Final Report
Residues Utilisation and Stewardship Strategy

Prepared for

North East New South Wales
Forestry Hub

July 2021




MS2

About us

MS2 is an Australian sustainability consultancy with expertise in product stewardship, bioenergy, regulatory affairs, strategy, facilitation and communications.

Director Russ Martin has over 30 years' experience in product stewardship, public policy, bioenergy and sustainability, both in government and as an advisor to industry and governments. These roles have been in the US, Australia, New Zealand and Middle East.

Russ also founded and serves as CEO of the not-for-profit Global Product Stewardship Council (GlobalPSC, globalpsc.net) and is Founder of the International Stewardship Forum series. Russ was awarded the Global Green Future Leadership Award by the World CSR (Corporate Social Responsibility) Congress.

Photo Credits

Russ Martin

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Prepared by
Martin Stewardship & Management Strategies Pty Ltd

Australian Business Number 65 115 490 327
PO Box 755 Turramurra NSW 2074 Australia
+61 417 445 644
admin@ms2.com.au
www.ms2.com.au

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1.0 Acronyms and Glossary

ACCU	Australian Carbon Credit Unit
ANZBIG	Australian New Zealand Biochar Industry Group
ARENA	Australian Renewable Energy Agency
Biochar	Biochar is produced from the slow baking of biomass in the near of total lack of oxygen. In this process, gas and oil separate from carbon-rich solids, producing fuels that can be used for energy and biochar for soil amendment. (Hawken 2017)
Bioenergy	Bioenergy is a form of renewable energy that uses organic renewable materials (known as biomass) to produce heat, electricity, biogas and liquid fuels. (ARENA)
CO_2	Carbon dioxide
CO_2eq	Carbon dioxide-equivalent
Coarse Woody Debris or CWD	"Forest residue or fallen coarse woody debris (CWD) encompasses a variety of woody material, including fallen logs, branches and twigs, stumps, roots and fragments of fallen trees. Because of its many roles, CWD is considered a critical structural and functional feature of many ecosystems. CWD provides habitat for many components of biodiversity as it provides foraging, nesting/breeding opportunities and regeneration niches." (DPI 2017)
CPMTP	Carbon Powered Mineral Carbon Technology & Products
DPI	NSW Department of Primary Industries
DPIE	NSW Department of Planning, Industry and Environment
EfW	Energy from waste
EfW Policy	NSW Energy from Waste Policy Statement (NSW EPA 2015)
Eligible Waste Fuels	"Waste or waste-derived materials considered by the EPA to pose a low risk of harm to the environment and human health due to their origin, low levels of contaminants and consistency over time." (NSW EPA 2016)
EPA	(NSW) Environment Protection Authority
FCNSW	Forestry Corporation of NSW
Forestry and Sawmilling Residues	"Uncontaminated, organic fibrous wood residues and natural wood wastes that result from forestry and sawmilling operations such as, heads, tree thinnings, sawmill sawdust, shavings, chips, bark and other offcuts." (NSW EPA 2016)
FSC	Forest Stewardship Council
GJ	Gigajoule or 1,000,000,000 joules
ha	Hectare(s)
Hub	North East NSW Forestry Hub

IFOAs	Integrated Forestry Operations Approvals
IPCC	Intergovernmental Panel on Climate Change
MJ	Megajoule or 1,000,000 joules
MS2	Martin Stewardship & Management Strategies Pty Ltd
Mt	Megatonne or 1,000,000 tonnes
MW	Megawatt
MWh	Megawatt hour is the amount of electricity generated by a one megawatt (MW) electric generator producing electricity for one hour
NCV	Nett calorific value
NEM	National Electricity Market
NET	Negative emissions technologies are large-scale carbon dioxide removal deployment. (IPCC 2018)
Net Zero	Net zero emissions are achieved when anthropogenic emissions of greenhouse gases to the atmosphere are balanced by anthropogenic removals over a specified period. Where multiple greenhouse gases are involved, the quantification of net zero emissions depends on the climate metric chosen to compare emissions of different gases (such as global warming potential, global temperature change potential, and others, as well as the chosen time horizon). (IPCC 2018)
NSW	New South Wales
PEFC	Program for the Endorsement of Forest Certification
PHA	Pellet Heaters Australia
PJ	Petajoule. 1PJ equals 10^{15} joules (1 million billion) or 278 gigawatt hours.
Resource recovery exemption	"A resource recovery exemption includes conditions for the use of the exempt waste as a fuel or in a thermal treatment process. The exemption may include specifications of how to use the exempt waste fuel, record-keeping and other requirements. Resource recovery exemptions are issued by the EPA that exempt a person from the various waste regulatory requirements that apply to the use of a waste fuel (e.g. waste disposal licensing, levy payments, etc.). The exemptions apply to waste fuels the EPA determines to be fit-for purpose, bona fide energy recovery opportunities." (NSW EPA 2016)
Resource recovery order	"A resource recovery order is issued to the generator and/or processor of the exempt waste fuel. The resource recovery order includes conditions that the generator/processor must meet to supply the waste as a fuel or in a process of thermal treatment. Orders may include specifications such as record-keeping, reporting and other requirements for the exempt waste." (NSW EPA 2016)
RRO	Resource Recovery Order (and exemption)

Thermal treatment	"In accordance with Schedule 1 of the *Protection of the Environment Operations Act 1997*, thermal treatment means the processing of waste by burning, incineration, thermal oxidation, gasification, pyrolysis, plasma or other thermal treatment processes." (NSW EPA 2016)
tph	Tonnes per hour
Uncontaminated wood waste	"Wood waste that is generated in primary and secondary manufacturing processes at facilities with demonstrated quality control over the uncontaminated wood waste stream." (NSW EPA 2016)
UNPRI	United Nations Principles of Responsible Investment 2020
Waste	"As defined in the Dictionary of the Protection of the Environment Operations Act 1997 and the Protection of the Environment Operations (Waste) Regulation 2014." (NSW EPA 2016)

2.0 Executive Summary

Forestry and sawmilling generate byproducts, known as residues, that can be processed into a wide range of intermediate and final products. MS2 has examined barriers and opportunities for optimising residues along the North East Coast of New South Wales (NSW), Australia, for the North East NSW Forestry Hub by conducting desktop research, site visits and stakeholder consultations across the region. The consultations formed the basis for an integrated stewardship strategy which addresses a range of commercial, regulatory and sustainability parameters.

Leaving coarse woody debris (CWD) such as bark on the forest floor following harvesting provides nutrient value and habitat value. The optimal amount of CWD to leave on the forest floor varies by the type of forest and local conditions. Beyond that base amount, forestry residues that lack viable end use markets are either burned in hazard reduction burns or become fuel load that poses bushfire risk and potential risk to timber resource value.

Products created from residues provide alternative income streams for forest growers and processors. Indeed, the stakeholder consultations revealed that timber industry residues, particularly from native hardwoods, are essential treatment and processing options that can utilise wastes that are problematic for other sectors. Expanding and creating end-use markets for forestry industry residues creates value for not only the forestry sector but other interrelated sectors as well. Thus, cross-sectoral approaches are likely to have the greatest chance for success. Finding markets for lower-value wood products, however, is a challenge in the NE NSW Hub region. The diverse range of practices, processes and products examined for timber and residues is shown in Figure 1.

Forestry and existing end use markets for forestry and sawmilling residues are affected by a broad range of factors, from environmental policies and practices and cost-effectiveness of transport to social license to operate. Most of these factors are ultimately affected by perceptions of communities and decision-makers around their sustainability, however there are significant gaps in knowledge and understanding that need to be addressed.

Common concerns to be addressed related to potential loss of koala habitat and loss of native forests due to forestry and bioenergy projects. Some of this concern stems from a lack of understanding about regulation of forestry and bioenergy, but lack of understanding about residues and their use is also a significant factor. Education and awareness about these issues should be integral to community outreach efforts, and include basic discussions around basic forest management, leaving CWD, conducting hazard reduction burns and improving markets for forestry residues that could otherwise pose bushfire risk. Public discussions / workshops should also include related industry sectors (such as bioenergy providers and other residue end users) to help enhance stakeholder engagement and community support.

Recommendations are provided in Table 1. Six key parameters (Industry, Stewardship, Social License, Regulatory, Transport and Data) have been identified and examined throughout this report. A tick in Table 1 indicates that a given recommendation addresses a given key parameter.

Table 1: Recommendations and Key Parameters Addressed by the Recommendation

Recommendations	Industry	Stewardship	Social License	Regulatory	Transport	Data
Investigate and trial negative emissions technologies (NETs) such as pyrolysis and partial gasification that use residues in conjunction with other non-residue feedstocks to produce biochar, heat, power, syngas and other products with commercial value. These NETs cannot realise their full sustainability and commercial potential without using residues as feedstock, especially with regard to carbon credits.	√	√	√	√	√	√
Conduct integrated trials in conjunction with other industry sectors whose byproducts can be used in conjunction with residues by the NETs or whose activities can benefit from the products of these processes.	√	√	√	√	√	√
Integrated trials should examine business cases considerations of system-wide costs and benefits, including carbon drawdown / sequestration and soil carbon in addition to improving carbon accounting methodologies.	√	√	√	√	√	√
Investigate optimal amounts of coarse woody debris/forestry residues to leave onsite under different circumstances to optimise their forestry value, reduce fire risk and quantify remaining residues available for market.	√	√	√	√		√
The forestry industry should consistently raise awareness and understanding that residues are not simply wastes, but feedstocks that are integral to the establishment of circular economies based on higher order use and improved sustainability across a broad range of products and related industry sectors	√	√	√	√		√
Conduct public workshops in relevant forestry regions and larger cities to present and discuss the generation of, uses of and stewardship aspects of forestry and sawmilling residues, preferably featuring key industry and government representatives. Such workshops could be in conjunction with industry workshops to refine estimates of residues and to scope the integrated trials.	√	√	√	√		√
Explore potential wood waste processing infrastructure and operations in the Hunter region and at least one location further north near a regionally significant forestry cluster. These operations could aggregate and process wood wastes of all kinds into intermediate and final products better optimised for transport and ultimate end uses more cost-effectively than having multiple generators and users doing so on their own, whilst potentially improving data on the flow of wood wastes.	√	√	√	√	√	√
Investigate and quantify the current and potential contributions of residues to carbon credits, including how residues are addressed in carbon accounting methodologies.	√	√		√	√	√
Develop an agreed higher order forest residues approvals matrix for using bioenergy and biochar feedstocks based on numerically rated economic, social and environments criteria that rank, in order of preference, and incorporate several policy changes that were pending at the time of publication.	√	√	√	√	√	√

Significant opportunities exist for forestry and sawmilling residues be used for bioenergy projects and carbon-negative processes that generate biochar, as well as power, heat and other commercially valuable products. Stakeholders highlighted a lack of industry-wide approaches to residue market development but indicated their willingness to participate in their development.

Globally, billions of dollars are being invested into means of carbon dioxide reduction that can provide substantial opportunities for forestry and sawmilling residues.

Regionally-focused strategies that improve local stability and reduce product volumes or otherwise improve transport efficiencies have the greatest likelihood of industry uptake and success. We recommend increased opportunities for government and industry funding to identify, trial and develop cross-sectoral opportunities consistent with the proposed trial framework in Figure 2. As part of the integrated stewardship strategy included in this report, we document such opportunities and reinforce the need for residue markets to increase sustainability and reduce carbon emissions while adding economic activity and increasing resilience for regional areas.

The case studies and stakeholder discussions for this project consistently reinforced the need for regulatory improvements raised in previous stakeholder discussions, most notably those of the Bioenergy Stakeholder Engagement Working Group (DPI 2020) about the NSW waste regulatory process. Addressing those identified regulatory barriers would likely result in commercial and sustainability benefits beyond those identified in this report.

Stakeholders noted a lack of dedicated State Government facilitation for projects, most notably for bioenergy, whereas Queensland, Victoria and South Australian governments actively facilitate the development of bioenergy projects. NSW is viewed as focusing more on regulating wastes than in viewing residues and materials as feedstocks for more sustainable, often circular, approaches. As a result, opportunities to address residues are not being fully and effectively addressed in State Government policy development and implementation.

Several stakeholders consulted have benefitted from Commonwealth funding for renewable energy, innovation or bushfire recovery projects. Several have also benefitted from regionally significant transport infrastructure projects. However, many have indicated unsuccessful funding applications or ineligibility for funding given their circumstances. Some stakeholders also indicated a perceived government and community bias against the forestry industry, especially on native forests compared to plantations.

This report was commissioned by the North East NSW Forestry Hub with funding from the Australian Department of Agriculture, Water and the Environment.

