EECA

Energy Efficiency and Conservation Authority
Te Tari Tiaki Pūngao

Forest residue harvesting for bioenergy fuels

May 2007 - Phase 1

Part 2 of 2

SCION
Next generation biomaterials

East Harbour

Contents

6. International overview

Developing countries

Access by the general populace to forests and rangelands for gathering woody biomass continues to be an important issue. About half the global consumption of biomass fuels is for simple, small-scale, domestic cooking and home heating use in developing economies. Individual households and small rural communities depend on this fuel for their survival.

The focus of biomass energy development in developing countries, particularly in India and South-east Asia, is following a different path to that of developed nations where large-scale electricity infrastructure already exists, and the method of generating it is the focus of change. In developing countries, there is little existing energy infrastructure, especially in rural areas. This means small communities are developing their own, often small-scale, distributed generation. These operations are often focused on gasification of wood and production of biogas. The methods of providing the fuel to these plants is frequently small-scale, labour intensive and based on the motor-manual model (that is, the labourforce uses powered hand tools as opposed to large mechanised systems).

Large-scale industrial energy plant based on forest-derived residues is uncommon.

Scandinavia and Europe

Scandinavia and Europe are the leaders in the industrial use of forestry biomass for energy production. There has been development of large-scale operations that integrate traditional forest timber harvesting with biomass harvesting. These developments were driven by rising oil and gas prices and concerns over greenhouse gas emissions and environmental sustainability.

In European Union countries there are significant subsidies for non-fossil fuel initiatives. Increased use of forest biomass is in part driven by environmental and sustainability issues as much as by economic and fuel supply issues.

In many countries the forest harvest is from natural forest or managed forests of indigenous species. These may have had little or no management and have large potential biomass volumes, or they may have been intensively managed and have comparatively low biomass volumes.

Many countries are also looking at growing short rotation timber crops such as willow or eucalypt species with biomass for energy as the primary objective. These areas are still small-scale when compared with the area of land under traditional forest management.

The nature of the forests, the terrain and the crops in Europe is generally quite different to that in New Zealand. In general the stands are older, slower growing, standing at high final crop stockings, with small piece size. The branch habit of the trees is different, with the crowns having many more, but much smaller, branches. There tends to be a lot less stem breakage at felling and the minimum small-end diameter from a merchantable log can be as small as 8cm. The result of this is that the logging residues produced, be they at a processing landing or on a cut-over, are quite different to what we would find in New Zealand. There is a lot less heavy stem wood residue and a lot more fine branch material.

In Sweden, Finland and Norway a significant proportion of their harvest is from ground-based systems, which are highly mechanised. These have in many areas had their work methods adjusted to leave the logging residue in piles (as opposed to spread out) to enhance the efficiency of the residue harvesting operation. Three principal systems have been developed for harvesting these residues;

- extract to roadside with a forwarder, pile and cover, store, chip with a trailer mounted mobile chipper, transport to point of use,
- pile on the cut-over, bale with purpose-built residue baler mounted on a forwarder (Figure 13), extract bales to roadside, store, transport bales to point of use, chip whole bales at point of use
- pile on the cut-over, store, chip with a chipper forwarder (Figure 14), tip into set-out bins, transport bins to point of use.

These systems, or variations of them, are used throughout Scandinavia and Europe.

Figure 13 - Above, forest residue baler, forwarder mounted. Note the bale on the ground in front of the rear wheels.

Figure 14 - Below, chipper forwarder and set-out bin (left), terrain chipper (right)

The aim of the baling systems is to produce a uniform product that is dense and easy to handle. Transport distance from forest to point of use can be high, and it is critical that trucks be as close to their maximum payload as possible. At transport distances of 60km, the cost of transport can be over half of the total delivered cost. The bales can be transported on the same trucks that carry logs, which may increase truck utilisation.

The chipper forwarders/terrain chippers are losing favour, in part due to handling issues around getting the chipped residues from the forwarder on to a truck, and in part due to the low utilisation and subsequently high cost of the chipper function. A large fixed installation chipper may operate at one-third of the cost of a mobile unit.

