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2021 Update of Tasmania's Emissions Pathway Review – technical report

Final report

Prepared for:

Tasmanian Climate Change Office

2021

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The findings in this report have been formed on the above basis.

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1 EXECUTIVE SUMMARY

1.1 Background

Under Tasmania's existing *Climate Change (State Action) Act 2008* (the Act), the state passed a legally binding target to reduce emissions by at least 60% below 1990 levels by 2050. Through the subsequent release of Climate Action 21, the Tasmanian Government has committed to a target of net zero emissions by 2050. As part of the independent review of the Act that is currently underway, the Tasmanian Government is seeking to set a more ambitious emissions reduction target for Tasmania, aligned with the goals of the Paris Agreement.

To assist with this process, the Tasmanian Government commissioned Point Advisory and Indufor to deliver this 2021 update of Tasmania's Emissions Pathway Review, building on the analysis undertaken by our teams as part of the 2019 review project.

This report provides an overview of the analysis undertaken for the Tasmanian Government to support the development of a new, more ambitious emissions reduction target for the state, and includes the following:

- A discussion of Tasmania's current emissions profile, and an indication of how this profile could look in the future.
- An overview of different emissions reduction opportunities available to Tasmania, their impact on Tasmania's emissions to 2050, how these may impact the economy and the overall costs and benefits of implementation[1].
- A discussion of the net zero target pathway options available to Tasmania, including a comparison with other Australian states and territories, and with other countries.

1.2 The need for climate action

There is now overwhelming evidence that the earth is warming and that our climate is changing. Rising temperatures as a result of climate change will have a significant impact on rainfall, evaporation and sea level, among many other things. These changes are likely to make our climate more varied and result in more frequent and severe extreme weather events.

To address this situation, in 2015, countries from around the world signed up to the Paris Agreement. This commits countries to keeping global temperature rise to well below 2 degrees Celsius, and to make every effort to keep them below 1.5 degrees Celsius, compared to pre-industrial levels. In practical terms, this means that greenhouse gas emissions need to peak now and reach net zero by 2050 at the latest. The Paris Agreement recognises the important role of sub-national governments in responding to climate change, however meeting this challenge is a shared responsibility that will require action from communities, businesses and governments from around the world.

1.3 Tasmania's emissions profile

1.3.1 Tasmania's historic greenhouse gas emissions

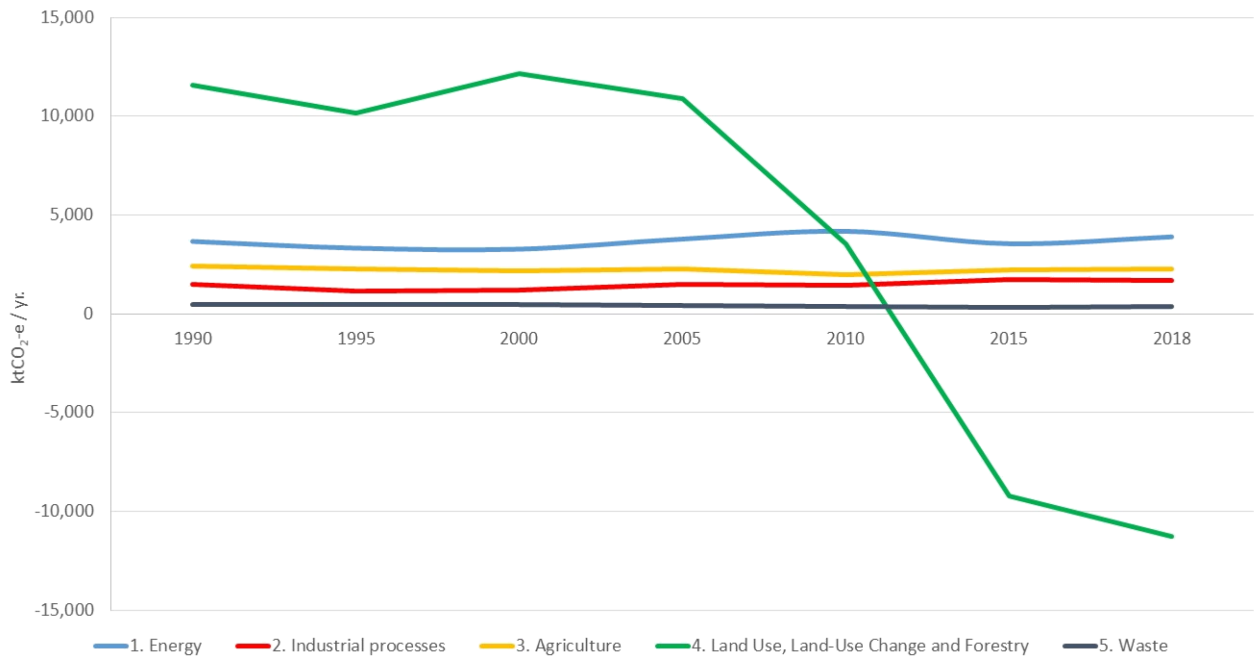
Tasmania's emissions profile is unique among Australian states and territories, as it has maintained net zero emissions since 2013[2]. This achievement has helped to establish Tasmania as an Australian climate change leader.

This achievement of net zero emissions is primarily because of Tasmania's large forest estate (which absorbs a significant amount of carbon dioxide from the atmosphere each year), and because the state generates a high proportion of zero emissions renewable electricity (Figure 1).

[1]The scope of this engagement did not expand to the modelling of dynamic relationships between economic aggregates and therefore, the assessment of costs and benefits was mainly qualitative, and should be considered as indicative of possible risks and opportunities rather than definitive.

[2] Based on the 2019 STGGI results provided by DISER. Note that net emissions went above net zero in 2014 but have remained net zero since.

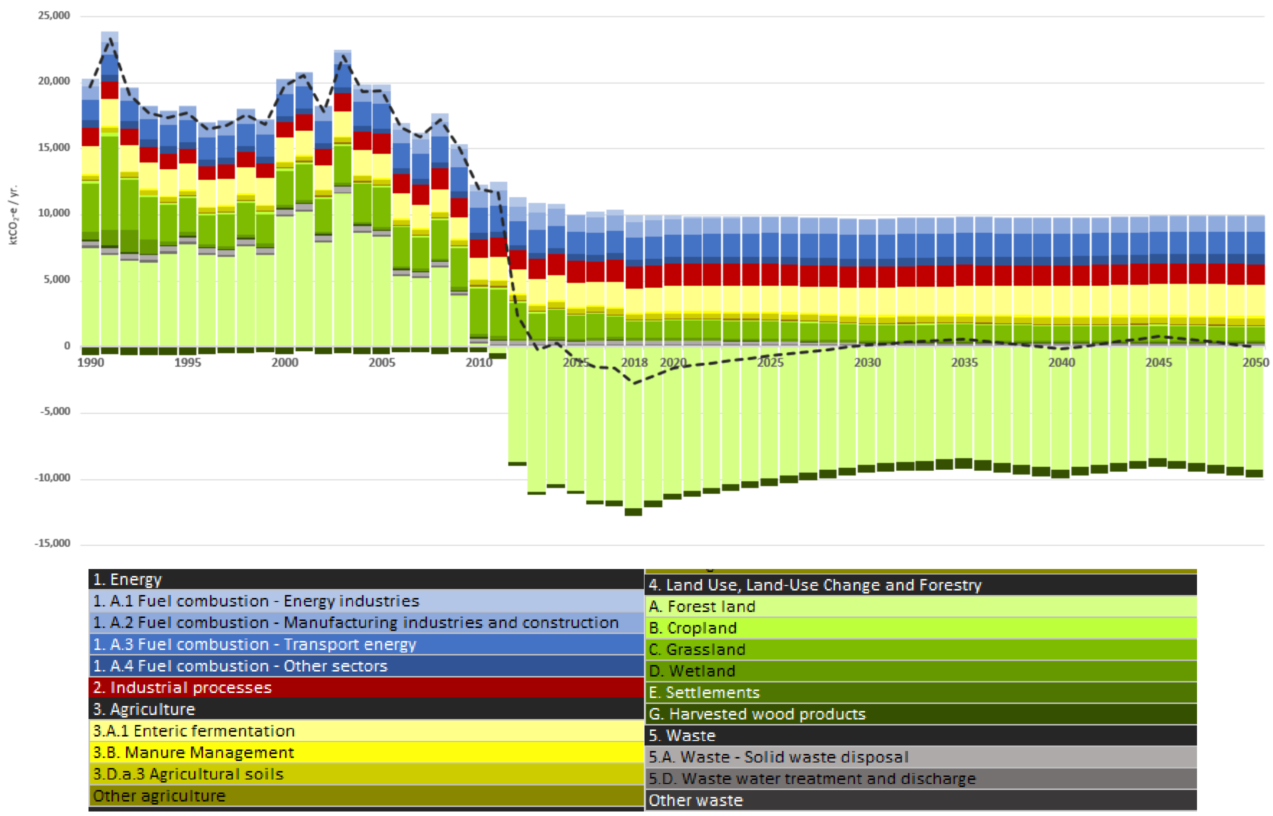
Figure 1. Tasmania's historical emissions profile, broken down by sector (1990 to 2018)



1.3.2 Tasmania's "reference case" emissions to 2050

Under current 'business as usual' national and state policy settings, Tasmania's reference case greenhouse gas emissions will likely remain well below net zero emissions until 2025. However, from 2030 net emissions hover very close to zero out to 2050, and in years where there are major bushfires modelled (2035 and 2045), the state becomes a net emitter. The reference case emissions modelling out to 2050 is presented in Figure 2.