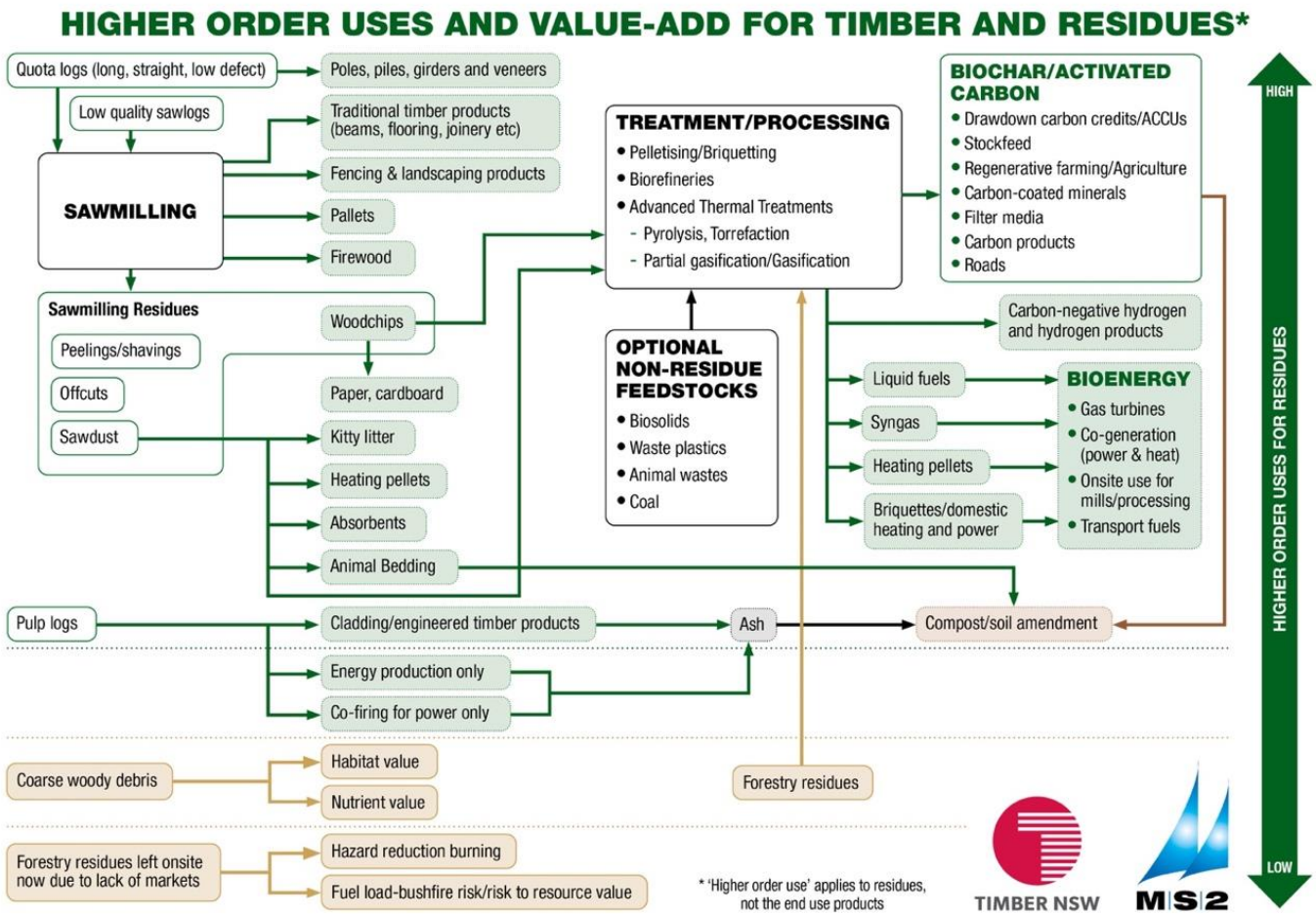


Figure 1: Finding Higher-order Uses and Value-add for Timber and Residues

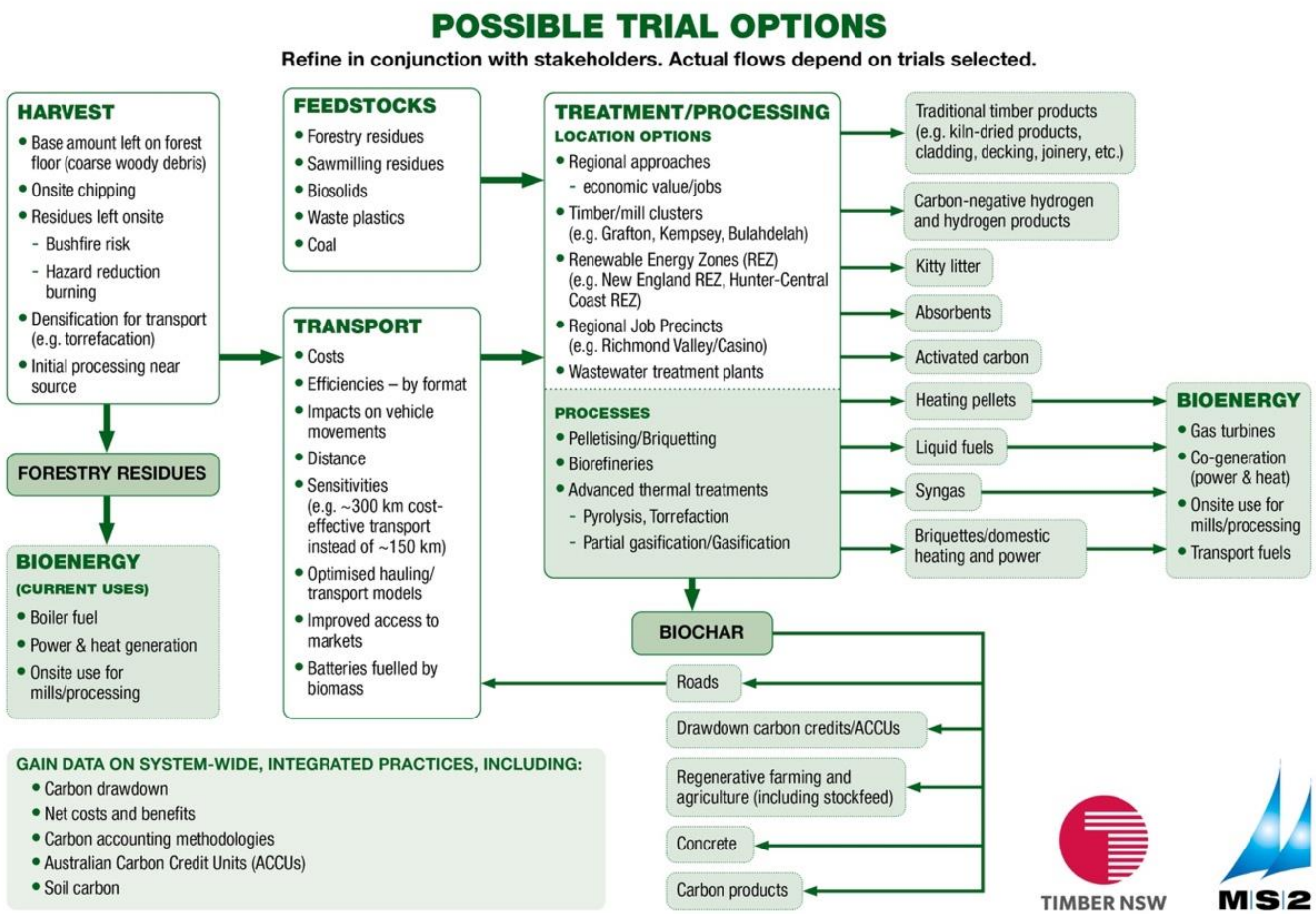


Figure 2: Possible Trial Options Framework

3.0 Introduction

Sustainability consultancy MS2[1] assisted the North East NSW Forestry Hub (Hub) in identifying the industry-relevant benefits for investment in forestry and sawmilling residues (residues) usage opportunities and identifying policy barriers associated with capitalising on opportunities across a range of commercial, regulatory and sustainability parameters.

The intent was to provide decision-makers with case studies and strategic recommendations to highlight current and potential contributions of forestry and related industries, along with a high-level integrated stewardship strategy specifically addressing market development for residues and carbon abatement (including carbon negative strategies and technology) in the Hub region (Figure 3).

The strategy was developed in the context of seeing stewardship as producers placing products on the market having responsibility for minimising the impacts of their products on human health and the environment.

Methodology

Stakeholders to be consulted for this report were developed in conjunction with the Hub's project manager. MS2 contacted stakeholders to seek their involvement and site visits where feasible. Appendix A lists the organisations that MS2 was able to consult.

Site visits and consultations were conducted over several months. In addition to reviewing operations and practices, the case studies and consultations focused on key parameters addressed throughout this report:

- Industry – commercially relevant for industries generating or using forestry and sawmilling residues;
- Stewardship – involves or demonstrates stewardship/sustainability considerations;
- Social License – currently or potentially affects broader community perceptions and social license to operate;
- Regulatory – relates to regulatory considerations;
- Transport – relates to transport or transport infrastructure; and
- Data – currently or potentially affects specific information gaps.

Stakeholders were also consulted on a range of issues around market development for residues, including effectiveness of the NSW forestry sector in developing markets, and asked whether they'd benefitted from particular government initiatives or funding.

Case studies of key stakeholders involved in generating or using residues were developed based on the consultations. Draft case studies and photos were provided to those stakeholders for their review to ensure accuracy and to protect commercially sensitive information that they wouldn't want to see in a public report. Various site visit photos have also been used throughout the report to help explain

[1] Martin Stewardship & Management Strategies Pty Ltd

particular topics; those photos have also been approved by the site visit participants. Results of consultations with industry organisations have been reflected in relevant sections throughout the report, rather than breaking them out as separate case studies.

In the context of this report, the integrated stewardship strategy we developed sought to:

- Recommend strategies to build an integrated stewardship model / circular approach in the region, incorporating potential changes in practices and policies, along with technological advances for not only the traditional timber industry itself, but also bioenergy, biochar, etc.
- Identify gaps in processing technologies and/or capacity, along with indicative investments necessary to address the gaps. Intent was to help lay appropriate groundwork for seeking potential investment / grant funding to address identified needs and integrate resulting environmental benefits of the investments.
- Identify and address key factors such as product type (hardwood, softwood, burnt timber, biochar, etc.), processing, storage, transport and related issues that would affect market range by product type.
- Identify and address key regulatory considerations.

Principal report findings were drawn from desktop research, case studies and consultations, and assessed against whether the finding addressed the key parameters. Recommendations have also been assessed against the six key parameters.

The contributions of staff and members of the Hub, Timber NSW, SEATA Group and the Australia New Zealand Biochar Industry Group (ANZBIG) to the development of this report were invaluable. We greatly appreciate the time, expertise and support provided by Dr Stephanie Hernandez, Maree McCaskill, Craig Bagnall and others, especially considering their limited resources.

Independent review of draft case studies and reports was conducted by John Polhill of Circular-e Solutions; his contribution is also greatly appreciated.

This project builds upon MS2's previous work on bioenergy for the forestry industry and the NSW Government, including *Transforming Wood Residues To Bioenergy: A Step-By-Step Guide* (Timber NSW and NSW Forest Industries Taskforce 2017) and the Bioenergy Stakeholder Engagement Working Group discussions that MS2 facilitated for the NSW Department of Primary Industries (DPI) (DPI 2020). While the report for DPI specifically addressed barriers and opportunities for bioenergy, MS2 applied a broader scope with regard to products, approaches and sustainability considerations for this report.

This project was commissioned by the Hub to address Hub Project A.2, *Smart utilisation of wood residue – sound outlets for timber residues* and made possible through funding provided by the Australian Department of Agriculture, Water and the Environment.

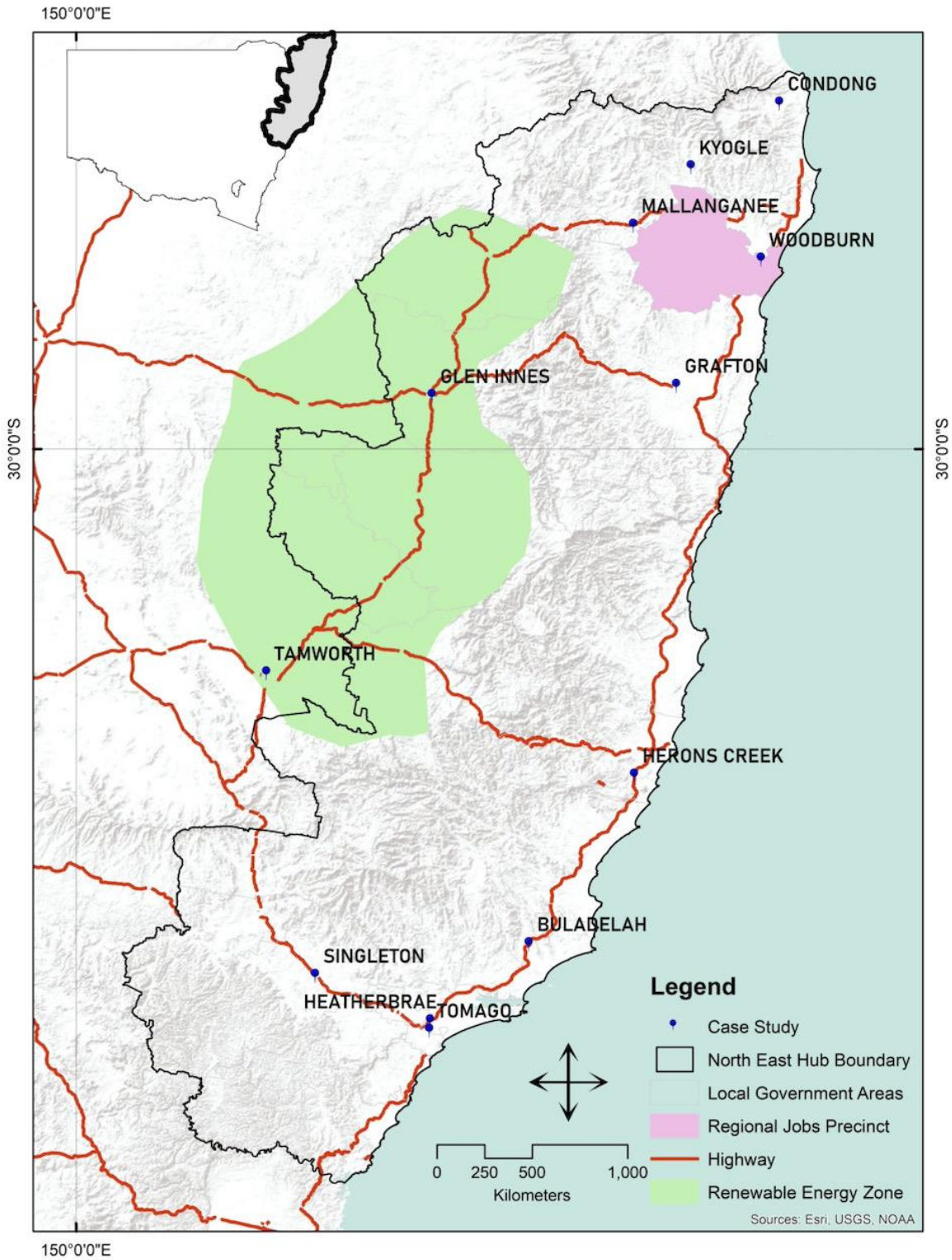


Figure 3: Hub and Relevant Regional Activities

Source: Dr Stephanie Hernandez, North East NSW Forestry Hub

4.0 Generation of Residues

Forestry and sawmilling generate byproducts, known as residues, that can be processed into a wide range of intermediate and final products. This section provides an overview of how residues are generated, especially in the Hub region.

4.1 Forestry and Sawmilling

Forestry and sawmilling operations generally occur in long-established clusters based on growing conditions by species. Within the Hub, the main clusters include Grafton, Wauchope/Kempsey and Bulahdelah.

Forest products are generally classified by 'higher order' uses. The most valuable log products are the most tightly specified. Trees that produce large, long and straight 'quota' logs with low levels of defect are the best suited to the production of high value wood products, such as utility poles. In contrast, smaller, poorer-formed trees with higher defect are typically only suitable for use as low value byproducts.

Higher value logs are graded, measured and marked onsite before being loaded for transport. In-truck weighing systems are frequently used, including for the lower grade products such as salvage sawlogs, pulpwood and firewood. Lower value byproducts are typically commodity products with generic specifications. Pulpwood and firewood are examples of low value wood that are a common byproduct of saw log-driven harvesting. They are sourced from a broad range of tree species, sizes and qualities. Some operations also chip on-site to maximise product recovery and optimise transportation.

Lower value pulp logs are often shipped directly to end use markets in order to minimise transport costs. Haulers and sawmill operators noted the time and effort involved in loading transport vehicles and cautioned to avoid double handling. They did not see likely advantage in regional transport hubs such as bulking depots for other truck movements, but preferred to see infrastructure improvements that would facilitate transport direct to end users or to major rail or shipping terminals such as Newcastle or Brisbane.

NSW government estimates (DPIE 2021a) for forestry activity in NSW are provided in Table 2. In 2019, 29% of forestry in NSW was native forestry and over 70% was on plantations; this rate was affected by the Forestry Corporation of NSW (FCNSW) having more restricted access to native forests following bushfires. The 2019 proportion of plantation forestry has increased compared to previous years' averages for 2009-2018. The majority (55.5%) of forestry in 2019 was on public land.

Table 2: NSW Forestry Summary

Tenure	Forest Activity	2019 Harvest (Ha)	Previous years' average (2009-18) Harvest (Ha)
State Forest	Native	4,850	6,940
	Plantation	8,200	8,300
Freehold / leasehold	Native	2,050	1,880
	Plantation	8,410	4,930
Subtotal	Native	6,900 (29.3%)	8,820 (40.2%)
	Plantation	16,620 (70.7%)	13,130 (59.8%)
Total	**Forestry**	**23,520**	**21,950**

Note: numbers may not add due to differences in the original report.

Public Land

The FCNSW manages wood resources on publicly owned State forests and other Crown-timber lands under the *Forestry Act 2012*. State forests are regulated by NSW Regional Forest Agreements and their subsidiary Integrated Forestry Operations Approvals (IFOAs) under the *Protection of the Environment Operations Act 1997*; IFOAs are intended to strictly regulate timber harvesting.

The NSW Department of Industry - Lands & Forestry regulates plantation forestry under the *Plantations & Reafforestation Act 1999*.

Private Land

Practicing commercial native forestry on private property requires an approved Property Vegetation Plan (PVP) and compliance with the relevant Forest Practices Code. Private native forestry is currently regulated under the *Biodiversity Conservation Act 2016* and *Local Land Services Act 2013*.

Recently over a two and a half year period, DPI modelled and mapped 395,782 net hectares of private native forest across 4,573 individual properties on the NSW north coast. DPI found that while the area legally available for timber harvesting on private land constitutes 72% of the region's private forest estate, timber harvesting is limited to 12% of the region's forest that are in public ownership. Similarly, Timber NSW's assessment is that only 13% (one million hectares) of the native forest in public ownership is managed for its timber values. (DPI 2021, Timber NSW 2021)

Thinning

Since colonisation, forests have become thicker and more prone to wildfire as the use of traditional Aboriginal burning practices has been curtailed. Thinning forests and removing invasive native scrub can promote forest health and mitigate wildfires, which are a major threat to biodiversity. Markets for low-value wood enable forests to be thinned through selective timber harvesting or mechanical fuel reduction to maintain in a healthy condition. (Timber NSW and NSW Forest Industries Taskforce 2017)

Thinning of dense regrowth benefits the health of the forest by providing more space and light for retained trees to grow and mature. On the left side of Figure 4, plantation thinning is shown producing trees that are thinker, straighter and freer of defects and branches than the unthinned trees on the right. Thinning of dense, even-aged regrowth can also promote biodiversity (NRC 2014).

