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# ECONOMICS OF PELLET PRODUCTION FOR EXPORT MARKET

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**Abstract**

Due to its renewable, clean-burning and cost-stable for home heating, wood pellet is gaining popularity day by day throughout North America. The use of pellets in co-firing with coal enhanced its utilization suddenly in Europe. As a result, some countries in Europe are planning to import wood pellets from Africa, America or neighboring European countries due to the shortage of wood in long term basis. This study focuses on the pellet production in Canada and its export to Sweden or the Netherlands. The transport and supply logistics were analyzed. The results showed that the total production cost of pellets was US$46.8 per metric tonne and among which 4.5 US$/tonne was the capital investment. The transport and supply logistics cost estimated as US$ 96.1 or 89.1 per tonne for exporting to Sweden and the Netherlands, respectively. The internal rates of return for the two cases were estimated as 24 and 37%, respectively, with a plant life of 10 years and the payout periods of 4 and 3 years, respectively.
**Keywords:** wood pellet, sawdust, pellet transportation, supply logistics.

## INTRODUCTION

The main problems of using biomass energy are its high moisture content and low heating value per unit volume. Pelletizing biomass enhances its volumetric density and calorific value, and improves its handling characteristics and combustion efficiency (Moran 2004). The raw materials for pellets are by-products from the lumbering, milling, woodworking and pulping industries. The pellets are of diameter of 6-12 mm, length of four times the diameter, energy content 3,120 kWh per cubic meter and dryness fraction of 92% (PiR 2006).

Pelletization has become a proven technology for improving biomass properties for its conversion into heat and power. There are currently more than 600,000 homes in North American using wood pellets for heat, in freestanding stoves, fireplace inserts and even furnaces (PFI 2006). Pellet fuel for heating can also be found in such large-scale environments as schools and prisons. Canada and the United States are the main producers of pellet in North America. The pellets are available for purchase at fireplace dealers, nurseries, building supply stores, feed and garden supply stores and some discount merchandisers. In short, pellet fuel is a way to divert millions of tons of waste from landfills and turn it into energy. The pellet production in Northern America was approximately 1.1 in 2004 and is expected to increase to 1.37 million tonnes in 2005 (Bioenergy 2000). Over the last few years the installed pellet production capacity in Europe has increased significantly and currently amounts 4.1 to 4.55 million tonnes annually (Bergman 2005). Biopellets market is becoming quite mature with serious outlets in the domestic market (heating) and the energy market (heat and power).

Biopellets are mainly attractive for power stations since they are composed of small particles. Therefore they can be readily crushed in coal mills and the resulting particles can be conveyed to the pulverized fuel burners just like coal powder. Many of European countries like the Netherlands are consuming pellet co-fired with coal in power plant. Dutch energy sector has a plan to replace coal with pellet by an amount of 5.46 million tonnes/year in 2008-2010 (Bergman 2005). Sweden is at present time the biggest producer of wood pellets in Europe, with a production exceeding 910,000 tonnes per year (Vinterback 2004). Sweden also imported about 163,800 tonnes of pellets and exported about 60,000 tonnes of pellets (Fernstrom 2002). About 13% of the pellets are utilized in small-scale boilers (<500kW) during 1998 (Danielsson 1999).

Wood pellet heating systems are considered an essential component of European plans to reduce green house gas (GHG) emissions to meet the obligations of the Kyoto Protocol and are targeted by incentive programs in countries such as Germany, Norway and Sweden (Malisius 2000). Sweden, the Netherlands and, to a lesser extent, Spain and Portugal, are currently export markets for Canadian wood pellets. Mactara Forest Products in Musquodoboit of Nova Scotia exports approximately 54,600 tonnes of bark pellets to industrial markets in Europe (Jannasch 2001). The purpose of this study is to analyze the economic feasibility of exporting wood pellet from British Columbia of Canada to European countries like Sweden and the Netherlands.

## COMPONENTS OF THE PELLET PRODUCTION FACILITY

Pellets are mostly manufactured from waste products from sawmills and other wood processing industries. The materials used include woodchips, sawdust and bark. No chemical additives are needed, with the natural lignin of the wood itself serving as a binder, although sometimes small quantities of maize starch are added as well. Pellets are attractive fuel due to less volume to transport and store (due to higher energy density), fewer deliveries, consistent size and moisture content, versatility. It can be used in stoves and boilers, easier to handle and ignite, less ash and emissions. It is dry and can be stored without degrading. It flows like a liquid and can be used in automatic machinery. The core process of the wood pelleting plant comprises of 5 stages (shown in Fig.1): drying, milling, pressing, cooling and screening. Wood pellet production and logistics are shown in Fig.2.

