Pellets – processing into a pellet fuel

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1. ABSTRACT

Wood pellets are gaining popularity around the world as a biofuel. The largest markets are in Sweden, Denmark, US and Austria, but it is growing in many other countries. The fuel is ideal for home heating, in small scale boilers as well as medium and larger scale boilers at heat plants. It is dry, clean and convenient to use. Typically the wood pellets are made of "wood waste", which usually is wet sawdust which has been dried, or made of dry shavings from sawmills or other solid wood remanufacturing industries.

In all these cases the raw material for the wood pellets come as a by-product or a waste product from the wood industry. The wood waste therefore carries a potential disposal cost. The cost of producing wood pellets is very dependent on the raw material used. In this paper some of the critical issues related to the raw material costs are evaluated, with a focus on evaluating the possibility of using short rotation crops for wood pellet production.

2. INTRODUCTION

Wood pellets are made from wood waste from the wood processing industry. The annual production around the world last year around 2.1 million tons (Wilson G, 2002). Production is increasing to meet increased demand in the Scandinavian countries, Germany, UK and Austria. In these countries pellets are used in small (10-150 kW) boilers in private homes, institutions and schools and larger systems in companies, for small district heating plants and as CHP (combined heat and power) plants. The most popular applications differ between countries, this is determined by cultural traditions of applied heating systems which is generally determined by energy and waste management policies.

3. PELLET MANUFACTURING CHAIN

Figure 1 simply illustrates the flow of wood fibres, from the raw materials to a pellet machine, and to the pellet market. It is the simplest pellet production, "cut down to the bone". It illustrates the way in which dry sawdust or dry shavings are pelletised and used without going through a bagging phase. As long as dry shavings and or dry sawdust are available this is likely to deliver the lowest cost wood pellets.

By using the dry material, a large number of parameters are linked to the process on the positive side. The parameters involved from the pellet machine to the pellet market includes the cooling process, the bagging process (if bagged), the wholesale process, transportation, the retail process, the final transportation and the final application. This is a generalisation as the distribution system may be set up differently for different customers, depending on time and energy consumption, capital costs and cost efficiency.

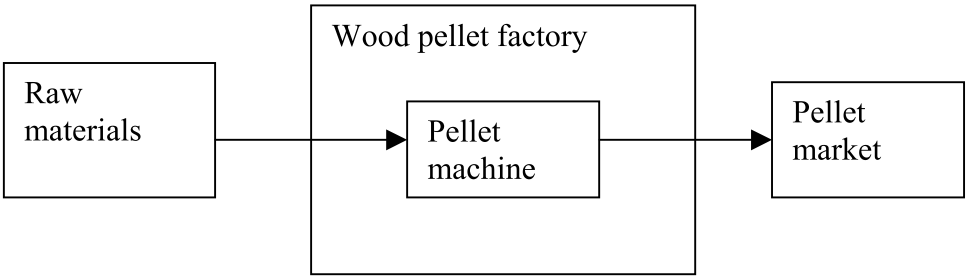


Figure 1. Illustration of the process between the raw material and the pellet market

4. THE MARKET

The wood pellets have to be priced to compete in the fuel market. The most obvious fuels to compare with are natural gas, fuel oil and electricity. In some areas in New Zealand it will have to compete with coal. The nature of wood pellets competitiveness to each of these fuels is very different. While the price is of utmost importance, convenience, environmental emissions and the feel good parameter, will have different values for the various fuel types. Firewood is also a special case as people who wish to chop their own firewood have the opportunity to have their fuel for free.

To meet the competitive market price, i.e., the price of alternative fuels, only the project that can produce wood pellets for this price will succeed. The price of the wood pellets may however not only be set up by the manufacturing costs itself, but may be supported by solving other problems for society (in particular of environmental nature) through energy policies and waste management policies. There will be some “pioneers” who are willing to pay a higher price for the pellets for the feel good parameter, but this market will be limited. But in general it is expected that the market for the wood pellets will grow with the increasing awareness of the benefits and with the increasing competitiveness of the wood pellets with increasing prices of natural gas, coal and electricity.

