Wood Waste Audit
Of the
Port McNeill Area

For the

Community Futures Development Corporation

of Mount Waddington

and

Mount Waddington Regional District

February 2002

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Table of Contents

Tables

Purpose

This study is to identify the opportunity available on Northern Vancouver Island to proponents of waste wood utilization such as co-generation. The study will analyze the estimated volume available, in what form and location, cost of processing and delivery, and conditions under which this volume could increase (potential volume).

Scope

The study was confined to an approximate 100km radius of the Twin Peaks area of Port McNeill and will include all dry land sorts, manufacturing facilities and woodlands operations

Introduction

Studies have been conducted by Licensees, the Forest Engineering Research Institute of Canada (FERIC) and potential proponents over the last several decades. During this time, the Regional District of Mount Waddington, in the economic development function, has attempted to act as facilitator between Licensees and proponents of waste wood utilization. This study was commissioned by the Regional District with funding by the Community Futures Development Corporation of Mount Waddington to acquire data and consolidate generic information of value to potential proponents and interested public through local government.

A sense of the available volume of dry land sort debris is relatively well understood. The other sources of waste wood potentially available particularly sources along roadside within the woodlands operations have not been well quantified. Along with summarizing all sources, this study attempts to quantify this material.

Waste Wood – described

Waste wood consists of various mixtures of bark, wood, tops, including foliage and branches that are ground-up, broken, crushed or whole. Waste wood is generated from manufacturing residue, friction and handling at dry land sorts and in yarding slash and at roadsides following harvesting.

Currently waste wood is piled and or burned at roadside or within logging slash to facilitate reforestation and reduce fire hazard. At dry land sort yards wood waste is burned as a cost-effective alternative to land filling or processing for removal.

Waste wood all has varying levels of contamination from mineral soil, rock, steel and rubber depending on sources. Levels of soil and rock contaminants are less from paved sort yards (see table 1).

Hog fuel is a non-specific term for waste wood, which has been reduced in size for convenient handling. It can consist of shavings, sawdust, ground or shredded bark and ground up wood in no particular proportion.

Several local sawmills and cedar shingle mills have invested in hogging machines to enable their waste to separately accompany chips which are being sold to pulp mills. The hog fuel costs of production and removal are borne by the operators while they are remunerated for chips. Hog fuel is burned along with other fuels or alone in boilers for generating steam for electricity or other processes, usually in pulp mills.

Table 1 Sortyard debris size class distribution*

Debris type	Piece size class (cm)	Sortyard debris composition (percent by weight)			
		Paved Sortyard		Unpaved Sortyard	
		Average %	Range %	Average %	Range %
Wood Debris	>30	35	17 - 67	13	8 – 24
	2.5 – 30	47	27 – 79	15	5 – 41
	<2.5	14	0 – 35	27	0 – 40
Rock, gravel, and sand	>30	<1	0 – 5	<1	0 – 0.7
	2.5 – 30	2	0 – 17	14	2 – 50
	<2.5	1	0 – 6	31	0 - 52

*Energy Balance, Carbon Emissions, and costs of Sortyard Debris Disposal, MacDonald, A.J., FERIC, March 2001

Energy Properties of Wood

Each species of tree has wood of unique properties regarding heat value. Heat value is defined as the quantity of heat evolved by the complete combustion of a unit mass of substance in an enclosure of constant volume. Heat value is expressed in units of (Imperial - Btu / lb or Metric - Mj/tonne). A British thermal unit (Btu) is the heat required to raise one pound of water one degree Fahrenheit. A Mega-joule is a metric unit measure of heat equivalent to I Btu x 1055 x 1000.

Water content of wood adversely affects the heat value of each species of wood. Moisture Content (MC) for the purpose of this study is expressed as the percentage of the total weight of the wood or the “wet basis”. In the case of waste wood, season, storage and handling all affect the moisture content. (See Table 2)

Table 2 Heat value in debris by species and moisture content*

Species	Heat value in debris (kj / kg) by % moisture content			
	45%	50%	55%	60%
Douglas fir	10407	9239	8071	6903
Western hemlock	9714	9609	7504	6399
Western red cedar	10072	8934	7797	6659
Lodgepole pine	10281	9124	7968	6811
White spruce	9164	8109	7054	5999

*Energy Balance, Carbon Emissions, and costs of Sortyard Debris Disposal, MacDonald, A.J., FERIC, March 2001

Oven dry samples of Port McNeill area sort yard hog fuel have been laboratory tested to yield heat values of 19,500 Mj / tonne. Forrester, P., FERIC, 1995

Unit measure of Waste Wood

Logs are generally measured in cubic metres of solid wood while chips and hog fuel is measured in Bone dry units (BDU =2.8 m^3). Weight scaling allows the conversion of cubic metre log volume to weight. These conversions vary by species mix and moisture content and allow measure of heat value from wood waste from dry sorts and the woods using percentages of waste generated from historical experience.

Green log weights vary by species and moisture content (season and weather) and based on samples from three weight scaling stations in the district, range from 0.85 m^3 / tonne to 1.0 m^3 / tonne (neutral buoyancy). For the purpose of this study, lower weights are used to be conservative.