### Drying

Green woodchips contain about 50-65% moisture content. High moisture content in the raw material will obviously increase the drying costs of the material. Moisture acts as one of the binding agents in the pelleting process. However, too much moisture makes the feedstock slippery and it slides through the holes too easily, thereby reducing pellet quality (Päivi 2001). So the material is dried to about 7-8% moisture content. The opinions vary regarding optimum moisture content. Pellets normally contain 8–15% moisture on the wet basis (wb), but according to Gunnerman (1977), who worked with high pelletizing temperatures (up to 180ºC), the optimum moisture content for the pellets was 17–20% wb. The temperature and moisture content are such that the lignin acts best as a pellet binding agent to obtain the necessary malleability of the product. This is the most critical stage of the process to achieve an optimum performance of the pellet press and to minimise wear on the press die and rollers. All existing dryers – drum dryer, steam dryer (direct or indirect) and hot air dryer – are in use.

### Milling

The raw material has to be milled to produce uniform material for feeding to the pellet mill. A hammer mill is normally used. The screen size depends on the diameter of the pellets to be produced. The hammer mill is normally powered by an electric motor. The energy is converted into heat, which is also used to extract further moisture from the raw material at this stage.

### Pressing

The dried product passes over a permanent magnet to remove any ferrous metal before it is fed into the press chamber of the pellet press. It is carried out in a normal pellet mill. Loose material is fed into the pelletizing cavity. Die rotation and roller pressure force the material through die, compressing it into pellets. Adjustable knives cut the pellets to the desired length. Pellet mills can be of the flat-die or vertical mounted ring die type. No additives are normally used and often done with dry steam conditioning. The lignin in the wood acts as a binding agent as it softens during the pelletizing process (Samson 2000). As with the hammer mill, a certain amount of additional moisture is extracted with the pellet mill.

### Cooling

Wood pellets leave the pellet mill at a temperature of about 100°C and need to be cooled down to about 25°C to harden, stabilize and form the wood pellet and to maintain the quality of the product during storage and handling. The cooling down process takes place in the counter current pellet cooler and is controlled with adjustable gates on the vibratory discharge hopper.

### Screening

The finished wood pellets are finally passed over the vibratory pellet screen to separate the fines from the pellets. The fines are returned to the process, whereas the dust free wood pellets are ready for storage or packaging. Normally the pellets are bagged automatically in 25kg, 40lb or big bags or stored in a silo.

## PELLET TRANSPORTATION

### Truck transport

It is generally applied for relatively short distances (< 100 km). Truck can reach to the remote areas of the production sites where train or ship infrastructure is absent. Cost and capacities of truck transport depend on the distances, scale, dedication, and legislation. The gross truck weight is restricted due to the forest road condition. Both transports from the forest to a terminal and from a terminal onwards to a harbor are likely to be dedicated: the trucks are only used for biomass transport and are thus empty on their return. Truck can be used in three cases of supply logistics of wood pellet.

- Transport from the production site to a terminal
- Transport from the terminal to the export harbour
- Transport from the import harbour to the energy plant

The first two logistics depends on the distance and type of truck used. The third transport link might be different as it is in other country. Different rules might apply for truck transport in different countries. The first truck stated in Table 1 is a Dutch truck with the maximum possible volume and weight capacity. The Swedish trucks have a capacity of 40 ton and 130 $m^3$. The last truck is solely used for transporting pellets. These trucks are specially equipped with spouts to quickly facilitate a large number of households with heating fuel. The bigger regular Swedish truck can also transport pellet at cheaper price. The truck capacities are restricted to the allowed gross combination weights (GCW) in different countries (Carlo 2003). Sweden/Finland, Norway, Europe (rest), and Canada have the GCW of 60, 50, 40 and 63 tonnes and the load capacities of 40, 30, 25 and 40 tonnes respectively. The truck transportation cost and energy use is shown in Table 2 as depicted by Suurs (2002). The energy use was found out considering total amount of diesel consumed during transport and converted it into energy unit taking the LHV of diesel as 35.7 MJ/l. Average speed and transfer time are also important in truck transport. According to Suurs (2002), trucks can be loaded or unloaded at a rate of two truckloads per hour. A value of 240 $m^3$/h is assumed for logs, bundles and bales and a value of 260 $m^3$/h for chips and pellets. Depending on the average speed and loading rate it takes a certain amount of time per truck to fulfill one transport cycle.

### Train transport

Train transport is applied for the longer distances (>100 km). Train transport may bypass two transfer points, the exporting harbor and the importing harbor. This would bring down the costs and the amount of time needed and also reduce the storage facilities of the production site. But the logistic conditions in different countries are really far from ideal. At some borders the engine has to be changed or sometimes even the whole train because of difference in track width. Trains are considered to carry a volume of 2500 $m^3$ and 1000 t with an average speed of 75 km/h. The prices depend on the availability of return-freights, the total volume of transport in the same direction, the transfer terminal policies and the route. Train transport costs are shown in Table 3.