By looking at the international market additional shipping costs may outweigh the high market prices in Europe. However the market in Europe is expected to increase significantly in an attempt for Europe to meet the obligations to the Kyoto Protocol. However, at the same time EU is expanding with new member countries from the eastern part of Europe. The forest resources in these new member countries are significant, which means that these countries may provide a significant part of the fuels to meet the growth in pellet production, in particular from resources in Poland. This is all in its initial development, so it is very hard to determine what kind of import prices the wood pellets will have to meet the European market in the near future.

Some of the Asian markets may also be of interest, if wood pellets become popular in Japan and China. The nature of the energy system in Japan shows that this may be an attractive market, and at the moment new wood pellets production are being established in Japan. The market for imported pellets is likely to occur only when the market starts building up. So it is also difficult to see what production costs have to be met to reach the Japanese market.

5. THE PELLET PLANT

In general the parameters illustrated in Figure 2 are very important for the final cost of the wood pellets. Each of these parameters may potentially reduce the overall production costs significantly, but in most cases only one of the parameters can be addressed in a potential wood pellet plant. A heat source is necessary as soon as the dry material runs short, operation costs will depend on how the plant is run and specifically a decision on running the machine flat out 24*7 gives a maximum payback on the capital investment. Where the investment will come from is important and the location important for many aspects, in an attempt to optimise the resource use.

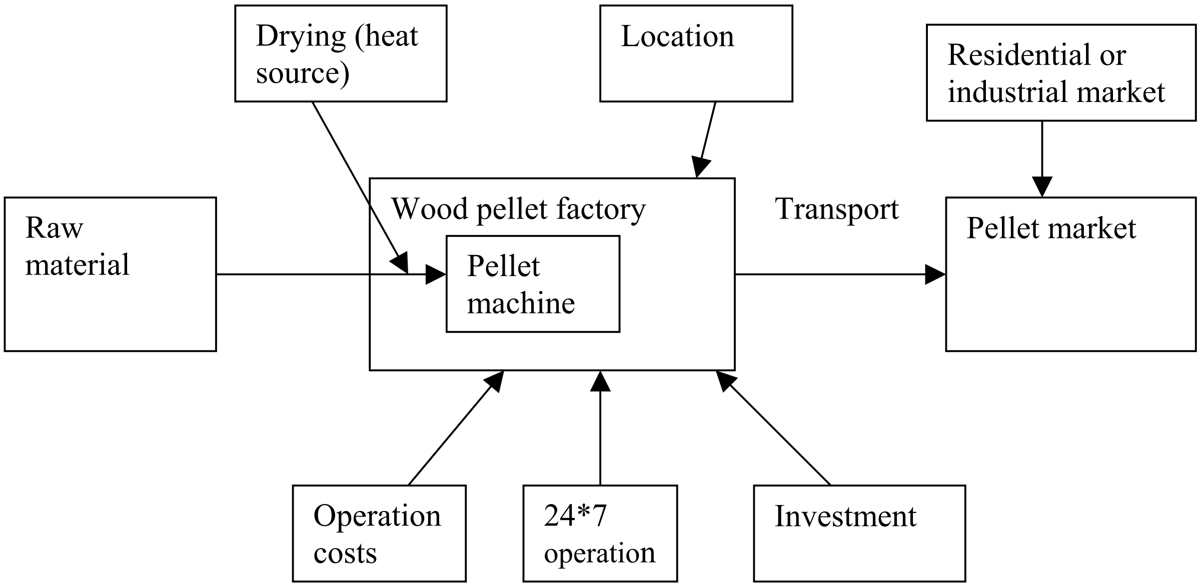


Figure 2. Illustration of various parameters, which determine the production cost of wood pellets

6. RAW MATERIALS

New Zealand (NZ) has abundance of raw materials, which is evaluated elsewhere (Nielsen *et. al*. 2003, Nielsen, 2003). There are over 20 large and 200 small to medium scale wood processing industries in New Zealand producing wood waste. Some of them use wood waste for their drying processes.