Figure 2. Medium emissions scenario, reference case emissions for Tasmania (1990 to 2050)



1.4 Opportunities to reduce emissions

The Tasmanian Government has the opportunity to make significant emissions reductions over the period to 2050. Through consultation with a range of Tasmanian Government agencies, 26 emissions reduction opportunities from across all sectors of the Tasmanian economy were identified and investigated in detail.

These opportunities vary in their level of technological development, cost to implement, and likely acceptability to the Tasmanian Government and public. While some of these opportunities align with existing government policy priorities, other opportunities - if pursued - would require further analysis in consultation with key industry sectors as they are likely to involve significant capital investment and research and development.

Opportunities that are considered moderately or highly 'achievable' for Tasmania over the next 10 years, while also delivering relatively large emissions reductions include the following:

- Feeding methane inhibitors to produce low methane livestock. Although feeding these supplements may represent a net cost, this is likely to be relatively low as a proportion of the total value of agriculture in 2050. In addition, there is the potential that feeding these supplements may result in productivity benefits, and reduced feeding requirements which may offset this cost (although this is not yet proven at a commercial scale).
- Driving higher uptake of electric vehicles within Tasmania's passenger vehicle fleet and decarbonising the heavy transport fleet via EVs, hydrogen and drop-in hydrocarbon fuels[3].
- Reducing energy-related emissions from manufacturing through demand management and energy efficiency, and through fuel switching with both electricity and bioenergy.

All 26 opportunities were assessed for the quantum of emissions reductions that could be achieved, and the economic impacts of implementing the opportunities. Importantly, this study demonstrates that all sectors have a role to play in reducing emissions, above the 'business as usual' National and State policy settings, to help Tasmania maintain its net zero emissions status in the medium-long term.

1.5 Emissions reduction pathways

A suite of 16 "best-fit" emissions reduction opportunities was determined through collaboration with a range of Tasmanian Government agencies based on how achievable they are likely to be in the current policy context. These were then modelled against the reference case emissions projections to reveal a "best-fit" emissions reduction pathway. The best-fit pathway is shown in Figure 3, with the dotted line showing net emissions.

This best fit pathway would see Tasmania maintaining net zero emissions easily from now until 2050, with the state becoming as a net sink of over 4,500 kt CO_2-e per annum in 2050. It should be emphasised however that the best-fit pathway will require action from the Tasmanian Government (through policy and programmatic support) to encourage the implementation of the identified emissions reduction measures.

Economic modelling conducted as part of this engagement showed that the transition to a net zero carbon economy could deliver economic benefits across most sectors, including agriculture, forestry and aquaculture, and manufacturing. However, this balance of benefits and costs was assessed mainly at a qualitative level, as dynamic Computer General Equilibrium (CGE) modelling (which would provide more certainty over the expected economic impacts of the emissions reduction pathways over time), was outside of the current scope of the engagement[4].

In addition to economic benefits, broader economic co-benefits associated with a transition to net zero emissions include:

- Improvements in energy efficiency and productivity leading to reduced costs for energy users and a relative "insulation" from fluctuations in commodity prices.
- An earlier transition to a low carbon economy minimises the risk of stranded assets - particularly for Tasmania's manufacturing sector as international demand for low-emission products and services increases.
- The positioning of Tasmania as a key player in the renewable hydrogen space through the Tasmanian Renewable Hydrogen Action Plan helps ensure that Tasmania is well placed to benefit from the emerging global hydrogen

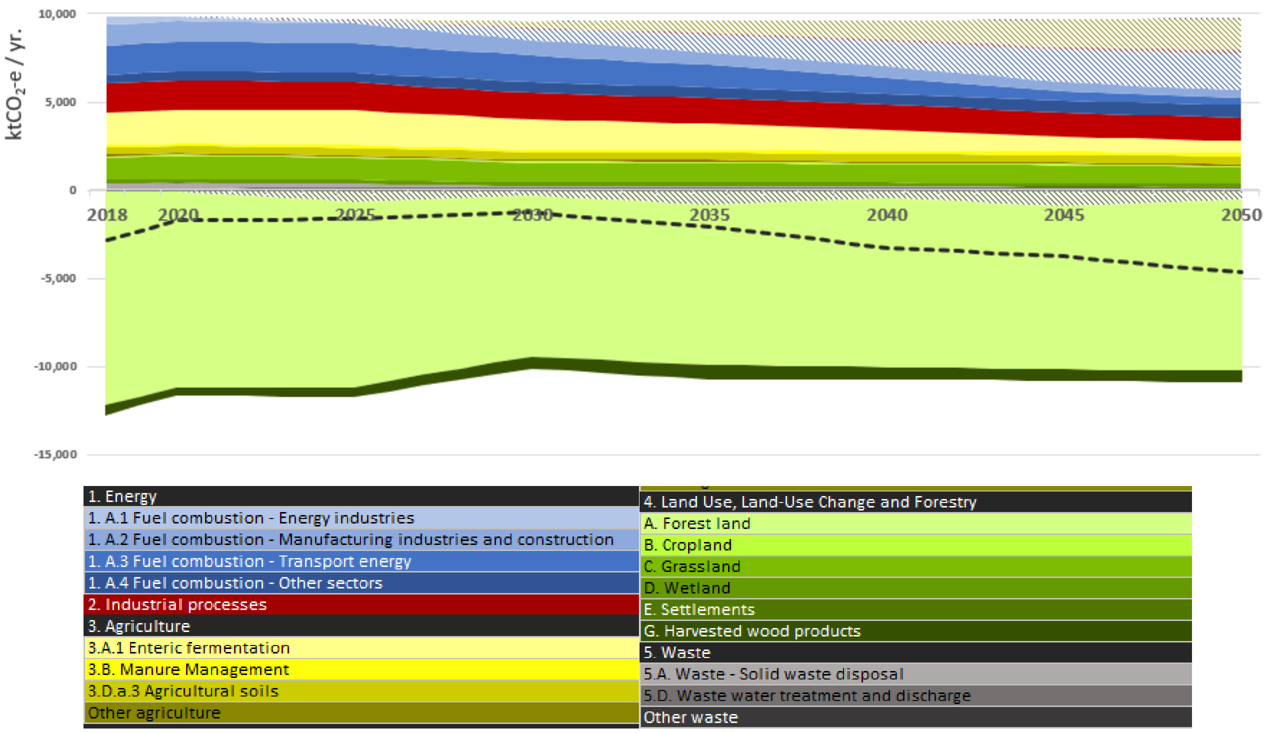
[3] Renewable hydrocarbon biofuels (also called green or drop-in biofuels) are fuels produced from biomass sources through a variety of biological, thermal, and chemical processes. These products are chemically identical to petroleum gasoline, diesel, or jet fuel.

[4] This CGE modelling is currently being undertaken as part of a separate scope of work, and will be used to complement the findings of this analysis.

industry. This could create opportunities including fuelling the heavy vehicle fleet in Tasmania with hydrogen and enabling commercial exportation of renewable hydrogen by 2030.

- The creation of additional investment opportunities for Tasmania. For example, the relocation of Australia's data centres to Tasmania due to its affordable low-carbon electricity and milder climate requiring less cooling.
- The transition to net zero also entails wider benefits for Tasmania's brand and its goods, services and tourism exports.

Figure 3. Best-fit emissions reduction pathway to 2050 (medium emissions scenario)



Furthermore, by achieving a successful transition to a low-emissions economy, Tasmania can have a positive influence on other Australian states and other countries in pursuing a low-emissions economy, by demonstrating leadership.

1.6 Emissions reduction targets

At the domestic level, all states and territories in Australia now have some form of net zero commitment by 2050. Most notably, Victoria has a legislated target to achieve net zero emissions by 2050, and the ACT has a net zero target by 2045. At the international level, a number of countries have set net zero emissons targets by 2050 (or earlier), including many that are enshrined in law.

With its significant forest estate and low carbon electricity sector, Tasmania is well placed amongst Australian states and territories to achieve net zero emissions at a relatively low cost. Our analysis indicates that under most-likely reference case assumptions, Tasmania could achieve and maintain net zero emissions much earlier than 2050, whilst continuing to grow the state's economy.

