BOUCHER CONSULTANCY

Woodchip Procedures for:

Forest residue
Dead farm wood
Tree felling residue

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1. Introduction

This document provides background information for organisations looking to supply woodchips to the biomass industry from forest/tree felling residue and dead farm wood. It also provides assurance to end users that woodchip suppliers have followed protocols and standards for chipping wood to specification.

Currently in Australia, 61 biomass plants are in operation, fuelled by sources such as animal waste, food waste, crop residue, and forest residue[1]. Most biomass systems that use woody waste obtain their biofuel from forest residue. Forest residue is the waste product of tree harvesting.

Benefits of using tree residue and dead farm wood for biofuel include: preservation of native trees and forests, prolongation of landfill lifespan, reduced fossil fuel consumption, and reduced greenhouse gas emissions.

Processing tree residue and farm wood requires additional quality assurance measures. Biomass boilers require consistency with moisture levels, size (diameter), and the removal of contaminants. Supplying woodchips which do not conform to a biomass boilers specification may reduce the boilers performance, reduce the boilers useful life, void the warranty, and increase toxic emissions.

2. Background Biofuel Information

2.1 Biomass Boilers

Biomass utilises the energy stored in organic material to generate heat. The heat can be used to produce steam, hot air, hot water or electricity. Biomass is best suited to industries requiring a constant heat load such as heated swimming pools, hospitals or manufacturing plants operating 24/7. Traditionally biomass boilers have higher establishment costs and lower operating costs compared to equivalent fossil fuelled systems.

In Australia biomass boilers are imported, as there are no local manufacturers. There are currently 21 international biomass boiler manufacturers who have distributors in Australia or who deal directly with the Australian market. Each manufacturer offers varying boiler sizes from household heaters to large systems that can generate electricity. Some biomass boilers can generate electricity for large populations, such as Ballarat.

The quantity of woodchips used in biomass boilers is dependent upon on the boiler size. Larger biomass systems in eastern Victoria consume over 100 tonnes of woodchips per week, whereas smaller systems such as the Beaufort Hospital consume 2-3 tonnes per week.

[1] http://biomassproducer.com.au/projects/

When purchasing a biomass boiler, the manufacturer requires information on the biofuel to be used. This assists in the boilers construction. A woodchip supplier will assist in the purchasing process by providing information on:

- The biofuel feedstock (straw, grains, sawdust, briquettes, wood pellets, shredded wood or woodchips)
- Moisture content of woodchips
- Woodchip dimension in mm
- Storage of woodchips
- Species of wood
- Calorific value
- Volatile matter of woodchips
- Fixed carbon content
- Ash content and fusion

All 21 international biomass manufacturers exporting to Australia accept woodchips as a biofuel.

2.3 EPA Victoria Requirements

A woodchip supplier utilising forest/tree felling residue or dead farm wood must ensure their woodchips are free of chemicals and contaminants prior to burning in a biomass boiler. Failure to do so may breach the Environmental Protection Agency (EPA) Victoria emission regulations under the Environmental Protection Act 1970. Under the EPA waste to energy guidelines, waste streams which pose minimal risk to the environment and human health, and are considered acceptable biofuel for energy recovery include:

- biomass from agriculture
- residues from plantation forestry and sawmilling operations
- untreated wood waste
- recycled oil that meets the specifications and standards set out in the Product Stewardship (Oil) Regulations 2000
- vegetable residue from virgin pulp production and from production of paper from pulp.

These wastes can be processed directly in purpose-built boilers, or as fuel replacement in existing facilities, if the following requirements are met:

- the wastes are fully characterised, uncontaminated and relatively homogenous
- the wastes have a minimum gross calorific value of 10MJ/kg as received (for thermal processes)
- emissions associated with the processing of such waste are consistent with the State Environment Protection Policy (Air Quality Management) 2001 (SEPP AQM).

EPA Victoria will conduct regular emission tests on biomass boilers greater than 3MW. EPA will test for particulate matter (TPM), sulphur oxides (SO_2), oxides of nitrogen (NO_X), hydrogen chloride (HCI), carbon monoxide (CO), total organic compounds (TOC) and hydrogen fluoride (HF).