The calculation of energy consumption of train is a complex matter. According to Carlo (2003), an amount of 0.63-0.70 MJ/tonne-km energy is needed for a train of 800 tonne and 2400 $m^3$, including the energy embodied in the vehicle and infrastructure. So for a distance of 1000-1500 km, the total energy expenditure would be in the range 630 to 1050 MJ/tonne.

### Sea transport

It is the best means for long distance. It has more transfer points than that has train transport. But it has low variable costs and a low energy use per tonne.km compared to other transport means. Ocean ships exist in a wide capacity range, from less than one to several hundred thousand tons dead weight (dwt). The bigger the cargo capacity of a vessel, the more efficient a transport can take place. According to Carlo (2003), the different types of ships available for woody biomass transport are shown in Table 4. The first two vessels (CV-I and CV-II) in the table are conventional bulk carriers of different sizes. The Tornator type is a bulk vessel as well but of a smaller size. The fourth ship is a large capacity bulk vessel used by Citadel Shipping for intercontinental pellets transport. But it is not dedicated to this type of cargo only.

In practice, ships are often hired on charter basis for a specific voyage (including bunker, canal tolls and port charges) or defined time. Prices change with routes, time, and market. Therefore, for an established biomass market, cost for a longer time period can best be derived from ship prices. Ship prices for various sizes of new and second hand bulk carriers and crude carriers are proportional to the cargo capacity (Suurs 2002). The costs for sea transport consist of capital costs, operation and maintenance costs, fuel costs, transfer costs and port charges.

## ECONOMIC ANALYSIS

The economic analysis performed on exporting wood pellet to Europe (mainly Sweden and the Netherlands) was based on estimations of the required capital investment, total production costs and cost of supply logistics. The whole process was evaluated on the basis of a discounted cash flow analysis to determine the internal rate of return and the payout period of the investment. A potential production and supply chain was set up in close collaboration with pellet producers to estimate the cost of logistics. This chain elaborates the involved costs of the production of pellets from sawdust in Canada and consumption in the power plants in Sweden and the Netherlands.

### Features of pellet plant design

The approach involved the design of a model industrial operation for pellet production, the assembly of data for the purchase and assembly of its components, and the estimation of its operating expenses, resulting in an estimate of pellet production costs. Information on pellet production was collected from various technical sources, including engineering firms that provide pellet processing expertise, equipment suppliers, and researchers and practitioners experienced with this topic. In the choice of construction materials, the most economical of available options was chosen.

In order to make an economic evaluation of pellet production, the different types of costs are divided mainly into capital and operating costs. Capital cost includes the cost of process equipments, installation, storage facilities, utility equipment, land, building and other infra-structure development. The purchase costs of different equipment are collected from the equipment manufactures and published literature sources. Inflation factors have been considered to find the equipment cost. Installation cost varies in the range of 40 to 75% of the purchase cost depending on the equipment (Mani et al 2006). Some equipment costs were based on Perry and Green (1999) and Walas (1990), information from equipment suppliers, and historical equipment costs from other sources. Cost analysis of dump trucks, front-end loaders and forklifts is based on the ASAE standard EP496.2 (ASAE 2004). When the specific equipment cost for a particular capacity was not available, the following cost vs. capacity relationship was used (Ulrich 1984).

$$C_{eq1} = C_{eq2}\left(\frac{C_1}{C_2}\right)^x \qquad (1)$$

$C_1$ and $C_2$ are the capacity of equipment 1 and 2, x is the exponent for the capacity of equipment (assumed as 0.6), $C_{eq1}$ = equipment cost ($) for the capacity $C_1$, and $C_{eq2}$ = equipment cost ($) for the capacity $C_2$.

The annuity (annual capital costs) can be calculated by multiplying the capital recovery factor (CRF) stated in equation (2) with the investment costs.

$$CRF = \frac{(1+i)^n i}{(1+i)^n - 1} \quad (2)$$

Where i is calculated interest rate in %, n is the utilization period in years. No investment subsidies are considered for the calculation of the pellet production costs.

The annual maintenance costs are calculated in percent of the whole investment costs on the basis of guiding values and are evenly spread over the years of the utilization period. The capital and maintenance costs are calculated for each unit of the overall pelletization plant, taking the different wear and utilization periods into consideration. The total capital and maintenance costs can be calculated by addition of these subtotals.

