to reasons respondents would choose to buy a wood pellet appliance. To ease in the analysis all responses were put into the following nine categories: efficiency, aesthetics, cost savings (economical), ease of use, an energy alternative, convenience, do not plan to buy, better for the environment, and other. The most popular response was that wood pellet appliances could provide a cost savings and were economical (fig. 8.4). The respondents' individual answers to this question can be found in Appendix 3 (question 9 – individual responses).

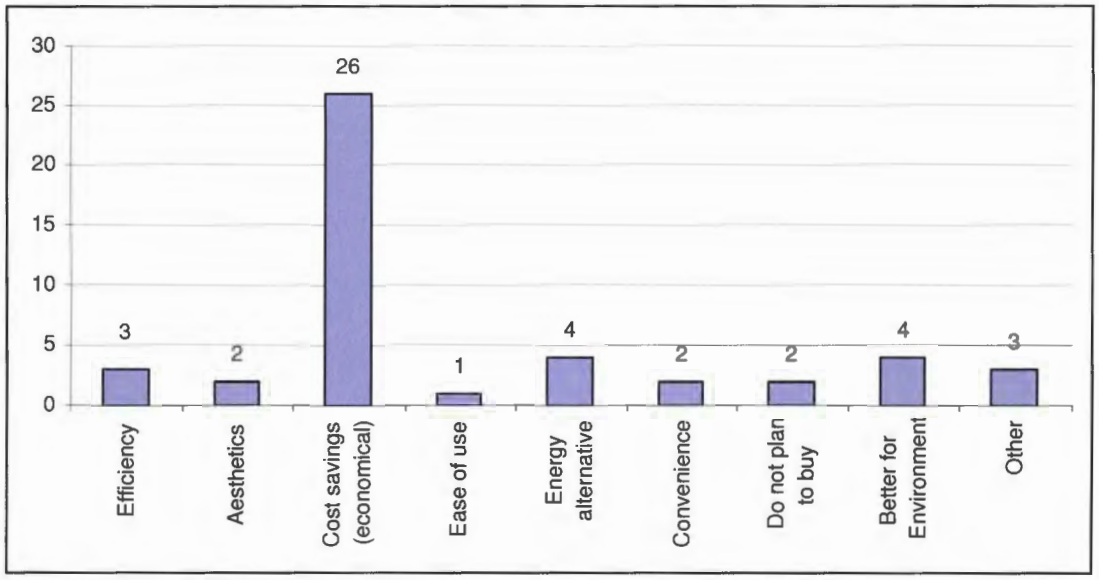


Figure 8.4. Evaluation of Respondents Reasons for Purchasing a Wood Pellet Appliance (n=47).

In the next set of Likert scale questions respondents were asked to select a rating that came closest to the best description of how they feel about wood pellet heating systems (1=totally disagree to 5=completely agree). These statements were based on the perceived attribute model (table 7.1). The results for each individual answer were then averaged. The results are provided in figure 8.5.

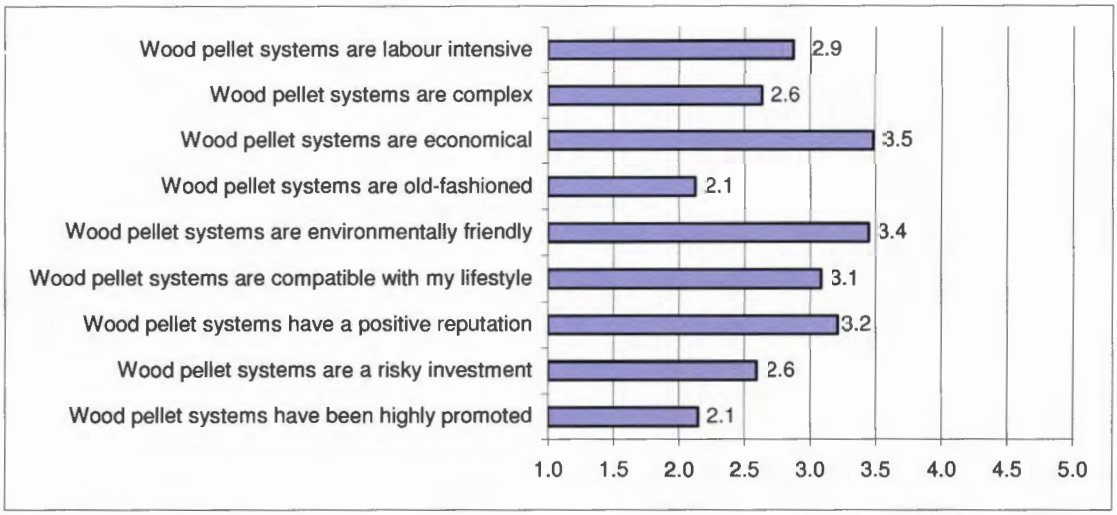


Figure 8.5. Evaluation of Perceived Attributes Questions (average) (Likert Scale: 1 – totally disagree and 5 – completely agree).

The results presented in figure 8.5 indicate that respondents more strongly agree with the statement that wood pellet systems are economical and are environmentally friendly and on average they more strongly disagree with the statement that wood pellet systems are old-fashioned and that they have been highly promoted.

In the last set of Likert scale questions respondents were asked to rate in importance (1=not important at all to 5=extremely important) a number of features that they feel would help in deciding whether or not to purchase a wood pellet heating system. The results for each individual answer were then averaged. The results are provided in figure 8.6.

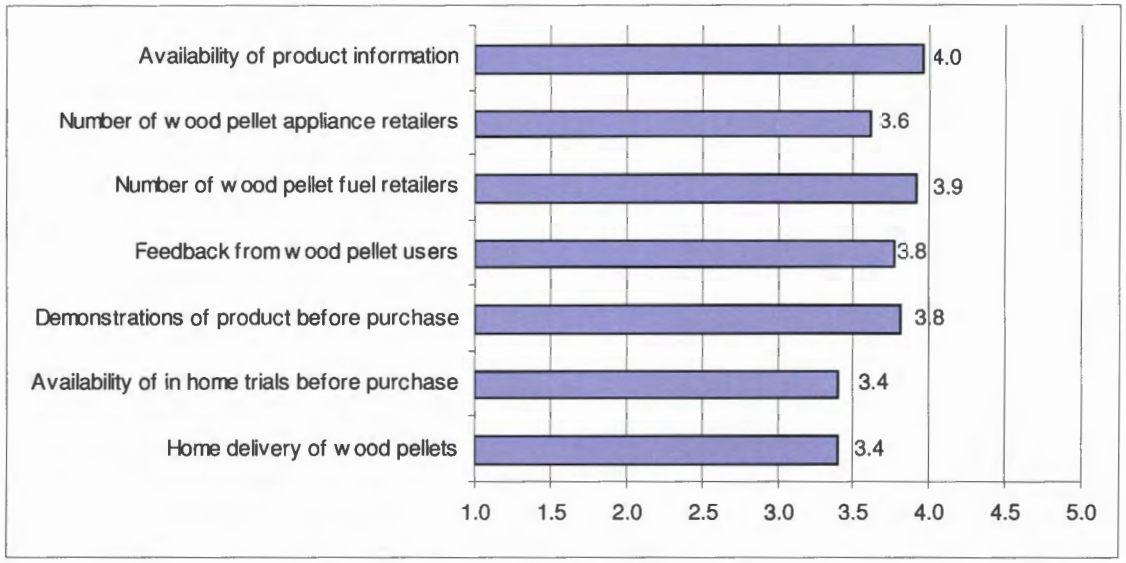


Figure 8.6. Evaluation of Important Features (average) (Likert Scale: 1 – not important at all and 5 – extremely important).

