ARUP

NSW Government Department of Planning, Housing and Infrastructure

Restart of the Redbank Power Station Project (SSD 56284960)

Independent Merit Review of the EIS

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Executive Summary

Merit Review Restart of the Redbank Power Station Project

The NSW Department of Planning, House and Infrastructure (DHPI) engaged Arup to conduct an independent merit review of the Environmental Impact Statement (EIS) for the Restart Redback Power Station Project (dated 20th February 2024). The EIS forms part of the application for approval under the State Significant Development (SSD) provisions (SSD 56284960).

The review aimed to assess whether the EIS adequately addressed six key criteria:

1. the availability of woody biomass supply,
2. the processing capacity of the facility,
3. compliance with the *NSW Energy from Waste Policy Statement* and the *Eligible Waste Fuels Guideline*,
4. the suitability of the proposed technologies in handling the feedstock,
5. the technical fitness of the technology and details of its commissioning, and
6. the effectiveness of emission control techniques and monitoring to ensure alignment with the *NSW Energy from Waste Policy Statement*.

The identified elements from each section and key considerations from the criteria above are:

Feedstock availability

The Verdant project faces significant challenges in securing a reliable biomass supply due to uncertainties around partnerships and feedstock reliability. Key risks include the unverified ability of suppliers to provide sufficient Invasive Native Species (INS), and discrepancies in high yield estimates from landholders. Challenges with alternative feedstocks such as Construction and Demolition (C&D) and Commercial and Industrial (C&I) waste arise due to regulatory restrictions and commercial barriers, including competitive gate fees and contamination risks. The project's ambitious yield estimates for Bana Grass, grown on degraded land, lacks independent validation and may fall short due to environmental and logistical constraints. Legislative reforms could further limit biomass availability, impacting feedstock sources critical for the facility's operational viability.

Processing Capacity

Excessive biomass moisture content poses significant risks to plant performance, emissions, and quality standards. The optimal moisture content for biomass combustion is 25%, but feedstock specifications allow for a wide range (10–50%), challenging combustion efficiency. Biomass storage in uncovered areas exacerbates moisture variability, degrading fuel quality and operational reliability. With projected increases in fuel consumption to 835,000 wet tonnes annually, concerns about ash handling arise due to incomplete combustion from high moisture levels, requiring system modifications. The plant's dependency on up to 700,000 tonnes of dry biomass annually remains unclear in terms of minimum feed rates, potentially increasing reliance on diesel and greenhouse gas emissions. Addressing these challenges is crucial for operational feasibility, environmental compliance, and meeting renewable energy targets.

Compliance with NSW Energy from Waste Policy

The NSW Energy from Waste (EfW) Policy Statement outlines a framework for facilities aiming to recover energy from waste in New South Wales, distinguishing between facilities using eligible waste fuels and Energy Recovery Facilities handling other waste materials. The Eligible Waste Fuels Guideline specifies strict standards for feedstocks to minimise risks to human health and the environment. Verdant Earth's proposal to use Domestic Biomass Fuel (DBF), including end-of-life waste woody biomass, does not qualify as an eligible waste fuel under the guideline due to contamination and inconsistency risks, particularly with copper chrome arsenate timbers often found in C&D waste. Furthermore, Verdant's strategy to secure biomass feedstock through partnerships with Materials Recovery Facilities lacks documentation and viable partnerships. The EIS references broad market analyses without detailed assessments of specific feedstocks, raising doubts about compliance with eligibility criteria. The Verdant Quality Assurance and Control Procedure also lacks chemical analyses to ensure feedstocks are free from contaminants, potentially impacting combustion processes, emissions, and regulatory compliance.

Proven Technologies and Handling Capabilities:

The Redbank facility, which previously operated with beneficiated dewatered coal tailings (BDT) and run-of-mine coal, is transitioning to a 100% biomass fuel operation. This shift presents significant operational challenges due to the differences in feedstock characteristics, primarily the moisture content which can vary significantly (10% to 50%). Higher moisture levels reduce boiler efficiency and increase flue gas flow, straining the system. Additionally, the lower density of biomass feedstock requires modifications to the conveyor systems designed for denser coal materials, potentially leading to overloading, inefficiency, and blockages. Elevated chlorine and phosphorus content in biomass feedstock further complicates operations, potentially causing corrosion in boilers and the formation of hazardous compounds like chlorine gas and dioxins. Effective pre-treatment technologies, such as washing or ash fraction removal, will be necessary to manage contaminant levels and ensure compliance with environmental regulations.

Technical Fitness and Commissioning Details:

The existing fluidised bed combustion (FBC) technology, designed for bed materials with a particle size range of 300 to 600μm, may face agglomeration issues due to the reactive ash-forming elements in biomass, like potassium and chlorine. These issues can degrade fluidisation quality and cause complete defluidisation, leading to significant operational challenges and potential shutdowns. Verdant has not assessed the impact of transitioning from coal to biomass on the operation of the bed material, which is essential to ensure that the FBC system can efficiently manage biomass feedstocks. Further evaluation and modifications to the bed material and fluidisation system will be required to maintain operational continuity and performance with biomass.

Emission Control Techniques and Monitoring:

The transition to biomass feedstock at the Redbank facility involves significant changes in its chemical composition, impacting emissions during combustion. Section 2.4 examines the potential effects of this shift on emissions, particularly focusing on the generation of contaminants and particulate matter (PM). Compared to coal, biomass fuel differs in physical characteristics and elemental composition, resulting in higher levels of PM, including fine particulate matter (PM2.5) that poses risks to air quality and human health. Biomass combustion releases volatile inorganic species, such as potassium hydroxide (KOH) and potassium chloride (KCl), which contribute to PM formation. Elevated levels of specific minerals in biomass, such as phosphorus, sodium, and calcium, exacerbate PM emissions by promoting both fragmentation of minerals and condensation of alkali vapours and sulphates. These changes can alter the size distribution and composition of particulate matter, potentially affecting environmental compliance and operational efficiency at the facility.

Additional Considerations

The Life Cycle Assessment (LCA) compares two scenarios: a biomass scenario using energy crops and land-clearing residues, and a black coal scenario that serves as a baseline despite the facility not using coal since 2014. Given the projected 6-year delay in the facility's operations, displaced generation would likely be part of NSW's renewable energy mix, complicating the net greenhouse gas impact assessment. Assumptions about methane capture efficiency and the potential benefits of bottom ash as a fertiliser substitute also need reassessment. The LCA must address inaccuracies regarding carbon monoxide and the carbon neutrality of wood fuel combustion, considering emissions from processing, transport, and storage. Further investigation is required into the particle size of dry matter, as carbon emissions can vary significantly with particle size, and clarification is needed on how biomass pulverisation has been modelled in the LCA to ensure accurate emission estimations.

Glossary

Abbreviation	Full Terminology
BDT	Beneficiated Dewatered Coal Tailings
EIS	Environmental Impact Statement
NSW DPHI	NSW Department of Planning, Housing and Infrastructure
ROM	Run of Mine
RPS	Redbank Power Station
NSW	New South Wales
NSW EPA	NSW Environmental Protection Authority
INS	Invasive Native Species
LLS	Local Land Services
C&I	Commercial and Industrial
C&D	Commercial and Demolition
EfW	Energy from Waste
MRF	Material Recovery Facility

1. Background and Scope of Work

Verdant Earth (the Proponent) has proposed the restart of operations at the Redbank Power Station (RPS), using biomass - excluding native forestry residues from logging - as a sustainable fuel source to ensure the ongoing generation of electricity (the Project). The facility is located at 112 Long Point Road West, Warkworth (Lot 450 DP 1119428).

Originally commissioned in July 2001, the Redbank Power Station was designed to utilise beneficiated dewatered coal tailings, a byproduct of coal processing, to produce electricity. The facility employs FiCirc® fluidised bed combustion technology, combined with a single 151MW steam turbine and related equipment, specifically engineered to burn low-value fuels such as coal tailings. However, since the supply of coal tailings from the Warkworth mine was no longer available, the power station has been under care and maintenance since October 2014. In light of the proposed restart, the Proponent has prepared an Environmental Impact Statement (EIS) to assess the potential environmental and social impacts of resuming operations (SSD 56284960) using biomass feedstock.