Sources of Waste Wood in the Port McNeill Area

The following table breaks down the type of waste wood, unit measure, and the facility source

Table 3 Facility Source and measure of wood waste

Facilities*	**Annual Volume (m^3)**	**Waste wood %**	**Weight conversion factor t / m^3**	**Green Weight (tonnes)**
Dry Land Sort yards				
CFP Beaver Cove	1,100,000	5.0	0.85	46,750
TimberWest BC	200,000	2.5	0.85	4,250
WFP Port McNeill	600,000	6.0	0.80	28,800
WFP Quatsino	700,000	7.0	0.85	41,650
Weyerhauser PM	300,000	6.0	0.85	15,300
Mill and Timber PH	120,000	3.0	0.80	2,880
S.A. Mowatt (Richply)	50,000	4.0	0.80	1,600
Subtotal Dry sorts	3,070,000			141,230
Mill Residue	Consisting of mostly sawdust in hog, this fuel requires little or no further processing for boiler use.			
Twin Peaks Area				15,000
Port Hardy Area				10,000
Port McNeill Forest Prod.				2,000
Others				1,000
Subtotal Residue				28,000
Total Facilities				177,300

* From Licensees, Operators and Work done by Frank Herman circa 1995

Woodlands operations

Woodlands operations on Northern Vancouver Island and their estimated current annual volume are shown in the following table. Based on Ministry of Forests analysis of residue surveys representing 659 ha from 156 blocks and reducing the numbers to account for anomalies, there is conservatively 6% waste at roadside on average for both old growth and second growth harvest areas.

Table 4 Volume by Licensee on Northern Vancouver Island (< 100km from Port McNeill)

Licensee	Tenure	Volume m³ /yr	Roadside waste %	tonnes / m³	Estimated green Tonnes of waste at Roadside
Canfor	TFL 37	1,060,000	6.0	0.85	54,060
	FL A19233	90,000	6.0	0.85	4,590
Weyerhaeuser	TFL 39 Bk 3	300,000	5.5	0.85	14,025
	TFL 39 Bk 2	100,000	5.5	0.85	4,675
TFL Forest	TFL 47 Bk 17	200,000	9.0	0.85	15,300
WFP	TFL 6	1,000,000	5.5	0.85	46,750
Richply	FL A19243	50,000	7.5	0.80	3,000
SBFEP and TSLs	All tenures	200,000	6.0	0.80	9,600
Miscellaneous	Wood Lots	20,000	6.0	0.80	960
Total		3,020,000	6%	0.85	152,960

Enhancing available wood waste

Woods

Waste wood is currently measured as avoidable waste, which includes excessive stump height, bucking waste, and logs and pieces meeting utilization specifications left behind. As well, unavoidable waste is measured which consists of decay and breakage judged to be unavoidable. Together, these figures, determined from sampling, are used for cut control purposes and are included in the annual cut calculations. Biomass not meeting utilization specifications such as branches and stems less than 10 cm in diameter is not currently measured and represents potential fuel.

Currently, logging operations during the yarding process expend some effort to eliminate the yarding of marginal logs with grapple yarders. Hoe forwarders bring less marginal wood as they can size up quality more conveniently. Due to the concentration of roadside waste wood and the need to free up planting spots spatially, excess roadside material is piled and burned.

An opportunity exists to revert to less discrimination in grapple yarding with the realization that the material would be loaded and or processed and hauled to a plant site. Potential increased volume available estimated by Licensees range from negligible to 40%.

As well, during hoe forwarding the last pass, instead of building piles the operator could, for the same effort, create more roadside accumulations thus increasing roadside volume.

Second growth harvesting results in generally less roadside waste than old growth with some exceptions. In second growth harvesting, the volume of large pieces of wood debris are not present reflecting the uniformity and health of the stand. If the tree felling has been mechanized and resulted in bunched tree-length stems being grapple yarded, a significant volume of tops remain at or near roadside where the processor tops them. Similarly, as with old growth, the Hoe forwarders currently yard less material to roadside and pile for burning if excessive.

Right of Ways

Commonly, right of ways cut through old growth or second growth stands experience less volume recovered than expected. This is due to confined handling space, buried logs, and increased breakage from loaders and construction equipment.

The study area involves new construction and or rebuilding of approximately 300 km / year. All residual waste wood within the right of way and not buried beneath the road prism is theoretically available. At 50 m^3 / hectare recoverable waste, this could conservatively represent 30,000 m^3 or 25,000 tonnes.

Roadside Brushing

Within 100 km of Port McNeill, approximately 2000 km of main and secondary roads are currently maintained for continuous use or periodically brought out of deactivation. Assuming a 20 year brushing cycle, roughly 100 km / year are brushed out with chippers, flails or manually with saws. Assuming a 6 metre width of activity and average annual increment, another 10,000 m^3 or 8,500 tonnes per year could be recovered.

Facilities

Mill Residue

The greatest enhancement of mill residue would come from more Mills in the vicinity and more mills could come from the convenience of a facility taking waste and producing waste heat for potential kilns, a chicken and egg situation. Mills create much higher volumes of residue per unit of wood converted than dry sorts and mill residue is generally “burn-ready” requiring no more hogging. The current *Proposed Forest Policy Changes*, (Province of British Columbia, December 2001) contains a proposal to end appurtency, requiring tenure holders to operate manufacturing facilities. This, given the wood basket of the North Island could potentially result in more independent manufacturing in the Port McNeill area.

