Fuel Pellet Manufacturing and Marketing Opportunities in British Columbia

Working Paper 96.10

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Fuel Pellet Manufacturing and Marketing Opportunities in British Columbia

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REPORT 372004/1
FUEL PELLET/BRIQUETTE STUDY

FUEL PELLET MANUFACTURING AND MARKETING OPPORTUNITIES IN B.C.

DATE 1 JUNE 1992

CONTENTS

APPENDICES

1 - Glossary
2 - Manufacturing Cost Estimates
3 - Capital Cost Estimates
4 - Financial Analyses
5 - Markets for Wood Pellets (by Jim McWilliams, Wood Products Consultant)
6 - Wood Residue for Pellet Manufacture (Jim McWilliams, Wood Products Consultant)

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SUMMARY

1. There are large surpluses of wood residues in many areas of B.C. It is becoming more difficult and costly to dispose of wood residues to landfills in an environmentally sound manner, and atmospheric emissions from incinerators have become unacceptable in many areas.

   The Federal and Provincial Governments are interested in promoting the increased utilization of these wood residues. Sandwell Inc., in association with Mr. Jim McWilliams, Wood Products Consultant, have been retained by the Industry Development Branch of the B.C. Ministry of Forests (now called Economics and Trade Branch) to assess the opportunities for the manufacture and marketing of fuel pellets and briquettes made of wood residues.

2. The terms of reference for this study specified a "Case Study" approach to be used to assess three locations for pellet plants: Merritt, Lower Fraser Valley and the Queen Charlotte Islands. Sandwell has assessed potential market opportunities for fuel pellets in North America and offshore. Case studies have been developed for typical fuel pellet plants, including description of the plants, capital and operating cost estimates, and financial analysis for each plant. The potential for generating electrical power using wood residues is evaluated for a small power plant on the Queen Charlotte Islands.

   This report summarizes the results of the market assessment and presents a detailed description of modern pelletizing equipment and technology. Listings of existing equipment suppliers and pellet mills in operation in Canada and the United States are also included.

3. The process of making pellets is intended to increase the value of a biomass fuel by increasing its energy density and ease of handling. Pelletizing process technology is well-established and the equipment for integrated and stand-alone plants is widely available.

   The pelletizing process generally includes wood residues storage and handling; feedstock drying and pulverizing; pellet production and cooling; and product handling, packaging and storage. Plant sizes typically range from a few tonnes per day to several hundred tonnes per day.

   Two classifications of fuel pellets are made from wood residues: residential and industrial. The same pelletizing technology is used to make both types; residue characteristics determine the acceptable end use. Residential pellets must have low ash, fines and moisture levels for effective combustion in residential stoves. Industrial users are less sensitive and can accept higher ash and moisture levels. Only certain wood residues are suitable for the production of residential fuel pellets. A wider range of wood residues can be used to make industrial pellets.

4. There are currently no producers or major users of industrial fuel pellets in B.C. Natural gas and wood residues fired directly are the common heat sources. Fuel pellets are not cost competitive with these fuels. At current natural gas prices, fuel pellets would have to sell at 25 to 35 $/t to be competitive, about 30 percent of current pellet costs. New power boilers, like

the plants at Williams Lake and Port Mellon, are designed to burn wood residues; pellets offer no significant advantages over direct burning for these plants.

A US government sponsored program led to the construction of a number of biomass-fired power plants in California. These have been considered as a potential market area for pellets from B.C. However, it was found that these biomass-fired power plants are well supplied with fuel and are paying only 44 to 50 $/BDt, far less than the cost to make and transport pellets from B.C. to California. In addition, coastal wood residues in B.C. contain salt from contact with salt water. Salt is undesirable in a biomass fuel as it can lead to excessive corrosion and exceedance of local air pollution control regulations.

It is concluded that there are no attractive opportunities in North America for industrial fuel pellets made from B.C. wood residues.

5. Residential fuel pellets can be produced effectively in very small scale plants and in large facilities. Pellets are a relatively low energy fuel which must compete with other available forms of energy, thus transport over long distances is not usually economic. Wood residues are readily available throughout most of North America. This wide availability and the low cost of raw material, the low capital cost of establishing a pelletizing plant, and the restrictions of markets due to transport costs, favours smaller pelletizing operations to satisfy local demands.

   General statistics concerning residential pellet consumption in Canada and the United States are not compiled. Total annual consumption of pellets in B.C. estimated in this study is about 10,000 t/a. The B.C. market is currently supplied by a large fuel pellet plant in Idaho and by small local producers. B.C. pellet plants have a current combined capacity of about 16,000 t/a.

   Markets for fuel pellets in neighbouring areas are similar. Several small pellet producers in Alberta and in Washington and Oregon supply local regions. Most have unused capacity and can increase pellet output with little or no additional capital investment.

   Potential market areas for a B.C. fuel pellet plant are currently well supplied and the market is not projected to grow significantly, unless energy prices rise. The current opportunity for a new residential quality fuel pellet producer in B.C. is probably not more than 3,000 to 5,000 t/a.

   Residential fuel pellets are usually sold in 40 pound (20 kg) bags. Prices vary widely depending on the location and supplier, ranging from 150 to 180 $/t in Victoria, to 125 $/t from a local producer in Creston. Wholesale prices for bagged pellets in B.C. and northwestern United States range from 85 to 130 $/t.

6. Overall, offshore markets for wood residue fuel pellets from B.C. are not attractive. Other fuels are readily available and significantly cheaper compared to imported wood pellets from B.C. In offshore markets, particularly the developing countries, it would not be economically effective to use scarce foreign currency to import relatively low energy wood pellets.

7. Wood products manufacturing plants and logging operations located throughout B.C. generate large surpluses of wood residues. These unused residues are currently disposed of by incineration or landfilling.

   Merritt is a typical interior location with respect to wood residue availability for a fuel pellet plant. Thus data from Merritt can be considered as generally applicable to other B.C. interior locations. The total quantity of unused sawdust and shavings presently available in the Merritt area is estimated to be over 80,000 BDt/a. These residues are suitable for production of residential quality fuel pellets.

In the Lower Fraser Valley large volumes of wood residues are produced. After accounting for existing uses, the quantities available are over 300,000 BDt/a of sawdust, shavings and trim, and over 400,000 BDt/a of bark. However, as much as 90 percent of the residues are contaminated with salt from coastal movement and storage of logs, and are thus not suitable for pellet production. Although, sufficient quantities of uncontaminated residues are available for small pellet production operations.

Floating wood debris is collected in a trap on the Fraser River near Agassiz. The collected material, about 150,000 wet t/a, a mixture of trees and roots, branches, slabs, bark, and chunks of wood, is not suitable for manufacturing pellets for residential use. It could be used to make industrial pellets, but extensive raw material preparation would be necessary.

Two types of wood residues are available on the Queen Charlotte Islands: mill residues from two small sawmills and logging residues. The total volume of sawmill residues is very small, about 5,000 BDt/a. The only concentrated sources of logging residue are the dry land, log sorting yards, which produce bark and wood debris containing various quantities of dirt, sand, gravel and rock. About 35,000 BDt/a of log yard residue are produced.

The sawmill and log yard residues are not suitable for the manufacture of fuel pellets for residential use, and the total quantity of residue is not sufficient for an industrial pellet plant. The residue available could be used directly as a fuel for a small thermal power plant.

8. The case studies developed for Merritt and the Lower Fraser Valley locations are presented as typical examples. They are two residential pellet plants, designed to produce 50,000 t/a and 10,000 t/a. The larger plant is assumed to be a stand-alone operation. The smaller plant is an add-on plant, integrated with an existing wood products plant. These cases illustrate the levels of capital investment required and potential financial returns for different pellet selling prices.

The estimated capital costs for these two cases are as follows:

	10,000 t/a	50,000 t/a
Total Plant Capital	$ 1,300,000	$ 3,500,000
Land Purchases	0	250,000
Initial Working Capital	100,000	620,000
Pre-operating Expense	40,000	130,000
Total Capital Investment	$ 1,440,000	$ 4,500,000

The estimated annual operating costs for these two cases are as follows:

	10,000 t/a	50,000 t/a
Raw Wood Residues	$ 0	$ 0
Wood Residue Transport	0	420,000
Fuel and Electrical Power	40,000	240,000
Operating & Maintenance Materials	180,000	900,000
Operating and Maintenance Labour	220,000	670,000
Administration and Overhead	50,000	300,000
Contingency	40,000	200,000
Total Annual Operating Cost	$ 530,000	$ 2,730,000

The estimated annual operating cost is equivalent to a unit production cost of 53 $/t for the smaller plant and 55 $/t for the larger, 50,000 t/a plant.

9. The calculated real rates of return, after provision for income taxes, illustrate that a residential fuel pellet plant could be financially viable. The estimated real rates of return over a 15-year analysis period, assuming various pellet selling prices, are as follows:

Net Pellet	Rate of Return - %	
Selling Price - $/t	10,000 t/a Plant	50,000 t/a Plant
100	19	26
90	15	21
85	13	18
80	11	15
70	5	8
60	-3	-3

At current local ex-plant pellet prices, which range from 85 to over 100 $/t, the financial return would be attractive. The projected returns are quite sensitive to the net selling price of the pellets. A decrease of 25 percent in the selling price, for example from 80 to 60 $/t, reduces the calculated returns from 11 and 15 percent respectively, to negative values.

10. B.C. Hydro is presently considering ways to reduce the high cost of electrical power on the Queen Charlotte Islands and is planning to issue a request for proposals under the IPP program, for a small power plant on the islands. A site in the Port Clements area is considered by Hydro to be appropriate. A wood residue fired power generating plant using local logging wastes could satisfy the power needs seen by B.C. Hydro.

The potentially available wood residue identified in this study is equivalent to a power plant output of about 7 MW. About 40,000 BDt/a of residue is currently available from sawmill and log yard wastes. Logging debris and possibly fuel wood could be collected to augment the residue fuel to support a larger power plant.

Preliminary capital and operating cost estimates for a 7 MW power plant and a return on investment analysis show a simple gross return of 14 percent, as follows:

Item	Amount	
Total Annual Revenues (at 0.10 $/kWh)	4,700,000	$/a
Total Annual Operating Costs	2,000,000	$/a
Gross Operating Profit	2,700,000	$/a
Total Capital Investment	19,000,000	$
Gross Rate of Return	14	%

A net power selling price of 0.10 $/kWh and a plant capacity factor of 85 percent have been assumed. This power cost is substantially less than the current cost for diesel generated power on the Queen Charlotte Islands.

These preliminary estimates indicate that a small wood residue fired power plant could be financially attractive, given the current high cost of electrical power on the islands.

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INTRODUCTION

In many areas of B.C. there is a large surplus of wood residues which is presently disposed of by incineration or landfilling. Both of these means of disposal are wasteful and can create adverse environmental impacts. The Federal and B.C. Provincial Governments are interested in promoting the increased utilization of these wood residues.

Sandwell Inc., in association with Mr. Jim McWilliams, Wood Products Consultant, have been retained by the Industry Development Branch of the B.C. Ministry of Forests (MOF) (now called Economics and Trade Branch) to carry out a study to assess the opportunities for the manufacture and marketing of fuel pellets and briquettes made from wood residues in British Columbia. This study is funded under the Partnership Agreement on Forest Resource Development: FRDA II 1991-1995, by the Federal Government of Canada, Forestry Canada and the B.C. Ministry of Forests.

The characteristics and availability of surplus wood residues in the province have been defined in a previous study carried out for the MOF (British Columbia Forest Industry Mill Residues 1989, Project No. B75439, August 1990). As specified in the Terms of Reference (TOR), the 1989 mill residues study has been used as the basis to this study; the 1989 data have been updated where required.

A "Case Study" approach has been used as indicated in the TOR. Sandwell has assessed potential market opportunities for fuel pellets in North America and offshore. With this market information and the wood residue data, case studies have been considered for two typical fuel pellet plants located in B.C. The potential for generating electrical power using wood residues is evaluated for a small power plant on the Queen Charlotte Islands.

This report summarizes the results of the market assessment and presents a detailed description of modern pelletizing equipment and technology. Listings of existing equipment suppliers and pellet mills in operation in Canada and the United States are appended. For the two typical plant case studies, a preliminary plant description, estimates of capital and operating costs, and technical and financial analysis of the proposed pellet plant are presented. The potential for a pellet plant in conjunction with electrical power generation is assessed for the Queen Charlotte Islands case.

PELLETIZING PLANTS

General

The process of making pellets and briquettes is intended to increase the value of a biomass fuel by increasing its energy density and ease of handling. The most critical operations in the pellet making process are drying and densification. To make quality pellets, the raw feedstock must have the correct size classification to achieve uniform drying; the dry biomass must be of the uniform particle size and moisture content to make a solid, consistent quality fuel pellet. The pellets or briquettes must be cooled and packaged so that they reach the user with a minimum of degradation during shipment.

There are numerous pellet plants currently in operation in North America which use waste biomass to produce fuel pellets for both residential and industrial use. Many pellet plants to make fuel from wood residues were installed during the late 1970's and early 1980's following the sharp increase in petroleum prices in the mid 1970's. Much development in pelletizing process technology took place during this period. Today, only a few of these plants survive; most became uneconomic to operate when oil prices fell.

In recent years there has been some renewed interest in the utilization of wood residues to make fuel pellets and briquettes. This interest is due largely to environmental pressures; it is becoming more difficult and costly to dispose of wood residues to landfills in an environmentally sound manner, and atmospheric emissions from incinerators have become unacceptable in many areas. In some areas restrictions have been placed on emissions from residential wood burning stoves.

The technology involved in the manufacture of fuel pellets and briquettes from wood residues is not complex compared to the industrial processes which produce the residues. It is technically feasible to install a small pellet plant to use wood residues from a single wood processing plant, and to build a larger stand-alone operation to use residues from several sources.

There are two classifications of fuel pellets made from wood residues, those intended for residential use, and those for industrial or commercial consumption. The same pelletizing technology is used to make both types of pellets; the raw wood residue feedstock characteristics determine the acceptable end use. Residential pellets currently being marketed have low ash, low fines and low moisture levels. These characteristics are required for effective combustion in residential pellet burning stoves. Industrial users are less sensitive to ash and moisture levels and do not require pellets that meet the stringent residential standards.

Only certain wood residues are suitable for the production of residential quality fuel pellets. A wider range of wood residues can be used to make industrial quality pellets. Thus, the characteristics of the wood residues available at a particular location define the type of fuel pellets that can be made.

