Cost of producing and delivering wood fuel

Introduction

This Technical Note provides a simple methodology for estimating the cost of producing wood fuel. It is an estimation taking into account the sourcing, collecting, and processing of forest residue into a specification compliant chip or hog fuel plus the cost of delivery to a heat plant facility for conversion into energy. Any royalties on the biomass to resource owners is not included and neither is the profit for undertaking the activity of sourcing raw biomass and delivering it to a customer as fuel. Design and operation costs of the heat plant are also not covered. It must be stressed that the costs developed for this model are indicative only and additional, detailed, site-specific calculations will be required to estimate a fuel's likely price to customers.

Note that this Technical Note is for hogged or chipped forest harvest residues and does not cover the production of wood pellets or other forms of wood fuel.

Dollar estimates are for 2007.

Harvesting methods

The method of recovery of residue dictates the quality, quantity and mix of the biomass available for processing into fuel:

1. Ground-based systems

Ground based collection of forest residues is often carried out on flatter land. Logging residues from both cut-over areas and from the landing areas are potentially available for collection although the preferred location for sourcing forestry-derived biofuel is the landing material.

On flat terrain specialised equipment allows de-limbing at the stump with the result that branch material is left in the forest. This can then be collected by specialised collection equipment, often referred to as forwarders. It is assumed that these forwarders are self-loading. Residue at the landing will mainly consist of stem off-cuts, but this will vary with crop and harvesting system, and large volumes of branches can occur.

2. Hauler systems

In steep terrain, hauler extraction may involve removal of trees intact up to the felling break point and smaller broken pieces, both of which have most of the branches still attached. As a result the landing residue may consist of stem off-cuts, branches and small diameter tops. In steep terrain there may be little recovery of cut-over residues. There will, however, be a larger amount of landing waste available with hauler systems. This is likely to increase the need for residues to be removed as harvesting occurs to allow adequate working space at the landing.

Biomass collection volumes

The quantity of forest residue likely to be available for collection and processing can be estimated from the figures in Table 1 below.

These values give the number of tonnes per hectare for an average mature *Pinus radiata* forest in New Zealand. Terrain, location and variations arising from different harvesting methods will have an effect on the figures but this average information should be able to provide an indication of the amount of fuel which will be available.

Table 1 - Tonnes of residues per hectare available for conversion into biomass fuel

	Ground-based logging flat to rolling terrain	**Hauler logging steep terrain**
Total extracted stem volume	500 to 700 m3 per ha	500 to 700 m^3 per ha
Stem waste at landing - Manual log making - Mechanised log making	 20 to 28m3 per ha (4%) 30 to 42m3 per ha (6%)	 25 to 35m^3 per ha (5%) 30 to 42m^3 per ha (6%)
Branch waste at landing	2.5 to 3.5m^3 per ha (0.5%)	15 to 21m^3 per ha (3%)
Total waste at landing	22 to 32m^3 per ha (4.5%)	40 to 56m^3 per ha (8%)
Stem waste on cut-over	25m^3 per ha (5%)	49m^3 per ha (10%)
Branch waste on cut-over	52m^3 per ha (10%)	58m^3 per ha (11%)
Total waste on cut-over	77m^3 per ha (15%)	107m3 per ha (21%)
Total in forest waste	100 to 130m^3 per ha (ca 20%)	140 to 160m3 per ha (ca 28%)

The use of computer-based value optimisation systems does not significantly alter the percentage of waste produced during log making, although it may affect the average length of the pieces.

Processing options

Most biomass fired energy plants require that wood fuel be either chipped or hogged to provide an easily managed fuel source. The processing of residue into chipped or hogged fuel could be carried out at four possible sites. The options are: at the stump (cut-over); at the landing; at a central point in the forest (may be the roadside or a point central to a number of landings or plantations); or at the utilisation/conversion plant. Choice will depend on type of residue (composition, volume, density, distribution, piece size), location, logistical difficulties, handling and transport costs. It is likely that, due to the cost and low economies of scale of moving a chipper between individual landings, residue will be taken to a central point for processing.

For simplicity only processing at a central site or at point of use is considered in this guidance note. The term ‘comminute’ is used to cover either chipping or hogging of the material. Comminution will generally be by passing the residue through a large chipper, tub grinder, horizontal or rotary hog or other similar specialist equipment which could be mobile or stationary.