2.4 Woodchip Moisture

Woodchips are categorised as wet or dry biofuel depending on the woodchip moisture content. Dry woodchips generally have < 30% moisture content whereas wet woodchips have > 35% moisture content. Woodchip moisture has a major impact on biomass boiler performance. Dry woodchips generate double the energy compared to wet woodchips. A boiler using wet fuel requires more woodchips to achieve the same boiler temperatures compared to dry woodchips.

Woodchip suppliers must not combine high moisture woodchips with low moisture woodchips. Woodchips with varying moisture levels will reduce the boilers performance and potentially damage the boiler. Combining wet and dry fuel in woodchip piles increases the likelihood of spontaneous combustion resulting in a woodchip pile fire. A supplier will need to store wet and dry biofuel separately.

Table 2 – moisture content of wood

Condition of wood	Water content	Heating value
Fresh timber	50% - 60%	2.0 kWh per kg
Timber stored for a summer	25% - 35%	3.4 kWh per kg
Timber stored for several years	15% - 25%	4.0 kWh per kg

Wood Fuels Handbook, 2015

As a biofuel supplier, the following areas should be considered for woodchip moisture content:

- Woodchip moisture content cannot vary throughout the year.
- Woodchips should be stored on a hard surface and undercover. Softwoods such as radiata pine will absorb moisture if kept outdoors.
- Woodchip moisture content must be compatible with the biomass boiler specifications.

2.5 Woodchip Particle Size

Biomass boilers have a specified range of woodchip diameter sizing. Generally small boilers require small woodchips, and larger biomass systems accept a wider size variety. For example, the small 110kW biomass boiler at the Beaufort hospital specifies woodchips up to 25mm. The larger 240kW boiler at Meredith Dairy specifies woodchips up to 45mm. Problems associated with oversized woodchips include blocking feeding augers and limiting the flow of woodchips into the combustion chamber. Woodchip suppliers will be required to chip wood according to client specifications. The biomass boiler table (Appendix 1) has woodchip diameter requirements for each biomass system. Typical woodchip sizes are:

- Small biomass system (<500kW) = 10mm to 30mm diameter woodchip
- Medium biomass systems (500kW – 2000kW) = 10mm to 50mm diameter woodchip
- Large biomass systems (3,000 kW +) = 10mm to 100mm diameter woodchip

The table below shows the size categories of woodchips from International Biomass Standard ISO 17225-4.

Table 3 – Woodchip categories from ISO 17225-4

Code	Maximum percentage particle size			
	< 4%	<20%	60% - 100%	<20%
P16	< 1mm	1-3mm	3-16mm	>16mm
P31	<1mm	1-6mm	6-31mm	>31mm
P45	<1mm	1-9mm	9-45mm	>45mm
P63	<1mm	1-11mm	11-63mm	>63mm
P100	<1mm	1-100mm	63-100mm	>100mm

2.6 Woodchip Contamination

Contaminants in woodchips will impact on biomass emissions and potentially reduce the boiler's performance, useful life, and void the warranty. Contaminants must be removed from any wood prior to chipping. Contaminants may include treated wood, plastics, organics, metals and painted wood.