All chippers are sensitive to contaminants and subsequent downtime. Development of comminution plant that is fast (high production), cheap and durable is seen as an important area of future research and development.

Much modelling and research has been done on which are the most efficient systems, and those with the least handling that take the residues from the forest directly to the point of use are most efficient. In general there are five different production systems or flows that can be used (Figure 15). Intermediate handling and processing add cost. Flows 1 and 5 are the simplest and, depending on the specifics of the situation, including transport distances, often the most efficient.

The flows can be described as:

1. raw residues transported directly from forest to the point of use and then processed

2. raw residues transported from forest via a central yard or accumulation point to the point of use and then processed

3. raw residues transported to a central yard for storage and/or processing; comminuted material transported to point of use

4. raw residues processed at source and transported via a central yard to a point of use

5. raw residues processed at source and transported directly to heating plant.

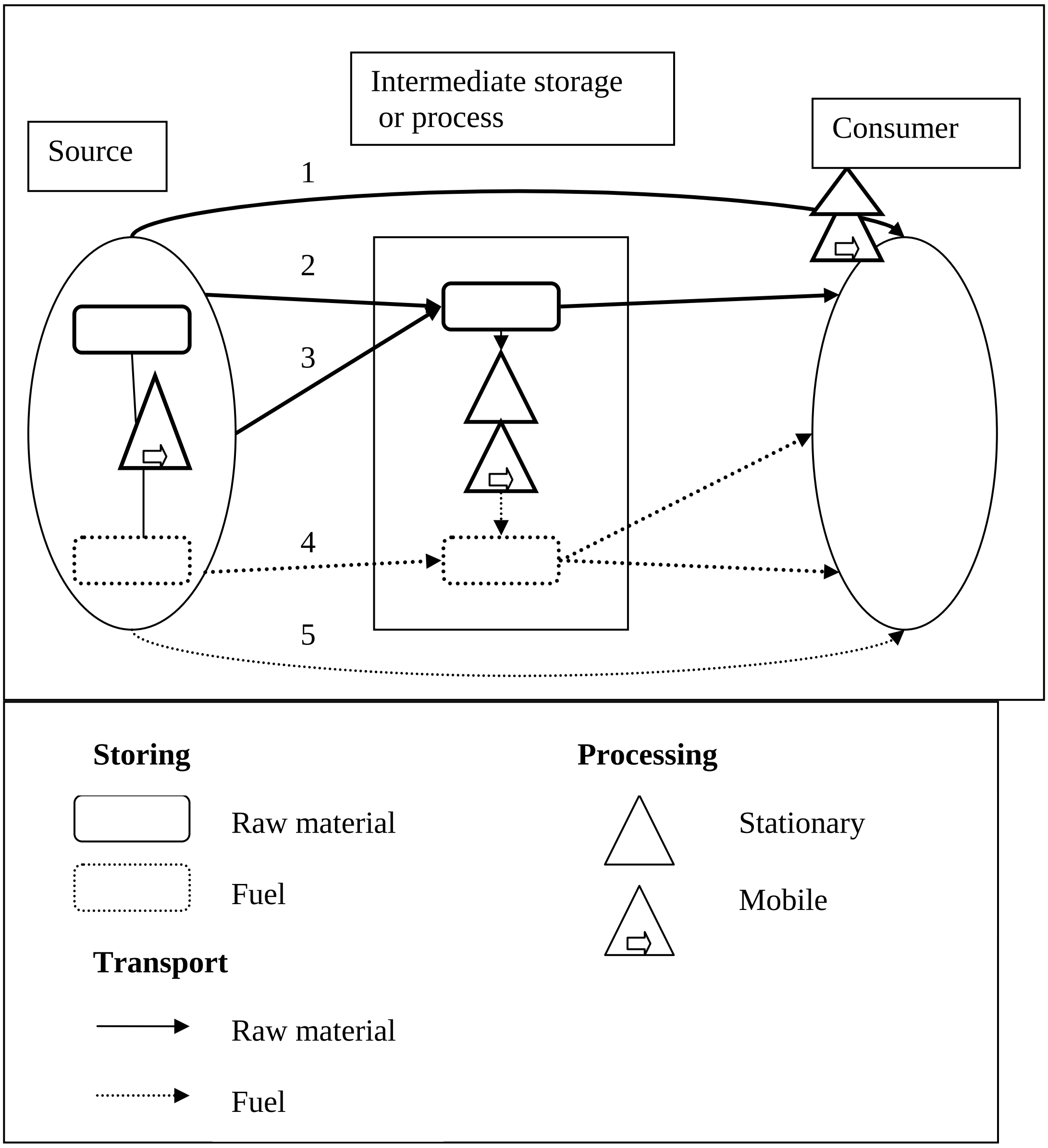

Figure 15 - Possible production flows from residue source to consumer (as in Andersson et al, 2002).

Within the flow types there is considerable variation around what type, and number, of machines are used.

In other European countries including the United Kingdom there is significant harvest from steep terrain, with whole tree extraction by cable logging being common. This often leads to large accumulations of logging residue at roadside. This material is potentially available for bioenergy use, and its extraction costs have been paid for by the traditional log products.

The options currently being employed to utilise this material consist of mobile chippers processing at roadside into trucks, or transport of raw residue to point of use for processing. Load compaction devices are employed to increase the density of the loaded residues and the truck payload. These countries also employ highly mechanised harvesting systems on flat to rolling terrain and have used residue harvesting systems similar to those used in Scandinavia.

A key point to remember is that the product being delivered is energy, not volume or weight of residues. Hence it is important to consider moisture content and drying and where this should be done to give the best results in terms of cost per delivered unit of energy. Payment by energy content is well developed in Scanadinavia.

North America