The raw materials that are of most interest to pellet production come from two distinct operations. The largest contributor will be from the sawmills that are processing full logs from the forest. This operation can produce large quantities of high quality wet sawdust. The other contributor will be the planer mills. These operations generally work with dried untreated timber and produce high quality wood products. The waste stream is a dry clean wood shaving that is ideal for pelletising. In this case the wood waste material is seen as a waste problem, with a cost to the operator.

A third material that will always influence the costing of the other two is the more common, low quality wood waste (hog fuel), which is often used for boiler fuel. This quality of wood waste is too low for pelletising or it needs to be further processed. It contains contaminants such as soil that make it undesirable as a high quality fuel for small stoves. However with the larger heat plants and handling systems, this is not too much of a concern. The cleaning systems that most larger heat plants have are equipped to remove many undesirables that may have been contaminating the wood waste. Also in this case the raw material is a waste and carries a cost to the operator.

In the case of using short rotation crops as feed stock for a wood pellet manufacture, many of these issues are different. If the short rotation crop was purely for bioenergy all costs should be adhered to the wood pellets, and in most cases will not be competitive. But some crop have other advantages, either with high value products (oils) or for environmental benefits (irrigation, desalination). This paper evaluates the "real" cost of wood pellet manufacturing and the impacts of changing some "variable" costs.

The processing chains may be summarised like the following:

1. Sawdust from the sawmill (Technology chain: Loading and transportation if going off-site, Drying, hammermill, pellet machine).

2. Dry shavings from the sawmill (Technology chain: Loading and transportation if going off-site, hammermill, pellet machine).

3. Whole trees (eucalypt): (Technology chain: Harvesting of trees, transportation "chipping/milling", drying, pellet machine).

4. Short rotation crops (short eucalypt): (Technology chain: Harvesting of stems/coppice, transportation "chipping/milling", drying, pellet machine).

The low quality wood waste has a price of around $10/ton. This price sets a benchmark price for other types of wood waste. The clean high quality wood waste will always receive a greater price per ton. Wood shavings on the other hand, although clean and dry, is a difficult waste stream to handle and also causes problems in the furnace as it is light and blows around. This results in the shavings leaving the furnace before complete combustion, causing damage to filtering equipment. In many ways this leaves the dry shavings to the pellet industry.

In the past the availability of high quality wood waste was not an issue. Now that more sawmills are seeing an advantage in recovering some value from their waste streams, the availability will diminish. The availability of dry wood shavings is also difficult to be sure of. At present some shavings are used for stock litter or bedding while a large proportion is landfilled. Therefore it will be important to obtain long term supply contracts of high quality sawdust.

The benefit of producing an entire crop to be processed into a form equivalent to that of sawdust which is immediately ready to be remanufactured in to wood pellets is away around securing a supply of high quality material for wood pellet production. Presently the process of processing the entire tree into what is commonly thought of as a waste product is not currently used. A quick look into the technologies needed for such a process has showed that there are machines that could be modified in some way to produce the quality of sawdust needed but nothing is immediately available.

Ideally the production of sawdust from a tree is best-accomplished in-forest. This reduces double handling of the tree. Another benefit of in-forest activity will mitigate any development of waste products, i.e., parts of the tree that are not beneficial to process can be simply returned to the site.

Recovery of in-forest residues is purely dependent on economics and the price that contractors obtain the material for. The recovery of the material in a developing industry has only just started. In the present context of wood pellet production, what is important is that the costs of the residues are critical in the short term, and also to the long term cost of material for a pellet manufacturer. A wood processing industry is only likely to “sell” its sawdust if they can get another fuel at the same price somewhere else.