Total waste wood

Total estimated waste wood available without assuming enhancement from increased roadside material is shown in Table 5.

Table 5 Volume summary

Source	Volume in green tonnes
Dry Land Sorts	141,230
Mill Residue	28,000
Subtotal Facilities	169,230
Roadside Post Harvest	152,960
Right of Way salvage	25,000
Roadside Brushing	8,500
Subtotal Woods	186,460
Total	355,690

Cost Analysis

Included with this study is a spreadsheet, which allows the user to change all the variables (white cells) in order to test sensitivities and input better information than time allowed the author. The following assumptions listed in order of increased cost are discussed:

Mill Residue - represents the least-cost fuel source ready for the boiler. Assumed is that the only cost is the hauling away of containers and replacing with empties and the unloading at a stockpile at the plant site. Hauling variables are readily adjustable.

Dry sort waste wood – is the most significant volume and is assumed to be loaded as generated at the sorts and hauled to the plant site in highway rated bins of 20 m^3. If the Licensees internalized the hauling cost of this material (in leu of tipping fees) it represents an approximate 15% reduction of fuel cost to the base case. One study, (Wood Fired Power Plants for Northern Vancouver Island, SNC Lavalin, April, 2000) estimated that a minimum tipping fee of $10.00 / green tonne would be required for financial viability.

Roadside waste material – represents the greatest volumetric uncertainty and variable cost. The model assumes a system where a hydraulic tracked loader loads bin trucks on spur roads where chip vans couldn't operate due to road conditions (grades, surfacing or alignment) as well as where significant volumes of oversized material were present. On roadsides where chip vans could operate, a loader as above would prepare the roadside ensuring reach by a self-loading self-propelled chipper, which could tow vans for blown chip loading. Assumed, is that the former operation would require yard processing while the later would not. In the base case these systems represent processed fuel costs ranging from $15.00 to $27.00 / tonne and $9.00 to $16.00 / tonne respectively depending on haul distance. The model also assumes a linear relationship of volume to distance. Further investigation of operational location and haul route could change this.
The spreadsheet clearly demonstrates the cost and fuel demand sensitivity to plant efficiency and heat value (determined from moisture content). One FERIC paper (Energy Balance, Carbon Emissions, and costs of Sortyard Debris Disposal, MacDonald, A.J., FERIC, March 2001) has noted considerable pay back from incorporating presses and dryers aimed at maximizing heat value. Within this model, for example, maintaining

the waste wood fuel at 45% moisture content saves about $400,000 / year. Similarly a 5% gain in plant efficiency (26% to 31%) represents an annual savings of $480,000. These savings are from reduced wood waste brought in from roadside operations.

Supplemental fuel

The model looks at using cedar or cypress pulp as a supplemental fuel based on the assumption of purchasing from local dry sorts for market price less booming and towing costs. The cost of this fuel as currently modeled (base case), is slightly less than the cost of wood waste from a 100-km haul distance ($28.36 / tonne versus $28.60 / tonne). The following table compares alternative fuel costs when factoring in efficiencies.

Table 6 Comparative fuel costs

Type of Fuel	**Unit Measure**	**Gj per Unit Measure**	**Cost per Unit Measure**	**Units per Gigajoule**	**Cost per Gigajoule**	**efficiency**	**True Cost**
Natural Gas	Gigajoule	1	$2.50	1	$2.50	80%	$3.12
#2 Fuel Oil	litre	0.037	$0.47	27	$12.69	80%	$15.86
Coal	tonne	29.00	$60.00	0.035	$2.10	70%	$3.00
Green Waste wood 55% MC	tonne	8	$15.00	0.125	$1.88	25%	$7.50
Green waste wood 45% MC	tonne	10	$15.00	0.10	$1.50	25%	$6.00
Purchased Cy pulp at 40% MC	tonne	12	$28.51	0.084	$2.40	25%	$9.60

Sensitivity Analysis

Scenarios	Waste wood required - tonnes	Cost / tonne	Cost / kWh
1. Base Case	285,394	$12.46	$0.021
2. DLS waste hauled at cost to Licensees	285,394	$9.56	$0.017
3. Moisture content @45% (Press A/O Dryer)	242,585	$10.60	$0.016
4. Scenario 2 plus 3	242,585	$8.18	$0.013
5. Efficiency drops from 26% to 21%	353,345	$14.79	$0.031
6. All roadside material Processed at Plant	285,394	$13.68	$0.023
7. Waste wood averages 60% MC	373,207	$15.45	$0.035

Conclusion

Given the high sensitivities of fuel demand to plant considerations namely efficiency and control of fuel moisture content, a moderate level of uncertainty regarding fuel volume from DLS and roadside should be tolerable.