The interest rate considered is generally 6% per year. (no difference between own and outside capital). Operating costs include the costs of raw materials, utilities (electricity, gas or others), labor (operating, maintenance, supervisory and fringe benefits), supplies (operating and maintenance), and general works (general and administration, property taxes and insurance). The maintenance costs vary from 2-10% of purchase cost depending on the type of equipment, wear and tear during operation (Mani et al 2006). The thermal energy cost for the dryer and reactor depends on the type of fuels, fuel properties, combustion efficiency etc. The costs such as insurance, overall dues, taxes and administration costs can be calculated as a percentage of the overall investment costs. These costs are calculated according to experiences already gained from pellet production plants in operation (data from engineering companies, a questionnaire survey or discussions with plant operators).

**Pellet production cost**

Table 5 shows the assumptions and costs of the various parameters used to determine production costs of pellet. The feedstock used was green sawdust with 40% moisture content. The price for sawdust delivered to a pellet plant in the interior of BC varies from $10-20/tonne depending on season, type of contract for the supply, and trucking distance. This includes the cost of sawdust as well as the cost of trucking. In case of an integrated saw mill and pellet mill the price becomes a matter of internal transfer price which in some cases is recorded at zero. In this analysis an average value, $15/tonne is assumed for the production of pellet. From these data, both the total pellet production costs as well as the costs caused by each unit or cost factor of the pelletization process were calculated.

The capital cost and the operating costs required were 4.49 and $42.34 per tonne pellets production, respectively, thus making a total of $46.83 (Table 6 and Table 7). The specific capital cost ($/tonne) in this case was quite low in comparison with the capital cost calculated by Mani et al (2006). This is due to the higher production capacity (100,000 tonne/year) as compared to 45000 tonne/year used by Mani (2006). The total production cost per tonne became higher due to higher operating cost as the raw materials cost (including trucking) increased considering wider circumference around the plant.

**Analysis of logistical and transportation costs**

Wood pellets are produced economically and stored in bag or loose form depending on the end user's need, type and supply system. For a short distance supply, truck transport is more realistic. Two possibilities are taken into account concerning long distance transport. For ship transport, pellets are transported to a nearby harbor from where they are shipped to the destination country's import terminal. For the train transport it is assumed that the biofuels are directly transferred on a freight train. In the destination country the pellets are delivered to an energy plant or other end-user from the harbor to the end-user if ship transport is applied.

Wood pellet transport system has a number of transfer points depending on the location of end-users. Present study is to find the logistical and transportation system of exporting pellet from British Columbia, Canada to Sweden or the Netherlands. The production site is somewhere in Prince George, Vanderhoof, William Lake, Kelowna or Quesnel area of British Columbia where forest density is high. The pellet mill is normally situated in close vicinity to sawmills in order to keep raw material transport cost nil. Table 8 shows the existing main pellet mills in British Columbia in different areas. Raw materials are collected locally from the surrounding area of the production sites. Truck is normally used for this purpose. Truck has normally a size of $15m^3$ with a power of 300 HP. Table 8 also shows the percentage of raw materials used from a certain distance to different pellet mills. It also shows the distance of production site (plant) from the railroad.

The nearest harbor from the pellet mills in British Columbia is Vancouver Port. The railroad distances from Vancouver Port to the pellet mills in the areas of Prince George and Vanderhoof are 1275 and 1386 km respectively (VIA 2006). The cost of transportation increases significantly if the production site is far away from the harbor. Four possible transfer points are assumed: the production site (Prince George or Vanderhoof), two transport terminals (export and import) and the end user (energy plant in Sweden or the Netherlands). The system consists of three transport sections:

- Prince George or Vanderhoof (Production sites) to Fibreco Terminals of Vancouver Port in British Columbia
- Long distance transport from Vancouver to Helsingborg or Varberg in Sweden (or Rotterdam or Vlissingen in the Netherlands) by sea
- Helsingborg or Varberg Port to Energy Plants in Sweden / Rotterdam or Vlissingen to Energy Plants in The Netherlands

When production site is not directly accessible by rail, truck is normally used to transport the pellet to the nearest loading station for rail car.  The different sizes of railcars are used to transport pellet from production site to Vancouver Port. The common sizes of railcars are Model 4750, 5700, 5150, 5240 with the effective payload of 80, 90, 93, and 100 metric tones respectively. The number shown after the Model is the capacity of the car in cubic feet. The pellet producers have a different mix of these rail cars and the mix is changing over time. The shipments to Europe are done with an average of two vessels per month at the present rate. Total shipment per year is currently 425,000 tonne which means approximately 18,000 tonne average per vessel (Staffan Melin, President, Delta Research Corporation, 501 Centennial Parkway, Delta, BC, Canada V4L 2L5). This is the statistical average and the actual volume per vessel is of course depending on the configuration of the holds.