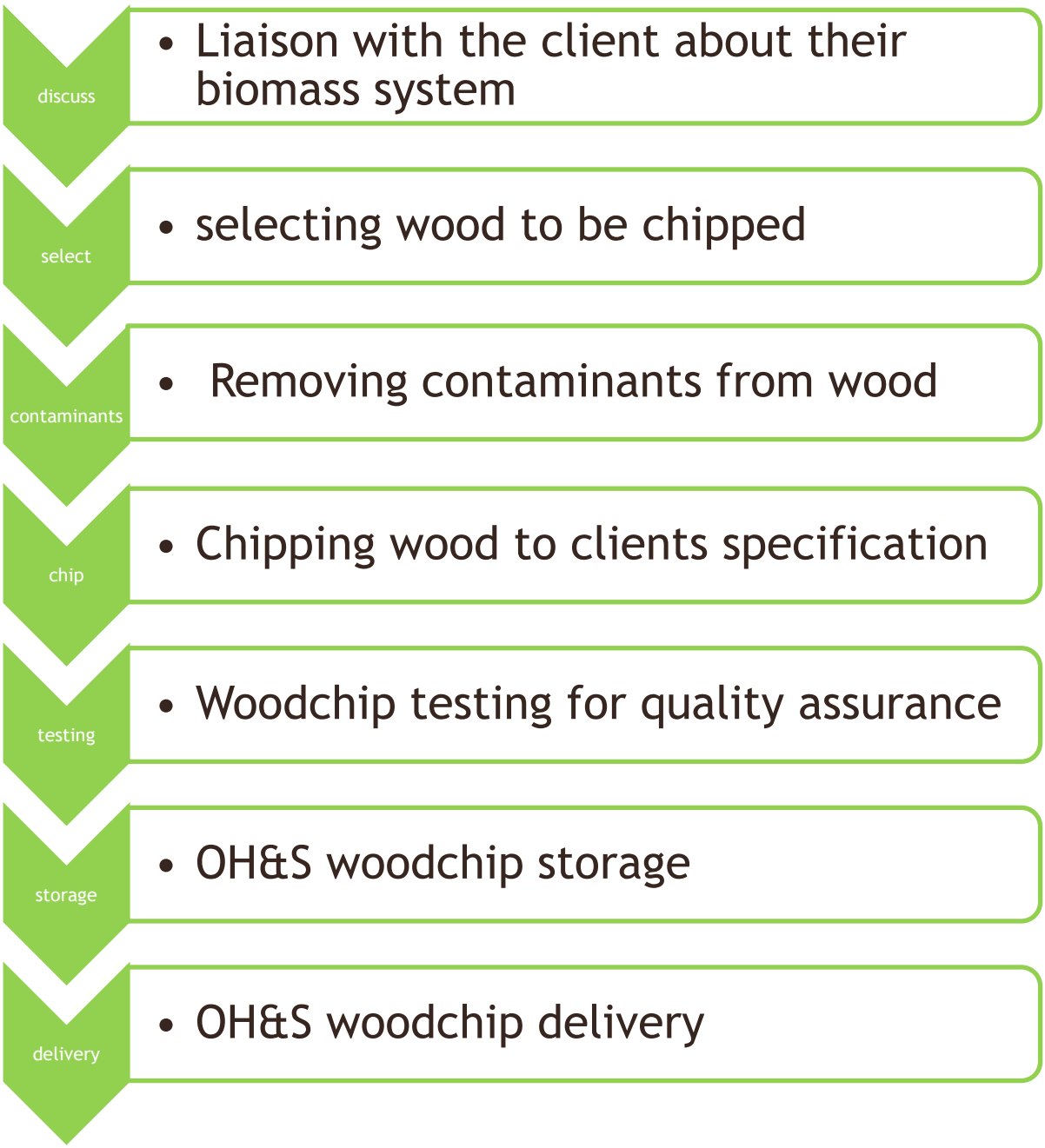
The most common contaminant in forest/tree felling residue and farm wood is grit, stones and dirt embedded in the wood. These items will increase wear on chipping systems and biomass boiler components and reduce the boiler performance. Wood contaminated with grit, stones and dirt must be separated from clean wood and not chipped.

2.7 Woodchip Calorific Value

Calorific value also known as heating value, measures the amount of energy in fuel. Calorific value is measured in megajoules per kg (MJ/kg). A higher calorific value requires less fuel to reach and maintain temperature. A lower calorific value requires more fuel to reach and maintain temperature. Different species of wood and moisture content impact on calorific values. woodchip suppliers may need to use a mixed variety of tree sources and wood, to ensure a consistent calorific value. Failure to ensure a consistent calorific value may impact on biomass boiler performance.

3. Woodchip Supply Chain

The supply chain graph identifies processes the woodchip supplier will follow when receiving, sorting, processing, testing, storing and delivering woodchips.