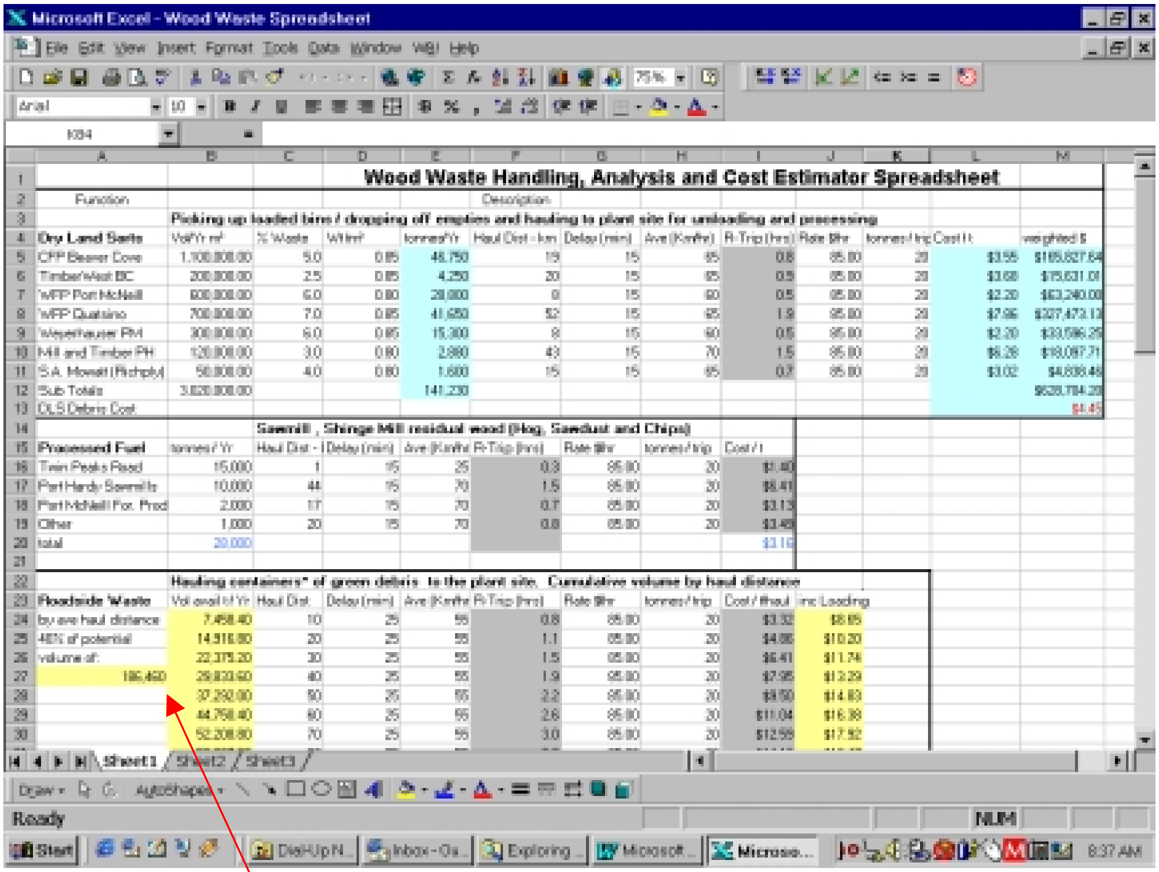
Appendix 1 Using the Spreadsheet

The following spreadsheet in MS Excel is used to rework estimates through to determine cost of fuel, required volume and whether or not enough fuel is available under various assumptions and variables.

All white cells are variables while shaded cells contain formulas and should be returned to original values after changes.

Variables include:

- Volume of DLS log production in m³
- Percent of Log Volume in waste
- Weight per m³ conversion
- Haul distance
- Delay time / trip
- Average trip velocity km/h
- Contract hauling rate all found (supply of trailers and tractors)
- Average load size in tonnes
-



Wood Waste Handling, Analysis and Cost Estimator Spreadsheet

Function — Description

Picking up loaded bins / dropping off empties and hauling to plant site for unloading and processing

Dry Land Sorts	Vol/Yr m³	% Waste	Wt/m³	tonnes/Yr	Haul Dist - km	Delay (min)	Ave (Km/hr)	R-Trip (hrs)	Rate $/hr	tonnes/trip	Cost / t	weighted $
CFP Beaver Cove	1,100,000.00	5.0	0.85	46,750	19	15	65	0.8	85.00	20	$3.55	$165,827.64
TimberWest BC	200,000.00	2.5	0.85	4,250	20	15	65	0.9	85.00	20	$3.68	$15,631.01
WFP Port McNeill	600,000.00	6.0	0.80	28,800	8	15	60	0.5	85.00	20	$2.20	$63,240.00
WFP Quatsino	700,000.00	7.0	0.85	41,650	52	15	65	1.9	85.00	20	$7.86	$327,473.13
Weyerhauser PH	300,000.00	6.0	0.85	15,300	8	15	60	0.5	85.00	20	$2.20	$33,596.25
Mill and Timber PH	120,000.00	3.0	0.80	2,880	43	15	70	1.5	85.00	20	$6.28	$18,087.71
S.A. Mowatt (Richply)	50,000.00	4.0	0.80	1,600	15	15	65	0.7	85.00	20	$3.02	$4,838.46
Sub Totals	3,020,000.00			141,230								$628,704.20
DLS Debris Cost												$4.45

Sawmill , Shinge Mill residual wood (Hog, Sawdust and Chips)

