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Estimating the implications of net-zero targets

Project number: PRE562-2021

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Forest & Wood Products Australia

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Estimating the implications of net-zero targets

Prepared for

Forest & Wood Products Australia

by

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EXECUTIVE SUMMARY

Context

With the recent publication of the Intergovernmental Panel on Climate Change Sixth Assessment Report providing more evidence of the need for urgent action to address climate change, Australian companies are increasingly expressing an ambition to achieve net-zero emissions by 2050.

The quantum of emissions reductions required is significant and there are often limited options for companies to achieve their targets through changes to their own operating processes in the short term. Therefore, many companies are considering the use of carbon offsets to reduce their overall net contribution to climate change, where the costs of their own mitigation options are excessively high. To date, there has been limited Australian analysis of the opportunity this presents for timber plantations and environmental plantings or the area of land required to support such targets.

Approach

This study investigated the greenhouse gas emissions (GHG) of the 50 highest valued companies traded on the Australian Stock Exchange (ASX50) to understand the quantity of emissions which would need to be mitigated or offset annually to achieve net zero emissions by 2050[1]. The reported emissions of these companies were used to determine the area of timber plantations or environmental plantings required to produce an equivalent volume of carbon abatement each year. From this, a measure of the carbon abatement efficiency (i.e. ha / tonne CO_2-e abated) was estimated for both timber plantations and environmental plantings.

The analysis relies on a simplified model of net carbon abatement from plantations and environmental plantings, which was developed as part of this study. The model is informed by the approach used to calculate net carbon abatement and to issue Australian Carbon Credit Units (ACCUs) set out in current Emissions Reduction Fund (ERF) methods. Estimates of carbon abatement for plantations are based estimates associated with radiata pine plantations while estimates of carbon abatement for environmental plantings are based on carbon sequestration rates associated with mixed species native plantings.

Findings

Key findings from this study include:

- Companies making up the ASX50 produce about 66 Mt CO_2-e each year (Scope 1[2] and Scope 2[3]). Roughly half of these companies are currently using or have expressed some interest in the use carbon offsets to achieve carbon emissions reduction targets.
- Under the current plantation forestry method, radiata pine plantations can provide between 14 and 17 tonnes CO_2-e of net abatement per hectare each year over a 25 year period. By comparison, environmental plantings provide between 5 to 11 tonnes CO_2-e of net abatement per

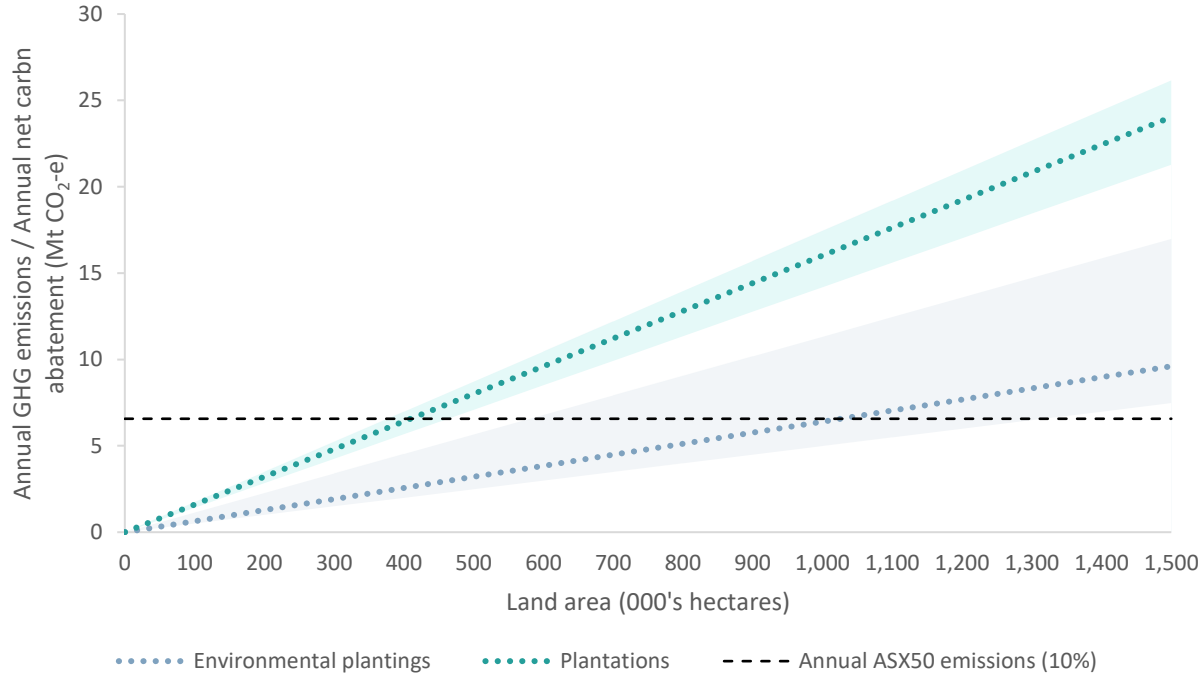
[1] Noting that not all ASX50 companies have made commitments to achieve net zero emissions by 2050.

[2] Scope 1 greenhouse gas emissions are the emissions released to the atmosphere as a direct result of an activity, or series of activities at a facility level. Scope 1 emissions are sometimes referred to as direct emissions (CER, 2021).

[3] Scope 2 greenhouse gas emissions are the emissions released to the atmosphere from the indirect consumption of an energy commodity (CER, 2021).

hectare each year, over the same period. These estimates are based on a permanence period[4] of 100 years.

- Plantations are found to abate more carbon per hectare than environmental planting due to higher growth rates in plantation species, which leads to higher rates of carbon sequestration, as well as the repeated cycles of harvesting, which create harvested wood products (HWP) that store carbon over long periods.
- To offset 10% of the annual emissions of all ASX50 companies for the next 25 years would require establishing 377 to 463 thousand hectares of plantations or 585 to 1,313 thousand hectares of environmental plantings. This comparison is presented in aggregate in Figure 1 and for a select number of companies in Table 1. For context, Australia's total commercial plantation area is currently about 2 million hectares. Therefore, to offset 10% of the ASX50's GHG emissions for the next 25 years using plantations would require establishing an area about 1 fifth the size of the current commercial plantation area, when midpoint estimates are considered.
- Along with storing carbon, HWP that are used in buildings can displace the use of more carbon intensive materials within the construction value chain. This can include the use of timber to replace steel and concrete in structural elements of buildings. This study has estimated the additional carbon abatement provided when timber replaces steel and concrete to demonstrate the additional advantages associated with establishing timber plantations to abate carbon emissions. Findings indicate that, when 1 hectare of plantation timber is used to construct predominantly timber buildings instead of predominantly steel or concrete buildings, embodied emissions are reduced by between 55 and 547 t CO_2-e. These emissions avoided are somewhat similar to Scope 3 emissions.[5]



[4] A permanence period defines how long a project must remain in place and may extend beyond the period for which a project can earn ACCUs. Plantation and environmental planting projects can choose between a permanence period of 25 or 100 years. Choosing the lesser permanence period will lead to a discounted number of ACCUs being issued (CER, 2016; CER, n.d.-b; CER, 2021-b)

[5] Scope 3 emissions are indirect greenhouse gas emissions other than scope 2 emissions that are generated in the wider economy. They include the emissions associated the extraction and production of purchased building materials. Scope 3 emissions are not reported under the NGER scheme (CER, 2021).