Pelletizing Technology

Pellet and briquette process technology is well-established and the machinery and equipment for integrated and stand-alone plants are readily available from a number of experienced suppliers. Flow schematics and a block flow diagram for typical fuel pellet plants using wood residues are shown in Figures 1, 2 and 3. The processes and equipment in a modern fuel pellet or briquette plant include the following:

Raw Wood Residue Receiving
- truck weigh scale and unloading facilities
- raw residue storage area
- reclaim facilities

Wood Residue Processing
- metal removal
- screening for stones, metal and other contaminants
- hogging or pulverizing
- drying

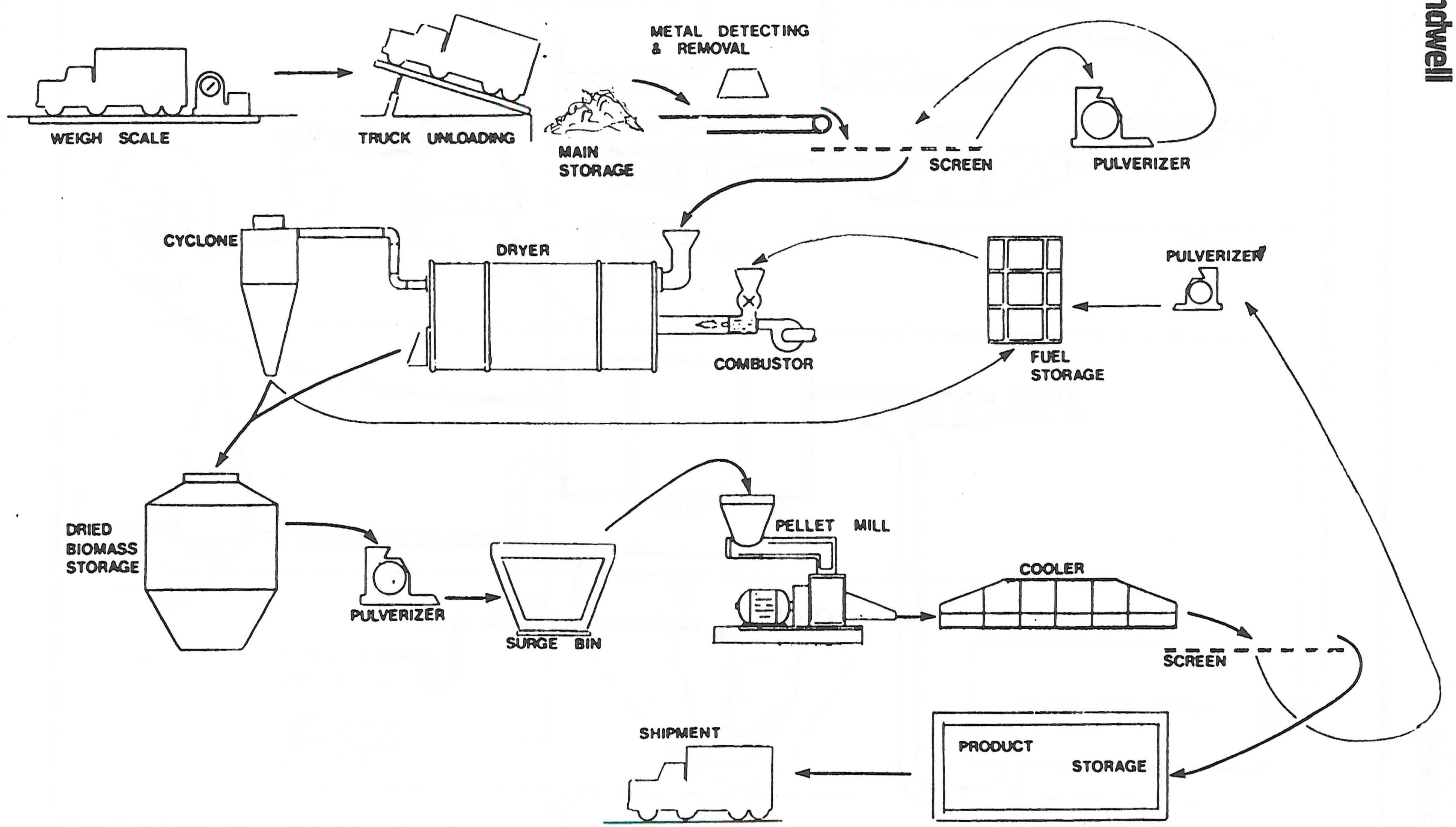

FIGURE 1 - FLOW SCHEMATIC OF PELLET PLANT

SOURCE: ENFOR PROJECT C - 258

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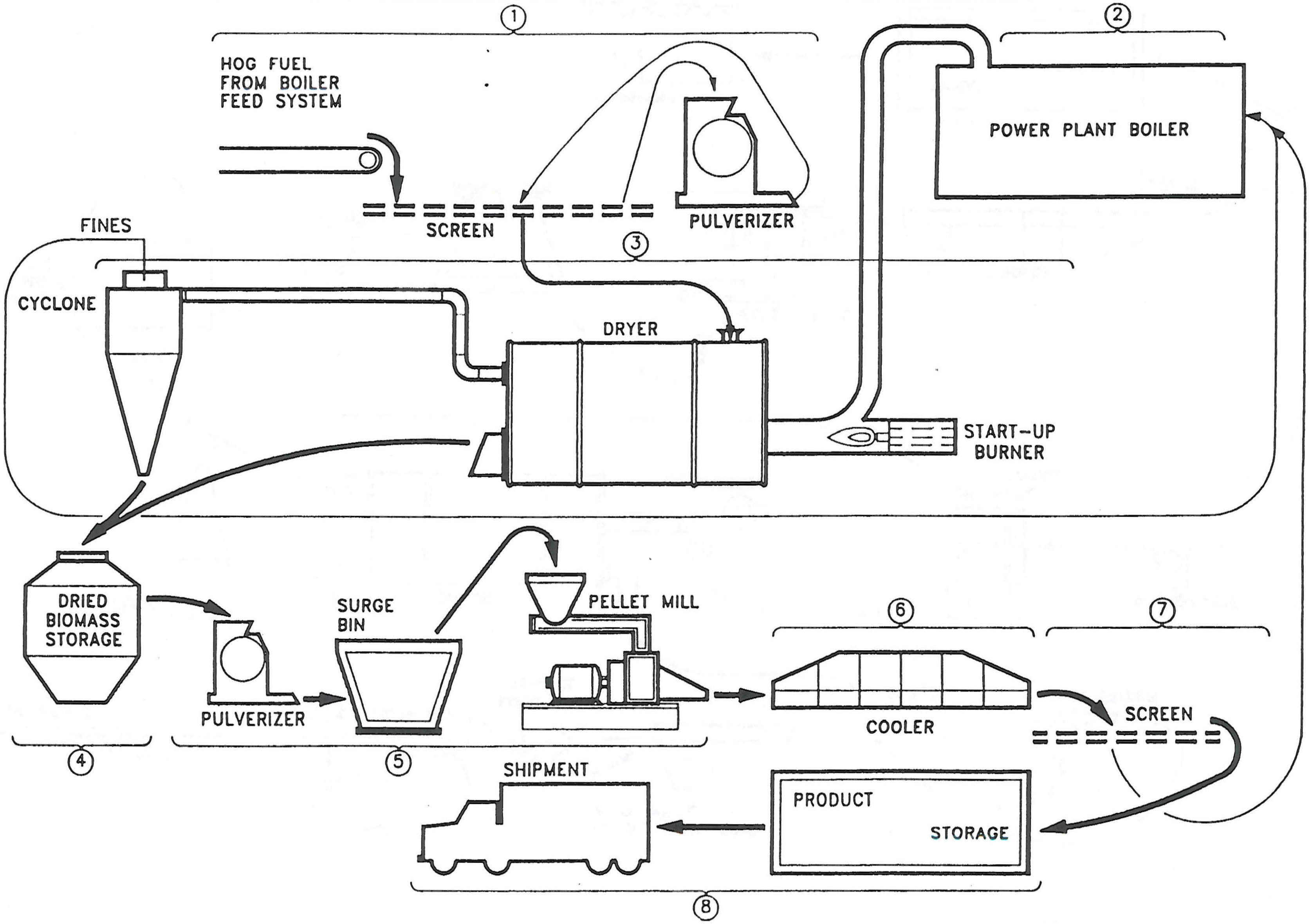

FIGURE 2 - FLOW SCHEMATIC OF ADD - ON PELLET PLANT

SOURCE: ENFOR PROJECT C - 258

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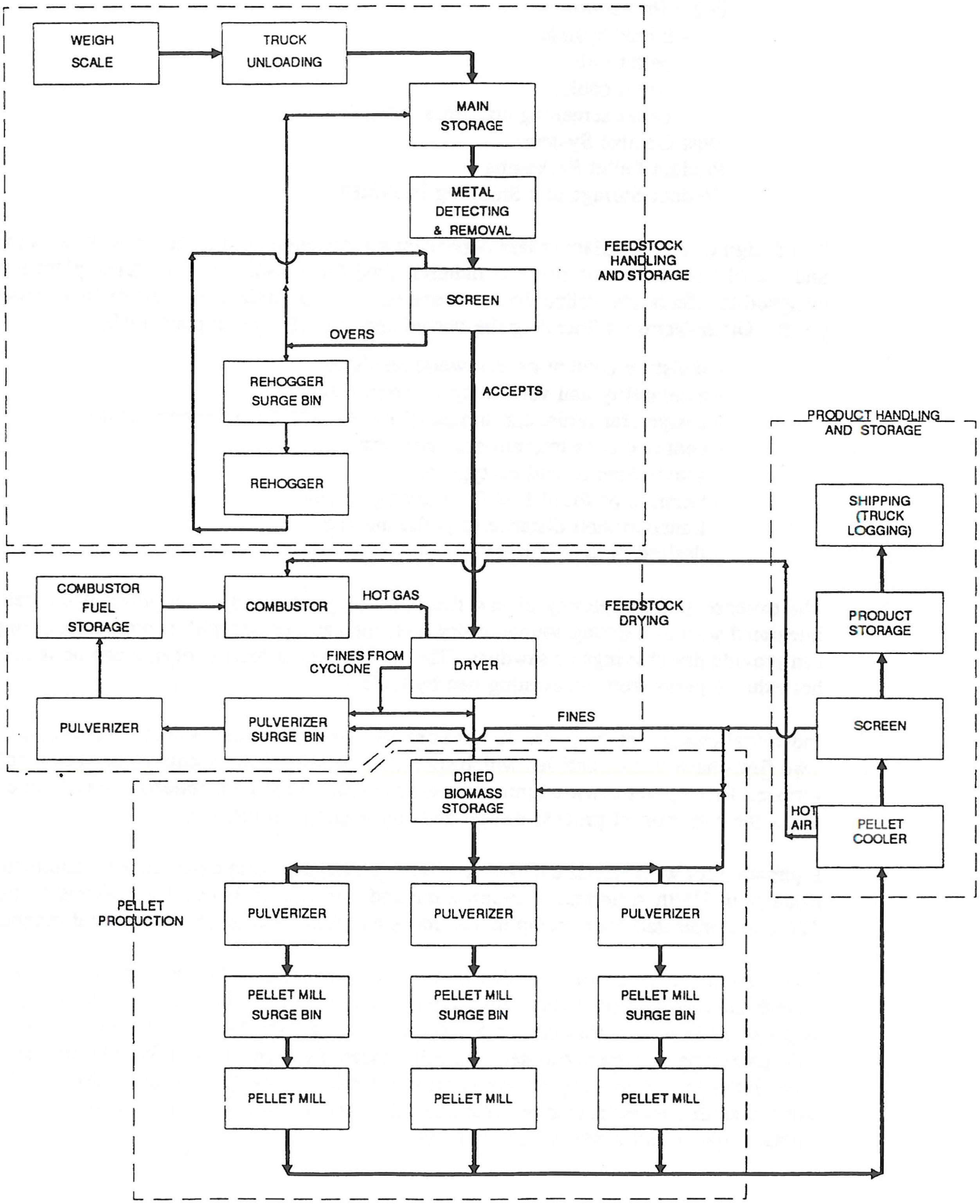
FIGURE 3 - PELLET PLANT BLOCK FLOW DIAGRAM



SOURCE: ENFOR PROJECT C-258

- dry feedstock storage
- secondary pulverizing
- screening and size classification
- prepared feed storage

Pellet Production

- infeed system
- pellet mill
- pellet cooler
- pellet screening and fines recycle

Dust Control Systems
Product Pellet Packaging
Product Storage and Shipping Facilities

The design of a pellet plant is less dependent on the pelletizing technology than on the plant location and the characteristics of the raw material feedstocks available. A pellet plant must be properly designed to effectively utilize the raw wood residues to produce an acceptable, consistent quality fuel pellet. Other factors influencing the design and cost of a pellet plant include:

- moisture content of raw wood residues
- availability and variability of wood residues
- design standards, e.g. industrial or agricultural equipment quality
- continuous or intermittent operation
- stand-alone or add-on type plant
- biomass or fossil fuel fired drying system
- transportation distance to pellet markets
- desired product quality

The expense and complexity of raw feedstock preparation can be reduced if the pellet plant can be integrated with an existing source of dry fuel, such as a planer mill or remanufacturing facility, which can provide dry shavings or sawdust. The cost for wood residue drying can be reduced by using the hot exhaust gases from an existing nearby boiler.

Individual equipment suppliers do not normally undertake total system design for a pelletizing plant. Two firms have been identified which specialize in providing a complete design, supply and construct service. Pellet plant construction is most often carried out by a general mechanical construction firm under the direction of process design and engineering consultants.

Equipment for wood residue handling is widely available from a number of manufacturers in B.C. and throughout North America. Comminution and size control is usually achieved using hammer hogs. These are protected from tramp metal, rocks and other debris, by screens and magnetic separators.

The equipment used for pelletizing wood residues and other materials is different from other densification equipment such as briquetters and log makers. Pellets are made by the forced extrusion of prepared feedstock through a die. The die can be a flat bed with a roller assembly; however, the industry standard is the perforated ring/roller assembly. Feedstock is forced from the inside of the ring through the perforations, by a rotating roller assembly. This arrangement is favoured by the four major companies that manufacture or assemble pelletizers in North America; California Pellet Mill, Kahl, Jesma-Matador and Andritz Sprout-Bauer.

The pellet output varies according to the die diameter and design, and also with feedstock composition. For example, a bark and white wood mixture can create more friction and the output can be twice that achieved with white wood alone. The "pelletizability" of a given feedstock should be assessed in test runs to define the range of permissable variations in mix and moisture content of the raw material.

The horizontal rotary dryer is the standard for the industry. The dryer can be fired with fossil fuel, or more frequently with biomass fuel.

Pellet quality is largely dependant upon the quality of raw wood residue feedstock. Pellets can be made using bark, sawdust, shavings or many other forms of biomass. The selected feedstock must be uniform in size and free of tramp materials such as rocks, metal, glass and other inorganic debris.

In general, white wood is preferred for making residential grade pellets, though standard grade pellets can be made using bark or bark and white wood mixes. Bark often increases production capacity on some pelletizing equipment and it can provide better binding of the pellet. Bark also produces a darker coloured pellet, which may be less acceptable in some markets. The pellet heat value is often increased by the addition of bark. The darker colour is acceptable to most industrial users. The heat value of fuel pellets made from wood residues is typically 18 to 20 GJ/t.

It is important to test both the raw feedstock and the finished fuel pellets continuously. For residential quality pellets ash content, chloride content, density, moisture levels, and the amount of fines are important. For industrial uses heat content and chloride content are most significant.

Equipment Suppliers

There are a number of North American and European suppliers of equipment for the manufacture of pellets and briquettes from wood residues. A partial list of some major equipment suppliers is presented in Table 1. Many of these companies make equipment for both residential and industrial grade pellet production.

Table 1 - Pelletizing Plant Equipment Suppliers

Equipment	Supplier	Location
Storage	Laidig	Surrey, B.C.
	Peerless	Penticton, B.C.
Handling and Conveying	Bulk Handling Systems	Eugene, Oregon
	American Fabricators	Woodburn, Oregon
Dryers Systems	Rader Companies	Portland, Oregon
	M.E.C Company	Neodosha, Kansas
	Kettenbauer GmbH & Co.	Murg, Germany
Pellet Mills	California Pellet Mill Company	San Francisco, California
	Andritz Sprout-Bauer	Muncy, Pennsylvania
	Bogma Maskin AB	Ulricehamn, Sweden
	Jesma-Matador AS	Esbjerg, Denmark
	Kahl	Germany
Wood Burners	Coe, Moore Canada Div.	Brampton, Ontario
	Energy Control Engineering	Minnetonka, Minnesota

Table 1 - Continued

Equipment	Supplier	Location
Baghouses	Clarke's Sheet Metal Andritz Sprout-Bauer	Eugene, Oregon Muncy, Pennsylvania
Hammer Mills	Schutte Pulverizer Company, Inc. Champion	Buffalo, New York Minnesota
Screens	Clarke's Sheet Metal Rader Companies	Eugene, Oregon Portland, Oregon
Full Pellet Plant Design	Brock Industrial Supply ESA Process Equipment, Inc. Natural Resource Recovery, Inc. Intermercato AB	Nampa, Indiana Vancouver, Washington Columbia City, Oregon Sweden (Vancouver rep.)
Pellet Mill Dies	Dorssers Inc.	Blenheim, Ontario

Operating Pellet Plants in North America

Table 2 presents a list prepared by the Fibre Fuels Institute in Duluth, Minnesota, of fuel pellet plants currently (January 1992) in operation in Canada and the United States. Most of these pellet plants are small operations supplying pellets for residential use to the local market. Only a few plants make industrial quality pellets.