Use of forest-derived biomass for energy production has had an on and off history in the USA. Initially driven by high oil prices and electricity shortages, production of electricity from forest residues was being carried out on a large scale in California in the 1980s and into the early 1990s. However, without continuing subsidies these operations were not viable, and some closed or are operated for peak load periods only. Some are functioning as disposal facilities for municipal green waste and charge for taking some of the material they use as fuel. In some cases the driver of biomass harvesting in the USA is the desire to reduce the potential forest fire fuel load in natural forests, especially those close to urban development. This is to reduce the risk, spread and intensity of wildfires which are common in some states. This is also a consideration in Australia.

In Canada and the USA in forest areas with flat to rolling terrain, it is common to find harvesting systems based around feller bunchers with whole tree extraction to roadside, where stems are delimbed and cut into logs. This can lead to large accumulations of branch and stem residues. There is increasing interest in utilising this material for bioenergy, pulp chip or both. They also employ cable logging systems with whole tree extraction and have resulting accumulations of landing residues. These accumulations are comparatively small compared to those found in the UK or New Zealand due to the species, piece size and type of log sales. However, due to the scale of the industry, there are significant volumes of material available for use at a regional and national level.

The systems used to recover the residues are commonly trailer mounted mobile chippers, which blow the chipped product directly into chip vans (semi-trailers) which are then taken to the point of utilisation and stored in outdoor piles.

In some pulpwood operations whole trees are processed at roadside using mobile trailer mounted chain flail delimber, debarker, chippers. The stemwood portion is chipped directly into chip vans and the limbs and bark can be recovered and processed into hog fuel with a tubgrinder or horizontal hog.

In some states in both Canada and the USA the forest industry is in decline, leading to reduced harvest and subsequently reduced volumes of both forest and wood processing residues. This leads to uncertainty around fuel supply from traditional forest harvesting. Growing short rotation crops dedicated to energy production is under investigation.

South America/Chile and Brazil
Brazil is a leading producer of ethanol from biomass, which is almost entirely based on its substantial sugar cane industry. It has a significant and developing pulpwood industry, and there are developments within this industry that are seeing some use of woody biomass, from harvesting residues, for energy production. Residues are being produced from the harvest of eucalypt pulp wood crops, which are being harvested and processed using mechanised harvesting systems. These operations are producing roadside residues which are then trucked to pulp mills for processing.

In 2006 the Government of Chile announced plans to boost biofuels production in order to reduce dependency on increasingly costly imported fossil fuels, especially gas from Argentina.

