Direct hogging / loading of wood fuel & Payment by energy

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Acknowledgments

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Direct hogging / loading of trucks with hogged wood fuel
Why is this of interest?

Fibre loss
- Estimated (reported o/seas) to be 5 to 10%

Cost of double / triple handling
- $1.50 to $2.00 tonne

Common in some countries to operate with direct to truck or set-out bin/trailer chipping/hogging

Avoids contamination risk during handling/reloading

Study was conducted on the Wood Weta operated by Plateau Bark based in Kawerau.

- WoodWeta has the potential to have the out-feed discharge at heights of up to 5.4 m, which is sufficiently high to discharge over the side of high-volume, bulk-carrier trucks.

- Conditions at the time of the study were dry, with a firm working surface.

Goal of this study - to determine the fibre loss associated with hogging onto the ground and compare this with hogging directly into a truck.

Potential differences in trucking costs were also of interest;
- hogging into a truck entails increased loading time, and the extra cost of the truck and driver may or may not be offset by the reduced fibre loss.
Fibre loss

Hog to ground
- 4.0%

Hog to truck
- 0.25%

Costs and Assumptions
Hogger gross production = 27 tonnes per hour.

<table>
<thead>
<tr>
<th>Hog to ground</th>
<th>Hog to truck</th>
<th>% Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recovered production</td>
<td>96%</td>
<td>99.75%</td>
</tr>
<tr>
<td>25.92 t/h</td>
<td>26.93 t/h</td>
<td></td>
</tr>
</tbody>
</table>

Costs per hour

<table>
<thead>
<tr>
<th></th>
<th>Hog to ground</th>
<th>Hog to truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loader 1</td>
<td>$100 /h</td>
<td>$100 /h</td>
</tr>
<tr>
<td>Hogger</td>
<td>$350 /h</td>
<td>$350 /h</td>
</tr>
<tr>
<td>Loader 2</td>
<td>* $50 per 25 t/ load</td>
<td>-</td>
</tr>
<tr>
<td>Truck</td>
<td>** $45 per 25 t/ load</td>
<td>** $130 per 25 t/ load</td>
</tr>
<tr>
<td>Total cost</td>
<td>$545 / hr</td>
<td>$580 / hr</td>
</tr>
<tr>
<td>Cost on truck</td>
<td>$21.03 /t</td>
<td>$21.54 /t</td>
</tr>
</tbody>
</table>

* Loader is $100 per hour, figures in table represent the cost of time taken to do the loading
** Truck is $140 per hour (high volume truck and trailer), figures in table represent the cost of time taken to do the loading
Summary

Cost estimate
- hog-to-ground operation was $21.03
- hog-to-truck at $21.54,
($0.51, or a 2.4% difference).

Effectively the cost of the two operations, was about the same.

The higher fibre loss in the hog-to-ground and reload system is offset by the slower truck loading time from the direct loading system.

Summary

These figures can be used for estimates to determine which system would be better under different circumstances;

- if the operating conditions were difficult (wet and muddy) and fibre losses were higher (10% for hog-to-ground and 0.5% for hog-to-truck);

  - then the cost difference would be greater and the hogging to truck would have an advantage of $0.79 per tonne or 3.5%.
If the truck waiting time is not included in the calculation, the effect of the fibre loss on the production cost is much more apparent.

In this situation the costs of production would be;
- $19.29 for hog-to-ground
- $16.71 for hog-to-truck,

a difference of 13.3%.

**Base case:**

In the hog-to-ground set-up it may be valid to assume that the truck loader will have to be present whether it is loading or not and therefore cannot be used for other work.

In this case all its time is attributable to the production of the hogged material on truck.

This would make the hog-to-ground operation more expensive ($22.95 per tonne, +$1.41 or +6.5%) as well as less efficient overall when compared to the direct hog-to-truck option.
The ability to operate direct to truck requires;
− a suitable working site, with space for trucks to turn and manoeuvre under the out-feed belt
− a hogger with a high out-feed conveyer, or
− a chipper with a direct-able discharge chute

NB - Wind can have an influence on the material loss in direct loading.

Payment by Energy Content
Payment by Energy Content

Wood residue can be measured and paid for by weight or volume but:

How much energy is in the fuel pile?