Table 2 - List of Operating Fuel Pellet Plants (1)

UNITED STATES - East	
Modular Energy Company	Bealton, VA
Kingsford Products Company	Parsons, WV
UNITED STATES - South	
Consolidated Pelletizers	Damascus, GA
Fiber Resources, Inc.	Pine Bluff, AR
Wood Recyclers, Inc.	Tulsa, OK
UNITED STATES - Midwest	
Claycamp's	Seymour, IN
Gilman Forest Products	Gilman, WI
Khoury, Inc.	Iron Mtn., MI
Little River Lumber	Piedmont, SD
Marth Wood Shaving Supply	Marathon, WI
Neo-Wood Products Company	Tiffin, OH
Pennington Seed Inc.	Greenfield, MO
Rivard's Quality Seeds	Argyle, MN
Tecor, Inc.	Houston, MO
Thronson Management, Inc.	Menominee, MI
Valley Forest Resources	Marcell, MN
Westway Trading Corporation	Mapleton, ND

Table 2 - Continued

UNITED STATES - West	
Agri-Systems	Billings, MT
Bear Mountain Forest Products	Hood River, OR
Bitterroot Timber Products	Darby, MT
Blackfoot Forest Products	Lincoln, MT
Browning Cut Stock	Juliaetta, ID
C.D. Pellet Company	Omak, WA
CNZ Corporation	Sheridan, WY
Coer D'Alene Fiber Fuels	Coeur D'Alene, ID
Eureka Pellet Mills	Eureka, MT
Fire Tec	Union, OR
Gold Country Pellet Fuel	Plymouth, CA
Great West Pellet Mills	Enterprise, OR
Jensen Lumber Company, Inc.	Ovid, ID
Kaaland Mill	Hamilton, WA
Lignetics of Idaho (60,000 t/a)	Sandpoint, ID
Manke Lumber Company (70,000 t/a)	Tacoma, WA
MJM Pellet Mill	Brewster, WA
Modoc Energy Products	Klamath Falls, OR
Northwest Pellet Mills, Inc.	Brownsville, OR
Panarama	Kettle Falls, WA
Precision Pellet Mfg.	Heber, AZ
Recycle King	Fresno, CA
Rocky Mountain Mills	Ravalli, MT
Simmons Densified Fuels, Inc.	Yakima, WA
South and Jones	Evanston, WY
Spokane Pres-To-Log	Spokane, WA
Swan Lake Pellets	Klamath Falls, OR
West Oregon Wood Products	Columbia City, OR
Wood Fuel Processing, Inc.	Yuba City, CA
Wood Pellet Company	Oakville, WA
CANADA	
Bioshell, Inc.	Montreal, PQ
Northern Combustion	Prince Albert, SASK
N.S. Bauman, Ltd.	Wallestein, ONT
Ag-Pro (2)	Creston, BC
Presto-Flame	Victoria, BC

(1) Source: Fibre Fuels Institute, January 1992.
(2) Added to FFI list.

The sharp increase in the price of petroleum energy in the late 1970's initiated the rapid search for alternate energy sources. The production of fuel pellets from low cost wood residues and other waste biomass materials became economically attractive and much research and development work was carried out. A number of pellet plants to make industrial fuel pellets from wood residues were built in North America and in Scandinavia.

Since then the worldwide price of petroleum energy has fallen, and remains today at about half of the peak levels. This has made many of the alternative forms of energy that were developed uneconomic. Industrial fuel pellets made from wood residues are no longer cost effective and are thus not being used in North America or in other countries. Most of the industrial pellet plants built in the 1980's have been shut down and dismantled.

A few industrial pellet plants that have specific markets do however remain in operation. Shell Biomass built three large plants, two of these are shut down and only one, which supplies fuel pellets to a nearby paper mill, remains in operation today. Sandwell is not aware of any wood residue fuel pellet plants supplying pellets to power plants in Canada or in the United States.

MARKET OPPORTUNITIES FOR WOOD PELLETS

General

Two potential market areas, as specified in the Terms of Reference, are considered in this study; within North America, and offshore markets in the Pacific Rim. Market opportunities in California are assessed in greater detail as there are several biomass-fired power plants in operation in California. The following section summarizes the market study findings, the details of the market study are presented in Appendix 5.

There are two distinct markets for fuel pellets based on pellet quality; industrial and residential. These demand quite different quality standards. Residential pellets currently being sold meet very high standards for ash, moisture, fines and chloride content. These standards have been developed in the USA by the Fibre Fuels Institute (FFI). The residential pellet burning stoves require this quality to operate efficiently. There are no similar standards for industrial fuel pellets. These must meet the requirements set by each user.

The FFI quality standards for residential fuel pellets are summarized in Table 3. Recently a second grade has been added which allows an ash content of up to three percent. Most residential pellets sales are premium grade since many existing stoves require the lower ash fuel. Newer models of pellet stoves can use the higher ash fuel.

Table 3 - FFI Quality Standards for Residential Fuel Pellets

Item	Units	Amount
Bulk Density	lb/ft^3	>40
Dimensions	inches	1/4 to 5/16
Fines Content	wt % < 1/8 inch	0.5
Chlorides	ppm	<300
Inorganic Ash	wt %	
- Premium Grade		<1
- Standard Grade		<3

The fuel quality standards used by the biomass-fired power plants in California vary widely depending on the type of combustion unit. At one power plant, fuel moisture can vary from 8 to 30 percent, ash content varies from 1.5 to 5.6 percent, and fuel size criteria includes 90 percent less than 4 inch and

25 percent less than 1/4 inch. Some of these plants also burn agricultural residues along with wood residues and in some cases up to 25 percent natural gas.

Transportation facilities and costs are major considerations in the marketing of both residential and industrial pellets and briquettes. The fuel pellets must be kept dry during transit and storage as moisture causes the pellets to swell and disintegrate. Excessive handling can break the pellets and create dust which can cause handling and spontaneous combustion problems.

Wood residue fuel pellets have a relatively low energy density compared to common fossil fuels. Thus the distance pellets can be shipped from producer to user is limited by the cost of transport. Pellet prices cannot be significantly greater than alternative fuels.

Some producers indicate that it becomes uneconomic to transport residential fuel pellets more than 300 to 500 km. Transportation costs beyond this range make it more practical to build a local pellet plant to supply the local market. Industrial pellets might be shipped greater distances in some cases where efficient bulk transport facilities are available. Typical fuel pellet transportation costs in B.C., for bulk shipment and for smaller quantities of bagged pellets for residential use, are shown in Table 4.

Table 4 - Typical Fuel Pellet Handling and Transport Costs ($/t)

Distance (km)	Bulk Shipment	Bagged on Pallets
<50	4 to 6	7 to 8
100	7 to 9	10 to 12
300	19 to 22	23 to 26
500	25 to 30	35 to 40

Since wood residues, and other materials that are suitable for pellet production, are widely distributed in most parts of North America, pellet plants can usually be built close to areas where there is sufficient market demand. Thus in the longterm, the market area for a plant producing residential pellets in B.C. should only include B.C. and parts of Alberta, Washington, Montana and Idaho.

In this market study the two types of fuel pellets, residential and industrial are considered separately.

Industrial Fuel Pellets

There are currently no producers or major industrial/commercial users of industrial fuel pellets in B.C. Natural gas and wood residues are the commonly used sources of heat. B.C. has an extensive gas distribution system and a large surplus of natural gas, which results in a relatively low gas price. At many of the pulp and paper mills in B.C. wood residues are burned directly in power boilers to produce process steam and in some cases electricity.

Fuel pellets are not cost competitive with natural gas and direct burning of wood residues. At current industrial natural gas prices, fuel pellets would have to sell at 25 to 35 $/t delivered to the user to be competitive. New power boilers, like the NW Energy plant at Williams Lake and the Canfor plant at the Port Mellon mill, are designed to burn wood residues; pellets offer no significant advantages over direct burning for these plants.

A US government sponsored incentive program led to the construction of a number of biomass-fired power plants near Antioch in California. These have been considered as a potential market area for pellets from a B.C. pellet plant. These plants can use two to three million t/a of biomass fuel.

Recently construction was started on a large pellet/briquette plant in Delta, B.C. to make 200,000 t/a to be marketed in northern California. This plant was almost half built before the project collapsed due to financial difficulties. Subsequent studies by the lenders concluded that the proposed plant was not viable and the project was abandoned. Despite several advantages, including low cost used equipment, no energy cost by using demolition debris for residue drying, a tidewater location, and low backhaul shipping rate, this project was not financially viable.

The potential industrial markets for fuel pellets in California and in other parts of the United States are currently not attractive for several reasons. The biomass-fired power plants in northern California are well supplied with fuel and are paying 44 to 50 $/BDt delivered to the power plants. This price is far less than that required to make and transport pellets from B.C. to California.

Coastal wood residues contain salt from contact with salt water. Salt in the fuel is undesirable as it can lead to excessive corrosion of the boilers and elevated levels of atmospheric emissions. Some Californian power plants use ammonia injection for NO_x control. When salt is present in the fuel, it causes a highly visible exhaust plume which does not meet the local air pollution control regulations.

Recent testing of B.C. coastal wood residues in California reportedly indicated that even small quantities of salt in the fuel are unacceptable. Most of the wood residues available on the coast are contaminated with salt and are thus not suitable for making pellets for the Californian market.

It is concluded that there are no attractive opportunities in North America for industrial fuel pellets made from B.C. wood residues. Local industries can burn wood residues directly in a more cost effective manner compared to fuel pellets. Low biomass fuel prices in California, salt in coastal wood residues and relatively high transportation and handling costs, 25 to 40 $/BDt, make the California market unattractive.

Residential Fuel Pellets

Residential fuel pellets can be produced effectively in very small scale plants as well as in larger facilities. Since pellets made from wood residues are a relatively low energy fuel which must compete with other available forms of energy, transport over long distances is not usually economic. Unless other forms of energy are not available, fuel pellets are not often sold more than 300 to 500 km away from the production plant.

The consumption of residential fuel pellets is related to the number of pellet burning stoves in use. General statistics concerning residential pellet stoves in Canada and the United States are not compiled. A local pellet stove distributor estimates there may be about 3,500 stoves in B.C. At an average pellet use of 2 to 3 t/a, total annual consumption of pellets in B.C. might be about 10,000 t/a.

The B.C. market is currently supplied by the large fuel pellet plant in Idaho and by small local producers. These include a plant in Creston that makes fuel pellets during the heating season and agricultural pellets during the summer, and existing pellet plants in Quesnel, Castlegar and Victoria. A plant near Aldergrove to start production this year is currently under consideration. These B.C. plants have a combined pellet production capacity of almost 16,000 t/a.

The residential market for fuel pellets in neighbouring areas is similar. There are several, relatively small pellet producers in Alberta and in Washington and Oregon, Table 2. They supply regional areas and most currently have unused production capacity. As the demand for pellets grows, these existing plants will be able to increase pellet output with little or no additional capital investment. There is considerable "latent" pellet production capacity.

Wood residue residential fuel pellets are usually sold in 40 pound (20 kg) bags. The bags are purchased individually or on pallets of 50 or 60 bags. Prices vary widely depending on the location and supplier. Bagged, premium quality fuel pellets for residential stoves are currently selling at 150 to 180 $/t from local retailers in Victoria. Retail prices in Edmonton, Alberta are 165 to 220 $/t. In Langley, B.C. pellets retail for 175 $/t, and in Creston, B.C. the local producer retails pellets for only 125 $/t. Typical wholesale prices for bagged pellets to retailers in B.C. and northwestern United States range from 85 to 130 $/t.

An approximate comparison of the cost of using wood residue pellets as residential heat source compared to other fuels is shown in Table 5.

Table 5 - Typical Heat Cost of Residential Fuel Values

Fuel	Typical Unit Cost	Cost of Heat ($/GJ)
Wood Pellets	150 $/t	9.30
Fuel Oil	0.28 $/litre	9.90
Natural Gas	4.80/GJ	6.40
Electricity	0.05 $/kWh	13.90
Cord Wood	100 $/cord	7.90

Wood residues suitable for fuel pellet production are readily available throughout most of North America and particularly in western Canada and the northwestern United States. This availability and the low raw material cost, the low capital cost of establishing a pelletizing plant, and the restrictions of markets due to the impact of transport costs, favours smaller pelletizing operations to satisfy local demands. The longterm markets for pelletizing plants in B.C. are regional, and thus are not large.

Growth in fuel pellet demand is currently restricted by the low cost of other forms of energy. Natural gas is abundant and very inexpensive throughout B.C., Alberta and the northwest US. Vancouver Island was considered an attractive market for pellet stoves, but now natural gas is available and pellet stove sales have decreased. Coal resources are also plentiful in western Canada. However, if energy prices rise significantly, fuel pellets will become more attractive and pellet markets would expand.

In summary, the potential markets for a B.C. fuel pellet plant are well supplied and the market is not projected to grow significantly, unless energy prices rise. The current opportunity for a new residential quality fuel pellet producer in B.C. is probably not more than 3,000 to 5,000 t/a.

Offshore Markets

The terms of reference include assessment of market opportunities in offshore countries such as India, Taiwan and Korea. These and other Asian countries can be reached by direct shipping lines and the availability of indigenous fuels is generally limited.

In many Asian countries wood and charcoal are used as residential fuels for cooking and heating. These fuels are obtained from local forests and woodlands, which in many cases are being over-utilized. In the larger urban centres, bottled fuels such as propane and liquid fuels such as kerosene are often the main domestic fuels. In richer Asian countries, such as Korea and Taiwan, coal is often used as a domestic fuel. Imported wood pellets could potentially be used in place of all of these fuels.

Industrial users in Asia tend to consume fossil fuels, mainly coal and petroleum products, which are often imported. In rural areas some small industries use wood and charcoal fuels. It is possible that these fuels could also be replaced in some cases by wood pellets.

The ability to sell wood pellets to replace existing domestic and industrial fuels in offshore markets will depend on reliability and convenience of the pellet supply and mainly on the cost of wood pellets compared to the fuels currently available. Consumers will not likely switch to another fuel unless there would be a significant cost saving.

The major expense to supply wood pellets to offshore markets would be transportation; the costs of pellet handling during shipping and receiving and ocean freight charges. There are three possible methods of shipping wood pellets from B.C. to offshore markets; bulk cargo, break bulk and containerized. Typical current transportation charges that would be applicable to wood pellet shipments from B.C. ports are shown in Table 6.

Table 6 - Estimated Shipping Costs of Wood Pellets to Asian Markets

Item		US$/t
Bulk (1)	- Freight to Coastal Port (assume 500 km)	20 to 30
	- Loading, B.C. Port Charges	5 to 10
	- Ocean Freight (40,000 dwt ships)	15 to 30
	- Off-loading, Local Freight and Handling	10 to 20
	- Total	50 to 90
Break Bulk	- Freight to Coastal Port (assume 250 km)	10 to 15
	- Loading, B.C. Port Charges	10 to 20
	- Ocean Freight	50 to 75
	- Off-loading Local Freight and Handling	10 to 20
	- Total	80 to 130
Containerized	- Freight to Coastal Port (assume 250 km)	10 to 15
	- Loading, B.C. Port Charges, Ocean Freight	80 to 125
	- Off-loading, Local Freight and Handling	10 to 20
	- Total	100 to 160

(1) Requires specialized ship loading and off-loading terminal facilities

To achieve low shipping costs, bulk shipments are made in large ships (25,000 to 50,000 dwts) which are loaded at specialized, dedicated, terminals facilities. The quantity of material for bulk cargo must be relatively large, typically 500,000 to 1,000,000 t/a, to justify the costs of the specialized loading and unloading facilities.

Bulk shipping of wood pellets is currently not considered to be a realistic option. The volume of pellets would not likely be sufficient to justify development of required terminal facilities. Freight to a port and the covered storage required for the pellets at the port would add to the cost of the pellets.

Special handling facilities, including a high capacity off-loading system, covered storage, and fire and explosion prevention systems, would also be required for receiving the wood pellets.

Break bulk shipping is currently used for wood pulp and lumber. To ship wood pellets in this manner would require packaging of the pellets into units suitable for cargo handling, such as bulk bags. The total costs for break bulk freight and handling are estimated to be 80 to 130 US$/t from a B.C. port facility to the offshore pellet user.

Containerized shipping of bagged and palletized wood pellets would minimize port handling and it would ensure the pellets remain dry during transit. The transportation cost for containerized pellet shipments to Asia is estimated to be 100 to 160 US$/t.

There are no established markets and selling prices for wood pellets in these offshore countries. However, pellet prices will be related to the current costs of other fuels, for which the pellets would be a substitute fuel. The energy equivalences of several common fuels compared to a tonne of fuel oil are shown in Table 7. It can be seen in Table 7 that a tonne of wood pellets contains about the same amount of energy as 0.45 tonnes of fuel oil.

Table 7 - Energy Equivalence of Various Fuels Compared to Fuel Oil

Fuel	Typical Higher Heat Value kJ/kg	TOE*/t
Wood Pellets	19,000	0.45
Fuel Oil	42,000	1.0
Kerosene	43,000	1.02
Coal	28,000	0.67
Wood (air-dried)	16,000	0.38
Charcoal	32,000	0.76
Natural Gas in kJ/m^3	37,000	-
Electricity in kJ/MWh	3,600	-

* TOE = tonne of oil equivalent

The cost of fuel oil varies widely from country to country, but currently it is available for about 150 to 250 US$/t delivered to large industrial users in several Asian countries. As an example, if it is assumed that imported fuel oil delivered to industrial consumers, costs 150 and 250 US$/t, the equivalent selling price of the other fuels, based on the equivalent energy content can be estimated. This is illustrated in Table 8.

There are many factors that affect the net energy available from these fuels, however, Table 8 gives an approximate comparison based on gross energy content of the various fuels and energy sources.

Wood pellets selling at 113 US$/t would be comparable to fuel oil costing 250 US$/t to large industrial users. At a fuel oil price of 150 US$/t, which is the current fuel price at a large pulp and paper mill in the Philippines, wood pellets would be worth 68 US$/t on an energy equivalent basis. The costs of making the wood pellets plus shipping costs from B.C. to Asian countries would be 100 to 200 US$/t. Thus, offshore pellet sales are not considered to be financially viable. For industrial use, wood pellets would also compete with coal, which currently sells internationally for about 60 US$/t, equivalent to only 35 percent of its gross energy value compared to fuel oil.