New Zealand and Australia
In New Zealand our forest residue biomass will initially come from exotic plantations grown for high-value timber. Bioenergy production is a possible by-product or secondary objective. In order to flourish it needs to be integrated with the primary objective (timber production), as is the case with biomass harvesting in Scandinavia.

There are two principal systems used in New Zealand and Australia, they are essentially the same as flows 2 and 3 in Figure 15. Both tend to use mobile equipment for the conversion of raw residues into a fuel product. The type of comminution equipment used varies considerably, from large chippers to small tubgrinders and low-speed high-torque hogs. Transport of the residues tends towards moving raw residues if short hauls are involved and to moving comminuted product for longer haul distances. The key driver for this decision is to get the maximum efficiency out of the transport system. This is despite the fact that fixed installation hoggers and chippers are usually far cheaper to run. In many cases the comminution equipment is servicing a number of clients over widely separated sites and needs to be mobile. It is also frequently an addition to an existing plant, which does not have the space or the will to invest in new fixed plant.

A recent New Zealand development in mobile residue processing is the WoodWeta, which has the ability to screen out dirt and fines before the raw material is size reduced. This may be significant especially if the raw material is dirty, which landing residues often are, or if the residue is being used for purposes other than boiler fuel, for example, liquid biofuels.

Summary

There is no one system that has become predominant internationally, or even in a particular country. Various systems are used, based on the specifics of the local environment, including: existing infrastructure, equipment and expertise, end-user requirements and residue characteristics, volume and distribution.

Storage of comminuted forest residues for long periods can lead to dry matter losses, pile heating, spontaneous combustion and increases in the moisture content of the fuel.

Storage of in-forest residues in raw form (including some baled residues) can lead to reduced moisture content, minimal dry matter losses and reduced cost of delivered energy.

Transport of in-forest residues is a significant proportion of the total delivered cost of energy and so maximising load density and transport efficiency is critical to minimising delivered cost of energy.

When large volumes of wood residues are aggregated for processing it may be possible to produce several products, some of which (pulp chip) have a higher value than biofuel.

Short rotation bioenergy crops will probably need a co-product to make them competitive with other wood fuel resources. This is to cover the costs of growing the crop, which are not usually attached to residue resources. Typically the co-product might be land treatment of effluent and/or production of pulp chip and/or extraction of chemicals during processing,

Short rotation crops, although more expensive, may provide a fuel security buffer for a bioenergy plant and may be only part of the fuel supply.

Key areas in the supply chain with significant potential to affect costs and efficiencies are storage and transport. Manipulating the order and timing of storage, transport and comminution between harvest and utilisation can have significant effects on the cost of delivered energy.

9. Conclusions

New Zealand has substantial potential for production of biomass fuels from forest harvest residues. In 2005 forest harvesting produced an estimated 1.04 million tonnes of landing residues. At present less than 100,000 tonnes per annum are being utilised.

Short rotation crops may provide some fuel as a supply buffer, but will be more expensive than residues due to growing costs.

The raw materials are diverse in their composition, piece size and location.

Aggregation of residues is necessary to some extent to get a sufficient quantity of residues at one place to make processing them viable.

Current transport, handling and compaction technology does not make transporting of unprocessed residues viable over longer distances.

Moving to payment by energy content not weight would be fairer to both producer and buyer and may lead to improvements in fuel quality.

There is a variety of machines available off the shelf for comminuting woody residues; most configurations have been tried in New Zealand and each has its pros and cons. Choice of which machine is best will depend on the type of fuel and logistical set-up of the operation.

Current wood residue operations operate on a variety of residues at a variety of locations, sometimes producing a range of products with end uses not limited to fuels.

Producing fuel with consistent high quality will be critical to getting widespread acceptance. Fuel quality issues that can be affected by the harvesting system are moisture content (storage and drying times), fines (processing and screening) and dirt contamination (handling, loading, screening and storage).

There is considerable scope for further applied research into harvesting and logistics of woody residues from all sources, particularly residue handling, transport and load compaction. Engineering solutions research could cover:

Handling/loading

- cut-off saws on loader grapples
- large volume buckets + hydraulic thumbs
- feeding from the hogger directly into the truck transporting the fuel (equipment design).