The EIS was publicly exhibited from Friday, 8 March 2024, to Thursday, 11 April 2024. Following the exhibition period, additional information was requested on 30 July and 20 August 2024, specifically regarding the terms of the Voluntary Planning Agreement with the local council and the status of Aboriginal site 'JP22' (AHIMS 37-6-1143), including whether this site could be affected by the project. A total of 21 organisations, including government bodies and key community groups, provided input and advice on the EIS.

Arup has been commissioned by the NSW Department of Planning, Housing and Infrastructure (DPHI) to conduct an independent merit review, focusing on the evaluation of the following critical project elements:

- **Adequate woody biomass supply** – Assessment of biomass availability and competition for feedstock to meet energy production goals.
- **Processing capacity of the facility** – Information on processing rates (typical, maximum, minimum), maximum waste throughput, and waste storage capacity.
- **Compliance with the NSW Energy from Waste Policy Statement** – Adherence to policy and guidelines, including the use of residual waste feedstock from resource recovery processes.
- **Proven technologies and handling capabilities** – Verification that the proposed technologies are reliable, well-understood, and can handle the intended waste feedstock.
- **Technical fitness and commissioning details** – Confirmation that the technology is suitable for its purpose, with adequate details provided for commissioning and proof of performance.
- **Emission control techniques and monitoring** – Compliance with emission control practices, sampling, and monitoring as per the NSW Energy from Waste Policy Statement (EPA, 2021).

The merit review has focused on the following key documents, as requested by NSW DPHI:

- The main EIS
- Appendix F – Plant Conversion Report;
- Appendix M – Fuel Supply Characterisation Study;
- Appendix N – Life Cycle Assessment;
- Submissions Report; and
- any additional information provided by Verdant which relates to the eligibility of proposed waste fuels and sourcing of waste
- Advice issued by NSW EPA as a State Government Agency

- Advice provided by the following public organisations:
  - Australian Forests and Climate Alliance;
  - Australian Foundation for Wilderness Limited;
  - Hunter Environment Lobby;
  - North East Forest Alliance; and
  - Nature Conservation Council of NSW

2. Merit Assessment

The following sections provide a review of the documents and reports outlined in Section 1, focusing on the critical project elements identified by DPHI and the Arup scope of work.

Arup has utilised a RAG (Red, Amber, Green) status system to classify the risk associated with each evaluated item. The definitions for each parameter's rating are outlined below

RAG Status	Definition
(Red)	Represents critical showstoppers that, based on the information provided, do not fulfil the requirements needed to ensure the facility can operate without any significant regulatory or operational issues.
(Amber)	Represents moderate risks that, based on the information provided, indicate partial fulfilment of requirements. These issues have the potential to impact process operations and significantly affect correct functioning in the short to medium term if not adequately addressed.
(Green)	Represents low-level risks that, based on the information provided, meet the majority of requirements.

Comments identified by Arup during this review, which require a response from the proponent or the provision of additional information, are summarised in the red tables at the end of each section.

2.1 Feedstock availability

Item to review	RAG Status
Whether there is likely to be adequate supply of proposed woody biomass to allow energy production at the level proposed by the Applicant, including consideration of any competition for woody biomass feedstock.	(Amber)

The Redbank Power Station's reliance on 100% biomass as a fuel source places a critical emphasis on the availability of adequate and suitable feedstock. With an expectation of using 700,000 dry tonnes of biomass per year, it is essential that the facility has a steady and reliable supply of suitable feedstock to meet both its operational demands and its regulatory compliance and environmental outcomes.

Any disruption in the feedstock supply due to insufficient volumes, delays in delivery, or changes in feedstock quality could significantly impact the facility's ability to generate electricity as planned. Without a consistent flow of biomass that meets the required specifications, the facility may face operational shutdowns, reduced energy output, and higher operational costs, potentially undermining the viability of the project.

Feedstock quality is just as important as its availability, as it directly affects the efficiency and stability of the combustion process. Biomass with inconsistent moisture levels, high contaminant levels, or varying particle sizes can cause both operational issues such as plant and equipment damage or lower energy output, as well as regulatory breaches or environmental harm.

The following sections highlight the key considerations that have been identified following the assessment of key factors that could impact feedstock availability and, in turn, the operation of the facility.

Uncertainty in biomass supply and credibility of supplier partnerships

Verdant has indicated that in year one, 500,000 tonnes of biomass (representing 71% of the total expected feedstock) will be sourced from Invasive Native Species (INS) control on agricultural land, where no higher-order uses have been identified. The EIS further states: *"Verdant has been working with Western Local Land Services (LLS) and a local business organisation, Western Regeneration Pty Ltd, based in Cobar, to enter into a supply agreement for up to 500,000 tonnes per annum of biomass from their approved INS clearing. Verdant Earth is also in discussions with the Central West LLS about establishing similar supply agreements with local landowners in their area"* (Page 64, EIS).

However, no supporting evidence has been provided to confirm the ability of these parties to reliably deliver the stated biomass volumes or whether they are engaged in other projects that might impact the availability of this feedstock. Additionally, there is no publicly available information to substantiate the capacity or operations of Western Regeneration Pty Ltd to facilitate the procurement of the required 500,000 tonnes of biomass. Notably, it appears that Western Regeneration Pty Ltd has been deregistered by the Australian Securities and Investments Commission (ASIC) since 2018[1]. However, it is worth mentioning that the Department has received a redacted Memorandum of Understanding (MOU) between Verdant and Western Regeneration Pty Ltd, dated 17 July 2023.

The independent market study of eligible waste fuels proposed for Redbank Power Station indicates that the landholders interviewed expressed in-principle agreement to supply Verdant with INS waste material, estimating a total of 4,200,000 tonnes available for management and supply from areas with high INS density (Page 22, ARCHE 2024 Higher Order Use Study).

The figure of 4,200,000 tonnes is based on information from three landholders: Landholder 1 (29%), Landholder 2 (14%), and Landholder 3 (57%) (Table 4-1, Page 23, Independent market study of eligible waste fuels proposed for use at Redbank Power Station).

However, discrepancies arise when these estimates are compared with publicly available information. For instance, Landholder 2's operations span 34,000 hectares of owned and leased land and involve a white dorper stud, commercial meat sheep operations, a red angus stud, commercial beef operations, and a meat goat enterprise. The report attributes 600,000 tonnes of INS to Landholder 2. Back-calculating using a yield of 25 tonnes/hectare as stated in the study suggests that 24,000 hectares—approximately 70% of their land—would need to be dedicated to INS supply, which appears inconsistent with their operational focus.

Similarly, no publicly available information regarding Landholder 1's land availability or operational activities of the organisation. This absence of data raises questions about the feasibility of supplying the 1,200,000 tonnes of INS attributed to them.

Furthermore, it is uncertain whether the processing centres expected to manage INS can provide feedstock that meets the physical and chemical characteristics required by the Redbank Power Station, such as particle size and moisture content. These processing centres may lack the necessary equipment and expertise to process this material. Additionally, it is uncertain whether they are willing to invest in the equipment needed for feedstock preparation. Their willingness to transport the INS to the Redbank facility also remains unverified.

Challenges in utilising C&D and C&I waste sources as Domestic Biomass Fuel (DBF)

It has been noted that *"The DBF Verdant are targeting as potential fuel includes Construction and Demolition (C&D) and Dry Sorted Commercial and Industrial (C&I) waste sourced primarily from industry skip and bulk bin collection, and demolition works, where this material is presently destined for landfill"* (Appendix M, page 55). From year three onwards, it is projected that the facility will utilise 50,000 tonnes of

[1] Source: https://publishednotices.asic.gov.au/browsesearch-notices/notice-details/WESTERN-REGENERATION-PTY-LTD-158867773/4014897d-b865-4062-a9b4-f42fce6890c1

Domestic Biomass Fuel annually. Verdant acknowledges that the use of this feedstock is subject to approval from the NSW EPA.

However, the NSW EPA Eligible Waste Fuel Guidelines define uncontaminated wood waste as excluding *"wood waste extracted from mixed waste streams, such as construction and demolition waste."* The guidelines further state that *"uncontaminated wood waste does not include wood waste recovered from highly variable streams, such as mixed municipal solid waste or construction and demolition waste, due to their potential to contain a large number of chemical and physical contaminants over time."* This definition clearly precludes the proposed C&D feedstock. Furthermore, the MRA report also concludes that C&D waste is ineligible and suggests either excluding C&D waste as a feedstock or going down the EfW regulatory pathway as an 'Energy Recovery Facility' as defined under the NSW EfW Policy Statement 2021.