The results in figure 8.6 indicate that respondents feel that availability of product information is very important in helping them to decide whether or not to purchase a wood pellet heating system. This was followed in importance by the number of wood pellet retailers and then feedback from other wood pellet users and the importance of demonstrations of product before purchase. The least two important features identified were the availability of home trials before purchase and home delivery of wood pellets.

The next question in the survey was interested in respondents' thoughts on what the government's priority should be to help reduce the consumption of energy. The reference to government was intentionally left vague, and by default, implied all levels of government from municipal to federal. The majority of respondents (79%) felt that governments should develop tax incentives to promote the efficient use of energy. The results of this question are presented in figure 8.7.

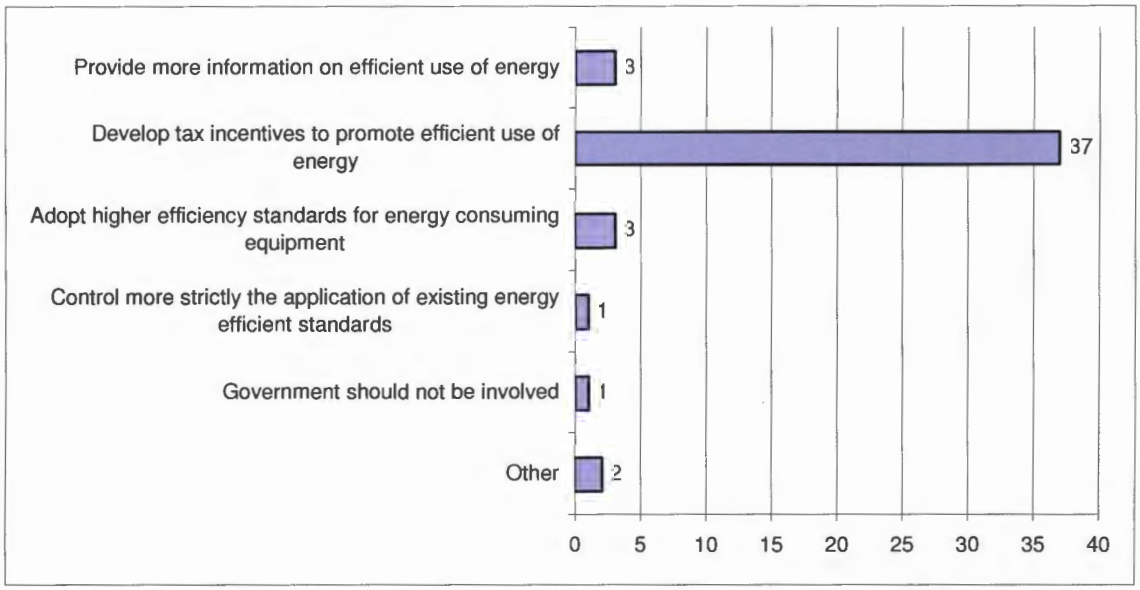


Figure 8.7. Perspective on Reducing Consumption of Energy (n=47).

The next question asked respondents whether or not they would be willing to pay more for energy produced from renewable sources than for energy produced from other sources and if yes, how much more would they be prepared to pay. Respondents were asked to select one answer only. The majority of respondents (55%) were not in favor of paying more (fig. 8.8).

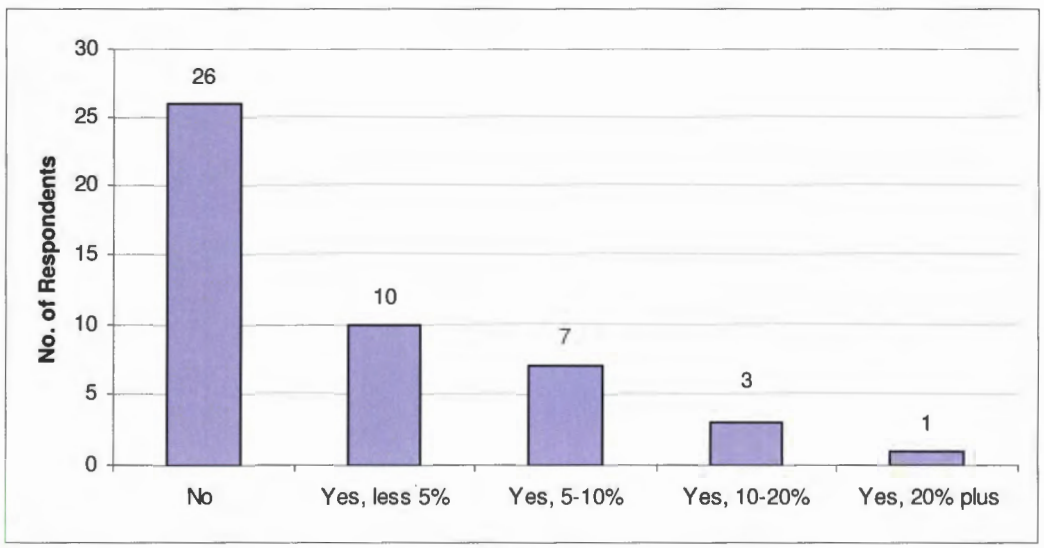


Figure 8.8. Perspective on Paying more for Renewable Energy (n=47).

In the next question, respondents were asked which product types they would be interested in learning more about. In this questions respondents were asked to select all the answers that apply to them. Interestingly, wood pellet furnaces received the most responses at 51% (fig. 8.9), followed by wood pellet stoves (fireplaces) at 47%.