Transport

- load compaction (raw and processed residues)
- truck design (for raw and unprocessed residues).

Processing

- screening to remove dirt

- screening to upgrade/segregate products
- processing (comminuting) machine efficiency and throughput
- effect of particle size demanded on productivity.

Logistical

- segregation before piling
- loading, machine selection and operation
- processing into trucks not piles (cost analysis around logistics).

Fuel quality

- impact of ash content on operating costs
- payment by fuel value.

8. Recommendations for Stage II

From the relative cost contributions (Table 4, Page 28) the highest consistent cost contributor is comminution or hogging. Transport costs are variable with distance but contribute significantly. With the current practice of hogging onto the ground, handling losses are often comparatively small (10%) but significant and could be largely eliminated by system design changes. Direct loading could also potentially eliminate a loader and an operator from the system, reducing cost by around 6%.

There is a need for information to go to processors/users of biofuel on payment by energy and its implications.

The scale of the opportunity to supply energy from forest residues can be seen in the graph below, although these figures need refining to be accurate at a regional level.

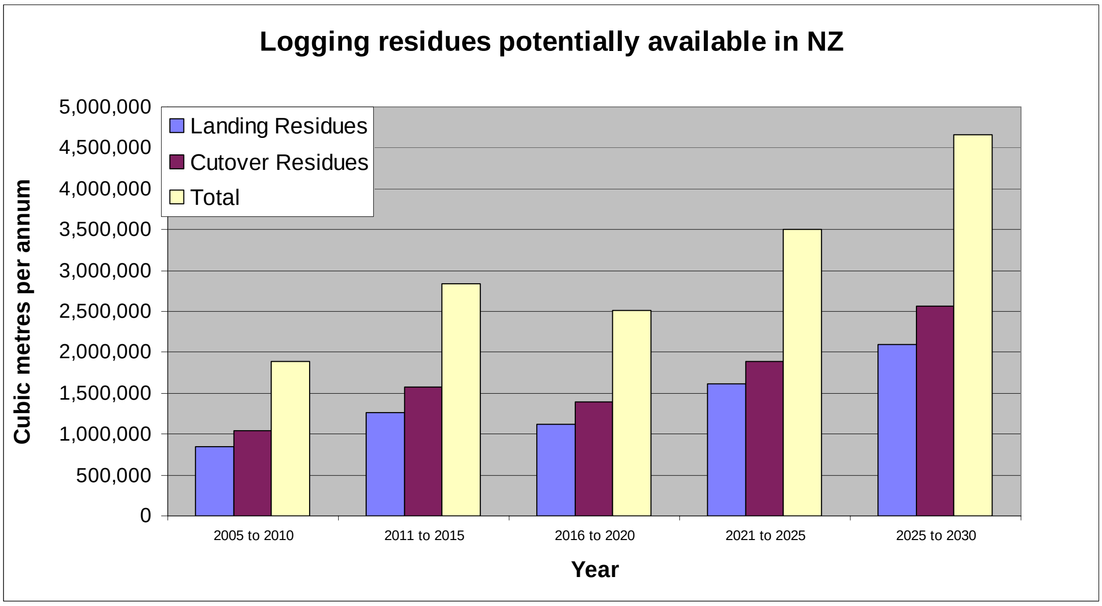

Figure 16 – Logging residues potentially available in NZ

It is recommended that further work be done on:

1. System design and management and hogger design requirements to facilitate direct loading of trucks to eliminate:
   - handling losses associated with hogging onto the ground
   - fuel contamination
   - cost (loader and operator).

2. Describing and developing a payment by energy system including equipment required, costs, operation and its implications for biomass fuel suppliers and buyers.

3. Comminution efficiency:
   - machine design (review)
   - knife design (review)

- comparison of fuel consumption versus product out by different machines
- impact of knife wear on product throughput and hogger fuel consumption
- impact of knife design and number
- impact of particle size demand on productivity.