The power plant in Helsingborg has storage on the dock in the port and the product is transported from the storage directly by conveyor belt into the power plant. In Varberg, the storage is located in the port and is discharged from dockside by truck directly into a storage located about 100 meters away. From the storage, the pellets are trucked a distance of 80 km to the power plant. In Rotterdam or Vlissingen of the Netherlands, the ocean vessel discharges the pellets directly into barges by means of floating crane. The barges transport the pellets up the river to the power plant at a distance of approximately 75 km away from the port.

**European market price of pellet**

Pellets are exported in tonnage but paid for by the tested GJ (Gigajoule) or MWh content, i.e. by the calorific value of pellet. A typical compensation formula used is as follows.

$$\text{Price of Pellet} = \text{Contractual Price} \times (\text{Calorific Value} / 4.8) \quad (3)$$

A 4.8 is a benchmark calorific value in MWh/metric tonne often used in setting price for the pellets. Other adjustments are made on basis of currency exchange adjustment factor, consumer price index, freight adjustment factor etc. So the compensation formula is a quite complex matter. Current price achievable in the European market is around $151.5/tonne at a calorific value of 4.8 MWh/tonne.

### Profit analysis

The profitability of the pellet was evaluated on the basis of a production chain of producing pellets in British Columbia from sawdust for the use in Sweden or the Netherlands. The analysis included a cost analysis of pellet production, transportation and handling of the pellets, intermediate storage and transfer operations, sea transportation and transportation to the end-user. A 100,000 ton/year wood pellet production is considered as the basis of this economic analysis.

The revenues are based on the market price reported in the above section. The tax-rate was set to 35% of the profit before tax (item E). The internal rate of return was estimated on a constant market price and based on a plant lifetime of 10 years, equal to the depreciation period. Internal rate of return for exporting to Sweden is estimated as 24%, whereas the value is 37% for exporting to the Netherlands. The difference is due to the higher sea transportation cost for Sweden. The payout periods for exporting to the two countries are 4 and 3 years, respectively.

## CONCLUSION

The main cost factors for exporting wood pellets are the transportation and supply logistics among which sea transportation alone contributes 35-38% of the total cost depending on the distance of the export countries. It is followed by the pellet production cost, which amounts to about 30%. In the production of pellet raw material cost plays the major role followed by the drying cost. The pelletization itself and personnel costs are also of great relevance. The pellet production in British Columbia and exporting it to Sweden or the Netherlands makes higher internal rate of return, and lower payout periods.

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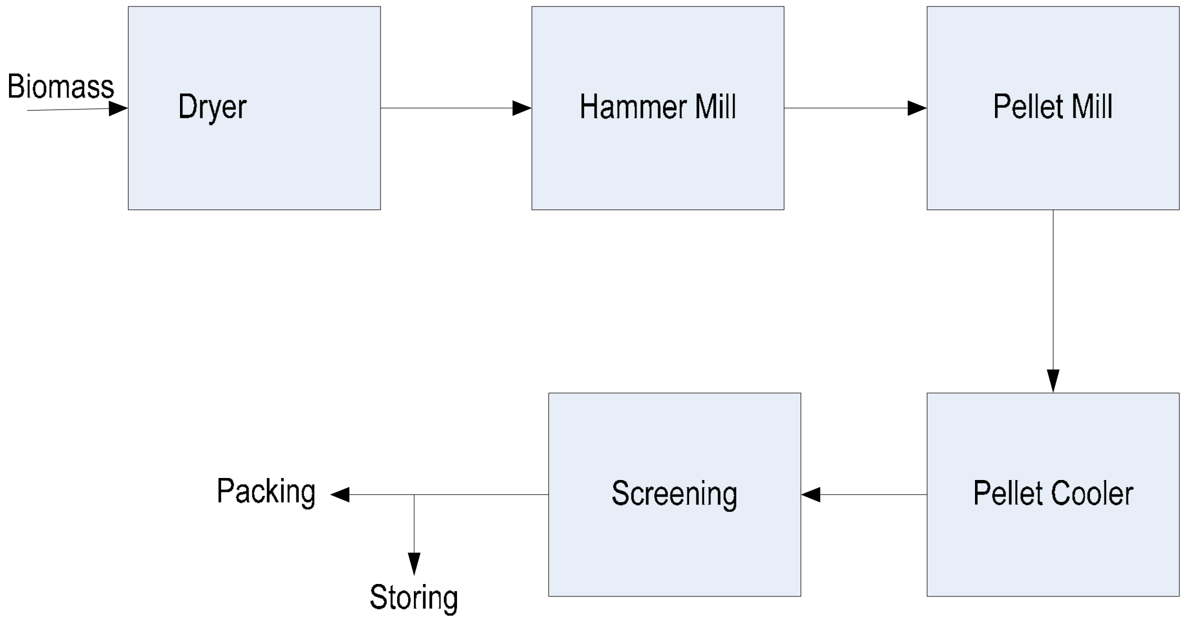