Figure 4: Thinned trees to the left and unthinned trees to the right

Coarse Woody Debris

Forest residue includes fallen coarse woody debris (CWD) such as fallen logs, branches and twigs, stumps, roots and fragments of fallen trees (Figure 5 and Figure 6). CWD is a critical structural and functional feature of many ecosystems and provides habitat for foraging, nesting/breeding and regeneration for wildlife. Managed native forests on the North Coast typically support approximately twice the volumes of CWD as unmanaged forests, mainly due to there being more pieces of smaller material following thinning. (DPI 2017)

Figure 5: Coarse woody debris

Figure 6: Coarse woody debris

Harvested trees undergo extensive grading and tracking to ensure optimal end use. The assessment of wood value initially occurs in the forest. Further grading takes place along the timber supply chain. When commercial tree species are harvested, the merchantable portion of the tree is separated from the non-merchantable portion.

Felled trees are commonly serviced at the stump, with their branches and head/crown trimmed while in the forest. The useable portion of the tree and sometimes the larger branches are then extracted via 'skidders' (Figure 7) to a 'landing' where they are further processed (Figure 8) and graded into log products. Processors may also be active solely at the stump, with residues left near the stump and only the final processed logs removed to a landing.

Figure 7: Skidder removing felled logs to a landing

Figure 8: Onsite log processing

Onsite grading (Figure 9) includes taking measurements of the size (diameter and length) and shape (straightness) of the useable sections of assessed trees and estimating the presence of internal and length defects such as rot, decay, knots and spiral grain. These attributes determine the proportion of useable wood (Figure 10) and its likely value in the marketplace.

Figure 9: Onsite grading

Figure 10: Initial sorting at log landing

Usable logs are loaded for transport (Figure 11), with sawlogs transported directly to sawmills and pulp logs transported directly to their end use markets.

Figure 11: Wood chip or pulp grade logs loaded for transport

Forestry residues are left onsite or processed for subsequent use. Depending on the viability of end use markets, some forestry residues are piled to dry for subsequent processing or to facilitate hazard reduction burning (Figure 12, Figure 13).

Figure 12: Forestry residues

Figure 13: Forestry residues

Stakeholders consistently highlighted the impacts of transport costs on tight margins and resulting impacts on demand for residues and related products. One significant barrier is that end use markets, especially for higher value products, are rarely located near the forestry and sawmilling operations.

Similarly, end users such as power stations, mines or large manufacturers that require large volumes of lower grade residues are often far from where the residues are being generated.

Once shipped, pulp logs are chipped onsite for use as biomass fuel in boilers or mixed with water and other materials to make engineered timber products such as exterior cladding.

According to DPI, the demand for pulp logs has decreased dramatically since 2013, resulting in large volumes of biomass left in the forest following extraction of high-value logs. (DPI 2017)

Sawmilling residues include peelings/shavings (Figure 14), offcuts (Figure 15), sawdust (Figure 16) and woodchips (Figure 17).

Figure 14: Peelings/shavings

Figure 15: Offcuts

Figure 16: Sawdust

Figure 17: Woodchips

Disposal costs mean that forestry and sawmilling residues are not sent to landfill.

Lower grade sawmilling residues are generally sold to local horticultural uses, while some are given away for animal bedding as long as the end user arranges cartage. Most mills used to burn their excess residues onsite, however all sawmills consulted for this report ended the practice years ago. While continuing to burn residues onsite could have produced small quantities of heat or energy, creating markets for residues was seen as preferable and discontinuing onsite burning was regarded as better for community relations and simplifying regulatory requirements.

Case studies of forestry and sawmilling for Hurfords Hardwoods and J. Notaras & Sons are provided at the end of this chapter.

4.2 Residues in the Hub Region

For use in bioenergy, the NSW Eligible Waste Fuels Guidelines (NSW EPA 2016) define forestry and sawmilling residues as:

> *Uncontaminated, organic fibrous wood residues and natural wood wastes that result from forestry and sawmilling operations such as, heads, tree thinnings, sawmill sawdust, shavings, chips, bark and other offcuts.*

Given different sources and uses, this report regularly examines forestry residues and sawmilling residues separately, as shown in Figure 1 (repeated here as Figure 18).

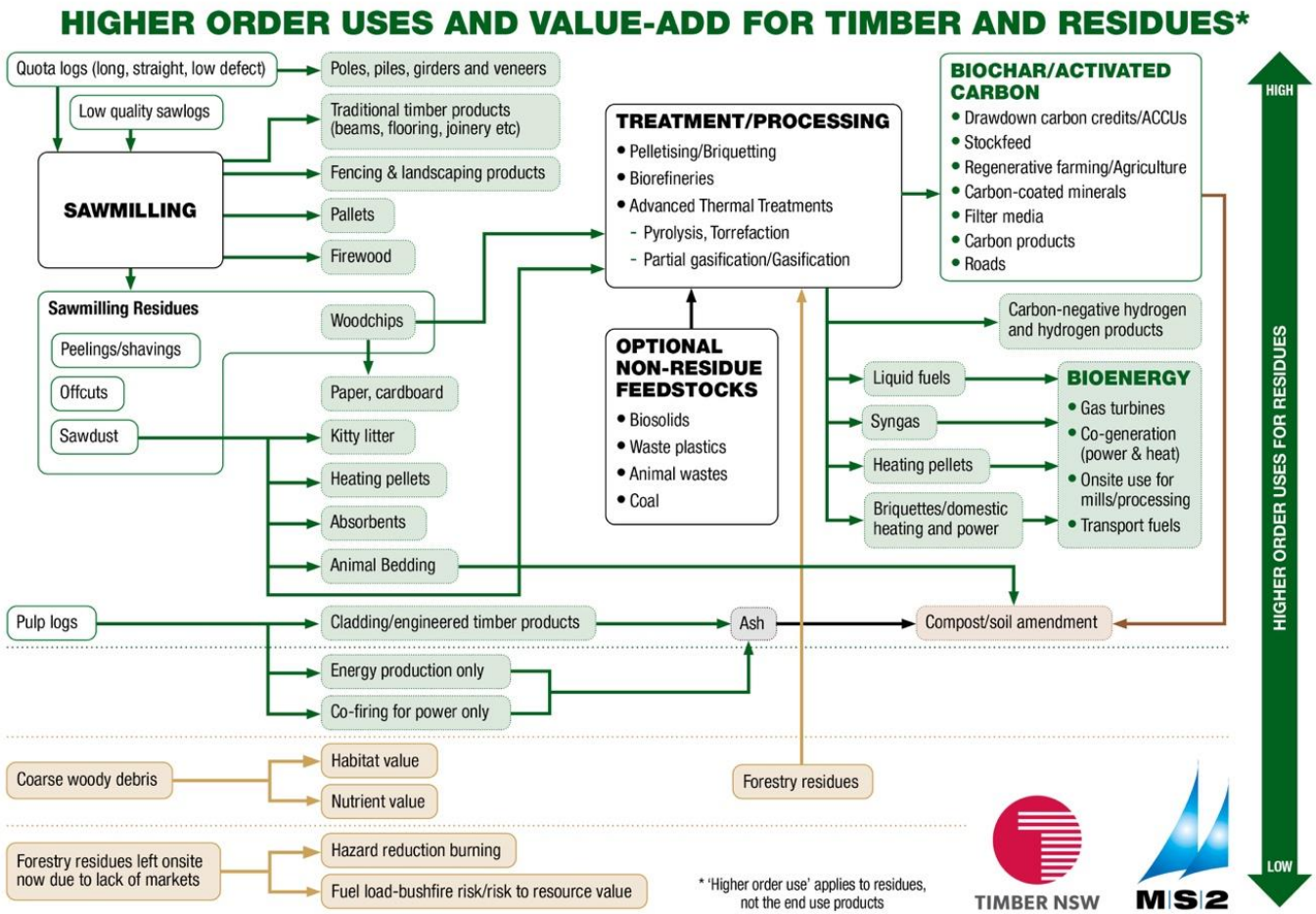


Figure 18: Generation and Usage of Forestry and Sawmilling Residues

Over several years, DPI has conducted research to quantify residues in the Hub's three forestry clusters: Grafton, Kempsey and Bulahdelah.

> "*For the purpose of this report the residue available in native forests (public and private) is limited to logs meeting pulp specification only, the bulk of which is currently left in the forest as harvest residue, though when assessing ecological sustainability all coarse woody debris is considered. We have estimated the available biomass from residues generated from integrated harvest operations which target the production of high-value logs (e.g. sawlogs, poles). For plantations, "pulp logs", as well as "total residues" (option of in-field chipping) were considered. For sawmills, all "green" residues were considered potentially available for bioenergy generation.*" – (DPI 2017)

Within a 100 km radius of each cluster, total available green harvest residue ranged from ~186,000 tonnes/year for Bulahdelah to 464,000 tonnes/year for Grafton. Harvest residues from public native forests were highest around Bulahdelah and Kempsey. Private native forest residues and hardwood plantation harvest residues were highest around Grafton. Increasing the radius to 150 km would substantially increase the volumes of residues available from plantation softwoods. (DPI 2017)

Average moisture content and basic density of the "pulp-quality" biomass were 38% and 710 kg/m^3, respectively, for native forest hardwoods. The calorific value of samples collected from a range of hardwoods did not vary greatly, ranging from 18.6 MJ/kg for blackbutt to 19.3 MJ/kg for red mahogany. Within a 100 km radius of each cluster, estimates for sawmill residues (green) range from 46,000 tonnes/year for Bulahdelah to 118,000 tonnes/year for facilities around Kempsey. (DPI 2017)

DPI estimated additional sources of biomass, including residues from agricultural crops (45,000-78,000 tonnes/year) and waste currently disposed of in landfills (approximately 700,000 tonnes/year) (DPI 2017). For context, the CSIRO (2016) estimates that over 70 Mt of biomass is potentially available each year from agricultural crop stubble, grasses and forestry alone.

The DPI research provides a necessary start to understanding residues in the Hub region and is useful for strategic planning purposes. However, significant developments since the research was conducted, including devastating bushfires, the COVID-19 pandemic and restricted access to forests will have altered the generation and usage of residues. This research should be revisited in ways that allow meaningful comparison with the baseline data while aiming to refine understandings of residues as identified later in this report.

4.3 Relevant Legislation and Practices

This section provides an overview of relevant legislation and practices for forestry and the use of forestry and sawmilling residues and uncontaminated wood waste in a range of uses, including traditional bioenergy and other thermal treatment processes.

Most industry stakeholders interviewed see forestry as heavily regulated, yet contrast that regulation with public perception about their activities.

A common theme across industry stakeholders (though most were reluctant to have specific quotes on regulatory activities attributed to them) was that public perceptions were driving regulation of

the industry more so than evidence about the industry's actual impacts and benefits. Many also felt that the sustainability aspects of the industry were not being understood or considered.

> *"We're one of the most regulated and most sustainable industries in Australia."* - Marius Heymann, S A Relf & Sons

4.3.1 NSW Energy from Waste Policy and Eligible Waste Fuels

The NSW Environment Protection Authority (EPA) regulates the processing and storage of bioenergy feedstock and emissions from bioenergy facilities (into the air, water and soil).

Prior to 2013, s.97 of the Protection *of the Environment Operations (General) Regulation 2009* prohibited the burning of *"native forest bio-material… in any electricity generating work"*. In 2013, this regulation was amended to remove this prohibition, bringing NSW into line with other Australian states.

The NSW EPA classifies native forestry and sawmill residues as waste, even though they never go to landfill. Regardless of whether they would be considered waste by the industry, all native forest residues to be used as fuel must meet the waste regulatory requirements explained below.

Using biomass for bioenergy is regulated under the NSW Energy from Waste Policy Statement (EfW Policy) (EPA 2015). Section 3 of the EfW Policy provides clarity and outlines the regulatory process for using residues. Allowances are made for eligible waste fuels through regulation under resource recovery orders (RROs) and exemptions.

The EfW Policy (EPA 2015) defines an 'eligible waste fuel' as:

> *"Waste or waste-derived materials considered by the EPA to pose a low risk of harm to the environment and human health due to their origin, low levels of contaminants and consistency over time."*

The EfW Policy (EPA 2015) categorises the following wastes as eligible waste fuels (emphasis added):

1. **biomass from agriculture**
2. **forestry & sawmilling residues**
3. **uncontaminated wood waste**
4. recovered waste oil
5. organic residues from virgin paper pulp activities
6. landfill gas and biogas
7. **source-separated green waste (used only in processes to produce char)**
8. tyres (used only in approved cement kilns).

The EfW Policy (NSW EPA 2015) states (emphasis added):

> *"**Eligible waste fuels may be thermally treated** using a range of treatment technologies, **provided a resource recovery order and exemption has been granted** by the EPA. The origin, composition and consistency of these wastes must ensure that emissions from thermal treatment will be known and consistent over time.*
>
> *"Facilities proposing to use eligible waste fuels must meet the following criteria:*

- *ability to demonstrate to the EPA that the proposed waste consistently meets the definition of an EPA-approved eligible waste fuel*
- ***confirm there are no practical, higher order reuse opportunities for the waste***
- *fully characterise the waste and/or undertake proof of performance*
- *meet the relevant emission standards as set out in the Protection of the Environment Operations (Clean Air) Regulation 2010."*

In 2016, the NSW EPA published Eligible Waste Fuels Guidelines (NSW EPA 2016). Key definitions from the EfW Policy were repeated in the Eligible Waste Fuels Guidelines for consistency, but key concepts were elaborated upon.

Untreated, uncontaminated wood wastes and some engineered wood products can also gain approval as an eligible waste fuel. As with other eligible waste fuels, there must be demonstrated processes to ensure that feedstocks remain clean and uncontaminated.

The Eligible Waste Fuels Guidelines (NSW EPA 2016) define 'uncontaminated wood waste' as:

> *"Wood waste that is generated in primary and secondary manufacturing processes at facilities with demonstrated quality control over the uncontaminated wood waste stream."*

The Eligible Waste Fuels Guidelines (NSW EPA 2016) also state:

> *"Uncontaminated wood waste includes pre-consumer manufacturing and processing waste materials such as off-cuts, saw dust, wood shavings, untreated packaging crates, untreated pallets and engineered timbers made with urea formaldehyde or phenol formaldehyde resins only.*
>
> *Demonstrated control refers to both the generation and collection of the waste material. The facility must have robust quality assurance and/or quality control (QA/QC) procedures, a well-controlled Chain of Custody for the raw materials, generation of waste and collection systems.* ***Facilities with control of their waste stream must also have comprehensive knowledge and control of the sources of waste and the original input materials, as well as knowledge and control of potential contaminants****. (emphasis added)*
>
> *Uncontaminated wood waste excludes:*
>
> - *post-consumer waste*
> - *wood waste extracted from mixed waste streams, such as construction and demolition waste*
> - *anything defined as a source separated green waste*
> - *treated timber*
> - *painted or coated wood and most engineered wood products."*

4.3.2 Resource Recovery Orders and Exemptions

The use of forestry and sawmilling residues and uncontaminated wood waste as feedstocks in commercial scale bioenergy generation requires both development consent from Local Government and formal approval from the NSW EPA.

In accordance with the NSW *Environmental Planning & Assessment Act (1979)*, Local Councils are the authority that approves the biomass to bioenergy production process.

The NSW EPA provides technical review and input to the Local Government Development Consent process to ensure matters specific to the protection of the environment are reflected in Development Consent approvals.

Approval to process and use eligible waste fuels in bioenergy generation is granted by the NSW EPA to generators and processors of eligible waste fuel on a case-by-case basis through RROs and exemptions. Local Councils require the NSW EPA to have issued an RRO before they will issue a development consent.

As noted in the EfW Policy (NSW EPA 2015),

> *"Resource recovery orders and exemptions are issued by the EPA under Part 9 of the Protection of the Environment Operations (Waste) Regulation 2014 and exempt a person from the various waste regulatory requirements that apply to the use of a waste fuel (e.g. waste disposal licensing, levy payments, etc.). The exemptions apply to waste fuels determined by the EPA to be fit-for-purpose, bona-fide energy recovery opportunities."*

Bioenergy project proposals for biomass are subject to case-by-case assessment. Applicants are ultimately responsible for determining whether particular approvals are legally required. The NSW EPA does not provide legal advice and reserves the right to take appropriate enforcement action.