If Tasmania were to set a target to achieve and maintain net zero emissions earlier than 2050, it would position itself as a climate change leader, at both the national and global level. Five target timeframes for the achievement of this target have been suggested in Table 1, and outline the relative benefits and risks of each option. Importantly, the ability to achieve these targets is largely influenced by the LULUCF sector maintaining removals at levels broadly aligned with those seen over the past five years. It is expected that this trend will continue into the future under most-likely conditions. Importantly, under the best-fit emissions reduction pathway, net zero emissions are forecasted to be achieved from now until 2050, so all targets should be achievable, provided the right policy and economic support is provided.

Table 1. Potential emissions reduction target setting options – benefits and risks

Target option	Benefits	Risks
Net zero emissions by 2030	• Would be the most ambitious state-level net zero emissions target in Australia. • Highly ambitious at the global level, outside of countries that have extensive forest resources and relatively low emissions electricity sectors. • Aligned with climate science, and therefore robust and defensible. • First mover advantage.	• Could be seen as too difficult / costly to achieve, which may make stakeholders hesitant to commit. • Likely to require significant investment and research and development to support businesses to transition.
Net zero emissions by 2035	• As for 2030 target.	• As for 2030 target.
Net zero emissions by 2040	• Would be the most ambitious state-level net zero emissions target in Australia. • Ambitious at the global level. • Aligned with climate science, and therefore robust and defensible. • First mover advantage.	• Could be seen as not being ambitious enough given Tasmania's unique position of already having achieved net zero emissions since 2013, and its significant advantages compared with other states. • There is the risk that if Tasmania waits too long to set a net zero emissions targets, then the state may miss the opportunity to catalyse innovative research and development and practices, and the associated additional economic activity arising from being a global leader in new technologies and systems.
Net zero emissions by 2045	• Would be aligned with ACT's net zero emissions target so still very ambitious at the national level. • Ambitious at the global level. • Aligned with climate science, and therefore robust and defensible.	• As for 2040 target.
Net zero emissions by 2050 ***(Tasmanian Government's current emissions reduction target policy position)***	• Aligned with climate science, and therefore robust and defensible.	• As for 2040 target.

2 INTRODUCTION

2.1 Context

2.1.1 The need for action

There is now overwhelming evidence that the earth is warming and that our climate is changing. Rising temperatures as a result of climate change will have a significant impact on rainfall, evaporation and sea level, among many other things. These changes are likely to make our climate more varied and result in more frequent and severe extreme weather events.

To address this situation, in 2015, countries from around the world signed up to the Paris Agreement. This commits countries to keeping global temperature rise to well below 2°C above pre-industrial levels, with aims to limit warming to 1.5°C. In practical terms, this means that greenhouse gas (GHG) emissions need to peak now and reach net zero by 2050 at the latest. The Paris Agreement recognises the important role of sub-national governments in responding to climate change, however meeting this challenge is a shared responsibility that will require action from communities, businesses and governments from across the world.

2.1.2 Australian federal climate change policy

The Federal Government has adopted targets for reducing Australia's total emissions by 26% to 28% by 2030, relative to a 2005 base year as part of its Nationally Determined Contribution (NDC) under the Paris Agreement. Importantly, this is not in line with what would be required to reduce emissions to a level that keeps temperature increases to the 2°C threshold, let alone 1.5°C. In line with this, the Climate Action Consortium rates Australia's NDC as 'insufficient' and with a level of ambition that - if followed by all other countries - would lead to global warming of over 2°C and up to 3°C. In addition, if all other countries were to follow Australia's current policy settings, global warming could reach over 3°C and up to 4°C ("highly insufficient"). This "insufficient" trend is seen across the world (Figure 4)[5].

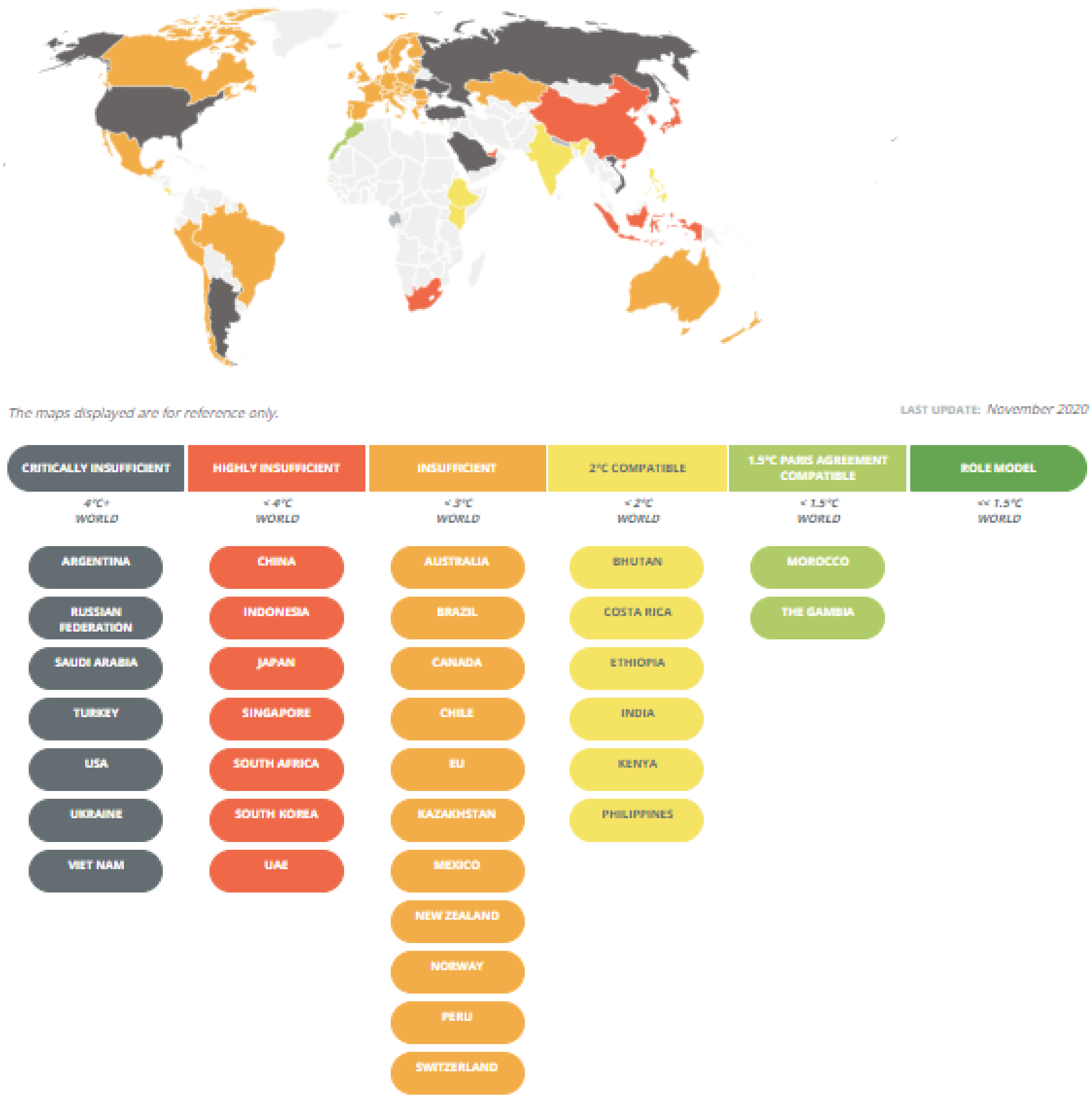
This report assumes that the Australian Government does not take any **additional** climate change mitigation policy action beyond that which is currently in place or has been committed to. However, if the level of ambition at the national level increased in the future, this would complement any additional actions taken by the Tasmanian Government, which could also improve the political feasibility of certain opportunities, and would support Australia's NDC potentially moving from "insufficient" to at least "2°C compatible" and perhaps even to a "Role model" status.

More recently, the Federal Government has said it wishes to reach net zero emissions 'as soon as possible' and 'preferably by 2050', however it is yet to make any firm commitments.

2.1.3 Tasmanian climate change policy

Under Tasmania's existing *Climate Change (State Action) Act 2008* (the Act), the state passed a legally binding target to reduce emissions by at least 60% below 1990 levels by 2050. Through the more recent release of Climate Action 21, the Tasmanian Government has committed to a target of net zero emissions by 2050. As part of the independent review of the Act that is currently underway, the Tasmanian Government is seeking to set a more ambitious emissions reduction target for Tasmania, aligned with the goals of the Paris Agreement.

[5] https://climateactiontracker.org/countries/ Note that for countries coloured in grey, it means there is no data currently available on their NDCs.



