REPORT: CHARACTERSING SEQ SOFTWOOD PLANTATION RESIDUES TO INFORM EMERGING MARKETS

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Forest Resource Security

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Characterizing South East Queensland softwood plantation harvest residues to inform emerging markets

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Abstract:

This report evaluates the quality and energy potential of softwood plantation harvest residues from south-east Queensland, focusing on the impact of comminution method (chipping or grinding) and, in the case of chipping, the impact of screening. The study sampled harvest residues (biomass, mainly clearfall tops and other off cuts) from whole tree roadside processing and cut-to-length at stump harvesting operations, and examined their moisture content, ash content, and net energy value. Totally 26 samples from 16 harvesting sites have been submitted for analysis, with all but one sample being from Southern Pine sites. While statistically meaningful comparisons were not possible due to limitations in the sample sets, the following trends are evident:

- Unscreened 'Bruks' chips (ex-Fraser Coast roadside processing residues) have a higher moisture content (38% vs 30%) and lower ash content (0.74% vs 4.36%) compared to unscreened grindings (ex-Beerburrum cut-to-length operations). Net energy values are similar (20.33 MJ/kg);
- Unscreened 'Bruks' chips were higher in moisture content (38%) than screened Bruks chips (26.5%) whereas both had similar ash content (0.63% and 0.64%) and net energy value (20.50 and 20.04 MJ/kg) respectively);
- Screened Bruks fines had a much higher ash content (6.74%) compared to screened chips (0.64%) yet moisture content and net energy values were similar;

Introduction

Queensland has 216,000 hectares (ha) of plantations including almost 188,000 ha managed by HQPlantations (HQP), which is mainly (97%) softwoods. In south-east and central Queensland, HQP's softwood estate comprises Southern Pines (126,000 ha, mainly *Pinus elliottii* x *P. caribaea* hybrids) and Araucaria (42,000 ha). These plantations are harvested using whole tree harvesting with roadside processing or cut-to-length at stump harvesting methods. A recent study assessed the availability, locations, and uses of woody waste in southern and central Queensland, focusing on materials from forestry, construction, and demolition. Key factors influencing reuse include low delivered costs, landfill charges, contamination, and processing requirements. High-quality wood waste from sawmills and softwood plantations offers promising recycling opportunities, while municipal, demolition, and CCA-treated timber are less desirable due to contamination. There is potential for biofuel production, but costs remain high. This study indicated that an updated audit of unused waste materials in landfills is needed to identify further recycling opportunities (Strandgard, 2022). Earlier studies in Southern Pines indicated that following the removal of sawlogs, pulp logs and other commercial log classes there remains a considerable weight of harvesting residues on harvested sites (in the cut-over area and at roadsides/landings) varying from 30 to 100 green metric tonnes per hectare (GMt/ha) (Ghaffariyan and Apolit, 2015; Berry, 2018). Depending on markets, extraction and haulage costs and feedstock quality and prices, a proportion of these residues has the potential to be recovered for a range of end uses including as source of bioenergy, for compost or mulch markets and as biochar for a wide range of end uses, subject to sufficient material being left on site for long term site sustainability reasons.

Literature review

Biomass characteristics play an important role in product classification, economic values, and types of usage. Recently a literature review project was initiated by the International Energy Agency (IEA), Bioenergy Technology Collaboration Programme, which aimed to review and identify the top biomass characteristics as they relate to commercially viable biomaterial and bioenergy processes. The search was restricted to woody biomass and raw feedstock materials. Review results were classified based on region including Africa, America, Asia, Europe and Oceania. Each case study was described based on the study background, type of biomass and biomass attributes that were measured. The key biomass characteristic that was consistently highlighted in almost all reports was moisture content which highly impact the gross calorific value. Moisture content in biomass is crucial for forest biomass utilization because it directly impacts energy efficiency and combustion performance. High moisture content reduces the gross calorific value, requiring more fuel to produce the same amount of energy. It also complicates storage and transportation, potentially leading to microbial degradation or energy loss. Managing moisture ensures optimal energy output and cost-effective use of biomass as a renewable energy source. Ash content and net calorific value were the next most frequently mentioned characteristics with bulk density, contamination, particle shape and nutrient (elemental) content all of lesser importance (Ghaffariyan, 2023). The ash content of biomass wood chips is important to measure because it affects the efficiency of combustion, impacts equipment maintenance, and influences the environmental impact of ash disposal. Measuring the net calorific value of biomass is crucial because it determines the energy output during combustion, helping to assess their suitability as a fuel source and optimize energy production.

One of the key characteristics is particle size distribution of wood chips. Handling and combustion of solid biofuel, ventilation properties and storage types can be impacted by particle size (Kristensen and Hofman, 2000). According to Kuptz et al. (2019) wood chip quality is a key factor to achieve low-emissions combustion of small boilers with capacity less than 100 kW. Screening and drying can help increasing homogeneity of the wood chips to meet chip quality standards such as ISO 17225-4. Visser (2010) described screening as a method that could remove oversize and undersize particles, dirt and stones from the wood chips and that it will require additional costs that should be carefully considered. Once fine materials are removed by screening the biomass fuel quality will increase due to changes made on ash content and combustion characteristics.