Figure 1. Estimated land requirements to offset 10% of ASX50 emissions for the next 25 years

This study was commissioned to provoke thought about the implications of ASX50 companies meeting their net zero targets by using carbon offsets. It finds that, if forestry offsets were to be used by major companies, timber plantations are considerably more efficient (in terms of CO_2-e tonnes sequestered per hectare of land) than environmental plantings. The study has relied on desktop research, publicly available data, and several simplifying assumptions to make broad comparisons possible. It has not considered, for example, the risks associated with fire which is applicable to both plantations and environmental plantings. It has also not considered the additional environmental benefits that could be generated from both plantations and environmental plantings, such as increased biodiversity, erosion protection or improved amenity.

Table 1. Estimated land requirements to offset 10% of the GHG emissions of select ASX50 companies for the next 25 years

Company	Market capitalisation ($ million)	Annual emissions - scope 1 and 2 (Mt CO_2e)	Land requirement with plantations (000's hectares)	Land requirement with EP (000's hectares)	Wood volume produced (000's M^3/harvest)
Commonwealth Bank of Australia[1]	180	0.1	0.6 - 0.7	0.9 - 2.1	327 - 402
BHP[2,4]	158	5.1	29 - 36	46 - 102	16,184 – 19,872
CSL[3]	134	0.1	0.5 - 0.7	0.8 - 1.9	294 - 361
Westpac Banking Corporation[1]	92	0.1	0.6 - 0.7	0.9 - 2	320 - 393
National Australia Bank[1]	88	0.1	0.5 - 0.6	0.8 - 1.8	282 - 347
Australia and New Zealand Banking Group[1]	80	0.1	0.6 - 0.7	0.9 - 2	319 - 392
Fortescue Metals Group[2]	75	2.1	9 - 11	14 - 32	5,024 – 6,169
Wesfarmers[2]	71	1.6	12 - 15	18 - 41	6,540 – 8,030
Woolworths Group[2]	50	2.4	13 - 17	21 - 47	7,422 – 9,114
Rio Tinto[2]	49	15.0	86 - 106	134 - 300	47,374 – 58,170

[1]Certified carbon neutral; [2]Net zero target; [3]No targets set; [4]GHG emissions are based on reported emissions in 2019-20, with no consideration of the proposed deal which would see Woodside Petroleum take control of BHP's petroleum assets

Source: Market Index (2021); CER (2021-c); UniSuper, 2021; Macdonald-Smith (2021); NCEconomics calculations

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1 INTRODUCTION

1.1 Project background

Many publicly listed companies have set targets to achieve net zero[6] emissions by 2050 (CER, 2021). Such targets can be achieved through actions to reduce the production of a given company's greenhouse gas (GHG) emissions (i.e. mitigation) or through the purchase of nature-based solutions, such as carbon offsets. These decisions are based on the marginal costs of reducing emissions through mitigation versus the cost of purchasing offsets in the market.

1.2 Project aims

Natural Capital Economics (NCE) was engaged by Forest and Wood Products Australia (FWPA) to undertake a thought-provoking investigation into the ability of nature-based mechanisms to deliver the required volume of carbon offsets for major corporations to meet their net zero emissions targets as well as the potential role timber plantations may have as an effective and efficient pathway for achieving these targets.

This project has focused on four key areas of investigation which include:

- The volume of GHG emissions and the emission reduction targets set by Australian companies which are part of the ASX50[7].
- The quantum of land required for ASX50 companies to achieve net zero using carbon offsets generated through plantation forestry[8] and how it compares to the quantity of land required to generate carbon offsets through environmental plantings[9].
- The establishment costs of plantations and environmental plantings.
- The added carbon abatement benefits plantations provide by providing harvested wood products (HWP) which can be used to reduce the use of more carbon intensive material. Specifically, this was examined through the lens of using timber instead of steel or concrete as a structural building material.

[6] 'Net zero emissions' refers to achieving an overall balance between GHG emissions produced and GHG emissions taken out of the atmosphere (Climate Council, 2020)

[7] ASX50 refers to the 50 highest valued companies publicly traded on the Australian Stock Exchange

[8] Plantations are defined as forests established for harvest (Australian Government, 2017)

[9] Environmental plantings refer to non-harvested mixed species plantings. They may be established to enhanced biodiversity, to sequester carbon, shelter for stock, manage salinity or for amenity value (CER, 2015; CSIRO, 2011)

2 METHOD

This study has involved high-level desktop analysis, drawing on publicly available data, with limited data validation. It began with an investigation into the GHG emissions of ASX50 companies and their emissions targets, with information primarily gathered from the Clean Energy Regulator (CER). When CER data was unavailable, data was collected from company annual reports, company sustainability reports and news articles. This process is further detailed alongside findings in part 3.1 of this report

Collecting emissions data on the ASX50 directly from the CER provided a high level of certainty as to the accuracy, timing, and boundaries of emissions estimates by companies. A lower level of certainty was available when collecting emissions data from other sources due to the presumption of less robust reporting requirements, and less explanatory information. For some companies, the boundaries of emissions reporting extended beyond those required when reporting to the CER (i.e. global emissions). In the absence of more detailed information, this data was included in our estimates of ASX50 emissions. This approach is not expected to have had a significant influence on the total estimated emissions of the ASX50, given the very high proportion of emissions which have been obtained directly from the CER.

The review of ASX50 emissions was followed by the development of a model to estimate the net carbon abatement and number of Australian Carbon Credit Units (ACCUs) which could be earned per hectare for both timber plantations and environmental plantings. These estimates were compared to the emissions of ASX50 companies enabling the quantification of land required to offset these emissions.

Data to develop this model were primarily sourced from the Australian Bureau of Agricultural and Resource Economics (ABARES), Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the CER.

The model draws on the approach used to calculate net abatement in the Emission Reduction Fund (ERF) Plantation Forestry Method[10] and the Reforestation by Environmental or Mallee Plantings Method[11]. A full description of the model and its inputs is included in Appendix A.

The final step of this study involved estimating the reduction in embodied carbon emissions that could be achieved by using HWP to replace more carbon intensive building materials. This benefit is not accounted for in the Plantation Forestry method. It is also not applicable to environmental plantings as the Reforestation by Environmental or Mallee Plantings Method does not allow for harvesting. However, it was included to provide an indication of the quantum of emissions that could be avoided, should there be an appropriate method for capturing reductions in embodied carbon emissions associated with building materials[12].