Fig.1 Flow Diagram of pelleting process

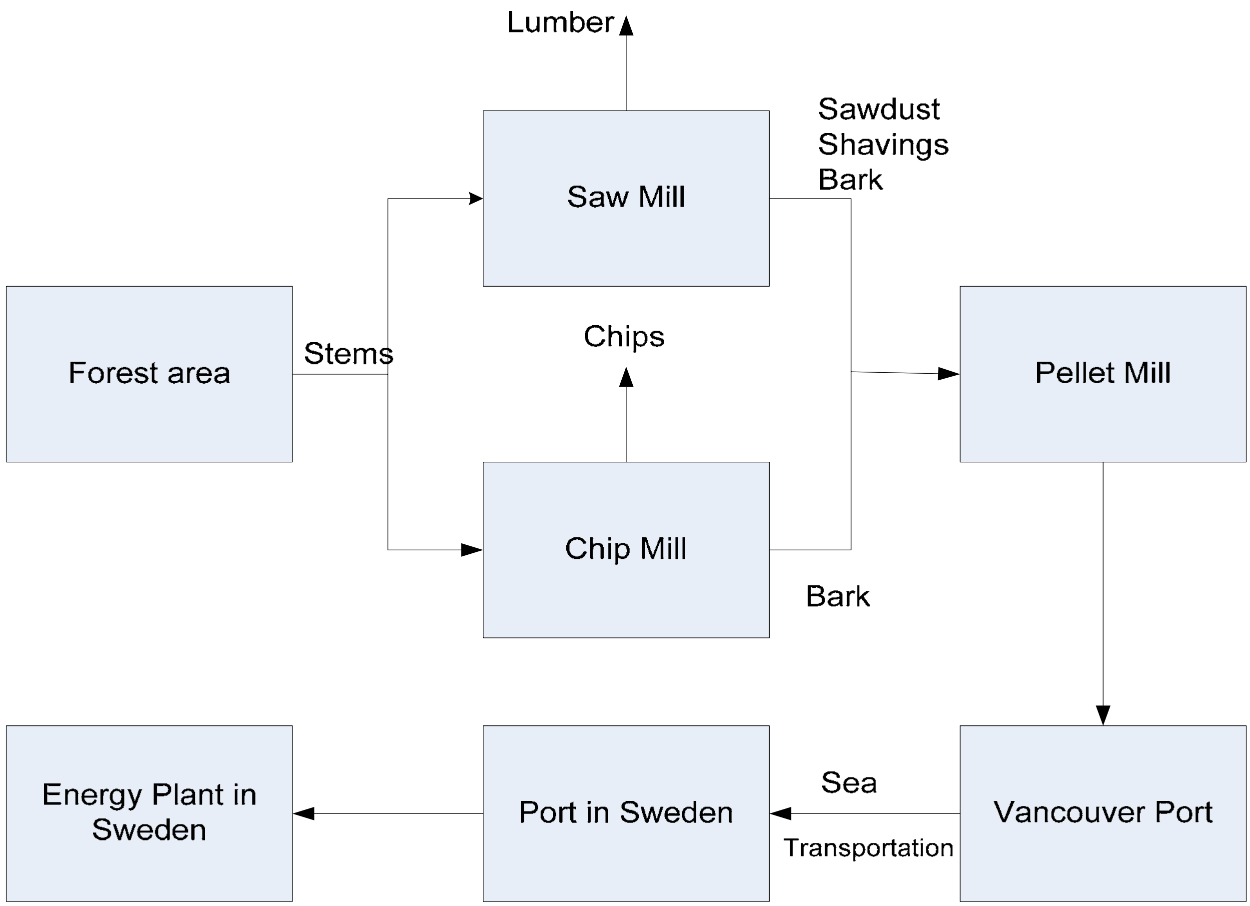


Fig.2 Wood pellet production and logistics

Table 1 Characteristics of different truck types

| Truck type | Dutch bulk | Swedish bulk | Pellets truck |
|---|---|---|---|
| Truck capacity max (ton) | 25 | 40 | 35 |
| Truck capacity max ($m^3$) | 120 | 130 | 80 |
| Average speed (km/h) | 65 | 65 | 65 |
| Fuel use (L Diesel/100 km) | 34 | 45 | 45 |
| Km-costs (US$/km) | 1.56 | 1.07 | 1.39 |