Processed Fuel	tonnes / Yr	Haul Dist - km	Delay (min)	Ave (Km/hr)	R-Trip (hrs)	Rate $/hr	tonnes / trip	Cost / t
Twin Peaks Road	15,000	1	15	25	0.3	85.00	20	$1.40
Port Hardy Sawmills	10,000	44	15	70	1.5	85.00	20	$6.41
Port McNeill For. Prod	2,000	17	15	70	0.7	85.00	20	$3.13
Other	1,000	20	15	70	0.8	85.00	20	$3.49
total	28,000							$3.10

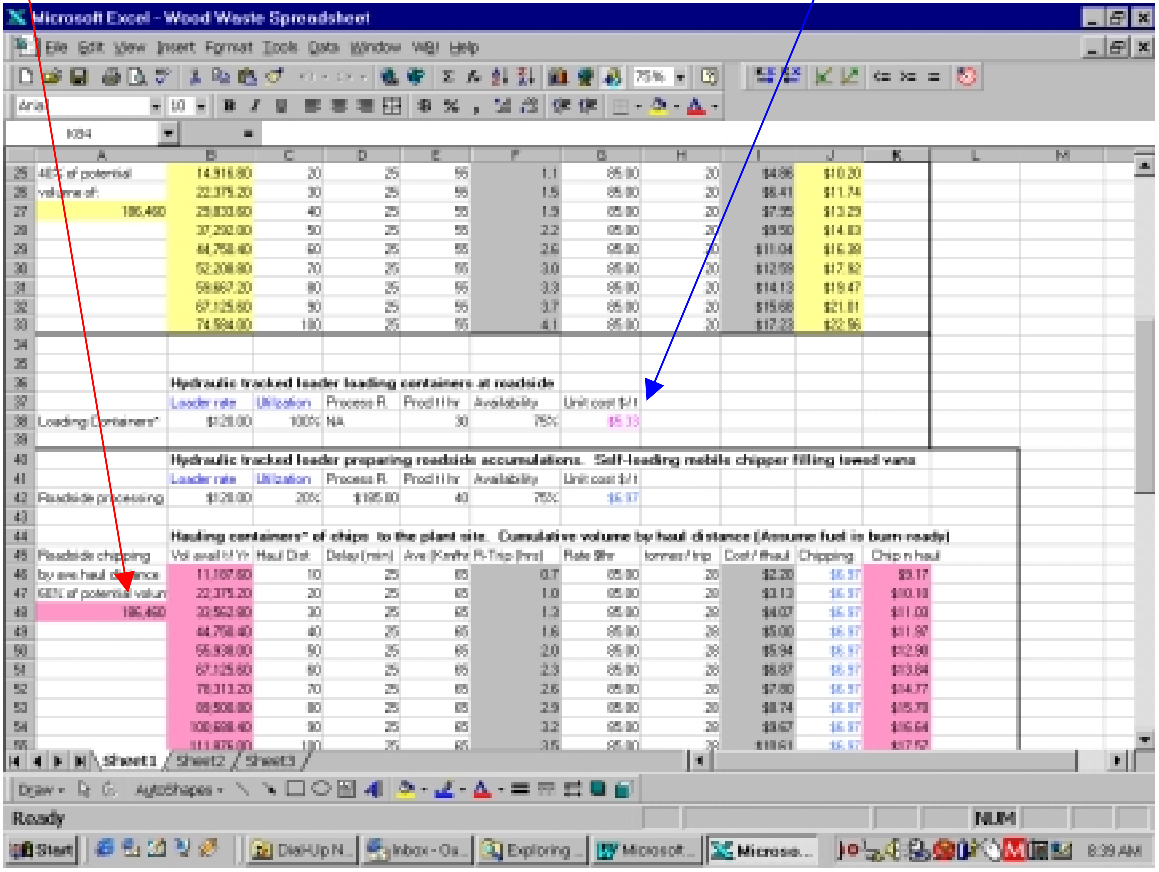
Hauling containers* of green debris to the plant site. Cumulative volume by haul distance

Roadside Waste	Vol avail t/ Yr	Haul Dist	Delay (min)	Ave (Km/hr)	R-Trip (hrs)	Rate $/hr	tonnes / trip	Cost / t haul	inc Loading
by ave haul distance	7,458.40	10	25	55	0.8	85.00	20	$3.32	$8.85
40% of potential	14,916.80	20	25	55	1.1	85.00	20	$4.86	$10.20
volume of:	22,375.20	30	25	55	1.5	85.00	20	$6.41	$11.74
186,460	29,833.60	40	25	55	1.9	85.00	20	$7.95	$13.29
	37,292.00	50	25	55	2.2	85.00	20	$9.50	$14.83
	44,750.40	60	25	55	2.6	85.00	20	$11.04	$16.38
	52,208.80	70	25	55	3.0	85.00	20	$12.59	$17.92

The total estimated volume at roadside is shown on two tables, one (above) assuming container hauled large pieces and from rugged terrain

The loading function of this table is modeled below.

