Expert report on Climate Change and Ecologically Sustainable Development matters

By Dr Annette Cowie

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Note to readers:

Dr Annette Cowie is a senior principle research scientist for Climate at the NSW Department of Primary Industries (NSW DPI). She concurrently holds an adjunct professor role at the School of Environmental and Rural Science within the University of New England. Dr Cowie is a distinguished scholar in the fields of soil science, plant nutrition, and sustainable resource management. With over 156 peer reviewed publications under her belt, her expertise and research interests include greenhouse gas (GHG) accounting for the land sector, particularly for soil carbon management, reforestation, wood products, bioenergy and biochar systems. Dr Cowie's research focuses on the science-policy interface, supporting holistic responses to climate change, and sustainable land management. Her research has been applied in development of climate policy for the land sector, including greenhouse gas accounting for inventory and emissions trading.

With expertise in estimation and accounting for GHG emissions and removals in forestry and agriculture sectors, Dr Cowie was responsible for drafting the expert report used to support the NSW Land and Environment Court in its understanding of the ecological and climate impacts of Verdant's restart of the Redbank Power Station. Specifically, her report sought to address Council's Amended Statement of Facts and Contentions (SoFCs) and the NSW EPA's response (DOC21/747187-18) to Verdant's Development Modification Application for the Redbank Power Station, NSW.

The key findings of Dr Cowie's independent report (Expert report on Climate Change and Ecologically Sustainable Development matters - Land and Environment Court Proceedings 2021/00128111) have been summarised below by Verdant but we attach the full report for greater context of our DA Modification proposal and its environmental impact (both ecologically and in regard to climate change).

Overview of findings

In her independent report, Dr Cowie states Verdant's proposal is ecologically sustainable due to its social, economic and environmental benefits as well as the mitigation measures put in place to protect the environment.

1. As her report states, the most important climate change mitigation measure is to transform energy and transport systems so that we can leave fossil carbon in the ground. Using bioenergy now, in conjunction with other renewables, is an important measure to achieve this.

2. The National Greenhouse Accounts Factors (NGAF) workbook (Department of Industry, Science, Energy and Resources [DISER] 2021), reports that under the IPCC Guidelines for National GHG Inventories (IPCC 2016), the emission factor for CO2 released from combustion of biogenic carbon fuels is zero. When emissions of CO2 from the combustion of wood waste residues are taken as zero, the total estimated GHG emissions represent a small percentage (3.5%) of the GHG emissions associated with burning coal.

3. Like many others, Dr Cowie believes that biomass is a storable, dispatchable energy source that can support the rapid expansion of intermittent renewables, providing grid stability.

Verdant's use of biomass at its power station

Verdant intends to use biomass fuel that meets the NSW EPA's Eligible Waste Fuel Guidelines in respect of Forestry and Sawmill Residues and Uncontaminated Wood Waste and also the requirements of the Protection of the Environment Operations (General) Regulation 2021 in relation to the use of native forestry biomass for electricity generation. Its team has identified sources of eligible feedstocks to utilise as biomass fuel, generally within a 300 km radius of the plant.

According to modelling, by ceasing the use of coal tailings at the site, GHGs are reduced by 96%. That's approximately 1,148 kg CO2e per MWh of generation.

As detailed in Dr Cowie's report, the current fate of these materials are as follows:

- Plantation residues are windrowed and burned in the forest;
- Pulp logs, heads and off-cuts from native forest harvest residues are retained in the forest, then partly consumed in a post-harvest burn;
- Sawmill residues are used for landscaping or animal bedding
- Pre-consumer manufacturing and processing waste is landfill with a portion used in particleboard manufacturing.

Per the above, the materials to be used as fuel have no higher-order reuse.

Emissions of biomass versus fossil fuels

As Dr Cowie explains, when biomass is combusted as an energy source it reduces the requirement for coal-fired electricity and fossil fuel emissions are avoided.

It is widely reported in scientific literature that forest bioenergy can deliver climate benefits if it displaces the use of fossil fuels and if the biomass is sourced sustainably – as Verdant's feedstock will be. Additionally, the use of sustainably-sourced forest biomass as a fuel is consistently recognised as an effective climate change mitigation measure by the IPCC:

> *In the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fibre or energy from the forest, will generate the largest sustained mitigation benefit. (IPCC AR4, Nabuurs et al., 2007)*
>
> *Sustainable forest management aimed at providing timber, fibre, biomass, non-timber resources and other ecosystem functions and services, can lower GHG emissions and can contribute to adaptation (high confidence). (IPCC SRCCL, IPCC 2019)*

In fact, in the IPCC Special Report on meeting the 1.5°C degree target (IPCC SR1.5, IPCC, 2018), bioenergy and bioenergy linked with carbon capture and storage are anticipated to provide a substantial fraction of future energy supply under stringent climate targets: the share of primary energy supplied by bioenergy is predicted to increase from a median value of 10.3% in 2020 to 26.4% by 2050 under pathways that meet the 1.5°C target.

An ecologically sustainable development

Dr Cowie recognises the use of biomass for bioenergy generation as an essential contribution to climate change mitigation as the world transitions away from fossil fuels. Specifically, she states switching from the use of coal tailings to waste wood residues offers benefits in all four pillars of ecologically sustainable development (ESD), including:

1. Precautionary principle

Climate change is a significant threat to human systems and the environment. The most important climate change mitigation measure is transforming energy, industry, and transport systems so that fossil carbon is not emitted into the atmosphere. As Dr Cowie writes, bioenergy based on sustainably produced biomass contributes to climate change mitigation and supports the decarbonisation of the economy. Strategic use of bioenergy can play a vital role in decarbonising the NSW grid, which remains dominated by coal-fired electricity.

Society needs a portfolio of measures to address climate change. Biomass is a storable, dispatchable energy source that can support the rapid expansion of intermittent renewables, providing grid stability and balancing power. Furthermore, the strategic use of biomass can allow faster and deeper penetration of wind and solar, thus supporting the rapid transition away from fossil fuels, at a lower cost (Li et al., 2020).

Dr Cowie believes the electricity generated from biomass under Verdant's proposal would reduce NSW GHG emissions directly by displacing coal emissions.

2. Inter-generational equity

Emissions of CO2 from the combustion of fossil fuels cause permanent warming. Taking action now to support rapid decarbonisation reduces the absolute quantity of CO2 in the atmosphere and therefore reduces future warming.

Delaying action, which leads to additional fossil fuel emissions, will burden future generations to achieve deep emissions reductions and deploy large-scale carbon dioxide removal strategies, which will be costly and have adverse effects on natural ecosystems and food security (IPCC SRCCL, 2019). Dr Cowie states Verdant's proposal will reduce fossil fuel emissions, reducing the burden on future generations to undertake carbon dioxide removal and adapt to extreme climate change.

3. Conservation of biological diversity and ecological integrity

Biodiversity and ecological integrity are threatened by climate change. Action to address climate change through bioenergy reduces this threat. In accordance with applicable forestry regulations governing native forestry in NSW, no additional trees will be harvested for bioenergy and the fulfilment of Verdant's proposal.

Potential impacts of Verdant's proposed modification on biodiversity and ecological integrity of multiple-use native forests are managed through forestry regulations (licence conditions specified in the Coastal Integrated Forestry Operations Approval, EPA 2018b) requiring that sustainable forest management practices are applied, and threatened species are protected. These regulations aim to protect the environment while enabling the sustainable supply of native timber. As stated in the report, Dr Cowie argues the proposal will reduce fossil fuel emissions, thus contributing to reducing global warming and its impacts on biodiversity and ecological integrity.