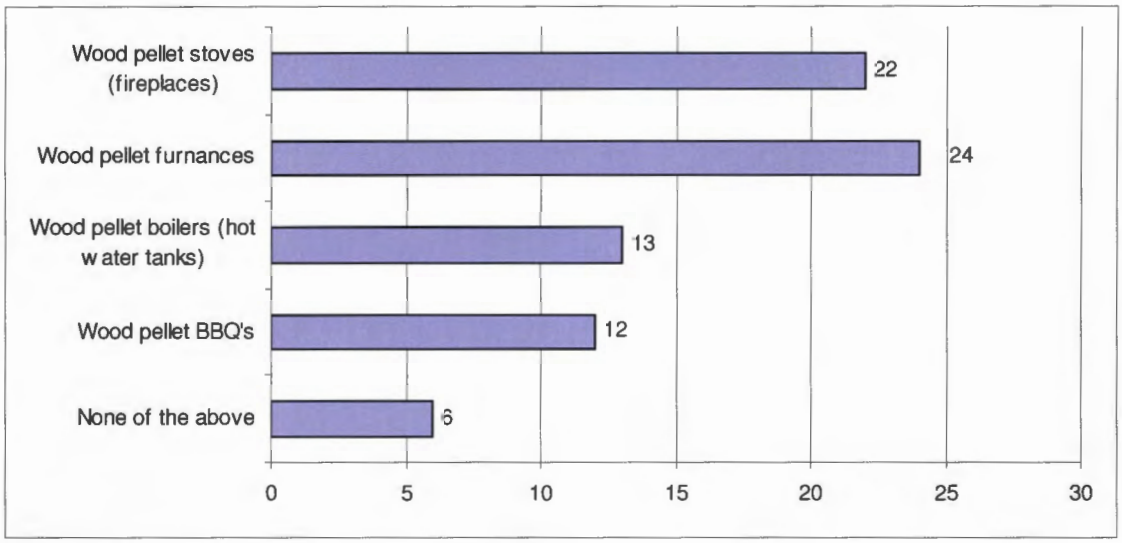


Figure 8.9. Product Types of Interest (n=77).

Table 8.1 outlines the demographic characteristics of the respondents. The majority of respondents were male (72%). A number variety of age categories were covered by the survey, however, there were no respondents under the age of 20 and only two respondents were over the age of 60. The average respondent had a College diploma or Bachelors degree. The average household income (per year) of respondents was $90,000 to $119,000.

Table 8.1. Demographic Characteristics of Respondents

Demographic Factor	Respondents (n = 47)	%
Gender		
Male	34	72
Female	13	28
Age		
Below 20	0	0
20-29	7	15
30-39	11	23
40-49	15	32
50-59	12	26
60+	2	4
Educational Level		
High School	8	17
College Diploma	14	30
Trade Program	3	6
Bachelors Degree	18	38
Masters or Doctoral Degree	4	9
Other	0	0
Household income per year		
$29,000 or less	1	2
$30,000 to $59,999	4	9
$60,000 to $89,999	11	23
$90,000 to $119,000	15	32
$120,000 to $149,000	9	19
$150,000 or more	7	15

8.2 Survey Discussion

The results of the survey provide interesting insights on the perceptions of wood pellets by potential adopters in the Prince George market. Rogers (2003) describes the innovation decision process as one in which an individual passes from first knowledge of the innovation to forming an attitude about it, to deciding whether or not to adopt or reject, to implementation of the new idea, to the confirmation decision. Rogers (2003)

describes this behavior as essentially dealing with the uncertainty involved with a new alternative compared to one that is in existence. In general, the results of the survey show respondents are interested in wood pellets and are somewhat knowledgeable of the technology, but they also have a number of concerns. The respondents appear to be somewhere between the knowledge (initiation) and the implementation stage. There were no adopters identified in the survey, and based on the low market penetration of this technology in Prince George, it is clear that the wood pellet market is in the early stages of development. Therefore, it is suggested that the Prince George wood pellet market is moving slowly up the S-shaped diffusion curve and is somewhere between the innovator and early adopter stage (fig. 8.10).

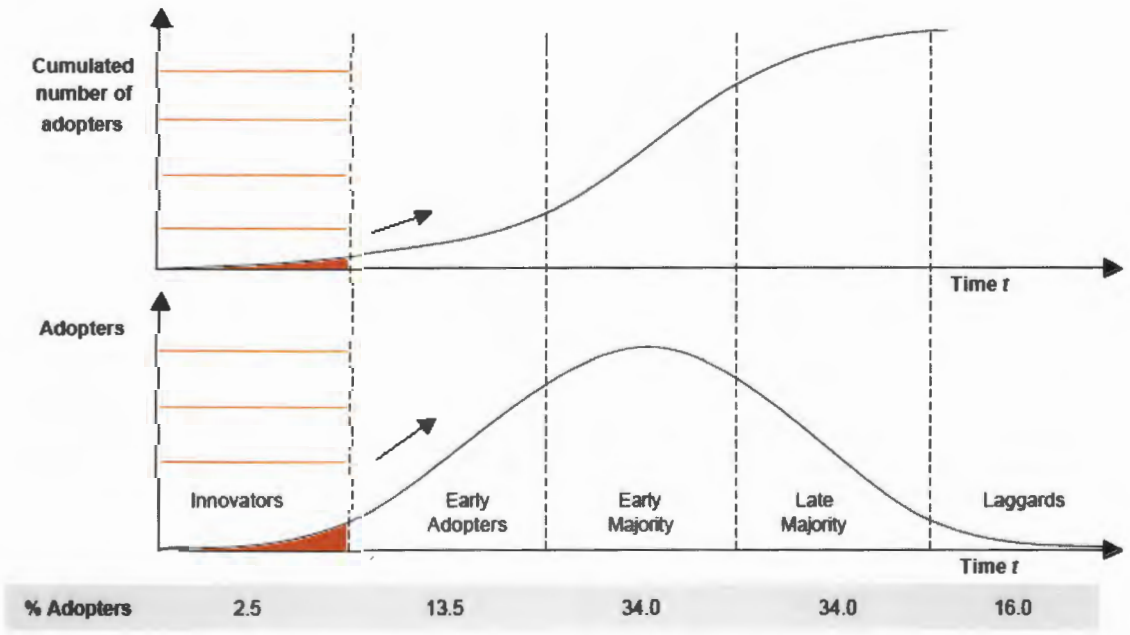


Figure 8.10. S-shaped Diffusion Curve and Adopter Categories – Prince George Pellet Market.

In these early stages of adoption communication is one of the key components identified by Rogers (2003) to spread information of the technology and increase the rate of adoption. The respondents noted a lack of promotion, and showed they would be interested in learning more about the product (importance of production information was rated high). Clearly the wood pellet industry needs to do a better job of promoting the technology and increasing consumers' knowledge of the product.

The respondents rated cost and availability of wood pellet fuel as the highest rated wood pellet feature. If wood pellets are to compete effectively with traditional fuels on the basis of costs/economics they need to be promote their message, which is, that wood pellet fuel offers a cost advantage over traditional heating systems. It will be important for wood pellet manufacturers and retailers to effectively promote locations where wood pellets can be purchased, and to ensure customers that supply issues will not occur. Respondents also found the quality of wood pellet appliance, ease of use and reputable installers are important factors. It will be important for wood pellet manufacturers and wood pellet appliance retailers to keep these features in mind when promoting their products. Wood pellet appliance retailers (and manufacturers) should work closely with installers to ensure the product is being correctly installed (according to manufacturing specifications) so that customers receive all of the benefits of their wood pellet systems. At this early stage in the adoption process it will be important that customers remain satisfied with their decision to adopt. In the epidemic models of diffusion the spread of information from adopter to potential adopter increases the rate of adoption. Any negative feedback can slow the spread. Therefore, it will be important that this is

avoided. The two least important features identified were government incentives to help cover the purchasing costs and technical features of the wood pellet appliance.