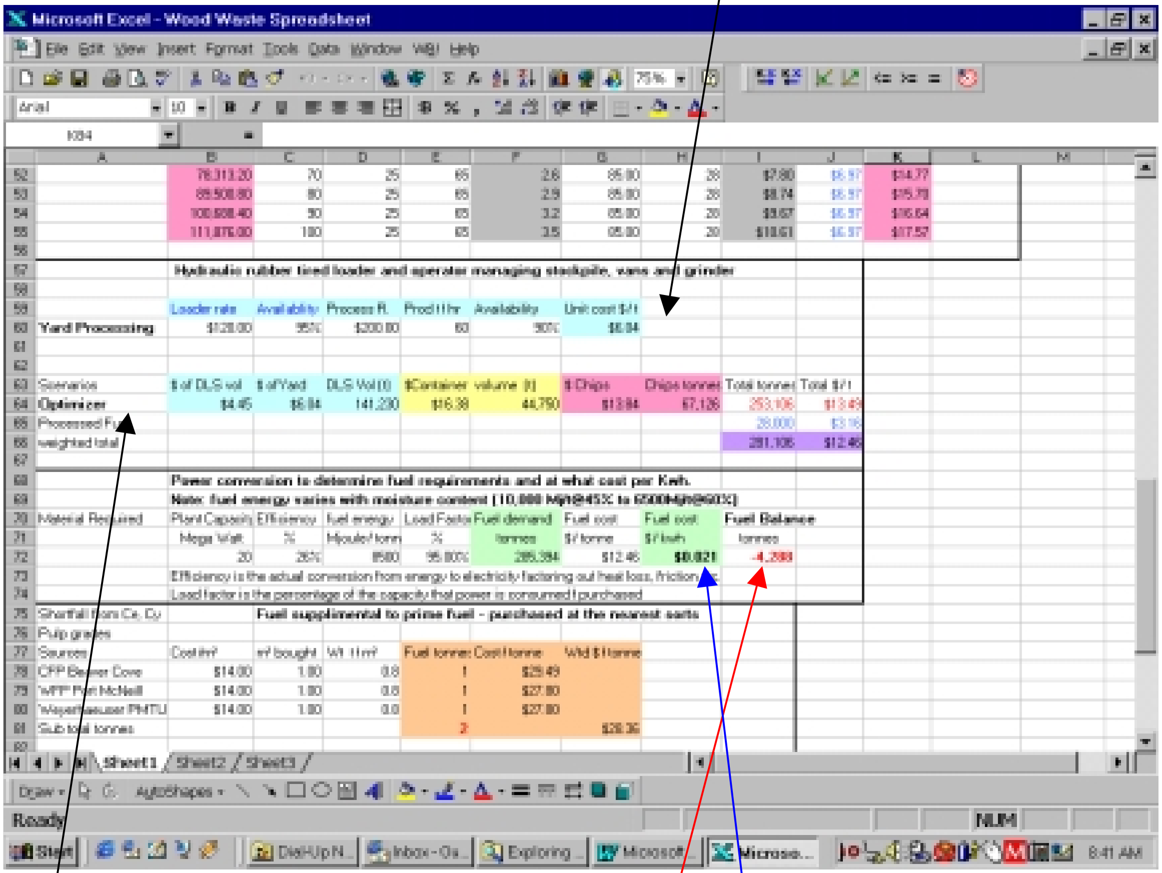
Total Volume from the roadside areas – this table assumes roadside chipping and blowing into Chip Vans and assumes some level of roadside preparation prior to chipping. It is assumed that dollies are used to tow chip vans with the tracked chipper.



	A	B	C	D	E	F	G	H	I	J	K
25	40% of potential	14,916.80	20	25	55	1.1	85.00	20	$4.86	$10.20	
26	volume of:	22,375.20	30	25	55	1.5	85.00	20	$6.41	$11.74	
27	186,460	29,833.60	40	25	55	1.9	85.00	20	$7.95	$13.29	
28		37,292.00	50	25	55	2.2	85.00	20	$9.50	$14.83	
29		44,750.40	60	25	55	2.6	85.00	20	$11.04	$16.38	
30		52,208.80	70	25	55	3.0	85.00	20	$12.59	$17.92	
31		59,667.20	80	25	55	3.3	85.00	20	$14.13	$19.47	
32		67,125.60	90	25	55	3.7	85.00	20	$15.68	$21.01	
33		74,584.00	100	25	55	4.1	85.00	20	$17.23	$22.56	
34											
35											
36		**Hydraulic tracked loader loading containers at roadside**									
37		Loader rate	Utilization	Process R.	Prod t/hr	Availability	Unit cost $/t				
38	Loading Containers*	$128.00	100%	NA	30	75%	$5.33				
39											
40		**Hydraulic tracked loader preparing roadside accumulations. Self-loading mobile chipper filling towed vans**									
41		Loader rate	Utilization	Process R.	Prod t/hr	Availability	Unit cost $/t				
42	Roadside processing	$128.00	20%	$195.80	40	75%	$6.97				
43											
44		**Hauling containers* of chips to the plant site. Cumulative volume by haul distance (Assume fuel is burn ready)**									
45	Roadside chipping	Vol avail t/ Yr	Haul Dist	Delay (min)	Ave (Km/hr	R-Trip (hrs)	Rate $/hr	tonnes / trip	Cost / t haul	Chipping	Chip n haul
46	by ave haul distance	11,187.60	10	25	65	0.7	85.00	20	$2.20	$6.97	$9.17
47	60% of potential volum	22,375.20	20	25	65	1.0	85.00	20	$3.13	$6.97	$10.10
48	186,460	33,562.80	30	25	65	1.3	85.00	20	$4.07	$6.97	$11.03
49		44,750.40	40	25	65	1.6	85.00	20	$5.00	$6.97	$11.97
50		55,938.00	50	25	65	2.0	85.00	20	$5.94	$6.97	$12.90
51		67,125.60	60	25	65	2.3	85.00	20	$6.87	$6.97	$13.84
52		78,313.20	70	25	65	2.6	85.00	20	$7.80	$6.97	$14.77
53		89,500.80	80	25	65	2.9	85.00	20	$8.74	$6.97	$15.70
54		100,688.40	90	25	65	3.2	85.00	20	$9.67	$6.97	$16.64
55		111,876.00	100	25	65	3.5	85.00	20	$10.61	$6.97	$17.57

