Bio - Mass Supply Chain
And Logistics
Bio-Mass Production (Trial Work)

Commenced in January 2003, when the first SCS Ripper machine was transported from Canterbury to Kinleith. Initial trials concentrated on reject pulp logs and waste in close proximity to Kinleith site.

The initial objective was to find a cost effective and sustainable alternative fuel source, in advance of predicted price hikes in natural gas.

Bio-Mass Trials

The very earliest trials at Kinleith in 2003 were an inter-company arrangement between:

- CHH Pulp & Paper – as operators of the JV Cogeneration plant at Kinleith.
- BioGrid – specialists in residue utilisation.
- CHH Forests – as forest estate owners and operators

From the outset CHHP&P agreed to fund the direct operational costs, with both Biogrid and Forests making staff available to manage the trials. The process was one of trial and error, and as the P&P staff were unfamiliar with the forest, they were reliant on Forests staff to source sufficient fibre of the quality required.
Trial Objectives

- Determine the cost of processing forest residue from various sites.
- Determine the viability & reliability of the SCS ‘Ripper’.
- Estimate the volume of wood waste available in the forest.
- Determine a value of the wood waste as a fuel.
- Determine a cost of transport.
Kinleith Cogeneration Plant

Kinleith’s No8 boiler is co-fired using wood waste (Bio-Mass) and Natural gas to generate up to 180 tonnes of steam per hour @ 4500 kPa, which is used onsite for the pulp & paper process after passing through the 40 MW steam turbine. 41% of the bio-mass budgeted to be used in the No8 boiler in 2006 is generated on the Kinleith site through the debarking and chipping plants. The balance comes from external sources.

The Kinleith Cogen plant produces approximately 47% of the electricity needs of Kinleith P&P mill. The plant uses a combination of Black Liquor (primarily lignin), natural gas, oil and wood waste to create steam, which in turn drives the turbine/generator.

The Cogen plant is a Joint Venture between CHH and Genesis Energy, and is operated under contract by CHH.

Black liquor from the chemical pulping process makes up approx 60% of the total energy inputs, and along with wood waste (13%) makes up 73% of energy consumption at Kinleith. The benefit both bring to Kinleith is the fact that 100% of that energy input is renewable and not associated with fossil fuels.
Cogeneration Plant Energy Inputs

On-going uncertainty around the cost of natural gas was one of the key reasons why CHHP&P decided to trial the usage of forest bio-fuel. Bio-fuel could not only be a cost effective alternative to gas, but a renewable non fossil fuel energy source.

Along with Black Liquor, which is a derivative of the chemical pulping process, bio-fuel makes up 72% of Kinleith’s energy supply. The amount of black liquor is generally constrained by the mills recovery boiler capacity, however bio-fuel could easily displace more of the natural gas, should gas prices require it.
Energy inputs to the Kinleith plant in 2003 were:

**Electricity**: 57%
**Gas**: 33%
**Oil**: 2%
**Wood waste**: 8%

100% of the Wood waste is used in the Cogeneration plant. Only 15 - 16% of the total wood waste consumed as Bio-Mass is sourced directly from the Forests surrounding the Kinleith mill, as the bulk of the bio-mass coming from the two large log debarkers on site is the primary fuel source.
Energy Costs

Since the commencement of the Bio-Mass production trials in 2003 the cost of energy at Kinleith has increased by 24%/annum.

The biggest increase has been in natural gas (61%), with the future prospects being uncertain, as the Taranaki gas fields continue to decline in capacity. Increased gas prices will mean wood waste bio-mass becomes more and more attractive, as an environmentally friendly alternative to the more costly fossil fuel. Natural gas makes up 21% of the energy input, but commands 43% of the energy cost.
The Kinleith Cogen plant uses approx 320,000 MT of bio-mass annually. The bulk of that fuel comes from the:

- Bark from the Kinleith chipping plants (Kinleith mill takes in approx. 1.8million tonnes of logs with their bark attached.
- Sawdust from CHH WP sawmill (Putaruru)
- Residues from Kinleith Plymill
- Log yard waste-primarily bark.

Adjacent to the Cogen plant the pile in the above photograph is holding approx 350,000 tonne of bio-mass. That pile is primarily bark, sawdust and shavings, with all of the Forest Bio-mass being delivered directly to the Cogen plant.