2.2 Objective of this report

The objectives of this report are to present the following:

- A synopsis of Tasmania's emissions inventory as captured in the Australian Government's *State and Territory Greenhouse Gas Inventories* (STGGI), and the key sources driving the inventory.
- The most-likely emissions pathway out to 2050 (termed the "reference case") across all sectors reported in the STGGI, taking into account the factors (economic, policy-related, technological and climatic) that are likely to influence the state's future emissions profile.
- A range of sector-specific opportunities available to Tasmania to reduce or sequester emissions out to 2050, and the expected costs and benefits, across a range of stakeholders, both public and private.
- The emissions reduction pathways available to Tasmania, accompanied by a high-level economic analysis in order to inform the Tasmanian Government of the likely implications of pursuing different pathways, noting that significant uncertainty will unavoidably surround the outcome of any pathway over a long-time horizon.
- Appropriate emissions reduction target(s) for Tasmania to 2050 informed by the evidence base built throughout the project.

This report builds on the previous emissions pathways review undertaken by Point Advisory and Indufor in 2018/19. The updated desktop analysis undertaken for the current project has been complemented by interviews with members of a cross-agency Project Reference Group members to consult on our methodology and assumptions, a discussion on 23 March 2021 specifically on the land use, land use change and forestry (LULUCF) sector and a presentation of draft results to Project Reference Group members on 25 March 2021.

2.3 Methodology summary

The methodology used to achieve the objectives of this report is presented below:

Section 3: Tasmania's historical emissions profile

- For each material emissions source within the STGGI, an in-depth review of historic trends was conducted, and the Australian Government's most recent emissions projections[6] (and confidential projections for Tasmania specifically) were used to identify the key parameters that impact activity data and the drivers of change into the future. This analysis was confirmed by discussions with key stakeholders from the Australian Government's Department of Industry, Science, Energy and Resources (DISER).

Section 4: Tasmania's emissions forecasts to 2050

- Building on this initial analysis, a **baseline emissions inventory for forecasting** to 2050 was defined, built on key past activity data and emissions intensities. This was aligned with emissions data for Tasmania provided in the STGGI.
- **Key drivers of change for each sector** were identified that could impact Tasmania's reference case emissions to 2050, including:
  - national and state policies that are in force, or have been agreed to be put in place during this timeframe;
  - likely changes in demand for commodities based on reliable economic studies; and
  - forecasted technological changes based on robust market studies by industry groups, government bodies and/or consultants.
- Using the information gathered from this initial analysis, for each sector of the STGGI, **three reference case emissions scenarios**[7] **were investigated out to 2050**:
  - High emissions (pessimistic): considered lower than expected ambition in national and state policies and is based on higher than expected Tasmanian population and economic growth. In addition, in certain cases changes to technological uptake are not as fast as expected.
  - Medium emissions (most likely): considered the 'most-likely' under current national and state policy settings and is based on expected Tasmanian population and economic growth.
  - Low emissions (optimistic): considered higher than expected ambition in national and state policies and is based on lower than expected Tasmanian population and economic growth.
- In order to plan Tasmania's transition to a low carbon economy and understand the implications of different emissions trajectories to 2050, an **economic model linking high level sectors of the economy to the STGGI sectors** was developed.

[6] https://www.industry.gov.au/sites/default/files/2020-12/australias-emissions-projections-2020.pdf

[7] Reference scenarios assume that the Tasmanian Government does not take any additional climate change mitigation policy action beyond that which is currently in place or has been committed to.

Figure 5. Mapping electricity and transport STGGI sub-sectors to corresponding sectors of the Tasmanian economy

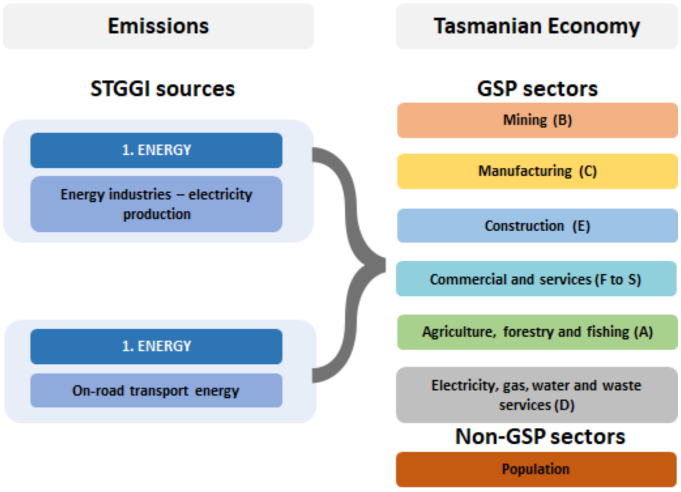
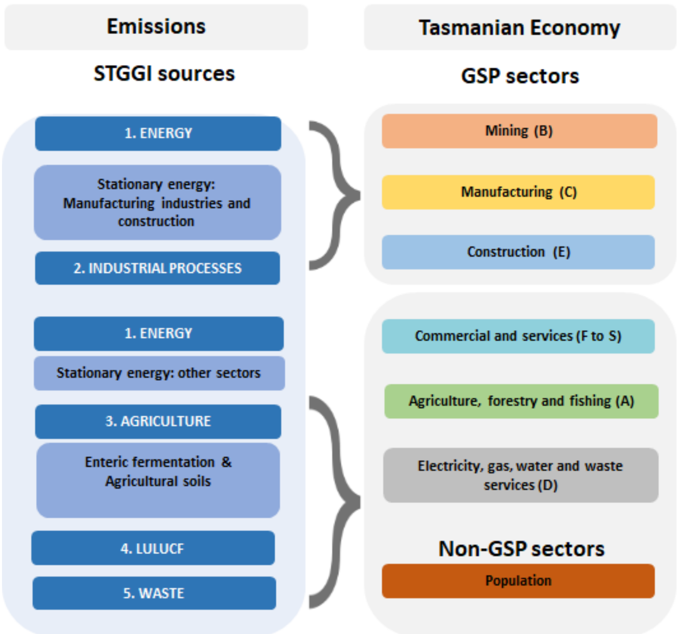


Figure 6. Mapping other STGGI sub-sectors to corresponding sectors of the Tasmanian economy



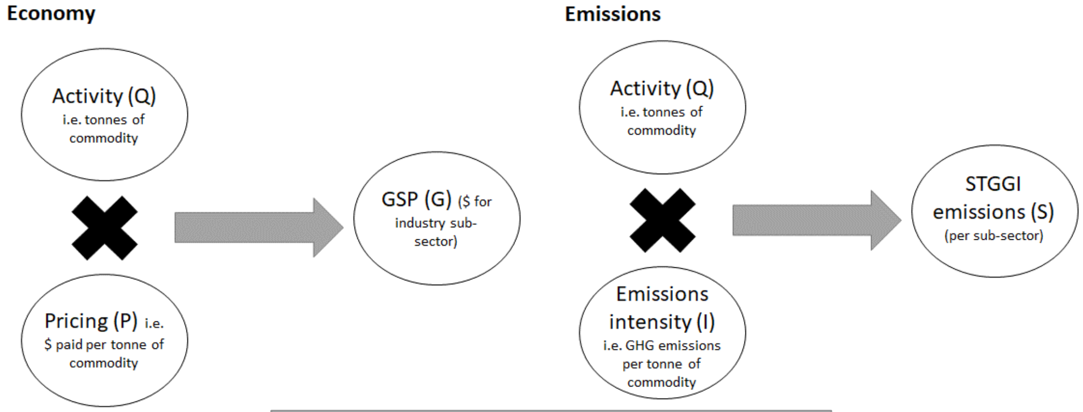
This model maps the STGGI sectors to the Australian Bureau of Statistics (ABS) Gross State Product (GSP) sectoral data for Tasmania, which disaggregates this data using Gross Value Added (GVA) by each Australian and New Zealand Standard Industrial Classification (ANZSIC) economic sector. Figure 5 and Figure 6 illustrate the linkages between the STGGI sub-sectors and the corresponding ANZSIC sectors of the Tasmanian economy.

To identify the possible economic impacts associated with modelled future emissions trajectories, it was first necessary to develop a relationship between Tasmania's key economic sectors and the emissions inventory. The three key variables that drive Tasmania's GSP and STGGI emissions:

- Activity (Q). This is the quantum of output delivered by an economic activity e.g. tonnes of beef produced.
- Pricing (P). This is the price paid per unit volume for a particular commodity or service.
- Emissions intensity (I). This is related to emissions intensity per unit of commodity/service; improvements in this factor will be driven by technological efficiencies or productivity improvements. Emissions intensity can also be expressed per $ of GSP, with the price of commodity/service impacting intensity.

Changes in these variables drive changes in Tasmania's economic output and emissions inventory out to 2050. As much as possible, it has been attempted to remove the impact of pricing from calculations, as large variations are likely to take place over the period of analysis (2050), which would introduce confusion. Similarly, the economic modelling refers to real rather than nominal values to allow meaningful comparisons over the period. Figure 7 provides a high-level overview of the combined emissions and economic modelling structure used for this project.