A summary of research findings published in various countries (**Appendix A)** provides an overview of the latest available knowledge on biomass screening studies.

Study objectives

This project seeks to achieve following objectives:

a) Characterise a range of typical SE Queensland softwood plantation harvest residues to determine their moisture content (%), ash content (% ash of dried sample) and net energy value (MJ/kg Dry Matter); and
b) Investigate the impact of biomass screening on moisture content and net energy (calorific) values.

Materials and study method

Samples for analysis were opportunistically collected from operations where biomass recovery operations are current including:

- Bark-on harvest residues directly chipped or grinded in-field;
- Tub-grinded samples derived from residues previously chipped in-field;
- Screened fractions of chips previously chipped in-field;
- Screened samples of biochar derived from forest residues; and
- Chips from green off saw offcuts from previously de-barked sawlogs.

Representative samples from each material source (typically 5 kg minimum) were sent to Southern Cross University's Environmental Analysis Laboratory (EAL) at Lismore where the requested analyses were either performed directly by EAL or were sub-contracted to other accredited laboratories. The analyses requested by EAL for chipped and grinded samples are summarised in **Table 1**.

Table 1*: EAL sample analyses requested.*

EAL code	Name of test	Sample type
SS-PREP-024	Ash analysis preparation	Chipped or grinded samples
SS-SING-021	Ash content by combustion	Chipped or grinded samples
SS-SING-219	Solids Energy Code (Calorific Value)	Chipped or grinded samples

Data Analysis

Due to the low number and non-random nature of the parameters associated with each sample, it was not possible to perform any meaningful statistical analysis between different sets of samples. For example, due to the nature of biomass recovery operations at different centres all chipped (unscreened and screened) samples were sourced from whole tree harvest/roadside processed sites at Fraser Coast using a Bruks chipper, whereas all grinded samples were sourced from cut-to-length harvested sites at Beerburrum where the residues were pre-stacked with a forwarder or dozer before being grinded at roadside, with no screening involved. Instead, the data arising from the various samples is presented in a series of graphs and tables with simple means calculated.

Results

Biomass samples have been collected from 16 harvest sites in south-east Queensland representing a variety of species, harvest techniques and biomass samples as summarised in **Table 2**. The biomass collection and processing techniques sampled to date include:

- Direct collection and in-field chipping of harvest residues (following whole-tree harvest and roadside processing) using a Bruks chipper mounted on an Ecolog forwarder.
- Forwarder-based collection of residues (following cut-to-length at stump harvesting) and delivery to roadside stacks for in-field grinding using a 1000 hp horizontal flat-bed grinder.
- Screening or further processing of Bruks chips at a centralised hub.
- Processing of solid harvest residues (bin wood) into biochar ('Carbonchips') using a Tigercat Carbonator followed by screening into different size fractions.

Appendix B contains a series of images depicting the various harvest residues and their recovery and processing which are typical of the samples collected and analysed for this project.

Table 2. *Summary of samples sent[1] to EAL for analysis (as at December 2024)*

Species	**Harvest technique**	**Biomass samples**
Hybrid Pine (22)	Whole tree harvest, Roadside processed (14)	Bark-on, in-field chipped, unscreened (6)
		Bark-on, in-field chipped, screened chips (3)
		Bark-on, in-field chipped, fines ex-screening (2)
		Bark-on, in-field chipped in field, then then grinded (2)
		Bark, ex-harvest site (1)
	CTL at stump, residues forwarded to roadside (8)	Bark-on, grinded (7)
		Bark, ex-harvest site (1)
Hybrid Pine wildlings (2)	Whole tree harvest (2)	Biochar (2)
Caribbean Pine (1)	Whole tree harvest, Roadside processed (1)	Bark-on, chipped (1)
Araucaria (1)	Whole tree harvest, process at ramp (1)	Bark-off chips ex sawmill (1)

Details of all available results from the various samples are presented in **Appendix C**.

Details of the two biochar samples are included as **Appendix D**.

A series of comparison graphs for selected comparisons are presented in **Figures 1 to 3**.