3.1 Discuss – Liaison with the client about their biomass system

Each biomass boiler has a unique design and biofuel needs to conform to the manufacturer's specifications. For example, Remeha biomass boilers have woodchip specifications (link: Remeha biomass boilers). Woodchip suppliers will need information about the Clients biomass boiler to produce woodchips to specification. The woodchip supplier will need to know:

- Whether the biomass boiler has been manufactured to accept dry biofuel (<25% moisture) or wet biofuel (30% - 60%). Waste wood will be unsuitable for a boiler designed for wet fuel.
- Whether the biomass boiler will accept woodchips
- Recommended woodchip moisture content
- Recommended woodchip dimensions

As shown in the table on Appendix 1, each manufacturer specifies different woodchip dimensions and moisture levels. Generally, smaller biomass systems will specify small woodchip dimensions and lower a moisture content. Larger biomass systems can take a variety of woodchip sizes and moisture contents.

3.3 Physical – Removing physical contaminants from wood

Contaminated materials will impact the performance of the biomass system and create toxic emissions. Toxic emissions will not be compliant under EPA Victoria legislation. Wood with physical contaminants are categorised as class B under Standard ISO 17225-1 and not suitable for chipping. Removing physical contaminants will upgrade the wood to class A and suitable for chipping.

3.4 Chip – Chipping wood to client specifications

The wood chipping process is generally performed by contractors. Woodchip suppliers need to confirm that contractors can chip to various sizes to accommodate large and small biomass systems. Removing bark and leaves will reduce the ash content and reduce boiler maintenance and cleaning.

3.6 Test – Woodchip testing for quality assurance

Woodchip testing will be performed bi-annually by laboratories in accordance with European Standard EN 15234-4, Quality Assurance Woodchips. Woodchip testing measures the following areas:

Woodchip diameter – diameter according to International Biomass Standard ISO 17225-4. Woodchips will be measured in the following classifications P16, P31, P45, P63 and P100.

Moisture content – one of the key parameters for woodchips as a high moisture content will negatively impact on heat and performance.

Ash – the mineral residue remaining after a complete combustion. A high value results from a low-quality woodchip and will require higher maintenance and ash removal. Chipping wood with bark and leaves will increase ash content.

Calorific value – the energy content of the woodchips measured in MJ per kg.

Bulk density – the weight of the woodchips. Density may impact on the capacity of storage units, augers and feeders. Hardwoods generally have a higher density than softwoods.

Trace metals – can determine if the woodchips are contaminated by measuring metals such as arsenic, chromium and mercury.

Woodchip Lab Testing

HRL Technology Group are a laboratory located in Melbourne (Mulgrave) that specialise in Biomass analysis. To analyse woodchips in accordance with EN15234-4, HRL Technology Group quoted a cost of $1,290 (as of December 2018). Every 6 months, suppliers will send a woodchip sample to HRL Technology Group in a sealed plastic bag. See Appendix 2 for the lab testing proforma.

Woodchip Testing – Internal

For woodchip suppliers, the most important internal test for woodchips is a moisture test. Moisture meters cost between $30 to $1,000, and provide a moisture reading in percentage terms.

3.7 Storage - OH&S woodchip storage

Health and safety hazards can be associated with the storage and transportation of wood chip fuels. Health and safety hazards include airborne dust, gaseous toxic emissions, spontaneous combustion, asphyxiation, and explosive atmospheres. International standards/procedures for biomass storage and transportation do not currently exist. Best practice suggests the following risks need to be considered when processing woodchips.

Asphyxiation - Wood chips stored in confined spaces with no airflow may produce dangerous (toxic) levels of carbon dioxide. Combining moist woodchips with warm temperatures and limited airflow can cause rapid decomposition and produces high concentrations of carbon dioxide. Entering a confined storage of

woody biofuel has caused asphyxiation with 14 fatalities in Europe between 2002 and 2011.[2] To minimise asphyxiation from woodchip storage the supplier and/or client must:

- Ensure the storage space is well ventilated
- Monitor the temperate inside the woodchip pile. Higher temperatures above 40^0 can increase carbon dioxide levels
- Regularly 'turn over' woodchip piles to minimise temperature build up
- Ensure staff and/or clients are aware of the potential dangers
- Restrict access to woodchip piles by unauthorised persons
- Ensure appropriate signage is installed to highlight dangers within storage spaces