Even if approval for the use of this feedstock is granted by the NSW EPA, an additional commercial challenge has been identified in the C&I and C&D Woody Biomass Feedstock Review Report by MRA (Appendix M, page 183). The report highlights that *"In order to access the market, Verdant will need to meet, if not beat, the current gate fees offered by their competitors"* and notes that *"Verdant's proposed gate fee is higher than both the existing arrangements and what the interviewees nominated."*

Additionally, the independent market study on eligible waste fuels for the Redbank Power Station highlights that Verdant plan to use Uncontaminated Woody Waste (UWW) as an energy source only if it is available and has no other valuable use. However, the study expresses doubt about the availability of this material, given its potential for other uses. As a result, UWW is not assigned a specified tonnage for use at Redbank but may serve as an opportunistic fuel source.

Risks Associated with variable biomass suppliers and feedstock quality

Verdant Earth has stated: *"Verdant Earth have been developing supply agreements with companies that have commercial volumes available of waste biomass from approved clearing activities. It is, however, important to note that suppliers will change from year to year as market conditions and project development will create opportunities for feedstock fuel sources"* (Appendix M, page 53).

To support this claim, Verdant has provided data on woody vegetation clearing rates across adjoining LLS regions. However, the reliance on a dynamic supplier base, with suppliers potentially changing annually, poses significant risks to feedstock availability. This variability may create challenges in securing consistent volumes of biomass needed for operations, as availability will depend on annual market conditions and project developments.

Furthermore, Verdant has emphasised the importance of maintaining high standards for feedstock quality, as indicated in the *Verdant Quality Assurance and Control Procedure for Receipt and Use of Biomass* (Page 223, Appendix M). Frequent changes in suppliers could compromise the consistency and quality of feedstock, potentially disrupting operational processes and impacting the overall efficiency and reliability of the facility. This risk underscores the need for a robust strategy to ensure stable and high-quality feedstock supplies despite the projected fluctuations in supplier arrangements.

Insufficient evidence for Bana Grass yield estimates and potential feedstock risks

The EIS notes that "*Verdant's discussions with local mine sites have revealed the potential for the establishment of an 8,000 ha crop of Bana Grass, which would yield an average of 50 dry tonnes per hectare (approximately 400,000 tonnes per annum), providing over half of the total feedstock requirements for the power station*" (Page 64, EIS). However, the proposed yield estimate lacks independent, publicly available evidence to support this claim. Studies on Bana grass indicate yield variability based on factors such as climate, soil conditions, and agricultural practices. While optimal scenarios can produce high yields, actual results may differ significantly for the NSW scenario, especially when being grown on degraded mine sites with variable soil conditions and profiles.

Without robust data or local field trials confirming that 50 dry tonnes per hectare is consistently achievable in the proposed conditions, there is a risk of lower yields than anticipated. This would directly impact the projected feedstock supply and the facility's operational reliability. Furthermore, potential challenges such as water availability, fertilisation costs, and pest management could further constrain actual yields.

Uncertainty in alternative feedstock sources and operational impact

Verdant has stated: *"Note that these are indicative targets and that actual feedstock mix may vary due to fuel availability, and fluctuations in market conditions. Other potential sources of eligible waste fuels with no higher order uses will also be considered"* (Appendix M, page 62).

This acknowledgment highlights the proponent's recognition of potential challenges in securing the required feedstock volumes due to market fluctuations and availability constraints. While Verdant has suggested the possibility of sourcing alternative eligible waste fuels, there is a lack of clarity regarding what specific types of feedstocks are being considered as substitutes.

Moreover, it is unclear how these alternative feedstocks will meet the facility's stringent quality standards, including moisture content and particle size, which are critical for efficient operation. The introduction of alternative feedstocks may also pose risks to the operational process, potentially affecting equipment performance, energy output, or compliance with environmental regulations.

The absence of detailed information on the assessment, selection, and integration of these alternative feedstocks raises concerns about the facility's ability to adapt to feedstock variability without compromising operational efficiency or sustainability goals.

Challenges in biomass sourcing: impact of increased sourcing radius on transport costs, feedstock availability and emissions

According to the EIS, "*potential cropping land increases over fourfold from 100 km to 200 km, and tenfold from 100 km to 300 km, resulting in a total potential land area of 37,278 hectares"* (Appendix M, Page 130). However, expanding the sourcing radius to these greater distances could pose logistical and economic challenges. "*It is estimated that 112 daily movements (56 round trips) using B-double trucks would be necessary to transport the required biomass"* (EIS, Page 68). While the expanded land availability increases the biomass supply options, it also suggests that the facility may need to source feedstock from beyond the 100 km radius, which will lead to higher transportation costs.

Additionally, there is an increased risk of competition for feedstock, as feedstock suppliers may prioritise closer, established facilities, increasing the risk of feedstock competition. This preference could divert feedstock away from the Redbank facility, potentially impacting feedstock availability. Therefore, while the expanded sourcing area offers more land, it also introduces significant risks related to transportation costs and competition from alternative waste management facilities, which could compromise the facility's ability to secure a stable and cost-effective feedstock supply.

Energy crops and agricultural residues commonly have very low bulk densities, severely restricting economic transport distances without the use of compaction such as pelletising or baling. The need for compaction, and the responsibility of suppliers to implement this for these feedstocks, has not been clearly addressed or discussed with stakeholders, as it was not mentioned in any of the sections involving stakeholder engagement, such as the report '*Market study of eligible waste fuels proposed for use at Redbank Power Station'*.

Furthermore, it is mentioned that *"Verdant assessed the availability of biomass from Ag Residues within a 300 km radius of Singleton as 1,023,172 tonnes/year"* (Page 25, Appendix H - Higher Order Use Study), however, the emissions modelling considered that the energy crops will be transported over a distance of 50 km to the power station (Page 13, Response to submission, Appendix L - Lifecycle Assessment). This discrepancy indicates that the emissions estimates may underrepresent the real emissions for transporting feedstock over a distance greater than 50 km, or if only a 50 km radius from the facility is selected to collect biomass, the availability of agricultural feedstock is much lower than initially reported.

Land availability vs. feedstock security: gaps in assurance for reliable biomass supply

The EIS and Appendix M frequently mention land availability for growing feedstock. For instance, it is stated that "*Within 300 km of the Redbank Power Station, the NSW Department of Primary Industries determined that there is over 8 million hectares of potential suitable land for growing energy crops*" (Page 7, Appendix M). While this states that there is a substantial area of land available, it is important to distinguish between land availability and feedstock security. The information provided indicates that Verdant is confident in its ability to secure the necessary feedstock based on land availability. However, this assumption does not inherently ensure the actual accessibility or suitability of the land for feedstock generation. Furthermore, this assumption overlooks critical factors such as the accessibility of essential services required for growing energy crops, such as water, which could be a significant limiting factor to expected crop yield.

Similarly, the use of invasive native species (INS) as a feedstock is influenced by land availability that is subject to INS clearance approvals. Despite the approvals, the actual rate of INS clearance can be very low due to practical and economic barriers, including the cost of clearance. Western Local Land Services (WLLLS) has reported estimated costs associated with various INS clearance technologies, highlighting the significant financial challenges that can be faced by landholders in managing INS effectively[2]. For the Redbank facility, it remains unclear how it plans to address these costs and whether it can compete with the lower costs of other technologies. This raises questions about the feasibility and sustainability of relying on INS as a consistent feedstock source.

Although the proponent states that it is in, or has had, discussions with entities like Western Local Land Services and Western Regeneration, the information provided lacks details on the reliability and long-term security of these feedstock sources. Most of the documentation refers to land or feedstock availability, but no concrete evidence or assurance is provided regarding the consistency or guaranteed supply of this feedstock. The lack of information on feedstock security presents a potential risk to the facility's ability to maintain a stable and predictable feedstock supply for its operations.