[1] Awaiting results from 8 samples. Numbers in brackets = number of samples collected and sent to EAL

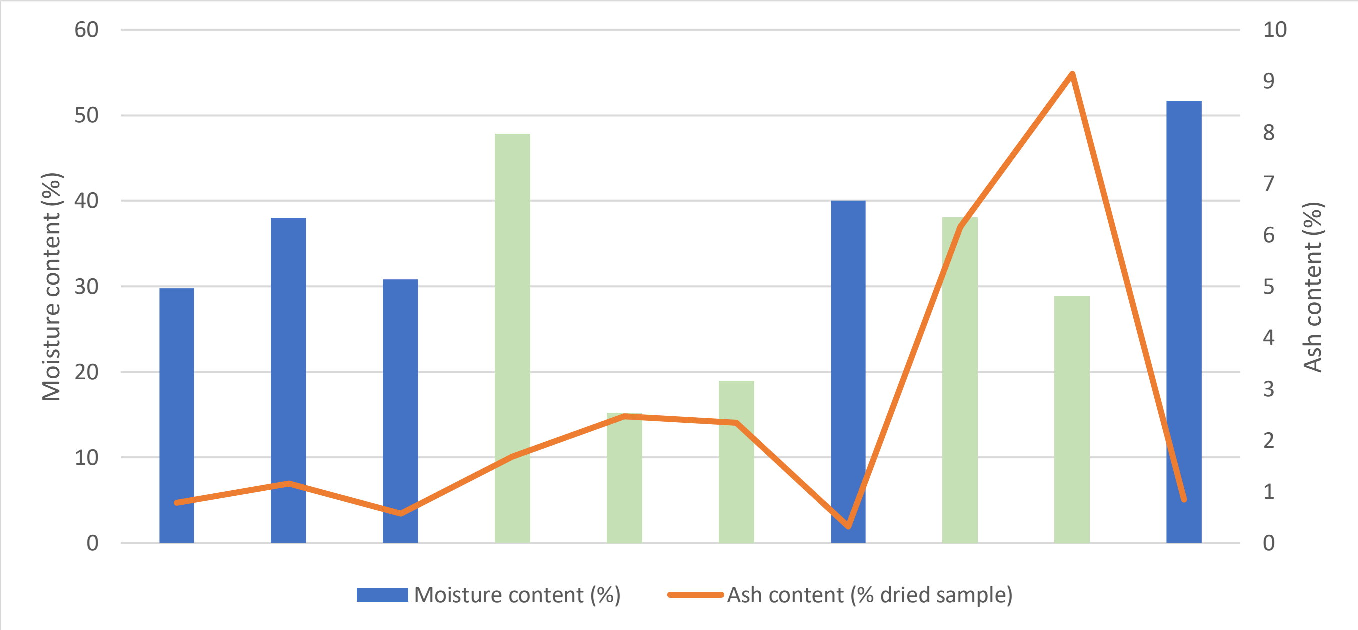

Figure 1. *Moisture content (%) and ash content (%) from unscreened 'Bruks' chips (Blue, ex-Fraser Coast whole tree harvest roadside processing sites, N=5) and unscreened grindings (Green, ex-Beerburrum CTL harvest, grinding of pre-stacked residue piles, N=5)*

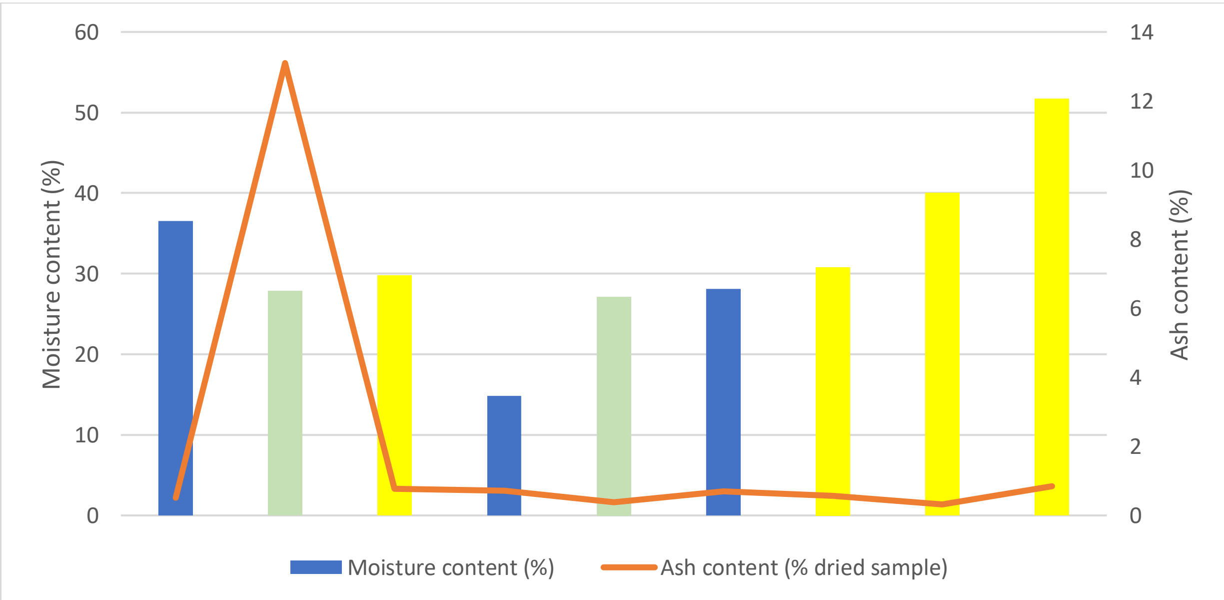

Figure 2*. Moisture content (%) and ash content (%) from unscreened (Yellow, N=4), screened (Blue, N=3) and screened fines (Green, N=2) 'Bruks' chips (ex-Fraser Coast whole tree harvest roadside processing sites)*