Figure 7. Conceptual overview of the combined emissions and economic model



$$\frac{S}{G} = Q \times P \times I$$

Section 5: Opportunities to reduce emissions

- To inform the **emissions reduction opportunities investigated** for Tasmania, we used the list of 24 opportunities previously identified (and previously vetted by Tasmanian government stakeholders) as a starting point. We then undertook individual interviews with Reference Group members from each STGGI sector to identify additional opportunities to include.
- Using these prioritised opportunities, the **likely abatement or sequestration associated with each was quantified**. The core approach to this analysis was built on relevant research conducted in this space previously (i.e. using secondary data rather than original modelling).
- Point Advisory and Indufor then held **one working session with reference group members from the Tasmanian Government** in March 2021. Our team worked with the workshop participants to validate the opportunities in and analyse them in terms of:
  - the likely timeframes for implementation
  - the level of achievability based on economic viability, technical feasibility and policy alignment
- Our team conducted a **high-level assessment of costs and benefits** (supplementing the previous work undertaken in 2018/19) to understand the impacts associated with the implementation of each opportunity. Where quantitative data was available, the impacts were quantified, based on the magnitude of impacts to the Tasmanian economy (i.e. limited to what is material). Otherwise a qualitative review was undertaken.

  It is important to note that some of the economic impacts identified represent “transfers” from one sector to the other, for example, for transport, from one source of energy (fuel) to another (electricity), from one economic agent to another (e.g. households / government), or from one sector (stationary energy) to another (LULUCF) in cases where bio-energy can be a substitute for electricity.

  Additionally, the Tasmanian economy is closely linked to Australian and international economies, with import / export relationships for goods and services produced / consumed in Tasmania. This means that the value chain of a specific product or service is usually split between various jurisdictions without a clear model for the value add split of this specific product. It is therefore difficult to project the impact of proposed opportunities on Tasmanian economic sectors.

  Transfers between sectors linked to specific opportunities could only be assessed qualitatively at this stage (see Appendix 2) and much more in-depth analysis would be required to estimate the net impact on the Tasmanian economy, taking into account import / export effects. This is beyond the scope of the present project.

Section 6: Emissions reduction pathways

- During the **working session with reference group members from the Tasmanian Government** in March 2021, Point Advisory and Indufor asked participants to provide feedback on the previously identified "best-fit" pathway for Tasmania, and identify additional opportunities to include, or others that should be removed.
- Building on this analysis, **economic modelling of the potential impact the "best-fit" pathway** may have on Tasmania's GSP to 2050 was carried out.

Section 7: Emissions reduction targets

- Using the evidence gathered throughout the project, and feedback from participants at workshops, suitable **evidence-based emissions reduction targets** were developed.

2.4 Limitations

It should be noted that the transition to a low-emissions economy for any state will be a long journey to a desired destination, but through very uncertain territory. This section outlines some of the limitations of the different aspects of this project.

Tasmania's emissions forecasts to 2050

The reference case only considers changes in emissions sources that are material (>1%) to Tasmania's STGGI, thus excluding smaller sources from further analysis. For example: although emissions from the aquaculture sub-sector are expected to increase into the future, with several major new projects under consideration that could potentially double the State's salmon output over the next 12 years[8], this sector did not meet this materiality threshold (comprising just 0.3% of the inventory).

In addition, a key uncertainty regarding Tasmania's reference case emissions to 2050 is the rate of technological change that could happen over this period. In general, rapid emissions-reducing technological change will decrease global mitigation costs and hence increase the uptake of mitigation technologies and practices. However, the specific nature of this change can result in different impacts across sectors. For example, in the agricultural sector the development of technologies to reduce the production of methane by cattle and sheep would serve to improve the attractiveness of livestock-based agriculture in a carbon-constrained world.

By contrast, advancements in the development of plant-based meat substitutes could result in accelerated movement away from animal-based agriculture and growth in the production of crops or horticulture.

In the transport sector, increased internal combustion engine (ICE) fuel efficiency could prolong the use of ICE vehicles, while rapid decreases in electric vehicle (EV) cost could accelerate the transition away from ICE vehicles.

That said, the reference case modelling captures some important aspects of the uncertainty by examining three scenarios (high, medium and low emissions forecasts) to provide an indicative spread of the potential future emissions forecasts out to 2050. This approach is intended to enable the Tasmania Government to understand the inherent uncertainty associated with forecasting emissions in the long-term.

LULUCF modelling

This project incorporated the further development of a customised model for projecting LULUCF emissions to 2050, based on the United Nations Framework Convention on Climate Change (UNFCCC) reporting categories and STGGI data from 1990 to 2019; and using the customised model previously developed by Point Advisory and Indufor for the original Tasmania's Emissions Pathway Review in 2018/19.

It was beyond the scope of this engagement (and the previous report) to use the Australian Government's Full Carbon Accounting Model (FullCAM), the model used to construct Australia's national greenhouse gas emissions account for the land sector, as this would have required a considerably higher level of project resources to establish and calibrate the full suite of data required to model Tasmania as a whole. However, high-level projections have been generated and tested through a high-level extrapolation of STGGI report data, based on using observed relationships between emissions trends and key drivers, and published data on those drivers where available.

This approach to modelling of emissions and removals in the LULUCF sector was considered appropriate for the purpose of this project, which required a high-level analysis and testing of emissions reduction options to inform

[8] https://dpipwe.tas.gov.au/Documents/salmonplan.pdf

further policy consideration. However, it is important to recognise the limitations of this approach. These limitations include, most notably, reliance on ongoing relationships between emission trends and the key drivers selected as the basis for informing future projections. In most cases, the assumption is based on a linear relationship between emissions trends and these key drivers, when some relationships may be non-linear; and emissions trends may be dependent on the cross-impact of interrelated factors or interdependences between key drivers. Should the Tasmanian Government seek to capture and more accurately reflect this complexity of key drivers in the LULUCF, Point Advisory and Indufor would recommend the use of FullCAM to align with national accounts and methodologies.

Treatment of the risk of major bushfires

Another limitation of special note is the treatment of the risk of major bushfires that may occur before 2050.

The impact of bushfires (also referred to as wildfires in National Inventory Reports) on emissions levels is captured in STGGI reporting under multiple LULUCF subcategories; firstly, through emissions attributed to the combustion of vegetation fuels (predominantly from the *Forest Land remaining Forest Land* land-use category, and other land uses); and secondly, through any subsequent conversion of land use, if the pre-existing forest land (or other forms of vegetated land) is not restored over time.

The average annual impact of bushfires and prescribed burning on LULUCF sector emissions can be calculated using historical data and this provides a sound approach to modelling impacts for 'average' years. However, in relation to modelling the impact of major or catastrophic bushfires into the future, this project did not identify a source of published forecast data that was fit for purpose in terms of forecasting fires on forest land across Tasmania.

Hence for this project, new assumptions were made about the frequency of major bushfires and the impact of these bushfires on relevant LULUCF emissions reporting categories. These assumptions were based largely on trends observed in historic data, as well as relevant research on the modelled impact of climate change on climatic conditions and the risk of fires, including the Tasmanian Government's *Climate Action 21: Tasmania's Climate Change Action Plan 2017-2021*, which observed that Tasmania is expecting to experience longer fire seasons with more frequent and intense bushfire events[9].

In the context of this observed variation in bushfire impacts over time, and the complexity of climate change impacts, there is clearly uncertainty around the timing and scale of major fires into the future – and this represents a limitation in the LULUCF modelling of fire impacts over the next 30+ years to 2050. Notwithstanding this uncertainty, the limitations of the project modelling of bushfire impacts is contained in two ways.

Firstly, the modelling for this analysis incorporated low, medium, and high scenarios, which are intended to provide a range of possible outcomes. The high scenario incorporates an assumed scale of a major fire impact (up to 500,000 ha), which far exceeds the largest area of bushfire impacts in any given year over the past 70 years.

Secondly, in accordance with agreed international conventions, the Australian Government has established natural disturbance provisions to place an upper limit (or cap) on the impact of bushfires on the national greenhouse gas inventory . This effectively means that Australia, with States and Territories incorporated, can exclude the impact of major fires on annual accounts, provided the area burned is restored over an allocated period – and if not, the land use conversion and associated emissions are then recorded in the inventory. This means that if Tasmania were to experience a mega fire of historic proportions, such as those recently seen in Victoria in 2009, and NSW and Victoria in 2019/20, then Tasmania and the Australian Government have provisions to excise the burnt areas from the national inventory and monitor their regeneration and recovery over time, ahead of reincorporating back into the inventory.

Emissions reduction pathways to 2050

This report presents 26 emissions reduction opportunities for Tasmania across all STGGI sectors. The selection of these opportunities was informed by discussions with the Tasmanian Government through the Project Reference Group, and desktop research by Point Advisory into international trends in emissions abatement.