Respondents were asked for their main reasons for buying or not buying a wood pellet appliance. This question allowed respondents to answer in their own words (i.e. fill in the blank question). This provided for a number of interesting responses and comments. Overall, this question was useful in identifying a number of barriers and opportunities facing the local market. The following is a brief summary:

Table 8.2. Barriers and Opportunities for Wood Pellet Market in Prince George

Barriers	**Opportunities**
Potential adopters have no reason to switch to wood pellet technology	Wood pellets offer potential cost savings
Cost of switching perceived to be high	Potential adopters find wood pellets a energy source alternative
There are unknown risks associated with adopting wood pellet systems	Positive environmental perceptions
Negative environmental perceptions	Wood pellets appliances perceived to be highly efficient
Wood pellet systems perceived to be inconvenient	Wood pellets provide an aesthetic appeal
Potential adopters do not have enough information (lack of knowledge)	

The primary questions to be critically evaluated were based on the perceived attribute model proposed by Rogers (2003). A number of Likert scale questions were used to test this model, based on the framework developed (fig. 6.1 and table 7.1). The

results of the specific perceived attribute questions were extracted from the survey and averaged, the results are shown in figure 8.11.

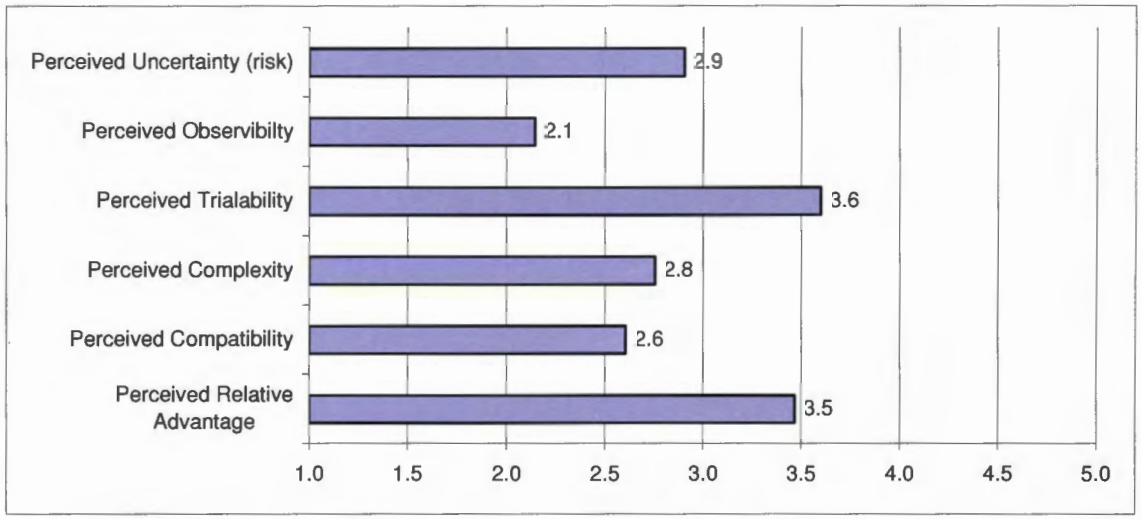


Figure 8.11. Evaluation Perceived Attributes (average).

The respondents identified that perceived trialability was very important, therefore, they feel there is value in being able to experiment with and have demonstrations of wood pellet systems prior to purchase. However, the survey showed that home trials were found not to be important. Obviously there are some inherent challenges with home trials of wood pellet systems and this probably led to the low rating. However, the literature suggest that in other technologies where technological lock-in is severe the ability to home trial can be an important mechanism to ease the uncertainly of consumers. One possible solution is for appliance manufacturers and the pellet industry to look at offering incentives such as: service guarantees, maintenance guarantees, warranties, etc. This would be an effective way of reducing consumers'

reservations, uncertainties, and risk factors. Another option could be to setup a leasing or rent to own program.

Perceived observability was rated the lowest of all the perceived attributes (fig. 8.11). These questions were based on whether respondents felt that wood pellet systems had been highly promoted. The wood pellet industry needs to increase the observability of their product. It is suggested that in-store demonstrations and the use of tradeshows and home shows is an effective way to overcome the low observability of wood pellets systems. Furthermore, mass media promotion through local television, radio or newspaper would also increase the observability of the industry. Locals may also be interested in taking a pellet mill tour and learning more about the industry.

The perceived relative advantage (fig. 8.11), which was measured by the degree to which potential adopters perceived wood pellets as being economical and environmentally friendly, rated high. This provides areas of opportunity for the industry, which should be promoted. It will be important for the wood pellet industry to find ways to transition potential adopters from their traditional heating systems to wood pellet systems, using positive economic and environmental promotion strategies could be a way to accomplish this.

In the literature review it was found that in some markets there is a perception that wood pellet systems are old-fashioned and outdated. This was not found to be the case for this survey. Therefore, this is another opportunity for the industry; to promote wood

pellets as a new technology. The other perceived compatibility question was whether respondents felt wood pellets were compatible with their lifestyle. Although this question was not rated high, it appears that wood pellets were generally compatible with the lifestyle of the majority of respondents.

The perceived attribute of complexity shows that respondents find wood pellet systems to be somewhat labour intensive and complex. The wood pellet industry needs to find ways reduce the complexity of the product and/or delivery systems. For example, improvement to wood pellet appliance technology could allow for less ash deposits (which need to be cleaned out of the appliance regularly) and/or extending the running time of the appliance so that less filling up of a pellet hopper is required. Furthermore, if the efficiency of the appliance was increased this could reduce both the ash deposits and could potentially extend the running time. In Europe the wood pellet industry has experimented with the home delivery of wood pellets as a way to decrease the complexity of having to purchase wood pellet fuel regularly. However, in this survey respondents did not rate this option as an important feature. The concept of home delivery is an area that should be studied further.

The perceived attribute of uncertainty (risk) was tested by asking respondents to rate whether they feel wood pellets were a risky investment. The results were that the majority of respondents did not feel that wood pellets would be a risky investment and perceived wood pellets to have a positive reputation. A few respondents did list some risk

related answers in their response to the factors effecting their decision not to purchase wood pellet (e.g. increase risk of fire, pellet supply) (fig. 8.3).

One of the key potential drivers in the adoption process can be government intervention. Several questions in the survey looked at whether respondents felt that government should be involved in the promotion of wood pellet systems. The survey indicates that the majority of respondents agreed with the idea of the government offering tax incentives to promote efficient use of energy systems. Currently in Canada, there are no tax incentive programs for installing (using) wood pellet systems. In the EU (notably Sweden) the use of tax incentives has been a popular mechanism to promote the use of bioenergy technologies (e.g. wood pellets).