In 2000 approx 153,000 tonne of Bio-Mass was burnt to produce 288,500 tonnes of steam, which is equivalent to 61,270 tonnes of displaced carbon by not burning natural gas. In 2004 approx 320,000 tonnes of Bio-Mass was burnt to produce 574,400 tonnes of steam, which is equivalent to 122,000 tonnes of displaced carbon by not burning natural gas.

The trial volume contributed 50,000 tonnes of Bio-Mass i.e: equivalent to 1475 tonnes of displaced carbon.
Much of the supply process evolved through trial and error, as we refined the match between resource availability and cost effectiveness. Initial trials were done on a cost plus basis, with CHH P&P carrying 100% of the direct costs and CHH Forests providing the personnel to manage the field operations. It became obvious quite early in the piece, that the hogging of fresh harvest waste was not going to yield bio-mass with acceptably low moisture content, and as such a cost effective alternative to gas.

Trials were conducted taking fuel to the Hogger, and the Hogger to the fuel, however we soon discovered that the Hogger had to get closer to the fuel source because of the costs of hauling light payloads long distances. Processed fuel could be loaded and transported more efficiently than unprocessed waste. The above steps in the supply chain evolved from 18 mths of trials.

In January 2005 PhD student Stefano Grigolato (working for Forest Research) completed a study titled ‘Supply & Transport of Logging Residues for Energy Production’. The objective was to ‘Define a methodology for estimating the availability and the volume of logging residues and for calculating the supply cost from the forest to the power plant’. The study was done in Kinleith forest using the CHHF GIS database. His paper has since been published and is available through SCION.
Trial work and cost comparisons proved that the best quality bio-mass, with the higher calorific value, could be produced from harvest waste > 12 mths old. There were seasonal variations as the older wood soaked up moisture in winter, however waste > 24 mths old was on the verge of decay and reduced value as a result.

Using the CHH Geographic Information System, we mapped the entire Kinleith forest by clearfell year and by Q within each of those years ie: in 2004 we mapped all stands clearfelled since January 2002. Visually it was obvious where the harvest was concentrated, and where those blocks lay in relation to the internal arterial roading network, geographic barriers (rivers) and where we could situate the Hogger.

It also gave us the opportunity to plan operations for winter and summer, as the forest has quite distinct soil differences best suited to one or other.
Our operations to date have proved the best bio-mass comes from blocks harvested 12 -24 mths previously. It is normal practice to cease all maintenance work once environmental rehabilitation work has been completed, following harvesting. Once we identify the target salvage areas through using the GIS, the next step is to visit every single landing in those areas to:

- confirm road access is still possible.
- confirm the landings have not been ripped, bedded and planted.
- confirm the waste is dry and the landing not under water.
- confirm the volume of waste recoverable off each landing (A, B or C)
- confirm there are no other pulp logs which could be salvaged as merchantable logs, rather than hogged.

Landings such as that shown above are not a salvage option as the poor drainage has negated the drying benefits expected from 18mth old logging waste.

Inspections of the block usually take place with the loader driver responsible for salvaging and loading the waste. That way he can assess the machinery combinations required to match the hoggers production capacity. Maps are supplied to the salvage contractors, showing any known hazards and the rating on each landing. Each block also requires a hazard register to record the known hazards.
Road damage in the CNI pumice soils is not unusual, therefore site inspections are critical when going back to blocks 12 – 24 mths after harvesting ceased. A worst case scenario could mean leaving waste unsalvaged, as the cost of repairing the road would be greater than the value gained from salvaging the bio- mass in that part of a block.

As principal we have hazard identification responsibilities under the HS&E Act.
Harvest Waste

The volume of waste on individual landings varies, depending on the harvest system used ie: downhill hauler settings had more waste than uphill hauler settings. Landings that had Waratah heads delimbing and log making had a higher % of blocks than conventional motor manual systems.

Early trials showed waste on landings to be 3-4% of the total volume harvested from any particular setting. Settings where the trees were hauled to the landings with branches on, were always going to yield more waste than settings where trees were delimbed in the cutover. Despite the branches appearing to be bulky, they yield far less bio-mass than log off cuts. No attempt has been made to salvage waste from cutover, primarily because we have sufficient waste on landings to meet our needs.