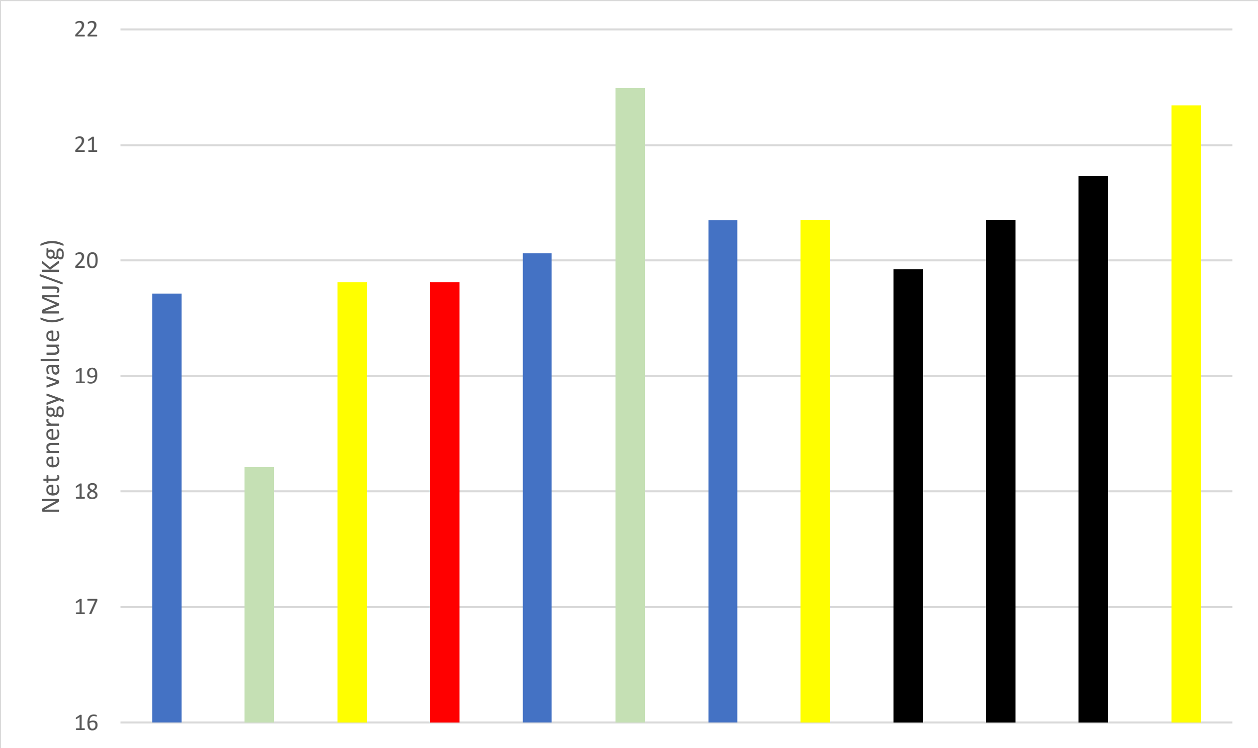

Figure 3. *Net energy value (MJ/kg dry matter) for various biomass samples (N=12) including Bruks chips_unscreened (Yellow, N=3), Bruks chips_screened (Blue, N=3), Bruks chips_screened fines (Green, N=2), grinded Bruks chips_unscreened (Red, N=1) and Grindings_unscreened (Black, N=3)*

Mean values and corresponding sample numbers for the various metrics illustrated in Figures 1 to 3 are presented in **Table 3**.

Table 3. *Moisture content (%), Ash content (%) and net energy value (MJ/kg dry matter) based on mean values between various sample comparisons*

	# samples	**MC %**	**Ash %**	**MJ/kg dry matter**
Unscreened chips vs grindings				
Bruks chips_unscreened (ex-Fraser Coast roadside processing)	5	38.06	0.74	20.33 (N=4)
Grindings_unscreened (ex-Beerburrum cut-to-length residue stacks)	5	29.77	**4.36**	20.33 (N=3)
Unscreened vs screened Bruks chips ex-Fraser Coast roadside processing				
Unscreened	4	**38.08**	0.63	20.5 (N=3)
Screened	3	26.5	0.64	20.04
Screened fines	2	27.51	**6.74**	19.85
Net energy value comparisons				
Bruks chips_unscreened	3	33.54	0.56	20.5
Bruks chips_screened	3	26.5	0.64	20.04
Bruks chips_screened fines	2	27.51	**6.74**	19.85
Grinded Bruks chips_unscreened	1	37.99	1.16	19.81
Grindings_unscreened38%) and lower in ash content	3	27.32	**2.16**	20.33

Detailed results from the two biochar samples are presented in **Appendix D**.