Looking at wood processing residues, the wood processing industry is increasingly aware of waste management to reduce costs. Although efforts to reduce waste and use it on site are increasing, some still enter the waste management sector.

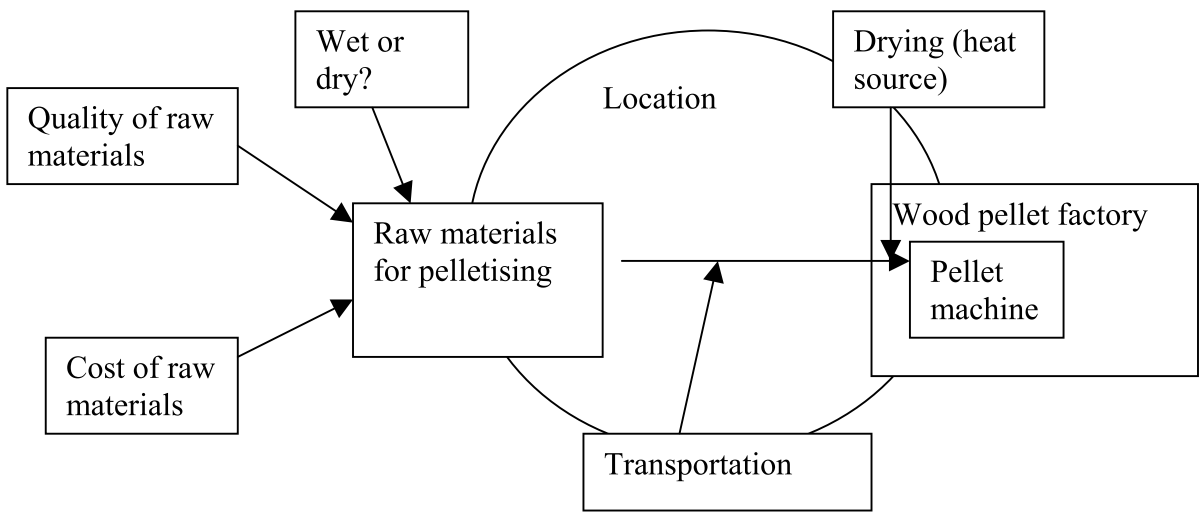
7. DRYING

There are many different types of energy sources that can be utilised for drying wood waste, flue gas, steam, hot water, and hot oil etc. If at all possible it would be ideal for a plant to be situated near to a low cost heat source or even better a waste heat source.

The is due to the high costs involved in drying wet sawdust to the correct moisture content (M C) for pelletising The cost of drying can be as high as one third the cost of production depending on the heat source.

8. LOCATION

Location is vital to keeping the costs of production down. Transport of sawdust could cost up to $10/ton if moved in the range of 50 km. This could easily double the value of the wood waste to the site. Ideally the supply of wood waste should be adjacent to the pellet plant. If the wood waste could be conveyed or blown to the site, this would greatly reduce the transport cost.



Location to the market is also vital. For the bulk market where pellets are delivered by truck the costs will be similar to the costs of acquiring the wood waste. To be competitive the industrial customers need to be in the immediate vicinity of the supplier.

The residential market is different. Because the value of the product will be higher, the transport costs will be considered acceptable. The product is usually stored in sealed plastic bags. This means they are not at risk of absorbing moisture and therefore can be stored outside or in other areas where the introduction of moisture is a concern. This makes the pellet fuel a very flexible alternative. It can be transported long distance without fear of deterioration of the product.

9. TECHNOLOGY/HARDWARE

A pellet plant is a combination of a number of different technologies, which have to be designed for the planned production. However the large number of parameters to take into account make a firm statement about design difficult. What is the ratio between wet and dry materials? Do you want flexibility in your production and what kind of flexibility. Do you want the flexibility on the drying capacity or the flexibility on the pellet production, making it possible to match a changing market? The flexibility would be seen if the machine is a large machine, which only runs for a planned 8 hours a day, making it possible to triple the production if required. Making the production in 8 hours instead of 24 hours will reduce the costs on salaries, but to be fully flexible the fuel handling and drying system have to be triple the size also. This means that the plant in principle is three times bigger at the time of set-up than a competitive plant, which may be running 24*7 on a smaller machine.