The volume of roadside material assumes a linear relationship between distance and volume (the total estimated volume is available at 100 km while 10% is available at 10 km) and is expressed as cumulative volume in tonnes.

The table below includes the estimated cost of the **processing** (Hogging) in the yard



	A	B	C	D	E	F	G	H	I	J	K
52		78,313.20	70	25	65	2.6	85.00	28	$7.80	$6.97	$14.77
53		89,500.80	80	25	65	2.9	85.00	28	$8.74	$6.97	$15.70
54		100,688.40	90	25	65	3.2	85.00	28	$9.67	$6.97	$16.64
55		111,876.00	100	25	65	3.5	85.00	28	$10.61	$6.97	$17.57
56											
57		**Hydraulic rubber tired loader and operator managing stockpile, vans and grinder**									
58											
59		Loader rate	Availability	Process R.	Prod t/hr	Availability	Unit cost $/t				
60	**Yard Processing**	$128.00	95%	$200.00	60	90%	$6.04				
61											
62											
63	Scenarios	$ of DLS vol	$ of Yard	DLS Vol (t)	$Container	volume (t)	$ Chips	Chips tonnes	Total tonnes	Total $/t	
64	**Optimizer**	$4.45	$6.04	141,230	$16.38	44,750	$13.84	67,126	253,106	$13.49	
65	Processed Fu								28,000	$3.16	
66	weighted total								281,106	$12.46	
67											
68		**Power conversion to determine fuel requirements and at what cost per Kwh.**									
69		**Note: fuel energy varies with moisture content (10,000 Mj/t@45% to 6500Mj/t@60%)**									
70	Material Required	Plant Capacity	Efficiency	fuel energy	Load Factor	Fuel demand	Fuel cost	Fuel cost	**Fuel Balance**		
71		Mega Watt	%	Mjoule/ tonne	%	tonnes	$/ tonne	$/ kwh	tonnes		
72		20	26%	8500	95.00%	285,394	$12.46	**$0.021**	-4,288		
73		Efficiency is the actual conversion from energy to electricity factoring out heat loss, friction etc									
74		Load factor is the percentage of the capacity that power is consumed (purchased									
75	Shortfall from Ce, Cy		**Fuel supplemental to prime fuel - purchased at the nearest sorts**								
76	Pulp grades										
77	Sources	Cost/m³	m³ bought	Wt t/m³	Fuel tonnes	Cost/tonne	Wtd $/tonne				
78	CFP Beaver Cove	$14.00	1.00	0.8	1	$29.49					
79	"WFP" Port McNeill	$14.00	1.00	0.8	1	$27.80					
80	"Weyerhaeuser PMTU	$14.00	1.00	0.8	1	$27.80					
81	Sub total tonnes				2		$28.36				