Once granted, RROs are usually valid for several years, but they can be regularly renewed as long as the conditions continue to be met.

4.3.3 Higher Order Use

One of the most significant constraints on the use of residues identified in this report relates to the EPA's limited ability to interpret higher order use or reuse, given the limitations of the EfW Policy (EPA 2015) and other aspects of the NSW regulatory framework for waste.

Under the EfW Policy, the EPA must confirm that there are no practical, higher order reuse opportunities for the waste when evaluating whether to grant RROs and exemptions. As noted by the Bioenergy Stakeholder Engagement Working Group (DPI 2020) and consistently reinforced through site visits and stakeholder discussions for this report, the NSW waste regulatory framework effectively classifies all materials as 'wastes' subject to different regulatory approaches, rather than seeing intermediate or final products as resources or potential feedstocks for other processes. This regulatory framework also limits the ability of the EPA and stakeholders to take more encompassing views of resource flows as part of broader circular economy approaches and restricts approvals for bioenergy projects in particular.

EPA staff are provided little guidance on what constitutes higher order reuse, other than the Eligible Waste Fuel Guidelines (EPA 2016), which focus on the limited, decades-old waste hierarchy (Figure 19).

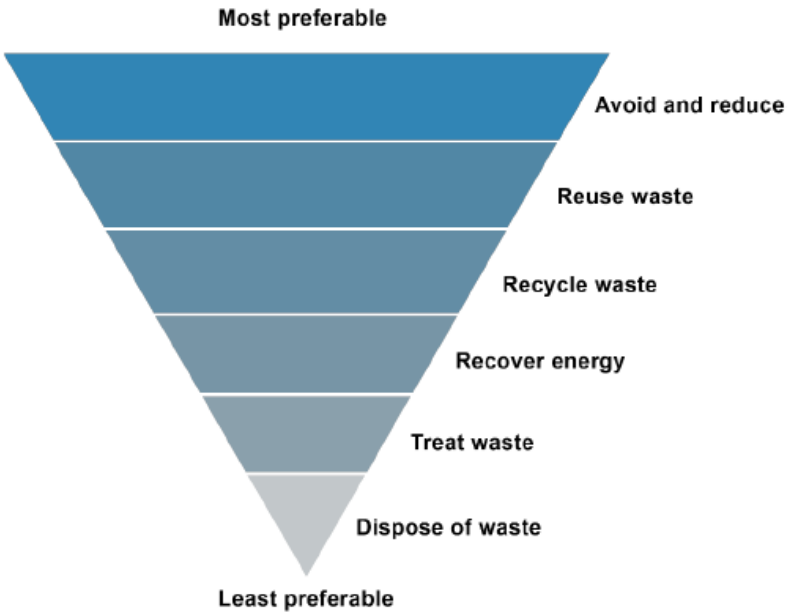


Figure 19: Hierarchy of waste management options

(EPA 2016)

Some of the relevant criticisms or limitations of this approach raised by stakeholders in the Bioenergy Stakeholder Engagement Working Group (DPI 2020) and reinforced in stakeholder consultations for this project include:

> *"The definition of 'waste' under NSW Waste Avoidance and Resource Recovery Act (WARR) legislation is a problem, and makes it hard to see materials as a resource. This leads to a huge administrative barrier."*
>
> *"The feedstock is not thought of as a feedstock until it's also classified as a waste."*
>
> *"There is no way for a waste product to be reclassified from being a 'waste' to being a product or feedstock."*
>
> *"If something has a value, then it is a product, not a 'waste'. All products sell, e.g., Hurford product goes to Broadwater for cogeneration; a chain of custody process is in place."*
>
> *"NSW is an outlier compared to other states. For example, at Boral, virgin sawdust on site is treated as a product, but after it is transported it is treated as a 'waste' product. Similarly, wood fibre from a wood chipping operation would not be considered as 'waste', but the same product becomes 'waste' if it has been transported. Such regulatory uncertainty makes it hard to do business."*
>
> *"The 'waste' definition creates uncertainty for investors. For example, the biochar operation near Casino is subject to many regulatory hurdles because it involves material defined by the EPA as 'waste'."*

The current NSW waste regulatory approach also does not reflect more recent developments such as the National Waste Policy 2018 (Commonwealth of Australia 2018) or NSW Circular Economy Policy Statement (NSW Government 2019) that reflect these more encompassing approaches. However, these circumstances may change with pending changes to the EfW Policy that were not available at time of publication.

In June 2021, the NSW Government released Stage 1 of the NSW Waste and Sustainable Materials Strategy 2041. As part of the Strategy, the NSW Government "will conduct a series of feasibility assessments and engage with the community, local government and proponents about the suite of infrastructure investment needed to help us manage our waste into the future". This work should provide opportunities to address infrastructure needs identified in this report. (DPIE 2021b)

While the NSW Waste and Sustainable Materials Strategy 2041 focuses initially on anaerobic digestion and biogas, there may be opportunities for addressing other concerns raised in this report. This assessment is based on the Strategy's statements such as

> "*In addition, the Carbon Recycling and Abatement Fund will include funding to support biogas recovery from waste. We will also look at establishing a new regulatory framework to further incentivise the uptake of anaerobic digestion facilities and biogas production. This could include:*
>
> - *creating a market-based instrument requiring landfills and thermal energy from waste facilities to surrender a minimum amount of biogas from waste certificates a year*
> - *streamlining planning approval processes for anaerobic digestion infrastructure, particularly where they are co-located with high energy or heat users or energy producers*
> - *supporting emerging uses for biogas – for example, the conversion of biomethane into renewable hydrogen and graphite*." (DPIE 2021b)

Biomass from native forests is prohibited from use for electricity generation in accordance with the Protection of the Environment Operations (General) Regulation 2009; however, the Regulation specifically exempts native forest residues from forestry operations authorised by a private native forestry property vegetation plan, integrated forestry operations approval or an invasive native species order.

> "*Bioenergy is a commercially viable solution that demonstrates how a circular economy functions, recovering resources at their highest order use.*" – (Bioenergy Australia 2020)

In consultation with industry and government stakeholders, MS2 incorporated views on higher order uses for residues in Figure 18 to provide a more detailed consideration of higher order use for forestry and sawmilling residues.

We recommend that the higher order uses diagram and other aspects of this report be discussed and refined over time in consultations with stakeholders, especially the NSW EPA, to help raise awareness and understanding of these issues.

4.3.4 Community Perception / Social License to Operate

The Ethics Centre (2018) defines social license to operate as "the acceptance granted to a company or organisation by the community". Community perceptions have significant impacts on the forestry industry and end uses for residues, especially on licensing of bioenergy projects.

Common concerns to be addressed related to potential loss of koala habitat and loss of native forests due to forestry and bioenergy projects. Some of this concern stems from a lack of understanding about regulation of forestry and bioenergy, but lack of understanding about residues and their use is also a significant factor.

Education and awareness about these issues should be integral to community outreach efforts, and include basic discussions around basic forest management, leaving coarse woody debris, conducting hazard reduction burns and improving markets for forestry residues that could otherwise pose bushfire risk. Public discussions / workshops should also include related industry sectors (such as bioenergy providers and other residue end users) to help enhance stakeholder engagement and community support.

> *"We have to address the community's concerns about loss of koala habitat. I hold green groups more responsible for koala losses by locking up forests instead of managing them responsibly. We lost koalas from bushfires that could have been avoided."* – Industry stakeholder

The public's opposition to coal and preference for renewable energy has generally not translated into support for bioenergy, despite its benefits. Addressing the data gaps that contribute to this situation will help increase social license to operate for the forestry industry and assist market development for residues.

Several industry stakeholders feel that these community perceptions and knowledge gaps have led to government opposition to forestry and bioenergy, representing direct threats to the sector, including restricted access to forest resources. These factors impact both residue generation and end use markets.

> "*The EPA has become an activist bureaucracy that would completely curtail the native forest industry if they could. The bushfires have already affected our resource base, especially on the south coast, but also on the north coast. Private property access has been under threat. The Koala SEPP would have sterilised the industry, and while it was overturned, the misperceptions of the industry remain*." - Steve Dobbyns, Timber NSW Board

> *"The public's awareness of environmental issues has improved, but their actual understanding is still lagging. The EPA tries to regulate to that awareness and public need, without understanding actual risks and practices. As a result, they treat everyone like criminals without understanding what actually happens on the ground."* – Industry stakeholder

One of the clearest examples on social license to operate relates to the proposed conversion of the Verdant Technology power plant (formerly the Redbank Power Station) in Warkworth NSW, near Singleton in the Hunter Region. The owners are seeking to convert a 151 MW coal waste-fired power station dormant since 2014 into a power station using 100% biomass to supply power for over

200,000 homes in the region as part of a renewable energy zone. (Verdant Technologies 2021)

Despite Verdant's plans to convert a coal-fired plant to 100% biomass sourced from forestry residues and mixed waste timber from a 400 k radius of the plant, a group of 31 NGOs has published an open letter in the local paper claiming the plan would "fuel native forests' demise" and "accelerate and intensify the exploitation of native forests in NSW and push koalas and many threatened and critically endangered species closer to extinction". (Newcastle Herald 2021)

Views such as these reinforce the need to gain a fuller understanding of the sustainability impacts and opportunities involved with generating and using residues, as identified throughout this report, and to ensure that stakeholders are more effectively engaged than they have been to date. Actual data gaps need to be addressed, as do gaps in understanding and valuing various approaches.

Some differences relate to the concept of higher order use examined elsewhere in this report; for example, some see leaving forests untouched as a higher order use for forests, while others see higher order use in the range of products forests can provide. The forestry industry needs to better demonstrate how it is showing stewardship by minimising impacts where possible and actively working to be as sustainable as possible.

The University of Technology Sydney's Institute for Sustainable Futures has been undertaking research and community consultations on social license to operate across a range of practices. MS2 consulted with the organisation about their research, but consultations have been delayed by the COVID-19 pandemic, and final results were not available at the time of publication.

4.3.5 Regional Strategies and Initiatives

In addition to the forestry clusters of Grafton, Kempsey and Bulahdelah, the Hub's coverage includes several regionally significant areas for strategic planning (Figure 3). Renewable Energy Zones (REZ) intended to facilitate development of renewable energy projects include the New England REZ and Hunter-Central Coast REZ. The Richmond Valley Regional Job Precinct encompassing Casino is also intended to facilitate economic development and job creation within the area.

In addition, Bioenergy Australia (2020) has identified and expands upon a range of significant NSW policies and initiatives "where sustainable bioenergy systems can be utilised to deliver site-specific and industry outcomes including:

1. NSW Circular Economy Policy
2. Energy from Waste Policy
3. NSW Climate Change policy
4. NSW Decarbonisation Innovation Study
5. NSW Special Activation Precincts
6. NSW Net Zero Plan
7. Clean Energy Initiatives"

These are in addition to the national Bioenergy Roadmap currently under development and amendment of the EfW Policy.

Stewardship strategies and project trials based around these locations can leverage existing NSW Government research and planning processes to deliver regionally-significant opportunities for

forestry and related sectors in addition to building regional community resilience.

4.4 Case Study – Hurfords Hardwood

Hurfords Hardwood is a fourth-generation family business dedicated to the mixed hardwood timber industry since 1932. In addition to one cypress mill in Queensland, Hurfords operate four mixed hardwood mills in northeast NSW (Bulahdelah, Kempsey, Casino and Kyogle). Hurfords' products include kiln-dried high-value timber products such as flooring, cladding, decking and joinery.

The forestry shown in this report is on a Hurfords plantation near Mallanganee NSW, and shows trees from replanting a paddock in 1997 at ~200 trees per ha. The harvesting shown is the first thinning, and locations for the thinning are rotated through approved areas of the plantation. The trees remaining after thinning are straighter, with fewer branches and able to access more sunlight for growth. This process saves money compared to clearfelling and avoids the costs of replanting while producing healthier, more valuable forests that are also easier to manage. The process also reduces fuel load and improves access for conducting hazard reduction burns.

Hurfords is aiming to restore a grassy woodland through reducing understory. The intent is to improve grazing for cattle and native animals. Grazing cattle helps to further reduce fuel load and control weeds, whilst providing short-term cash flow to cover operating costs.

> *"Sustainability is core to our business. I'm proud to be in a sustainable industry that leads to healthier forests and producing products that sequester carbon."* – Andrew Hurford

Hurfords recognises the value in leaving some base amounts of coarse woody debris, especially bark, on the forest floor for nutrient and habitat value, but note that additional research is needed on the optimal amount of material to leave on the forest floor for each type of forestry operation.

Hurfords rate the NSW forestry sector at only about 50% effectiveness in developing markets for residues. Sawmilling residues used to just be burned onsite but go to better uses now, which is less contentious and provides improved social license to operate with communities around the mills. Residential landscaping and mulching are the highest uses available for residues now, followed by sale to Cape Byron Power for bioenergy. Excess forestry residues, however, are still reduced through RFS-approved hazard reduction burns when higher order uses are not available. Hurfords would rather create markets for these residues, but have previously been harmed by bushfires and are therefore especially mindful of bushfire risk.

Hurfords see circular economy approaches, biorefineries, biochar, syngas and related products as the best examples for market development currently available. Biochar offers additional value in replanting efforts.

> *"If we don't create markets for residues, they get burned anyway, either in hazard reduction burns or in bushfires. Why not get added value from residues instead of losing them in burns?"* – Andrew Hurford

Using bushfire-burnt timber from plantations is not a limiting factor in alternative uses such as biochar, but bushfire-burnt native timber is not accessible to the industry even though clearing the burnt timber could assist regeneration efforts.

Currently low values of end use products are limiting factors for market development, as are lack of multiple buyers for products from residues and limited access to large end users and major transportation infrastructure.

> *"Timber supply is restricting our ability to meet current demand from homebuilders in NSW. We have almost unprecedented demand for our products, but we've been hit by bushfires, we have community misperceptions that influence regulatory oversight, then the region got hit by flooding. This is all hurting our local industry and leading to a higher level of imports to meet market demand."* – Andrew Hurford

Hurfords received funding under bushfire recovery grants to replant and restore the worst fire-affected areas across three years of replanting, but these have been delayed by flooding in the region. Other areas are likely to recover on their own.

Any infrastructure improvements to improve transport to Brisbane or to improve intermodal transport to ports are welcomed by Hurfords. The region has benefitted from some infrastructure improvements, but transport out of Kyogle in particular is problematic.

Key considerations

- Appropriate thinning on a rotational basis produces healthier, more valuable timber within a given site.
- The most appropriate amount of residues to leave on the forest floor when harvesting remains to be determined for some forestry operations.
- Residues beyond the base amount that do not go into end use markets either must be managed through hazard reduction burns or become a bushfire risk. Creating markets for these extra residues facilitates finding higher order uses and greater sustainability.
- Industry market development for residues is generally lacking, especially for industry-wide initiatives.
- Timber supply is a significant restriction for the timber industry, and affected by bushfires, NGO opposition to the timber industry, and flooding. Such factors lead to an increase in imports, rather than domestic supply, to meet market demand.
- Regional transport infrastructure improvements such as motorway transport to Brisbane or intermodal transport to ports would benefit the forestry sector in the region.

4.5 Case Study - J. Notaras & Sons

J. Notaras and Sons (Notaras) is a sawmill and processing plant located in South Grafton NSW operating as a company since 1952. Notaras uses a Boron treatment on all timber products that are lyctus borer susceptible, as they are destined for indoor uses. Roughly 98% of Notaras products are kiln-dried for value-add, and include tongue and groove flooring, parquetry, decking, steps and risers. Hardwood destined for external use is “Tanalith E” treated to prevent rot and insect attack. No residues from the sawmill (i.e., sawdust and woodchips) are treated.

All sawdust and woodchips from the mill are sold to other businesses. Consistent with other stakeholder views, Notaras stated that there is room to improve the effectiveness of the NSW forestry sector in developing markets for residues. The perception is that market development has been led principally by individual companies, including the contractor that collects Notaras's residues every day (production would have to halt if the bins were full).

Residues were burned onsite until 1995, when more alternative uses were available, and the equipment was decommissioned.