Due to the limited role government is currently playing in the Canadian industry, the role of the supplier (i.e. wood pellet producers/retailers, wood pellet appliance manufacturers/retailers) becomes increasingly important. The economic and social streams both recognize the importance that supply side factors play in the diffusion (adoption rates) of an innovation (Mahapatra et al. 2004). It will be the responsibility of suppliers to disseminate information, product improvement and product differentiation.

This survey has been effective in identifying a number of barriers and opportunities for the local wood pellet market. The research hypotheses that the use of the perceived attribute model will provide a better understanding of the local perceptions

of wood pellet and will explore the factors that influence consumers decision to either adopt or not adopt this technology has proven to be correct.

8.3 Limitations and Future Research

For many respondents wood pellet use may represent a rather new technology that they are not very familiar with. One issue of the survey design was that questions (specifically the Likert scale questions) did not allow respondents to answer, "don't know". This option has been made available in other studies. This could better measure the knowledge of potential adopters, however, the downside is that by adding this option respondents could choose this option as a default, which could reduce the accuracy of the study. Future studies will need to consider this option carefully.

A number of adoption surveys have added in a variety of questions to identify the adopter characteristics of respondents (i.e. innovators, early adopters, early majority, late majority and laggards). One approach commonly used is to relate these adoption characteristics to socioeconomic and communication characteristics of the respondents. However, these studies make assumptions on the appropriate characteristics to use and what types of questions best answer this. Therefore, due to the complexity of trying to determine the best measures, this variable was not added to this study. However, if done correctly this could have provided insight into important adopter characteristics of potential adopters of wood pellet technology.

The study was limited to one geographic area and therefore this limits the generalizability of the results. Furthermore, there may have been some bias due to sampling technique and non-response errors, although care was taken to minimize these biases. Insights regarding non-adopters of wood pellet heating systems are provided by this survey. It would be beneficial in future studies to ensure that adopters of wood pellets are included in the analysis. Adding this dimension could lead to a better understanding of the purchase adoption process. Future studies should also attempt to measure the actual market penetration rate of wood pellet heating systems. If market penetration rates can be determined a Bass model (or equivalent) could be used to predict and analyze the future penetration of wood pellets.

Chapter Nine - Conclusion

The first part of this paper was exploratory research on the state of the wood pellet, it's associated technologies, and a review of local and international wood pellet markets. This information is important, as minimal amount of this type of research has been done in Canada. The objective was to provide an overview and identify some of the key factors that influence the market. It was determined that the market penetration rates of wood pellets in Canada are low and are most commonly used residentially in wood pellet stoves/fireplaces. Canada produced about 915,000 tons of wood pellets in 2005 and is expected to export about 582,000 tons. Therefore, Canada is a net exporter of wood pellets. Markets in Europe use the majority of these surplus wood pellets. The European's (specifically Sweden) have not only developed residential markets but also small to large district heating and cogeneration operations. The use of wood pellets in most European markets is being driven by higher energy costs and geopolitical factors. Many European countries have been active in promoting technologies that use energy from renewable resources and are placing a greater emphasis on energy security. These countries are offering incentives and research money to help develop wood pellet markets. In Canada no such incentives are currently in place.

In Canada the wood pellet suppliers, wood pellet retailers, wood pellet appliance manufacturers and wood pellet appliance retailers are the key drivers of the market (supply side factors). The onus is on these players to promote and grow the business domestically. In order to grow the market it will be important for these players to develop

comprehensive strategic plans which should involve all interested parties. The recent development of the Wood Pellet of Association of Canada is a step in the right direction. This association is just in its infancy and has yet to develop its web page, branding, and marketing campaigns.

The second part of this paper had the objective of developing a better understanding of the perceptions of wood pellets and to explore the factors that influence a consumers decision to adopt or not adopt this technology. The research method was a survey focused on residents of Prince George, BC. A number of adoption and diffusion theories were analyzed to develop a better understanding of adoption and diffusion characteristics and to aid in the development of the survey. It was found numerous research studies have used the Rogers models of adoption and diffusion. This is the model that was chosen and Rogers (2003) perceived attributes model was tested. The results of the survey provided a number of interesting insights into the local perceptions of wood pellets. The hypotheses tested was that perceived attribute model would be able to provide a better understanding of the local perceptions of wood pellet and help provide a better understanding of the factors that influence consumers decision to either adopt or not adopt this technology. This has proven to be correct. The results of the survey provide a better understanding of the barriers and opportunities for the local wood pellet market. One to the major challenges facing the local wood pellet market is its ability to move potential adopters away from their traditional heating systems. Technological lock-in is clearly an important factor. The survey also identified that the wood pellet industry needs to do a better job of providing information on the potential benefits of wood pellet

systems and effectively communicating this information. In the initial stages of market development effective communication strategies and effectively promoting the product to potential adopters is a key component for success (Rogers 2003). It was found that wood pellets have the perception or being economical and environmentally friendly and were not perceived to be a risky investment or old-fashioned. The survey also showed that trialability of wood pellet heating systems was important and there was value in being able to experiment with and have demonstrations of wood pellet systems prior to purchase. These represent a number of opportunities for the wood pellet industry.

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Appendix 1

Typical Wood Pellet Properties	
Higher Heating Value BTU/lb	8790
Moisture Content	5.0 - 5.5%
Non-combustible ash	.39 %
Bulk density as delivered	40.7 lbs/ft3
Flame temperature	1200 - 1400
Elementary Analysis	
Carbon	53.6 %
Hydrogen	6.2 %
Nitrogen	.1 %
Sulfur	ND to < .1 %
Chloride	ND to < .1 %
Oxygen	40.1 %
Ash Analysis-Metals Scan Mg/kg	
Aluminum	11600
Barium	1160
Cadmium	< 5
Calcium	123000
Chromium	100
Cobalt	< 20
Copper	100
Iron	18600
Lead	< 50
Magnesium	24800
Manganese	12700
Phosphorus	5500
Potassium	54500
Silicon	66000
Sodium	3600
Strontium	600
Titanium	800
Vanadium	< 50
Zinc	1130
Carbonate CO3 (on ash)	27.7 %

Appendix 2

NEWS RELEASE

February 17, 2006

Houston Pellet Limited Partnership

Houston, BC – Canadian Forest Products Ltd., Pinnacle Pellet Inc., and the Moricetown Band are pleased to announce the formation of a partnership for the development of a wood pellet production facility to be located adjacent to the Canadian Forest Products Ltd. sawmill in Houston, BC.

The wood pellet plant is part of a larger project that includes the installation of a new bark-fired energy system at the Houston sawmill. The combination of the wood pellet plant and the bark-fired energy system provides an economically viable, value-added alternative to the Tier 1 Beehive Burner currently operating at Canadian Forest Products' Houston Sawmill.