In addition, an assessment of each opportunity's "achievability" in the Tasmanian context was assessed based on technical viability, policy alignment and economic impact. The future "best-fit" emissions reductions pathway was then constructed based on a 'package' of these opportunities. As with the reference case emissions projections, there is significant uncertainty associated with the identification and modelling of emissions reduction opportunities.

[9] Tasmanian Climate Change Office, 2017. *Climate Action 21: Tasmania's Climate Change Action Plan 2017–2021*. Hobart, Tasmania.

Assessment of the costs and benefits for each opportunity

The assessment was based on Point Advisory's analysis and the information gathered through both the 2018/19 project and new resources (if available) and is valid at a specific point in time and within the boundaries of the assessment.

It must be emphasised again that the assessment of the costs and benefits for each opportunity was primarily qualitative, with quantitative analysis where information was available, and that additional modelling would be required to confirm that the anticipated balance of costs and benefits are correct. The scope of this engagement did not expand to the modelling of dynamic relationships between economic aggregates and the assessment of costs and benefits should be considered as indicative of possible risks and opportunities rather than definitive.

Economic projections to 2050

The economic modelling used a simple but integrated approach to sectoral modelling, linking outputs to demographic, technological and economic input/output parameters.

Generating economic projections of emissions to 2050 is profoundly uncertain. The economic modelling therefore did not aim to forecast the future of Tasmania's economy; rather it aimed to support the Tasmanian Government's considerations of how to create favourable conditions for a successful decarbonised regional economy to 2050.

The limitations of the conceptual economic-emissions model include:

- It is not a dynamic model and hence does not purport to represent actual emissions / GSP outcomes, rather to articulate, in a simplified way, the relationships between emissions and economic output.
- Even if such relationships are correct at one point in time, they will shift as sectors adjust, and based on exogenous factors; it was not within the scope of this project to attempt to model such complexity.
- The overlap and exclusivity between opportunities considered could not be modelled.

As mentioned above, the economic modelling undertaken for this report is not dynamic and did not use a Computable General Equilibrium (CGE) approach, which was outside the scope of this engagement. However, CGE modelling is being undertaken as part of a separate project (*2021 Emissions Pathway Review CGE Modelling project*) undertaken by Victoria University and Point Advisory on behalf of the Tasmanian Government. The analysis conducted to develop this report has been used as a key input into this CGE modelling.

The ensuing report and conclusions should be read in the context of the above limitations.

3 TASMANIA'S HISTORICAL EMISSIONS PROFILE

Key points

- Tasmania's emissions profile is unique among Australian jurisdictions given the significant amount of carbon sequestered through the managed forest estate and its low emissions intensity electricity generation.
- Emissions from the LULUCF sector have had a major influence on Tasmania's total annual emissions and underpin the State's achievement of zero net emissions for the first time in 2013.
- Over the past 15-20 years, the volume of logs harvested from Tasmania's forests has decreased significantly, meaning that the LULUCF sector has changed from being a significant net emissions source to a significant net sink.
- The energy sector represented 47% of Tasmania's emissions inventory (excluding LULUCF) in 2018, with on-road transport emissions contributing nearly half of these emissions.
- Agricultural emissions represented 29% of Tasmania's emissions inventory (excluding LULUCF) in 2018, dominated by enteric emissions from dairy and beef cattle, and sheep.
- Industrial process emissions represented 20% of Tasmania's emissions inventory (excluding LULUCF) in 2018, with nearly half of these coming from cement clinker production, followed by ferromanganese production, aluminium smelting and the use of refrigerants.
- Emissions from both solid waste disposal and wastewater treatment represented just 5% of Tasmania's emissions inventory (excluding LULUCF) in 2018, dominated by emissions from organic material decomposing at landfills.

Tasmania's GHG emissions accounts are presented in the STGGI, which is produced annually by DISER. The STGGI is prepared as part of the National Greenhouse Gas Inventory (NGGI), which is submitted annually in accordance with Australia's UNFCCC and Kyoto Protocol obligations. The STGGI draws on the information provided in the NGGI and disaggregates it by state and territory.

The NGGI contains national GHG emissions estimates for the period 1990 to the current reporting year. The emissions calculations are compiled in accordance with the Intergovernmental Panel on Climate Change (IPCC) *2006 IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC 2006). The aim is to ensure that the estimates of emissions are accurate, transparent, complete, consistent through time and comparable with those produced in other countries.

Under the UNFCCC, the NGGI must report net emissions from the following sectors:

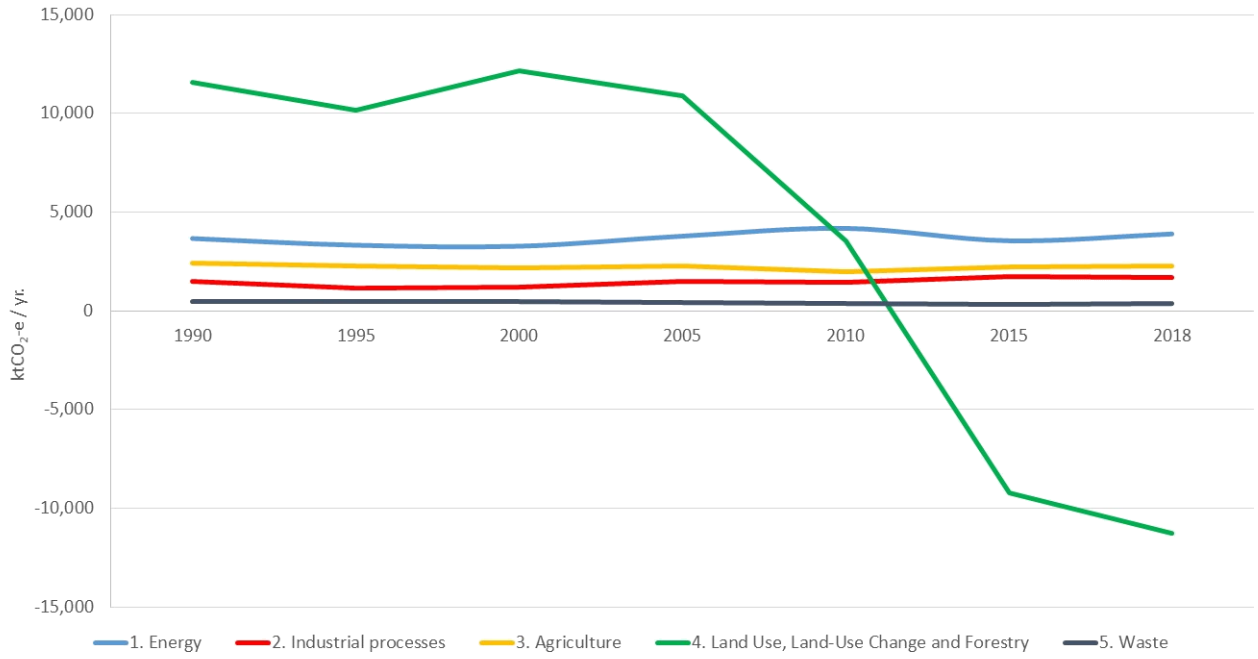
1. Energy;
2. Industrial processes and product use;
3. Agriculture;
4. LULUCF; and
5. Waste.

Tasmania's emissions profile is unique among Australian states and territories, as it has maintained net zero emissions since 2013[10]. This achievement has helped to establish Tasmania as an Australian climate change leader.

The achievement of net zero emissions is primarily because of Tasmania's large forest estate (which absorbs a significant amount of carbon dioxide from the atmosphere each year), and because the state generates a high proportion of zero emissions renewable electricity (Figure 8).

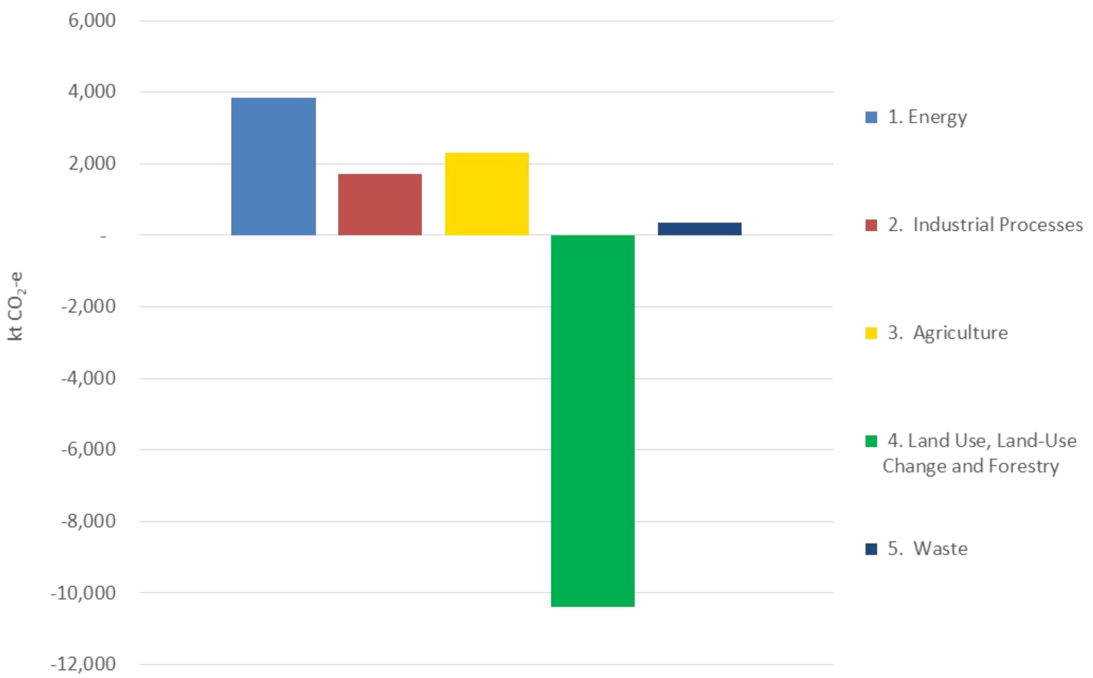
[10] Based on the 2019 STGGI results provided by DISER. Note that net emissions went above net zero in 2014, but have remained net zero since.