Thek and Obernberger (2002) show that the manufacturing costs of wood pellets falls from 140 Euro to 90 Euro per ton of pellets by running the plant on full capacity, 24 hours a day and 7 days a week compared to one shift 5 days a week. This indicates that it is cheaper to run a smaller machine at a higher rate than a larger machine at a lesser rate. But due to the many different variable factors, it may not be right in any case. It is mostly to do with the capital cost of the equipment. The larger pellet press involves larger handling systems and a larger site area.

There are many pellet machines on the market today, with several different mechanisms for producing the pellets. The best option is a reliable system that produces a consistent quality of pellet. If these pellets are destined for the international market they have to meet very strict criteria. Such quality controls as density, abrasion resistance, moisture content, ash content and others. These types of standards are likely to be adopted once a certain level of production is reached within New Zealand.

10 CURRENT ENERGY CLIMATE

The energy market in New Zealand has been shown to be a very volatile area over the last few years especially the natural gas and electricity market. With the pending gas shortages and likely increase in supply charges it could be quite a risk to use natural gas for drying the wet wood waste. The electricity prices on the spot market can make a high power user, which relies on the spot market for purchasing electricity very vulnerable to these changes. Both of these issues suggest that it should at least be considered to using a companies own wood waste to produce heat with the possibility of co-generation to avoid the risk of being effected by high electricity prices. It does however, mean that relatively large operations are required, to make use of a cogeneration plant, which is likely to have at least 1 MW electricity capacity. As the extra investment in using a wood waste boiler compared to a natural gas boiler is relatively minor. A typical set-up at a wood pellet plants utilises wood waste for drying in most countries. A decision to include a cogeneration option, is much more complicated, in particular the drying requirement needs have to be evaluated.

11 A PELLET PLANT MODEL

In Figure 3 a relatively simple set-up of a wood pellet plant is illustrated. In this case wood waste is used for co-generation of heat and power in a co-generation plant. Heat from the plant is used to dry the wet sawdust for the pellet plant operation and surplus heat sold for district heating or industrial cluster heating. Electricity is used for internal electricity consumption and surplus electricity sold to the grid. A simpler set-up is that of the existing pellet plant in Christchurch by "Nature's flame", which uses a drum drier for drying the wet sawdust and electricity is purchased from the grid. Each set-up has its own advantages, and obviously the inclusion of a co-generation plant is only relevant if the sale of electricity can cover the extra investment.