Notaras use a range of approaches to help control energy costs, including delayed working hours (starting primary production at 9am, when the rate paid for energy drops) and solar. Three years ago, Notaras installed a solar network with a 5-6 year payoff period that is intended to last for 25 years. Energy costs have decreased as a result.

> *"At J. Notaras & Sons Pty Ltd, we always emphasise sustainability as well as quality. No materials are wasted at our location. We use shavings for fuel for our kilns to produce steam to dry our timber. We have long been one of the largest suppliers of kiln-dried hardwood appearance timber in Australia."* – Notaras website.

All of Notaras's timber is sourced through the State Forests via Forestry Corporation of NSW; this resource contract ends in 2023. Consequently, changes in practices are unlikely until Notaras can know for sure that they will have appropriate resource supply. Notaras notes increased inquiries and some market tightening for residues with the recent contractions in timber production.

"Everything comes down to the resource. We don't have the material to sell; most mills are in the same situation." – Donna Layton

Notaras noted an increased demand for wood residues to produce animal bedding because of the RSPCA's increased standards for animal bedding.

Potential usage of residues is limited by the need to keep treated timbers out of residue streams, even though the range of timber products requiring treatment appears to be growing.

Although Notaras enjoy high employee retention, they are concerned with maintaining a highly-skilled but aging workforce and mindful of the need to ensure appropriate training opportunities for all employees.

Key considerations

- Instability in resource security may directly impact the commercial viability of sawmills and subsequently the availability of residues for various end uses.
- Sawmills have a range of commercial incentives to adopt sustainable practices.
- While burning residues onsite used to be standard practice for sawmills, the practice has been abandoned over time and as alternative uses have become available.
- Increased consumer demand for treated timber over time could affect residue streams, given the need to keep many residue streams free of treatments in order to ensure greater access to markets.

5.0 Uses of Residues

In the absence of viable markets, forestry residues are ultimately burned through hazard reduction burns or through bushfires.

5.1 Bioenergy

Forestry and sawmilling residues and uncontaminated wood waste are recognised feedstocks for bioenergy generation in NSW. Bioenergy is a form of renewable energy produced from organic matter, also known as 'biomass'.

The Intergovernmental Panel on Climate Change (IPCC) recognises bioenergy as a key contributor towards the reduction in carbon emissions in all scenarios that would meet the Paris Agreement target of "well below 2 degrees".

> "*Bioenergy use is substantial in 1.5°C pathways … due to its multiple roles in decarbonizing energy use*". – IPCC (2018)
>
> "*Utilisation of organic waste to produce energy can play a central role in the national transition to a circular, low carbon economy*." – Bioenergy Australia (2020)
>
> "*Bioenergy has the potential to attract at a minimum $3.5-$5 billion investment, mostly in regional economies*." – Bioenergy Australia (2020)

Using bioenergy for boiler fuel or generating heat and power is often secondary to core businesses, so locations of those end users will limit the catchment of residues that they can draw from and impacts transport efficiencies/cost. Where the energy needs are fixed for the foreseeable future, these users provide stability to bioenergy markets but do not necessarily represent opportunities for increased market development.

The case studies and stakeholder discussions for this project consistently reinforced concerns about regulatory constraints raised in previous stakeholder discussions, most notably those of the Bioenergy Stakeholder Engagement Working Group that MS2 convened and facilitated for DPI (DPI 2020). The regulatory constraints are largely around how NSW classifies and regulates wastes, especially for bioenergy. These issues and some pending changes are addressed in the previous chapter.

Bioenergy case studies for Cape Byron Power, MSM Milling and Weathertex are provided at the end of this chapter.

5.2 Biochar

Biochar is produced from the slow baking of biomass in the near or total lack of oxygen. In this process, gas and oil separate from carbon-rich solids, producing fuels that can be used for energy and biochar for soil amendment. Biochar sequesters most of the carbon present in biomass feedstock and can bury the carbon in soil for decades or centuries. (Hawken 2017, IPCC 2018)



The IPCC has recognised biochar as one of six key Negative Emissions Technologies (NETs) critically required to address climate change. (IPCC 2018)

As noted by the Australian New Zealand Biochar Industry Group (ANZBIG) in its submission on the NSW Energy from Waste Policy Statement (ANZBIG 2021),

> *"Modern technology can also be used to sustainably convert unused biomass into long-term stable biochar via pyrolysis, providing a carbon-rich solid product for numerous applications. These include applications in agriculture, construction and roads, steel reductants, and biomaterials for the new carbon economy – replacing fossil-fuel derived carbon in solid carbon materials."*

For every tonne of infeed biomass, around one-third to one-half of the carbon can be sequestered into solid biochar, depending on the technologies and practices used. Biochar bioenergy systems provide both energy and significant carbon sequestration. (ANZBIG 2021)

ANZBIG (2021) estimates the theoretical potential for unused biomass conversion to biochar and its co-products in Australia as:

- Up to ~50-100 million tonnes per year of residues no longer burned/landfilled
- Up to ~15-30 million tonnes per year of biochar potentially produced
- Biochar saleable economic value $7.5-$15 billion (@AUD $500/t)
- Additional carbon credit value (current market value) $1.5-$3 billion (@ AUD$100/t)
- Up to ~30-60 million tonnes per year of carbon dioxide-equivalent (CO_2eq) removal (Negative Emissions/Drawdown) (equivalent to several percent of Australia's 2019 total greenhouse gas emissions)
- Up to ~50-100 PJ/year of Biogas (syngas) for national energy security
- Up to ~50,000 jobs (rural and regional focused)

Biochar can also provide significant land management benefits, especially for agriculture.

> *"Studies show an average crop yield increase of 15 percent, with the greatest impact on soils that are acidic and degraded – the soils often found in areas struggling with food insecurity. What's more, biochar can improve plants' ability to absorb nitrate fertilizers, possibly allowing farmers to get the same effect out of smaller nutrient application, which cuts costs and reduces runoff and damage to aquatic ecosystems."* – Drawdown (Hawken 2017)

When consulted, ANZBIG leadership reinforced that it is difficult for biochar to gain market traction on its own; however, the diverse applications for biochar use, especially in stockfeed, concrete and road construction, offer significant opportunities for market expansion that in turn will increase demand for residues.

A range of applications for biochar currently being considered by Envirochar (based in Tomago NSW) is provided in Figure 20.

envirochar
Carbon Enhanced Minerals

FIELDS TRIALLED

SOIL REMEDIATION

Soil
- Biological activity

Remediation
- Add in:
  - Carbon
  - Sea minerals (input mussel/oyster shells)
  - Seaweed extract
  - Minerals – Bentonite/Zeolite

Stop Soil Leaching
- Total N
- Total Ph

WATER

Filtration
- In-line water filtration
- Pools
- Fish tanks
- Fisheries
- Removal of Total N and Total P

Remediation
- Blue/green Cyano bacterial algal blooms
- Algal Blooms (no toxin release)

HORTICULTURE

- Volume of water required
- Use pesticides
- Avoids root rot
- Fungal problems

Licenced Industrial/Medical
- CBD Hemp Growth (40%)

Sports Fields
- Golf, football, tennis etc.
- Rate of grass growth
- Biological activity
- Deeper roots

Glasshouse
- Add in biochar CO2 to increase plant growth rate
- Can input green waste
- Control internal temperature

LIVESTOCK

- Overuse of antibiotics worldwide
- Animals now immune

- Gut health
- Antibiotic and hormone usage
- Growth
- Food intake
- Mortality rate:
  - Cows – milk fever/aggression
  - Toxins
  - Chickens – spotty liver/stress
- Odour
- Excrement:
  - Cows – powerful fertiliser
  - Chickens – lower ammonia
  - Pigs – lower ammonia

WASTE

- Kills pathogens
- Produce fertiliser

Industrial Food Waste
- Dumping costs

Sewerage
- Mitigate Petrochemicals
- = PFOS/PFAS
- = Benzine/Fluorine
- Input mussel/oyster shells
- Filtration to fertiliser

Plastic
- Breaks down to silica and calcium
- Used as soil enhancer

CONSTRUCTION

Glass
- Can process bottles with labels/cellulose residual
- Crushed clean glass made into asphalt and concrete

Concrete
- Biochar/Zeolite mix Reduces the amount of cement needed, reducing CO2 by up to 50%,
- Biochar makes concrete set better and makes concrete water proof

Wood
- Potential for CND processing to make carbon for steel industry

envirochar.com.au

Figure 20: Biochar applications being considered by Envirochar

Source: Ray Dagger, Envirochar

Carbon credits through biochar (co-pyrolysing with biomass) are symbiotic with forestry, biochar, residues, biosolids and net zero commitments. However, these relationships are only just beginning to be commercialised and additional supporting research is necessary.

Globally, billions of dollars are being invested into means of carbon dioxide reduction that can provide substantial opportunities for forestry and sawmilling residues.

Voluntary markets for carbon dioxide reduction (CDR) credits will significantly drive demand for carbon sequestration and NETs and anticipated carbon credits worth over US$100-200/t CO_2eq over the coming decade (Figure 21), largely due to increased private 'net zero' commitments. For example, by 2030 Microsoft has committed to being carbon negative, and by 2050 Microsoft "will remove from the environment all the carbon the company has emitted either directly or by electrical consumption since it was founded in 1975". (Microsoft 2020)

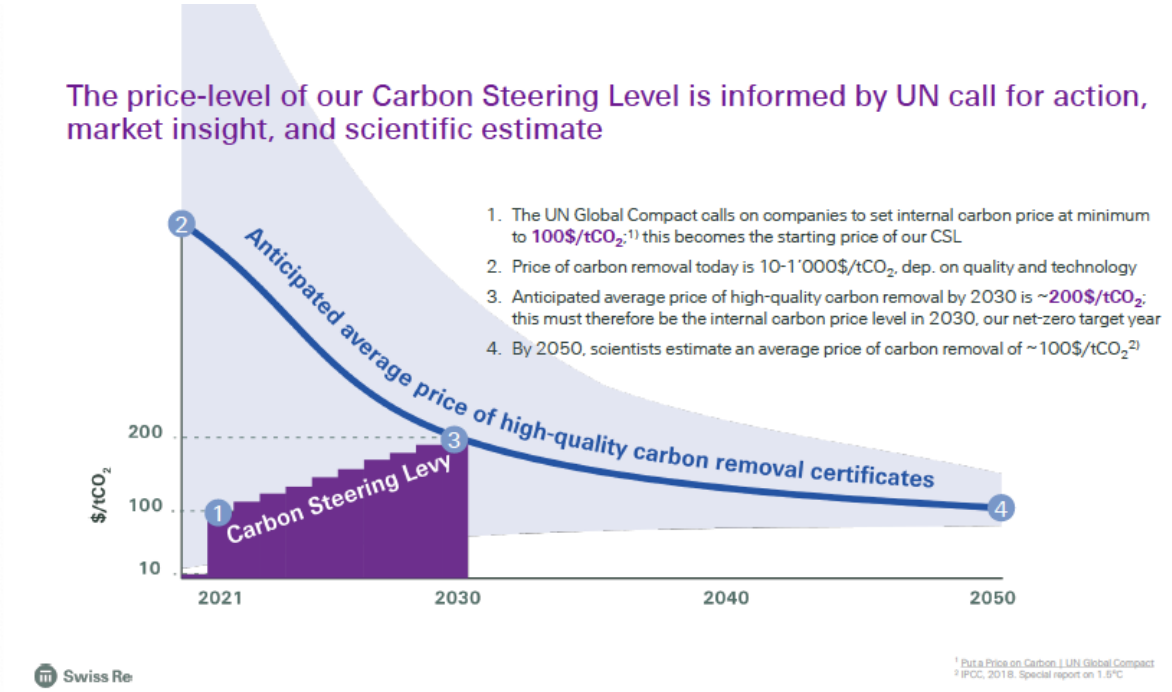


Figure 21: Net zero commitments' impacts on carbon price

(Swiss Re 2021)

The true scale of private investment in CDR and net zero commitments is evident in several examples of private investment (Swiss Re 2021):

- Insurer Swiss Re's US$50m commitment to achieve net zero by 2030.
- Microsoft's net zero by 2030 commitment, valued at US$1bn.
- Jeff Bezos's US$10bn personal investment to reverse climate change.

Private demand for carbon trading is also evidenced in NASDAQ's acquisition of a majority stake in Puro.earth, the world's first marketplace to offer industrial CDR that are verifiable and tradeable. Puro.earth offers CDR to Microsoft and other organisations. (NASDAQ 2021)

Increased terrestrial soil carbon is also bankable as carbon credits from a range of feedstocks in the form of Australian Carbon Credit Units (ACCUs). Each ACCU issued represents one tonne of CO_2eq stored or avoided by a project and is registered with Australia's Clean Energy Regulator using approved methodologies. Of the many uses for biochar, the carbon benefits for biochar are currently only reflected for soil carbon, as methodologies for other processes have not been developed or approved.

> "*Australia's Emissions Reduction Fund (ERF) recognises the role of biochar in increasing soil carbon, but not the value of the biochar itself. For biochar to be cheaper, we need to get the carbon credits for carbon drawdown reflected in its price*." – ANZBIG

ANZBIG recently developed an industry Code of Practice to promote the sustainable use of biomass residues as a resource and provide confidence in the quality of biochar grades. Increased awareness and applied use of the Code of Practice, coupled with improved carbon accounting practices, will help create additional uptake of products and processes using residues and other 'waste' feedstocks in NETs.

In NSW, land application of waste materials as fertiliser or soil amendment is regulated under the Resource Recovery Order (RRO) and exemption process examined elsewhere in this report. Biochar cannot be applied to land without an approved RRO in place. The EPA can issue general RROs and exemptions for materials applied within approved parameters. The forestry industry and related sectors would benefit from a general exemption covering land application of biochar produced using residues and other feedstocks using approved processes.

Biochar is illustrated further in case studies for Mara Seeds, SEATA Group and Carbon Powered Mineral Carbon Technology & Products (CPMTP) at the end of this chapter.

5.3 Pellets and briquettes

Residues and agricultural by-products can be used to produce pellets suitable for heating, kitty litter, animal bedding and absorbent. Larger briquettes can be formed in a similar fashion and used for heating.

Stakeholders expressing an opinion were divided on their perceived values of pellets and briquettes as end uses for residues, with some noting the energy intensity of producing pellets and low market value for some pellet products.

Pellets are addressed in the case study for Pellet Heaters Australia (PHA) at the end of this chapter. The above right photo of briquettes shows a secondary byproduct use trialled at Weathertex, also at the end of this chapter.

5.4 Other Technologies and Practices

Achieving 'net zero' requires both lowering emissions and adopting NETs. Net zero requires innovative, integrated solutions that optimise existing technologies and approaches while rewarding innovation and sustainable business practices. Forestry and sawmilling residues that could otherwise become 'wastes' or pose bushfire risk are critical feedstocks to a range of integrated stewardship initiatives from traditional co-firing and bioenergy power generation to regenerative farming and negative-emissions technologies producing biochar, syngas, carbon-negative hydrogen and other products.

> *"Biomass energy is a viable solution if it uses appropriate feedstock, such as waste products or sustainably grown, appropriate energy crops. Optimally, it also uses a low-emission conversion technology such as gasification or digestion."* – Drawdown (Hawken 2017)

There is considerable overlap between the technologies examined in the remainder of this chapter. Separating them would involve overly technical explanations that would be unwarranted for the scope of this report. In addition, technology providers have given MS2 significant detail that is commercially sensitive. We respect that confidentiality and have worked with all case study participants to ensure they are comfortable with making the information in their case studies publicly available.

Pyrolysis and partial gasification processes are outlined in case studies for SEATA and CPMTP at the end of this chapter. The following case study for Boral Timber addresses solid fuel gas turbines.

5.5 Case Study – Boral Timber

Operating for over a century, Boral Timber is Australia's largest sawmill processor of hardwood products. Based primarily within NSW, Boral Timber is one of Australia's largest suppliers of certified hardwood and softwood, with products including flooring, structural timber, decking, furniture timber, decorative timber and cladding.

In August 2018, ARENA announced funding of up to $500,000 to Boral Timber to investigate the feasibility of building a biofuels refinery using the waste sawmill residues from Boral's sawmill at Herons Creek near Port Macquarie. If the investigation was successful, the proposed $80 million biorefinery could convert up to 50,000 tonnes p.a. of sawmilling residues into transport-grade renewable diesel and bitumen. This project has, however, been put on hold while alternatives described below are investigated.