Harvest levels in Kinleith Forest were almost double in 2003, what they are in 2005. As a result the volume of waste was considerably higher in those 2003 stands, as harvest crews wasted more merchantable volume, and left it in windrows at the back of log landings. At predicted harvest levels there will not be sufficient harvest waste on log landings to meet Kinleith’s demand for Bio-fuel by 2007.
Log off-cuts like those shown on this slide make prefect bio-mass as they contain bulk, and make the cartage of unprocessed waste economic. Lots of branches on a landing may look good, however needles and small branches yield bio-mass of questionable value. A trial with eucalyptus branches from a promising looking block yielded bio-mass resembling silage. Once landings have been left unsalvaged beyond 18 months, branches have already started to decay, making the larger pieces of wood the target.
Multi - Tine Grapple

Collection & Loading

On the average log landing the harvest waste is a combination of branches and short logs or blocks, none more so than hauler landings. Conventional log grapples were not suitable for grabbing the smaller piece sizes and short blocks, and the most cost effective solution is to grab as much as you can first time. Making multiple grabs wastes time and leaves too much smaller waste behind. The above grapple was purpose built for the waste collection and loading phase, with later versions refining the product further. This multi-tined grapple allows most of the dirt to fall from the grab when picking up small pieces on a dirt surface.

To build a fully rigged multi-tined grapple from scratch, one can expect to spend $50 – 70,000.
Collection & Loading
Collection & Loading

Not all waste can be accessed by the excavator loaders easily, with some large landings being so wet or rough, the truck has to sit on the road for loading. On occasions the loaders have had to make as many as 4 swings to get the waste to a point where it could be loaded. It can only be justified if the bulk of waste involved can justify the time spent, as show above. The mix of large pieces in the above waste mix makes the process cost effective.

In difficult terrain a night shift was used to salvage enough waste to keep up with the primary haul capacity and hogger capacity, as a day shift alone couldn’t keep up.
In the past 12 mths approx 8000 hectares of forest land in Kinleith Forest has been sold for dairy conversion. Much of that land was previously covered in mature P radiata, so before the areas could be grassed, the blocks had to be stumped and the waste pushed into windrows. The above photo is an example of a recently converted block, with large volumes of wood waste in the windrows. Such windrows would cover at least 10+% of the land area in many of the worst blocks. The normal course of events would see those windrows left for a year or two before the farmers pulled them apart with excavator loaders and burn the wood waste. By using the Ripper to hog the waste, the land converters were able to have close to 100% usable land within 12 mths.

Stumps have a higher resin content and calorific value, however they have more dirt attached, and can't match the bio-fuel output from conventional forest waste. If dirt could be screened from the stump hogging successfully, the CWR hogger could stay put in one place for 2-3 yrs chewing up dairy conversion waste.
Post Waste Removal

Conversion Waste

The above photo is an example of how dairy conversion farmers can reclaim their total land area within 12 mths, by removing and hogging the wood waste from the windrows. After removing the wood waste the farmer is left with piles of topsoil which were pushed into the original windrow.
Bio-Fuel Cost Neutral Comparison to Gas

Points to Note
Yellow line (bottom) is the calculated cost neutral value of wood waste vrs gas at 2005 prices. It assumes 5% ash content at the various moistures.

Blue line (Top) is the calculated cost neutral value of wood waste vrs gas at 2006 prices. It assumes 5% ash content at the various moistures.

Red Triangle is the calculated cost neutral value of wood waste vrs gas at 2006 prices. Based on actual measured moisture and ash content from various sites.

Green dot is the actual delivered and hogged cost + CHH forest charge of $5/t

The calculated fuel value includes a fuel handling (on site), maintenance and ash disposal cost, the model also assumes there is a ROI required on the extra equipment necessary to burn Woodwaste.

HOG10 is the lowest value fuel costing more to deliver than the alternative gas natural cost.

HOG7 the value is low because of the 10.3% ash it cost more to deliver than its calculated value.

HOG4 its calculated value is greater that the gas alternative mainly due to the low ash content at 2.2% and the delivered costs were lower than the calculated value.

If all the fuel was from HOG4 we would be winning.
As the annual harvest in Kinleith Forest has been 6000 – 7000 hectares/annum, the number of log landings number in the hundreds. Prior practice has been to rehabilitate landings by ripping and bedding them ready for replanting. That practice did not consider the option of returning to salvage the harvest waste, left on that landing, generally on the outer extremities of the landing. Salvaging from bedded landings requires careful machine operation, as often the landings were already planted.