Table 8 - Fuel Values Based on an Energy Equivalence to Fuel Oil (US$/t)

Fuel	Oil at 250 US$/t	Oil at 150 US$/t
Wood Pellets (<10% moisture)	113	68
Fuel Oil	250	150
Kerosene	255	155
Coal	170	100
Wood (air-dry)	95	60
Charcoal	190	115
Natural Gas - in US$/GJ	6.20	3.70
Electricity - in US$/MWh	21	13

For residential use, imported pellets would have to compete with local biomass fuels as well as coal and oil. For example in India rural dwellers do not use commercial fuels and get their fuel wood free or at a very low cost. In many urban areas of India quality fuel wood currently sells for 40 to 45 $/t. This, as shown in Table 8, is equivalent to about half of its energy value compared to fuel oil at 250 US$/t. In both the rural and urban locations in most Asian countries, the costs of transportation would make imported wood pellets uncompetitive with the fuels currently used.

In most offshore countries, particularly developing countries, it would not be economically effective compared to other fuels, to use scarce foreign currency to import relatively low energy wood pellets.

Overall, offshore markets for wood residue fuel pellets from B.C. are not attractive. Other fuels are readily available and these are significantly cheaper compared to imported wood pellets from B.C.

WOOD RESIDUE VOLUMES AND CHARACTERISTICS

General

Wood residues are produced in B.C. by wood products manufacturing plants and logging operations. The residues from manufacturing plants, which include sawmills, plywood plants, shake and shingle mills and lumber remanufacturers, are typically bark, sawdust, shavings and trim ends. Chips, because of their value to pulp mills, are not considered to be residue. Residues accumulate at logging sites and at dry land log sorts in the form of bark, branches, slabs and chunks.

There are wood products manufacturing plants and logging operations throughout B.C. and these generate large surpluses of wood residues. These unused residues are currently disposed of by incineration or landfilling. These means of disposal are wasteful and they can have adverse affects on the environment.

The residues from wood products manufacturing plants are cleaner and often drier and are thus better suited than logging residues for fuel pellet production. For residential fuel pellets, residue quality is important. Wood residues which have high levels of ash are not suitable. Residues from logs which have been in contact with salt water can be contaminated with salt. As noted earlier, even a small amount of salt in pellets can be detrimental for burning.

The volumes of the different types of mill residues produced in B.C. and the methods of utilization or disposal are summarized in a comprehensive report prepared for the Ministry of Forests Wood Residue Task Force. This report entitled "*British Columbia Forest Industry Mill Residue for Calendar Year 1989*", was published in 1990 by the B.C. Ministry of Forests. As indicated in the Terms of Reference, this report was the basis used to assess the availability and characteristics of wood residues. Additional recent data was developed in this study for Merritt and the Queen Charlotte Islands.

This section presents a summary of the wood residue study, further details are given in Appendix 6.

Merritt

Merritt is a typical interior location with respect to wood residue availability for a fuel pellet plant. Thus the following examination of the wood residue available in the Merritt area also provides data which is generally applicable to other B.C. interior locations.

There are three dimension type sawmills and a smaller specialized lumber mill in Merritt and a veneer mill nearby. These mills have log yards. There is also a remanufacturing plant in Merritt. The type, estimated volume and current utilization of wood residues produced by the mills in the Merritt area are summarized in Table 9, based on the estimated log consumptions in 1990.

Table 9 - Estimated Wood Residues in Merritt Area - 1990

Residue Type	wet t/a	BDt/a
Log Yard Residue	30,000	15,000
Bark	175,000	90,000
Sawdust and Shavings	190,000	115,000
Total	330,000	220,000

The kraft pulp mill in Kamloops uses some of the sawdust and shavings from the sawmills in Merritt. They currently pay 10 $/BDU or 5 $/green t FOB the sawmill for sawdust and shavings which are purchased on an as required basis. Hog fuel from the Weyerhaeuser sawmill in Merritt is presently being trucked to the pulp mill where it is burnt to make steam. Other local sawmills have wood residue burners for disposal of their green residues.

The total quantity of unused sawdust and shavings presently available in the Merritt area is estimated to be over 80,000 BDt/a. These residues are suitable for production of residential quality fuel pellets.

Lower Fraser Valley

In the Lower Fraser Valley, the Chilliwack Forest District, large volumes of wood residues are produced. The total quantities reported for 1989 are as shown in Table 10.

The 1989 MOF residue study reports that about 64 percent of these wood residues and 50 percent of the bark are utilized. The largest use is for steam generation at coastal pulp mills where the residues and bark are burnt directly in power boilers. There is currently a large surplus of wood residues, thus the sawmills receive no net revenue for the residues, the pulp mills pay only the transportation cost.

Table 10 - Estimated Wood Residues in Lower Fraser Valley (1989)

Residue	BDt/a
Sawdust	780,000
Shavings	104,000
Trim	57,000
Yard Debris	19,000
Total	960,000
Total Bark	890,000
Total Residues	1,850,000

Some sawdust and shavings are used at local pulp mills for pulp production. There is a particle board plant (MacMillan Bloedel K 3 plant) and a wet fibreboard plant (Canfor) which use some wood residue, but these plants do not use any bark.

After accounting for existing uses, large amounts of residues are still unutilized. Estimated quantities available in the Lower Fraser Valley area are over 300,000 BDt/a of sawdust, shavings and trim, and over 400,000 BDt/a of bark.

As much as 90 percent of the logs which are used to make wood products in the Lower Fraser Valley area have been either stored or transported in salt water. As discussed previously, residues which contain salt are not desirable for combustion in pellet stoves or in many types of industrial burners. The local boilers have been designed to withstand the increased levels of corrosion and emissions caused by the salt. The biomass-fired power plants in California have tested and rejected wood residues from the B.C. coast because of the salt levels which caused excessive atmospheric emissions.

Due to the relatively high salt and ash contents, most of the hog fuel produced by mills in the Lower Fraser Valley is not suitable for making residential fuel pellets. Sufficient quantities of uncontaminated residues are available for small pellet production operations. The main coastal species, hemlock, balsam and cedar, produce pellets with ash contents that exceed the 1 percent standard for premium grade residential pellets. Cedar residues produced by shake and shingle mills in this area also contain high levels of ash and cannot be used to make premium grade pellets.

Floating wood debris is collected in a trap on the Fraser River near Agassiz. Natural and man-made debris flowing in the river and is trapped. The collected material, about 150,000 wet t/a, a mixture of trees and roots, branches, slabs, bark, and chunks of wood, is disposed of by burning after a portion is used to make fire wood for provincial parks.

This debris is not suitable for manufacturing pellets for residential use. It contains high levels of dirt and ash, and it is variable in composition. It would be difficult for a pellet plant to maintain a consistent feed needed to make acceptable quality fuel pellets. It might be usable to make industrial pellets, but additional raw material preparation would be necessary to provide an acceptable feedstock.

The wood residues available in the Lower Fraser Valley are not ideally suited for making industrial fuel pellets because of salt contamination and relatively high ash contents. However, if markets for industrial pellets develop in the future, selected residues, possibly processed to reduce salt levels, could be used for industrial fuel pellet production.

Salt contamination and high ash levels are also undesirable in residential fuel pellets. Selected residues which have low levels of salt and low proportions of cedar residues, could be used to make residential quality fuel pellets.

Queen Charlotte Islands

Two types of wood residues are available on the Queen Charlotte Islands, mill residues from two small sawmills and logging residues.

The volume of sawmill residues is very small. The sawmill at Port Clements operates one shift per day, and in recent years it has operated an average of 150 days per year. This mill cuts mainly cedar and a small amount of pine. The mill does not have a chipper or a debarker, thus the wood residue is mostly slabs with bark on, edgings, and trim ends. The amount of wood residue produced is estimated to be about 50 t/d, equivalent to about 7,500 t/a. The other sawmill at Masset has operated an average of 180 d/a during the last four years. It produces about 1,800 t/a of wood residue.

The forest harvest on the Queen Charlotte Islands is approximately 1.8 million m^3/a. MacMillan Bloedel Limited has the largest cutting rights, about 1,000,000 m^3/a, mostly on Graham Island.

The only concentrated sources of logging residue are the dry land, log sorting yards. Logs are delivered to these yards for scaling, grading, bucking and sorting prior to shipment. This process produces wood residues which consist largely of bark and wood debris.

There are paved and unpaved dry sort log yards. Debris from unpaved yards contains large amounts of dirt, gravel and rock mixed with the wood residue. On the Queen Charlotte Islands the yards are mostly unpaved. The typical volume of log yard residue produced on a paved sort is about 4 t (wet) per 100 m^3 of logs processed; at an unpaved yard, there is about 6 t (wet) per 100 m^3 of logs.

Geographically, the dry land sorts are spread out at various locations, some of which are not accessible by road. MacMillan Bloedel Limited operates six dry land sorts. The yard name, and estimated quantities of yard residues generated at each are as follows:

Dry Land Sort	Yard Residue (wet t/a)
Ferguson Bay	14,000
Skidegate	8,000
Aleford	3,000
Deenan Bay	9,000
McClinton Bay	9,000
Total	43,000

The two largest yards at Ferguson Bay and Skidegate are paved and accessible by road from Port Clements. There are several smaller yards on the Queen Charlotte Islands which are unpaved and accessible only by water from Port Clements.

Debris from an unpaved log sort yard contains large quantities of dirt, sand, gravel and rock that make it unsuitable for direct burning. Equipment is available to remove these foreign materials and convert the yard debris to hog fuel. However, this would not likely be viable to handle relatively small quantities of residue in a remote location.

The sawmill residues and the log yard debris available on the Queen Charlotte Islands is not suitable for the manufacture of fuel pellets for residential use. It has a high proportion of bark and dirt, it consists of mixed tree species, and it is not uniform enough for the manufacture of a high quality fuel pellet. Even for industrial grade pellets the log yard residue would not be a preferred material as it would likely require cleaning to remove non-combustible contaminants.

Wood residues also accumulate at the logging sites in the forests. This material, which includes bark, branches, small logs and log chunks, would be difficult to collect and transport and it would be contaminated with dirt and gravel. It would not be suitable for industrial pellet manufacture without cleaning. However, it could be used as fuel in a wood burning power generation plant.

In summary, there is not a sufficient quantity of suitable wood residues to supply an industrial pellet plant in the Queen Charlotte Islands. There is, however, a significant volume of log yard residues and a small amount of sawmill residues, which are a potential fuel source for a power plant. The total annual quantity of wood residues potentially available is estimated as follows:

Sawmill Residues	5,000 BDt/a
Log Yard Residues	35,000 BDt/a
Total Residues	40,000 BDt/a

It should be possible to combine these residues with logging residues collected from the logging sites, to provide an adequate quantity of fuel to supply a small thermal power plant.

CASE STUDY - B.C. INTERIOR NEAR MERRITT

General

The assessment of potential markets for fuel pellets produced in B.C. indicates current opportunities are limited. However, to illustrate the potential for fuel pellet production and the cost structure for new plants, should markets develop in the future, case studies for two typical pellet plants have been prepared.

For these examples, the pellet plants are located in the B.C. interior; Merritt was chosen as a location that is typical of any of several interior regions where a pellet plant could be built.

These case studies illustrate the levels of capital investment required for a small 10,000 t/a pellet plant and for a larger, 50,000 t/a plant. The financial analyses show the cost structure and the potential returns assuming various selling prices for the fuel pellets. The capital costs in this study are for new equipment. In some cases, particularly for the smaller pellet plant, it may be possible to find used equipment which would reduce the required capital investment.

The Thompson/Okanagan Economic Development Region, which includes Merritt, and other interior locations offer several advantages for a fuel pellet plant. These areas are central in the province and close to potential pellet markets and there is an abundant supply of suitable wood residues. In addition, the residues are free of salt and some are relatively dry. The local remanufacturing plants could provide a high quality feedstock such as shavings and sawdust.

For this case study, two typical pellet plant configurations have been considered: a stand-alone plant with a capacity of 50,000 t/a; and a smaller add-on type plant with a capacity of about 10,000 t/a.

Both plants would make residential quality fuel pellets. The 50,000 t/a pellet plant would be similar in size to existing pellet plants in Idaho and Quebec. The add-on type plant is expected to be the more common type built in the near future as regional markets gradually expand. It has been assumed that the fuel pellets would be marketed in B.C. and in nearby regions of Alberta and the northwestern United States.

Description of Plant - 50,000 t/a Residential Quality Pellet Plant

The pellet plant is based on an average design pellet output rate of 12.5 t/h. The plant would operate an average of 4,000 hours per year, typically on a one-shift basis during the warmer months when sales are slower, and on a two-shift basis during most of the heating season. The plant would operate 250 to 300 d/a.

A typical process flowsheet for this pellet plant is presented in Figure 2. Wood residues, sawdust and shavings, would be delivered by truck from nearby sawmills and remanufacturing plants. The trucks, 10 to 20 per day, would be weighed and residues transferred to the wood residue storage pile. Concrete retaining walls would contain the outdoor pile. The feedstock would be reclaimed by front-end loader and feed by conveyor into the pellet plant.

The raw feedstock preparation would include magnetic separators to remove ferrous metals followed by a screening system. Screen accepts would go to a pulverizer, which would reduce the feed to small particles. The fines from the screens would be used as fuel in the residue dryer. A separate pulverizer would also be installed to process fuel for the dryer.

The pulverized feedstock would then be fed to a dryer and dried to about 10 percent moisture content. The dried feedstock would be fed to the pellet mill pulveriser or hammer mill, and thence to the feedstock surge bin. Feed conditioning would use steam to ensure uniformity of feedstock temperature and moisture content.

From the surge bin the dried, pulverized residue would be fed to the pellet mills. For this plant capacity, two pelletizers would be installed. These would operate in parallel. Pellet cooling and screening would be carried out in a double pass unit. Reject fines from the cooler would be sent to the dryer fuel bin.

The cooled pellets would be bagged, palletized and conveyed to covered storage sized to hold about 5,000 tonnes of pellets. There would be loading facilities for transfer from the storage area onto trucks which would transport the pellets to wholesalers and retailers. The drying, pelletizing, bagging and storage areas would be in a single building.

Estimated Capital Cost - 50,000 t/a Pellet Plant

The detailed estimates of the capital costs for a 50,000 t/a pellet plant to make residential quality fuel pellets for local markets, are presented in Appendix 3. The total estimated plant capital cost is $3,500,000, as summarized in Table 11.

Table 11 - Estimated Capital Cost - 50,000 t/a Pellet Plant ($)

Structures	770,000
Equipment	1,850,000
Owner's Overhead and Expense	150,000
Engineering & Project Management	250,000
Contingency	480,000
Total Plant Capital	3,500,000
Land Purchases (Allowance)	250,000
Initial Working Capital	620,000
Pre-operating Expense	130,000
Total Capital Investment	4,500,000

Estimated Operating Cost - 50,000 t/a Pellet Plant

The estimated operating costs are detailed in Appendix 2 and summarized in Table 12.

Table 12 - Estimated Operating Costs - 50,000 t/a Pellet Plant

	$/a	$/t
Raw Wood Residues	0	0
Wood Residue Transport	420,000	8.4
Fuel and Electrical Power	240,000	4.8
Operating & Maintenance Materials	900,000	18.0
Operating and Maintenance Labour	670,000	13.4
Administration and Overhead	300,000	6.0
Contingency	200,000	4.0
Total Operating Costs	2,730,000	54.6

This estimate assumes that the dryer is fired with wood residues. If natural gas would be used instead of wood residues, the plant capital would be reduced, but the operating costs would be increased by about 10 $/t of pellets.

Description of Plant - 10,000 t/a Residential Quality Pellet Plant

The pellet plant design is based on a small wood residue pelletizing system added onto an existing wood products plant that would supply wood residues to the pellet plant, Figure 1. The design pellet production rate would be 5 t/h in a single line. The plant would operate 2,000 hours per year, on a one-shift basis to produce 10,000 t/a of pellets. The pellet plant would run on the same period as the wood products plant, typically about 250 d/a.

Sawdust and shavings would be conveyed directly to a storage bin which would feed the screen ahead of the dryer. The dried feedstock would go to a storage bin ahead of the pulverizer. From the pulverizer the feed would go to a surge bin and then to the pelletizing mill. Pellet cooling and screening would be carried out in a double pass unit. Reject fines from the cooler would be sent to the dryer fuel bin. The cooled pellets would be bagged, palletized and conveyed to covered storage sized to hold about 400 tonnes of pellets. There would be loading facilities for transfer onto trucks.