As part of a comprehensive effort to re-evaluate feedstocks and energy needs, Boral Timber determined that, system-wide, biomass boiler systems often only operate as low as 40% thermal efficiency, whereas the efficiency of indirect LPG gas systems can exceed 90%.

Boral Timber received a NSW Government grant to investigate the use of solid fuel gas turbines using sawdust and sawmill shavings, and determined that this approach appears to offer an ideal means of

generating electricity directly from residues generated at the point of manufacturing. Boral Timber's Kyogle board plant is being converted to this process as a trial to confirm its anticipated cost-effectiveness for the company. Given the likely transition under this process, Boral Timber felt that site visits by MS2 would be best once the new technology is installed (commissioning is anticipated in April 2022).

When asked about whether this approach would represent higher order use and therefore assist with licensing / permitting, Boral Timber stated:

> *"The direct conversion of high calorific, low bulk density feedstocks (like sawdust) into renewable, dispatchable grid electricity is a far better solution than any road or rail freight options to date. The use of the existing transmission network is a far better logistical solution." – Peter Robson*

Transport infrastructure impacts Boral Timber's operations to the extent they see the North Coast split into two basins North and South of Coffs Harbour. The sheer quantity of traffic lights in Coffs Harbour serve as a significant barrier to truck movements. The 14 km Coffs Harbour bypass should address this concern, once complete in 2025.

Boral Timber also see potential benefits in decentralising power generation utilising this resource / residue in other areas of forestry management, again by reducing the physical freight logistics. There are significant volumes of this high calorific value, low bulk density feedstock in rural regions. A 1MW generator would need ~800 kg per hour of biomass. It would output ~ 6,500 MWh annually and need ~ 5,200 tonnes of biomass annually.

Key considerations

- Solid fuel gas turbines using sawdust and shavings could represent opportunities for sawmills to generate power onsite using byproducts for which they'd otherwise need to find markets.
- Transport can be a significant barrier to using residues more sustainably.

Note: In July 2021, Boral Limited entered into an agreement with Allied Natural Wood Enterprises Pty Limited (Pentarch Group) to sell its Australian hardwood and softwood timber business.

5.6 Case Study – Cape Byron Power Broadwater Mill

Cape Byron Power generates bioenergy at two power stations co-located at existing sugar mills in Broadwater and Condong using biomass across both sites. Each site has a 30 MW boiler for base load power generation sold into the National Electricity Market (NEM) and an 8 MW turbine, at Broadwater, run seasonally (typically June to December each year) to produce electricity and steam for the processing of locally grown sugar cane. Together, the two sites represent one of the largest renewable base load generators in Australia. The site visit and photos for this report are the Broadwater site.

Cape Byron Power's electricity is predominantly produced from sugar cane milling waste, along with certain types of wood residues and energy crops as biomass fuel. During sugar cane processing, bagasse from the processing becomes the primary biomass source, with supplemental use of other materials. Cape Byron Power does not source any native timber directly from state forests or private

native forest. Other than the bagasse, feedstocks are received as logs and sawmill waste. Chipping is conducted on-site by an approved contractor.

A primary driver for the current approach was that capital equipment would otherwise be inactive the six months of the year when sugar was not being processed. One difficulty of the current model is that both feedstock prices and the rate power is sold into the NEM can both vary significantly. For example, during MS2's site visit, we watched from the control room in real time as power was selling for negative $3.90 per megawatt hour (MWh) in South Australia due to uptake of renewables while Queensland had a temporary spike of over $1,500 per MWh; both prices changed within minutes.

> *"As long as there's a sugar and a timber industry, there's room for operations like Cape Byron Management; CBM's issue is the (energy) market."* – Mark Greenaway

Given the large volume of feedstocks utilised, transport costs are especially significant for Cape Byron Power. The cost-effective transport range is in the order of 180-200 km.



Key considerations

- Bioenergy projects can use biomass feedstocks with no higher order uses to generate energy and offset the use of coal, including for base load generation.
- Co-location and base load power generation complements the solar and wind renewable energy base, is more economically viable than just generating power for the sugar cane processing, as capital equipment is active and generating income throughout the year and not just the 6 months out of the year when processing occurs.
- Constant energy market fluctuations introduce commercial uncertainty for bioenergy projects, especially when coupled with feedstock price variations. Bioenergy projects need to properly consider these risks and uncertainties in business planning and supply contract negotiations.
- Transport costs are one of the most significant factors in end use markets for residues. Opportunities for vertical integration may be worth pursuing.

5.7 Case Study – MSM Milling

MSM Milling in Manildra NSW is a large scale producer of canola oil and a significant player in the Australian edible oil market. In addition to processing and selling cooking oil, MSM also produces pelletised compound stock feeds utilising whole grains and other milling and oilseed processing byproducts.

In 2012/2013 MSM was struggling with high thermal energy costs and considered coal and biomass as possible fuel options. The site was on LP gas, as no gas pipeline was available. While butane and propane were costing in the range of $22-25 / GJ delivered (and up to $30 / GJ at times), coal could be delivered on-site for around $6.40/GJ. As such, gas was considered prohibitively expensive, and given it would always need to be delivered by truck, the view was formed that a long-term alternative to gas was needed.

The company was told in a 2013 energy audit conducted on behalf of the EPA that coal would be the logical fuel source and it would be a straightforward exercise to get coal approved as a boiler fuel due to the fact that it was a well-known fuel that fit within an existing regulatory framework.

In 2013 a policy change allowed burning of native forest biomass for electricity generation, however a subsequent drop in gas prices caused MSM to put the decision to change fuel sources and invest in a new boiler system on hold for some time.

After some years of effort, in mid-2018 MSM secured $2 million in ARENA funding to replace the LPG-fuelled boilers with a 5 MW biomass-fuelled boiler using locally-sourced residues. This funding was the catalyst for proceeding with the biomass project, and coincided with another increase in gas prices.

MSM notes the market significance of being able to demonstrate reliability of fuel supply. A 2015 letter from Forest Corporation noting that the 15-20,000 tpa sought by MSM at the time was well within their ability to supply was crucial to securing funding against the total project cost of around $5.38 million.

MSM uses ~ 4,000 tonnes p.a. of residues and silvicultural thinnings, mainly woodchips sourced from local mills, up to ~150mm and sawdust not exceeding 50% by volume. MSM pays on a moisture-adjusted basis to ensure the actual energy cost is constant, and not impacted by changes in moisture content. Moisture content and transport costs are significant drivers for final delivered feedstock cost. MSM's biomass storage and handling system is designed to promote aeration and drying in order to increase effective nett calorific value (NCV) prior to combustion.

Requiring a steady energy supply 24/7 with no seasonality, MSM's demand for residues is basically constant, and will not increase significantly unless additional new grain processing capacity is bought on stream. Chipping is seen as suitable and straight-forward; pellets are viewed as overly complex and energy-intensive and do not improve the biomass as a suitable feedstock. MSM feels that their systems for residue management and utilisation are virtually fully optimised, noting:

> *"I don't see how we can make it any more efficient, if I'm honest." – Bob Mac Smith*

The project saves around 4,000t CO_2eq per annum and over 80,000t CO_2eq over the project life.

MSM feels that sustainability is integral to their approach (one of the top four business considerations, along with functionality, price and reliability) and is embraced by the community and by customers, who respond favourably to MSM's use of bioenergy.

> *"With coal, the locals would have been up in arms, so bioenergy instead of coal makes a massive difference – all of it positive." – Bob Mac Smith*

Sustainability is also viewed as a significant factor in a "commodity business with wafer-thin margins".

MSM is quite satisfied with their current feedstock specifications and make clear that that there is no commercial incentive to stray from the tight specifications. Using chipped pallets (a potential EPA concern raised by MS2) is not an option due to EPA licencing conditions and emission concerns. Varying from their approved feedstock specifications would jeopardise their equipment operation and EPA license, and therefore their fuel supply. MSM also notes that a business of their size has to be risk-averse, and they wouldn't risk a stranded investment by varying from their feedstock specifications.

Key considerations

- Consideration of bioenergy as a primary fuel source can be complex and time-dependent.
- Demonstrated security and reliability of fuel supply are key commercial considerations.
- Bioenergy, especially over coal as an alternative, helps improve standing with customers and the communities in which businesses operate.
- There are strong commercial and regulatory drivers against varying from approved feedstocks for bioenergy.

- Risk-averse regulatory approaches can bias against bioenergy, as its performance characteristics and emissions profiles are not as well understood as traditional energy sources such as coal. This bias should diminish over time as more performance data is available for regulatory authorities.
- Biomass would not be commercially competitive with natural gas if natural gas was available within a reasonable distance of MSM's plant.

5.8 Case Study – Weathertex

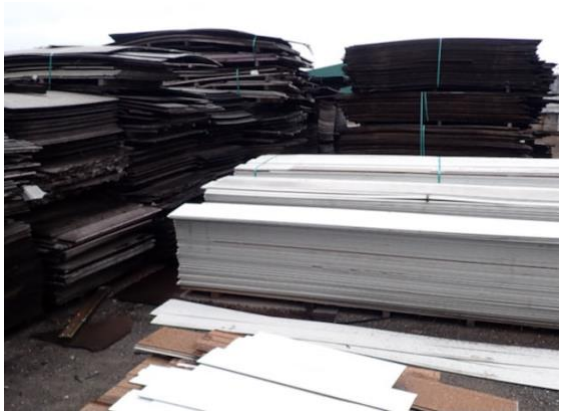
Weathertex in Heatherbrae NSW is a specialist exterior wall panels supplier and weatherboard company. Weathertex has been using a blend of chipped reject hardboard and coal as boiler fuel for engineered timber products since 1974.

Unlike traditional engineered timbers that use various glues and resins, Weathertex has used a Masonite process since 1939. A paraffin wax addition comprises less than 3% of total product weight, with hardwood timber comprising the remainder; no other glues or resins are used.

Weathertex produces exterior grade wet processed fibreboard as defined in AS/NZS 1859.4 and ISO/DIS 27769. Weathertex purchases pulp logs that are already debarked and trimmed, then chips the logs on-site. Steam and pressure are used to soften the natural lignin in the timber fibre, which is then pressed into a sheet without the need for binders. Some Weathertex products have a thin coating of an acrylic primer.

One overall business consideration for timber products noted by Weathertex is that consumer markets are moving more towards FSC certification over PEFC certification, and Australian native forests cannot become FSC-certified.

Management of offcuts and rejects can be problematic for Weathertex, given their relatively small volumes generated and the view that lower grade uses seem wasteful for engineered timber products. Briquetting of scrap materials for home heating has been trialled and represents a relatively high-value use but also high associated costs of production, and often competes with trailer loads of firewood from state forests.



While there is consumer demand for chipped scrap materials for soil amendment and animal bedding, consumers often expect these to be available free of charge as 'waste' products. Weathertex note the potential commercial opportunities for having a regional reprocessor that could draw wood fibres and scraps from a range of small generators and consolidate their outputs for sale more cost-effectively than the small generators that have other core business priorities.

Waste pallets are generated in small amounts; these pallets are reused or recycled wherever possible, with the remainder sent to timber waste bins. While Weathertex's boilers could technically accept chipped pallets, processing costs to chip the pallets and a focus on primary fuel sources mean that chipped pallets are not used as boiler fuel. Burning coal is also considerably cheaper, given the labour costs of chipping pallets separately.

Being in close proximity to coal supply makes the use of biomass for energy harder to justify, but the relatively low price for coal is not the only consideration for Weathertex; boiler design is also an important factor. Weathertex uses boilers with unique designs and the business case for bioenergy

over coal has not been evident for both boilers. Weathertex is beginning to question the availability of coal for relatively small operators from say 2030 to 2050.

The use of pulp logs represents a potential supply risk for Weathertex, as they represent a lower-order use for the logs and are therefore given less consideration by suppliers.

> *"We're already a forest residue. We're part of a forestry industry. But they're not trying to produce pulp logs, they're trying to produce high-quality logs. Harvesters aren't trying to supply Weathertex."* – Conal O'Neill

While clarifying higher order uses for residues may seem fairly obvious in many instances, a fair amount of discretion is still usually involved. The dynamic nature of determining higher order uses for regulatory consideration is also a concern as competing markets for alternative uses of residue grow and change over time.

As with other stakeholders, Weathertex's potential use of bioenergy is directly affected by the cost and reliability of alternative sources of energy.

> "*High gas prices got us very close to turning a gas-fired boiler into a biomass boiler, but then COVID led to a domestic glut and prices dropped again. We also renegotiated gas connection pipeline fees, so now we're less exposed on gas prices."* – Conal O'Neill

Key considerations

- Use of woody biomass for bioenergy production in NSW goes back to at least 1974.
- Where salvage logs can be used but transport distances from their sources are high, the most cost-effective supply option can be to transport logs whole then chip on-site.
- Processing and transport costs, plus low demand for various alternative products, limit Weathertex's reprocessing of offcuts and rejects. These needs would better be addressed by a reprocessor drawing wood waste feedstocks from the region and supplying a range of products.
- Processes that guarantee feedstocks will be clean and uncontaminated are essential.
- Determining higher order uses for residues is not as straightforward as it might appear, and can vary over time with changes in market demand and supply costs.

5.9 Case Study – Mara Seeds

Mara Seeds is a family-owned business established in 1967 at Mallanganee NSW (50 km west of Casino), providing grass seed, oilseed, cereal grain, stock feeds and organic yearling beef that is grass fed or grain finished. In 1996, Mara Seeds changed its approach to an all-organic farming system to allow for the development of specialised niche products. In 2014, SOFT Agriculture Pty Ltd (Sustainable Organic Farming Techniques) was established as Mara Seeds' marketing and processing arm, with a focus on "carbon smart" farming. The newly-formed Mara Investment Corp. produces food-grade hemp, quinoa and chia at Culmaran Creek.

High speed granulation coats seeds in biochar and is used to ensure that all stock feeds have biochar; the 8-9% productivity gain is seen as more than paying for biochar infusion. Biochar is integral throughout all operations due to its value for stock feed efficiency, soil carbon, odour reduction and contribution to other interests including reforestation. Mara Seeds also recognise the potential for biochar in alternative markets such as concrete and asphalt.

Approximately 1 semi-trailer of wood chips per day, or ~9,000 tonnes per annum, is used primarily in biochar, compost and animal bedding. Introducing biochar saves two weeks of composting while reducing odour.

> *"People see with their noses, so we can reduce impacts on neighbours. With benefits of biochar, including odour reduction, residues and timber products will be more valuable. Biochar is part of the story for forestry, and together we build carbon levels every day."* – Stuart Larsson

Abattoirs turn bones from meat processing into a bone broth that is fed back into the biochar process. Syngas is used for onsite power generation, and in combination with solar could be used to provide power back to the grid.

> *"There's no such thing as waste; everything can be used. We use pyrolysis, so we don't waste residues. All of our activities feed back into more productive farming. Invite governments here to see how the whole process can go full circle."* – Stuart Larsson

Mara Seeds sees the greatest opportunities for intervention by the forestry sector and governments as being in adding value to residues and exploring opportunities for additional uses, noting in particular the difficulties that can arise when people have to pay to dispose of 'wastes'. Similarly, there is a need to continue avoiding potential contaminants such as treated timber and to enable more cost-effective transport of feedstocks and products to end markets.

Mara Seeds has not benefitted from government initiatives or funding, despite several applications for grant funding. Funding for grant matching has been a specific limitation.

Key considerations

- Biochar provides a range of benefits including feed productivity, odour reduction, soil carbon and strengthening products such as concrete and asphalt while reducing their carbon footprints.
- Forestry and sawmilling residues are essential to the production of biochar.
- Market value for biochar is significantly higher in stock feed and integration into other products than on its own.
- Integrated activities provide greater commercial and sustainability opportunities for residues and biochar together.

5.10 Case Study – Pellet Heaters Australia

Pellet Heaters Australia (PHA), based in Woodburn NSW, produces kitty litter, heating pellets and spill absorbents from pine sawdust and hardwood shavings.

PHA does not have the feedstock specifications typical of other processes, as they are typically using byproducts where the species is more significant than the form of the feedstocks. One complication of this approach is that forestry and sawmilling operations do not necessarily prioritise the species preferred and sought by PHA (tallowwood in particular).