Similarly, the Independent Market Study of eligible waste fuels proposed for use at the Redbank Power Station identifies three landholders as potential contributors to the feedstock supply. However, the security of this feedstock remains unclear, particularly regarding the ability of these landholders to meet the expected quantities and maintain supply consistency over time. Additionally, the study does not provide detailed information about the specific requirements or commitments needed from these landholders to ensure the long-term viability of the feedstock supply. This uncertainty poses further challenges to the reliability and sustainability of the proposed feedstock strategy.

Potential impact of legislative changes on biomass feedstock availability for stage 1 operations

Verdant has outlined that the first stage of its operations at the Redbank Power Station will involve using "*biomass sourced primarily from approved land clearing activities, which currently have no higher order uses"* (Page 5, Appendix M). However, the NSW EPA has flagged as part of its review that recent changes stemming from the NSW Government's response to reviews of the Biodiversity Conservation Act 2016 (BC Act) and the Local Land Services Act 2013 (LLS Act), will introduce additional risk related to future biomass feedstock availability. These legislative amendments aim to strengthen environmental protections and include:

1. Reinforcing Environmental Protections: Measures will focus on reducing the extent of land clearing while increasing areas of native vegetation preserved and permanently managed through set-asides.
2. Improved Management of Invasive Native Species: These changes aim to minimise misuse of invasive species management provisions for clearing purposes.
3. Eliminating Set-Aside Discounts: Amendments will ensure that areas preserved are greater than those cleared, enhancing environmental offsets.

[2] https://www.lls.nsw.gov.au/__data/assets/pdf_file/0007/1137175/WLLS-INS-Management-Guide-W.pdf

These impending legislative reforms introduce significant risks to the availability of biomass feedstock for Verdant. The reinforced restrictions and oversight on land clearing activities directly affect the pool of accessible biomass, particularly from native vegetation areas that may be classified under stricter conservation requirements. Without clear provisions to accommodate biomass production, the supply chain for Verdant's projected feedstock requirement of 150,000 tonnes for Stage 1 could face substantial disruption.

The scale of the impact is yet uncertain, but if amendments curtail the availability of biomass from land clearing operations, Verdant may need to explore alternative sources or strategies to meet its operational needs. This would likely entail logistical challenges and potential cost increases, compounding the complexities of transitioning to biomass-based operations.

Proponent to provide verified data to demonstrate what suitable agricultural land the organisation can realistically secure for feedstock production and supply.

Proponent to provide further details of feedstock chemical characterisation to demonstrate eligibility under the NSW Energy from Waste Policy and Eligible Waste Fuels Guidelines.

Proponent to provide further information to verify the credibility and current operational status of potential feedstock suppliers, along with evidence of their capacity and operational capability to provide the expected feedstock quantities.

Proponent to develop a comprehensive risk assessment to evaluate the potential impacts of legislative changes on biomass supply, including preparation of adaptive management strategies to respond effectively to these changes.

Proponent to develop a risk assessment and a contingency plan to address potential risks associated with supplier variability and inconsistencies in feedstock quality.

Proponent to provide information on feedstock availability and composition that matches the specified quality standards, as the feedstocks currently provided indicate levels of moisture content, chlorine, and potassium that exceed the developed fuel specifications for optimal facility operation.

2.2 Processing capacity of the facility

Item to review	RAG Status
Whether there is sufficient information regarding the processing capacity of the facility including typical, maximum and minimum rates of processing, the maximum annual throughput of waste and the maximum volume of waste to be stored at the premises at any one time.	

The processing capacity of the facility is closely related to the quality of feedstock, as variations in these characteristics can significantly affect the plant's operational efficiency. Inconsistent feedstock quality, such as fluctuating moisture content, can lead to operational disruptions. Furthermore, variations in feedstock quality can cause wear and tear on equipment, leading to increase in potential downtime, further reducing the facility's overall efficiency and reliability.

The following sections highlight the key considerations from assessment of the processing capacity of the proposed Redbank Power Station, specifically evaluating whether sufficient information has been provided regarding the facility's processing capabilities and whether feedstock characteristics align with the expected processing capacity of the facility.

Impact of excessive biomass moisture content on plant performance, emissions, and quality assurance standards

It was stated in Appendix F that "*at biomass fuel moisture levels above about 25%, the plant electrical output is reduced due to flue gas system limitations. The maximum heat input (Gross heat release) occurs at 25% fuel moisture content*" (Page 17, Appendix F). Additionally, the EIS notes that "*general biomass fuel specifications target an expected 25% moisture content*" (Page 66, EIS). This threshold is critical as high moisture content in biomass demands more energy to evaporate water before combustion, decreasing the net heat output. Consequently, the boiler's performance may drop below the 100% Maximum Continuous Rating (MCR) steam load, jeopardising operational efficiency and the ability to meet energy demand.

The biomass fuel specifications indicate that the moisture content range for the feedstock is "*between 10 and 50%"*, which presents a significant variability in moisture levels (Page 237, Appendix M). This broad range introduces operational challenges when optimising the combustion process, as the performance of the combustion system is highly sensitive to moisture content.

Moisture content in biomass directly influences the combustion efficiency of the process and the overall energy output form the facility. Biomass with higher moisture content requires additional energy to evaporate the water, which reduces the heat available for combustion and increases the flue gas volume. Higher moisture levels also lower the effective calorific value of the biomass, thus impacting the stability of combustion, leading to lower combustion temperatures and a potential increase in emissions, such as unburned hydrocarbons and particulate matter. On the other hand, very dry biomass may result in more intense combustion, potentially causing issues such as excessive temperature fluctuations.

Furthermore, the Best Available Techniques (BAT) Reference Document for Large Combustion Plants highlights that *The risks of explosive dust formation and fires in fuel processing and transportation are normally controlled by keeping the fuel moisture content above 40*%[3].

The facility's *Quality Assurance and Control Procedure for Receipt and Use of Biomass* mentions the inclusion of a "*fuel testing report and compliance certificate*." However, it remains unclear whether this certificate will pertain to each specific delivery or represent a generalised sample. Testing bulk biomass may not accurately represent moisture variability within the load, potentially overlooking non-compliant batches.

Furthermore, while the procedures reference European standards for ensuring biomass quality, there is no alignment provided with relevant Australian standards, such as AS/NZS 1080.1:2012, which outlines methods for testing moisture content in timber. This raises questions about the relevance and adaptability of the stated standards in ensuring the quality and compliance of biomass fuel in an Australian context.

Feedstock storage

It was noted in EIS that "*All acceptable biomass feedstock received and discharged at the Redbank Power Station will be stored in the existing coal tailings storage area as originally approved*" (Page 73, Appendix M). Additionally, it was indicated that "*Biomass fuel storage will be stored in an uncovered area. Covered storage is more commonly used overseas in colder, wetter climates for protection against the elements and to maintain a more consistent moisture content fuel*" (Page 20, Appendix F).

However, biomass presents distinct challenges compared to coal due to its physical and chemical properties. Unlike coal, which is dense and less susceptible to weather impacts, biomass materials are highly vulnerable to moisture. Exposure to rain or high humidity can lead to the absorption of water, causing biomass to swell, disintegrate, and lose its calorific value, rendering it unsuitable for combustion. Furthermore, biomass has a lower energy density than coal, necessitating approximately twice the storage space for equivalent energy production.

These characteristics underscore the importance of adequate storage infrastructure and solutions, such as covered and climate-controlled facilities, to maintain biomass quality and operational reliability. Without

[3] https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-11/JRC_107769_LCPBref_2017.pdf

proper storage and handling, the risks of fuel degradation and operational inefficiencies are heightened, potentially impacting the plant's performance and environmental outcomes.

Ash generation from biomass combustion

Figure 7 (below) indicates that projected fuel consumption will increase from 600,000 wet tonnes per year to 835,000 wet tonnes per year. Despite this rise, the report states that ash handling will remain unchanged, utilising either a wet paddle mixer or a dry ash transfer system from a 500m³ silo (Page 18, Appendix F).

This projection assumes a residual ash production of 3-5% of the feedstock by weight, based on a worst-case scenario of 5% (Page 32, Appendix L). However, this estimate may need to be revised, as the ash generation could increase if combustion efficiency declines, especially if the moisture content exceeds the expected 25%. Such an increase in moisture could lead to higher ash production due to incomplete combustion, potentially requiring modifications to the ash handling system.