Quantification of embodied emissions reductions was estimated by drawing on previous research undertaken by NCEconomics (Perry et al., 2021), which described the volume of wood used in buildings of various types and the reduction in embodied emissions associated with constructing buildings which use wood for structural components instead of those buildings which use steel or concrete. This information was converted to a per ha basis using estimates of wood harvested from ABARES (2016).

[10] The Plantation forestry method enables ACCUs to be earned for eligible and approved plantation forestry projects (CER, 2021-b)

[11] The Reforestation by Environmental or Mallee Plantings Method enables ACCUs to be earned for eligible reforestation projects which involve establishing and maintaining vegetation.

[12] The forestry industry is currently attempting to have a method accepted by the ERF that would allow reductions in embodied emissions associated with structural building materials to be eligible for ACCUs.

In the models developed for this project, a range of values are used for most inputs, which reflects the uncertainty associated with some of the input parameters. This allowed a Monte Carlo simulation with 20,000 iterations to be run for sensitivity analysis.

3 RESULTS

3.1 ASX50 greenhouse gas emissions

The ASX50 includes 50 companies which emit about 66 Mt CO_2-e annually when considering scope 1[13] and scope 2[14] emissions. This estimate is primarily based on emissions data from 2019-2020. Of these 50 companies, at least 26 report their emissions directly to the CER as required under the National Greenhouse and Energy Reporting Act 2007. These 26 companies account for 98% of the estimated emissions of the ASX50.

Figure 2 presents the number of companies in the ASX50 and their estimated annual emissions. It also presents the number of companies which are part of the ASX50 and which have set a net zero target or expressed an ambition / support for achieving net zero emissions. Finally, it presents the number of ASX50 companies which are currently using / or have indicated an intention to use carbon offsets in the future.

Figure 2 shows that 26 of the 50 companies in the ASX50, report net zero targets. Of these companies, 17 express targets that are linked to a 2050 timeframe, and 9 companies have committed to an earlier timeframe. Of the ASX50, 24 companies have expressed some interest in using carbon offsets to meet targets. These 24 companies emit about 50 Mt CO_2-e or 75% of total reported emissions of the ASX50.

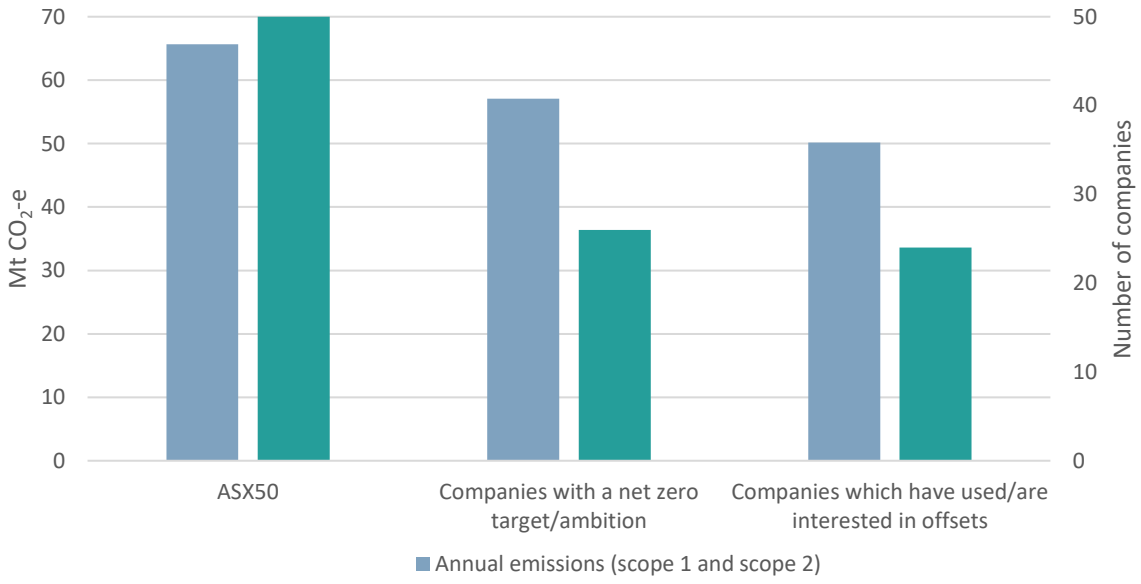

Figure 2 Reported GHG emissions of ASX50

Figure 3 presents the annual emissions and market capitalisation of each sector in the ASX50 as a percentage of the total. Sectors are ordered based on market capitalisation value. It shows that the financial sector is the most valuable sector, accounting for 35% of the total value within the ASX50. The financial sector is followed by materials and health care in terms of total value. By contrast, the materials sector is the largest sector in the ASX50 based on GHG emissions accounting for 59% of the total annual emissions. This is followed by the energy sector which accounts for 26% of the total

[13] Scope 1 greenhouse gas emissions are the emissions released to the atmosphere as a direct result of an activity, or series of activities at a facility level. Scope 1 emissions are sometimes referred to as direct emissions (CER, 2021)

[14] Scope 2 greenhouse gas emissions are the emissions released to the atmosphere from the indirect consumption of an energy commodity (CER, 2021)

emissions. Figure 3 illustrates that emissions and market value are not necessarily aligned and that only a relatively small number of sectors are responsible for the majority of the total GHG emissions of the ASX50.

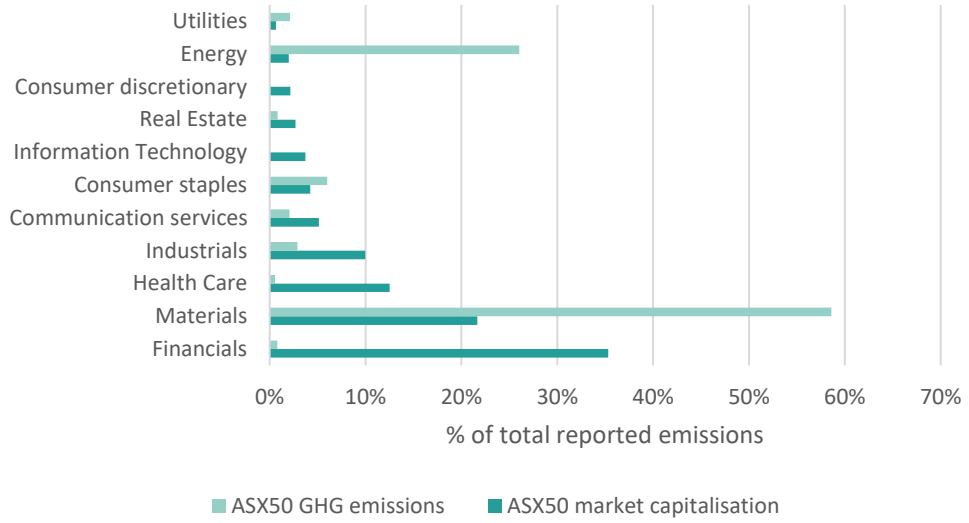

Figure 3. Reported annual GHG emissions of ASX50 by sector and market capitalisation (% of total)

Source: Market Index (2021); CER (2021-c); Publicly reported emissions estimates

Figure 4 present the companies which are part of the ASX50 which emit the most GHG emissions each year. The largest producer of GHG emissions in the ASX50 is Rio Tinto, which produces about 15 Mt CO_2-e each year or roughly 23% of all ASX50 annual emissions. The top three largest producers of GHG emissions produce about half of the total emissions, while the top 5 and top 10 produce about 70% and 90% of the total, respectively. Like Figure 3, Figure 4 demonstrates how GHG emissions in the ASX50 are highly concentrated, with only a few companies being responsible for most of the GHG emissions. This finding is not unexpected due to the differing nature of companies involved.