4. Energy in energy out balance for three forest residue scenarios with variable transport distances.

9. Glossary

GJ = gigajoule

MJ = megajoule

RTFEL = rubber tyred front end loader

Comminution = size reduction, making big bits into lots of little ones

Chipping = size reduction via a chipper (sharp knife-type blades which work on one face of a carefully presented log)

Hogging = size reduction via a hogger (hammer-type knives working any face of bin full of pieces)

Shredding = size reduction via a shredder (hook-type knives working any face of a bin full of pieces)

Semi-trailer = a trailer that has a set of axles at one end and a tow hitch that rests on the rear of the towing vehicle at the other

Biofuel = forest residue, sawdust, bark, mill waste, yard waste

Forest residue = skid waste, one component of biofuel

Comminute = to convert from few large input objects to many output objects

Hog fuel = comminuted wood waste, relatively large chunks

Chip = comminuted wood or wood waste, small pieces suitable for pulping

Shred = comminuted wood waste, larger (longer but thinner) chunks than hog fuel

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Appendix I

Operation Summary – Ripper

Central Wood Recyclers (CWR), Taupo

The Ripper (Figure I-1) is being operated by Noel Richmond, based out of Taupo. This machine covers several sites, is currently at Ohaaki north of Taupo, but has worked at Tokoroa, Napier and KK Forest near Bennydale.

Figure I-1 – The Ripper working in forest to farm conversion near Ohaaki

The principal role of this machine (one of two Rippers operated by CWR) is to provide boiler fuel to the cogeneration plant at the Kinleith Pulp and Paper Mill near Tokoroa. This machine could be supplying up 70,000 tonnes per annum of hogged wood (Figure I-2). This model of the Ripper is track mounted and is self-propelled. It can be driven by remote control by the excavator operator. The positioning, feeding and engine speed are all controlled by the excavator operator, who is effectively driving two machines.

Figure I-2 - Wood fuel from the Ripper

This machine has also processed logging residue into planting mulch near Wellington, and logging residue from a superskid in KK Forest near Bennydale. The superskid residue was also used as boiler fuel at the Kinleith Cogen plant.

On the day the Ripper was visited at the work site it was working from windrows of forest waste from a forest to farm conversion operation. The material in the windrows was 9-year-old radiata pine, in whole tree form. These trees had been pulled out of the ground complete with the stump and major roots and piled nine months previously. This material had dried out somewhat from its green state and was starting to decay.

The windrows were being pre-treated by a 24-tonne excavator with a multi-tine grapple. This machine was taking the windrows apart, snapping the tree lengths in two and restacking the material. Due to its age the material was snapping easily. This operation made the material a better size for in-feeding into the Ripper, and removed some of the dirt attached to the stumps and needle material attached to the branches.

Figure I-3 – Windrows of 9-year-old trees (nine months since windrowing) in new pasture

Figure I-4 – Excavator pre-treating windrows, one windrow is piled into two rows for feeding into the Ripper.

The Ripper was driven alongside the windrows of repiled material and processed material which dropped off the out-feed conveyer in to a long pile of processed material. This was then loaded into a large truck and trailer unit (Figure 5) for transport (70 km) via private forest roads to the Kinleith Pulp Mill near Tokoroa.

Figure I-5 – Truck and Trailer unit transporting hog fuel

The reason for the use of the private off-highway roads is that it allows greater payloads to be carried than are allowed on public roads. If running on-highway this truck would be allowed a payload of 21.3 tonnes, off-highway it was carrying an average of 35 tonnes (33 to 37).

The operation was producing 250 to 300 tonnes per day, depending on the type of material found in the windrows and other operational issues. The operation had four machines and three operators onsite, with an estimated cost of $710 per hour. The estimated cost of production was $22 to $24 per tonne. Moisture content tests and dirt/ash content tests of the material were done on a regular basis. However, at this stage all payments were weight based. Transport costs were estimated at $11 per tonne. Total delivered costs were between $33 and $35 per tonne. At an average moisture content of 57% wet basis the delivered cost of the fuel is estimated at $4.70 per gigajoule.

A useful future development would involve using the sampling results to convert to payment by energy content.

Scion wishes to acknowledge Noel Richmond of Central Wood Recyclers and Gordon Dahm of Rob Dahm Limited for the information provided and access to the operation.