Discussion

Noting the limitations associated with the various comparisons highlighted in the previous section, the following trends are considered noteworthy:

- Unscreened 'Bruks' chips (recovered directly ex-Fraser Coast roadside processing residues) have a higher moisture content (38% vs 30%) and lower ash content (0.74% vs 4.36%) compared to unscreened grindings (ex-Beerburrum cut-to-length operations where the residues are collected and pre-stacked before roadside grinding). The net energy values are the same in both cases (20.33 MJ/kg)

- Unscreened 'Bruks' chips samples were higher in moisture content (38%) than screened Bruks chips (26.5%) whereas both had similar ash content (0.63% and 0.64% respectively) and net energy value (20.50 vs 20.04 MJ/kg respectively)
- Screened Bruks fines had a much higher ash content (6.74%) compared to screened chips (0.64%) yet moisture content and net energy values were similar
- All sample groupings had broadly similar net energy values (mean of 20.12 MJ/kg, N=12). Inexplicably, the lowest (18.21) and highest (21.49) values were both sampled from Bruks screened fines
- For the fine and coarse biochar samples respectively, total organic carbon (58.3% and 68.7%) and C/N ratio (1,215 and 970) are both considered to be acceptable according to the sample providers (Carbonchip)

Conclusions and Recommendations

Reviewing international studies indicated that screening biomass wood chips could help to improve product quality. This research confirmed that screening could help reducing moisture content of wood chips up to 11.5 %. This may have a positive impact on the price of wood chips and help reduce transport cost due to reducing the weight per load.

The following recommendations are made for industry users based on this research, including the literature review:

1. **Optimize Biomass Recovery**: Implement advanced harvesting techniques to optimize biomass recovery. Training personnel in effective collection methods can enhance the quantity and quality of biomass available for further processing.
2. **Enhance Biomass Screening Processes**: Invest in improved screening technology to reduce contamination and improve the homogeneity of wood chips. This can enhance calorific value and optimize combustion efficiency.
3. **Invest in Biofuel and Bioenergy Technology**: Explore partnerships and funding opportunities for developing cost-effective biofuel and bioenergy production methods. Addressing the current high costs can unlock significant energy production potential from wood waste.

4. **Promote Research and Development**: Conduct more targeted research to more gain a more comprehensive understanding of biomass characteristics and related supply chain challenges one there are clearer signals regarding potential markets and end users.

These recommendations aim to enhance the efficiency, sustainability, and economic viability of biomass utilization in Queensland's forestry sector.

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APPENDIX A: Summary of published biomass recovery studies with a focus on wood chip screening

Australia

There are different types of woody biomass including sawdust, wood shavings, chips, fines, bark, oversize chips, and large section size woods that can be used for bioenergy production (https://www.agriculture.gov.au). Biomass quality is important for energy production. Key factors include mechanical contamination level (such as sand, grit and stones) and moisture content. Moisture content can be managed by passive management methods such as air-drying and protecting from the moisture. Screening can be also applied by screen shakers to segregate particle size to sort biomass. Effective screening and conveying systems can transport biomass to storage points efficiently while minimising the contamination level (https://www.pyrenees.vic.gov.au).

Germany

Hartmann et al. (2006) tested five horizontal and three rotary screening methods under five different screen hole diameters (3.15, 8, 16, 45, 63 mm, round holes). Study results confirmed that consistency and comparability of the measurements using horizontal and rotary screening are key to consider. When an image analysis system was applied, the difference between measurements with reference method was low while application of horizontal screens resulted in median size distribution to range between 33% to 50% of the reference median value of particle length distribution. Hartmann et al. (2006) mentioned that these deviations might have been caused by higher particle misplacement especially for larger particles. In another study, Kuptz et al. (2019) sampled wood chips from harvesting residues that were collected in biomass terminals within 6 case studies. Drum and star screens were used for the screening process. Natural air drying was applied in storage piles, in rolling bed, walking floor and belt and batch container dryer. Moisture content was 51% which was high to be used in small boilers. Natural drying reduced moisture content to 35% while artificial drying reduced it to 15%. Screening also helped with drying samples. Ash content, fines, oversize particles and share of N, S, CI, K and Si were reduced by screening (Kuptz et al. 2019). Pollex et al. (2020) sampled low wood quality biomass including branches and chips from roadside maintenance practices. Application of screening and drying reduced soil contaminants. Screening helped with reducing the share of fine materials.

Italy

Nati et al. (2010) studied the impact of blade wear and screen size on wood chips distribution. They sampled wood chips from two different species (poplar and pine), two tree parts (branches and logs) under two screen types (large and medium) for testing. The results indicated that chips from logs had a lower share of oversize particles compared with tops and branches. Chips from poplar were larger than pine for the same mesh size and had a higher share of oversize particles. Smaller size mesh screen did not significantly reduce the share of oversize particles from pine thus using a standard mesh size was recommended.