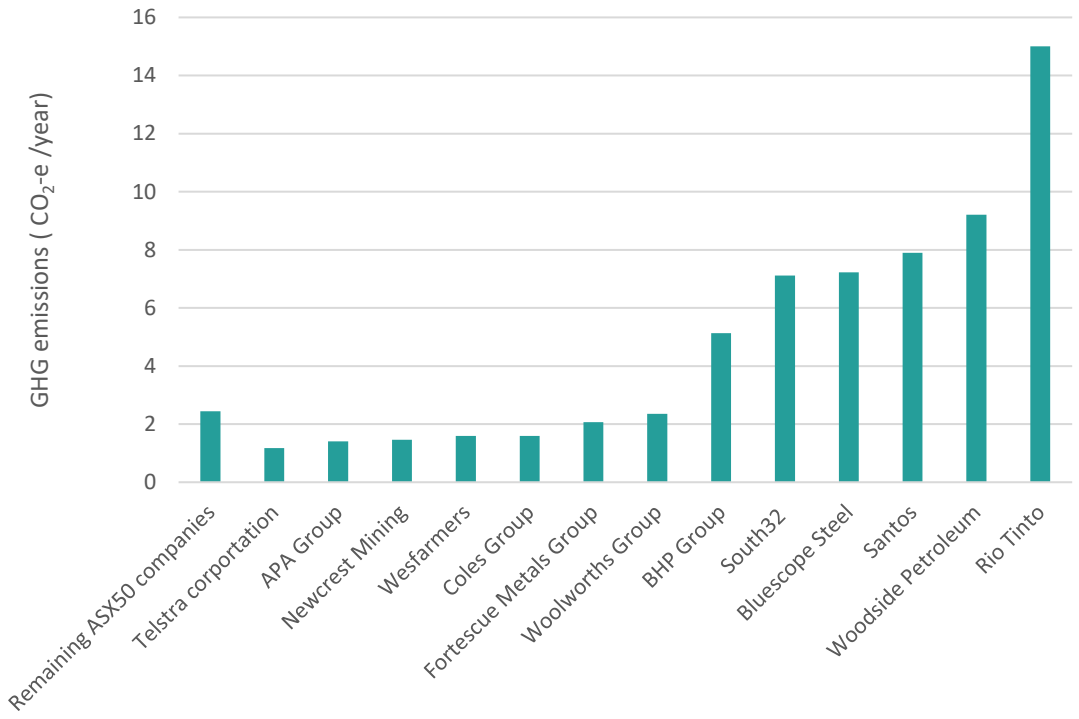

Figure 4. Largest ASX50 GHG emitters

Source: Market Index (2021); CER (2021-c); APA Group (2020); Publicly reported emissions estimates

3.2 Net abatement and ACCUs

The number of ACCUs that can be earned from a timber plantation and an environmental planting depends on the relevant ERF methods and reflect the volume of net carbon abatement achieved. The number of ACCUs which could be earned from a radiata pine plantation has been estimated based on the Plantation Forestry Method. Similarly, the Reforestation by Environmental or Mallee Plantings Method has been used to estimate the number of ACCUs which can be earned from environmental plantings. Under both methods, ACCUs are earned at the end of each reporting period throughout the crediting period, with both methods defining the crediting period as 25 years (CER, 2016; CER, n.d-b; Queensland Government, 2021). Furthermore, each method defines a permanence period (i.e. how long the plantings must remain in place) of either 25 or 100 years. Choosing the lesser permanence period will lead to a discounted number of ACCUs being issued (CER, n.d.-b; CER, 2021-b). A further 5% discount also applies to all sequestration project, which is known as the "risk of reversal buffer" (CER, 2018).

Under the Plantation Forestry Method, credited ACCUs cannot exceed the 100 year average value of the carbon pool, which takes into consideration the carbon stored in plantation trees and HWP (Australian Government, 2017). This condition does not apply to environmental plantings.

Table 2 present the estimated total carbon abatement which can be reported over the life of a given plantation or environmental plantings project. Based on this modelling, 1 hectare of radiata pine which is harvested every 30 to 35 years can abate about 355 - 435 t CO_2-e when considering the 100-year average volume of carbon stored in the plantation and HWP. By contrast, 1 hectare of environmental plantings is estimated to abate between 125 – 281 t CO_2-e, when considering the 25 year crediting period. These results indicate that plantations abate between 1.3 and 3.5 times more CO_2-e per hectare that environmental plantings.

Table 2. Total carbon abatement which can earn ACCU's over project life

Project type	Carbon abatement per hectare (t CO_2-e)		
	Low	Mid	High
Environmental planting	125	160	281
Radiata pine plantation	355	401	435

Source: NCEconomics calculations

The number of ACCUs that could be earned for each hypothetical project is presented in Table 3 based on the annual average number over a 25 year period. The number of ACCUs that a timber plantation could earn is estimated to be 14 – 17 ACCUs each year when averaged over 25 years. For environmental planting, the number of ACCUs is estimated to between 5 – 11 using the same assumptions. These estimates assume a 100 year permanence period and take into account the risk of reversal buffer.

In this studies modelling, a plantation project sequesters enough carbon to reach the long term average value of its carbon pool before the end of the 25 year period, meaning the results reflect the maximum number of carbon credits that could be earned. An environmental planting project also sequestered enough carbon to reach its long term average value of its carbon pool before year 25, however, to be consistent with the relevant ERF method this has not restricted the number of ACCUs that can be earned. Therefore, for environmental plantings, ACCUs continue to be earned for all carbon abatement up to year 25. Variation in annual net abatement and therefore accumulation of ACCUs between plantations and environmental plantings is attributed to higher growth rates in plantation species, which lead to greater rates of carbon sequestration. In addition, the process of harvesting plantations results in the long-term storage of carbon in HWP.