Mould Spores – Moist woodchips, warm temperatures, and restricted airflow may produce mould spores. Inhaling mould spores can lead to health problems (such as aspergillosis in the lungs). Mould will not occur in woodchips that have a moisture level <10%. Woodchip suppliers need to continually monitor woodchips for mould through physical inspection. To prevent mould spores a woodchip supplier and/or client must:

- Store woodchips in a ventilated area
- Monitor woodchip pile for mould
- Provide staff training on the characteristics and dangers of mould in woodchips
- Provide staff with masks, if mould is suspected
- Educate staff regarding mould spores and prevention measures
- Regularly 'turn over' woodchip piles to minimise mould growth
- Restrict access by unauthorised persons to woodchip piles
- Monitor woodchip pile temperature. Higher air and woodchip pile temperatures increase the likelihood of mould.

Woodchip Dust - Wood dust is generated during the chipping process and subsequent handling. Woodchip dust can cause irritation of the lungs, skin disorders and asthma. To minimise woodchip dust the supplier and/or client must:

- Wear a filter mask with a P3 filter when chipping wood
- Use wood chipping equipment that incorporates dust extraction and collection

Dust explosions and fires – In some instances dust has been proven to be as flammable as other accelerants such as petroleum. Dust explosions are common within the wood processing industry. Factors which contribute to dust explosions include:

- Fine dust particles
- Dust particles suspended in the air
- Oxygen
- Enclosed or partly enclosed space which creates a pressure effect
- Ignition source

[2] http://www.hse.gov.uk/research/rrpdf/rr1077.pdf

Wood with a low moisture content will create more dust than wet wood. To prevent dust explosions the supplier and/or client must:

- Reduce the generation of dust. This can be achieved by utilising dust extractors
- Remove and clean any accumulation of dust. Dust cannot accumulate on equipment or any horizontal surface
- Train staff regarding the risks of dust explosions and safety procedures
- Seal plant and equipment to minimise mechanical friction
- Remove dust from hot surfaces such as lights and heaters
- Reduce the generation of dust by keeping speeds low and designing dust-minimising chutes
- Avoid the use of compressed air to clean dust accumulations. This will create dust clouds and increase the risk of explosion.
- Ensure fire alarm systems are integrated allowing for shutdown of plant and heating, ventilation and cooling (HVAC) equipment.
- Ensure fire hydrants are located externally

Spontaneous combustion - Occurs when decomposing material generates enough heat to ignite without a source. Once enough heat is generated, the risk of spontaneous combustion is extremely high. Oxygen can cause the woodchip to ignite and spontaneously combust. Woodchips with a higher moisture content or moist woodchips mixed with dry woodchips have a higher risk of spontaneous combustion. Moist woodchips stored for a long period of time are at higher risk of spontaneous combustion. To reduce the risk of spontaneous combustion the supplier and/or client must:

- Not mix wet and dry biomass within the same storage pile
- Measure the temperature and moisture levels of stored woodchips and monitor temperature trends. This should be conducted twice per week.
- Ensure staff are trained regarding the causes of spontaneous combustion and follow safety procedures
- Use a thermal imaging camera to detect combustible hotspots within the woodchip pile
- Not compact a woodchip pile. Woodchips can be compacted by equipment and vehicle traversing over the pile

Fire Protection – Woodchips are extremely flammable and can ignite from external accelerants (such as cigarettes and embers from bushfires). To reduce the risk of fire the supplier and/or client must:

- Store woodchips undercover
- Install an emergency sprinkler system and firefighting hoses, pumps and extinguishers
- Watch for ember attack if fires are nearby. Embers can travel up to 6km from a bushfire
- Keep other combustible material away from woodchip piles
- woodchip piles should be kept to a manageable size. There are no regulations on woodchip pile size in Australia but the United States regulate 20 metres in height, 100 metres wide and 170 metres long under standard fire standard NFPA 230.[3]
- Ensure staff are trained regarding bushfire risk and prevention

[3] https://s0.hfdstatic.com/sites/the_hartford/files/wood-chip-mulch-storage.pdf

3.8 Delivery - OH&S woodchip delivery

Some of the health and safety hazards associated with woodchip storage carryover to woodchip delivery. Hazards such as contamination, mould, spontaneous combustion, carbon monoxide poisoning and dust explosions can impact on driver safety and woodchip quality.