The pelletizing equipment would be housed in additions onto existing buildings. It is assumed that no additional mobile equipment would be required for the pellet plant.

Estimated Capital Cost - 10,000 t/a Pellet Plant

The detailed estimates of the capital costs for a 10,000 t/a pellet plant to make residential quality fuel pellets for local markets, are presented in Appendix 3. The total estimated plant capital cost is $1,300,000, as summarized in Table 13.

Table 13 - Estimated Capital Cost - 10,000 t/a Pellet Plant ($)

Structures	270,000
Equipment	710,000
Owner's Overhead and Expense	40,000
Engineering & Project Management	90,000
Contingency	190,000
Total Plant Capital	1,300,000
Land Purchases	0
Initial Working Capital	100,000
Pre-operating Expense	40,000
Total Capital Investment	1,440,000

Estimated Operating Cost - 10,000 t/a Pellet Plant

The estimated operating costs are detailed in Appendix 2 and summarized in Table 14.

Table 14 - Estimated Operating Costs - 10,000 t/a Pellet Plant

	$/a	$/t
Raw Wood Residues	0	0
Wood Residue Transport	0	0
Fuel and Electrical Power	40,000	2
Operating & Maintenance Materials	180,000	18
Operating and Maintenance Labour	220,000	22
Administration and Overhead	50,000	5
Contingency	40,000	4
Total Operating Costs	530,000	53

In this estimate it is assumed that the dryer is fired with wood residues. It is also assumed that the operating crew for the pellet plant would include four operators and that maintenance and additional operating labour would be supplied by existing personnel from the wood products plant.

Financial Analyses

The market evaluation carried out as part of this study indicates the potential markets for residential fuel pellets are currently satisfied and are not likely to grow substantially unless fossil fuel prices rise. Without a defined market, it is not possible to project the financial viability of a proposed development. However, costs have been developed in this study for two sizes of fuel pellet plants to illustrate the levels of capital required and potential returns using current pellet prices.

A simple method of evaluating the financial worth of a project is the gross rate of return on the total capital investment, before any interest charges, depreciation or taxes are considered. The gross returns of the proposed residential fuel pellet plants, assuming operation at design capacity, are summarized in Table 15.

Table 15 - Pellet Plant Gross Return on Investment ($)

Item	50,000 t/a Plant	10,000 t/a Plant
Annual Sales Revenue	4,250,000	1,000,000
Annual Operating Cost	2,730,000	530,000
Gross Margin	1,520,000	470,000
Total Capital Investment Required	4,500,000	1,440,000
Gross Rate of Return	34%	33%

The gross return indicates a payback period of about 3 years for the total capital investment based on pellet prices of 85 $/t for the larger plant and 100 $/t for the 10,000 t/a plant.

The illustrative assessment of financial viability is based on the cash flow projections for the period from the first draw down on capital funds to the end of the first 15-year operating period. A more detailed projected cash flow statement is presented in Appendix 4. This is based on a discounted cash flow analysis to determine the discounted rate of return on capital employed.

The analytical approach used to evaluate the project determines the financial return on the project as a whole, without regard to the method of financing that might be subsequently arranged. This is a widely accepted way of evaluating projects, providing a common measure of profitability that can be used by lenders and investors. The calculation involves estimating all the cash flows associated with the project. These are then discounted to the present and the internal rate of return is calculated.

The calculated real rates of return, after provision for income taxes, illustrate that a fuel pellet plant could be financially viable. The real rates of return over a 15-year analysis period, with various pellet selling prices, are shown in Table 16.

Table 16 - Pellet Plant Financial Returns

Net Pellet Selling Price	Rate of Return - % 50,000 t/a Plant	Rate of Return - % 10,000 t/a Plant
100	26	19
90	21	15
85	18	13
80	15	11
70	8	5
60	-3	-3

At current local ex-plant pellet prices, which range from 85 to over 100 $/t, the financial return would be attractive. The returns are quite sensitive to the net selling price of the pellets. A decrease of 25 percent in the selling price, from 80 to 60 $/t, reduces the calculated returns from 11 and 15 percent respectively, to negative values.

CASE STUDY - LOWER FRASER VALLEY

Although much of the wood residues in the Lower Fraser Valley are contaminated with salt, the volume of uncontaminated residues is about 75,000 BDt/a (150,000 t/a wet). This quantity is sufficient for the production of about 70,000 t/a of residential wood pellets.

The two case studies considered previously, for construction of 50,000 t/a and 10,000 t/a pellet plants in the B.C. Interior near Merritt, are also applicable to the Lower Fraser Valley. Both capital and operating costs at a Lower Fraser Valley location would be generally similar to those developed for the plants near Merritt. A pellet plant in the Lower Fraser Valley would have better access to Vancouver Island and to markets in the Pacific Northwest.

CASE STUDY - QUEEN CHARLOTTE ISLANDS

General

As discussed earlier, the wood residues available on the Queen Charlotte Islands are not suitable for production of residential fuel pellets, which are now sold with a low ash content, and the total available volume of residues is too small to justify a plant to make industrial quality pellets. However, these wood residues could be collected to a central location and burnt in a small thermal power plant.

Potential for Electrical Power Generation

Electrical power is presently supplied on the islands by a 6 MW hydro plant on Moresby Island, which started operation in 1990, and two 5 to 8 MW diesel plants, one at Masset and the other at Sandspit. B.C. Hydro reports that the cost of power from the diesel plants is high, about 0.13 to 0.16 $/kWh.

B.C. Hydro is presently considering ways to reduce the high cost of power and is planning to issue a request for proposals under the IPP program, for a small power plant on the islands to replace the high cost diesel units. A central site in the Port Clements area is considered by Hydro to be the most appropriate to utilize the existing power distribution system on the islands. A wood residue fired electrical power generating plant using local logging wastes would satisfy the power needs seen by B.C. Hydro.

The potentially available wood residues identified in this preliminary study, about 40,000 BDt/a, are equivalent to a power plant output of about 7 MW. Logging debris and possibly fuel wood could be collected to augment these residues for a larger power plant.

Estimated Capital Cost - 7 MW Electrical Power Plant

A preliminary estimate of the capital cost of a 7 MW power plant, which would burn wood residues, is shown in Table 17. This estimate assumes the power plant would be located in the vicinity of Port Clements on Graham Island.

This preliminary cost estimate is based on a power plant which would include a fuel receiving, preparation and storage area. Residues delivered to the plant would be hogged and screened to a uniform particle size. Prepared residue would be stored and conveyed to the storage bin feeding the combustor.

Table 17 - Estimated Capital Cost - 10 MW Power Plant ($)

Structures	2,500,000
Plant Equipment	10,000,000
Owner's Overhead and Expense	1,800,000
Engineering & Project Management	1,200,000
Contingency	2,500,000
Total Plant Capital	18,000,000
Land Purchases	0
Power Distribution System	0
Initial Working Capital	300,000
Pre-operating Expense	700,000
Total Capital Investment	19,000,000

The combustor would be a cell-type unit, capable of burning wet coastal residues with minimum comminution, with the steam boiler attached. The condensing steam turbine unit would have a water-cooled condenser with a cooling tower. Air emissions would be treated in a multiclone dust collector ahead of a precipitator. Switchgear and transformers for connection into the local B.C. Hydro system are included in the power plant estimates. The tie-line, relaying and metering equipment have not been included.

Estimated Operating Cost - 7 MW Power Plant

The estimated operating costs for the 7 MW power plant are presented in Table 18. These preliminary estimates are based on a stand-alone power plant located near Port Clements. It has been assumed that the power plant would not have to pay for the wood residues, but collection and delivery to the power plant site would cost an average of 14 $/BDt. It is assumed that some residues would be delivered by truck, and some would come by barge from remote log sorting yards.

Table 18 - Estimated Annual Operating Costs - 7 MW Power Plant

	$/a
Wood Residues	0
Wood Residue Collection and Transport	600,000
Operating and Maintenance Materials	200,000
Operating and Maintenance Labour	600,000
Administration and Overhead	350,000
Contingency	250,000
Total Annual Operating Costs	2,000,000

The total on-site staff is estimated at 14 plant operating and maintenance labourers and two supervisory and staff personnel. Additional contract services would be hired during the annual maintenance shutdowns and for other extraordinary maintenance. The administration and overhead allowance includes property taxes and insurance, staff salaries, purchased services, communications, office and general expenses.

Preliminary Assessment of Power Plant Development

The estimated gross return for the 7 MW power plant development is summarized in Table 19. A net power selling price of 0.10 $/kWh and a plant capacity factor of 85 percent have been assumed. This power cost is substantially less than the current cost for diesel generated power on the Queen Charlotte Islands, which B.C. Hydro indicates is 0.13 to 0.16 $/kWh.

Table 19 - Projected Gross Return of Investment for 7 MW Power Plant

Item	Amount ($/a)
Total Annual Revenues (at 0.10 $/kWh)	4,700,000
Total Annual Operating Costs	2,000,000
Gross Operating Profit	2,700,000
Total Capital Investment	19,000,000
Gross Rate of Return	14 %

This gross return indicates a payback period of about seven years for the total capital investment, which can be considered attractive for this type of investment.

This assessment indicates that mill and log yard residues potentially available on the Queen Charlotte Islands would be adequate to supply a residue-fired electrical power plant of about 7 MW. If logging residues can be used to supplement these residues, a larger power plant could be operated. The costs presented here are preliminary; detailed local studies are necessary to define these costs more closely. However, these preliminary estimates indicate that a small power plant could be financially attractive, given the current high cost of electrical power on the islands.

CONCLUSIONS

1. There are large quantities of wood residues available in the Lower Fraser Valley and Merritt areas of B.C., that are currently wasted, which could be used for making fuel pellets. The quantity and quality of wood residues available on the Queen Charlotte Islands are not suitable for fuel pellet production.

2. There are currently no markets for industrial quality fuel pellets produced in B.C. from wood residues. Regional industrial plants burn wood residues directly and would not obtain any significant benefits by switching to wood pellets. The biomass-fired power plants in California are well supplied with fuel and are currently paying less than half the cost of making and transporting fuel pellets from B.C. In offshore markets, fuel pellets from B.C. would not be cost effective compared to other available fuels.

3. Markets for residential quality fuel pellets are regional due to the relatively high cost of transportation, the widespread availability of wood residues, and the low capital cost of a small pelletizing plant. There are numerous small wood residue pelletizing plants in B.C. and Alberta and in neighbouring areas in the United States.

4. Fuel pellets from a large pellet plant in Idaho are currently sold in B.C. This B.C. market opportunity has been apparent to several local companies who have recently started making pellets or are considering installing small pelletizing plants in B.C. These plants have the capacity to supply the existing demand for residential quality fuel pellets.

5. The opportunity for a new residential quality pellet producer in B.C. is limited, and may be only 3,000 to 5,000 t/a over the next few years. Thus, there may be opportunities for small, add-on type fuel pellet plants, added to existing wood products plants.

6. The two pellet plant case studies illustrate that the financial returns are attractive at current pellet prices. However, the regional demand for fuel pellets is small and growing slowly. Markets are not available to support a 10,000 t/a or a 50,000 t/a pellet plant.

7. The wood residues available on the Queen Charlotte Islands, if they can be collected at a single location, are sufficient to supply a thermal power plant with a capacity of about 7 MW. With additional logging residues, there could be adequate fuel for a larger power plant. Based on preliminary capital and operating cost estimates and the current high cost of diesel generated power on the islands, the financial returns for a 7 MW wood residue fired power plant could be attractive.

Prepared by: ______________________ ______________________
Lanny Harris, P.Eng. Ian Rowe, P.Eng.

Approved by: ______________________
Sandwell Management Consultants

APPENDIX 1

GLOSSARY

APPENDIX 1 - GLOSSARY

a	annum
AD	air dry
ADt	air dry metric tonne
ADt/d	air dry metric tonnes per day
BD	bone dry
BDt	bone dry tonne
cm	centimetre
d	day
GJ	gigajoule
GJ/t	gigajoules per tonne
h	hour
hp	horsepower
kJ	kilojoule
kg	kilogram
km	kilometre
kg/ADt	kilograms per air dry tonne
kW	kilowatt
kWh	kilowatt hour
lb/ft^3	pounds per square foot
m	metre
m^3	cubic metre
MW	megawatt
MWh	megawatt hour
ppm	parts per million
t	metric tonne
t/h	metric tonnes per hour
°C	degree celsius
%	percent
$	Canadian dollars

APPENDIX 2

MANUFACTURING COST ESTIMATES

Sandwell

REPORT 372004/1
FUEL PELLET/BRIQUETTE STUDY

FUEL PELLET MANUFACTURING AND MARKETING OPPORTUNITIES IN B.C.

DATE: 1 JUNE 1992

APPENDIX 2 - MANUFACTURING COST ESTIMATES

OPERATING STATISTICS

ITEM	UNITS	AMOUNT Large Plant	AMOUNT Add-on
Pellet Production Rate	t/d	200	40
	t/a	50,000	10,000
Wood Residue Consumption			
Pellet Production	t/a (wet)	88,000	16,500
Residue Dryer	t/a (wet)	18,000	3,500
Total	t/a (wet)	106,000	20,000
Purchased Electrical Power			
Unit Consumption	kWh/t pellets	120	90
Annual Consumption	MWh/a	6,000	900
Labour Force			
Operating and Maintenance	no.	10	3.5
Staff	no.	3	0.5
Annual Operating Period	days	300	250

MANUFACTURING COST ESTIMATES

ITEM	RATE $/UNIT	ANNUAL COST - $/a Large Plant	ANNUAL COST - $/a Add-on
Variable Costs			
Wood Residue (transportation only)	4 /t (wet)	420,000	0
Electrical Power	40 /MWh	240,000	40,000
Operating & Maintenance Materials	18 /t pellets	900,000	180,000
Total Variable Costs		1,560,000	220,000
Fixed Costs			
Operating & Maintenance Labour	-	670,000	220,000
Administration and Overhead	-	300,000	50,000
Contingency	5%	200,000	40,000
Total Fixed Costs		1,170,000	310,000
Total Annual Manufacturing Cost		2,730,000	530,000
Unit Manufacturing Cost ($/t pellets)		55	53

APPENDIX 3

CAPITAL COST ESTIMATES

SANDWELL INC. **CAPITAL COST ESTIMATE**

PROJECT: 372004/1 - WOOD RESIDUE PELLET PLANT (ADD-ON TO EXISTING PLANT) - 10,000 t/a DATE: 16-Apr-92

CLIENT: B.C. Ministry of Forests

AREA	FUNCT.	DESCRIPTION	MATERIAL		LABOUR	TOTAL COST

SANDWELL INC. **SUMMARY OF CAPITAL COST**

PROJECT: 372004/1 - WOOD RESIDUE PELLET PLANT (ADD-ON TO EXISTING PLANT) - 10,000 t/a DATE: 16-Apr-92

CLIENT: B.C. Ministry of Forests

DIRECT COSTS	MATERIAL		LABOUR	TOTAL COSTS
FEEDSTOCK HANDLING AND STORAGE	40,000		15,000	55,000
FEEDSTOCK DRYING	450,000		185,000	635,000
PELLET PRODUCTION	200,000		50,000	250,000
TOTAL DIRECT COSTS	**690,000**		**250,000**	**940,000**
INDIRECT COSTS				
PROVINCIAL SALES TAX				40,000
OWNER'S CONSTRUCTION OVERHEAD				40,000
ENGINEERING AND PROJECT MANAGEMENT				90,000
CONTINGENCY				190,000
TOTAL INDIRECT COSTS				**360,000**
TOTAL PLANT CAPITAL				**$1,300,000**

SANDWELL INC. **CAPITAL COST ESTIMATE**

PROJECT: 372004/1 - WOOD RESIDUE PELLET PLANT (ADD-ON TO EXISTING PLANT) - 10,000 t/a DATE: 16-Apr-92

CLIENT: B.C. Ministry of Forests

AREA	FUNCT.	DESCRIPTION	MATERIAL		LABOUR	TOTAL COST
		FEEDSTOCK HANDLING AND STORAGE				
		Civil/Structural (assumed to be available at existing plant)				
	.13	Concrete, storage area walls	0		0	0
	.14	Structural and Misc. Steel	0		0	0
	.18	Roofing	0		0	0
	.22	Painting	0		0	0
	.23	Interior Fire Protection	0		0	0
	.26	Yard Lighting	0		0	0
	.51	Allowance for Land Purchase and Legal Surveys	0		0	0
	.52	Design Surveys	0		0	0
	.53	Test Drilling	0		0	0
	.54	Clearing and Demolition	0		0	0
	.55	Mass Excavation and Fill	0		0	0
	.56	Grading	0		0	0
	.58	Compaction	0		0	0
	.61	Fencing	0		0	0
	.69	Landscaping	0		0	0
			0			
		Sub-total Civil/Structural	**0**		**0**	**0**
		Mechanical, Electrical, & Instrumentation				
		Weigh Scale	0		0	0
		Truck dump/pile	0		0	
		Front end loader	0		0	0
		Underpile reclaimer	0		0	0
		Metal detection and removal	0		0	0
		Screen	12,000		4,000	16,000
		Hog	0		0	0
		Raw Feed Storage Bin	10,000		3,000	13,000
		Conveyors	8,000		5,000	13,000
		Motors	4,000		1,000	5,000
		Starters and MCCs	3,000		1,000	4,000
		Power wiring	3,000		1,000	4,000
		Process controls	included in pellet plant control system			
		Total, Mechanical, Electrical, & Instrumentation	40,000		15,000	55,000
		TOTAL FEEDSTOCK HANDLING AND STORAGE	40,000		15,000	55,000