Table 3. Estimated average annual number of ACCUs earned over 25 year crediting period

Project type	Australian Carbon Credit Units (1 ACCU = 1 t CO_2-e)		
	Low	Mid	High
Environmental planting	5	6	11
Radiata pine plantation	14	16	17

Note: the plantation estimates take into consideration emissions associated with harvesting and processing HWP.
Source: NCEconomics calculations

3.3 Land requirements to offset ASX50 annual emissions

Based on the estimated number of ACCUs which could be earned each year from plantations or environmental plantings, the area of land required to offset 5, 10 and 20% of the GHG emissions of the ASX50 for the next 25 years was estimated (Table 4). The 25 year period aligns with the crediting period for both ERF methods. Using a longer assessment period also reflects the requirement that recurrent emissions need to be offset annually to remain net zero. The 5, 10 and 20% scenarios reflect our understanding that ASX50 companies will likely rely on a mixed approach (mitigation and offsets) to achieve their emissions reduction targets.

Table 4. Estimated land requirements to offset ASX50 emissions for the next 25 years

ASX50 GHG emissions offset over 25 years (% of total)	Area of plantations (000's hectares)			Area of environmental plantings (000's hectares)		
	Low	Mid	High	Low	Mid	High
5	188	205	231	292	513	656
10	377	410	463	585	1,025	1,313
20	754	820	926	1,169	2,051	2,625

Source: NCEconomics calculations

Figure 5 presents the upper, lower, and midpoint estimates of net carbon abatement from plantations and environmental plantings and the area of land required to offset 10% of the annual GHG emissions of the ASX50 (horizontal dashed line) over the next 25 years. The results indicate that it would require between 377 and 463 thousand hectares of plantations or between 585 and 1,313 thousand hectares of environmental planting to offset 10% of the annual GHG emissions of the ASX50 over the next 25 years. For context, Australia's total commercial plantation area is about 2 million hectares, while the area of agricultural land in Australia is estimated to be 377 million hectares (ABARES, 2019; ABS, 2021-b). Therefore, the area of plantations required to offset 10% of the GHG emissions of the ASX50 over the next 25 year is equivalent to about 20% of the current area of Australia's commercial plantation estate or 0.1% of Australia's agricultural land. Figure 5 also highlights the relatively wide range in the estimated environmental plantings results compared to the plantations results. This is primarily a result of larger range in the estimated rates of carbon sequestration associated with environmental planting. For both environmental plantings and plantations, the rate of carbon sequestration is influenced by biomass growth rates (Unwin & Kriedemann, 2000). Growth rates, depend on the species of tree or plant used as well as other factors including soil quality and water availability.

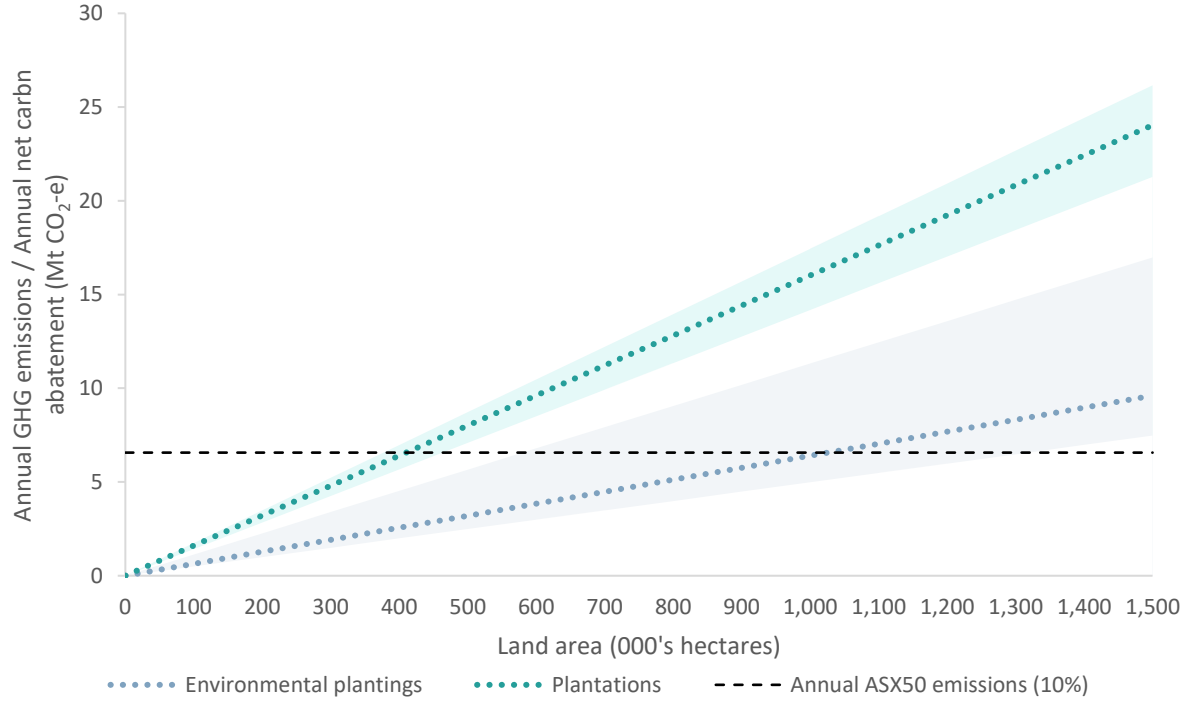

Figure 5. Estimated land requirements to offset 10% of ASX50 emissions for the next 25 years

Source: NCEconomics calculations

Table 5 (overleaf) presents the market capitalisation and GHG emissions of the 10 most valuable companies within the ASX50 which report GHG emissions to the CER. For each of these companies Table 5 also presents the area of land required to offset 10% of their annual emissions if ACCUs generated from either plantations or environmental plantings were used as well as the volume of wood that could be obtained from a single harvest of this land. As the largest GHG emitter in the ASX50, Rio Tinto would require the greatest area of land to offset 10% of its GHG emissions (between 86 and 300 thousand hectares depending on the offset project).[15]

[15]The GHG emissions of Rio Tinto have been obtained from the CER (2021-c). In 2020, Rio Tinto (2020) "set an ambition to reach net zero carbon emissions across" its operations by 2050. Rio Tinto also indicated that carbon offsets will form part of its decarbonisation strategy.

Table 5. Estimated land requirements to offset 10% of the GHG emissions of select ASX50 companies for the next 25 years

Company	Market capitalisation ($ million)	Annual emissions - scope 1 and 2 (Mt CO_2e)	Land requirement with plantations (000's hectares)	Land requirement with EP (000's hectares)	Wood volume produced (000's M^3/harvest)
Commonwealth Bank of Australia[1]	180	0.1	0.6 - 0.7	0.9 - 2.1	327 - 402
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Rio Tinto[2]	49	15.0	86 - 106	134 - 300	47,374 – 58,170

[1]Certified carbon neutral; [2]Net zero target; [3]No targets set; [4]GHG emissions are based on reported emissions in 2019-20, with no consideration of the proposed deal which would see Woodside Petroleum take control of BHP's petroleum assets

Source: Market Index (2021); CER (2021-c); UniSuper, 2021; Macdonald-Smith (2021); NCEconomics calculations

3.4 Establishment costs of plantations and environmental plantings

An understanding of establishment costs, ongoing costs and land acquisition costs is a key component in determining which is the most economically efficient method of abating GHG emissions from society's perspective.