4. Improved valuation, pricing and incentive mechanisms

Dr Cowie believes Verdant's proposal is consistent with the principle of pursuit of goals "in the most cost-effective way". She states that the modification will enable the beneficial utilisation of a currently idle facility and thus supports efficiency by saving natural resources that would have been utilised in the construction of a new facility.

Conclusion

In summary, Dr Cowie believes Verdant's proposal is ecologically sustainable due to its social, economic and environmental benefits as well as the mitigation measures put in place to protect the environment.

Verdant's proposal will decrease future emissions, and perhaps most importantly, it would leave coal in the ground.

As stated in the report, the climate impact of accelerated release of CO_2 through the combustion of harvest debris, that would otherwise have decayed in the forest, and the additional emissions from fossil fuel use in the supply chain are counteracted by the avoidance of coal-fired electricity generation. At the same time, the proposal meets all four pillars of ecologically sustainable development.

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Land and Environment Court Proceedings 2021/00128111

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Context

1. The Applicant has applied to Singleton Council to modify the terms of the consent for the construction and operation of Redbank Power Station. Redbank Power Station was commissioned in July 2001 to burn beneficiated dewatered coal tailings as the main fuel, sourced from nearby Warkworth mine, with run of mine coal as a backup fuel. The facility has been out of operation since October 2014 and the Applicant is proposing to restart the plant using up to 100% biomass as fuel. Biomass is a renewable fuel that reduces greenhouse gas (GHG) emissions when it displaces fossil fuels, so can contribute to the NSW climate change target of net zero in 2050.

Purpose of this report:

2. This report addresses Council's Amended Statement of Facts and Contentions (SoFCs), filed on 15 September 2021 and the NSW EPA's response (DOC21/747187-18, dated 16 September 2021), with respect to greenhouse gas impacts and ecologically sustainable development.

Expert witness code of conduct

3. I have read, understood and agree to be bound by the Expert Witness Code of Conduct in the Uniform Civil Procedure 2005 Rules (Code of Conduct). I have prepared this report in accordance with my obligations as an expert witness under the Code of Conduct. I have made all inquiries which I believe are appropriate. There are no matters of significance which I regard as relevant that have been withheld from the Court.

My curriculum vitae detailing my qualifications and experience is provided in Appendix A to this report.

Documents relied on

4. The following documents were relied on in preparing this report:

- Redbank QA/QC Supply Chain and Material Handling dated 30 July 2021 and the Addendum Report dated 15th October 2021.
- Air Quality Impact Assessment Redbank Power Station LEC proceedings no. 2021_128111 by EMM August 2021 (hereafter AQIA)
- Supplementary Air Quality Report by EMM 20 October 2021.
- B&PPS Report C12195-01 "Hunter Energy Redbank Power Station Thermal Efficiency" (B&PPS (a))
- B&PPS Report C12198-01 "Redbank Power Station – Description of Proposed Modifications for Conversion to Fire Biomass Fuels" dated 20 October 2021 (B&PPS (b))
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Biomass materials to be used as fuel

5. The Applicant intends to use biomass fuel that meets the NSW EPA's Eligible Waste Fuel Guidelines in respect of Forestry and Sawmill Residues and Uncontaminated Wood Waste and also the requirements of the Protection of the Environment Operations (General) Regulation 2021 in relation to the use of native forestry biomass for electricity generation. The Applicant has identified sources of eligible feedstocks to utilise as biomass fuel that are available generally within a 300 km radius of the plant. Additional feedstocks may be available outside this radius. According to the B&PPS Report, the power plant will utilise up

to 850,000tpa woody biomass (at 25% moisture, equivalent to 637,500 t dry matter). The Supply Chain and Material Handling report states that approximately 70% of the biomass will be obtained from approved forestry residues, 15% from sawmill operations and 15% from uncontaminated wood wastes by weight. The quantities of each biomass type are tabulated in **Table 1**.This quantity of biomass is less than the available biomass resource quantified in the DPI North Coast Residues study (Ximenes et al., 2017).

6. The current fate of these materials is as follows:

- Plantation residues are windrowed and burned in the forest;
- Pulp logs, heads and off-cuts from native forest harvest residues are retained in the forest, then partly consumed in a post-harvest burn;
- Sawmill residues are used for landscaping or animal bedding
- Pre-consumer manufacturing and processing waste is landfill with a portion used in particle board manufacturing.

7. The material to be used as fuel by the Applicant would be biomass with no higher order reuse, as it would be required to meet the criteria for obtaining a Resource Recovery Order and Exemption from the EPA in accordance with the Eligible Waste Fuel Guidelines.

Table 1 The total quantities of biomass to be used

Biomass type	% contribution	t dry matter
plantation and native forest harvest residues	70	446,250
sawmill	15	95,625
pre-consumer manufacturing waste	15	95,625
total		637,500

Contention 8 Greenhouse gas impacts

Evidence for climate change

8. Council's Contention 8:

The modification application should be refused because the greenhouse gas emissions resulting from the burning of biomass will have an unacceptable climate impact.

Contention 8 (a) The evidence of climate change impacts is summarised in Bushfire Survivors for Climate Action Incorporated v Environment Protection Authority [2021] NSWLEC 92 at [76] ("BSCC") and adopted here.

Contention 8 (b) Policies require or encourage the reduction of greenhouse gas emissions to prevent warming above 1.5°C: see Art 2(1)(a), Paris Agreement [2016] ATS 24 and BSCC at [79] and [86].

Contention 8 (c) The recent 6th Assessment Report from the Intergovernmental Panel on Climate Change ("IPCC") Working Group I entitled "Climate Change 2021 - The Physical Science Basis - Summary for Policy Makers" has established the following known scientific facts:

(i) ***It is unequivocal that human influence has warmed the atmosphere, ocean and land. Widespread and rapid changes in the atmosphere, ocean, cryosphere and biosphere have occurred. Observed warming is driven by emissions from human activities. Human-induced climate change is already affecting many weather and climate extremes in every region across the globe.***

(ii) ***Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in*** CO_2 ***and other greenhouse gas emissions occur in the coming decades. Many changes in the climate system become larger in direct relation to increasing global warming. They include increases in the frequency and intensity of hot extremes, marine heatwaves, and heavy precipitation, agricultural and ecological droughts, proportion of intense tropical cyclones, and reductions in snow cover***

(iii) ***With every increment of global warming, changes get larger. Projected changes in extremes are larger in frequency and intensity with every additional increment of global warming.***

9. The scientific evidence for climate change, and its impacts, and the need for policies consistent with the goal of the Paris Agreement, are clear, and are not disputed.

Remaining carbon budget

10. ***Contention 8 (d) The "carbon budget" (i.e. the amount of*** CO_2 ***that can be emitted before exceeding the 1.5°C global warming target) has shrunk to 300 Gt*** CO_2 ***with an 83 per cent chance of success. Current global emissions are around 40 Gt*** CO_2***, meaning there is only around 7.5 years of emissions before we breach this critical threshold.***
11. The IPCC AR6 WGI report ""Climate Change 2021 - The Physical Science Basis" has quantified the carbon budget for several global temperature limits and various levels of probability. The budget for 1.5, 1.7 and 2.0°C, with 83% likelihood of success, is 300, 550 and 900 Gt CO_2, respectively. The values with 67% likelihood of success are 400, 700 and 1150 $GtCO_2$, respectively. The IPCC has not interpreted these findings to show that there are 7.5 years remaining at current rate of emissions before the budget for 1.5°C is exceeded. There are many uncertainties around the quantification of the carbon budget, particularly the trajectories of non-CO_2 greenhouse gases such as methane, that impact the size of the carbon budget. "Higher or lower reductions in accompanying non-CO_2 emissions can increase or decrease the values by 220 $GtCO_2$ or more." (IPCC, 2021, Table SPM.2). The IPCC has modeled many pathways for achieving the long-term temperature goal, many of which include "overshoot" and subsequent deployment of carbon dioxide removal, to meet the 1.5 or 2°C goal.
12. Forest-based bioenergy systems could cause a short-term increase in emissions if a new regime is introduced that increases extraction of biomass, reducing the forest carbon stock by a greater amount than the substitution benefit from displacing fossil fuels. A short-term increase in emissions is suggested in Contentions 8 as being compatible with the urgent need for mitigation and the shrinking remaining carbon budget. However, the relationship between net emissions, global warming and climate stabilisation is complex. The IPCC SR1.5 report shows many alternative trajectories towards stabilization temperatures of 1.5 and 2

°C, many of which involve an overshoot, followed by a period dominated by carbon dioxide removal.