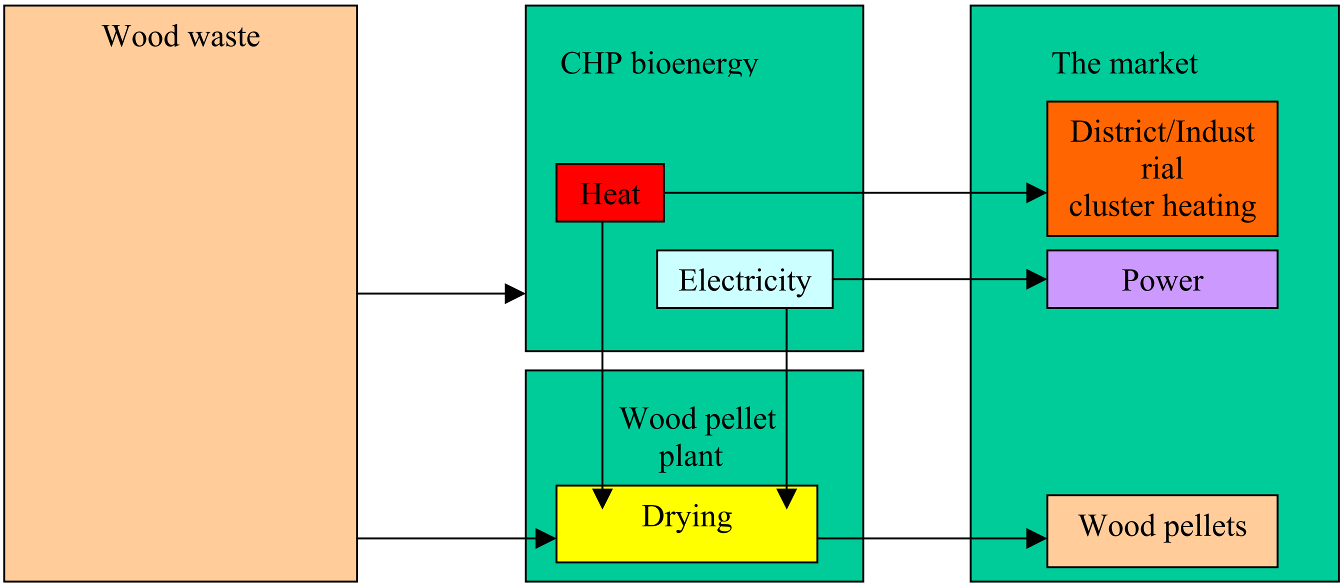


Figure 3. Pellet evaluation model

An evaluation model has been developed which uses the set-up in Figure 3. It is an energy/mass balance model, which can be used to evaluate the sensitivity of a number of parameters. In this connection the sensitivity of the wet fuel price is evaluated.

11.1 Situation

By using around 20,000 tons of low quality wood waste, the heat plant is producing 36,000 MWh of steam, which is used for the production of 320 kW of electricity for internal usage, i.e. the pellet plant. The capacity of the heat plant is that it can dry around 15,000 tons of high quality wet sawdust for production of wood pellets. The pellet plant is capable of producing 8,000 ton of pellets per annum and is set at this level.

12 INFLUENCE OF COSTS OF WET SAWDUST AND WET FUELS ON PELLET PRODUCTION COSTS

The results on the sensitivity of the price of wet sawdust to the final total manufacturing price of wood pellets are shown in Table 1. Obviously a large number of technical and economic assumption have been taken to get to these numbers. Therefore the figures should not be regarded as firm for any wood pellet production. The aim in this comparison is only to show how sensitive the manufacturing costs of the wood pellets are to the costs of the wet sawdust. An increase in cost of $40/ton of wet sawdust from 10 to $50/ton increases the manufacturing price by $72/ton of final product. So the increase in costs is almost equal to the price of the wet sawdust on a dry basis.

Table 1. The total production costs of wood pellets as a function of wet sawdust costs ($10-50/ton), using the mass and energy balances of the simple pellet plant model

Sawdust for pellets	$10/ton wet	$20/ton wet	$30/ton wet	$40/ton wet	$50/ton wet
Production cost $/ton of pellets	$145.14	$163.14	$181.14	$199.14	$217.14

If the costs of the wet sawdust for pelletising is set constant at $10/ton (wet) and the cost of wet sawdust paid for fuel are changed in a range from $0 to $20/ton, the prices of the wood pellets are shown in Table 2. It indicates that when the wet sawdust (or other wet wood waste) is “free” the manufacturing costs is around $145/ton but increasing by $31/ton if the fuel cost is increased by $20/ton of wet wood waste for fuel.

In Table 3 the wet sawdust for pelletising is set at $50/ton (close to the costs of pulp chips) and the cost of wet wood waste for fuel increasing in the range from $0 to $20/ton. The production costs with “free” wet wood waste is $217/ton with a price of $50/ton of wet sawdust, but increasing to $248/ton when the wet wood waste for fuel increases to $20/ton.