The costs of establishing timber plantations and environmental plantings are presented in Table 6. Based on estimates from ABARES (2019-b), the cost of establishing a timber plantation is between $1,900 - $2,100 per hectare. By comparison, the costs of establishing environmental plantings are estimated to be between $1,000 - $9,100 per hectare (Environments by Design, 2016; CSIRO, 2011; Summers et al., 2014). These costs do not consider inflation or on-going costs. While the estimates are based on limited reference material, they demonstrate the wider range of establishment costs associated with environmental plantings. This is likely to reflect the diversity of species/locations in which environmental plantings are established compared to plantations.

Table 6. Estimated establishment costs by project type

Project Type	Establishment cost range ($/hectare)
Timber plantation costs	1,900 – 2,100
Environmental plantings	1,000 – 9,097

Source: ABARES, 2019-b; Environments by Design,2016; CSIRO, 2011; Summers et al., 2014

The costs of acquiring land can be considerable. Rural Bank (2021) report that the median value of Australian farmland was $5,907 per hectare in 2020. Industry representatives consider the cost of land in areas suitable for commercial plantation to be greater than $8,000 per hectare (C Taylor, pers. comms, 5 August 2021). Environmental plantings may be established as joint ventures with farmers, in which case, the purchase of land may not be required (CER, n.d.-b).

Based on findings from this study, environmental plantings would require about 60% more land to achieve the same volume of carbon abatement. Notwithstanding the estimates in Table 6, similar costs for land and establishment would translate into costs which are 60% higher for environmental plantings than timber plantation per t CO_2-e abated. This is significant given currently the ASX alone emit about 66 Mt CO_2-e per year. These estimates are based on midpoint estimates of carbon abatement achieved by timber plantations and environmental plantings.

3.5 Harvested wood products

The Plantation Forestry Method recognises the benefit HWP can have by storing carbon (embedded carbon) and reducing the volume of GHG emissions released into the atmosphere. The size of this benefit is linked to the length of time carbon remains stored, which is tied to the life expectancy of HWP. HWP used in construction, like structural timber, are expected to have a relative long life by comparison to a HWP like paper (Australian Government, 2017). In general, this means they can store carbon for longer creating more benefit. The Plantation Forestry Method only recognises carbon stored in HWP in use. This approach underestimates the carbon storage of HWP as these products can continue to store carbon for long periods after disposal in landfills (Ximenes et al., 2019).

In addition to storing carbon, HWP can provide a benefit by reducing the volume of emissions released into the atmosphere through preventing the use of more carbon intensive materials (reducing embodied emissions). For example, if timber is used in place of steel and concrete when constructing buildings. The reduction in embodied emissions will depend on the difference between the embodied emissions of the materials being replaced and the embodied carbon of the replacement HWP.

In a previous study, NCEconomics investigated the reduction in embodied emissions which could be achieved by constructing buildings which primarily use wood for structural components instead of buildings which primarily use steel or concrete. Drawing on estimates from this study (Perry et al., 2021), the embodied emissions reductions have been estimated if plantation timber, which is planted to generate ACCUs, is used for this purpose. The results of this analysis are presented in Figure 6. Further information on the inputs and assumptions used for these calculations are provided in Appendix B.

Figure 6 presents the estimated reduction in embodied emissions which can be achieved by using 1 hectare of plantation timber to construct houses predominantly made from timber instead of steel. The benefit ranges from 55 to 197 t CO_2-e. when between 5 and 13 timber houses are built instead of steel houses. Alternatively, 1 hectare of plantation timber can be used to construct between 10 and 23 predominantly wood midrise apartments, which reduces embodied emissions by about 240 to 547 t CO_2-e when they are constructed instead of predominantly concrete apartments.

Figure 6. Estimated reduction in embodied emissions through substitution of steel and concrete buildings for wood

Figure 7 demonstrates the cumulative benefit of using HWP to construct predominantly wood buildings instead of predominantly steel houses or concrete apartments. The reduction in embodied emissions shown is in addition to benefits derived from carbon sequestration that generate ACCUs.

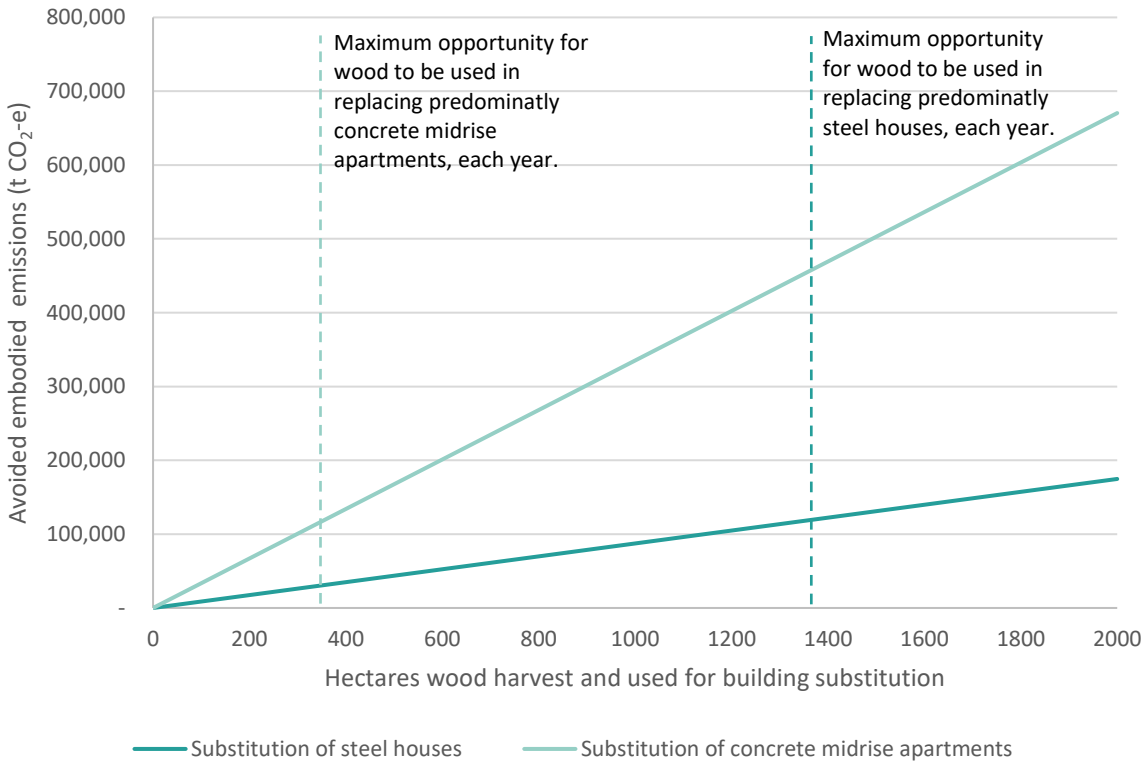

Figure 7. Avoided emissions when HWP are used to construct predominantly wood buildings instead of predominantly steel or concrete buildings

Source: NCE modelling.