Pinnacle Pellet Inc. is a privately held company with a reputation for producing high quality wood pellets. Pinnacle Pellet Inc. is based in Quesnel and currently operates production facilities in both Williams Lake and Quesnel.

The Moricetown Band and Canadian Forest Products Ltd. have a long-standing mutually beneficial relationship. Kyahwood Forest Products is a profitable joint venture between the two parties that directly employs 75 people in Moricetown, BC for the purpose of lumber remanufacturing and finger jointing. Chief Warner William commented, "The investment and involvement in the pellet plant further solidifies the relationship and is a further step by the Moricetown Band to achieve economic self-sufficiency".

The combined wood pellet and bark energy system project has been under development for the past two years. Construction is scheduled to commence in the second quarter of 2006 with wood pellet production beginning in the fourth quarter. The bark-fired energy system will be commissioned in the second quarter of 2007. This timeline will ensure the closure of the Tier 1 Beehive Burner by the regulated December 31, 2007 phase out date.

The wood pellets produced at this facility will be suitable for both industrial and home heating consumption and will be sold into a combination of the North American, Asian and European markets.

To facilitate the offshore shipment of wood pellets, the Houston Pellet Limited Partnership's project also proposes the development of a wood pellet receiving and storage facility adjacent to Ridley Terminals Inc. in Prince Rupert, BC.

The bark-fired energy system will consume all of the bark produced at the Canadian Forest Products Ltd. Houston sawmill and will provide the heat required for both lumber and pellet production.

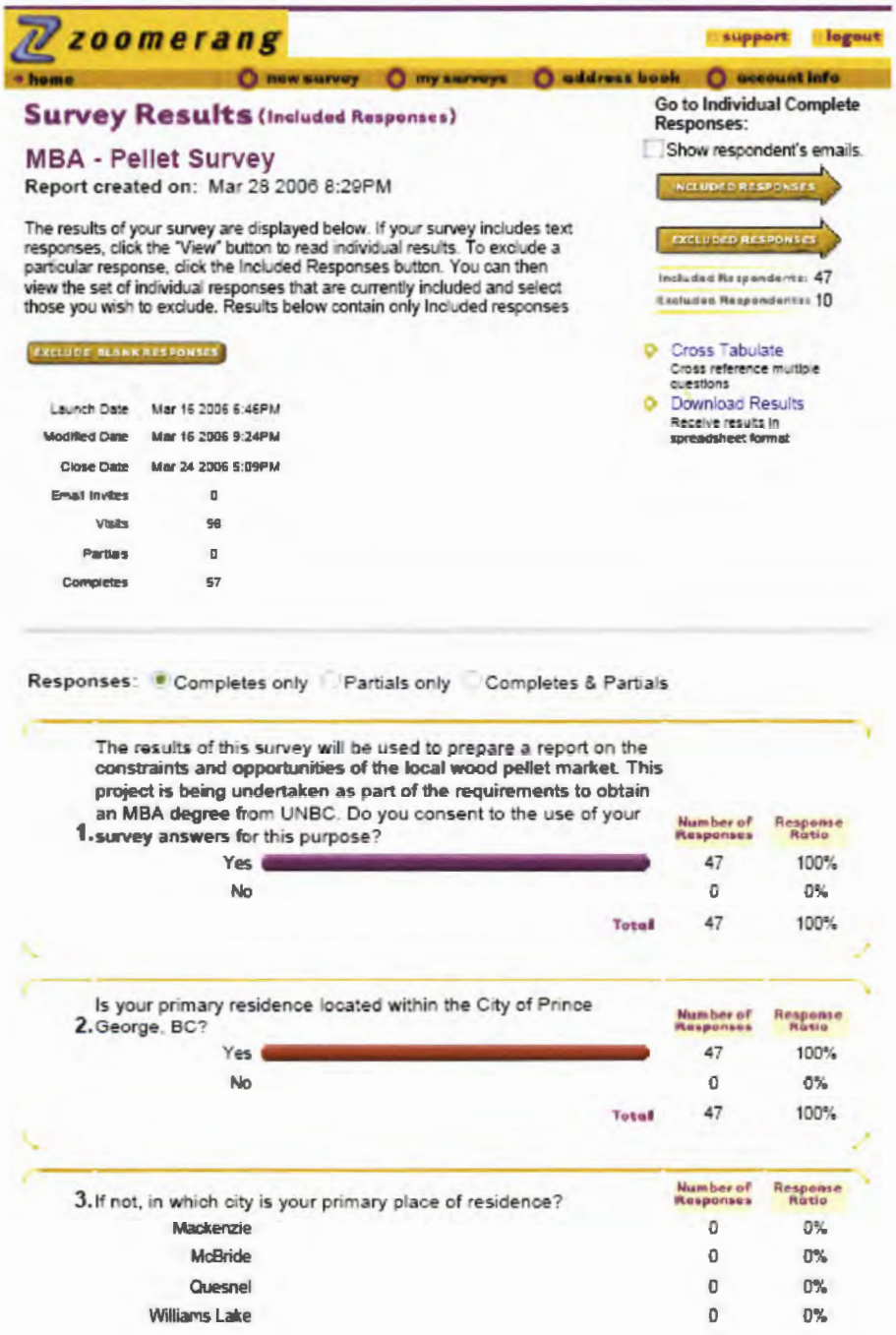
This project not only supports economic diversification within the region, but also supports the growing movement from fossil to renewable fuels.

- 30 -

For more information, please contact:

Leroy Reitsma
Business Development Manager, Houston Sawmill
Canadian Forest Products Ltd.
250.845.5224 (Work)
250.845.8285 (Cell)

Appendix 3



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Survey Results (Included Responses)

MBA - Pellet Survey

Report created on: Mar 28 2006 8:29PM

The results of your survey are displayed below. If your survey includes text responses, click the "View" button to read individual results. To exclude a particular response, click the Included Responses button. You can then view the set of individual responses that are currently included and select those you wish to exclude. Results below contain only Included responses

EXCLUDE BLANK RESPONSES

Launch Date	Mar 16 2006 6:46PM
Modified Date	Mar 16 2006 9:24PM
Close Date	Mar 24 2006 5:09PM
Email Invites	0
Visits	98
Partials	0
Completes	57

Go to Individual Complete Responses:

Show respondent's emails.