PHA note that increased demand for various residues can reduce their feedstocks potentially available, given their role as a relatively small end user of byproducts. Coupled with the fact that their equipment works optimally with certain hardwood species that are not necessarily targeted by foresters and sawmills, PHA note that they are often unable to produce products economically and/or in the quantities the market requires. For FY 2020-21, PHA's production has been at least 30% below market demand due to limited hardwood shavings supply; this volume shortfall is often made up by imports.

The public's demand for more sustainable products is reflected in PHA's reported sales, as is demand for Australia-made products. PHA's production and therefore sales are also affected by factors such as the RSPCA's higher standards for animal bedding (under the RSPCA Approved Farming Scheme). When the RSPCA increased standards for animal bedding, this increased demand for residues from sawmills. As these and other factors have increased demand for residues, it has led to higher prices and made it more difficult for PHA to source appropriate feedstocks.

PHA has not benefitted from government grants programs or investment, noting that while they investigated grant opportunities, they did not fit within available categories for grant recipients. Competitors in Victoria received government grants to use scrap pallets in competing products, and Victoria is viewed as having a more facilitative process. This view is consistent with reports from a KPMG report for Bioenergy Australia (KPMG 2018) and the Bioenergy Stakeholder Engagement Working Group (DPI 2020), both of which found more facilitative approaches in Victoria, Queensland and South Australia while NSW is seen as more regulatory in nature.

Key considerations

- While pelletised products represent viable residue products, they are still subject to similar market forces as other end uses.
- Lack of appropriate feedstock supply can be more of a limiting factor than others; other infrastructure and planning considerations are irrelevant if feedstock supply is the limiting factor.
- Small end users of lower-grade residues can have proportionately greater impacts on their operations due to competition from other uses.
- Other states are seen as being more facilitative of promoting end uses of residues, namely for bioenergy, compared to NSW.

5.11 Case Study – SEATA Group

SEATA Group are technology developers who have constructed a field pilot system for their industrially-scalable pyrolysis and partial gasification technology at Glen Innes NSW. Trials of clean biomass feedstocks are proposed to commence mid-late 2021, following relevant approvals. While target feedstocks are weighted heavily towards many forms of waste biomass, the technology can also take any other carbonaceous inputs via co-feed systems, including end of life waste plastics, coal/tailings and high-moisture items such as biosolids, animal wastes and kelp/algae, turning these wasted resources into the building blocks of new products in a circular economy approach.

SEATA's negative-emissions technology produces clean, high-energy syngas and solid char. Liquid products such as tars, resins and biooils are not produced, as they are superheated into the gas in order to produce a higher-energy, hydrogen-rich syngas. The syngas can be used directly in renewable energy (power/heat), or further processed into other valuable commodities (derivatives):

- carbon-**negative** hydrogen;
- high purity carbon dioxide (food-and medical-grade);
- biomethane;
- green ammonia;
- green methanol;
- green olefins (for bioplastics); or
- other valuable derivatives.

SEATA's key sustainability considerations include producing industrial-scale sequestration of carbon dioxide into biochar from pyrolysed biomass. A SEATA plant processing waste biomass at 5 tph (their first commercial target) has the potential to deliver around 17,000 (and up to 30,000) tonnes of CO_2eq drawdown, with further designs to 40tph (and theoretical capability beyond that). This level of CO_2 removal is unprecedented to date and would present a step change in helping mitigate climate change and achieving net zero targets.

SEATA supports undertaking case studies at a commercially relevant scale with co-aligned industries and stakeholder groups, including government regulators and NGOs, to help address risk perceptions and provide stakeholders with enough information to better understand opportunities available for improving sustainable practices through their technology. SEATA's directors noted that:

> *"Public perception for bioenergy (all forms, including with biochar) is very important. In particular improving understanding that huge volumes of biomass resources are currently being burnt straight into the atmosphere or landfilled each year, which could be positively re-purposed to help people and our planet. Resources are required to address the lack of awareness around these issues and to undertake genuine engagement with people who may have questions about these technologies in order to build trust in our community. It's all about trust."*

Consistent with the Bioenergy Stakeholder Engagement Working Group discussions (DPI 2020), SEATA highlighted a range of important improvements required in NSW regulatory frameworks, including:

- Feedstocks are currently being defined and regulated as wastes, rather than as resources.
- The need to regularly update key policies and guidelines to enable positive innovation, including the NSW Energy from Waste Policy and related Eligible Waste Fuel Guidelines to better reflect available technologies and practices (whilst protecting unwanted practices as originally intended).
- Need for improved regulatory pathways to promote trials and demonstration projects to drive innovation – "let us walk before we run".

Benefits of different products from the SEATA process can be tailored depending on the feedstocks used, and matched to intended market uses. For example, char made from a broad range of feedstocks can be used in roads or concrete, while agriculture and regenerative farming require higher grade biochar derived from more selective feedstocks used. SEATA is a foundation member of

ANZBIG, who have developed a Code of Practice classifying biochars into three grades to enable key markets – Premium, Standard and Industrial grades.

Key considerations

- Biomass residues are critical to carbon sequestration through emerging pyrolysis and partial gasification technologies.
- Technologies such as SEATA's pyrolysis and partial gasification can also utilise other problem carbon-based wastes such as biosolids, animal wastes and waste plastics (among others) as co-feedstocks.
- Flexibility in feedstocks that can be used allows for greater feedstock security (a key requirement for bioenergy plants) and ability to develop more sustainable options.
- Stakeholders support commercially-relevant trials and case studies to help address risk perceptions and expand knowledge on how wasted resources and problematic materials can be addressed through integrated approaches.
- Better engagement is needed with stakeholders and the community.
- Bioenergy barriers and opportunities in NSW raised in the Bioenergy Stakeholder Engagement Working Group discussions were reinforced, including improving current regulatory constraints in a positive manner to drive innovation.

5.12 Case Study – Carbon Powered Mineral Carbon Technology & Products

Carbon Powered Mineral Carbon Technology & Products (CPMTP) is a technology provider currently developing technology in Appleby, just outside of Tamworth, to produce carbon-coated minerals. Whilst originally intending to produce carbon-coated mineral products and wood shavings for animal bedding, CPMTP has so far been involved and worked with various institutes on a number of R&D projects including carbon-coated mineral based fertilisers and additives for animal feed, using feedstocks such as woodchip, sawdust, crop straw, clays and natural minerals.

Clean, untreated feedstocks are used in order to simplify regulatory requirements (no inputs are considered 'wastes') and the minerals involved are natural. Hardwood chips and sawdust are best for producing animal feed; softwoods require some extra steps for beneficial use.

"There are huge opportunities for forest residues to go into biochar. Horticulture and Broadacre are especially good markets, given quantities involved, cost-competitiveness and ability to generate value and jobs in rural areas." – Terri Sun

"Gasification can produce a diverse range of options through generation of heat, power and biochar." – Terri Sun

CPMTP views sustainability through the impact of the products itself, especially for increasing animal health and soil carbon sequestration, but also in emissions reduction and enhanced plant growth. Improved animal gut health, coat health and hoof growth are additional benefits. Biosolids in conjunction with residues would represent useful feedstocks and means of turning wasted resources into valuable commodities benefiting agriculture and the environment while creating jobs and investment in rural areas.

CPMTP also highlight potential connection to the power grid. In contrast to some other stakeholders, CPMTP sees much higher costs associated with producing biogas as a primary product – hence their focus on other products.

Ability to accommodate a range of feedstocks means that CPMTP is open to a range of processing and transport options, including bringing mobile chipping and biochar technologies on or near harvest sites, to reduce residue feedstock transport and supply costs. Bark is viewed as especially good, given its mineral content. CPMTP sees value in conducting trials across a range of sectors to better document these options, their costs / benefits, risks and effectiveness.



Although CPMTP has not benefitted from any particular government initiatives or funding, the R&D Tax Incentive has assisted the company, especially when the business has been substantially involved in the R&D projects with minimum income from that source. Most of their activities have been self-funded to date.

> *"We are now available to show proof of concept based on residues and produce a product that is good both for agriculture and the environment. Technologies like ours are available and could get residues fully used for a circular economy." – Terri Sun*

CPMTP sees likely commercial challenges in a potentially crowded consumer market, however great opportunities in the horticulture, agriculture and livestock industries where the real impact can be made. Production costs need to be taken into consideration in order to be competitive and to be accepted by the large agriculture industries. However, commercial and sustainability benefits of adding biochar to stockfeed, fertilisers, roads and concrete open up a wide range of commercial options.

Key considerations:

- Using residues to make biochar can create a range of commercial and sustainable opportunities.
- While there are new markets for biochar, incorporating natural minerals in producing carbon coated minerals is commercially viable.
- Simpler, more straightforward regulatory requirements are associated with using basic, clean feedstocks such as residues.
- Broader sustainability benefits of biochar include feed efficiency, animal health and enhanced soil health and soil carbon content.
- Stakeholders are keen to work with various sectors in order to develop and trial new approaches and opportunities based on common interests, feedstocks and regional significance, whilst having varying technologies and products.
- Agriculture and livestock are especially promising sectors for collaborations, with added potential to expand economic development and job creation in rural areas.
- The wastewater sector also shows significant potential for collaboration given the volumes being generated and compatibility with biochar production.

6.0 Integrated Stewardship Strategy

As established by the United Nations Principles of Responsible Investment 2020 (UNPRI), the risk of a strong policy response to climate change is becoming inevitable. In financial circles, this phenomenon, known as the inevitable policy response (IPR), predicts a sharp and disruptive government response to the climate crisis the closer we get to 2025. (UNPRI 2020)

> *"Government action to tackle climate change has so far been highly insufficient to achieve the commitments made under the Paris Agreement, and the market's default assumption appears to be that no further climate-related policies are coming in the near-term. Yet as the realities of climate change become increasingly apparent, it is inevitable that governments will be forced to act more decisively than they have so far.*
>
> *The question for investors now is not if governments will act, but when they will do so, what policies they will use and where the impact will be felt. The IPR project forecasts a response by 2025 that will be forceful, abrupt, and disorderly because of the delay."* (UNPRI 2020)

Along with the tightening of financial regulations will come the scrutiny of supply chains and the inevitable tightening of regulations around resources, products and materials otherwise seen as 'wastes'. It is therefore advantageous for those who are aware of these coming changes to get ahead of the curve, make the necessary changes in an orderly fashion, and position themselves as leaders in the new circular and sustainable economy. At the same time, billions of dollars are being invested into means of carbon dioxide reduction that can provide substantial opportunities.

Coupled with the risks of disruptive policies and further climate change impacts, the forestry industry faces difficulties recovering from devastating bushfires, the COVID-19 pandemic and restricted social license to operate. Strengthening and expanding market development for forestry and sawmilling residues through an integrated stewardship strategy that build upon existing efforts and collaborates with related industries provides opportunities across the industry to recover and become more resilient while providing regionally-significant economic development, job creation and more sustainable communities.

6.1 Forestry Health and Reducing Bushfire Risk

Common stakeholder concerns about using forestry residues for bioenergy relate to sustainability considerations over nutrient depletion, biodiversity and climate implications. In addition to previous research including DPI work on residues in the Hub region (DPI 2017), research stakeholder discussions for this project reinforced these as common concerns across a range of stakeholders.

Research by DPI found that removal of additional biomass for bioenergy from native forests results in increased loss of nutrients, including nitrogen. However, the lost nitrogen is largely replenished naturally during the longer native forest harvest cycles. Retaining bark and leaves onsite and minimising post-harvest regeneration burns are the key actions to minimise impacts on nutrient availability due to extraction of biomass. (DPI 2017)

In preliminary assessments by DPI, bats' and birds' responses before and after thinning young regrowth (a potential source of residue) were mostly neutral to positive. (DPI 2017)

Leaving coarse woody debris such as bark on the forest floor following harvesting provides nutrient value and habitat value. The optimal amount of CWD to leave on the forest floor varies by the type of forest and local conditions, and requires further research.

6.2 Market Demand for Residues

Beyond the base amount of CWD left onsite for nutrient and habitat value, forestry residues that lack end use markets are either burned in approved hazard reduction burns or become fuel load that poses bushfire risk and potential risk to timber resource value.

In research by the NSW DPI on residues in the Hub region (DPI 2017),

> *"(t)he greenhouse gas balance carried out here clearly shows that, from a climate perspective, using biomass that would have otherwise been left in the forest to burn and/or decay for bioenergy generation results in positive outcomes, especially if biomass is used to produce electricity displacing the use of coal. This is true even when the carbon dioxide emissions from burning the biomass to generate energy are included in the calculations. In practice, the CO_2 released will be reabsorbed by the growing trees in a sustainable harvest system, eventually negating the impact of such emissions."*

Creating or enhancing market demand for forestry residues adds commercial value to forestry operations, reduces bushfire risk and commercial risk due to lost resource value and provides useful feedstocks for a broad range of technologies and processes in addition to reducing the air quality impacts of hazard reduction burns. Climate outcomes are positive for traditional bioenergy.

While some individuals and companies within forestry have been proactive in market development, stakeholders felt strongly that the overall industry has not. Diverse business models make it difficult to address comprehensively, however the demand for industry-wide approaches is strong. There is a clear need to better convey the diversity of the industry and integration with other sectors. While this report will hopefully be of assistance, it needs to be part of a comprehensive approach to increase awareness and understanding with regulators and the broader community to help reinforce social license to operate.

> "*Forestry Corporation, and the industry broadly, should be more proactive on developing markets, but many don't understand the issues well enough. Small companies like us don't have the money to throw into market development."* – Marius Heymann, S A Relf & Sons

Many of the market development opportunities for residues provide net sustainability benefits, the full extent of which requires better quantification and communication with key stakeholders.

6.3 Processing and Transport

A range of industry stakeholders commented on the intersection of transport economics and market development, with many saying that most markets for residues needed to be within 100-150km in order for transport to be economically viable. However, this is based on current circumstances and

market prices. For end use markets paying higher prices for residues or products made from residues, the distance for transport to be economically viable could be greater.

6.4 Regulatory Considerations

As noted by DPI (2017), recent legislative developments may assist development of markets such as bioenergy and high-value chemicals, including:

- *"The change in legislation in NSW allowing the burning of native forest wood waste for electricity generation;*
- *The change to the Renewable Energy Target (RET), which has reinstated native forest wood waste as an eligible renewable energy source;*
- *The previous clause that precluded Carbon Farming Initiative (CFI) projects from using native forest biomass has been removed under the Emissions Reduction Fund (ERF).*

Despite the increased knowledge base around benefits of biochar including improved soil carbon, in NSW, biochar cannot be applied to land as a fertiliser or soil amendment without a separate resource recovery order and exemption that can be expensive and time-consuming to obtain. Rather than having to pursue such actions on a case-by-case basis and given the potential financial benefits of acting quickly, the forestry industry should cooperate with the EPA to seek blanket RROs and exemptions for biochar and other relevant products that use residues in established and verified processes. More end users will be able to respond more quickly and sustainability outcomes, including carbon dioxide removal, can be delivered rapidly. Absent blanket exemptions, the forestry sector should facilitate the application processes for end users as part of comprehensive market development efforts.

This strategy has been developed within the context of existing regulatory frameworks. However, the case studies and stakeholder discussions for this project consistently reinforced concerns about regulatory constraints raised in previous stakeholder discussions, most notably those of the Bioenergy Stakeholder Engagement Working Group (DPI 2020). Addressing those identified regulatory barriers would likely result in commercial and sustainability benefits beyond those identified in this report. Specifically, the forestry industry should consistently raise awareness and understanding that residues are not simply wastes, but feedstocks that are integral to the establishment of circular economies based on higher order use and improved sustainability across a broad range of products and related industry sectors.

6.5 Integrated Product Use Demonstrations / Trials

Opportunities for regional processing that can value-add locally, improve industry sustainability outcomes and reduce transport needs or increase cost-effective transport distances need to be explored as part of an integrated stewardship strategy.

Integrated harvesting and processing trials conducted by the forestry industry in conjunction with related industries and relevant state and local government agencies provide substantial means of addressing many of the barriers and opportunities for residue market development identified in this report. A framework for developing and conducting such trials is provided in Figure 2 (repeated as Figure 22).