13. If a change in forest management to supply biomass for bioenergy causes a temporary increase in CO_2 emissions that is reversed as the forest grows, this CO_2 does not consume the carbon budget, and has a climate impact equivalent to short term climate forcers (Cherubini et al., 2014). On the other hand, if it leads to a reduction in forest carbon stock in the long term (a reduction in the equilibrium value) this is equivalent to CO_2 emissions from fossil sources, and does expend the carbon budget.
14. The most important climate change mitigation measure is to transform energy and transport systems so that we can leave fossil carbon in the ground (eg Climate Council, 2015; Welsby et al., 2021). Using bioenergy now, in conjunction with other renewables, is an important measure to achieve this. Biomass is a storable, dispatchable energy source that can support the rapid expansion of intermittent renewables, providing grid stability and balancing. In the longer term, biomass is likely to be primarily used in applications where the substitution of carbon- based fuels is particularly difficult, such as in aviation and long-distance marine transportation, and for bio-based products (bio-plastics, chemicals etc).
15. Concern about near-term emissions is not a strong argument for stopping investments that contribute to net emissions reduction beyond 2030. Many mitigation strategies require an up-front GHG-investment, such as in manufacture of solar panels and wind turbines, development of battery systems, infrastructure to support electrification of car fleets, rail infrastructure, that will utilise the remaining carbon budget. The development of biomass supply systems to provide bioenergy, or biobased products to displace steel, cement and other GHG-intensive products, should be considered equivalent to such GHG-investments, if it leads to a long-term reduction in terrestrial carbon stock.
16. It is critical to focus on the global emissions trajectory required to achieve climate stabilization, acknowledging possible trade-offs between short- and long-term emissions reduction objectives. A strong focus on short-term carbon balances could result in decisions that make long-term climate objectives more difficult to meet (Cowie et al., 2021). Switching from coal to sustainably-harvested woody biomass as an energy source reduces atmospheric CO_2 over time scales relevant to climate stabilisation. As the NSW grid remains dominated by coal (EPA, 2018a), and for the reasons set out above, this proposal would contribute significantly to the goal of keeping coal in the ground, directly reducing the fossil fuel emissions by around $1MtCO_2e$ (AQIA), nearly 1% of the annual emissions for NSW.

Greenhouse gas impacts of utilisation of forest-based biomass for bioenergy

17. ***Contention 8 (e) When biomass is combusted as an energy source, CO_2 emissions are released into the atmosphere, adding to the stock of atmospheric carbon and thereby increasing the atmospheric concentrations of greenhouse gases, which are the driver of human induced climate change.***
18. When biomass is combusted as an energy source and this reduces the requirement for coal-fired electricity, fossil fuel emissions are avoided. If the CO_2 emissions associated with any reduction in terrestrial carbon stock and supply chain of the bioenergy system are less than the emissions displaced, there is a net reduction in greenhouse gas emissions. When biomass used for energy is obtained from sustainably managed sources, the CO_2 emitted is reabsorbed when the biomass is regrown. It is widely reported in scientific literature that forest bioenergy can deliver climate benefits if it displaces the use of fossil fuels and if the biomass is sourced sustainably (e.g., Marland and Schlamadinger, 1997; Kraxner et al., 2003; Lundmark et al., 2014; Smyth et al., 2014; Creutzig et al., 2015; Gustavsson et al., 2017;

Gustavsson et al., 2021; Kilpeläinen et al., 2016; Favero et al., 2017; Vance, 2018, Nabuurs et al. 2017; Dwivedi et al., 2019; Favero et al., 2020). The use of sustainably-sourced forest biomass as a fuel is consistently recognised as an effective climate change mitigation measure by the IPCC:

In the long term, a sustainable forest management strategy aimed at maintaining or increasing forest carbon stocks, while producing an annual sustained yield of timber, fibre or energy from the forest, will generate the largest sustained mitigation benefit. (IPCC AR4, Nabuurs et al., 2007)

Sustainable forest management aimed at providing timber, fibre, biomass, non-timber resources and other ecosystem functions and services, can lower GHG emissions and can contribute to adaptation (high confidence). (IPCC SRCCL, IPCC 2019)

19. In the IPCC Special Report on meeting the 1.5°C degree target (IPCC SR1.5, IPCC, 2018), bioenergy and bioenergy linked with carbon capture and storage (BECCS) are anticipated to provide a substantial fraction of future energy supply under stringent climate targets: the share of primary energy provided by bioenergy is predicted to increase from a median value of 10.3% in 2020 to 26.4% by 2050 under pathways that meet the 1.5°C target.
20. In sustainably managed forests, when biomass created as a by-product of tree-harvesting for sawlogs or pulp is used for bioenergy generation, the carbon emitted in this process is re-absorbed by growing trees, as part of the natural carbon cycle. Sustainable forest management ensures that annual biomass removals do not exceed annual forest growth. The forest carbon stock is therefore stable; the same quantity of CO_2 is released as is sequestered by the forest each year, so there is no net transfer of carbon from the forest to the atmosphere.
21. Combustion of biomass emits carbon that is part of the short-term carbon cycle, and when replanted the carbon is sequestered again as the forest regrows. Thus, sustainably-sourced forest biomass is essentially carbon neutral, apart from supply chain emissions incurred in processing and transporting biomass. That is, burning biomass that is regrown after harvest adds no extra CO_2 to the atmosphere, whereas burning fossil fuels transfers geologically-stored carbon to the atmosphere, where it causes permanent warming (Cherubini et al., 2014, 2021).
22. Council's amended statement of facts and contentions (15 September 2021) lists among the issues raised in submissions received the claim that "Burning wood emits 50% greater greenhouse gases than coal." Similar claims have been made by others (Cowie et al., 2021). Such claims lack scientific credibility, and are based on inappropriate methods that overlook the fundamental differences between biomass and coal explained above (Cowie et al., 2021). At the point of combustion, wood and coal have similar CO_2 emission factors, as the ratio of heating values between the two fuels is similar to the ratio of carbon content. Properties such as moisture content, grindability and heating value affect the energy efficiency of the plant, whether burning biomass or coal as fuel. Comparing emissions at the point of combustion does not show the effect on atmospheric GHG concentrations of switching from coal to biomass. Instead of comparing GHG emissions at the point of combustion, the biogenic carbon flows and fossil GHG emissions associated with the complete life cycle of the bioenergy system need to be compared with the GHG emissions of a realistic reference system (counterfactual scenario) where energy sources other than

bioenergy are used. Also, indirect impacts (positive or negative) on land use, wood products and fossil fuel use need to be considered.

23. The use of biomass for bioenergy generation can make an important contribution to climate change mitigation as the world transitions away from fossil fuels (Ximenes 2021). This proposal seeks to utilise biomass residues that would otherwise return to atmosphere as they decompose. It would have a small, temporary effect on terrestrial carbon stock, counterbalanced by the immediate benefit from displacing coal emissions (see modelled example below). It would thus support decarbonisation of the NSW grid, contributing to the NSW goal of Net Zero by 2050.