Figure 1 – Self-loading disc chipper

Figure 2 – Self-loading tub grinder

Figure 3 – Horizontal hogger with excavator loader

Figure 4 – Horizontal rotary hogger, self-propelled, requires loader to infeed raw material

As a result of residue collection and processing there will be a quantity of "green" biomass that is available as a fuel. It is likely that the moisture content will need to be reduced before combustion. This may be achieved by natural drying by storing for three to six months or by passing through a dryer at the combustion site. This report does not consider the cost of storage or forced drying. (Refer Technical Note TNSB24, *Woody Biomass Fuel Drying,* for forced drying options.)

Table 2 - Range of costs for chipping residue ($ per tonne)

	Low cost	High cost
Chipping at central site using mobile plant. (CC)	$7 to $9	$10 to $12
Chipping at point of use using fixed plant (CM)	$3 to $5	$6 to $9

Transport

Transport costs which are 'off-highway' are likely to be lower than those for transport on the highways due to the higher gross vehicle weights allowed on some private forest roads. The reduced costs may only be able to be realised if the destination does not involve any highway travel. It is probable that heavier loads may be possible when transporting processed residues on highways due to the increased density of chips. This would give lower transport costs per tonne for processed residues.

Due to transport costs, the distance between plantations and the heat plant is likely to be the major consideration in determining the feasibility of forest residue collection.

Table 3: Range of costs for off- and on-highway transport ($ per tonne per km)

	Low Cost – long haul	High Cost – short haul
Off-highway uncomminuted (TL)	$0.17	$0.51
On-highway uncomminuted (TN)	$0.22	$0.65
On-highway comminuted (TC)	$0.17	$0.45

Note: The $ per tonne per km costs need to multiplied by the haul distance to give the total transport cost. For very short haul distances (<5km) the costs may be in the order of $1 per tonne per kilometre.

Delivered energy costs

While the characteristics of each source of residue being considered for recovery and processing into a fuel will vary for individual locations, a range of typical costs has been established[1]. These are based on a combination of actual and theoretical costs. They are adequate for an initial study of the viability of recovering residue as a fuel source, but a full costing analysis using site-specific data is recommended prior to committing to any project.

No allowance has been made for the cost of storage in the forest or at the combustion site. If residue or chips are delivered to the plant un-dried there may be the need to add drying costs to the model if the fuel is to be used immediately. It is also assumed that there is no fee for the residue itself. If the forest owner wanted a fee for the residue this would need to be added to the calculations.

Costing model

A typical collecting and processing model is shown in Figure 5. This is based around a simple scenario but with minor modification can be adopted for other scenarios. The model assumes residue is collected from 15 to 20 landing sites, delivered to a central site and then transported to the mill for use as fuel. Comminution may be carried out at the central site or at point of final use. This model can be modified to cover other scenarios.

[1] Acknowledgement to Peter Hall of Scion for cost data.