Figure 7 – Redbank anticipated performance – Biomass fuel firing

	Units	1994 Consent	1997 Consent	Proposed Mods
Fuel Type	-	Coal tailings	BDT	Biomass fuel
Reference fuel moisture	%	dry basis	25	25
Net Plant Output (reference)	MW	100	128	128
Fuel gross specific energy	GJ/te	13 (dry)	21 (wet)	15.21 (wet)
Fuel energy consumption (annual)	GJ/annum	12.7 million	12.7 million	12.7 million
Approximate fuel consumption[6]	Te/annum	975,000 (dry)	600,000 (wet)	835,000 (wet)
Approximate fuel consumption	Te/annum	975,000	450,000	626,000
Calculated efficiency (GSE basis)	%	*22.7%* [7]	29.9%	27.2%

Biomass supply thresholds and operational efficiency

It has been indicated that "*The plant consists of two fluidised bed combustion steam generator units of FiCirc™ design and a single 151MW steam turbine and associated balance of plant equipment*" (Page 5, Appendix F), and the EIS states that the plant will operate using up to 700,000 tonnes of dry equivalent biomass per annum as feedstock fuel. However, no information is provided on the minimum feed rate required for efficient plant operation without resorting to additional external fuel sources, such as diesel.

This lack of clarity could have significant implications for the operational feasibility and environmental performance of the plant. If the biomass supply falls below the efficient threshold, reliance on external fuels like diesel could increase, leading to higher greenhouse gas emissions and operational costs.

This issue was not comprehensively addressed in the Response to Submission Appendix E – AQ and GHG Addendum. While Verdant Earth noted that diesel would be used for an average of 40 hours per year to accommodate two outages (one minor and one major), the response did not account for the potential need for additional diesel usage during unanticipated outages due to insufficient feedstock supply. Furthermore, it failed to consider how supply shortages could result in operational inefficiencies that increase reliance on non-renewable fuels.

Understanding this threshold at which the plant can operate efficiently is essential for ensuring consistent plant operation, minimising disruptions, and maintaining compliance. Additionally, insufficient supply planning could compromise the project's ability to meet its renewable energy generation targets, and the GHG emission assessment will need to be further reviewed.

Proponent to provide on-site management strategies for controlling moisture content in feedstock, beyond solely relying on 100% supplier compliance, as this may also impact feedstock availability, given that not all available suppliers will be willing or able to meet the required feedstock quality standards.

Proponent to provide evidence that feedstock storage in open air will not adversely affect the feedstock quality or the process. This should be supported by examples of facilities currently operating under similar conditions, without on-site pre-treatment or processing, and relying on third-party suppliers for feedstock QA/QC. This should include details of equipment used, operational conditions of the combustion process, and acceptable moisture content levels.

Proponent to provide information supporting the assumptions regarding the volume and quality of ash production and evaluate the impact of changes in fuel type composition on ash generation over time, considering potential annual variations.

Proponent to provide a sensitivity analysis considering a variance of 10% to 50% above or below the 25% moisture content to evaluate its impact on air quality, greenhouse gas emissions, ash production, feedstock requirements, and the station's reliability as a power source for the National Electricity Market, supported by evidence to define an acceptable moisture content range.

2.3 Compliance with NSW Energy from Waste Policy Statement and Eligible Waste Fuel Guideline.

Item to review	RAG Status
Whether the project adequately addresses all aspects of the NSW Energy from Waste Policy Statement and Eligible Waste Fuels Guideline, including that the waste used as a feedstock in the facility would be the residual from a resource recovery process that maximises the recovery of material (e.g. it satisfies the relevant waste hierarchy).	

The NSW Energy from Waste Policy statement outlines the policy framework and technical criteria that apply to facilities proposing to recover energy from waste in NSW.

The policy establishes a 2-door framework for assessment of EfW proposals – those that propose to use low risk waste materials referred to, and defined as, Eligible Waste Fuels, and those that propose to recover energy from any other waste material that is not an eligible waste fuel, which are defined as Energy Recovery Facilities.

The supporting Eligible Waste Fuels Guideline provides further details on the types of eligible waste fuels, the requirements for waste characterisation, and the regulatory framework for using these fuels. These guidelines must be carefully assessed by any proponent seeking to develop an EfW project to ensure compliance with regulatory and environmental standards.

It should be noted that the technical requirements associated with having a proposal assessed as an ‘Energy Recovery Facility’ under the policy framework are significantly more onerous than a facility proposing to recover energy from only eligible waste fuels.

It is therefore critical that the information provided to validate the type, origin, composition, supply and consistency of eligible waste fuels is rigorous and robust to ensure that its consideration as a low risk to human health and the environment from energy recovery practices is valid.

The following sections highlight the key considerations that have been identified following the assessment of compliance with the NSW EfW policy statement and the eligible waste fuel guideline.

Ineligibility of domestic biomass fuel under eligible waste fuels guideline

Verdant Earth has acknowledged that Domestic Biomass Fuel (DBF), intended for use at its facility, does not currently qualify as an eligible waste fuel under the **Eligible Waste Fuels Guidelines**. As stated, *"DBF is not currently prescribed as an 'eligible waste fuel' under the Eligible Waste Fuels Guidelines. DBF fuel will include end-of-life waste woody biomass sourced and prepared to specification and fit-for-purpose at Redbank Power Station (subject to NSW EPA approval as an eligible waste fuel)"* (Page 55, Appendix M).

Furthermore, feedback from the **NSW EPA** has further emphasised that Domestic Biomass Fuel is unlikely to be approved as an eligible waste fuel. Concerns raised include the potential for contamination and the inconsistency or heterogeneity of the feedstock's composition. These issues pose significant challenges for maintaining compliance with regulatory standards and ensuring operational reliability at the facility. The NSW EPA also stated that "*Domestic Biomass Fuel is not an eligible waste fuel and the approval pathway to enable it to be an eligible waste fuel is not through a Specific Resource Recovery Order and Exemption. The EPA would like to highlight that the Proposal has been assessed using only standard fuels and eligible waste fuel and should not rely on changes to policies or legislation if the proposed feedstock becomes compromised*"

Similarly, the MRA report included in the Fuel Supply Characterisation Study (Page 184, Appendix M) also reinforces these concerns, explicitly concluding that construction and demolition (C&D) waste, a potential source of Domestic Biomass Fuel, is ineligible under the current guidelines, and suggested as one of their recommendations to exclude C&D waste as a feedstock to align with the regulatory framework.

One of the biggest risks associated with producing woody biomass feedstock from processing mixed C&D waste is the inclusion of copper chrome arsenate (CCA) timbers, that are often difficult to identify and/or segregate from other clean timbers, and that can have a significant impact on copper, chrome and arsenic contaminant loading in both bottom ash and air emissions.

This could lead to further problems with the proposed reuse of bottom ash from the facility, if increased levels of these heavy metals means that it won't comply with the chemical criteria set out in the NSW EPA *ash from burning biomass order and exemption 2014*.

Challenges in securing domestic biomass fuel through materials recovery facilities

The NSW Energy from Waste Policy Statement views energy recovery as a supplementary waste management solution, specifically for residual waste generated from material recovery processes or source-separated collection systems. In alignment with this policy, Verdant has proposed entering into joint venture partnerships with Materials Recovery Facilities (MRFs) to process waste and recover woody biomass feedstock to meet the required specifications, as outlined in a Specific Resource Recovery Order and Exemption (Page 56, Appendix M).

However, Verdant's EIS lacks sufficient documentation to substantiate the existence of established partnerships or to identify MRFs willing to collaborate in this capacity. Additionally, significant challenges are posed by the strict feedstock quality requirements, including a moisture content of 25% and precise particle size specifications. The proposed feedstock specification requirements are unlikely to align with the standard operations of most MRFs without significant modifications, which may be financially or operationally impractical.

Most MRFs in NSW are designed to sort and recover commingled recyclable materials, typically sourced from household waste, and do not usually include timber or biomass material in their input streams. It would be challenging to utilise this network of facilities to provide suitable feedstock for the Redbank facility without significant changes to collections systems, supply contracts, and plant and equipment.

MRFs or processing facilities that typically handle timber are C&D waste processing facilities that can sort timber from mixed C&D waste, however, as noted in the section above, this timber is considered higher risk by the EPA due to the heterogeneity of the feedstock composition and the risk of contamination.