Climate effects of sustainably-harvested forest-based bioenergy

24. ***Contention 8 (f) The emissions from burning biomass are instantaneous, but their removals from atmosphere are not. Rather, there is a significant time lag with the critical factor being the "cumulative net emissions" (i.e. the additional CO_2 emitted and accumulated in the atmosphere by burning biomass over time), compared to its alternative fate of being left to remain incorporated into the forest ecosystem, including the component which is incorporated into the soil carbon pool.***
25. Bioenergy obtained from residues that would otherwise be burned in the forest (plantation harvest residues) or decompose quickly (sawmill residues used for landscaping) does not affect biogenic carbon fluxes; the same quantity of biogenic CO_2 is emitted under the bioenergy case as in the without-bioenergy case. The beneficial use of this biomass for bioenergy provides an immediate climate benefit through the avoidance of fossil fuel emissions that lead to permanent atmospheric warming.
26. The lag described in contention 8 (f), between emissions and removals, is only relevant if there is harvest of additional trees for bioenergy, and is only apparent if the assessment is limited to the individual compartment harvested, ignoring the remainder of the managed forest estate. Emissions from sustainably harvested biomass are part of the short -term carbon cycle, and do not contribute to permanent warming. A forest estate is managed such that different areas are harvested each year, while the remainder of the forest continues to grow. If the forest is harvested on a sustained yield basis, as is required for NSW public forests managed for timber production according to Regional Forest Agreements and the Forestry Act 2012, the biomass removed does not exceed the growth of the forest, across the whole forest estate, so there is no lag before the carbon in harvested biomass is sequestered again. Assessment at the estate level, sometimes referred to as landscape level, is the appropriate spatial scale for assessing the climate effects of bioenergy (Cintas et al., 2017; Peñaloza et al., 2019; Cowie et al., 2021). In the case of this proposal, the Applicant proposes to utilise biomass that meets the requirements of the Protection of the Environment Operations (General) Regulation 2021, which excludes additional harvest of trees in native forests for bioenergy, so the issue of a lag between emissions and removal through forest growth is not applicable.
27. If there is a change in forest management such that additional biomass is removed for bioenergy – for example, removing additional residues that would otherwise have decayed in the forest - there can be a temporary increase in CO_2 emissions that is reversed as the forest grows; this CO_2 does not deplete the remaining carbon budget (see 0), and has a climate impact equivalent to short term climate forcers (Cherubini et al., 2014). There is no net contribution to atmospheric CO_2 emissions unless forest carbon stock is depleted to a

greater extent than fossil emissions are displaced, after accounting for any emissions from fossil fuel combusted in the supply chain. The Applicant proposes to utilise biomass materials including native forest harvest residues, so the issue of a temporary increase in emissions is potentially relevant. However, the modelled example presented below shows that the "payback time" is less than 2 years for this biomass source when it displaces coal tailings.

28. The extraction of harvest residues for bioenergy hastens the return of the carbon to the atmosphere, for that fraction of residues that would have decomposed in the forest. Residues that decompose in the forest provide no long-term climate benefit, whereas residues used for bioenergy to displace fossil fuels provide permanent mitigation, enabling fossil fuels to remain in the ground, and this benefit accumulates with sequential harvests. Furthermore, it is uncertain how long this biomass would remain in the forest in reality, because residues remaining after a post-harvest burn may also be affected subsequently by hazard reduction burns, or by bushfires, that are expected to increase in frequency and severity under climate change.
29. For the fraction of residues that would have been burned in the forest (plantation residues and the portion consumed in a post-harvest burn in a native forest harvest), using for bioenergy reduces emissions, as field-burning is less efficient, producing more non-CO_2 GHGs than combustion in an engineered plant with emissions controls.
30. Forest biomass is renewable if it is harvested from forests that are managed such that there is no loss of productive capacity – i.e., so that growth rate and therefore capacity to sequester carbon are maintained over successive rotations. Sustainable forest management is key to maintaining healthy and productive forests. NSW has strong regulations governing forestry operations that require that sustainable forest management practices are applied, to ensure forest heath is maintained, and adverse impacts of forestry operations are minimised (such as impacts on water quality, biodiversity, soil erosion). The NSW native forests that are managed for production of forest products have a lower forest carbon stock than their potential maximum carbon carrying capacity. Nevertheless, when the mitigation benefit of wood products (that store carbon and displace GHG-intensive building products) and bioenergy (that displaces fossil fuels) are taken into consideration, the combined mitigation benefit of managed forests exceeds that of conservation forests (Ximenes et al., 2012; **Figure 1**).

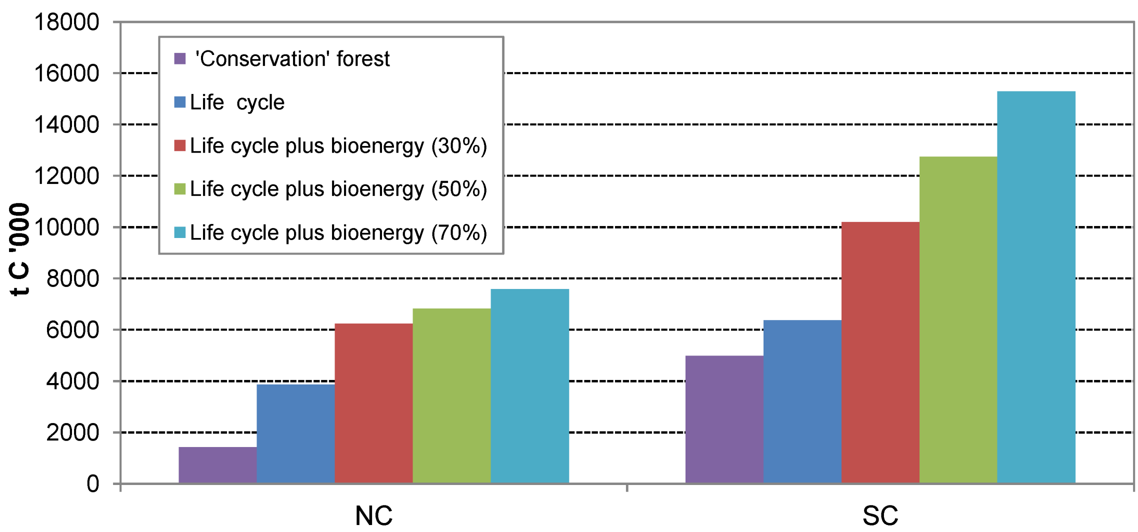


Figure 1 Mitigation benefit (t C benefit per region) of using harvest residues for bioenergy, compared with "conservation" and "life cycle" scenarios in the NSW north coast (NC) and south coast (SC) forest regions. The "life cycle" scenario includes the net effect of carbon storage in wood products and substitution benefits, minus supply chain emissions, also including change in carbon in harvest residues. Source: Ximenes et al., 2012.

31. In summary, this proposal will not lead to additional harvest of trees in native forests. Rather it will utilise harvest residues, comprising tops, off-cuts and low-quality stems, and mill residues, with no higher value application. In the case of native forest harvest residues, in the absence of the project, this biomass would decompose on the forest floor, or be burned, in accordance with the relevant forestry regulations (Integrated Forestry Operations Approval under the Forestry Act 2012 or Private Native Forestry plan under the Local Land Services Act 2016). In the case of plantation residues and sawmill residues, in the absence of the project, the material would be immediately burned or would quickly decompose, respectively, returning the carbon to atmosphere. Use for bioenergy gives an immediate reduction in fossil fuel emissions, and a near immediate net climate benefit (see modelled example below).