Woodchip contamination - Woodchip delivery vehicles should be clean prior to loading woodchips. Rubbish or waste left in a trailer will combine with woodchips and contaminate the load. To reduce the risk of contamination the delivery driver must:

- Ensure the trailer is clean and empty before loading woodchips

Mould spores – May be present in woodchips if they have not been stored correctly. To reduce the risk of mould spore inhalation the delivery driver must:

- Wear a filter mask with a P3 filter when loading and unloading woodchips
- Not store woodchips for long periods in a delivery vehicle

Carbon dioxide poisoning – carbon dioxide poisoning may occur if the woodchips have a higher moisture content, the air temperature is warm to hot and the trailer is sealed with no ventilation. To reduce the risk of carbon dioxide poisoning when delivering woodchips, the vehicle driver must:

- Not enter a trailer when loaded with woodchips
- Not store woodchips for long periods in a delivery vehicle

Spontaneous combustion – Can occur if woodchips are decomposing and generating enough heat to self-ignite. To reduce the risk of spontaneous combustion when delivering woodchips, the vehicle driver must:

- Not load a trailer with woodchips that are hot
- Not store woodchips for long periods in a delivery vehicle

Dust explosions – Most trucks/trailers are enclosed to minimise spillage and dust during delivery. Woodchips with a low moisture content will have a higher risk of dust explosions. To reduce the risk of dust explosions when delivering woodchips, the delivery driver must:

- Ensure delivery vehicle is equipped with fire extinguishers
- Load the woodchips slowly into the delivery vehicle to minimise dust clouds

Summary

- In Ballarat, Botanical Resources Australia, SPE, Pyrenees Sawmill, Ballarat Landscape Supplies, and Central Highlands Water have expressed interest in supplying woodchips to biomass users.
- One of the key criteria for quality woodchips is consistent moisture content. The moisture content must be within the manufacturers specifications and wet biofuel cannot be mixed or interchanged with dry biofuel. Woodchips that are not to moisture specification can reduce the performance of the boiler, reduce the life of the boiler and void the warranty.
- Woodchips with a low moisture content, low ash content and high calorific value will perform best in a biomass boiler. Chipping wood that has little or no bark will lower the ash content. Chipping wood with leaves attached will increase ash content.
- Bi-annual woodchip testing will ensure the woodchips comply with the European standard 15234-4. The independent test will report on the calorific value, moisture content, woodchip dimensions, trace metals, ash content and bulk density.
- OH&S risks are associated with woodchips. These risks can impact on human health. Mould, carbon dioxide toxins, dust, and spontaneous combustion need to be considered when chipping, storing and delivering woodchips.
- Staff training on the supply chain will need to be undertaken. This will ensure employees are safe, and wood chips are of a high quality.

Appendix 1

Table 6 – Biomass boilers available for purchase in Australia

Manufacturer	Country	Capacity	Moisture	Material	Material diameter
Moderator	Poland	30kW-240 kW	<25%	wood chips, sawdust, bark, peat, pellets, briquettes	P45
Mabre	Italy	25kW-4MW	<20%	Biomass: olive pits, nuts shells, manure, stone fruit pits, grain, wood chips, wood pellets	P45
Lin-ka	Denmark	100kW-15 MW	Up to 35%	Straw/woodchips/ Pellets/briquettes	P45
Granpal Medium (dry)	Poland	15kW-600 kW	up to 25%	Wood chips, sawdust, shredded wood waste, straw pellets, cereal grains, fruit stones,	P45
Granpal Mega	Poland	800kW-7 MW	up to 50%	Wood chips, sawdust, shredded wood waste, straw pellets, cereal grains, fruit stones,	P45
All Power Labs	United States	150kW	Up to 40%	woodchips	P16 – P45
Uniconfort	Italy	200kW-30 MW	Various moisture levels	Woodchips, pellets, bark, olive and vine prunings,	P30 – P45. Larger size chips for bigger systems
Polytechnik	Austria	500kW-20MW	20% - 60%	Woody biomass, pellets, bark, sawdust	P50
Hargassener	Austria	3kW-800kW	20% - 35%	woodchips, pellets, woodlog	P16 – P45

