Estimation of the availability and cost of supplying biomass for bioenergy in Canterbury

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Abstract

A model has been developed to estimate regional supply and delivered cost of forest and wood processing biomass available for bioenergy. In Canterbury the biomass supply potentially available is estimated at 200 000 oven dry tonnes annually. The cumulative average cost of delivered biomass ranges between $9 and $57/odt differing with biomass type and transport distance. The opportunity costs make up a large proportion of the total cost of delivery for the pulp, sawdust, bark and chip biomass and should be included in any estimate of cost for these biomass streams. Transport costs can contribute significantly to the delivered price of landing and cutover residues. Estimating the cost of supplying biomass for energy generation is only part of the picture. This then needs to be added to other costs associated with bioenergy systems to provide an estimate of the total cost of generating energy from biomass.

Introduction

This paper reports on the development of a model to analyse the impacts of a number of factors on the amount of forest biomass available for bioenergy and the delivered cost to potential new bioenergy plants. Such a model can be integrated with an energy plant system model (Rutherford and Williamson 2006) to provide decision makers with information on the optimum site and size for a potential plant and the biomass cost component of energy generation.

There are four main sources of biomass for bioenergy: (i) forest arisings from thinning and clearfelling operations; (ii) biomass from integrated harvesting regimes; (iii) plantations grown for energy; (iv) residues from wood processing. New Zealand has not commercially used integrated harvesting (harvesting of both wood fibre and biomass for bioenergy) or plantations grown specifically for energy. Therefore only forest and wood processing residues are currently available for the production of bioenergy. Forest residues are not generally used for bioenergy and reasons for this include long term supply issues and the high cost of getting the residues to a bioenergy plant (East Harbour Management Services 2002).

Factors affecting the availability and cost of forest residues for energy are: (i) growth rate, age class, tending regime and harvesting practices; (ii) spatial distribution of forests; (iii) feasibility of collecting residues from different areas and off steep terrain; (iv) the logistics of transporting the residues from the forest to bioenergy plant including chipping and (v) competition for the wood resource from other fibre and energy uses.

Wood processing residues usually refer only to sawmill residues as other wood product manufacturing such as MDF or LVL production use all the wood within the process. Factors affecting the availability and cost of sawmill residues are the spatial distribution of the wood processing sites, and competition for the residues from other users. Many sawmill residues are used for energy at the sawmill, or sold for animal bedding, landscaping and other wood products.

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Methods

The model estimates the biomass supply from forest and sawmills. The forest biomass forms considered include chiplogs, landing residues and cutover residues. The sawmill biomass considered includes sawdust, bark and chips.

The modelling approach used to estimate biomass availability included the following procedures:

- Break down of the forest area by stand age and forest management regime for major forest companies;
- Estimation of remaining forest area based on NEFD (MAF 2004);
- Estimate biomass supply for each of the forest biomass streams for a number of rotation ages and forest management regimes utilising STANDPAK growth and yield models (Whiteside 1990)

- Determination of slope based on a Digital Elevation Model (utilising ArcView GIS software);
- Estimate wood processing residues based on a phone survey of large sawmills.

It was assumed that hauler harvesting will take place on slopes over 17 degrees and that 9% of total recoverable volume (TRV) is available at the landing. Cutover residues on slopes higher than 17 degrees were excluded from the analysis as they are not able to be recovered or the recovery cost is too high. On slopes lower than 17 degrees it was assumed that ground based harvesting will be undertaken and 5% of TRV was available at the landing.

The modelling approach used to estimate the cost of biomass delivered to a potential bioenergy plant for the forest and sawmill residues included the following steps:

- Identification of the location of forest at the stand level as obtained from large forest companies;
- Estimation of remaining forest location based on the Land Cover Database (Ministry for the Environment. 2004);
- Identification of the sawmills location
- Identification of potential bioenergy sites;
- Estimation of distance from the forest stand and the sawmill to the bioenergy plant utilising ArcView GIS Software;
- Estimation of collection, chipping and screening costs for chiplogs, landing and cutover residues;
- Estimation of opportunity cost for chiplogs, sawdust, bark and chip;
- Estimation of transport cost for all biomass streams;
- Development of cost supply curves for each of the biomass streams.

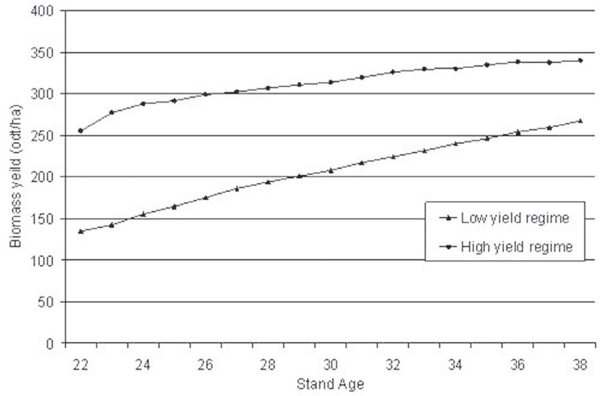
The model was developed using data from the Canterbury area, and results are presented here.