A set of standards were agreed with the Forestry division so planted landings could be salvaged, and the level of damage minimised and controlled.
Primary Haul

As the areas being targeted for waste collection have been harvested 12 - 24 mths previously, the supporting roading infrastructure isn’t what it would be if harvesting was still taking place. Seldom are T&T units used in the primary haul phase, as often the roads are poorly maintained, with few turnaround points. Heavy duty bin trucks are made for the job, as they can handle the bulk of raw forest waste and maximise the payload volume.

Every effort is made to restrict the primary haul distance to <10km, as it isn’t cost effective to cart payloads of 7 – 10 tonne, any further. Where the waste includes large volumes of branches, the payloads are the lowest and carting low payloads longer distances soon eats into the cartage contractors profitability. Where access is poor we have had to use more than one loader/truck combination to keep up with the hogging capacity of the Ripper machine.

As the whole supply chain cannot justify spending more than a bare minimum on road maintenance, the best option is to park up during periods of very wet weather.
The most cost effective supply chain has been when the Hogger was moved to the fuel source, and not vice versa. The site in the above photo is the ideal site, and one that fits the following criteria perfectly:

- Minimum area 0.5 hectare.
- Must be near to flat, as uneven ground is unacceptable when tipping articulated truck loads of forest waste.
- Must be sufficient room to:
  - Site and move the Hogger
  - Store waste (preferably a weeks supply)
  - Store processed bio-mass
  - Turn trucks when unloading
  - Build a loading ramp
  - Turn and load trucks when loading out bio-fuel
  - Store support vehicles, fuel tanks etc.

The most cost effective solution is to site the Hogger within 10 km of the waste supply source, as the primary haul rate table uses the same cost from 1 – 10km. A pumice or rock surface is preferred, as it allows the machinery to operate in all weather and reduces maintenance costs.

Being close to an internal arterial road allows the contractors to utilise their trucks more efficiently through improved cycle times. In Kinleith forest we would look for old quarries or Superskids, which both fit the key criteria.
The ‘Ripper’ machine in the above photo is the second used on this project, as the first machine was written off after a fire in the engine bay. The newest machine has huge advantages over the first, not only in reliability, but in its ability to move about the hogging site on tracks. Being self propelled, the Ripper can move to the fuel stockpiles, rather than having to move the waste to the Ripper.

What the Ripper does not have is the ability to screen out dirt or stones. We have done work with a power screen under the outlet conveyor, and that successfully removed most of the dirt. As dirt % > 2-3% is unacceptable, more work needs to be done on reducing the amount of dirt through the use of screens as not all boilers are as accommodating as the one at Kinleith. For bio-mass to improve its cost competitiveness Vs gas, cleaning up the fuel is a must.
Bio-Mass produced from harvest waste has improved the steam generation at the Kinleith Cogen plant. The coarser fuel type aids the combustion of lower grade wood waste ie: bark & sawdust. The cleaner the fuel the higher the value to CHHP&P.
Quality Bio-Mass

Bio-Mass Specification

Grade Name: HOGF
Destination: CHH Kinleith Cogeneration Plant
Size:
  Nominal end section 50mm x 50mm
  Nominal piece length 100mm
Calorific Value:
  Minimum = 16j/g Oven Dry Calorific value (kj/g)
  Test Frequency = 1 / 2000 tonnes
Moisture:
  Maximum = 60%
  Target = 50%
  Exceptional = <45%
  Test Frequency = 1 sample / 200 tonne of HOGF
Ash Content:
  Target = < 10% (Dry basis 1.5 – 5%)
  Test Frequency = 1 sample / 200 tonne of HOGF
Contaminants:
  No steel or metal, rocks, glass or other contaminants.
General:
  Bio-Mass is to be produced from sound wood waste i.e:
  generally
  from logging residues < 2yrs from time of clearfell. Rotten logs are unacceptable.
Species:
  Any exotic forest tree species from within the CHH Forest fee estate.
Delivery:
  Deliveries to be weighed over CHH Kinleith weighbridge.
Bio-Mass Quality Assurance

To be competitive with other fuel options (gas) the bio-mass being produced must meet an agreed specification. That specification includes:

- size characteristics
- moisture content (preferably <50%)
- contamination levels (dirt, foreign materials)
- Must be from sound material (no rot)

Samples are taken regularly throughout each work days, with a single sample taken from those amalgamated samples, and sent to an independent lab daily for analysis. That analysis is used by CHHP&P to compare the landed cost of the bio-fuel with natural gas.