INCLUDED RESPONSES

EXCLUDED RESPONSES

Included Respondents: 47

Excluded Respondents: 10

Cross Tabulate
Cross reference multiple questions

Download Results
Receive results in spreadsheet format

Responses: Completes only | Partials only | Completes & Partials

1. The results of this survey will be used to prepare a report on the constraints and opportunities of the local wood pellet market. This project is being undertaken as part of the requirements to obtain an MBA degree from UNBC. Do you consent to the use of your survey answers for this purpose?	Number of Responses	Response Ratio
Yes	47	100%
No	0	0%
Total	47	100%

2. Is your primary residence located within the City of Prince George, BC?	Number of Responses	Response Ratio
Yes	47	100%
No	0	0%
Total	47	100%

3. If not, in which city is your primary place of residence?	Number of Responses	Response Ratio
Mackenzie	0	0%
McBride	0	0%
Quesnel	0	0%
Williams Lake	0	0%

Vanderhoof	0	0%
VIEW Other. Please Specify	1	100%
Total	1	100%

4. Which of the following best describes your primary place of residence? Please choose one only.

	Number of Responses	Response Ratio
Own my own house	43	91%
Own my own townhouse/condo/apartment	1	2%
Renting a house	1	2%
Renting an townhouse/condo/apartment	1	2%
Living at home	0	0%
VIEW Other. Please Specify	1	2%
Total	47	100%

5. Which of the following is your primary home heating fuel source? Please choose one only.

	Number of Responses	Response Ratio
Natural gas	46	98%
Electricity	1	2%
Oil	0	0%
Firewood (cord-wood)	0	0%
Wood pellets	0	0%
Do not know	0	0%
VIEW Other. Please Specify	0	0%
Total	47	100%

6. Are you planning to purchase a heating appliance that uses wood pellets in the near future?

	Number of Responses	Response Ratio
1-6 months	0	0%
6 months to a year	0	0%
1 – 5 years	7	15%
5 years plus	1	2%
Not planning to purchase	39	83%
Total	47	100%

7. Please rate the features below in importance as it relates to purchasing an appliance (stove/fireplace, furnace or hot water tank) that uses wood pellet fuel. Select one rating for each on a scale of 1-5 (1) is "not important at all" and (5) is "extremely important".

The top percentage indicates total respondent ratio, the bottom number represents actual number of respondents selecting the option

	1 Not at all important	2	3	4	5 Extremely important
1. Cost (price) of the wood pellet appliance	4% 2	4% 2	19% 9	43% 20	30% 14

2. Payback period of the wood pellet appliance	6% 3	8% 4	19% 9	32% 15	34% 16
3. Technical features of the wood pellet appliance	6% 3	6% 3	28% 13	40% 19	19% 9
4. Quality of the wood pellet appliance	4% 2	0% 0	15% 7	37% 17	43% 20
5. Ease of use of the wood pellet appliance	4% 2	4% 2	11% 5	47% 22	34% 16
6. Customer service and support for the appliance	6% 3	6% 3	23% 11	32% 15	32% 15
7. Government incentives to help cover purchasing costs	11% 5	11% 5	21% 10	43% 20	15% 7
8. Reputable wood pellet appliance installers	4% 2	4% 2	19% 9	34% 16	38% 18
9. Cost of wood pellet fuel	4% 2	2% 1	4% 2	32% 15	57% 27
10. Availability of wood pellet fuel	4% 2	2% 1	6% 3	28% 13	60% 28

8. What would be your main reason for not buying a wood pellet appliance?

VIEW 47 Responses

9. What would be your main reason for buying a wood pellet appliance?

VIEW 47 Responses

10. Select what rating comes closest to the best description of how you feel about wood pellet heating systems. Select one rating for each on a scale of 1-5 (1) is "totally disagree" and (5) is " completely agree".

The top percentage indicates total respondent ratio, the bottom number represents actual number of respondents selecting the option	1 Totally disagree	2	3	4	5 Completely agree
1. Wood pellet systems are labour intensive	9% 4	15% 7	60% 28	15% 7	2% 1
2. Wood pellet systems are complex	13% 6	28% 13	45% 21	13% 6	2% 1
3. Wood pellet systems are economical	4% 2	4% 2	38% 18	45% 21	9% 4
4. Wood pellet systems are old-fashioned (outdated)	36% 17	28% 13	26% 12	9% 4	2% 1
5. Wood pellet systems are environmentally friendly	6% 3	13% 6	26% 12	40% 19	15% 7
6. Wood pellet systems are compatible with my lifestyle	4% 2	21% 10	45% 21	21% 10	9% 4
7. Wood pellet systems have a positive reputation	2% 1	9% 4	60% 28	26% 12	4% 2
8. Wood pellet systems are a risky investment	9% 4	38% 18	40% 19	11% 5	2% 1
9. Wood pellet systems have been highly promoted (advertised)	30% 14	38% 18	26% 12	0% 0	6% 3

11. In order to help in deciding whether or not to purchase a wood pellet heating system, please rate the following features in importance. Select one rating for each on a scale of 1-5 (1) is "not important at all" and (5) is "extremely important".

The top percentage indicates total respondent ratio, the bottom number represents actual number of respondents selecting the option

	1 Not at all important	2	3	4	5 Extremely important
1. Availability of product information	2% 1	4% 2	23% 11	36% 17	34% 16
2. Number of wood pellet appliance retailers	2% 1	6% 3	36% 17	38% 18	17% 8
3. Number of wood pellet fuel retailers	2% 1	2% 1	26% 12	43% 20	28% 13
4. Feedback from wood pellet users	2% 1	9% 4	26% 12	38% 18	26% 12
5. Demonstrations of product before purchase	4% 2	6% 3	26% 12	32% 15	32% 15
6. Availability of in home trials before purchase	6% 3	17% 8	28% 13	28% 13	21% 10
7. Home delivery of wood pellets	9% 4	9% 4	17% 8	40% 19	26% 12

12. Would you be prepared to pay more for energy produced from renewable sources than for energy produced from other sources and if yes, how much more would you be prepared to pay? Please choose one only.

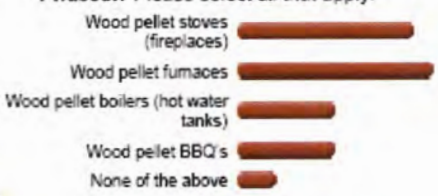
	Number of Responses	Response Ratio
Not willing to pay more	26	55%
Yes, less than 5%	10	21%
Yes, 5-10%	7	15%
Yes, 10-25%	3	6%
Yes, more than 25%	1	2%
Total	47	100%

13. What should be the government's priority to help people reduce the consumption of energy? Please choose one only.

	Number of Responses	Response Ratio
Provide more information on efficient use of energy	3	6%
Develop tax incentives to promote efficient use of energy	37	79%
Adopt higher efficiency standards for energy consuming equipment.	3	6%
Control more strictly the application of existing energy efficient standards	1	2%
Government should not be involved	1	2%
VIEW Other. Please Specify	2	4%
Total	47	100%

Appendix 3 (cont.)

14. What product types would you be interested in learning more about? Please select all that apply.



	Number of Responses	Response Ratio
Wood pellet stoves (fireplaces)	22	47%
Wood pellet furnaces	24	51%
Wood pellet boilers (hot water tanks)	13	28%
Wood pellet BBQ's	12	26%
None of the above	6	13%

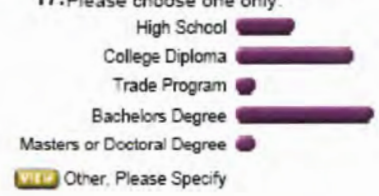
15. What is your gender?