Results: Canterbury study

The study area covers three Territorial Authorities (TLAs), Christchurch, Selwyn and Waimakiriri. Part of Hurunui TLA was also included to cover the Ashley forest which is on the border between Waimakiriri and Hurunui TLAs. The sawmills included are McAlpines Ltd., McVicar Timber Ltd., Mitchell Brothers Sawmill, Selwyn Sawmill, Shands Road Sawmill, Stoneyhurst Sawmill and Sutherland Sawmill. Three potential sites for bioenergy plants were identified, all are in the vicinity of wood processing sites (for biomass supply and RMA reasons). The sites identified were at the Sefton MDF plant, the Shands Road Sawmill and at the Selwyn Sawmill in Hororata.

The biomass available for bioenergy varies with forest management regime and stand age. Figure 1 provides an example of the total forest biomass available for the highest and lowest yielding regimes. The results presented here include chiplogs, landing residues and cutover residues and exclude other biomass removed from the stand at harvest. The lower yield management regime (plant 1500 stems/ha, waste thin to 600 stems/ha and production thin to 200 stems/ha) has the lowest biomass available for bioenergy, probably largely due to the inclusion of production thinning and lower stocking than the high yield regime (plant 555, no pruning or thinning). Each forest stand was assigned a forest management regime and, depending on slope, the amount of landing and cutover residue was estimated. In 2007 it was estimated that 76% of the harvested area was on slopes less than 17 degrees, and this was reduced to 65% in 2011 and to 59% in 2015.

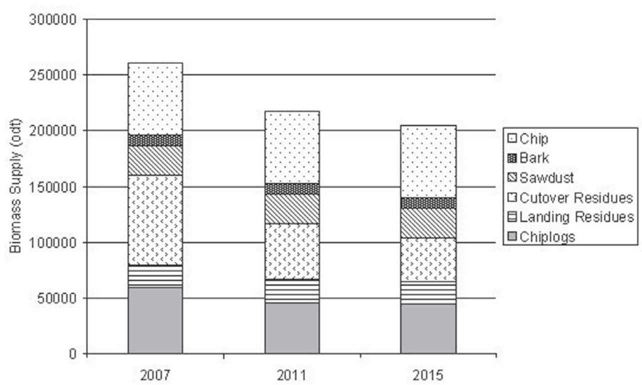
Figure 1. Biomass for bioenergy yield for high and low yield forest management regimes in Canterbury.



Results from the sawmill survey indicted that the total amount of residues generated was about 100 000 odt/y. Chip makes up the majority of the biomass (64 %), followed by sawdust (26 %) and then bark (10%).

Analysis of biomass available for bioenergy was conducted for 2007, 2011 and 2015. Total biomass available for bioenergy in the Canterbury study varied each year between 204 000 and 260 000 odt (Figure 2). The variation was largely due to the changes in the area harvested and the type of harvesting that occurs. In 2007 more area was harvested compared to 2011 and 2015. It was also predicted that in 2007 most harvesting was on slopes less than 17 degrees using ground based methods.

Figure 2. Biomass streams and supply in Canterbury area.



The average delivered cost of the total amount of biomass varied by year and potential bioenergy plant location. Estimated delivered cost of the total biomass

Figure 3. Average delivered cost of the total biomass for each potential bioenergy plant in 2007, 2011 and 2015.

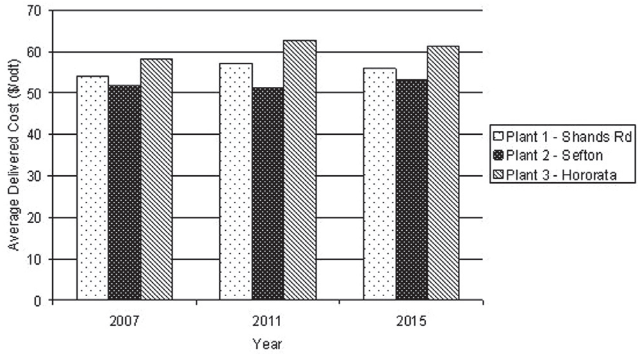


Figure 4. Cumulative Average delivered cost of biomass in 2007.

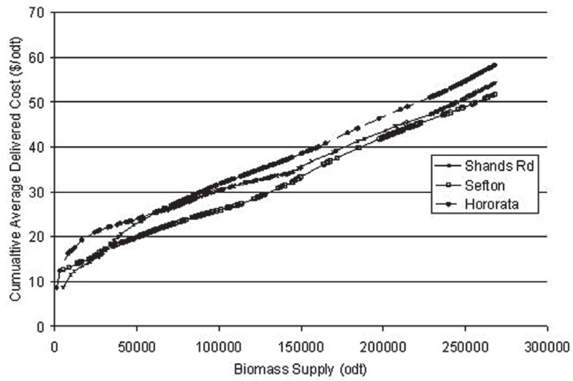


Figure 5. Composition of average delivered cost of each biomass stream to Sefton in 2007.