The Ripper machine has the capability to increase or decrease the size of the bio-mass by changing the internal screening. CHHP&P prefers a courser piece size, as it contributes to better combustion and hence steam production when blended with the lower quality fuel supplies (bark/sawdust).

The newest Ripper machine has been 100% reliable and is approaching 12 mths with limited maintenance downtime. Such reliability contributes to higher bio-fuel output and the potential to operate double shifts, should demand require it. The contractor now has the opportunity to take the machine away to work for other customers, knowing they have sufficient processed product in stock to meet the monthly quota from CHHP&P.
To date 100% of the bio-fuel has been produced within the CHH Forests estate, and as a result, the cartage contractor can take advantage of the private road network to maximise its payload. The above T&T unit will max out in volume before it maxes out in weight, as the low moisture content in the bio-fuel results in most T&T loads being 31 – 34 tonne.

Truck utilisation is the key to minimising costs, therefore where and when possible Dahm will use his trucks for both the primary & second haul phases. At the end of each work week all trucks will take a load home on the secondary haul leg, regardless of whether they are T&Ts or single articulated units.

Kinleith forest has 250+km of sealed highway, therefore siting Hogging sites close to those arterial routes speeds up delivery to Kinleith and minimises wear and tear on the T&T units.

As part of the trial work we loaded the trucks with ash from the Cogen plant and returned it by backload to the forest. Those trials had significant cost advantages to CHHP&P, as the ash must be disposed of daily in landfills. Although the trials were successful, CHHP&P is working with Environment Waikato to ensure the ash has no detrimental environmental impacts in the forest. As there were no toxicity issues with the ash the in forest disposal remains a real option.
Payments & Invoicing

- All supply chain phases paid off net weight of bio-mass over weighbridge ie:
  - Collection & loading
  - Primary Haul
  - Hogging
  - Secondary haul.
  - Invoicing to CHHP&P

Invoicing & Payments

From the outset it was envisaged costing & selling the bio-fuel in BDMTs, however because of the variability of the fuel types it was soon found to be unworkable. The most significant issue was paying the contractors the equivalent of a tonne rate, when potentially every single load could have a different moisture content and value. The contractors accepted that some fuel would be low in moisture content, and as a result the primary haul phase in particular, would struggle with low payloads.

Since the earliest trials the onus was on the contractors to minimise costs, and it should not have been CHHP&P’s responsibility to pay for inefficiencies in the supply chain. From day one the supply chain involved 2 separate contractors ie:

- Central Wood Recyclers – the hogging contractor. CWR has the excavator loading the hogger, the Ripper Hogger and the wheeled loader pushing up the bio-fuel and loading trucks.
- Rob Dahm Ltd – has the waste collecting and loading excavators (2), the primary & secondary haul trucks.

As the operation is controlled by monthly quota, there is nothing to stop the contractors over producing in any one week or month, if they wish to use their machinery elsewhere. Neither contractor nor any single phase in the supply chain can be paid without a load of bio-fuel going over the weighbridge at Kinleith. Prior to the old Ripper machine being burnt out, this did cause issues for Dahm, as the Ripper was out of commission regularly for major repairs. Any single load of bio-fuel over the weighbridge generates payments to both contractors for all phases of the supply chain, in addition to generating an invoice for CHHP&P for those actual delivered costs.
Bio-fuel Production 2005

Target 50,000 tonne

Actual Production 46,870 tonne.

Average Delivered cost
$35.32/ tonne.

Since June 2004 Kinleith has taken approximately 4000 tonne/month of biofuel produced from Forest waste. In the past 12 mths, a higher % of that waste has come from land conversion areas, where P radiata stumps have been removed and cleaned by excavator loaders prior to being hogged. The challenge has been to minimise the % of dirt, as the target % is <3%, whereas some samples have been as high as 10%. Dirt decreases the efficiency of the boiler and increases the volume of ash residue, which must be disposed of daily.

YTD average delivered cost of bio-fuel is $35.32, with an average secondary haul distance of 45 km. The rising cost of fuel has increased production costs by approximately 10% since January 2005, however that needs to be compared with the 61% increase in the cost of natural gas over the past 2 yrs.

Despite the delivery target being 50,000 tonne in 2005, the volume has been constrained by CHHP&P at that level, and does not reflect the availability of waste, nor the productive capacity of the supply chain.