Finland/Sweden

To measure chip load values, chip size and geometry the screening methods and optical analysis can be used according to Karjalainen and Bergström (2018). For wood chips used for bioenergy it was suggested using the round apertures of 63 mm, 45 mm, 16 mm, 8 mm and 3.15 mm (ISO 17827-1:2016). To meet the ISO 17827-2:2016 standard the fine materials could be sieved using round aperture of 3.15 mm and sieves of 2.8 mm, 2.0 mm, 1.4 mm, 1.0 mm, 0.5 mm and 0.25 mm made of wire cloth. Another case study was conducted using wood chip samples from timber harvesting residues that had been stored for 5 months at the fuel yard of a CHP plant in Sweden. Mechanical screening was applied, and the results indicated a reduction in ash content and fine materials in the accepted share of wood chips. Sand and soil contaminant was also reduced as fuel analysis showed a reduction on silicon and aluminium (Bozaghian Baeckman et al. 2020).

USA/Canada

Woo (2015) studied the impact of screening on productivity and size distribution using two types of screens (star and deck) for hog fuel and wood chips. The stands were composed of *Pseudotsuga menziesii* (Douglas-fir) and *Tsuga heterophylla* (Western hemlock). The size categories for screens included 10 mm (under), 10-50 mm (accept) and 50 mm (oversize). The star screen was found to be more productive than the deck screen. Producing wood chips resulted in higher machine productivity than producing hog fuel. Within the screened materials, the largest share of accepted materials was 13 mm. The largest share of oversize materials was 25 mm and the highest proportion of under size materials were sawdust (Woo, 2015; Woo and Han (2018)). Another study was conducted in North Carolina in a loblolly pine (*Pinus taeda*) plantation where whole tree chips and harvesting residue chips were compared. This showed there was little difference between wood chips taken from both harvesting alternatives. The correlation between blade wear and chip size distribution was weak. When blades became dull the frequency of large size wood chips decreased (Groover, 2011).

APPENDIX B – **Selected images showing softwood harvest residue recovery and processing techniques typical of those reported in this project**

Bruks chipper on Eco Log forwarder picking up, chipping residues in-field and emptying them into a hook bin for delivery to a central hub where further screening (or grinding) may be performed, depending on prevailing markets


Doosan loader loading pine wildling harvest residues (including stumps, 33 Boonooroo) into binwood truck for conversion to biochar via Carbonator


Forwarder recovery of harvest residues following cut-to-length at stump harvest operation (14 Landsborough, higher residue levels than usual on this ex-CSIRO pasture research site)

Horizontal flatbed grinder processing roadside stacked CTL harvest debris at Beerburrum before re-loading and transport to a bioenergy facility in northern NSW

APPENDIX C – Summary of harvest residue samples collected and analysed

Taxa	**Logging Area**	**Cpt**	**Plantation estate**	**Harvest method** Whole tree harvest (WT) Cut to length at stump (CTL)	**Comminution method**	**Sample type**	**Moisture content (%)**	**Ash content (% dried sample)**	**NET Energy Value (MJ/kg DryMatter)**
Pinus hybrid	Boonooroo	29	Fraser Coast	WT	Bruks chipper	Screened chips	36.58	0.52	19.71
Pinus hybrid	Boonooroo	29	Fraser Coast	WT	Bruks chipper	Fines from screened chips	27.88	13.10	18.21
Pinus hybrid	Boonooroo	29	Fraser Coast	WT	Bruks chipper	Unscreened wood chips	29.78	0.78	19.81
Pinus hybrid	Boonooroo	29	Fraser Coast	WT	Grinded Bruks chips	Unscreened chips-then grinding	37.99	1.16	19.81
Pinus hybrid	East	226A	Fraser Coast	WT	Bruks chipper	Screened chips	14.83	0.71	20.06
Pinus hybrid	East	226A	Fraser Coast	WT	Bruks chipper	Fines from screened chips	27.14	0.39	21.49
Pinus hybrid	East	226A	Fraser Coast	WT	Bruks chipper	Screened chips	28.10	0.70	20.35
Pinus hybrid	East	226A	Fraser Coast	WT	Bruks chipper	Unscreened wood chips	30.81	0.57	20.35
Pinus hybrid	Landsborough	14	Beerburrum	CTL	Flatbed grinder	Grindings - unscreened	47.80	1.68	19.92