Figure 8. Tasmania's historical emissions profile, broken down by sector (1990 to 2018)



Since 2013, total emissions from the energy, industry, agriculture and waste sectors were less than the amount of carbon dioxide absorbed by the LULUCF sector. Figure 9 shows the contribution of each these sectors to the state emissions profile for 2018 (the baseline year for this report). Total emissions in 2018 were -2,825 kilotonnes (kt) of carbon dioxide equivalent (CO_2-e).

Figure 9. Tasmania's greenhouse gas profile by sector in 2018



3.1 Historical emissions by sector

The following sections provide more information on each emissions sector and sub-sector. Please note that additional detail has been provided for changes to the LULUCF accounting methodology over time because of the significant impacts these recalculations have made on the Tasmania's STTGI emissions profile, compared with the relatively minor changes seen for other sectors.

3.1.1 LULUCF

The *LULUCF* sector comprises both GHG emissions and removals associated with forest land, cropland, grassland, wetlands, settlements, and harvested wood products. In 2018, Tasmania's LULUCF sector was a net carbon sink, contributing -11,229 kt CO_2-e to the state's emissions profile and offsetting in full the 8,404 kt CO_2-e from all other sectors combined (Table 2).

Table 2. LULUCF categories reported in National Inventory Report and State and Territory inventories[11]

LULUCF source and sink categories and subcategories	2018 STGGI emissions/removals ($ktCO_{2e}$)
A. Forest Land	**-12,168**
1. Forest land remaining forest land	-9,490
Harvested native forests	*n/a*
Pre-1990 plantations	*n/a*
Other native forests	*n/a*
Fuelwood	*n/a*
2. Land converted to forest land	-2,678
Plantations and natural regeneration (including post-1990 plantations)	-2,146
Regrowth on deforested land (includes regrowth on previously cleared land)	-532
B. Cropland	**76**
1. Cropland remaining cropland	69
2. Land converted to cropland (includes conversion of forest land and wetland to cropland)	7
C. Grassland	**1,204**
1. Grassland remaining grassland	-206
2. Land converted to grassland (includes conversion of forest land and wetland to cropland)	1,410
D. Wetland	**221**
1. Wetland remaining wetland	224
2. Land converted to wetland	-3
E. Settlements	**15**
1. Settlements remaining settlements	-1
2. Land converted to settlements	16
G. Harvested Wood Products	**-577**
Total LULUCF category (2018)	**-11,229**

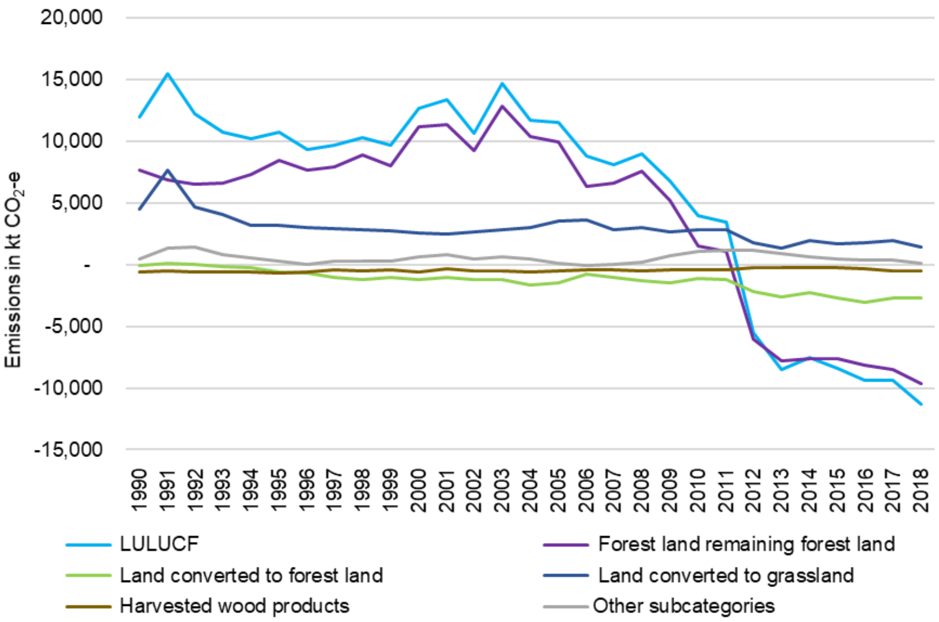
Key drivers

The contribution of the main LULUCF subcategories to the total LULUCF emissions profile is shown in Figure 10.

The largest source of sequestration from LULUCF is the *forest land remaining forest land* sub-category followed by the *land converted to forest land* sub-category. The *forest land remaining forest land* sub-category has influenced both increases and decreases in Tasmania's total net emissions since 1990 (Figure 10). This sub-category comprises emissions from changes in carbon stored in *harvested native forests*, *other native forests*, *pre-1990 plantations* (plantations established before 1990), and *fuelwood* (for residential use).

[11] Source: STGGI 2019 (May 2021). Note the breakdown of Forest Land remaining Forest Land for STGGI 2019 is not published in STGGI

Figure 10. Tasmania's emissions from the LULUCF sector and selected subcategories[12]



Changes in emissions from *forest land remaining forest land* have been largely driven by changes in the levels of timber harvesting in Tasmania's native forests, i.e. changes within the *harvested native forests* sub-category. Changes in emissions from *harvested native forests* arise from the net result of uptake due to forest growth (above and below ground as determined from the growth models) *and* losses due to forest harvesting. Losses occur with the removal of forest products (transferred to harvested wood products) and movement of residue material (including belowground biomass) to dead organic matter (DOM) and soils.

Between 2007 and 2012, the total volume of logs harvested from Tasmania's forests decreased by around 65%[13] due to multiple factors, including changes in global commodity prices, increasing demand for plantation timber over native forests, and restructuring of the industry. These changes resulted in a significant reduction in emissions associated with harvesting activity (Figure 11). Tasmania's *forest land remaining forest land* sub-sector changed from a major source of greenhouse gas emissions at 7,447 kt CO_2-e in 1990[14] to become a carbon sink of -9,490 kt CO_2-e in 2018.

When there are significant increases in timber harvesting levels, emissions from the forest land remaining forest land sub-category will typically increase in the short term, due to the losses arising from the removal of forest products and the movement of residue material. This is evident in the increase in GHG emissions in the late-1990s to mid-2000s, when native forest harvest levels increased, and emissions increased likewise (Figure 11). Thereafter, depending on the level of ongoing timber harvesting, the regrowth of harvested areas can result in higher levels of sequestration and GHG removals during early stages of the growth cycle.

Conversely, when timber harvesting activity decreases, emissions will typically decrease in the short term; and if there continues to be a large proportion of young regrowth across the forest estate, this can lead to relatively higher levels of growth and sequestration (removals) that will contribute further to the emissions reduction benefit. This is evident in the significant reduction in emission levels between 2007 and 2012, while followed the significant reduction in timber harvesting in Tasmania's forests, for reasons outlined above.