SANDWELL INC. **CAPITAL COST ESTIMATE**

PROJECT: 372004/1 - WOOD RESIDUE PELLET PLANT (ADD-ON TO EXISTING PLANT) - 10,000 t/a **DATE: 16-Apr-92**

CLIENT: B.C. Ministry of Forests

AREA	FUNCT.	DESCRIPTION	MATERIAL		LABOUR	TOTAL COST
		FEEDSTOCK DRYING				
		Civil/Structural	Included in building	allowance		
	.13	Building allowance	200,000		70,000	270,000
	.14	Structural and Misc. Steel	included in building	allowance		
	.18	Roofing	" "	"		
	.22	Painting	" "	"		
	.23	Interior Fire Protection	" "	"		
	.26	Yard Lighting	" "	"		
	.51	Land Rights and Legal Surveys	" "	"		
	.52	Design Surveys	" "	"		
	.53	Test Drilling	" "	"		
	.54	Clearing and Demolition	" "	"		
	.55	Mass Excavation and Fill	" "	"		
	.56	Grading	" "	"		
	.58	Compaction	" "	"		
	.61	Fencing	" "	"		
	.69	Landscaping	" "	"		
		Total; building	200,000		70,000	270,000
		Mechanical, Electrical, & Instrumentation				
		Dryer and Auxiliaries	190,000		90,000	280,000
		Pulveriser surge bin	2,000		1,000	3,000
		Pulveriser	8,000		2,000	10,000
		Feedstock blower/filter	5,000		2,000	7,000
		Combustor fuel storage	5,000		1,000	6,000
		Combustor	20,000		11,000	31,000
		Conveyors	10,000		5,000	15,000
		Motors, including pulveriser	4,000		1,000	5,000
		Starters and MCCs	3,000		1,000	4,000
		Power wiring	3,000		1,000	4,000
		Process controls	included in pellet	plant control system		
		Sub-total Mech/elect/instrument	250,000		115,000	365,000
		TOTAL FEEDSTOCK DRYING	**450,000**		**185,000**	**635,000**
		PELLET PRODUCTION				
		Civil/Structural	Building included in	Feedstock Drying		
		Mechanical, Electrical, & Instrumentation				
		Pulverisers, 1	15,000		5,000	20,000
		Pellet mill surge bins	5,000		2,000	7,000
		Pellet mills, 1	70,000		19,000	89,000
		Mill feeder	5,000		1,000	6,000
		Feeder conditioner	8,000		2,000	10,000
		Steam supply/control	2,000		0	2,000
		Dies, 2 (1 spare)	4,000		0	4,000
		Pellet cooler	18,000		5,000	23,000
		Screening, including air system	15,000		2,000	17,000
		Product storage	10,000		2,000	12,000
		Packaging plant	24,000		5,000	29,000
		Motors, including pulveriser	5,000		2,000	7,000
		Starters and MCCs	1,000		1,000	2,000
		Power wiring	1,000		1,000	2,000
		Process controls	17,000		3,000	20,000
		Sub-total Mech/elect/instrument	200,000		50,000	250,000
		TOTAL PELLET PRODUCTION	**200,000**		**50,000**	**250,000**

SANDWELL INC.			DETAILS OF CAPITAL COST ESTIMATE			
PROJECT: 372004/1 - WOOD RESIDUE PELLET PLANT - 50,000 t/a					DATE:	16-Apr-92
CLIENT: B.C. Ministry of Forests						
AREA	FUNCT.	DESCRIPTION	MATERIAL		LABOUR	TOTAL COST

SANDWELL INC. — SUMMARY OF CAPITAL COST

PROJECT: 372004/1 - WOOD RESIDUE PELLET PLANT - 50,000 t/a — DATE: 16-Apr-92

CLIENT: B.C. Ministry of Forests

DIRECT COSTS	MATERIAL		LABOUR	TOTAL COSTS
FEEDSTOCK HANDLING AND STORAGE	420,000		90,000	510,000
FEEDSTOCK DRYING	910,000		270,000	1,180,000
PELLET PRODUCTION	650,000		160,000	810,000
TOTAL DIRECT COSTS	1,980,000		520,000	2,500,000
INDIRECT COSTS				
PROVINCIAL SALES TAX				120,000
OWNER'S CONSTRUCTION OVERHEAD				150,000
ENGINEERING AND PROJECT MANAGEMENT				250,000
CONTINGENCY				480,000
TOTAL INDIRECT COSTS				1,000,000
TOTAL PLANT CAPITAL				$3,500,000

SANDWELL INC. — DETAILS OF CAPITAL COST ESTIMATE

PROJECT: 372004/1 - WOOD RESIDUE PELLET PLANT - 50,000 t/a — DATE: 16-Apr-92

CLIENT: B.C. Ministry of Forests

AREA	FUNCT.	DESCRIPTION	MATERIAL		LABOUR	TOTAL COST
		FEEDSTOCK HANDLING AND STORAGE				
		Civil/Structural				
	.13	Concrete, storage area walls	20,000		10,000	30,000
	.14	Structural and Misc. Steel	2,000		1,000	3,000
	.18	Roofing	4,000		2,000	6,000
	.22	Painting	2,000		1,000	3,000
	.23	Interior Fire Protection	3,000		1,000	4,000
	.26	Yard Lighting	3,000		1,000	4,000
	.52	Design Surveys			1,000	1,000
	.53	Test Drilling			1,000	1,000
	.54	Clearing and Demolition			2,000	2,000
	.55	Mass Excavation and Fill	2,000		2,000	4,000
	.56	Grading			1,000	1,000
	.58	Compaction			1,000	1,000
	.61	Fencing	2,000		3,000	5,000
	.69	Landscaping	2,000		3,000	5,000
		Sub-total Civil/Structural	40,000		30,000	70,000
		Mechanical, Electrical, & Instrumentation				
		Weigh Scale	70,000		8,000	78,000
		Truck dump/pile	assumed self-unloading trucks			
		Front end loader	102,000			102,000
		Underpile reclaimer	100,000		30,000	130,000
		Metal detection and removal	30,000		4,000	34,000
		Screen	20,000		2,000	22,000
		Hog surge bin	10,000		1,000	11,000
		Hog	20,000		3,000	23,000
		Conveyors	14,000		5,000	19,000
		Motors	6,000		2,000	8,000
		Starters and MCCs	4,000		2,000	6,000
		Power wiring	4,000		3,000	7,000
		Process controls	included in pellet plant DCS			
		Total, Mechanical, Electrical, & Instrumentation	380,000		60,000	440,000
		TOTAL FEEDSTOCK HANDLING AND STORAGE	420,000		90,000	510,000

SANDWELL INC. | **DETAILS OF CAPITAL COST ESTIMATE**

PROJECT: 372004/1 - WOOD RESIDUE PELLET PLANT - 50,000 t/a | **DATE:** 15-Apr-9

CLIENT: B.C. Ministry of Forests

AREA	FUNCT.	DESCRIPTION	MATERIAL		LABOUR	TOTAL COST
		FEEDSTOCK DRYING				
		Civil/Structural	Included in building allowance			
	.13	Building Allowance (package price)	280,000		90,000	370,00
	.14	Structural and Misc. Steel	included in building allowance			
	.18	Roofing	. .	.		
	.22	Painting	. .	.		
	.23	Interior Fire Protection	. .	.		
	.26	Yard Lighting	. .	.		
	.51	Land Rights and Legal Surveys	. .	.		
	.52	Design Surveys	. .	.		
	.53	Test Drilling	. .	.		
	.54	Clearing and Demolition	. .	.		
	.55	Mass Excavation and Fill	. .	.		
	.56	Grading	. .	.		
	.58	Compaction	. .	.		
	.61	Fencing	. .	.		
	.69	Landscaping	. .	.		
		Total, building	280,000		90,000	370,00
		Mechanical, Electrical, & Instrumentation				
		Dryer and Auxiliaries	500,000		135,000	635,00
		Pulveriser surge bin	4,000		2,000	6,00
		Pulveriser	15,000		3,000	18,00
		Feedstock blower/filter	10,000		3,000	13,00
		Combustor fuel storage	8,000		2,000	10,00
		Combustor	55,000		20,000	75,00
		Conveyors	20,000		8,000	28,00
		Motors, including pulveriser	8,000		2,000	10,00
		Starters and MCCs	5,000		2,000	7,00
		Power wiring	5,000		3,000	8,00
		Process controls	included in pellet plant controls			
		Sub-total Mech/elect/instrument	630,000		180,000	810,00
		TOTAL FEEDSTOCK DRYING	**910,000**		**270,000**	**1,180,00**
		PELLET PRODUCTION				
		Civil/Structural				
		Building Allowance including warehouse (package price)	250,000		80,000	330,0
		Mechanical, Electrical, & Instrumentation				
		Pulverisers, 2	30,000		9,000	39,0
		Pellet mill surge bins	8,000		3,000	11,0
		Pellet mills, 2	142,000		30,000	172,0
		Mill feeder	7,000		1,000	8,0
		Feeder conditioner	15,000		2,000	17,0
		Steam supply/control	2,000			2,0
		Dies, 4 (2 spare)	10,000			10,0
		Pellet cooler	33,000		4,000	37,0
		Screening, including air system	31,000		4,000	35,0
		Product storage	20,000		4,000	24,0
		Packaging plant	52,000		5,000	57,0
		Motors, including pulveriser	13,000		4,000	17,0
		Starters and MCCs	3,000		2,000	5,0
		Power wiring	4,000		2,000	6,0
		Process controls	30,000		10,000	40,0
		Sub-total Mech/elect/instrument	400,000		80,000	480,0
		TOTAL PELLET PRODUCTION	**650,000**		**160,000**	**810,0**

APPENDIX 4

FINANCIAL ANALYSES

Sandwell

REPORT 372004/1
FUEL PELLET/BRIQUETTE STUDY

FUEL PELLET MANUFACTURING AND
MARKETING OPPORTUNITIES IN B.C.

MINISTRY OF FORESTS
ECONOMICS AND TRADE BRANCH
VICTORIA BRITISH COLUMBIA

DATE: 1 JUNE 1992

APPENDIX 4 - FINANCIAL ANALYSIS - WOOD RESIDUE PELLET PLANT (ADD-ON TO EXISTING PLANT) - 10,000 t/a

	Project Year																
	-2	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sales																	
Pellet Production (tonnes)			8,000	9,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Inventory Change (tonnes)			1,000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sales Volume (tonnes)			7,000	9,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Average Plant Net Selling Price ($/t)			90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
Total Sales Revenues ('000 $)			630	810	900	900	900	900	900	900	900	900	900	900	900	900	900
Pellet Manufacturing Costs ('000 $)																	
Variable Costs																	
Wood Residue			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electrical Power			40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Operating & Maintenance Materials			160	160	180	180	180	180	180	180	180	180	180	180	180	180	180
Total Variable Costs			200	200	220	220	220	220	220	220	220	220	220	220	220	220	220
Fixed Costs																	
Operating & Maintenance Labour			220	220	220	220	220	220	220	220	220	220	220	220	220	220	220
Administration and Overhead			50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Contingency			40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Total Fixed Costs			310	310	310	310	310	310	310	310	310	310	310	310	310	310	310
Total Manufacturing Cost			510	510	530	530	530	530	530	530	530	530	530	530	530	530	530
Capital Expenditures ('000 $)																	
Plant Capital	360	840															(120)
Working Capital		100															(100)
Pre-operating Expense		40															
Incremental Capital Reinvestment			0	20	0	20	0	20	0	20	0	20	0	20	0	20	0
Total Capital Expenditures	360	980	0	20	0	20	0	20	0	20	0	20	0	20	0	20	(220)
Projected Cash Flow Summary ('000 $)																	
Total Sales Receipts			630	810	900	900	900	900	900	900	900	900	900	900	900	900	900
Manufacturing Costs			510	510	530	530	530	530	530	530	530	530	530	530	530	530	530
Cash from Operations			120	300	370	370	370	370	370	370	370	370	370	370	370	370	370
Income Tax Paid			0	60	90	90	90	90	90	90	90	90	140	140	140	140	140
Net Cash from Operations			120	240	280	280	280	280	280	280	280	280	230	230	230	230	230
Capital Expenditures	360	980	0	20	0	20	0	20	0	20	0	20	0	20	0	20	(220)
Net Cash Flow	(360)	(980)	120	220	280	260	280	260	280	260	280	260	230	210	230	210	450

Internal Rate of Return = 15%

Average Annual Cash Flow = 300 ,000 $/a

FUEL PELLET MANUFACTURING AND MARKETING OPPORTUNITIES IN B.C.

DATE: 1 JUNE 1992

APPENDIX 4 - FINANCIAL ANALYSIS - WOOD RESIDUE PELLET PLANT - 50,000 t/a

	Project Year																
	-2	-1	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Sales																	
Pellet Production (tonnes)			40,000	45,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Inventory Change (tonnes)			3,000	1,000	0	0	0	0	0	0	0	0	0	0	0	0	0
Sales Volume (tonnes)			37,000	44,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000	50,000
Average Plant Net Selling Price ($/t)			75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
Total Sales Revenues ('000 $)			2,775	3,300	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750
Pellet Manufacturing Costs ('000 $)																	
Variable Costs																	
Wood Residue			370	380	420	420	420	420	420	420	420	420	420	420	420	420	420
Electrical Power			210	220	240	240	240	240	240	240	240	240	240	240	240	240	240
Operating & Maintenance Materials			790	810	900	900	900	900	900	900	900	900	900	900	900	900	900
Total Variable Costs			1,370	1,410	1,560	1,560	1,560	1,560	1,560	1,560	1,560	1,560	1,560	1,560	1,560	1,560	1,560
Fixed Costs																	
Operating & Maintenance Labour			670	670	670	670	670	670	670	670	670	670	670	670	670	670	670
Administration and Overhead			300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Contingency			200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Total Fixed Costs			1,170	1,170	1,170	1,170	1,170	1,170	1,170	1,170	1,170	1,170	1,170	1,170	1,170	1,170	1,170
Total Manufacturing Cost			2,540	2,580	2,730	2,730	2,730	2,730	2,730	2,730	2,730	2,730	2,730	2,730	2,730	2,730	2,730
Capital Expenditures ('000 $)																	
Plant Capital	1,170	2,730															(390)
Working Capital		620															(620)
Pre-operating Expense		130															
Incremental Capital Reinvestment			0	50	0	50	0	150	0	50	0	50	150	0	50	0	0
Total Capital Expenditures	1,170	3,480	0	50	0	50	0	150	0	50	0	50	150	0	50	0	(1,010)
Projected Cash Flow Summary ('000 $)																	
Total Sales Receipts			2,775	3,300	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750	3,750
Manufacturing Costs			2,540	2,580	2,730	2,730	2,730	2,730	2,730	2,730	2,730	2,730	2,730	2,730	2,730	2,730	2,730
Cash from Operations			235	720	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020	1,020
Income Tax Paid			0	10	220	220	220	220	220	220	220	220	390	390	390	390	390
Net Cash from Operations			235	710	800	800	800	800	800	800	800	800	630	630	630	630	630
Capital Expenditures	1,170	3,480	0	50	0	50	0	150	0	50	0	50	150	0	50	0	(1,010)
Net Cash Flow	(1,170)	(3,480)	235	660	800	750	800	650	800	750	800	750	480	630	580	630	1,640

Internal Rate of Return = 11% **Average Annual Cash Flow =** 700 ,000 $/a

APPENDIX 5

MARKETS FOR WOOD PELLETS

Markets for Wood Pellets

Markets for Wood Pellets

I. Introduction

The interest in densifying wood residues into pellets, cubes or briquettes for fuel gained momentum in the U.S. and Canada as a result of the Middle East oil crisis which began in 1977. Supply became uncertain and oil prices rose sharply. Plants were built to serve industrial and institutional users.

In areas where natural gas is not available wood pellets can compete with other energy sources on a cost basis. The increasing prevalence of cheap natural gas limits this use. However, residential use of pellet stoves, particularly in the U.S. pacific northwest, has grown substantially.