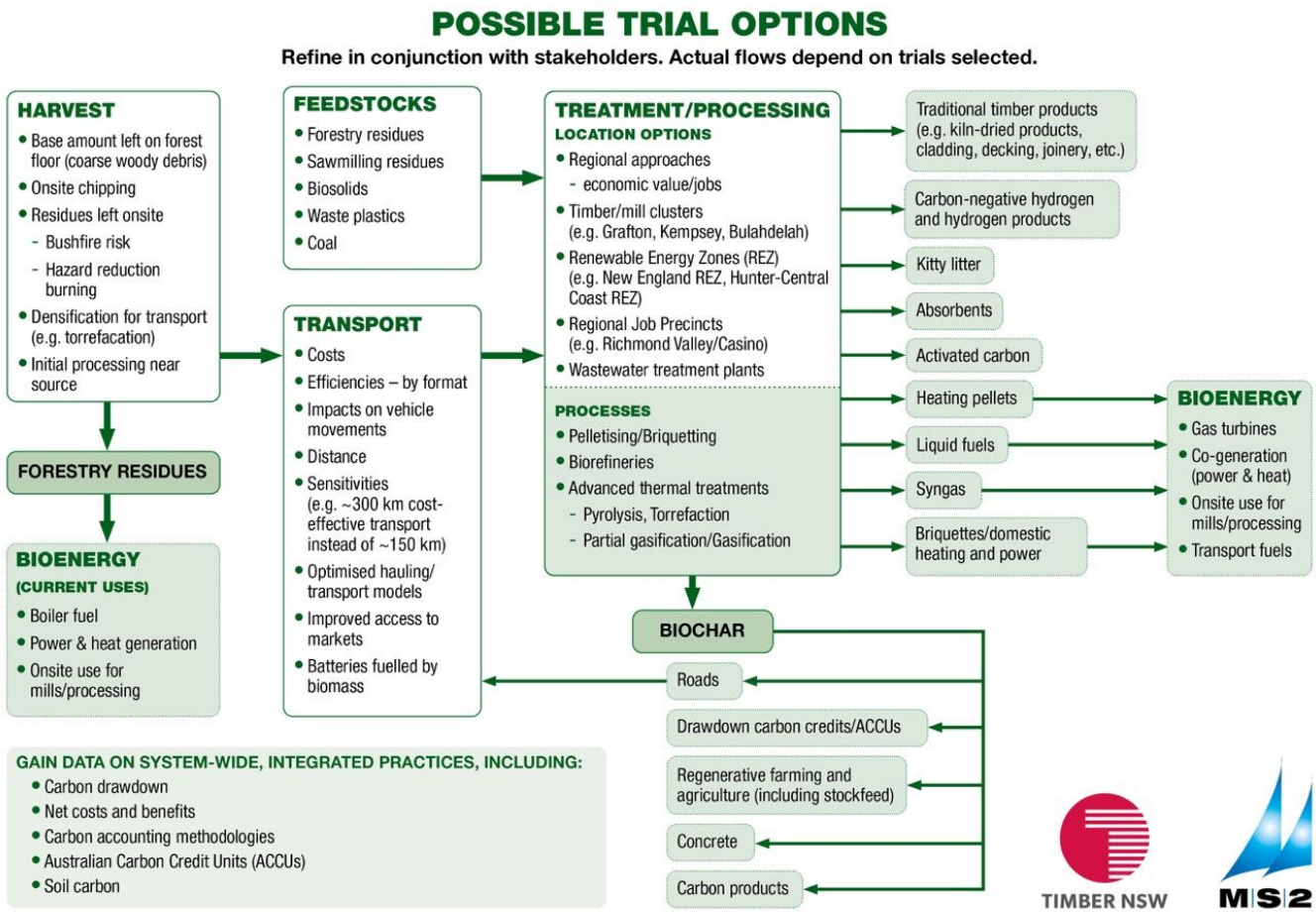


Figure 22: Framework for Proposed Trials

While specific project requirements and funding needs would need to be established in conjunction with trial partners, integrated approaches and participation of multiple sectors should help spread risks, increase likelihood of obtaining funding, address knowledge gaps collectively and better spread awareness of trial benefits and business case considerations.

Example 1: Residue feedstocks alone (no co-feedstocks) to evaluate higher-grade biochars for standard- or premium-grade markets in regenerative agriculture, animal feeds, etc.

Example 2: On-site residue chipping is conducted during harvesting for transport to a nearby wastewater treatment plant (preferably one connected to an ocean outfall to evaluate outfall removal). Residues and biosolids are combined and treated onsite through either a biorefinery or pyrolysis and partial gasification to produce a range of products. If successful, additional related benefits could also be examined which could provide further higher value to the overall process (e.g. energy for pumping, water treatment/desalinisation, heat for related anaerobic digestion facilities, etc.).

Example 3: Animal wastes and residues from agriculture / livestock operations (say poultry litter with sawdust or abattoir wastes with other residues) are combined and processed through pyrolysis and partial gasification in a Renewable Energy Zone. Biochar is infused in stockfeed incorporated in a cyclical model for regenerative farming and agriculture in addition to providing onsite power generation in remote locations. Soil carbon, animal health and feed efficiencies are examined in detail.

Each example would have clearly defined trial boundaries and seek system-wide data to be shared with all project partners, including regulators. Feedstocks should be initially tested / validated in initial testing to provide technical, commercial and regulatory confidence for investment in subsequent trial stages. Similar transport aspects would likely be examined for each example, and resulting products would be used either within the trials themselves or sold to local markets to the fullest extent possible. Each is intended to become a flagship model for different approaches and demonstrating the feasibility of the particular approach.

Such integrated approaches, using residues and other feedstocks that would otherwise be considered wastes in negative emissions technologies to produce a range of products including energy and biochar that can feed back into the systems, help deliver against a range of UN Sustainable Development Goals, circled in Figure 23. Direct connections with Sustainable Development Goals noted by ANZBIG are shown with solid circles, while possible connections are shown in dashed circles.

Figure 23: Potential roles of integrated solutions to assist in meeting the UN SDGs

(ANZBIG 2021)

> "*At local scales there is robust evidence that soil carbon sequestration, restoration of degraded land, or conservation agriculture management practices have co-benefits in agriculture and that many measures are cost-effective even without supportive climate policy*." – Intergovernmental Panel on Climate Change

7.0 Findings and Recommendations

Principal report findings are compiled in Table 3, which spans multiple pages. Each finding is drawn from the case studies and consultations, and assessed against whether the finding addresses the following key parameters examined in this report:

- **Industry** – commercially relevant for industries generating or using forestry and sawmilling residues;
- **Stewardship** – involves or demonstrates stewardship / sustainability considerations;
- **Social License** – currently or potentially affects broader community perceptions and social license to operate;
- **Regulatory** – relates to regulatory considerations;
- **Transport** – relates to transport or transport infrastructure; and
- **Data** – currently or potentially affects specific information gaps.

Table 3: Principal Findings and Key Parameters Addressed

Findings	Industry	Stewardship	Social License	Regulatory	Transport	Data
Appropriate thinning on a rotational basis produces healthier, more valuable timber within a given site.	√	√	√			
The most appropriate amount of residues to leave on the forest floor when harvesting remains to be determined for some forestry operations.	√	√	√			√
Forestry residues beyond the base amount that do not go into end use markets either must be managed through hazard reduction burns or become a bushfire risk. Creating markets for these extra residues facilitates finding higher order uses and greater sustainability.	√	√	√	√		
Industry market development for residues is generally lacking, especially for industry-wide initiatives.	√					
Timber supply is a significant restriction for the timber industry, and affected by bushfires, NGO opposition to the timber industry, and flooding. Such factors lead to an increase in imports, rather than domestic supply, to meet market demand.	√	√				
Regional transport infrastructure improvements such as motorway transport to Brisbane or intermodal transport to ports would benefit the forestry sector in the region.	√				√	
Instability in resource security may directly impact the commercial viability of sawmills and subsequently the availability of residues for various end uses.	√	√				
Forestry and sawmilling operations have a range of commercial incentives to adopt sustainable practices.	√	√	√	√	√	

Findings (continued)	Industry	Stewardship	Social License	Regulatory	Transport	Data
While burning residues onsite used to be standard practice for sawmills, the practice has been abandoned over time and as alternative uses have become available.	√	√	√	√		
Increased consumer demand for treated timber over time could affect residue streams, given the need to keep many residue streams free of treatments in order to ensure greater access to markets.	√			√		
Solid fuel gas turbines using sawdust and shavings could represent opportunities for sawmills to generate power onsite using byproducts for which they'd otherwise need to find markets.	√	√				
Transport can be a significant barrier to using residues more sustainably.	√	√			√	
Bioenergy projects can use biomass feedstocks with no higher order uses to generate energy and offset the use of coal, including for base load generation.	√	√	√	√		
Co-location and base load power generation complements the solar and wind renewable energy base, is more economically viable than just generating power for sugar cane processing at sugar mills, as capital equipment is active and generating income throughout the year and not just the 6 months out of the year when processing occurs.	√	√				
Constant energy market fluctuations introduce commercial uncertainty for bioenergy projects, especially when coupled with feedstock price variations. Bioenergy projects need to properly consider these risks and uncertainties in business planning and supply contract negotiations.	√	√				
Transport costs are one of the most significant factors in end use markets for residues. Opportunities for vertical integration may be worth pursuing.	√				√	
Consideration of bioenergy as a primary fuel source can be complex and time-dependent.	√	√				
Demonstrated security and reliability of fuel supply are key commercial considerations.	√					
Bioenergy, especially over coal as an alternative, helps improve standing with customers and the communities in which businesses operate.	√	√	√			
There are strong commercial and regulatory drivers against varying from approved feedstocks for bioenergy.	√			√		
Risk-averse regulatory approaches can bias against bioenergy, as its performance characteristics and emissions profiles are not as well understood as traditional energy sources such as coal. This bias should diminish over time as more performance data is available for regulatory authorities.	√	√	√	√		√

Findings (continued)	Industry	Stewardship	Social License	Regulatory	Transport	Data
Biomass would not be commercially competitive with natural gas if natural gas was available within a reasonable distance of certain operations.	√					
Use of woody biomass for bioenergy production in NSW goes back to at least 1974.	√	√				
Where salvage logs can be used but transport distances from their sources are high, the most cost-effective supply option can be to transport logs whole then chip on-site.	√				√	
Processing and transport costs, plus low demand for various alternative products, limit some operations' reprocessing of offcuts and rejects. These needs would better be addressed by a reprocessor drawing wood waste feedstocks from relevant regions and supplying a range of products.	√				√	
Processes that guarantee feedstocks will be clean and uncontaminated are essential.	√	√		√		
Determining higher order uses for residues is not as straightforward as it might appear, and can vary over time with changes in market demand and supply costs.	√	√		√		
Lack of appropriate feedstock supply can be more of a limiting factor than others; other infrastructure and planning considerations are irrelevant if feedstock supply is the limiting factor.	√					
Small end users of lower-grade residues can have proportionately greater impacts on their operations due to competition from other uses.	√					
Other states are seen as being more facilitative of promoting end uses of residues, namely for bioenergy, compared to NSW.	√	√		√		
Biomass residues are critical to carbon sequestration through emerging pyrolysis and partial gasification technologies.	√	√				
Technologies such as pyrolysis and partial gasification can also utilise other problem carbon-based wastes such as biosolids, animal wastes and waste plastics (among others) as co-feedstocks.	√	√	√	√		
Flexibility in feedstocks that can be used allows for greater feedstock security (a key requirement for bioenergy plants) and ability to develop more sustainable options.	√	√				
Stakeholders support commercially-relevant trials and case studies to help address risk perceptions and expand knowledge on how wasted resources and problematic materials can be addressed through integrated approaches.	√	√	√	√	√	√

Findings (continued)	Industry	Stewardship	Social License	Regulatory	Transport	Data
Better engagement is needed with stakeholders and the community.	√		√			
Bioenergy barriers and opportunities in NSW raised in the Bioenergy Stakeholder Engagement Working Group discussions were reinforced, including improving current regulatory constraints in a positive manner to drive innovation.	√	√	√	√		
Using residues to make biochar can create a range of commercial and sustainable opportunities.	√	√				
While there are new markets for biochar, incorporating natural minerals in producing carbon coated minerals is commercially viable.	√					
Simpler, more straightforward regulatory requirements are associated with using basic, clean feedstocks such as residues.	√	√		√		
Broader sustainability benefits of biochar include feed efficiency, animal health and enhanced soil health and soil carbon content.	√	√				
Stakeholders are keen to work with various sectors in order to develop and trial new approaches and opportunities based on common interests, feedstocks and regional significance, whilst having varying technologies and products.	√	√	√			
Agriculture and livestock are especially promising sectors for collaborations, with added potential to expand economic development and job creation in rural areas.	√					
The wastewater sector also shows significant potential for collaboration given the volumes being generated and compatibility with biochar production.	√	√	√			

Recommendations derived from desktop research, site visits, consultations, the integrated stewardship strategy and the findings in Table 3 are provided in Table 4 and assessed against the same key parameters (Industry, Stewardship, Social License, Regulatory, Transport and Data) identified and examined throughout this report. A tick in Table 4 indicates that a given recommendation addresses a given key parameter.

Table 4: Recommendations and Key Parameters Addressed by the Recommendation

Recommendations	Industry	Stewardship	Social License	Regulatory	Transport	Data
Investigate and trial negative emissions technologies (NETs) such as pyrolysis and partial gasification that use residues in conjunction with other non-residue feedstocks to produce biochar, heat, power, syngas and other products with commercial value. These NETs cannot realise their full sustainability and commercial potential without using residues as feedstock, especially with regard to carbon credits.	√	√	√	√	√	√
Conduct integrated trials in conjunction with other industry sectors whose byproducts can be used in conjunction with residues by the NETs or whose activities can benefit from the products of these processes.	√	√	√	√	√	√
Integrated trials should examine business cases considerations of system-wide costs and benefits, including carbon drawdown / sequestration and soil carbon in addition to improving carbon accounting methodologies.	√	√	√	√	√	√
Investigate optimal amounts of coarse woody debris/forestry residues to leave onsite under different circumstances to optimise their forestry value, reduce fire risk and quantify remaining residues available for market.	√	√	√	√		√
The forestry industry should consistently raise awareness and understanding that residues are not simply wastes, but feedstocks that are integral to the establishment of circular economies based on higher order use and improved sustainability across a broad range of products and related industry sectors	√	√	√	√		√
Conduct public workshops in relevant forestry regions and larger cities to present and discuss the generation of, uses of and stewardship aspects of forestry and sawmilling residues, preferably featuring key industry and government representatives. Such workshops could be in conjunction with industry workshops to refine estimates of residues and to scope the integrated trials.	√	√	√	√		√
Explore potential wood waste processing infrastructure and operations in the Hunter region and at least one location further north near a regionally significant forestry cluster. These operations could aggregate and process wood wastes of all kinds into intermediate and final products better optimised for transport and ultimate end uses more cost-effectively than having multiple generators and users doing so on their own, whilst potentially improving data on the flow of wood wastes.	√	√	√	√	√	√
Investigate and quantify the current and potential contributions of residues to carbon credits, including how residues are addressed in carbon accounting methodologies.	√	√		√	√	√
Develop an agreed higher order forest residues approvals matrix for using bioenergy and biochar feedstocks based on numerically rated economic, social and environments criteria that rank, in order of preference, and incorporate several policy changes that were pending at the time of publication.	√	√	√	√	√	√

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Appendix A: Organisations Consulted

- Allied Natural Wood Exports
- Australia New Zealand Biochar Industry Group (ANZBIG)
- Boral Timber / Boral Limited
- Cape Byron Power
- Carbon Powered Mineral Carbon Technology & Products (CPMTP)
- Envirochar
- Grants Sawmilling Co.
- Hurford Hardwood
- J. Notaras & Sons
- Mara Seeds
- MSM Milling
- North East NSW Forestry Hub
- NSW Department of Primary Industries
- Pellet Heaters Australia (PHA)
- Redbank Power Station / Verdant Technologies Australia
- S A Relf & Sons Pty Ltd Hardwood Sawmillers
- SEATA Group
- Timber NSW
- UTS Institute for Sustainable Futures
- Weathertex

Additional public and private organisations were contacted about participating in this project, but formal interviews did not take place.