&

What did it cost per unit of energy?

Purchasing energy

• Electricity – $16 to 18 per GJ
• Gas - $14 per GJ
• Diesel - $48 per GJ ($1.10 / litre)

Typically pay for the energy content, if by volume (m3 or litre, its because the energy in that unit is always the same).
Payment for wood energy

- Payment by weight for wood fuel biomass is currently the most common practice in New Zealand, particularly at large-scale industrial sites.

- Payment by volume is sometimes used at smaller sites.

- This is often a quick and convenient method of paying for the material, as it is transported by truck to facilities that have, or are near, weighbridges.

- The forestry and wood processing industries have a long history of using weight as a measure for paying for logs and log transport and the infrastructure for weighing trucks is well established.

Improving wood fuels and increasing use

- To increase and improve the use of woody biomass as a fuel its value needs to be better understood, and improved where possible.

- The easiest method to increase the value of woody biomass as a fuel is to ensure it is clean and dry.

- A dry fuel has lower moisture content and therefore higher energy content per unit of weight or volume.
Benefits of energy payment

• A clean fuel is easier to handle and has lower operating costs than a fuel with contaminants such as dirt and stones. These contaminants cause machinery breakages, blockages, and reduced energy recovery.

• A clean fuel has higher energy content and lower ash content. Low ash content can result in better combustion characteristics and lower ash disposal costs.

• A payment system based on energy content is one method of ensuring a high-value fuel – the higher the quality of the fuel, the higher the energy content, the higher the value to both seller and purchaser.

The drawback of paying for biomass by weight is that the energy content of a given volume or weight of wood is not necessarily constant. This is particularly so for forest-derived residues, which have varying sources, supply chains and storage times. The weather is also a factor.

The two main parameters which affect the energy content of woody biomass are:

• moisture content

• contamination with dirt, which ultimately affects ash content.

Different to many other common forms of energy (gas, diesel and, to some extent, coal where the energy content per unit of volume or weight is constant
Issues with weight payment

In paying for a material with variable energy content by weight or volume, the fuel buyer ends up not knowing exactly what the cost of energy is.

It is in the interests of the fuel supplier to know at least what volume of material they have produced, as dry material weighs less (less revenue in a weight-payment system) but takes just as much effort to produce (volume of throughput).

The reality is that paying for wood fuels by weight actively discourages the fuel supplier from producing a clean, dry fuel, as it is not in his financial interests to do so.

![GJ / t, by moisture content diagram]

35% difference in energy content between wood at 60% mc and 50% mc
Energy by weight and volume by moisture content, volume by weight and density by volume by moisture content

*Note 1 m³ of solid wood = approximately 2.5 m³ of chip or 2.7 m³ of hogged wood

<table>
<thead>
<tr>
<th>Moisture content (wet basis)</th>
<th>GJ / t</th>
<th>Solid m³ / t</th>
<th>GJ / m³</th>
<th>t / m³ Solid</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>12.8</td>
<td>1.59</td>
<td>8.05</td>
<td>0.63</td>
</tr>
<tr>
<td>35</td>
<td>11.7</td>
<td>1.48</td>
<td>7.92</td>
<td>0.68</td>
</tr>
<tr>
<td>40</td>
<td>10.6</td>
<td>1.36</td>
<td>7.77</td>
<td>0.73</td>
</tr>
<tr>
<td>45</td>
<td>9.5</td>
<td>1.25</td>
<td>7.60</td>
<td>0.80</td>
</tr>
<tr>
<td>50</td>
<td>8.5</td>
<td>1.14</td>
<td>7.48</td>
<td>0.88</td>
</tr>
<tr>
<td>55</td>
<td>7.4</td>
<td>1.02</td>
<td>7.23</td>
<td>0.98</td>
</tr>
<tr>
<td>60</td>
<td>6.3</td>
<td>0.91</td>
<td>6.92</td>
<td>1.10</td>
</tr>
<tr>
<td>65</td>
<td>5.3</td>
<td>0.80</td>
<td>6.66</td>
<td>1.26</td>
</tr>
<tr>
<td>70</td>
<td>4.2</td>
<td>0.68</td>
<td>6.15</td>
<td>1.47</td>
</tr>
<tr>
<td>75</td>
<td>3.2</td>
<td>0.57</td>
<td>5.63</td>
<td>1.76</td>
</tr>
</tbody>
</table>