Manufacturer	Country	Capacity	Moisture	Material	Material diameter
Binder	Austria	200kW-20MW	Max 40%	A variety of biomass including seeds, pits, grains, woodchips and pellets	P16 - P31
Pasqualicchio	Italy	30kW-4MW	Up to 30%	Maize, nut shells, olive pits, olive pomace, wood chips, pellets	P30 - P45
Enertech	Philippines	1MW-10MW	Up to 30%	Rice hulls, coconut shells, woodchips, pellets	P20 - P50
Airtight solutions	New Zealand	300kW-3MW		Dust, woodchips, pellets, briquettes	P20
TFD Biomass boilers	South Africa	500kW-10MW	Up to 50%	Wood chips, pellets or similar	P45
Powermax	China	50kW-20MW	?	A large range of biomass material including woodchips and pellets	P45
Fengyu Group	China	30kW-15MW	<15%	Woodchips, sawdust, straw,	P10
Ankur	India	20kW-2MW	Up to 20%	Firewood, woodchips, bamboo, corn, saw mill waste	P30
Vincke	Czech Republic	3MW-25MW	Doesn't specify	Almond hulls, tree prunings, bark, saw trimmings, wood	P45
D'Allesandro Termomeccania	Italy	100kW-4MW	Up to 30% and up to 50% for GM model	Woodchips, pellets, almond husk, olive husks	P50
Justsen	Denmark	1MW-20MW	10% to 55%	Wood waste (wet or dry) pellets, briquettes, straw pellets, grains.	<P50
Volter	Finland	100kW	Up to 20%	woodchips	P16-P30

Appendix 2

Woodchip testing to be carried out bi-annually by the supplier. HRL Technology Group in Melbourne analyse woodchips and provide a 'Product Declaration Report' in accordance with standard EN15234-4. This form can be used by the supplier to verify woodchip quality to clients.

Woodchip Lab Testing Form (EN 15234-4)		
Item	**Unit**	**Value**
Woodchip supplier		Choose an item.
Wood origin and source		Choose an item.
Particle size class, P	mm	Choose an item.
Moisture	w-% dry	Choose an item.
Ash	w-% dry	Choose an item.
Calorific value	MJ/kg	Choose an item.
Carbon	w-% dry	Click or tap here to enter text.
Hydrogen	w-% dry	Click or tap here to enter text.
Nitrogen	w-% dry	Choose an item.
Sulphur	w-% dry	Click or tap here to enter text.
Chlorine	w-% dry	Choose an item.
Copper	mg/kg dry	Click or tap here to enter text.
Lead	mg/kg dry	Click or tap here to enter text.
Nickel	mg/kg dry	Click or tap here to enter text.
Mercury	mg/kg dry	Click or tap here to enter text.
Zinc	mg/kg dry	Click or tap here to enter text.
Bulk Density	Kg/m^3	Choose an item.

Appendix 3

The supplier completes the Woodchip Declaration Form when woodchips are delivered to a client. The criteria used in the form are taken from standard EN 14961. Criteria are categorised in drop down boxes and include the supplier, the origin of wood, the class of wood, particle size and moisture content.

Woodchip Declaration Form (EN14961)	
Supplier	Choose an item.
Delivery quantity	Click or tap here to enter text.
Date chipped	Click or tap here to enter text.
Origin	Choose an item.
Classification	Choose an item.
Woodchip class	Choose an item.
Particle size	Choose an item.
Moisture content	Choose an item.
Ash Content	Choose an item.
Calorific value (MJ/kg)	Choose an item.
Bulk Density (kg/m^3)	Choose an item.
Chemical treatment	Choose an item.