	Number of Responses	Response Ratio
Male	34	72%
Female	13	28%
Total	47	100%

16. What age group would you fall into?

	Number of Responses	Response Ratio
Below 20	0	0%
20-29	7	15%
30-39	11	23%
40-49	15	32%
50-59	12	26%
60+	2	4%
Total	47	100%

17. What is the highest level of education that you have obtained? Please choose one only.



	Number of Responses	Response Ratio
High School	8	17%
College Diploma	14	30%
Trade Program	3	6%
Bachelors Degree	18	38%
Masters or Doctoral Degree	4	9%
Other. Please Specify	0	0%
Total	47	100%

18. What is your annual household income (pre-tax)?

	Number of Responses	Response Ratio
$29,999 or less	1	2%
$30,000 to $59,999	4	9%
$60,000 to $89,999	11	23%
$90,000 to $119,999	15	32%
$120,000 to $149,999	9	19%
$150,000 or more	7	15%
Total	47	100%

Individual responses

4. Which of the following best describes your primary place of residence? Please choose one only.

#	Response
1	Sharing a home with my sister and her daughter

8. What would be your main reason for not buying a wood pellet appliance?

#	Response
1	Insurance company implying that wood is a higher risk than natural gas as a source of primary heat.
2	already have gas fireplace and furnace
3	cost
4	Would not want the associated mess that comes wit it, or pay for the installation of it. I would have to crunch the numbers on the cost. Does it take up more room in the house?
5	Not knowledgable enough re the pros & cons
6	Not enough information about the product
7	As I transfer lots, would it be worth my while to spend the money on a wood pellet appliance.
8	Cost of purchasing & installing wood pellet appliance.
9	They are NOXIOUS polluters disguised as energy efficient appliances. I live next door to someone who has one and I can't open a window without filling my house with the combusion exhaust.
10	Cost efficiency
11	pollution
12	The cost.
13	Payback, installation constraints, utilization, convenience
14	air quality
15	Cost to replace existing fuel source
16	Unfamiliar with the product and perhaps initial cost.
17	Expense, very little information available
18	Already invested in very efficient natural gas furnace
19	Not familiar with price volitility for pelets in the future.
20	Cost
21	No reason at this point in time.
22	I think it increases the risk of fire in the house. Take extra room in the basement.
23	need to keep refueling my main source of heat
24	Cost of purchase
25	I don't know the technology or selling points of wood pellet appliance.
26	It would increase particulate levels in the air shed of PG
27	There's no reason, at the moment I'm not in the market to buy one.
28	I'm satisfied with natural gas
29	already have a functioning heat source
30	My home is set up for natural gas already. I own a wood burning stove. Currently the price of pellets is not an incentive for me to switch.
31	Natural Gas works, is clean, and so far, the price has not forced a closer look into alternatives.

32	Cost
33	Already have gas furnace
34	Additional smoke and fine particulate matter in the Prince George bowl area, increasing the already poor air quality.
35	I have one now! A parlor stove in basement
36	Currently, lack of knowledge about the appliance.
37	I have been fed up with using wood fuel for 10 years in Romania. Definetively it is much more confortable to use natural gas or electricity for heating.
38	cost to switch over
39	That there is too long of a pay back period for the investment, or that there is a considerable risk that the availability of the pellets may diminish, or the price go high after conversion. The people that supply the material to produce pellets will sell to the highest bidder and with the amount of energy projects going in around the area my fear is that the pricing would jump significantly for pellet suppliers.
40	Cost
41	Not sure where to place it in our house, and how long it would take for pay back
42	price and availability and convenience
43	Satisfied with gas heat.
44	I already have a wood burning stove in by residence
45	Cleanliness of burn, availabiltity of appliance and pellets. Cost.
46	cost
47	technological lock-in

9. What would be your main reason for buying a wood pellet appliance?

#	Response
1	less dependence on natural gas.
2	look and feel - comfort of wood fire
3	efficiencty
4	Only if their was a savings.
5	Savings over natural gas
6	Not sure that I would buy one
7	Long term savings
8	Rising cost of natural gas.
9	I would never buy one. I wouldn't even let them GIVE me one.
10	Cost efficiency
11	heating costs
12	The savings, if any.
13	payback and convenience
14	cost, no impact to the enviroment
15	Reduction in energy costs
16	Cost effective, enviromental concerns.
17	renewable fuel source
18	Price and price volatility of alternates
19	clean, cost effective
20	Ease of use
21	Have used one before instead of wood stove. I like the constant unattended feed it provides. Also I believe it is a lot cleaner than a wood stove in terms of emissions. The outside air brought into the firebox directly makes it a lot more efficient

22	economical heat source
23	esthetics in a small living area
24	Save $$$
25	If it was an efficient cost effective means of heating my home.
26	$$$ Less expensive than gas
27	Using waste product appeals to me.
28	the cost
29	Need an economical heat system/ new construction
30	Cleaner burning fuel with less worry about chimney fires. Esier to operate than wood burning stoves. I still prefer natural gas appliances though over pellet.
31	It would have to pay for itself in a few years (<5) in differential heating costs and NOT taken any more labour on my part than the Natural gas system I have now
32	Cost
33	Better for the enviroment
34	Reduce dependence on Natural gas, not have to pay the monthly Terrasen Gas bill to foreign ownership
35	If I move then I would buy a new one
36	I have heard these appliances are very effecient. however would need more information.
37	It is hard for me (taking into consideration what I have said above) to find a reason for this.
38	only if it was economical
39	If it proved out to be less expensive than natural gas over the mid term (3-5 years)in order to pay back the investment and then remained competative with other energy sources.
40	cheaper heating
41	To save on our gas bill
42	convenience
43	back-up heat
44	Cost would be important as without benefit there would be no need to replace my existing stove
45	Cost effective versus natural gas.
46	reduced pollution
47	save $ on heating bills

13. What should be the government's priority to help people reduce the consumption of energy? Please choose one only.

#	Response
1	$$ for R&D of alternate energy sources
2	People should not reduce the consumption of energy

19. Thank you for your time, please feel free to include any comments.

#	Response
1	I am not sure if I would totally depend on wood pellet as a source of heat. I have electric stove, even though my furance is natural gas. I could use pellet for the hot water. keep natural gas as furance and keep the electric range. Therefore, my home would have a mixture of heating sources.
2	interested in this
3	wood pellet stoves need better advertising
4	On question 18 I did not answer because it is not relevant to your survey!
5	I have limited knowlege regarding pellet fuel
6	We have thought about purchasing a furnace, but in order to justify such a large purchase we need to be convinced that it will payoff which reduced costs, and it will not become hard to use.
7	As unique source of heating it might be fun at the begining but believe me, after a few Canadian winters, people will be sick of it. I think that a good idea would be to use this wood fuel based appliance in completing an another existing appliance based on natural gas or electricity.