Without evidence of viable partnerships or a clear strategy to achieve compliance with the feedstock quality standards, the feasibility of securing Domestic Biomass Fuel (DBF) feedstock for operational use remains highly uncertain. This uncertainty raises concerns regarding the project's ability to meet both regulatory and operational expectations.

Potential compliance risks due to feedstock variability from changing suppliers

The issue of feedstock variability due to changes in suppliers, as noted by Verdant, could present a compliance challenge under the NSW EPA's Eligible Waste Fuel Guideline. According to these guidelines, any eligible waste fuel used in energy recovery must consistently meet strict origin, composition, and consistency criteria.

The NSW EPA's Eligible Waste Fuel Guideline state, "*The overarching principle of the eligibility of a waste as an eligible waste fuel is that it should pose a minimal risk of harm to the environment and human health due to its origin, low levels of contaminants and consistency over time. The proponent must consider the consistency of the proposed waste fuel to ensure its potential environmental impact will not vary over time*"[4]. Additionally, a valid Resource Recovery Order and Exemption must be in place for all eligible waste fuels prior to their use.

Changing suppliers may introduce variability in the feedstock, potentially affecting its compliance with criteria established by the EPA under a specific Resource Recovery Order and Exemption. This could lead to issues with maintaining the required fuel quality or consistency over time, which are critical outcomes for meeting operational performance standards and regulatory outcomes.

Market analysis for higher-order reuse of feedstocks

As part of the eligibility requirements for waste fuel under the **Eligible Waste Fuel Guidelines**, the proponent is required to demonstrate that there are no practical, higher-order reuse opportunities for the waste being proposed. Section 6 of the independent market study on eligible waste fuels examines feasible uses for the anticipated feedstocks. While the report identifies that a significant proportion of the feedstock lacks higher-order reuse options, this analysis is not specific to the secured feedstock intended for the facility. Instead, it evaluates the broader availability of feedstocks across a wide area. There is a potential risk that the feedstock genuinely available for the facility may already have established recycling applications.

Furthermore, for uncontaminated woody waste, the study indicates that more than 66% of this feedstock is recyclable. Consequently, this material would not meet the eligibility criteria outlined in the Eligible Waste Fuel Guidelines.

It would be beneficial if the proponent could provide additional evidence demonstrating higher-order reuse opportunities specifically for the secured feedstock intended for use by the facility, thereby narrowing the focus to opportunities relevant solely to this feedstock.

Feedstock quality analysis

The **Eligible Waste Fuel Guidelines** specify that applications to use forestry and sawmilling residues must include information regarding any treatments the waste has undergone, such as sprays or fire retardants, commonly used in bushfire management. Fire retardants are commonly used to manage bushfire risks, particularly in relation to strategic containment efforts. These chemicals, which include but are not limited to ammonium sulphate, diammonium sulphate, and ammonium phosphate can remain in forestry residues and, if not properly accounted for, could introduce contaminants into the biomass feedstock.

Similarly, conventional agricultural systems in Australia use a wide range of agricultural chemicals to boost yields and quality of produce, as well as pesticides to control weeds, insect pests, and disease. The NSW

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[4] https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/waste/22p3822-eligible-waste-fuels.pdf

EPA Eligible Waste Fuels Guidelines clearly outlines that biomass from agriculture "*may contain pesticide or herbicide residues. The risks presented by these residues will be assessed as part of the resource recovery order and exemption application*"[5]. Most of the commonly used pesticides either containing chlorine (e.g., atrazine, 2,4-dichlorophenoxyacetic acid, pentachlorophenol dichlorprop, etc.) and/or are embedded with dioxin precursor structures (e.g., dichlorprop, decamethrin, niclosamide, etc.)[6].

Even though Verdant is aware that this is a requirement for feedstock eligibility, the *Quality Assurance and Control Procedure for Receipt and Use of Biomass* does not include specific information regarding chemical analysis to determine that the feedstock is free from pesticides, herbicides, fire retardants and other chemical components. The Verdant *Quality Assurance and Control Procedure for Receipt and Use of Biomass*, only outlines a set of parameters to be analysed by the feedstock supplier, including moisture content and ash (Page 240, Appendix M). The omission of these chemical components from the feedstock analysis raises concerns about potential environmental and operational impacts, as their presence could affect combustion processes and emissions.

Proponent to clarify the changes to the composition of the proposed feedstock supply if DBF is not determined to meet the requirements of an eligible waste fuel, as this could have implications for the how the proposal is assessed under the EfW policy framework.

Proponent to provide details regarding potential compliance risks arising from feedstock variability and availability, and outline how the facility will manage situations where feedstock eligibility is compromised for these reasons.

Proponent to provide additional evidence demonstrating higher-order reuse opportunities specifically for the secured feedstock intended for use by the facility.

Proponent to provide information regarding feedstock management that addresses contaminants associated with pesticides and fire retardants, as these were not included as part of the quality requirements.

2.4 Proven technologies and handling capabilities

Item to review	RAG Status
Whether the proposed technologies are proven, well understood and capable of handling the proposed waste feedstock.	

The Redbank facility previously operated using BDT as the primary fuel and run-of-mine coal as a supplementary fuel. Transitioning to a 100% biomass fuel-operated facility introduces operational challenges due to the fundamental differences in the chemical and physical characteristics of the feedstock.

The following sections highlight the key considerations that have been identified following the assessment and evaluation of key feedstock characteristics (such as moisture content, density, chlorine, and phosphorus), on the facility's operations. It also highlights the core differences between biomass and previous fuel types that need to be carefully considered in the transition.

[5] https://www.epa.nsw.gov.au/-/media/epa/corporate-site/resources/waste/22p3822-eligible-waste-fuels.pdf

[6] https://link.springer.com/article/10.1007/s12649-016-9744-5

Impact of feedstock moisture content on operational performance and feedstock quality

Verdant has specified that the Redbank Biomass facility *"is designed to process feedstock with a moisture content of 25%, allowing for a range or limit between 10% and 50%"* (Table 5.1, Page 63, Appendix M). However, during the FiCir Boiler Performance analysis, Boiler & Power Plant Services Pty Ltd identified significant implications of deviations from this design specification[7]. Increased moisture in the feedstock directly results in higher fuel consumption and diminished overall process efficiency. As detailed in the boiler performance report (Appendix F – Response to submissions), "*increasing the moisture content in fire-damaged tree trunks from 15% to 45% caused a 75% rise in fuel requirements. This was due to both the energy-intensive evaporation of the additional moisture and a decrease in boiler efficiency from 81.5% to 72.1%. The reduction in efficiency arises because more energy is diverted from generating usable heat to evaporating excess moisture"*. Additionally, Verdant noted that higher moisture levels elevated flue gas flow, compounding operational challenges (Page 5, Appendix F).

Despite the boiler being designed to accommodate feedstock with a 25% moisture content, the absence of an on-site pre-treatment process to regulate and manage feedstock moisture content poses significant challenges. Elevated moisture levels in feedstock introduces complexities in the operation of fluidised bed boilers. For instance, increasing fuel moisture (at a fixed excess air level), reduces the temperature throughout the fluidised bed volume due to the energy consumed in evaporating water, even when residence time increases, because of the apparent influence of the latent heat of water evaporation[8]. This variability can lead to suboptimal fluidisation, increased risk of agglomeration within the bed material, and impacting residence time to complete fuel combustion.

High moisture content in feedstock increases energy consumption requirements. Extra energy is consumed to evaporate the water content, reducing the heat available for practical use. This process also increases the volume of flue gases due to the water vapour and heated combustion air, placing additional strain on the system.

During biomass storage and drying, moisture content facilitates chemical precipitation (e.g., chlorides, sulphates, phosphates) and leaching of critical elements like calcium, potassium, and magnesium, while microbial proliferation in moist conditions poses health risks associated with mould and fungus growth[9].

To address these issues, implementing a robust on-site pre-treatment process, such as drying, is highly recommended. Such measures would help maintain optimal combustion performance, minimise operational inefficiencies, and reduce environmental impacts[10].