Climate change effects of removal of forestry residues for bioenergy – modelled example

32. ***Contention 8 (i) The proposed burning of biomass will result in additional cumulative net emissions of*** **CO_2** ***that will have an unacceptable adverse climate impact having regard to the IPCC's findings about the climate's reduced capacity to withstand further emissions into the future.***
33. The FullCAM model (e.g. Richards and Evans, 2004; Roxburgh et al., 2019) was developed to underpin Australia's national greenhouse gas inventory and is used in the Emissions Reduction Fund to model emissions and removals associated with land management activities. The model has been extensively tested, and calibrated for a range of forest types and forest management operations, across Australia. It models carbon stock change over time in the tree components, forest debris and soil carbon pools, as well as carbon in the wood products pool, for a nominated location in Australia. The model is parameterised from by a database containing spatial information on climate and soil type and appropriate forest types and management regime options.
34. The FullCAM model was used to quantify the effect on cumulative net GHG emissions from using native forest harvest residues for bioenergy in comparison with the approved fuel (beneficiated dewatered coal tailings). Native forest harvest residues were used for this example because this is the biomass source for which the alternative fate is decomposition in the forest, and use for bioenergy could lead to a temporary increase in CO_2 emissions. This is not a risk for other biomass sources that would be burned in the forest or decompose quickly. Thus, this assessment illustrates the climate effects of the biomass source that has the smallest net climate benefit. All other sources would deliver a greater benefit.

Method for quantifying the climate effect of using harvest residues for bioenergy

35. The methods used to assess climate effects of bioenergy have a large impact on the results of assessment. Application of appropriate spatial and temporal system boundaries is critical to accurate determination of the climate effect of forest-based bioenergy. The system boundary should include the forest carbon pools (above and below-ground live biomass,

deadwood, litter and soil carbon); plus effects on wood products, and the energy sector (Cowie et al., 2021).

36. Another critical issue in quantifying the climate effects of forest-based bioenergy is the choice of the reference system, which should reflect the alternative fate of the land and biomass resources (what would happen in the absence of the project – the counterfactual scenario) (Lamers and Junginger, 2013; Parish et al., 2017; Koponen et al., 2018). In this proposal, the feedstock is a by-product of forest harvest to meet timber supply agreements, where the timber is utilised for long-lived hardwood products such as decking and flooring. Harvest residues are currently retained in the forest, where post-harvest burning is commonly undertaken, to reduce the fuel load and encourage regeneration. Thus, a fraction of the harvest residue is burned, but the majority of the stem and branch biomass remains, to decompose in the forest. In this proposal, the forest harvest regime is not affected – the forest will continue to be harvested for wood products, so there is no effect of bioenergy on land use or wood products produced. NSW legislation prohibits the felling of trees in native forests for bioenergy. As no additional trees will be harvested there is no effect on carbon stock in tree biomass. Thus, the appropriate reference land use for this proposal is continued harvest, and utilisation of wood products, with harvest residues retained in the forest, where a fraction is combusted in a post-harvest burn.
37. Redbank power station is approved to operate using coal tailings. Therefore, the electricity generated from biomass can be considered to displace electricity from coal tailings. However, as the plant is currently not operating, it is also valid to consider that this proposal would displace NSW coal-fired electricity generation, so bituminous coal is also a relevant reference.
38. The FullCAM model was run using the options shown in **Table 2**, and the allocations of biomass to various pools shown in **Table 3**. The default rates of decomposition for the pools are given in **Table 3**. **Table 4** lists the assumptions applied in calculating the emissions saved in the bioenergy scenario compared with the reference scenario, per hectare of forest harvested. Noting that the proposal by the Applicant uses only a fraction of the mill residues produced, two cases are modelled with respect to the fate of mill residues: first, all mill residues are assumed to be used for bioenergy in addition to the harvest residues; second, only the harvest residues are used for bioenergy.

Table 2 Model set-up

FullCAM Version	2020 Public Release
Location	Buladelah: -32.4N, 152.2E
Forest type	Eucalyptus tall open forest
"Thin" (selective harvest)	50% forest affected, in 1 January 2020
Post-harvest fire	"Prescribed burn" 1 July 2020

Table 3 Allocation of tree biomass to pools at harvest[1], and half-life of pools

Scenario	Pool	Stem %	Branch %	Bark %	Leaf %	Half life (y)
Reference	Deadwood	20	100	100	100	5.948
	Wood products (construction)	40				35

	Mill residue	40				0.5
Bioenergy Case 1	Deadwood	5	20	100	100	5.948
	Wood products (construction)	40				35
	Mill residue	0				0.5
	Bioenergy	55	80			n/a
Bioenergy Case 2	Deadwood	5	20	100	100	5.948
	Wood products (construction)	40				35
	Mill residue	40				0.5
	Bioenergy	15	80			n/a

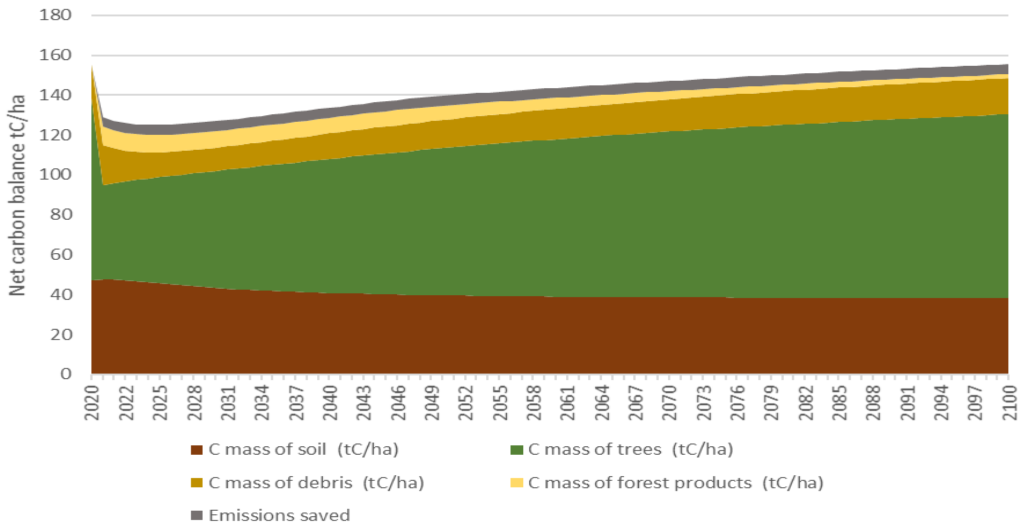
[1]Allocation to pools based on Ximenes et al., 2017

Table 4 Conversion assumptions

	Reference	Bioenergy	Additional reference energy option	
Fuel	Coal tailings	biomass	Bituminous coal	NSW average grid
Energy content (GJ/t supplied)[1]	16.01	15.21		
Efficiency of conversion (%)[2]	28.3	27.2	36	
Combustion emissions (kg CO_2e/MWhe)	1148	1277[3]	902.4[4]	810[4]
Supply chain emissions due to processing, biomass transport and onsite fuel consumption (kg CO_2e/t biomass DM)[2]		32		

[1]B&PPS (b); [2]B&PPS (a); [3]Based on non-CO_2 emissions from AQIA and C content of eucalyptus biomass from TNO (2021); [4]NGAF(2020)