Table 2. The total production costs of wood pellets (raw material $10/ton) as a function of cost of wet fuel (0-$20/ton), using the mass and energy balances of the simple pellet plant model

Sawdust for fuel	$0/ton wet	$5/ton wet	$10/ton wet	$15/ton wet	$20/ton wet
Production cost $/ton of pellets	$145.14	$152.90	$160.66	$168.42	$176.18

Table 3. The total production costs of wood pellets (raw material $50/ton) as a function of cost of wet fuel, using the mass and energy balances of the simple pellet plant model

Sawdust for fuel	$0/ton wet	$5/ton wet	$10/ton wet	$15/ton wet	$20/ton wet
Production cost $/ton of pellets	$217.14	$224.90	$232.66	$240.42	$248.18

13 DISCUSSION

Wood pellets are getting more and more popular around the world, as a biofuel. The largest markets are in Sweden, Denmark, US and Austria, but is growing in many other countries. The fuel is ideal for home heating, in small scale boilers as well as medium and larger scale boilers at heat plants. It is dry, clean and convenient to use. Typically the wood pellets are made of “wood waste”, which typically is wet sawdust, which has been dried or made of dry shavings from sawmills or other solid wood remanufacturing industries.

In all these cases the raw material for the wood pellets come as a by-product or a waste product from the wood industry. The wood waste therefore carry a potential disposal costs. However there are also many potential benefits by using the material to make other products. The cost of producing wood pellets is very dependent on the raw material used. In this paper some the of the critical issues related to the raw material costs is evaluated, with a focus on evaluating the possibility of using short rotation crops for wood pellet production.

The first question to answer is whether there is a limiting or a maximum price you would pay for the raw materials, and is the raw material form short rotation crops above that. In this case the raw materials should be compared with the cost of other uses of wood waste like remanufacturing board or pulp chips. If the price per tons of pulp chip is higher than the price you are willing to pay for the raw material for wood pellets you would prefer to sell it for pulp chips. The value of a ton of pulp turned into its final product, paper is much higher than the final price of wood pellets. The price of wood pellets at the residential market is $300/ton, around $1,500/ton of MDF boards and around $2,000 /ton of plain white paper, depending on quality.

The figures listed in Tables 1, 2 and 3, indicates that if the wet sawdust costs $50/ton or close to the price of pulp chips, the profit margin gets slim to meet a market price of $300/ton. If the wood waste for fuel at the same time increases from “free” to a cost of $20/ton the price gets very close to the market price of $300/ton (including GST). Obviously these calculation includes a large number of assumptions, and figures which can be changed in many different ways. For any set-up of a pellet plant it will be important to evaluate sensitivity of a number of parameters including the cost of the material to be pelletised and the fuel source.

14. CONCLUSIONS

Wood pellets currently sold in the New Zealand market are made from wood waste from the wood processing industry. The wood waste being currently obtained for free or for low costs. In this way it is a feasible option to manufacture wood pellets. Minimum processing is involved in taking dry shavings or wet sawdust through to a saleable wood pellet. Other factors that influence the feasibility are the avoided costs for removal and dumping of wood waste, because the pelletising process also solves a waste problem. The offset of these costs can quite often make the difference as to whether a project can succeed.

When the raw material to be used for wood pellets is not a waste product or by product, then the full cost of land use, silviculture and harvesting are directly transferred to the production cost of the wood pellet. This is seen in the evaluation of the costs of raw materials evaluated in the paper. With a cost of $50/ton of wet sawdust for wood pellet production, (which is close to the costs of pulp chips) the profit margin is very slim in meeting a market price of

\$300/ton incl. GST for wood pellets. The price of pulp is an indicator of the full costs of chipping whole trees and the process of converting whole trees into wood pellets is very likely to be more expensive than converting whole trees into pulp chips. Hence the conversion of eucalypt trees into wood pellets will have to be linked with exploitation of other products and environmental benefits.

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