Pinus hybrid	Glasshouse	206	Beerburrum	CTL	Flatbed grinder	Grindings - unscreened	15.20	2.47	20.35
Pinus hybrid	Glasshouse	206	Beerburrum	CTL	Flatbed grinder	Grindings - unscreened	18.95	2.34	20.73
Pinus caribaea	North Dempster	110	Fraser Coast	WT	Bruks chipper	Unscreened wood chips	40.05	0.32	21.34
Pinus hybrid	Glasshouse	205	Beerburrum	CTL	Flatbed grinder	Grindings - unscreened	38.09	6.16	2.49
Pinus hybrid	Glasshouse	203	Beerburrum	CTL	Flatbed grinder	Grindings - unscreened	28.82	9.14	2.59
Pinus hybrid	East	244	Fraser Coast	WT	Bruks chipper	Unscreened wood chips	51.68	0.85	3.02
Pinus hybrid	East	239	Fraser Coast	WT	Bark	Bark	27.70	1.02	2.91
Pinus wildlings	Boonooroo	33	Fraser Coast	WT	Carbonator	Biochar fine	53.50	39.02	biochar
Pinus wildlings	Boonooroo	33	Fraser Coast	WT	Carbonator	Biochar coarse	60.43	28.18	biochar
Pinus hybrid	West	237A	Fraser Coast	WT	Bruks chipper	Unscreened wood chips	no data yet	no data yet	no data yet
Pinus hybrid	West	237A	Fraser Coast	WT	Bruks chipper	Unscreened chips-then grinding	no data yet	no data yet	no data yet
Pinus hybrid	Rose	201	Beerburrum	CTL	Flatbed grinder	Grindings - unscreened	no data yet	no data yet	no data yet
Pinus hybrid	Rose	201	Beerburrum	CTL	Flatbed grinder	Grindings - unscreened	no data yet	no data yet	no data yet
Araucaria cunninghamii	Little Derrier	3	Mary Valley	WT	chipper ex-mill	woodchips-no bark	no data yet	no data yet	no data yet
Pinus hybrid	Rose	201	Beerburrum	CTL	Flatbed grinder	Grindings - unscreened	no data yet	no data yet	no data yet

Pinus hybrid	Tahiti	204A	Fraser Coast	WT	Bruks chipper	Unscreened wood chips	no data yet	no data yet	no data yet
Pinus hybrid	Tahiti	214	Fraser Coast	WT	Bruks chipper	Unscreened wood chips	no data yet	no data yet	no data yet

(NB: Data highlighted yellow considered unreliable and excluded from analyses)

APPENDIX D – Biochar analysis reports

BIOCHAR 'TOTALS' ANALYSIS REPORT

		Sample 1	Sample 2
	Product Name:	240621_01	240621_02
	Product Type:	Biochar Fine	Biochar Coarse
	Manufacturing Site:	HQPlantations	HQPlantations
	Manufactured Date:	21/06/2024	21/06/2024
	Application:	..	..
	Test Applicable:	SS-PACK-163	SS-PACK-163
Parameter	**Method Reference**	**R5800/1**	**R5800/2**
Wet Bulk Density (g/cm3)	AS4454:2012 Appendix J	0.72	0.68
Dry Bulk Density (g/cm3)	AS4454:2012 Appendix J	0.33	0.27
Moisture Content (%)	**Inhouse S2 (105°C)	54	60
Loss on ignition (%)	Calculation (100 - Ash %)	61.0	71.8
Ash Content (% ash)	Inhouse 750˚C by combustion	39.0	28.2
pH	Rayment & Lyons 2011 - 4A1 (1:10 Water)	9.19	9.26
Electrical Conductivity (dS/m)	Rayment & Lyons 2011 - 3A1 (1:10 Water)	0.33	0.39
Total Sulfur (%S)	Rayment & Lyons 2011 - 17C1 Aqua Regia	0.22	0.02
Total Hydrogen (%)	ASTM D5291	0.83	0.87
Total Oxygen (%)	**Calculation (100 - TOC - TN - H - ASH)	1.81	2.13
Total Organic Carbon (%)	LECO Trumac Analyser - Inhouse S15b	58.3	68.7
Total Carbon (%)	Inhouse S4a (LECO Trumac Analyser)	58.3	68.7
Total Nitrogen (%)		0.05	0.07
C/N Ratio	**Calculation - Total Organic Carbon/Total Nitrogen	1,215	970
H/Corg Molar Ratio	**Calculation - Hydrogen/Total Organic Carbon	0.01	0.01
O/Corg Molar Ratio	**Calculation - Oxygen/Total Organic Carbon	0.03	0.03
Acid Neutralising Capacity (% $CaCO_3$)	AS4454:2012 Appendix H	2.50	2.10
METALS			
Total Calcium (%)	Rayment & Lyons 2011 - 17C1 Aqua Regia	0.60	0.43
Total Magnesium (%)		0.21	0.11
Total Potassium (%)		0.14	0.10
Total Sodium (%)		0.07	0.06
Total Sulphur (%)		0.22	0.02
Total Phosphorus (%)	Rayment & Lyons 2011 - 17C1 Aqua Regia	0.06	0.02
Total Zinc (mg/kg)	Rayment & Lyons 2011 - 17C1 Aqua Regia	17.6	4.76
Total Manganese (mg/kg)		161	163
Total Iron (mg/kg)		16,225	17,202
Total Copper (mg/kg)		17.8	9.97
Total Boron (mg/kg)		18.5	14.4
Silicon (mg/kg)		826	824
Total Aluminium (mg/kg)		3,098	1,138
Total Molybdenum (mg/kg)		<1	<1
Total Cobalt (mg/kg)		2.13	1.15
Total Selenium (mg/kg)		<1	<1
Total Cadmium (mg/kg)		<0.5	<0.5
Total Lead (mg/kg)		1.59	<1
Total Arsenic (mg/kg)		2.14	<2
Total Chromium (mg/kg)		77.8	21.5
Total Nickel (mg/kg)		7.16	2.99
Total Mercury (mg/kg)		<0.1	<0.1
Total Silver (mg/kg)		<1	<1