Appendix II

Operation Summary - Woodweta

Plateau Bark, Kawerau

The Woodweta (Figure II-1) is operated by Terry Robinson and Ian Mclaughlin, based out of Kawerau. The machine covers several tasks and has worked as far away as Invercargill and Whangarei.

Figure II-1 – Woodweta working at roadside, in forest near Kawerau

Its principal role is to provide boiler fuel for the energy plant at the Kawerau industrial site. It is anticipated that it will provide up to 30,000 tonnes per annum of hogged fuel (Figure II-2) for the energy plant.


Figure II-2 – Wood fuel from Woodweta


Figure II-3 – Loader feeding in logs

On the day the Woodweta was observed it was involved in a trial, processing unmerchantable logs of 4m to 6m in length, which were stacked on a landing edge. The logging site was approx 2km from the energy plant. The logs were a mix of radiata pine, eucalypt and acacia, and varied from 10cm to 30cm in diameter (Figure II-3). It was also planned that the machine would process the piles of branches and heads around the edge of the landing.

The fuel was being processed into a stockpile on the ground and reloaded into chip liners for transport to the mill site. The Woodweta has an outfeed conveyer that is long enough to feed directly into a chip truck over the top of the truck's bin. It is preferable to use this option where possible as less product is lost if trucks are loaded directly.

The Woodweta is also used to process log yard waste, general mill waste, sawmill off-cuts, superskid residues, packaging and demolition waste and reject board from panel plants. The processed wood is generally used as boiler fuel.

Production rates vary with the type of product being processed, and material with a piece length of < 3m is preferred. A mix of sizes of material going into the machine works well, and the operation tries to get a mix of long and short material to in-feed at the same time.

Under good conditions the Woodweta is expected to produce around $100m^3$ of product an hour. The cost of the processing is in the order of \$4.50 per m^3 or \$13 per tonne. The cost of loading and transport is additional to this, and in this case would have been approximately another \$2 per m^3 or \$5.60 per tonne. In this operation the moisture content of the wood was around 42 to 44% wet basis so this would equate to a delivered cost of \$2 per gigajoule (cost of coal is around \$4.50 to \$5.50 per gigajoule).

Using the weight of the material produced as a measure can be misleading, as when producing wood fuel, having a greater weight per tonne is not an advantage, as this generally indicates a higher moisture content, and hence a lower fuel value.

One of the developments that both the operators of the Woodweta and the fuel purchaser are hoping to implement over the next few months is payment by energy content as opposed to payment by weight. This is a key issue in getting a quality product delivered to the user as payment by weight can lead to wet low-energy-value fuels being delivered. This can give poor combustion plant performance and a distorted view of forest residue fuels.

The WoodWeta can be set up so that it pre-screens the raw material to remove dust and dirt before the material reaches the grinding disc. This enables the operation to produce a clean fuel with a low level of dirt contamination and hence a low ash content. It also reduces wear on the machine.

Using this system the salvage of landing edge residues is considered to be viable for operations with short haulage distances. The sections of stem material cut out in normal New Zealand log making operations are considered to be an ideal size for feeding into the WoodWeta. The branch material could also be consumed, if it was mixed with stem wood sections.

The Woodweta is mobile, and is built on a three-axle semi-trailer. It can be towed from site to site and set up relatively easily as long as ground conditions are firm. The unit weighs 30 tonnes and is not suitable for moving into soft or wet conditions.

With some planning around presenting the residues for extraction and processing it is anticipated that the efficiency of the operation could be improved as the material would be easier to access and the Woodweta could be positioned to feed directly into chip liners.

Scion wishes to acknowledge Terry Robinson, Ian Mclaughlin and Don Ford for the information provided and access to the operation.

Appendix III

Operation Summary – Crambo 6000

Materials Processing, Kawerau

The Crambo 6000 is being operated by Peter Fredricson of Materials Processing. The machine is based out of Kawerau, and operates at the Kawerau Mill's industrial site, but also works other sites, including the Rotorua Landfill, where it processes green and construction/demolition waste.