Estimates of market share and building approvals suggest about 15,500 steel houses and 5,000 concrete apartments were constructed in 2020. This limits the potential reduction in embodied emissions to about 120,000 t CO_2-e each year for the replacement of each building type. This is equivalent to about 1,400 hectares of construction specific HWP for use in constructing timber houses and 400 hectares of construction specific HWP for use in constructing midrise timber apartments. Wood has the potential to be used in various applications across the construction industry to reduce embodied emissions.

4 DISCUSSION AND CONCLUSIONS

This study finds that based on the land area, plantations are more efficient than environmental plantings at carbon abatement. This is consistent with international research (Forster et al., 2021). Plantations have the potential to earn more ACCUs than environmental plantings per hectare and this means they could offset the GHG emissions of the ASX50 with a much lower land requirement. This finding includes consideration of the carbon released into the atmosphere during harvest events.

Based on midpoint estimates, plantations require 60% less land than environmental planting to abate an equivalent volume of GHG emissions. This equates to 410 thousand hectares of timber plantations instead of 1,025 thousand hectares of environmental plantings if the ASX50 decided to offset 10% of their own emissions for the next 25 years.

In 2017-18, Australia's commercial plantation estate covered 1.95 million hectares (ABARES, 2019). To offset 10% of the ASX50 GHG emissions for the next 25 years, the plantation estate would need to be increased by around a fifth over the current area of commercial plantations, when midpoint estimates are considered. The scale of this increase is not inconsistent with existing industry strategies. The increase would still leave Australia's commercial plantation estate more than 0.5 million hectares short of the target set for 2020 by the Planation 2020 vision (Plantations for Australia: The 2020 vision), which was established through a strategic partnership between Australian, State and Territory Governments and the plantation timber growing and processing industry.

The Australian government also has a goal of planting 1 billion trees by 2030 (Australian Government, 2018). This is equivalent to about 400 thousand hectares of land. This number of trees would therefore be enough to offset about 10% of the ASX50 GHG emissions over the next 25 years or about 4% using environmental plantings, if eligible to earn ACCUs. Further emissions reductions would require further investment than is planned by this commitment.

The use of HWP has been shown to reduce embodied emissions by replacing more carbon intensive materials. When replacing predominantly steel houses the additional reduction in emissions is about 87 t CO_2-e per hectare of wood used. Constructing predominantly timber midrise apartments can reduce emissions by about 335 t CO_2-e per hectare of wood used when they are constructed instead of predominantly concrete midrise apartments. The upper limit of these benefits is restricted by the number of these types of building currently being built. Embodied emissions reductions could however also be achieved when wood is used as an alternative material in other settings. Likewise, opportunities such as using harvest residues from new plantations to produce renewable energy, green hydrogen or biochar provide examples of further opportunities to potentially increase climate mitigation benefits (DAWE, 2019; Ximenes, 2021; Cho, 2021; Peacock, 2021). These pathways to reducing emissions are not available to environmental planting as they are not eligible for harvest under the current rules of the ERF.

Considerations when interpreting the results

This study has based its investigation of carbon abatement from plantations on a long rotation (harvested every 30 to 35 years) radiata pine plantation managed for sawlog production. In 2017-18, radiata pine accounted for 74.5% of Australia's softwood plantation estate which is about 53% of the total commercial plantation area (ABARES, 2019). Further investigation into different plantation species (e.g. other softwood and hardwood species like southern pines or Tasmanian blue gum) and different harvest cycles (long rotation and short rotation plantations) would be expected to increase the range of outcomes associated with carbon abatement from plantations.

This work has estimated the area of land required to offset the GHG emissions of the ASX50 if plantations or environmental planting were used to generate ACCUs. This study has not considered if estimate amount of land is available to use for this purpose. Currently, under the Plantation Forestry

Method, new plantations are only eligible to earn ACCUs if they are occur in regions defined under the national plantation inventory (CER, 2021-b).

Under the Plantation Forestry Method and the Reforestation by Environmental or Mallee Plantings Method, participants are obligated to take actions to recapture carbon released during fire events if they occur during the permanence period (CER, 2020). Alternatively, they can return an equivalent number of ACCUs. This study has not considered the risks associated with fire, which would release carbon into the atmosphere. This risk is applicable to both plantations and environmental plantings. However, there may be a greater commercial incentive to protect plantations from fire, which means such plantings are at lower risk.

Environmental plantings may comprise a range of species that have the potential to provide improved biodiversity, erosion protection, sheltering stock, managing salinity or amenity as well as carbon sequestration (CSIRO, 2011). Plantations also have the potential to provide wider environmental benefits, for example by improving soil and water quality, salinity mitigation, carbon abatement and improved biodiversity (DAWE, 2019).

As a trade-off to environmental benefits, plantations and environmental planting can also reduce water availability by using more water than was previously used at the same site (i.e. by crops or pasture) (O'Loughlin & Sadanandan Nambiar, 2001). Changes in water availability are influenced by many factors including site and ecosystem details and management. This study has not attempted to estimate the differences in the provision of environmental benefits between plantations and environmental plantings. However, wider environmental benefits may be a factor in whether plantation or environmental plantings are used to offset carbon emissions.

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APPENDIX A – COMPARING THE CARBON ABATEMENT OF PLANTATIONS WITH CARBON ABATEMENT OF ENVIRONMENTAL PLANTINGS

Aim

As part of this study, we created a model to understand the net carbon abatement achievable from timber plantations under the Plantation Forestry Method and environmental plantings under the Reforestation by Environmental or Mallee Plantings Method. This enabled an understanding of the area of land required for each type of project to generate the same volume of carbon abatement as well as the area of land required for each type of project to generate carbon offsets (ACCUs) equivalent to the GHG emissions of the ASX50.

Model Inputs and Approach

The model inputs are presented in Table 7 and the model is visually represented in Figure 8.

For environmental plantings net carbon abatement is determined based on average annual net carbon abatement for 20 years with net carbon abatement after year 20 decreased based on a growth decline factor.

For plantations, net carbon abatement is determined using estimates of average annual rates of carbon sequestration for radiata pine. All harvest emissions are accounted for when the harvest age is reached using a set percentage of the wood harvested as a reference point. The volume of wood harvested is based on estimates of log yield from a radiata pine forest with the outputs from harvest set by typical percentages from a radiata pine plantation managed for sawlogs. Finally, the volume of carbon sequestered and stored in HWP is determined based on the volume of HWP harvested. This is converted to a carbon dioxide equivalent volume and then decayed annually, based on the half-life of those products.