COMPOST 'AVAILABLES' ANALYSIS REPORT

			Sample 1	Sample 2
		Product Name:	240621_01	240621_02
		Product Type:	Biochar Fine	Biochar Coarse
		Manufacturing Site:	HQPlantations	HQPlantations
		Manufactured Date:	21/06/2024	21/06/2024
		Test Applicable:	SS-PACK-173	SS-PACK-173
Parameter		**Method reference**	**R5800/1**	**R5800/2**
Exchangeable Calcium	**(cmol$_+$/kg)**	Rayment & Lyons 2011 - 15D1 (Ammonium Acetate)	12.7	11.5
	(kg/ha)		5,711	5,172
	(mg/kg)		2,549	2,309
Exchangeable Magnesium	**(cmol$_+$/kg)**		3.08	2.39
	(kg/ha)		838	650
	(mg/kg)		374	290
Exchangeable Potassium	**(cmol$_+$/kg)**		2.25	2.20
	(kg/ha)		1,969	1,930
	(mg/kg)		879	861
Exchangeable Sodium	**(cmol$_+$/kg)**		1.90	2.26
	(kg/ha)		978	1,165
	(mg/kg)		437	520
Exchangeable Aluminium	**(cmol$_+$/kg)**	**Inhouse S37 (KCl)	<0.01	<0.01
	(kg/ha)		<1	<1
	(mg/kg)		<1	<1
Exchangeable Hydrogen	**(cmol$_+$/kg)**	**Rayment & Lyons 2011 - 15G1 (Acidity Titration)	<0.01	<0.01
	(kg/ha)		<1	<1
	(mg/kg)		<1	<1
Effective Cation Exchange Capacity (ECEC) (cmol$_+$/kg)		**Calculation - Sum of Ca,Mg,K,Na,Al,H (cmol$_+$/kg)	19.9	18.4
Calcium (%)		**Base Saturation Calculations - Cation cmol$_+$/kg / ECEC x 100	63.8	62.7
Magnesium (%)			15.4	13.0
Potassium (%)			11.3	12.0
Sodium - ESP (%)			9.52	12.3
Aluminium (%)			0.00	0.00
Hydrogen			0.00	0.00
Calcium/Magnesium Ratio		**Calculation - Calcium / Magnesium (cmol$_+$/kg)	4.13	4.83

APPENDIX E – Acronyms /abbreviations table

Acronym/Abbreviation	Full Form/Description
Ash content	The amount of ash (in %) found in the wood samples after drying
Biochar	A form of charcoal produced from wood for energy purposes
Calorific value	A specific type of energy value, focused on the heat released from combustion.
C/N	Carbon to Nitrogen Ratio
Carbonator	A machine used for converting wood residues to biochar
CHP	Combined Heat and Power
Cl	Chlorine
Comminution method	The method used to break down or process wood (e.g., chipping, grinding)
CTL	Cut-to-Length Harvesting Method
EAL	Environmental Analysis Laboratory
Energy value	This can be broader than calorific value, referring to the total energy potential of a substance, which could include different forms of energy.
Fines	Small particles of wood resulting from the screening process
GMt/ha	Green Metric Tonnes per Hectare
Gross Energy Value	It represents the total amount of heat released when a substance is completely burned, including the energy required to vaporize the water in the combustion products.
Ha	Hectares
HQP	HQPlantations
IEA	International Energy Agency
ISO	International Organization for Standardization
K	Potassium
MC	Moisture Content (in %) found in the wood samples
MJ/kg	Megajoules per kilogram
N	Nitrogen
Net Energy Value	Net Energy Value represents the amount of heat released when a substance is completely burned, but it excludes the energy used to vaporize the water in the combustion products. This means that the water vapor remains in gaseous form after combustion and does not release its latent heat.
S	Sulfur
Si	Silicon
SS-PREP-024	Ash Analysis Preparation (EAL Test Code)
SS-SING-021	Ash Content by Combustion (EAL Test Code)
SS-SING-219	Solids Energy Code (Calorific Value) (EAL Test Code)
WT	Whole Tree Harvesting Method

MORE INFORMATION

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