Figure III-1 – The Crambo 6000 processing wood waste into boiler fuel

The principal role of this machine, one of several hogging/recycling machines operated by Materials Processing, is to take a variety of wood waste streams which are produced at or come to the Kawerau industrial site, and convert the waste into boiler fuel for use in the energy plant. The machine could produce in excess of 80,000 tonnes per annum of hogged wood waste (Figure III-1) if it was fully utilised. This model is track mounted, self-propelled and can be driven by remote control, usually by the operator of the excavator which is feeding the wood waste into the Crambo.

The machine weighs 26 tonnes and is moved from site to site on a transporter. With the ability to self-propel and manoeuvre quickly and easily, the Crambo can work along a windrow of stacked material or around a landing with residues piled around the edge.

Figure III-2 – Wood fuel from the Crambo 6000

On the day the Crambo was observed it was processing a variety of wastes out of a single pile. This material was made up of pallets, packing cases, sawmill dockings, bark, old log waste mined from a landfill and oversized material screened out of hog fuel (Figure III-2). Due to the low speed operation of the augers and the knife shape, the Crambo tends to produce fuel with a different particle size and shape to high speed hoggers. The particles tend to be longer and thinner, and with fewer fines.

Figure III-3 – Materials being fed into the Crambo 6000

These materials had been stockpiled at Materials Processing's yard at Kawerau. The excavator, which is fitted with a bucket and hydraulic thumb, was sitting on top of the stock pile and loading into the Crambo for hogging. Being above the machine gives the excavator/hogger operator a clear view of the in-feed and out-feed. The Crambo is a low speed high torque hogger which has two shafts or augers that rotate at between 30 and 40 rpm. These have 67 knives each, in a spiral pattern. (Figure III-4, left). The knives grab the material that is fed in on the top, and tear and shred the wood into the screens (Figure III-4, right). Stem sections were part of the material being fed in and long sections are placed in the hopper with one end resting on the edge of the feed bin. This drops one end into the augers, allowing them to grip the log and pull it in (Figure III-5). Short wide stem sections such as slovens and large stem offcuts were also being fed in and were dragged into the screens by the hook-shaped knives.

Figure III-4 - Hogging augers and knives (left) and sizing screens (right)

Figure III-5 – Processing large stem waste section, 1.2m long and 35 to 40cm diameter

The fuel was dropped on the ground by the out-feed conveyer, then taken by a wheel loader to a screen where oversized material was removed for reprocessing. The hogged fuel was then transported a short distance by truck to the energy plant’s fuel pile.

Production rates vary with the raw material being processed. On large green log waste from the adjacent superskid (Figure III-6), it might be as low as 20 to 22 tonnes per hour. On the material being processed at the time of observation it was 30 to 32 tonnes per hour. On light material and bark it can be higher (40 tonnes per hour +).

Figure III-6 – Sections of stem wood waste from superskid to be processed with the Crambo

Given the above production rates, costs are estimated to be anywhere between $12 and $24 per tonne. However, on solid wood residues such as logging landing waste (a mix of stem wood and branches it is estimated to be around $18 per tonne or $1.90 per gigajoule. This does not include transport costs. For the residue produced at the yard where the machine was observed transport costs would have been another $3 per tonne or $0.30 per gigajoule. These costs assume a moisture content of 45% wet basis.

The material being produced by the Crambo could be loaded into either large ($30m^3$) hook bins, or directly into a truck. This option reduces losses of processed material and lessens the chance of dirt contamination but requires a well organised and continuous supply of trucks or bins to work into.

The fuel produced is currently being paid for by weight, but payment by energy content is a better option for both parties as the producer gets paid for the true volume of material processed and the buyer is paying for what they are using (energy). When purchasing wood fuel, paying by the weight of the material can lead to:

- the producer being paid for less than they should be if the raw materials are dry
- the buyer paying more than they should if the raw materials are wet.

Scion wishes to acknowledge the information and access to operations provided by Peter Fredricson and Bernie Tientjes of Materials Processing.

Further information is available from;

Bioenergy Knowledge Centre

Providing information on the utilization of wood waste for bioenergy

Telephone 0800 BIOENERGY (0800-246-363)
E-mail info@bioenergy.gateway.org.nz
www.bioenergy-gateway.org.nz