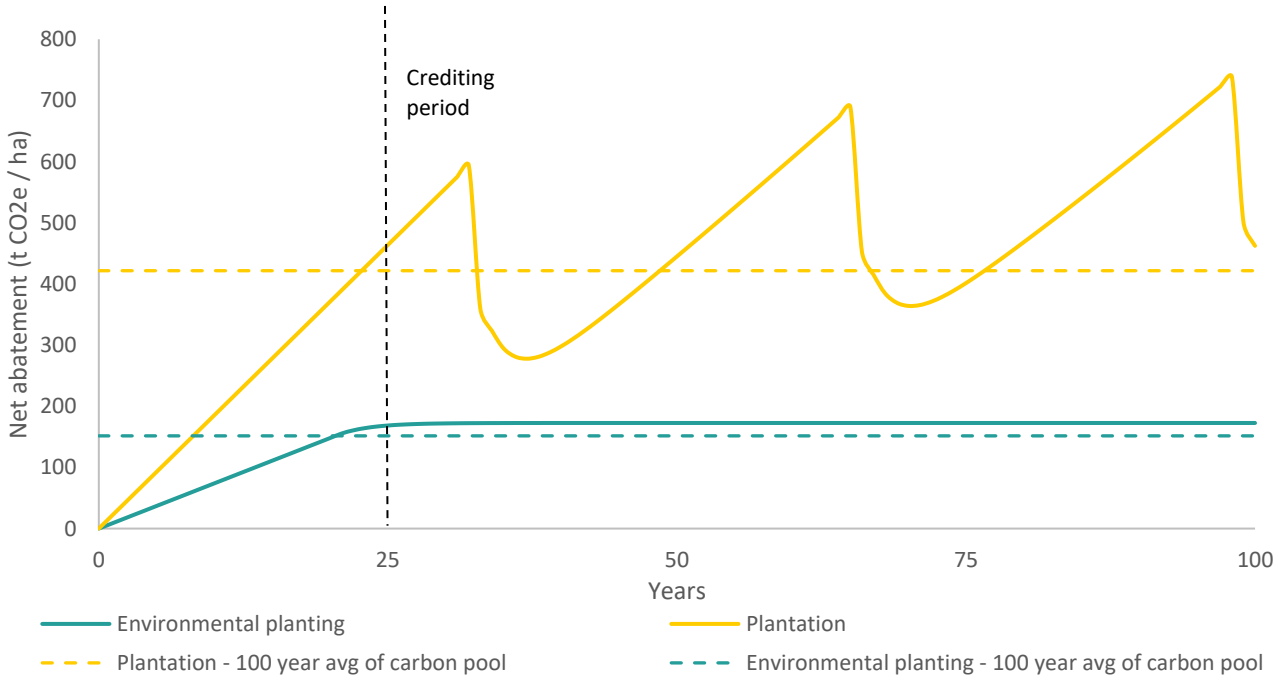

Figure 8. Net carbon abatement from plantations and environmental plantings (Based on model midpoint estimates for 1 hectare)

Table 7. Model Inputs - Comparing the carbon abatement of plantations with carbon abatement of environmental plantings

Description	Low	Mid	High	Units	Comments	Reference
CO2 sequestration rate - radiata pine	13.7	18.6	23.4	Avg t CO2-e / ha / year	Average over 30/35 years	ABARES, 2011; Private Forests Tasmania, 2011
Net CO2-e abatement - environmental plantings	3.6	7.4	16.4	Avg t CO2-e / ha / year	Average over 20 years	CER, 2015; CSIRO, 2011
Log yield - radiata pine	470	550	630	m3 / ha	Thinned radiata pine clear felled at 30 years. Yield from clear-fell and thinning. Includes sawlogs and pulplogs	ABARES, 2016
Harvest age - radiata pine	30	33	35	years		
Harvest emissions (as a % of CO2 in harvested wood)		3.5%		%		Australian Government, 2017
Growth decline factor - environmental planting		0.7		n/a		CSIRO, 2011
Cubic metres of softwood to tonnes of carbon dioxide		0.847		n/a		Based on first principles
Annual decay rate - sawnwood		2%		%		Smith & Ximenes, 2019
Annual decay rate - paper/particleboard		35%		%		
Harvest outcomes (as a % of total wood in plantation) - Deadwood		10%		%	Based on Radiata pine	DEE, 2017
Harvest outcomes (as a % of total wood in plantation) - Paper		31%		%		
Harvest outcomes (as a % of total wood in plantation) - Fibreboard		6%		%		
Harvest outcomes (as a % of total wood in plantation) - Construction		36%		%		

Description	Low	Mid	High	Units	Comments	Reference
Harvest outcomes (as a % of total wood in plantation) – Mill residue		17%		%		

APPENDIX B – USE OF HARVESTED WOOD PRODUCTS IN BUILDINGS

Aim

As part of this study, a model was created to understand the reduction in embodied emissions that could be achieved if the wood from plantations, that was planted to generate ACCUs, was harvested and used to reduce the use of more carbon intensive material. This was examined through the lens of using wood to construct predominantly wood houses instead of predominantly steel houses as well as using wood to construct predominantly wood midrise apartments instead of predominantly concrete midrise apartments. Constructing predominantly wood houses instead of predominantly steel houses was expected to have a lower benefit in terms of reduced embodied emissions than replacing predominantly concrete midrise apartment with predominantly wood midrise apartments due to the greater emissions intensity of concrete compared to steel. This analysis draws on previous work by NCEconomics.

Model Inputs and Approach

The model inputs used in this analysis are presented in Table 8

Estimates of the volume of wood used to construct various wood buildings (Perry et al., 2021) were combined with estimated volumes of wood harvested from a plantation which goes on to be used in construction (taken from this studies modelling) and estimates of the embodied emissions reductions that are available when constructing predominantly wood buildings instead of predominantly steel or concrete buildings (Perry et al., 2021) to understand the amount of each building type that can be built from 1 hectare of plantation timber and the associated reduction in embodied emissions that is available.

The upper limit of the embodied emissions reduction was determined by combining the total amount of each type of building being constructed each year with estimates of each materials market share.

Table 8. Model Inputs – Use of harvest wood products in buildings

Description	Low	Mid	High	Units	Comments	Reference
Wood used in timber framed house	0.04	0.08	0.24	m3 / m2		Perry et al., 2021
Wood used in timber midrise building	0.04	0.14	0.24	m3 / m2		
Carbon abatement - replacing steel with wood in Class 1 buildings	0.03	0.03	0.11	t CO2-e / m2		
Carbon abatement - replacing concrete with wood in mid-rise buildings	0.20	0.22	0.24	t CO2-e / m2		
Floor area – houses	185.52	231.9	278.28	Sqm		ABS, 2018
Floor area – Apartments	86.48	108.1	129.72	Sqm		
Market share of houses – Steel	0.11	0.14	0.16	%		Australian Construction Insights (2018)
Market share of midrise buildings - Concrete	0.23	0.28	0.34	%		Victorian Building Authority (2020)
Houses approved	91,555	114,444	137,333	No.	2020	ABS (2021)
Apartments - In a four to eight storey blocks approved (midrise)	14,396	17,995	21,594	No.	2020	