Results



39. **Figure 2** shows the net carbon balance of a hectare of forest in the reference scenario (harvest residues retained on site) and the bioenergy scenario (larger diameter debris removed and used for bioenergy), including also the carbon in products and the emissions displaced by used of forest biomass for energy. The carbon stock in the forest debris (deadwood and litter pools) is temporarily reduced in the bioenergy scenario (**Figure 3**). The debris decomposes over about 20 years in the reference scenario, after which there is no difference between the scenarios with respect to the forest carbon balance. When displaced fossil fuels are also considered, in the case where harvest residues and all mill residues are used for bioenergy, there is an immediate climate benefit – there is no "payback period". In the case where only the harvest residues are used for bioenergy, the fossil fuel emissions avoided in the bioenergy scenario exceed the difference in carbon stock between the reference and bioenergy scenarios after one year. Thus, there is a very short payback period of one year, in that case.
40. The model includes changes in soil carbon, as influenced by the two scenarios. The change in soil carbon, as modelled in FullCAM, is very small, presumably because the majority of the fine litter is removed in both scenarios through the post-harvest burn, and the coarser material (deadwood) decomposes largely above-ground, with little entering the soil profile. Note that all bark and leaf, which have high nutrient content, are retained in the forest in both scenarios, and as nutrients apart from nitrogen are non-volatile, these are retained in the ash generated through the post-harvest burn. Therefore, the removal of larger residues for bioenergy is not expected to deplete the fertility of the forest.
41. The difference in net carbon balance between the reference and bioenergy scenarios represents the GHG emissions saved in the bioenergy scenario. As shown in **Table 5**, per ha of forest harvested, from a single harvest operation, the bioenergy scenario (case 1) saves 41.9 t CO_2e, if it is assumed that the fuel source displaced is coal tailings, the approved fuel source for the plant, and harvest plus mill residues are used for bioenergy. Assuming alternatively that bioenergy displaces black-coal fired power in the NSW grid (bituminous coal), the savings are reduced to 32.6 t CO_2e /ha, or 29.1 t CO_2e /ha if compared with NSW grid emissions. Thus, whichever reference is used in the assessment, the proposal to utilise sustainably-sourced forest biomass for energy offers immediate climate change benefits.
42. This analysis focusses on the stand level, and shows a (short) temporary carbon debt in the deadwood pool. As noted above, the appropriate scale to consider climate effects of

bioenergy is the whole forest estate. If the analysis was expanded across the forest, the introduction of a new approach to management of harvest residues in each successive year of harvest would lead to a small decline in the total forest deadwood pool. This analysis shows that the payback time, at stand level, is very short when bioenergy displaces coal tailings, higher quality coal or the average electricity grid mix. At estate level, the small temporary decline in carbon stock in the harvested stands, representing a very small fraction of the forest area, would be negligible.

Conclusion

43. The climate impact of accelerated release of CO_2 through combustion of harvest debris, that would otherwise have decayed in the forest, and the additional emissions from fossil fuel use in the supply chain are counteracted by the avoidance of coal-fired electricity generation. The net effect of the proposal is to decrease future emissions, as the proposal would leave coal in the ground.

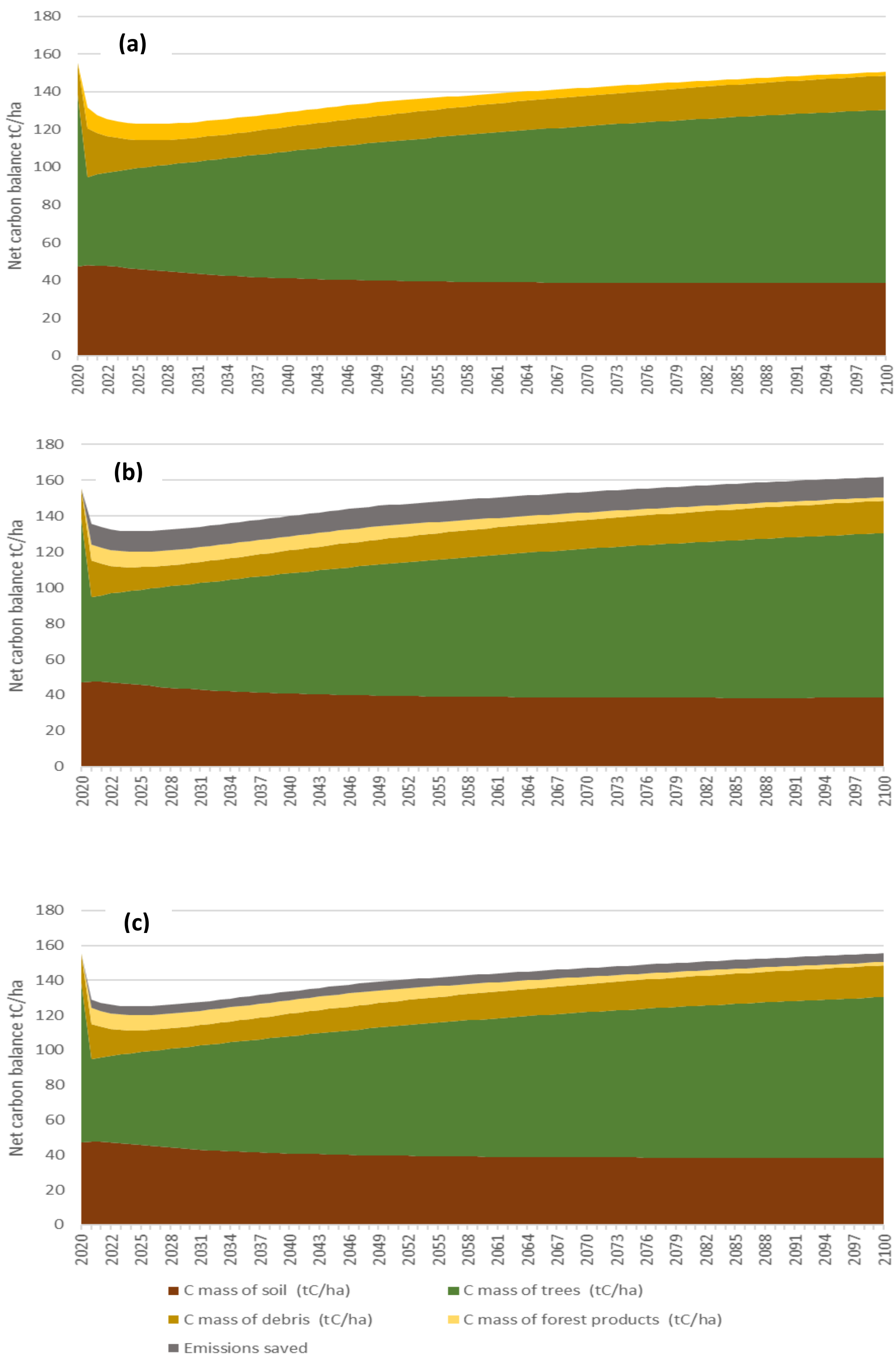


Figure 2 Net carbon balance of the reference scenario (a) and bioenergy scenarios (b) (c), including forest carbon pools, forest products and emissions displaced by bioenergy, expressed as tC per ha of forest harvested. (b): case 1 - harvest and mill residues used for bioenergy (c) case 2 - harvest residues only used for bioenergy.