Pellets can compete with alternative residential energy sources such as wood, propane, and electricity. In areas where natural gas is available pellet stoves are less popular. Pellets burn more cleanly and are more convenient to use than wood. In areas where clean air regulations apply pellet stoves are increasingly popular.

Pellet stoves are now attractive with large glass fronts and brass trim. Some are sold to upper scale customers who want an attractive, easy to use "fireplace" which is also energy efficient.

In this study, industrial, institutional, and residential use will be considered for the two broad geographical areas, western North America and offshore, that a pellet plant in B.C. could conceivably supply.

II. Western North America

1. General Comments

. Industrial

The potential users are operations with industrial-type boilers such as power plants, chemical plants, pulp mills, etc. Power plants in northern California which are required to burn bio-mass have been identified as a potential user of industrial pellets from B.C.

Residential

For residential use small round pellets (1/4 - 5/16" diameter) are produced. They are a very high quality pellet, burn cleanly and produce very little ash.

In November, 1991, the Fibre Fuels Institute and the Association of Pellet Fuel Industries established national standards for residential pellet fuel. A second grade was established. The two grades of pellets are Premium and Standard. Five fuel characteristics are prescribed in the grades. The only difference between the two grades is in the inorganic ash content:

Premium grade	- less than 1 percent ash
Standard grade	- less than 3 percent ash

More types of wood residue can be used to make Standard grade pellets.

Pellet stoves were designed to burn the low ash pellets. Recently, several manufacturers offer stoves that can burn standard grade pellets. Also, the burning pot on existing stoves can be modified.

Institutional

Institutions such as schools, hospitals, prisons, etc. can use pellets for fuel. Institutions are very desirable customers for pellet plants because they consume a high volume more evenly throughout the year. An institution burning coal could possibly convert to pellets and could burn the standard grade pellets. A new institution would burn the cheapest fuel available.

2. Specific Markets

A. Industrial Pellets - California

California has been considered as a potential market area for industrial pellets from a B.C. coastal plant because there are a number of small power plants that are required to burn bio-mass (non-fossil fuel) of which there is a shortage. Also, there is the opportunity to use cheaper ocean freight.

The Vancouver Energy Ltd. Project represented this concept. It proposed a large plant producing 200,000 tons per year (615 tons/day) with its own ship loading facility. Bio-mass burning power plants in California were the intended market.

Vancouver Energy Ltd. indicated that their potential market in northern California would consist of 17 co-generation plants which were located within 200 miles of the port of Antioch, CA. These plants ranged in size from 4 - 55 megawatts and would generate a total of 335 megawatts. The fuel consumption of these 17 plants would be approximately 2,000,000 B.D.T.'s per year.

For the following reasons this apparent opportunity has diminished in the past two years.

Jim Tischer, who purchases fuel for four 25-megawatt power plants in California, owned by Thermo-Electron, has provided the following information:

- The shortage of bio-mass fuel has been reduced in the Antioch area to approximately 150,000 tons per year. In April, 1991 the Gaylord Container Pulp Mill in Antioch, east of San Francisco shut down. Its supply of hog fuel is now available to the power plants.

  A major facility, Urban Wood Waste, has been built in Hayward, CA to convert pallets and demolition debris into fuel. The planned output is 300,000 tons per year.

  Three Thermo-Electron plants will start burning some natural gas in 1992. Their operating permits allow up to 25% gas to be burned for "flame stabilization." The price of gas is now low enough to be attractive.

- The experience with burning hog fuel from B.C. was unsatisfactory. The salt content was too high. Their boilers were not built to withstand salt corrosion. More importantly, the salt caused a visible plume from the stack, which is not permissible in California. The plume became visible even when the fuel contained only a small proportion of B.C. hog.

- The price of fuel has dropped in the San Francisco Bay area to \$35 - 40 per B.D.T. delivered. The Thermo-Electron forecast is to purchase 170,000 B.D.T.'s in 1992 for \$36.50 U.S. per B.D.T.

This indicates three major problems for a B.C. producer:

1. A project is not economically feasible at the current price.
2. Salt content is a major deterrent
3. The size of the market is smaller

The cost of delivering pellets from the Vancouver area by ship to power plants in California is high. Specialized facilities are required for efficient ship loading and unloading. Covered storage facilities are required at both dock terminals. The pellets have to be loaded and trucked to the power plants. The current price in California is about the production cost of a B.C. plant excluding the freight costs.

Review of the market in the area adjacent to the Port of Antioch, CA, which was chosen by Vancouver Energy Ltd., as being the most likely, showed a negative return. This indicates that inland areas of California would be even less attractive.

B. <u>Residential Pellets - Western Canada & U.S.</u>

The first pellet stoves were exhibited at the Portland Energy Show in 1983. One estimate is that 100,000 stoves have been purchased in the U.S. since then, mostly in the Pacific North-West.

There are about 30 pellet plants in the North-West including 5 or 6 large plants. There have been a number of unsuccessful pellet plants. According to Helmet Resch, *Forest Industries Magazine, December, 1989* "By 1986 about 40 such plants had been in operation but at least 19 of the 40 had closed."

Currently, the supply and consumption of pellets is about in balance. Some people predict a future shortage of pellets. Some people predict higher pellet production from existing plants. The balance is uncertain.

Existing Demand

B.C.

The residential consumption of pellets is directly related to the number of stoves that have been purchased. A large distributor of pellet stoves in B.C. estimates that there are presently 3,500 - 4,000 stoves in B.C. The average consumption of pellets is reported to be 2 - 3 tons per year. This indicates that the current annual consumption is approximately 10,000 to 12,000 tons per year. Vancouver Island is reported to consume 5,000 - 6,000 tons per year.

According to a recent report the total amount of wood fuel pellets sold in Alberta and the East Kootenay area in B.C. during 1991 was approximately 10,000 tons (This estimate is probably too high).

Alberta

The present consumption in southern Alberta is probably about 3,000 - 4,000 tons per year. At a low freight cost southern Alberta can be supplied from the Lignetics plant in Idaho or the Eureka plant in Montana.

U.S. Pacific North-West

Because there are large pellet plants located in Washington and Idaho, which are within 300 miles of the I-5 corridor between Washington and California the volume that could be presently sold from a B.C. plant is difficult to estimate.

Potential Demand

Forecasts vary about future sales of pellet stoves. Those from stove distributors and manufacturers are probably optimistic. Pellet stoves are popular in certain areas whereas in other areas there are virtually no sales. Stoves are popular in rural areas where natural gas is not available. In B.C., it is interesting that pellet stoves have not been popular in Whistler, a fast growing resort community which does not have gas. Vancouver Island, the Kootenays and the Okanagan are areas where more pellet stoves have been purchased.

Also, an increased awareness of clean air favours the use of pellet stoves over wood stoves. A B.C. stove distributor said he sold 500 stoves in 1986 and 1,500 stoves in 1991, with a further increase expected in 1992. The rate of increase of stove sales on Vancouver Island will decline because a natural gas pipeline has recently been completed to Vancouver Island and the distribution system is being installed. One estimate is that the B.C. consumption of pellets could increase to approximately 20,000 tons by the 1995 - 96 burning season.

In Alberta, where natural gas is prevalent, pellet stove sales are targeted at upper scale customers who want an attractive, easy to use fireplace which is also energy efficient.

One of the largest stove producers, Pyro Industries, Burlington, Washington, who make Whitfield stoves, indicate that their stove sales are increasing year over year, but are starting to reach a peak.

Pellet Supply

a) British Columbia

In B.C., there are currently two small pellet plants in operation and one starting up. There are at least two other prospective plants.

1) Ag Pro Can Inc., Creston, B.C.

This plant, which cost about $1 million, was built to pelletize alfalfa. This winter, for the first time, the equipment was used to make fuel pellets. The production was approximately 2,000 tons on a single shift basis.

The plan for next winter is to produce approximately 6,500 tons on a 3-shift basis, five days per week. The plant has one California pellet mill which produces 2.5 tons per hour. Most of the production will be sold in B.C.

and Washington. (They have shipped a small quantity to Williams Lake, B.C. and Regina, Saskatchewan.) They sell pellets in 40-lb bags which are returnable. The price to dealers, f.o.b. plant is $78 per ton. The retail price, f.o.b. plant is $115 per ton.

2) <u>Selkirk Remanufacturing Ltd., Castlegar, B.C.</u>

This lumber remanufacturing plant installed pellet equipment to utilize its sawdust and shavings. It has a dryer and a 2-ton per hour California pellet mill. Its estimated production is 1,000 tons per year.

3) <u>Pinnacle Feed and Pellet, Quesnel, B.C.</u>

This plant has made some wood pellets. As soon as bags are delivered, production will commence.

The plant has a single pellet mill, a small California pellet mill "Century" model with a 125 Hp motor. This mill has a maximum output of 1 ton per hour. There is no dryer. Raw material is dry planer shavings.

The plan is to produce approximately 500 tons this summer during the dry season and stock pile it for sale later. Then production will be governed by the order file. Sales areas will be the Cariboo, Okanagan and Lower Mainland.

At an output of 8 tons per shift, this plant could produce 2,000 tons per year on a single shift or 4,000 tons per year or a double shift. There is also the opportunity to add a second pellet mill. (A dryer would also be needed so that sawdust could be used as well as planer shavings.)

4) <u>Presto-Flame, Victoria, B.C.</u>

This operation which presently makes fire logs has announced its intention to make pellets. It is expecting financial assistance from the B.C. government. The owner said that a pellet mill previously purchased is too small (1/2 ton/hour) and that he intends to purchase a 2 ton per hour machine. He expects to start production in May 1992. His sales area will be Vancouver Island and presumably his product will replace pellets brought in from Washington. On a single shift, the production would be about 3,000 tons per year.

5) There is a prospective plant to be built in Aldergrove with an indicated start up by September 1992.

This would supply the B.C. market, allowing for additional stove sales in the 1991-92 season.

b) U.S. Pacific North-West

According to the Fibre Fuels Institute, there were 8 pellet plants operating in January 1992 in Washington. (If Montana, Idaho, Oregon, California are added, the number of plants is 30.) There is also one plant, Pacific Densified Fuels in Arlington, Washington, which is presently shut down.

Information is not available on the capacity (tons/hour) of the plants in Washington nor of the number of shifts per day or days per year normally operated. Because of seasonal demand and competition for the available market, pellets plants usually operate far below full capacity. This implies that production could be substantially increased, assuming that raw material is available. Also, the Pacific Densified Fuel plant in Arlington, Washington, could be started up. This will probably occur.

Pellet Selling Prices

The following information on pellet prices was obtained during the course of this study: (Premium grade in 40 or 50 lb. bags:)

a) Dealer Price - f.o.b. pellet plant

U.S.		
• Lignetics, Idaho	$100	US/short ton
	or $118	Cdn/short ton
B.C.		
• Ag Pro Can Inc.	$80	/ton
• Pinnacle Feed & Pellet	$105	/ton

b) Retail Price

Western Washington		$150	US/ton or $175/ton Cdn	
B.C.	Langley	$160	/ton	Pres-to-Log
	Creston	$115	/ton	Ag Pro
	Victoria	$200	/ton	
Alberta	Edmonton	$200	/ton	Lignetics
	Edmonton	$150	/ton	Pellet Power

The pellet sales price at the plant to a dealer in bags is approximately $105 to $120 per ton. Ag Pro Can Inc., which has just started producing in an existing agricultural plant, is offering their product at a very low price of $85 per metric ton.

The retail price varies according to location. Freight cost is a major component of retail price. Also, product quality and more than one source of supply affect price.

The cost of trucking pellets, bagged and loaded on one ton skids, is $20 - $25/ton for a 300 mile haul, assuming that a large truck like a Super-B train can be used. This is exclusive of the cost of loading and unloading by forklift.

Summary

a) British Columbia

The present consumption of pellets in B.C., at about 12,000 tons per year, would not support an industrial-scale pellet plant. The consumption will grow as more pellet stoves are sold in certain regions. But even 20,000 tons per year is not sufficient to support a large plant.

Also, the production of pellets at several locations in B.C. is increasing. For example, production could be:

• Ag Pro Can Inc., Creston, B.C.	6,500	tons/year
• Selkirk Remanufacturing Ltd., Castlegar, B.C.	1,000	tons/year
• Pinnacle Feed & Pellet, Quesnel, B.C.	2,000	tons/year
• Presto-Flame, Victoria, B.C.	3,000	tons/year
• Aldergrove Plant	say 3,000	tons/year
Total	15,500	tons/year

This would supply the B.C. market, allowing for additional stove sales in the 1991 - 92 season.

For B.C., supplying the modest demand from several small pellet plants is economically sound. Because of the seasonal pattern of consumption having another business assists small entrepreneurs to maintain a year-round cash flow.

b) Alberta

Southern Alberta is close to large plants in Idaho and Montana. In central and northern Alberta, the B.C. pattern of one or more small plants could develop.

c) U.S. Pacific North-West

Both the consumption and production of pellets is high in this area compared to the rest of North America.

For a mild winter, current production appears to satisfy demand. For a cold winter demand would probably exceed supply. However, unused plant capacity could satisfy the shortage.

A large new pellet plant in B.C. would face formidable competition for a market share in the U.S. Pacific North-West from existing producers, both in terms of volume and price.

III. Offshore

The Terms of Reference ask for an assessment of market opportunities in offshore countries such as India, Taiwan and Korea. These and other Asian countries can be reached by direct shipping lines and the availability of indigenous fuels is generally limited.

In many Asian countries wood and charcoal are used as a residential fuels for cooking and heating. These fuels are obtained from local forests and woodlands, which in many cases are being over-utilized. In the larger urban centres, bottled fuels such as propane and liquid fuels such as kerosene are often the main domestic fuels. In richer Asian countries, such as Korea and Taiwan, coal is often used as a domestic fuel. Imported wood pellets could potentially be used in place of all these domestic fuels.

Industrial users in Asia tend to consume fossil fuels, mainly coal and petroleum products, which are often imported. In rural areas, some small industries use wood and charcoal fuels. It is possible that these fuels could also be replaced in some cases by wood pellets.

The ability to sell wood pellets to replace existing domestic and industrial fuels in offshore markets will depend on reliability and convenience of the pellets supply and mainly on the cost of wood pellets compared to the fuels currently available. Consumers will not likely switch to another fuel unless there would be a significant cost saving.

The major expense to supply wood pellets to offshore markets would be transportation; the costs of pellet handling during shipping and receiving and ocean freight charges. There are three possible methods of shipping wood pellets from B.C. to offshore markets; bulk cargo, break bulk and containerized. Typical current transportation charges applicable to wood pellet shipments from B.C. ports are shown in Table 1.

Wood chips, coal, grain, sulphur and phosphates are commodities currently shipped from B.C. as bulk cargo. To achieve low shipping costs, bulk shipments are made in large ships (25,000 to 50,000 dwts) which are loaded at specialized, dedicated, terminals facilities. The quantity of material for bulk cargo must be relatively large, typically 500,000 to 1,000,000 t/a, to justify the costs of the specialized loading and unloading facilities.

Bulk shipping of wood pellets is currently not considered to be a realistic option. The volume of pellets that could be made would not likely be sufficient to justify development of required terminal facilities. Freight to a port and the covered storage required for the pellets at the port would add to the cost of the pellets. Special handling facilities, including a high capacity off-loading system, covered storage, and fire and explosion prevention systems, would also be required for receiving the wood pellets.

Table 1 - Estimated Shipping Costs of Wood Pellets to Asian Markets

	Item	US$/t
Bulk (1)	- Freight to Coastal Port (assume 500 km)	20 to 30
	- Loading B.C. Port Charges	5 to 10
	- Ocean Freight (40,000 dwt ships)	15 to 30
	- Off-loading, Local Freight & Handling	10 to 20
	- Total	50 to 90
Break Bulk	- Freight to Coastal Port (assume 250 km)	10 to 15
	- Loading B.C. Port Charges	10 to 20
	- Ocean Freight	50 to 75
	- Off-loading, Local Freight & Handling	10 to 20
	- Total	80 to 130
Containerized	- Freight to Coastal Port (assume 250 km)	10 to 15
	- Loading, B.C. Port Charges, Ocean Freight	80 to 125
	- Off-Loading, Local Freight & Handling	10 to 20
	- Total	100 to 160

Note (1): Requires specialized ship loading and off-loading terminal facilities.

Break bulk shipping is currently used for wood pulp and lumber. To ship pellets in this manner would require packaging of the pellets into units suitable for cargo handling, such as bulk bags. The total costs for break bulk freight and handling are estimated to be a 80 to 130 US$/t from a B.C. port facility to the offshore pellet user.

Containerized shipping of bagged and palletized wood pellets would minimize port handling and it would ensure the pellets remain dry during transit. The transportation cost for containerized pellet shipments to Asia is estimated to be 100 to 160 US$/t.