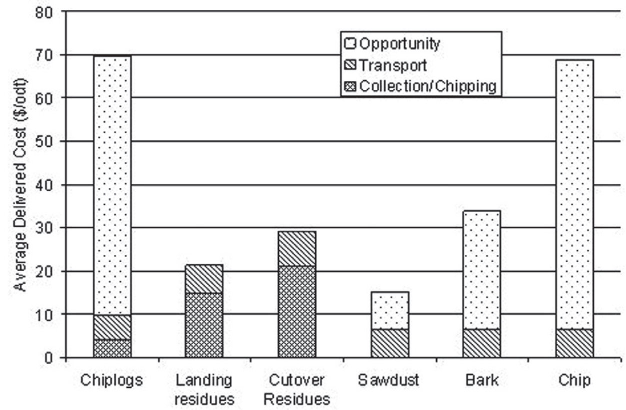
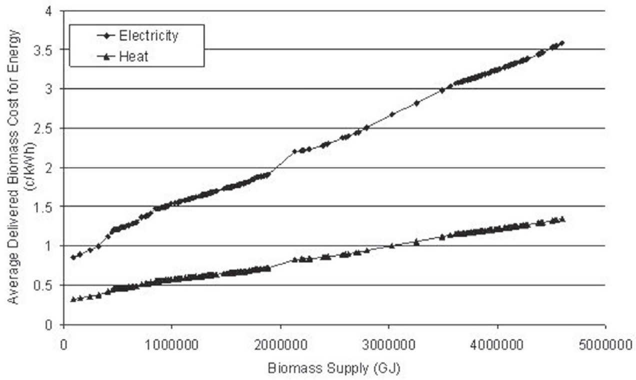


Figure 6. Average delivered cost of biomass for energy generation at Sefton in 2007.



supply ranged from $51 to $58/odt (Figure 3) or between $2.9 to $3.6/GJ. The difference in cost between years is explained by the location of harvesting sites in different years. The variation between potential bioenergy plant sites in a given year was related to the transport distance from each biomass location to the specific bioenergy plant.

At biomass supply of over 20 000 odt a bioenergy plant located at Sefton would have the cheapest delivered cost of biomass. The cumulative average cost of delivered biomass ranges between $9 and $57/odt (Figure 4) or $0.71 to $3.15/GJ depending on the biomass stream and the distance from the bioenergy site. These costs fell within the range given by East Harbour Management (2005). Figure 5 provides an indication of the make-up of the average delivered cost. Collection and chipping costs and opportunity costs remained the same for different distances but the transport costs changed with the travel distance. This figure gives the average cost of transport.

What does the biomass supply cost contribute to overall energy generation costs?

The cost of biomass supply in terms of the amount of energy generated also varies with the technology, efficiency and scale of the bioenergy system. For a biomass energy plant which only generates electricity at an efficiency of 30%, the cost of the biomass for the electricity ranged from 0.85c to 3.80 c/kWh as indicated in Figure 6. However, for an integrated system which produced both electricity and heat at a total conversion efficiency of 80%, this cost was reduced to 0.30 to 1.3 c/kWh. To estimate the total costs of energy production the biomass supply costs need to be added to the bioenergy plant capital expenditure, operation/maintenance and rate of return. These costs have been estimated for electricity from combustion and gasification systems based data from East Harbour Management Services (2005). Combustion costs are estimated at 10-12 c/kWh, giving a total electricity generation cost estimate of 10.85 to 15.8 c/kWh for a potential bioenergy plant at Sefton in 2007. The cost of generating heat only was estimated at 1 c/kWh (Li, pers comm) giving a total cost for heat production of 1.3 to 2.3 c/kWh. See Rutherford and Williamson 2006 for a more in depth analysis of the energy generation potential and cost.

Conclusions: Implications for estimating biomass for bioenergy costs

As the opportunity costs made up a large proportion of the total cost of delivery for the pulp, sawdust, bark and chip biomass these should be included in any estimate of cost for these biomass streams. The logistic system chosen for collecting and chipping the forest residues had a large impact on the delivered price of these biomass streams, and more information about the cost of different systems is needed. Transport cost did impact on the delivered price of biomass but it may not be the most important factor. If only landing and cutover residues were considered, without opportunity cost, then transport costs significantly impacted on the delivered price of these residues. However, transport cost was not the most significant influence on the delivered cost for chiplogs, sawdust, bark and chip. Estimating the cost of supplying biomass for energy generation is only part of the picture. The biomass availability and cost model will be integrated into a biomass energy system model which has been developed by Rutherford and Williamson (2006).

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