* Assuming 1 Euro = US$ 1.26

Table 2 Truck transport cost and energy use

| Fuel to be transported | Transportation cost (US$/t)* | | | | Energy use (GJ/t) | |
|---|---|---|---|---|---|---|
| | 50 km | | 200 km | | 50 km | 200 km |
| | 45% mc | <10% mc | 45% mc | <10% mc | | |
| Logs | 9.95 | -- | 26.21 | -- | 0.1 | 0.38 |
| Chips | 15.50 | 13.86 | 30.37 | 30.37 | 0.11 | 0.43 |
| Bales | 12.47 | -- | 28.85 | -- | 0.10 | 0.38 |
| Pellets | -- | 5.17 | -- | 13.99 | 0.07 | 0.23 |

Table 3 Train transport costs for different energy carriers for woody biomass (Carlo 2003)

| Biomass form | Distance in km | | | |
|---|---|---|---|---|
| | 500 | 1000 | 1500 | 2000 |
| Forest residues (US$/tdm)* | 36.04 | 51.41 | 66.91 | 82.28 |
| Pellets (US$/tdm)* | 11.34 | 16.13 | 21.04 | 25.83 |

* Transfer costs are included

Table 4 Characteristics of different ships

| Type | CV-I | CV-II | Tornator | Pellets |
|---|---|---|---|---|
| Capacity (t) | | | | 22000 |
| Capacity ($m^3$) | 21300 | 42600 | 7000 | 30000 |
| Ship dwt t | 15000 | 30000 | 5000 | 25000 |
| Vessel costs (MUS$) | 14.99 | 19.15 | 13.86 | 20.16 |
| Life time | 25 | 25 | 25 | 25 |

| | | | | |
|---|---|---|---|---|
| Fuel use HFO (t / km) | 0.03 | 0.04 | 0.015 | 0.04 |

MUS$ – Million US Dollars

Table 5 Parameter used in cost analysis

| | |
|---|---|
| Production site | Prince George, Vanderhoof area of BC |
| Pellet production rate | 13.4 tonne/h, i.e. 100500 tonne/a |
| Raw materials | Saw dust of 40% moisture content |
| Raw material cost | 15 US$/tonne |
| Moisture content of pellet | 10% |
| Annual operating hour | 7500 hours |
| Operating hour | 24 hours, 3 shifts, and 7 days in a week |
| Burner fuel | Wood shavings of 10% moisture content |
| Wood shaving cost | 40 US$/tonne |
| Labor cost | 20 US$/h |
| Electricity cost | 0.032 US$/kWh |

Table 6 Capital cost for a pellet production plant

| Items | Purchase cost, PC (US$) | Installation cost, IC (US$) | Life (year) | CRF | Annuity (US$) | Specific capital cost (US$/t) |
|---|---|---|---|---|---|---|
| Solid fuel burner | 184,545 | 92,272 | 10 | 0.1359 | 37,611 | 0.374 |
| Rotary drum dryer | 566,813 | 340,088 | 15 | 0.1030 | 93,377 | 0.929 |
| Drying Fan | 49,766 | 19,906 | 10 | 0.1359 | 9,466 | 0.094 |
| Multiclone | 49,766 | 19,906 | 15 | 0.1030 | 7,174 | 0.071 |
| Hammer mill | 95,881 | 38,352 | 10 | 0.1359 | 18,238 | 0.181 |
| Pellet mill | 510,760 | 255,380 | 10 | 0.1359 | 104,094 | 1.036 |
| Pellet cooler | 51,050 | 38,288 | 15 | 0.1030 | 9,198 | 0.092 |
| Screen shaker | 38,352 | 23,011 | 10 | 0.1359 | 8,337 | 0.083 |
| Packaging unit | 138,380 | 30,863 | 10 | 0.1359 | 22,994 | 0.229 |
| Storage bin | 38,352 | 23011 | 20 | 0.0872 | 5,350 | 0.053 |
| Misc. equipment | 170,112 | 68,045 | 10 | 0.1359 | 32,358 | 0.322 |
| Front end loader | 200,000 | - | 10 | 0.1359 | 27,174 | 0.270 |
| Fork lift | 164,000 | - | 10 | 0.1359 | 22,282 | 0.222 |
| Truck | 400,000 | - | 15 | 0.1030 | 41,185 | 0.410 |
| Office building | 72,051 | - | 20 | 0.0872 | 6,282 | 0.063 |
| Land use | 80,000 | - | 25 | 0.0782 | 6,258 | 0.062 |
| Total | 2809,829 | 949,125 | | | | 4.49 |
| Total Capital Cost, PC + IC = | | 3758,954 | | | | |