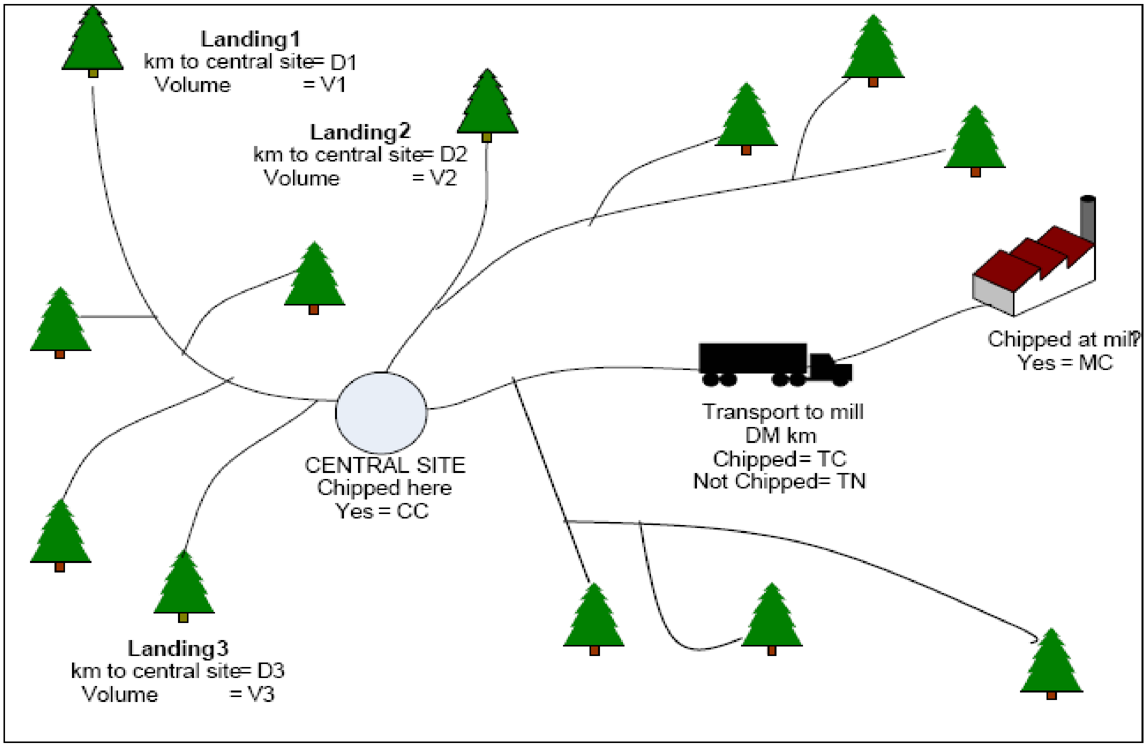

Figure 5 – Schematic of possible biomass system

Calculation details as follows:

The formula is: DC = (TL x DL) + (CC or MC) + (DM x TC or TN) * DMLf

Where:

DC = delivered cost of forest residues ready for use as fuel ($/tonne)

TL = $ cost per km of loading and transporting residue to the central site (Table 3)

D1, D2 & D3 are the distances between individual landings and the central site (km)

DL = D1 + D2 + D3 / (No. landings (km))

DM = distance from central site to the mill

CC = cost per tonne of chipping at the central site ($) (Table 2)

TC = cost per tonne of on-road transport for chipped residue ($) (Table 3)

TN = cost per tonne of on-road transport for unchipped residue ($) (Table 3)

MC = cost per tonne of chipping at point of use ($) (Table 2)

DMLf = dry matter loss factor (suggest 0.97)

In order to compare costs with those of alternative fuels, the energy output of the biomass residue should be calculated. On average, one tonne of comminuted forest harvest residue will provide 10 gigajoules (GJ) of energy. Therefore, cost per GJ is DC/10. To compare wood fuel with other fuels to show the economic feasibility of recovering forest residues for use as fuel a profit margin should be included to change the cost estimate to be an expected price for delivered fuel.

Likely production and delivery costs are in the range of $2.5 to $5 per GJ[2], with the range of variation largely driven by the transport distance, system used and amount of in-forest drying that is achieved. For the purposes of illustration, comparative costs of alternative fuels[i] are:

- Split firewood for home use $9 to 10 per GJ
- Briquettes $15 to $18 per GJ
- Wood pellets $24 to $25 per GJ (domestic supply)
- Coal, bulk supply $5 to $7 per GJ
- Gas, bulk supply $10 to $15 per GJ
- Diesel $23.5 to $28 per GJ

The total costs are made up of various handling, processing and transport costs. Looking at the proportion of the total which comes from each step is a useful way of looking at where there are potential gains to be made. Table 4 below shows the percentage attributable to the four biggest cost contributors for the system described in Figure 5.

Table 4: Percentage of delivered cost attributable to various steps in the process, by variable transport distance

Transport distance, km	25	45	65	85
Comminute (hogging)	36%	31%	29%	27%
2nd stage transport	25%	33%	38%	42%
1st stage transport	11%	10%	9%	9%
Handling/storage losses	7%	7%	7%	7%

These figures show that there is potential for significant cost reduction by gains in the transport and comminution phases. Any reduction in handling losses is a direct saving. Each loading operation contributes around 6%. Altering the operations to reduce handling and associated losses, as well as improving truck design, would potentially reduce costs by at least 10%.

For additional information and more recent 2016 costs *Residual biomass fuel projections for New Zealand* https://www.usewoodfuel.org.nz/resource/residual-biomass-fuel-projections-for-nz

[2] Costs as at February 2007