- 20% + 28%

Value of a tonne of wood fuel by moisture content and energy value

$3.00 per GJ, at 55% mc = $21.45 per tonne at 60% mc = $18.27 per tonne
Impact of Moisture content on Boiler efficiency

Boiler efficiencies are nominal
- For the fuel they were designed for
- Within a fuel specification range
- Fuels that are outside the design range (especially wet fuels) will reduce the efficiency of the boiler and its energy output.
- Fuels of over 60% mc wet basis should be avoided; low energy value, at 65%+, mc wet basis combustion may become unstable.
- Effect will vary with boiler design

Calculating Energy Content

- The relationship between moisture content and energy content can be used with the weight to calculate the energy content of the biomass.
- The equation used to estimate the energy content based on moisture content is:

\[
\text{Energy (GJ/t)} = -0.212 \times \text{Moisture content (\% wet basis*)} + 18.842.
\]
Setting up an energy-based payment system

Step 1: Determine a target value for woody biomass.
- The target value is what the purchaser wants to pay for energy from woody biomass. This can be calculated from the current contracted price per tonne of hogged woody biomass based on a maximum average acceptable moisture content (typically maximum moisture content is around 55%). In order to calculate the target value of the woody biomass, the energy content of the fuel must first be estimated.
- Once the energy content is known the target energy value can be set. For example, if the current price is set at $15 per tonne, and the energy content is 8.2 GJ per tonne (assuming 50% moisture content, wet basis) then the target energy value can be set as $1.83 per GJ.

• Step 2: Obtain the weight of the load.
• Step 3: Measure moisture content from a sample of each load of biomass.
• Step 4: Calculate energy content in the load using the formula shown previously.
• Step 5: Calculate total energy content in the load by multiplying energy content by weight of load.
• Step 6: Calculate value of the load by multiplying total energy content by energy value (for example, as above $1.83 per GJ).

Payment calculation example

- Target value for fuel = $2.50 per gigajoule
- Sample weight wet = 315 g
- Sample weight dry = 145 g
- Moisture content = 170 g
- MC wet basis = 54%

Using the equation:
Energy (GJ/t) = -0.212 x Moisture content (% wet basis) + 18.842

This gives the result of 7.36 GJ per tonne for energy content of the fuel.

- Load weight = 15.73 tonnes
- Energy content of load = 15.73 * 7.36 = 115.77 GJ

Value or cost of load = 115.77 x $2.50 = $289.42 = $18.40 per tonne
Ash content

• The wood naturally contains <1% ash and bark about 2% to 3%.

• Anything over this is probably due to contamination, typically dirt.

• Many boilers will cope with ash content of up to 5%. However, anything much higher than this is likely to affect boiler performance, and will have a significant effect on ash disposal cost, due to the increased quantity.

• It would be reasonable to have a specification which set a maximum ash content and periodically test for this. If the tests showed ash content over the agreed limit then the payment could be reduced by the same percentage that the ash has exceeded those limits, as the dirt that the ash came from has no fuel value.

For example, if the ash limit is set at 4%, and samples indicate an ash content of 6%, the payment could be reduced by 2%, as that is approximately the amount of material delivered that was not fuel.

Paying By Energy

Benefits

• The fuel purchaser gets the true value of the fuel, and is not paying for weight that has no fuel value:
  − water (moisture content) and
  − contamination (ash).

• The seller gets paid for the true value of the volume he has produced, particularly relevant to situations where dry material (high volume, low weight) is being processed and transported.

• There is an incentive for seller and processor to produce a better, more consistent fuel quality, avoiding unnecessary moisture content and dirt contamination.

• Moves away from the current common system, paying by weight, which actively discourages producers from producing a dry fuel.
Questions?

Full Reports are available from:

Bioenergy Knowledge Centre Website

http://www.bkc.co.nz/Reports/Publications/BioenergycaseStudies/ForestResiduesasFuel

1. Wood boiler fuel – payment by energy vs Weight

2. Forest residue recovery study – hogging direct to truck vs hogging to ground; fibre loss and cost issues.