Table 7 Annual operating cost and unit costs for the annual production of 100,000 tonnes of pellet from sawdust

| Description | Annual use | Annual cost (US$/a) | Unit cost (US$/tonne) |
|---|---|---|---|
| Raw materials | | | 18.41 |
| Sawdust | 150750 tonne/year | 1507,500 | |
| Truck fuel | 441 kW | 342,711 | |
| Drying | | | 6.54 |
| Solid fuel burner | 24.12 MMBTU | 11,629 | |
| Rotary drum dryer | 22.05 kW | 16,628 | |
| Dryer fan | 70,000 scfm | 27,455 | |
| Multiclone | | 995 | |
| Fuel consumption | Shavings 1914 kg/h | 459,429 | |
| Front end loader | | 136,348 | |
| Ash disposal | | 4,881 | |
| Hammer mill (electrical) | 106 kW | 27,531 | 0.27 |
| Pellet mill | | 63,135 | 0.63 |
| Pellet cooler | | 9,841 | 0.10 |
| Screening | | 2,531 | 0.03 |
| Packing | | | 0.64 |
| Packaging unit | | 5,201 | |
| Bagging bin | | 212 | |
| Fork lift | | 58,820 | |
| Pellet storage | | 767 | 0.01 |
| Miscellaneous equipment | | | 0.16 |
| Screw feeder, size reduction | | 2,436 | |
| Screw feeder, pelleting | | 2,436 | |
| Bucket elevator | | 3,164 | |
| Screw conveyor | | 8,421 | |
| Personnel cost | | | 8.03 |
| Drying | 1 people, 3 shift | 120,000 | |
| Pelleting | 1 people, 3 shift | 120,000 | |
| Packing | 4 people, 1 shift | 186,880 | |
| Extra labor | 1 people, 3 shift | 120,000 | |
| Secretary | 1 people, annual | 40,000 | |
| Manager | 1 people, annual | 100,000 | |
| Supervisor | 2 people, annual | 120,000 | |
| Land use and building | | | 0.02 |
| Repair and maintenance | | 2,401 | |
| Total operating cost/tonne | | | 42.34 |
| Total specific capital cost/tonne (From Table 6) | | | 4.49 |
| Unit cost/tonne | | | 46.83 |

Table 8 Existing pellet mills in British Columbia, their locations, and raw material distances

| Pellet mills | Mill location | | Raw material | |
|---|---|---|---|---|
| | Nearest city | Distance to railhead, km | % of raw materials | Distance from mills, km |
| Pacific Bio Energy (to be installed) | Prince George | At railhead | 15 | 75 |
| | | | 40 | 2 |
| | | | 45 | 1 |
| Premium Pellet | Vanderhoof | At railhead | 60 | On-site (pipeline) |
| | | | 40 | 50 |
| Westwood Fiber | Kelowna | 5 | 80 | 4 |
| | | | 20 | 100 |
| Princeton Cogen | Kelowna | 150 | 100 | 1 |
| Pinnacle Pellet | Quesnel | At railhead | 100 | 10 |
| Pinnacle Pellet | Williams Lake | At railhead | 100 | 1 |

Table 9 Costs analysis of pellet production & logistics

| | Export to the Netherlands | | Export to Sweden | |
|---|---|---|---|---|
| | US$/t | US$/a | US$/t | US$/a |
| Pellet production & product storage | 46.83 | 4706,482 | 46.83 | 4706,482 |
| Transportation to Vancouver Port* | 21.50 | 2160,750 | 21.50 | 2160,750 |
| Transfer, intermediate storage & loading* | 10.50 | 1055,250 | 10.50 | 1055,250 |
| Vancouver Port to import Port by Sea Transportation* | 45.00 | 4522,500 | 52.00 | 5226,000 |
| Transfer, handling and transportation to energy plant* | 12.12 | 1218,060 | 12.12 | 1218,060 |
| Total | 135.95 | 13663,042 | 142.95 | 14366,542 |

* Source: Staffan Melin, President, Delta Research Corporation, 501 Centennial Parkway, Delta, BC, Canada V4L 2L5

Table 10 Profitability analysis of exporting pellet to Sweden/The Netherlands

| | Items | Amounts in US$ (Netherlands) | Amounts in US$ (Sweden) |
|---|---|---|---|
| A | Revenue | 15225,750 | 15225,750 |
| B | Operating Cost | 13211,663 | 13915,163 |
| C | Operational Income, A-B | 2014,087 | 1310,587 |

| | | | |
|---|---|---|---|
| D | Depreciation | 451,379 | 451,379 |
| E | Profit Before Tax, C-D | 1562,708 | 859,208 |
| F | Tax To State, 35% on Profit | 546,948 | 300,723 |
| G | Net Income, E-F | 1015,760 | 558,485 |
| H | Cash Flow ( Net Income + Depreciation) | 1467,139 | 1009,864 |
| I | Internal Rate of Return | 37% | 24% |
| J | Payout Period | 3 years | 4 years |