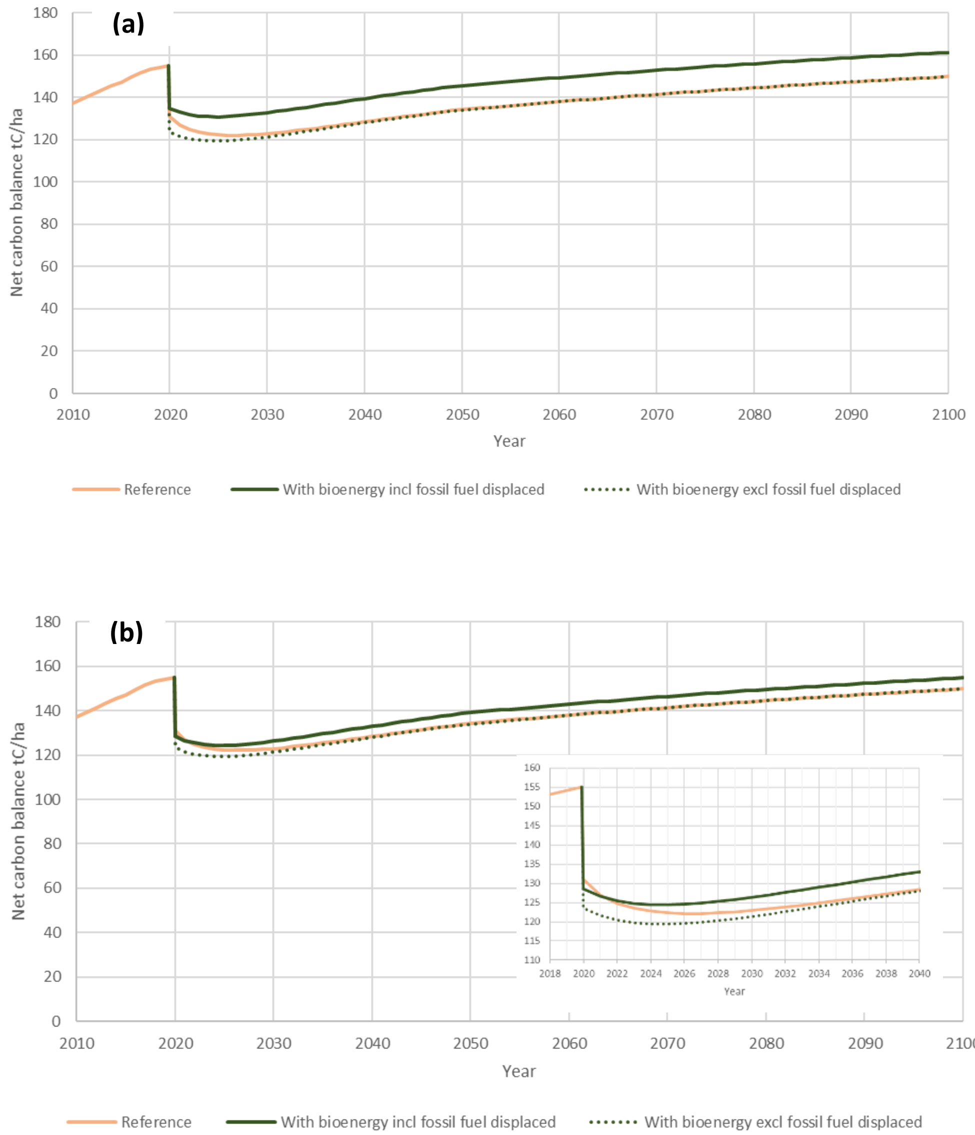


Figure 3 Net carbon balance of reference and bioenergy scenarios for a single harvest event occurring in 2020. Values excluding the fossil fuel displaced also shown. (a) case 1 - harvest and mill residues used for bioenergy (b) case 2 - harvest residues only used for bioenergy. Inset: detail 2018-2040.

Table 5 Emissions saved by the proposal to switch from coal to under alternative assumptions for displaced electricity source, based on one harvest event in 2020.

Displaced electricity source	**Redbank BDT**	**Bituminous coal**	**NSW grid**
Emissions factor (kg CO_2e /MWhe)	1148[1]	902[2]	810[2]
Case 1 Harvest and mill residues used for bioenergy			
Emissions saved at 2030 (t CO_2e /ha forest harvested)	36.2	26.9	23.4
Total emissions saved (t CO_2e /ha forest harvested)	41.9	32.6	29.1
Case 2 Harvest residues used for bioenergy			
Emissions saved at 2030 (t CO_2e /ha forest harvested)	12.7	8.6	7.1
Total emissions saved (t CO_2e /ha forest harvested)	18.4	14.3	12.7

Source: [1]AQIA [2]NGAF 2020

44. **Contention 8 (ll) The Applicant has not proposed any specific and certain action to mitigate and offset the environmental impact of the proposed modified development.**
45. Generation of low-carbon renewable energy, the key objective of the proposed modification, reduces net GHG emissions. Thus, there is no negative climate effect from the project to be offset.

Contention 15: Ecologically sustainable development (ESD)

46. ***Contention 15 The modification application should be refused because it has not been demonstrated that the proposed modified development is consistent with the principles of ecologically sustainable development.***

(a) The consideration of the public interest in accordance with section 4.15(1)(e) of the EP&A Act encompasses the consideration of the principles of ecologically sustainable development ("ESD") in cases where issues relevant to those principles arise.

(b) The EP&A Act defines ESD in accordance with section 6(2) of the Protection of the Environment Administration Act 1997.

(c) The information submitted with the modification application does not allow a proper assessment of whether the proposed modified development is inconsistent with the principles of ESD and therefore in the public interest.

47. The Protection of the Environment Administration Act (1997) states that "ecologically sustainable development requires the effective integration of social, economic and environmental considerations in decision-making processes", and it specifies four overarching principles for achievement of ESD: the precautionary principle; inter-generational equity; conservation of biological diversity and ecological integrity; improved valuation, pricing and incentive mechanisms. Fuel switching from coal tailings to biomass offers benefits in all pillars of ESD. I have dealt with each individually below.

48. **Precautionary principle**: Climate change is a major threat to human systems and the environment. The most important climate change mitigation measure is the transformation of energy, industry, and transport systems so that fossil carbon is not emitted to the atmosphere. Bioenergy based on sustainably produced biomass contributes to climate change mitigation and supports decarbonisation of the economy. Strategic use of bioenergy can play a key role in decarbonisation of the NSW grid, which remains dominated by coal-fired electricity (NSW EPA, 2018a). Biomass is a storable, dispatchable energy source that can support the rapid expansion of intermittent renewables, providing grid stability and balancing power. Strategic use of biomass can allow faster, deeper penetration of wind and solar, thus supporting the rapid transition away from fossil fuels, at lower cost (Li et al., 2020). Society needs a portfolio of measures to address climate change. Taking known beneficial action to address climate change, including strategic deployment of bioenergy, is consistent with the precautionary principle. The electricity generated from biomass under this proposal would reduce NSW GHG emissions directly, by displacing coal emissions, and provide grid stability to complement other balancing options, enabling accelerated expansion of wind and solar power, further reducing NSW GHG emissions and contributing to the global goal of net zero, required to reach the Paris Agreement.
49. **Inter-generational equity**: Emissions of CO_2 from combustion of fossil fuel cause permanent warming. Taking action now to support rapid decarbonisation reduces the absolute quantity of CO_2 in the atmosphere and therefore reduces future warming. Delaying action, which leads to additional fossil fuel emissions, will impose additional burden on future generations to achieve deep emissions reductions and deploy large-scale carbon dioxide removal strategies, which will be costly and have adverse effects on natural ecosystems and food security (IPCC SRCCL, 2019). The proposal would reduce fossil fuel emissions, reducing the burden on future generations to undertake carbon dioxide removal and adapt to extreme climate change.
50. **Conservation of biological diversity and ecological integrity**: Biodiversity and ecological integrity are threatened by climate change. Action to address climate change through bioenergy reduces this threat. In accordance with applicable forestry regulations governing native forestry in NSW, no additional trees will be harvested for bioenergy. Potential impacts of the proposed modification on biodiversity and ecological integrity of multiple use native forests are managed through forestry regulations (licence conditions specified in the Coastal Integrated Forestry Operations Approval, EPA 2018b) requiring that sustainable forest management practices are applied, and threatened species are protected. These regulations aim to protect the environment while enabling the sustainable supply of native timber. This proposal would reduce fossil fuel emissions, thus contributing to reducing global warming and its impacts on biodiversity and ecological integrity.
51. **Improved valuation, pricing and incentive mechanisms**: The proposal is consistent with the principle of pursuit of goals "in the most cost-effective way". The proposed modification will enable the beneficial utilisation of a facility that is currently idle. It thus supports efficiency in use of natural resources that have been utilised in construction of the existing facility.
52. ***Contention 15 (d) Protection of the environment from climate change implements ESD: BSCC at [61]. This modification increased greenhouse gas emissions from zero without offsetting reductions in real time, and for that reason alone should be refused.***
53. As noted in BSCC at [60] and [61] environment protection necessarily includes protection of the environment in New South Wales against the threat of climate change, which requires mitigation of the sources of greenhouse gas emissions. The proposed modification enables

biomass to be used as an energy source to displace fossil fuel emissions, contributing to climate change mitigation, as demonstrated above.