There are no established markets and selling prices for wood pellets in these offshore countries. However, pellet prices will be related to the current costs of other fuels, for which the pellets would be a substitute fuel. The energy equivalences of several common fuels compared to a tonne of fuel oil are shown in Table 2. It can be seen in Table 2 that a tonne of wood pellets contains about the same amount of energy as 0.45 tonnes of fuel oil. Coal and charcoal contain more energy than wood pellets, while wood contains less, as it is equivalent to about 0.38 tonnes of fuel oil.

Table 2 - Energy Equivalence of Various Fuels Compared to Fuel Oil

Fuel	Typical Higher Heat Value kJ/kg	TOE*/t
Wood Pellets	19,000	0.45
Fuel Oil	42,000	1.00
Kerosene	43,000	1.02
Coal	28,000	0.67
Wood (air-dried)	16,000	0.38
Charcoal	32,000	0.76
Natural Gas in kJ/m^3	37,000	—
Electricity in kJ/MWh	3,600	—

*TOE = tonne of oil equivalent

The cost of fuel oil varies widely from country to country, but currently it is available for about 200 to 250 US$/t delivered to large industrial users in several Asian countries. If it assumed that the delivered cost of imported fuel oil is 250 US$/t delivered to industrial consumers, the equivalent selling price of the other fuels, based on the equivalent energy content can be estimated. This is illustrated in Table 3. There are many factors that affect the net energy available from these fuels, however, Table 3 gives an approximate comparison.

Table 3 - Fuel Values Based on an Energy Equivalence to Fuel Oil
(Based on a Fuel Oil Price of 250 US$/t)

Fuel	US$/t
Wood Pellets (<10% moisture)	113
Fuel Oil	250
Kerosene	255
Coal	170
Wood (air-dry)	95
Charcoal	190
Natural Gas - in US$/m^3	0.22
Electricity - in US$/MWh	21

Wood pellets selling at 113 US$/t would be comparable to the current price of fuel oil to large industrial users. The costs of making the wood pellets plus shipping costs from B.C. to Asian countries. Table 1, would be 120 to 200 US$/t. Offshore pellet sales are not considered to be financially viable. For industrial use, wood pellets would compete with coal, which currently sells internationally for about 60 US$/t, equivalent to only 35 percent of its gross energy value compared to fuel oil.
For residential use, imported pellets would compete with local biomass fuels as well as coal and oil. For example, in India rural dwellers do not use commercial fuels and get their fuel wood free at a very low cost. In many urban areas of India, quality fuel wood currently sells for 40 to 45 $/t. This, as shown in Table 3, is equivalent to about half of its energy value compared to fuel oil at 250 US$/t. In both the rural and urban situations in most Asian countries, the costs of transportation would make imported wood pellets uncompetitive with the fuels currently used.

In most offshore countries, particularly poorer developing countries, it would not be cost effective compared to other fuels, to spend scarce foreign currency to import relatively low energy wood pellets. Overall, offshore markets for wood pellets from B.C. are not attractive. Other fuels are readily available and these are significantly cheaper compared to imported wood pellets.

APPENDIX 6

WOOD RESIDUE FOR PELLET MANUFACTURE

Wood Residue for Pellet Manufacture

Wood Residue for Pellet Manufacture

General

Wood residues are produced both by wood products manufacturing plants and by logging. The residues from manufacturing plants are typically bark, sawdust, shavings and occasionally trim ends. Chips, because of their value to pulp mills, are not considered to be residue. From forest operations residues accumulate at logging sites and at dry land log sorts in the form of bark, branches, slabs and chunks.

Wood products plants include sawmills, plywood plants, particle board plants, shake and shingle mills and lumber remanufacturers. Residues from these plants are produced in a form which is cleaner and more suitable for use than logging residues.

For manufacturing pellets the quality, and to some extent, species of the wood residues available is critical.

Whether or not the residues available have been derived from logs which have been transported or stored in salt water is an important fact. Salt penetrates into the bark and wood to some extent. Even a small amount of chloride in pellets or hog fuel can be detrimental for burning. Chlorides can cause severe corrosion in pellet stoves and unacceptable air emissions in many industrial burners.

In B.C., at the locations where wood products plants are located and where logging is occurring there is a surplus of wood residues which is not being utilized. They are being disposed of by incineration or land filling, both of which can have adverse environmental effects.

The volumes of the different types of mill residues produced in B.C. in 1989 and the current type of utilization or method of disposal is provided in a comprehensive report prepared in 1990 for the Ministry of Forests Wood Residue Task Force. (This is published as *British Columbia Forest Industry Mill Residue for Calendar Year 1989*, Province of British Columbia, Ministry of Forests.)

Case I — Lower Fraser Valley

In the Chilliwack Forest District very large volumes of residues are produced. The figures for 1989 are indicated below:

Sawdust	1,945,382	m^3 SWE
Shavings	259,127	m^3 SWE
Trim	141,296	m^3 SWE
Yard Debris	46,700	m^3 SWE
Total	2,392,505	m^3 SWE
Bark	892,420	B.D. Tonnes

About 50% of the bark and 64% of the wood residues are presently being utilized. The largest use is for steam generation at coastal pulp mills. This mixture of bark and wood material, known as hog fuel, is usually shipped by scow. Because there is a surplus of hog fuel, the sawmills do not receive any net revenue. The pulp mills pay only the transportation cost.

Some sawdust and shavings are used for pulp manufacture. There is one particle board plant (MacMillan Bloedel K 3 plant) and one hardboard/moulded fibre plant (Canfor) which use some wood residue (not bark).

More than 90% of the logs which are used to make wood products in this area have been either stored or transported in salt water. As discussed previously, residues which contain salt are not suitable for combustion in pellet stoves or in many types of industrial burners. (Local pulp mill boilers have been built to prevent severe corrosion.)

In 1989/90 Lignetics Inc., which operates a 150 ton per day pellet plant in Idaho, considered building a pellet plant in this area. They collected samples of residues from several mills. Analysis indicated that the salt content was too high. (Chloride content is one of the five standards for residential pellets. The Fibre Fuels Institute in the U.S. indicates that the chloride content should be less than 300 parts per million.)

Also, Vancouver Fibre Fuels shipped some hog fuel to California to be used for power generation. The salt content was found to be too high. (The moisture content was also too high.)

Because of the salt content most of the hog fuel produced by mills in the Lower Fraser Valley is not suitable for making residential pellets.

Lignetics also found that the predominant Coastal species, Hemlock, Balsam and Cedar produce pellets whose ash content exceeds the 1% standard for premium grade pellets. Douglas Fir sawdust was the preferred material.

The Cedar residues produced by shake and shingle mills in this area could not be used to make premium grade pellets because the ash content would exceed 1%. Cedar residues could probably be used to make standard grade pellets or industrial briquettes.

Floating wood debris is collected in a trap on the Fraser River near Agassiz. This is operated by the Debris Control Board which is funded by the Federal Government, Provincial Government and Forest Industry. During freshet, both natural and man-made debris comes down the river and is now caught by the trap. Later in the year the material can be recovered or burnt. However, this material is a mixture of trees with roots attached, branches, slabs, bark, chunks, etc. It is a mixture of coniferous and deciduous species.

Like logging and log yard residue, it is not suitable for manufacturing pellets for residential stoves. It does not contain salt, which is an advantage. It is so variable that a pellet plant could not adequately maintain the consistent feed stock necessary to make a high-quality pellet.

Some firewood is being cut by prisoners for the Provincial Parks Branch. Producing pulp chips from some of the material was attempted one year but at the current chip price was not viable.

It is not yet known whether a pellet suitable for industrial burning can be made from the residues available in the Lower Fraser Valley area.

Vancouver Energy Ltd. started to build a large (600 ton/day) briquette plant in Delta whose production was intended for sale to power plants in California. This plant was not completed and product acceptance was not proven.

B. H. Levelton and Associates Ltd. in Richmond have been working for several years to develop a water-resistant densified fuel. A pilot plant has not been built and not enough product has been made for burning trials to be conducted. This process can use hog fuel, including a high proportion of bark. The densification process reduces the salt content to one-third that of the hog fuel feed stock. This process could become commercially viable. Advantages would be increased heat value, lower salt content, lower transportation cost and suitable for outside storage.

There are several dry land log sorting yards along the Fraser River from which salt-free residue could be obtained. However, this is not a preferred type of material for making pellets.

Probably enough salt-free sawdust and shavings could be obtained for a small residential pellet plant, either from salt-free log sawmilling or from remanufacturing plants.

Case II — Merritt

The following examination of the wood residue available in the Merritt area will also provide typical information which is generally applicable to other B.C. Interior locations.

Because logging residue is much less suitable for pellet manufacture and more costly to obtain, only mill residues will be considered.

There are three sawmills which produce mostly dimension lumber and one smaller mill that produces more specialized product. The Tolko mill also produces veneer for plywood manufacture at another site.

The company names and single shift lumber capacity are indicated below:

Weyerhaeuser Canada Ltd.	225 M bd. ft. per shift
Aspen Planers Ltd.	160 M bd. ft. per shift
Tolko Industries Ltd.	120 M bd. ft. per shift
Ardew Wood Products Ltd.	75 M bd. ft. per shift

Each of these operations has a log yard associated with it. NMV Lumber Ltd. operates a remanufacturing plant in Merritt. In 1990 it processed approximately 23,000 M board feet of lumber and produced 6,000 tons of sawdust, shavings and trim ends.

The amount of wood residue produced in 1990 by the sawmills can be calculated from their log consumption, as indicated in the following table:

1990 - Volume of Wood Residues Produced in Merritt, B. C.

Company	Logs Cut (m^3)	Wood Residues (Wet Tons)		
		Log Yard	Bark	Sawdust & Shavings
Weyerhaeuser	441,000	11,000	70,000	53,000
Aspen Planers	198,000	5,000	32,000	24,000
Tolko	394,000	10,000	63,000	35,000
Ardew	61,000	2,000	10,000	7,000
NMV Lumber	—	—	—	6,000
TOTAL		28,000	175,000	125,000

The most desirable residue for pellet manufacture is sawdust. Planer shavings can be fractionated to sawdust size and mixed in. This mixture is uniform, clean and has a lower moisture content than log yard residue. Shavings are planed off kiln-dried lumber and have a moisture content of 18-20%. Most of the sawdust is produced in the sawmill. It has a moisture content of 45-50%. This mixture requires drying before pellets can be made.

The combined volume of sawdust and shaving produced in 1990 by the operations in Merritt was approximately 125,000 tons.

The Weyerhaeuser pulp mill in Kamloops uses some sawdust and shavings to make pulp. The volume used is much less than what is produced in the Kamloops area. The pulp mill has a choice of suppliers and has a record of intermittent purchases. The 72,000 tons of sawdust and shavings produced in Merritt, exclusive of the Weyerhaeuser mill, could be obtained for pellet manufacture. The balance required for a 50,000 ton per year pellet plant would be about 16,000 tons per year. This would be trucked 50 miles from the Weyerhaeuser mill in Princeton where the entire output of sawdust, approximately 65,000 tons per year, is presently being incinerated. The trucking cost would be about $8.00 per ton.

The sawmills in Merritt supplying sawdust would also supply hog fuel for the dryer in the pellet plant.

For the purpose of this study there is enough suitable residue in the Merritt area to support a 50,000 ton per year pellet plant.

Case III — Queen Charlotte Islands

1. **Mill Residues**

The volume of mill residues is very small. There are two small sawmills. The sawmill owned by Abfam Enterprises Ltd. and located at Port Clements produces approximately 45 M bd. ft. of lumber per shift, is operated only one shift per day, and does not operate continuously, as indicated below:

1988	70	days
1989	170	days
1990	220	days
1991	120	days

The 1992 forecast is to operate approximately 200 days. This mill is cutting Western Red Cedar principally and a small amount of Lodgepole Pine. Rough lumber is shipped by barge to Vancouver. Because the mill does not have a barker or chipper the residue is mostly slabs, edgings, and trim ends.

According to the owner, Jim Abbott, the amount of residue produced is about 50 tons per day or 10,000 tons per year based on the forecast 200 operating days for 1992.

The other sawmill, QCI Sawmill Ltd., is located at Masset. It is a very small mill which produces approximately 15 M bd. ft./shift. Its operating experience is:

1988	230	days
1989	200	days
1990	200	days
1991	100	days

In 1992 the mill is forecast to work 200 days cutting mostly Cedar and some Hembal. The mill does not make chips. The 1992 volume of residue will be approximately 10 tons per day or 2,000 tons per year.

2. **Logging Residues**

The forest harvest level on the Queen Charlotte Islands has been reduced to approximately 1.8 million m^3 (water scale basis) per year. MacMillan Bloedel Limited has the largest cutting rights, approximately 1,050,000 m^3 per year, most of which are on Graham Island.

The only concentrated sources of logging residue are the dry land log sorting yards. Logs are delivered to these yards for scaling, grading, bucking and sorting prior to shipment by log barge. This process produces wood residues.

There are two types of log yards; paved and unpaved. Log yard debris from an unpaved yard contains a large amount of dirt, gravel and rock mixed with the wood residue.

Geographically, the dry land sorts are at several locations, some of which are not accessible by road. Some logs are sorted in the water without producing any debris that is collected. MacMillan Bloedel Limited operates six dry land sorts. The location and the annual volume of logs processed is indicated below:

Ferguson Bay	350,000 m^3
Skidegate	200,000 m^3
Aleford	45,000 m^3
Deenan Bay	150,000 m^3
McClinton Bay	150,000 m^3
Moresby Island	150,000 m^3

The two largest yards, at Ferguson Bay and Skidegate, are paved. They are also accessible by road to Port Clements, which is a central location on Graham Island. The small yard at Aleford, which is accessible by road and ferry to Port Clements, is an unpaved yard. The other three are accessible by scow.

The typical volume of log yard residue produced on a paved sort is approximately 4 m^3 loose piled per 100 m^3 of logs processed. For an unpaved yard debris accumulates at the rate of 6 m^3 per 100 m^3 of logs processed.

To put this in perspective, MacMillan Bloedel Limited would, in the course of logging 1,050,000 m^3 per year, develop approximately 52,500 m^3 of debris. This is equivalent to 52,500 wet tons per year.

There are several small log sort yards. There is one associated with the Abfam Mill which processes approximately 65,000 m^3 of logs per year, including the logs cut in the mill. There is a small log yard near Queen Charlotte City.

If log yard residue is to be utilized at a central location the form of the material to be transported and the mode of transport will affect the delivered cost. From the paved sorts, the residue could be loaded onto a truck or barge in the form it develops. This material is very bulky and would be difficult to load. If a large hog was installed at a paved log sort the material could be reduced to hog fuel and transported more economically.

Debris from an unpaved log sort yard contains so much dirt, sand, gravel and rock that it is not suitable for use without prior cleaning. Equipment is now available which will separate the foreign material and convert the wood to hog fuel.

Log yard residue after cleaning and hogging is not suitable for the manufacture of pellets for residential burning. It has a high proportion of bark, and consists of mixed tree species. It is not uniform enough to make into a high quality pellet with a low ash content. Even for industrial grade pellets log yard residue would not be a preferred material because of its variability and cost of preparation.

Wood residues also accumulate at the actual logging sites. This material is difficult to collect and to transport. It consists of bark, branches, log chunks, etc. and would contain dirt and gravel. It is not suitable for pellet manufacture without expensive processing.

The following table provides a rough estimate of the volumes of residue produced at concentrated sources such as sawmills, and dry land log sort yards.

	Volume/Year (Wet Tons)
Sawmill Residues	
Abfam	10,000
Q.C.I.	2,000
Log Yard Residues	
MacMillan Bloedel	52,000
Other log yards	15,000
Small yards	5,000
TOTAL	84,000

There is also wood residue generated at the various logging operations on the Queen Charlotte Islands. This includes logging debris which accumulates besides roads and at landings.

There is only a small quantity of the preferred type of residue for pellet manufacture.

However, the residues available are a potential fuel source for a small power plant. It is not possible to estimate the delivered cost of residue without knowing a specific location. Only two of the large log yards are accessible by road. The others are accessible by water which indicates transport by scow or barge, for which no facilities presently exist.

Also, because residue from unpaved yards contains so much dirt and rock it could require cleaning before burning. This would depend on the type of burner installed.

Residue would probably be made into hog fuel and burned in that form. The cost of making pellets need not be incurred. Hog fuel can be burned cleanly and efficiently.

A proposal to build a small thermal power plant at Port Clements is being prepared by a group which includes Jim Abbott, the owner of Abfam Enterprises Ltd. and Gerry Johnson, Resource Management Ltd., both resident in Port Clement. Their proposal will include the types of fuel to be used and their respective costs. B.C. Hydro has met several times with this group.