Impact of biomass density on conveyor system design and operation

Verdant has indicated that the proposal "*includes the repurposing of several existing conveyors for transporting the biomass feedstock, specifically the CV76 Existing reclaim conveyor, CV34 Existing tailing/supplementary fuel conveyor, and CV35 Existing supplementary fuel conveyor"* (Page 21, Appendix F). These conveyors were originally designed to handle beneficiated dewatered coal tailings (BDT) and run-of-mine coal as supplementary fuels. According to literature, coal and coal tailings typically have a density ranging from 800 to 1500 kg/m³. However, the biomass feedstock expected for use at the facility has a significantly lower density, ranging from 160 to 490 kg/m³ [11,12,13].

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[7] Microsoft Word - B&PPS C12148-01 Redbank Performance using Bush Fire Damaged Trees - Issue 2.docx

[8] https://www.sciencedirect.com/science/article/pii/S0360544210002963

[9] https://www.sciencedirect.com/science/article/pii/S0016236115005578

[10] https://www.aee-intec.at/0uploads/dateien1299.pdf

[11] https://www.osti.gov/biblio/588739

[12] https://www.sciencedirect.com/science/article/pii/S003259101731001X

[13] https://www.tapcoinc.com/images/uploads/Tapco_Catalog_09_p88-94.pdf

This discrepancy in material densities may present several operational challenges. Lower-density materials like biomass take up more volume for the same mass when compared to denser materials such as coal or coal tailings. As a result, the conveyors, initially designed for higher-density fuels, may face issues with volumetric capacity[14]. Specifically, the conveyors may not efficiently handle the increased volume of biomass feedstock that needs to be transported. This increase in material volume can exceed the conveyors' designed capacity, potentially leading to overloading, inefficiency, and even potential blockages or overheating of the conveyor system due to higher material volumes. Additionally, there is no indication on how Verdant plans to meet the feed rate of existing conveyor systems or address the implications of the change in feedstock of their operations.

Additionally, the lower density of biomass can cause an increase in the energy requirement for moving the material. Since biomass takes up more space due to its low density, conveyors will need to move larger volumes of material for the same mass, which in turn requires more energy to operate the belts. The energy needed to move biomass could therefore be significantly higher than that required for coal tailings, demanding additional power or more frequent maintenance to maintain optimal performance.

Moreover, the design of the conveyors will need to be evaluated to ensure that they are capable of handling the different material flow characteristics of biomass. Biomass can be more friable, fibrous, or sticky compared to coal, further complicating its movement along the conveyor. Consequently, the repurposed conveyors might require modifications such as increased belt strength, adjusted skirt friction settings, or improved dust control measures to ensure smooth operation and reduce wear and tear.

Challenges of elevated chlorine and phosphorus content in feedstock

The facility has been designed to manage Beneficiated Dewatered Tailings (BDT) and run-of-mine (ROM) coal as supplementary fuel. With the transition to a 100% biomass feedstock for electricity generation, the proponent has proposed modifications to three key areas (Page 2, Appendix F):

- Internal roadways including new weigh bridges
- Supplementary fuel receival, storage, and reclaim
- Supplementary fuel transport equipment.

However, this transition has not fully considered the operational implications of changing from coal to biomass feedstock the fundamental differences between biomass and coal as fuels. Biomass contains larger quantities of alkali and alkaline earth elements (potassium, sodium, calcium, magnesium), phosphorus and chlorine than coal. As all the constituents of the biomass enter the boiler, several technical concerns arise. Higher fuel chlorine contents can lead to greater high-temperature corrosion in boilers. Accelerated fouling and slagging can occur when fuels containing high levels of potassium are utilised[15].

An analysis of the proposed biomass fuel for the Redbank Power Station highlights that "*perennial grasses contain significantly elevated levels of chlorine (1.42 ± 0.46% daf), potassium (37.6 ± 7% db), and phosphorus (8.4 ± 1.2% db). Similarly waste biomass from land clearing activities exceeds the chorine content (0.25 ± 0.17% daf)"* (Page 189, Appendix M). These values far exceed the feedstock specifications set by Verdant.

Such elevated levels of alkaline and halogen elements, particularly potassium and chlorine, present a range of technological and environmental challenges during biomass combustion and conversion processes.

[14] https://www.sciencedirect.com/science/article/pii/B9780128185858000039

[15] https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-11/JRC_107769_LCPBref_2017.pdf

One major issue is the volatilisation of potassium and chlorine, which leads to the formation of hazardous compounds such as chlorine gas (Cl_2) and hydrogen chloride (HCl)[16,17]. As the flue gases cool in the boiler section, a large portion of these chloride salts condense into solid particles or adhere to surfaces like heat exchangers or fly ash. Investigations have shown that between 40% to 80% of the total chlorine released is embedded in the ash when wood chips or bark are burned[18]. For straw or cereals combustion, this figure rises to 80% to 85%, especially when baghouse filters are used to capture particulate matter[19]. These compounds are highly corrosive gases, accelerating wear and damage to boiler tubes, heat exchangers, and other critical plant components, leading to increased maintenance costs and equipment downtime.

Similarly, due to the presence of high levels of chlorine, there is a risk that dioxins and furans are generated, which can cause significant environmental and human health impacts due to their toxicity and persistence. These components have high thermal and chemical stability in the environment and can only be destroyed above temperatures of 1,000 ºC. It should be noted that PCDD/F (Polychlorinated dibenzodioxins and dibenzofurans) are not only found in stack gases but also in solid residues from any combustion process, such as in bottom ashes, slags, and fly ash[20].

Another critical impact of biomass combustion is the formation of potassium salts, such as potassium chloride (KCl) and potassium sulphate (K_2SO_4), which are often water-soluble. This characteristic increases their leaching potential in combustion residues like ash[21].

Despite Verdant's stringent feedstock specifications to limit such problematic elements, perennial grasses and waste biomass from land clearing often exhibit levels of chlorine and potassium that are two to three times higher than the Verdant acceptable limits included in the *Quality Assurance and Control Procedure for Receipt and Use of Biomass*.

While Verdant has placed the responsibility of meeting these specifications on suppliers, the facility itself will bear the operational and environmental consequences if these elevated levels are not addressed. Implementing effective pre-treatment technologies, such as washing or ash fraction removal, or sourcing alternative feedstocks with lower contaminant levels, may be necessary to mitigate these risks, ensure stable operational performance, and ensure the facility can comply with the *Protection of the Environment Operations (Clean Air) Regulation*.

Proponent to provide details on the design limits/specifications of the existing CFB furnace with respect to moisture content, calorific value, fuel flow rate and how optimal combustion high moisture/low CV feedstocks will be managed.

Proponent to provide evidence that design biomass feed rates can be achieved by the retained belt conveyors (e.g., CV34 and CV35) across the full range of bulk densities for proposed biomass feedstocks.

Proponent to provide details on the impact of using standard fuels, including high chlorine and potassium feedstocks such as perennial grasses and energy crops, that do not comply with the key fuel specifications for optimal plant operations listed in Appendix M, Table 5.1. Impacts include excessive corrosion, slagging and fouling, fines particulates, and trace air pollutants.

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16 https://www.sciencedirect.com/science/article/pii/S0016236115005578

17 https://www.sciencedirect.com/science/article/pii/S0961953403001041

18 https://www.bios-bioenergy.at/images/bios/downloads/publikationen/Aschen+Aschenutzung-Ashes+AshUtilisation/004-Paper-Biedermann-AshRelated-Problems-BM-combustion-Possibilities-SustainableAshUtilisation-WREC2005.pdf

19 https://www.bios-bioenergy.at/images/bios/downloads/publikationen/Aschen+Aschenutzung-Ashes+AshUtilisation/004-Paper-Biedermann-AshRelated-Problems-BM-combustion-Possibilities-SustainableAshUtilisation-WREC2005.pdf

20 https://eippcb.jrc.ec.europa.eu/sites/default/files/2019-11/JRC_107769_LCPBref_2017.pdf

21 https://www.sciencedirect.com/science/article/pii/S0016236115005578

2.5 Technical fitness and commissioning details

Item to review	RAG Status
Whether the technology is technically fit for purpose, and the EIS includes adequate details of commissioning and proof of performance.	

The technical suitability of the operation is closely linked to the technologies employed, the handling capabilities, and the comprehensive assessment of feedstock characteristics. Ensuring that all systems are technically fit for purpose and undergo proper commissioning is essential for achieving optimal performance. As outlined in sections 2.2, 2.3, and 2.4, there are overlapping considerations that directly impact these aspects, highlighting the importance of incorporating feedstock characteristics and handling capabilities into the operational framework.