54. ***Contention 15 (e) The production of biomass from logging native forests is contrary to ESD principles after the 2019-2020 bushfires: Review of CIFOA Mitigation Conditions for Timber Harvesting in Burnt Landscapes, A Report to the NSW EPA by Dr A. Smith, 17 September 2020 ("the Smith Report").***
55. The cited report does not address removal of harvest residues for bioenergy. Applicable forestry regulations, including licence conditions, are in place to manage the ecological impacts of forestry operations considered in the cited report.

Response to EPA: Consistency with NSW Energy from Waste Policy Statement and NSW EPA Eligible Waste Fuels Guidelines

56. The proposed biomass feedstocks meet the definitions of Eligible Waste Fuels under the NSW Energy from Waste Policy Statement and EPA's Eligible Waste Fuel Guidelines. Use of these biomass sources for energy is consistent with the waste hierarchy as follows:

- Harvest residues comprise branches and low-quality stems that are unsuitable for higher value use as sawn timber. The current fate of this biomass is in-forest burning or decomposition. There is no higher order re-use opportunity for this material in NSW.
- The green fraction of mill residues has been identified as a currently under-utilised source of biomass for bioenergy (Ximenes et al., 2019). The proposal will utilise only a fraction of mill residues, so will not compete with current beneficial uses for energy generation, horticultural applications, animal bedding, and as feedstock for engineered wood products.
- Uncontaminated wood waste is currently landfilled; recovery of energy, avoiding disposal, is preferred under the waste hierarchy.

57. The EPA response notes that harvest residues left in situ provide environmental and habitat functions such as soil stabilisation, sediment trapping, nesting and roosting hollows, and food sources for wildlife, including threatened species. The regulations governing forestry operations in NSW prevent the removal of residues where these are required for erosion control or protection of threatened species. Thus, operations consistent with applicable regulations address these concerns.
58. The EPA response suggests that lower grade timber and residues potentially have higher order uses such pulp for paper products or landscaping material. However, there is no pulp mill in northern NSW, and it is not clear why export of wood chip or use for landscaping would be considered a higher value purpose compared with avoidance of NSW fossil fuel emissions, considering the urgent need to reduce GHG emissions.
59. Given the urgency of reducing GHG emissions to avoid dangerous climate change (IPCC 2021), proven options that avoid additional fossil fuel emissions should not be rejected. This proposal will contribute to the NSW net zero goal, by utilising existing residues from sustainable harvesting and wood processing.
60. NSW has strong regulations that govern the management of native forests for production of wood products, while providing environmental and social benefits. Forest management policy seeks to balance alternative objectives and manage inevitable trade-offs, and complements other policies on natural resource management, protected areas, threatened species management.
61. The EPA response refers to the findings and recommendations of the NSW Legislative Assembly Inquiry into the 'sustainability of energy supply and resources in New South Wales'. The findings of this inquiry are inconsistent with the large body of evidence that

demonstrates the potential for sustainably-harvested forest-based biomass for bioenergy. The findings of the inquiry pertain to operations that are not compliant with NSW forestry regulations, and are inconsistent with the proposed biomass feedstock (eligible waste fuels obtained as harvest residues, rather than additionally harvested trees), so are not relevant to this proposal.

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Qualifications:

B. Rural Science (Hons I), University of New England (UNE), 1983 University Medal, Booth Medal
M. Agricultural Science, University of Queensland, 1988.
Ph.D., UNE, 1994.

Current positions:

Senior Principal research scientist, Climate, NSW Department of Primary Industries (NSW DPI)

Concurrent: Adjunct Professor, School of Environmental and Rural Science, University of New England

Previous positions:

2009 –2013:	Director, Rural Climate Solutions, joint initiative of NSW DPI and UNE
2001- 2008:	Program Leader New Forests NSW DPI
1998-2000:	Research officer Forest Carbon Dynamics State Forests of NSW
1997	Principal Scientist - Resource Conservation, NT Dept Lands, Planning and Environment
1995-1996:	Research Officer Land Resource Management NT Dept Primary Industry and Fisheries

Summary bio:

Annette Cowie has a background in soil science and plant nutrition, with particular interest in sustainable resource management. Her expertise and research interests include GHG accounting for the land sector, particularly for soil carbon management, reforestation, wood products, bioenergy and biochar systems. Annette’s research focuses on the science-policy interface, supporting holistic responses to climate change, and sustainable land management. Her research has been applied in development of climate policy for the land sector, including greenhouse gas accounting for inventory and emissions trading.

Primary expertise:

- Estimation and accounting for GHG emissions and removals in forestry and agriculture sectors for inventory and emissions trading, including soil carbon management
- Climate change mitigation value of bioenergy and biochar systems, using whole system, life cycle perspective
- Sustainability and resilience assessment of agriculture, bioenergy, biochar including frameworks, indicators, standards and certification
- Translating science into policy for management of land degradation and mitigation of climate change.

Significant roles

- IPCC Sixth Assessment Report Working Group III Mitigation of Climate Change (Lead author Chapter 12 Cross sectoral perspectives)
- IEA Bioenergy Task 45 Climate and Sustainability Effects of Bioenergy within the broader Bioeconomy. Developing methods to assess and support sustainability of bioenergy systems (Co-Leader/ Leader 2000-)

- Land Degradation Neutrality Strategic Trust Fund (Board member, and expert advisor to the LDN technical advisory facility, 2018-).
- Lead author for IPCC Special Report on Climate Change and the Land (2017-2019)
- Scientific and Technical Advisory Panel to the Global Environment Facility (June 2012 – June 2018)
- UNCCD Science-Policy Interface (2014- 2019)
- Australian representative ISO Working Groups developing standards for carbon footprint of products, climate change vulnerability assessment, radiative forcing management, and sustainability of bioenergy
- Adjunct professor University of New England (2014 -)
- World Resource Institute Land Sector Working Group (WG member). Developing guidance to assist businesses applying the WRI/WBCSD GHG Protocol for GHG reporting.
- Verra Agricultural Land Management Working Group (WG member). Supporting emission trading method development for regenerative agriculture and soil carbon management, under the Voluntary Carbon Standard.
- Carbone4 Net Zero Initiative Working Group, supporting businesses to go beyond Carbon neutrality, to support the goal of Net Zero at the global level.
- Member of interim Domestic Offsets Integrity Committee (Nov 2010 – Feb 2012), advising the Minister on approvals for methodologies proposed under the Carbon Farming Initiative
- Program Leader CRC Greenhouse Accounting 2002–04 and Member of Management Team CRC Greenhouse Accounting 2002–2006
- Science Committee of Poultry CRC (October 2009 – 2014)

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