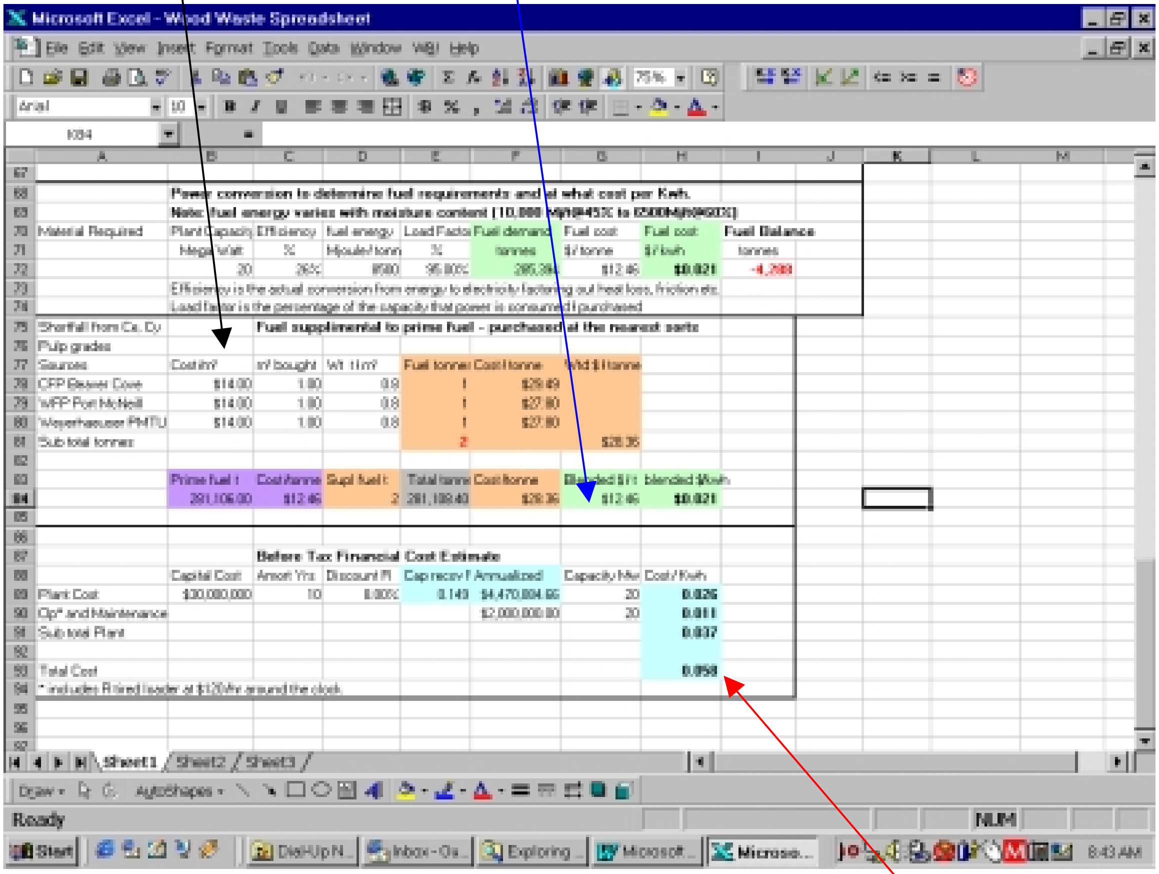
The **Optimizer** row is where one manually balances the volumes between roadside sources by haul distance in order to neutralize the fuel balance from the table below.

By changing the assumptions on this table one affects the fuel demand and when manually adjusted to assure enough fuel, a bottom line fuel cost per Kilowatt hour is derived.

In this table the variables available to the user are:

- Plant Capacity – the energy output design of the plant
- Plant Efficiency– the theoretical energy value transferred to electrical energy
- Fuel Energy – net energy available from the wood waste given species mix and moisture content
- Load Factor – percentage of the time the plant can sell power at the rated capacity

The next table demonstrates the effect of purchasing supplemental fuel from the dry land sorts in the form of Cypress or Cedar pulp. This can be done if all woods sources or other lessor-cost sources are not available to neutralize the fuel balance. The result of this table yields a blended cost per tonne for all fuel sources



	A	B	C	D	E	F	G	H	I
67									
68		Power conversion to determine fuel requirements and at what cost per Kwh.							
69		Note: fuel energy varies with moisture content [10,000 Mj@45% to 6500Mj@60%]							
70	Material Required	Plant Capacity	Efficiency	fuel energy	Load Factor	Fuel demand	Fuel cost	Fuel cost	**Fuel Balance**
71		Mega Watt	%	Mjoule/tonne	%	tonnes	$/tonne	$/kwh	tonnes
72		20	26%	8080	95.00%	285,394	$12.46	**$0.021**	-4,288
73		Efficiency is the actual conversion from energy to electricity factoring out heat loss, friction etc.							
74		Load factor is the percentage of the capacity that power is consumed / purchased							
75	Shortfall from Ca. Dy		**Fuel supplimental to prime fuel - purchased at the nearest sorts**						
76	Pulp grades								
77	Sources	Cost/m³	m³ bought	Wt t/m³	Fuel tonnes	Cost / tonne	Wtd $ / tonne		
78	CFP Beaver Cove	$14.00	1.00	0.8	1	$29.49			
79	WFP Port McNeill	$14.00	1.00	0.8	1	$27.80			
80	Weyerhaeuser PMTU	$14.00	1.00	0.8	1	$27.80			
81	Sub total tonnes				2		$28.36		
82									
83		Prime fuel t	Cost/tonne	Supl fuel t	Total tonne	Cost/tonne	Blended $/t	blended $/kwh	
84		281,106.00	$12.46	2	281,108.40	$28.36	$12.46	**$0.021**	
85									
86									
87			**Before Tax Financial Cost Estimate**						
88		Capital Cost	Amort Yrs	Discount R	Cap recov F	Annualized	Capacity Mw	Cost / Kwh	
89	Plant Cost	$30,000,000	10	8.00%	0.149	$4,470,884.66	20	**0.026**	
90	Op* and Maintenance					$2,000,000.00	20	**0.011**	
91	Sub total Plant							**0.037**	
92									
93	Total Cost							**0.058**	
94	* includes R fixed loader at $120/hr around the clock								
95									
96									
97									

The last table, although beyond the scope of the study adds the financial and operating cost of a power plant and allows the user to estimate a before tax total cost per kilowatt-hour.

These variables are:

- Capital cost of the facilities including interest during construction
- Amortization period of financial consideration
- Discount rate
- Plant capacity
- Annual Operating and Maintenance cost