This section further evaluates the impact of feedstock changes on bed material operations, specifically addressing how variations in feedstock composition may affect the efficiency and stability of the combustion process and overall plant performance.

Impact on bed material due to change in feedstock from coal to biomass

The existing fluidised bed combustion technology is designed to operate with a mean particle size of the bed material in the range of 300 to 600µm. The bed material is fluidised by primary air introduced through air distributors at the bottom of the bed, and by the gas generated during combustion (Page 3, Appendix M).

However, the use of biomass as a feedstock, instead of coal, introduces challenges related to bed material agglomeration. Biomass fuels contain a variety of ash-forming elements with reactive and fluxing properties, such as potassium and chlorine compounds. These elements have been shown to promote agglomeration during fluidised bed combustion (FBC) by causing the bed material particles to stick together. Agglomeration can lead to a decrease in fluidisation quality and, in extreme cases, to complete defluidisation - where the bed stops being effectively fluidised, causing significant operational problems and potentially leading to an unscheduled shutdown of the combustion system[22].

Verdant has not provided any information or assessment regarding the effects of transitioning from coal to biomass on the operation of the bed material. This is an important consideration, as the existing bed material may not be suitable for handling biomass without adjustments, especially when considering the increased risk of agglomeration. Therefore, further evaluation of, and potentially modifications to, the bed material and fluidisation system will be required to ensure the continued and efficient operation of the FBC system with biomass feedstocks.

Proponent to provide information or an assessment on the operation of the bed material from biomass fuels containing ash-forming elements with reactive and fluxing properties, such as potassium and chlorine compounds.

[22] https://pubs.acs.org/doi/full/10.1021/ef0400868

2.6 Emission control techniques and monitoring

Item to review	RAG Status
Whether the proposed emission control techniques and practices, including emission sampling and monitoring, that will be employed for eligible and standard fuels meet the NSW Energy from Waste Policy Statement (EPA, 2021).	

A change in biomass feedstock results in a shift in its chemical composition, which in turn affects the emissions expected to be generated during combustion. An analysis of the impact of this change on emissions associated with the feedstock intended to be used at the facility is provided in section 2.4.

This section offers further analysis on the potential impacts of biomass combustion on emissions, including the generation of contaminants and particulate matter, which could have significant implications for environmental compliance and operational efficiency.

Impact of biomass combustion on emissions

The properties of biomass fuel differ significantly from coal, leading to distinct particulate matter (PM) emission characteristics during combustion. Compared to coal, biomass combustion, particularly of wood and agricultural residues, produces higher quantities of PM. Additionally, the physical characteristics and elemental composition of the emitted PM vary notably between the two fuels[23].

The biomass fuel characterisation for Redbank Power Station, for example, highlights that "*perennial grasses exhibit elevated levels of chlorine"*, above those expected (Page 189, Appendix M). During biomass combustion, volatile inorganic species such as potassium hydroxide (KOH) and potassium chloride (KCl) are released into the gas phase. These compounds undergo complex chemical and physical reactions, contributing to the formation of fine PM. Studies have shown that PM emissions from agricultural biomass combustion are dominated by particles with diameters of less than 2.5 µm (PM2.5), which have significant implications for air quality and human health[24].

Furthermore, the feedstock analysis identified "*elevated levels of specific minerals across different biomass types, such as phosphorus in perennial grass, sodium and calcium in waste biomass from land-clearing activities, and calcium in agricultural wastes"* (Page 189, Appendix M). These minerals contribute to PM formation through two primary mechanisms[25,26]:

1. **Fragmentation of minerals**: Components rich in magnesium (Mg), calcium (Ca), phosphorus (P), iron (Fe), and silicon (Si) form coarse particles as they break down during combustion.
2. **Condensation of alkali vapours and sulphates**: Alkali compounds released into the flue gas condense and nucleate, forming additional coarse particles.

The elevated levels of alkali metals and chlorine in biomass also increase the volatilisation of these species, further exacerbating PM emissions and altering the size distribution and composition of the particulate matter.

[23] https://www.researchgate.net/publication/256493032_Ash_Transformation_Chemistry_during_Combustion_of_Biomass

[24] https://pubs.acs.org/doi/full/10.1021/acs.energyfuels.7b00229

[25] https://www.researchgate.net/publication/221987535_Particle_emission_from_combustion_of_oat_grain_and_its_potential_reduction_by_addition_of_limestone_or_kaolin

[26] https://pubs.acs.org/doi/full/10.1021/acs.energyfuels.7b00229

Proponent to provide additional details of air emissions resulting from combustion of feedstocks with elevated levels of volatile inorganic species, such as perennial grasses and agricultural residues.

2.7 Additional items reviewed

2.7.1 Lifecycle Assessment (LCA)

Understanding the Life Cycle Assessment is essential as it offers a thorough evaluation of the environmental impacts throughout the project's life.

The following section provides a summary of the Life Cycle Assessment review for the Redbank Power Station, with key aspects highlighted that require further investigation due to their potential influence on assessment of the project's environmental impacts.

Comparative scenario[27]

The LCA compares two scenarios, a biomass scenario (for energy crops and land clearing residues) and a black coal scenario (Figure 5 and 6, Response to submission Appendix L – Lifecycle Assessment). The black coal scenario has been included as this was the original fuel feedstock specified when the facility was first developed. However, the facility has not been operational with black coal as a fuel feedstock since 2014, and so it is incorrect to compare biomass as displacing black coal, but rather it would form part of the national electricity market and form part of the energy mix of NSW.

As it would form part of the energy mix of generation in NSW, it is also incorrect to assume that it is displacing any other form of generation but if it were, it would only displace what is currently in the NEM.

Furthermore, since the facility is not slated to be operational for 6 years, the generation it would be displacing would be the energy mix in 2030 rather than now, which would likely be close to 50% renewable. Over a 40 year project life it is feasible that at some point in this time horizon that generation would likely be displacing renewable power and have a net greenhouse gas impact, not benefit.

Reference to Methane Capture in Landfill

The results have been predicated on the assumption there would be 100% methane capture should waste products go to landfill. At best, average methane capture in Australia is circa 70%, and this therefore needs to be accounted for as part of this calculation.

Fertiliser Displacement

The results have been predicated on the assumption that the bottom ash could feasibly displace fertiliser use. It would be incorrect to assume that this would be an actual scenario given that at best this would be a product that may be used in conjunction with standard fertilisers to achieve desired agronomic benefit. The majority of emissions associated with fertilisers come from nitrogen (circa 70%). It is understood that the potential bottom ash fertiliser replacement would have minimal nitrogen content.

Reference to Carbon Monoxide not being a Greenhouse Gas

The LCA makes reference to the carbon monoxide (CO) not being considered as a greenhouse gas or having an impact on, however, this is disputable and while it is not currently accounted for under NGERs, CO does have an impact on global warming potential. Suggest removal of statement referring to carbon monoxide not having an impact.

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[27] Biomass and natural gas co-firing – evaluation of GHG emissions - ScienceDirect

Carbon Neutrality Principle of Combustion and Harvesting of Wood Fuel

The LCA seems to imply that the growing of trees for harvest and combustion has a greater net benefit than the combustion of the timber for power. However, it is not entirely clear. The report indicated "the carbon neutrality principle has not been applied" and the growing component and absorption of atmospheric carbon component of the process would outweigh the combustion release of stored carbon during power production. If this is the case, most literature would suggest that at best it is a carbon neutral (or close to it after accounting for wood processing) process. It is recommended that carbon neutrality principle be applied as well, accounting for the emissions associated with processing, transport etc.

Particle Size of Dry Matter

The quantity of carbon emissions associated with dry matter pulverisation can change dramatically depending on the particle size that the dry matter is processed to. Biomass that is pulverised to 0.1mm as opposed to 0.5mm could result in a 5.5-fold increase in carbon emissions. Please confirm to what extent the biomass pulverisation has been modelled

Proponent to provide additional evidence to support the claim that bottom ash could displace fertiliser use

Proponent to remove of statement referring to carbon monoxide not having an impact.

Proponent to confirm to what extent the biomass pulverisation has been modelled