These forest dynamics can lead to situations in which the level of annual harvesting may increase, and net emissions can continue to decrease (i.e. removals increase), if the level extent of regrowth is relatively high compared to ongoing harvest levels. This situation is evident in Tasmania's LULUCF sector reporting since 2014. Over the past seven years, the level of timber harvesting in both native forests and pre-1990 plantations has steadied, and there has been increased harvesting in post-1990 plantations, largely comprising hardwood plantations (which are captured in the *land converted to forest land* sub-category). Over this period, the forest land remaining forest land has remained a substantial net sink, at a relatively steady level (Figure 11). This is attributable to the regrowth and increased carbon

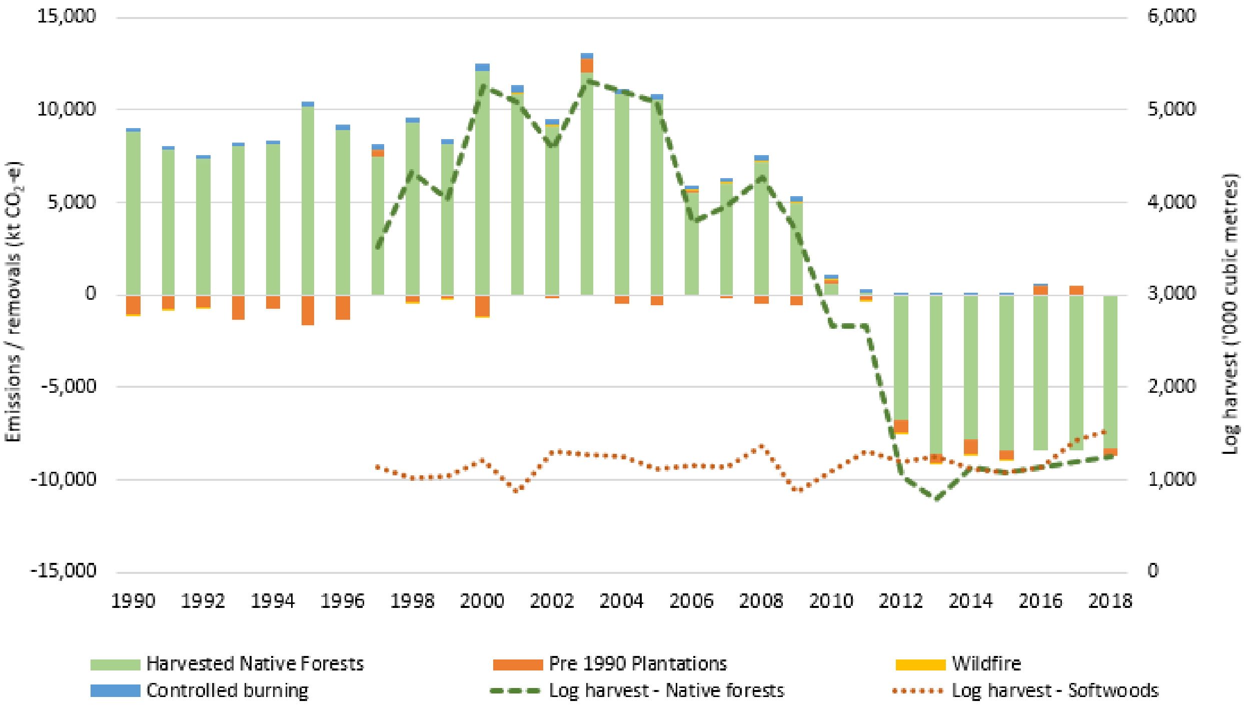
[12] Source: STGGI 2018

[13] Annual volumes of hardwood and softwood timber harvested from both native forests and plantations declined from a peak of 7.0 million cubic metres (m^3) in 2007-08 to 2.4 million m^3 in 2012-13. Total timber harvesting has since increased to 5.7 million m^3 in 2018-19.

[14] Emissions data based on STGGI 2018 data, which has updated previous reporting on the baseline year and subsequent years.

sequestration of previously harvested forests has exceeded annual emissions from timber harvesting activity. This sequestration has also offset the increase in the volume of harvested hardwood plantations over the past 10 years.

***Figure 11. Tasmania's emissions from forest land remaining forest land and timber harvesting levels*[15]**



These trends indicate that at current levels of harvesting, or a gradual uplift of harvesting levels in private forests, Tasmania's forestry industry can continue to support a significant net sink for emissions. In the absence of timber harvesting or other disturbance (e.g. bushfires), unharvested forests will eventually move through a mature stage, where they stop growing, to a senescent stage, where they start to decay and ultimately become a net GHG emitter.

In relation to other key LULUCF subcategories for Tasmania, the largest contributor to positive emissions was the *land converted to grassland* sub-category; with other emissions arising from conversion to croplands, wetland and settlements (shown as *Other subcategories* in Figure 7). However, total emissions from this sub-category are declining, and the total emissions in 2018 were approximately half the emission levels 10 years ago. In 2018 they represented around 14% of the total LULUCF emissions profile, in absolute terms.

Changes to accounting methodologies between 2016 and 2018 STGGI

In 2018 there were some significant changes to the accounting methodology applied for STGGI emissions reporting; and these changes resulted in notable changes in the LULUCF sector especially. A summary of these methodological changes is set out in the table below.

***Table 3. Summary of methodological changes to STGGI calculations for the LULUCF sector*[16]**

Category	Summary of methodological changes for STGGI calculations
Forest land remaining forest land	
Harvested native forests	• Minor update to the age structure of the managed forest estate over the full time series to reflect data on forests harvested in 2018.
Pre-1990 plantations	• Implementation of spatially-explicit modelling simulations for plantation harvesting and replanting schedules, as part of a broader suite of FullCAM updates. • Application of updates to climate data using a new method.

[15] Source: Australian Government data on Forest land remaining forest land subcategories; log harvest data from ABARES 2019

[16] Source: Australian Government Department of Industry Science Energy and Resources, 2020

Category	Summary of methodological changes for STGGI calculations
Other native forests	• Revision to estimates of bushfire emissions due to the inclusion of emissions from combustion of live biomass (e.g., leaves and branches). This has increased inter-annual variability, but on average it has resulted in higher emissions.
Land converted to forest land (sub-categories reported in STGGI as opposed to NGGI)	
Post-1990 plantations and natural regeneration	• Increase in net sequestration in Post-1990 plantations and natural regeneration, from 2012 onwards occurs mainly due to updates to climate data using a new method. • A decrease in net sequestration in years up to 2006 occurred mainly due to FullCAM improvements that resulted in slower tree growth.
Grassland	
Land converted to Grassland	• FullCAM improvements resulted in a slowing of most regrowth activity. This results in re-clearing activity producing fewer emissions from a lower biomass accumulation where it occurs. • There is an offsetting impact under lands converted to forest for regrowth on previously cleared lands.
Wetland	
Wetland remaining wetland	• Expansion to the scope of reporting to include methane emissions from artificial water bodies per the 2019 Refinements to the IPCC 2006 Guidelines.

The changes, applied retrospectively, resulted in an overall increase in baseline emissions in the LULUCF sector of approximately 1,440 kt CO_2-e in 1990, and an increase in the net sink provided by the LULUCF sector of approximately 1,770 kt CO_2-e in 2017. This means that the total reduction in LULUCF emissions since 1990 has increased, relative to reporting in 2017 and preceding years. This has contributed directly to retrospective recognition that Tasmania first achieved net zero emissions in 2013.

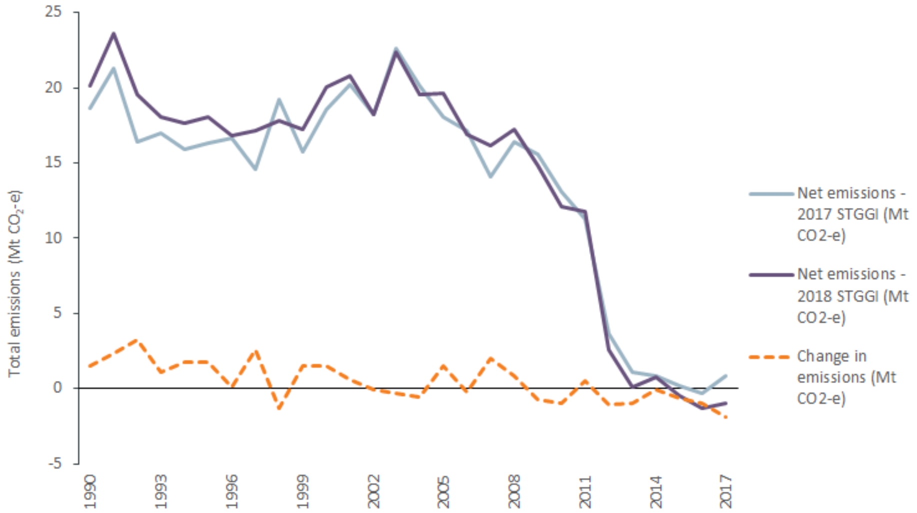
Changes in the emissions profile for pre-1990 plantations account for a significant component of changes to LULUCF contributions overall. The implementation of a spatially explicit harvesting modelling, being a key part of recent FullCAM improvements, was the main driver for recalculations in the pre-1990 plantations. This resulted in different harvesting and replanting dates spatially, which generally led to reduced emissions and increased net sequestration. Other FullCAM improvements resulted in slower tree growth, which together with new climate data, caused a decrease in net sequestration in most years up to 2001. However, the updates to climate data resulted in increased net sequestration from 2001 onwards.

Another significant change arising from methodological changes was in the emissions sequestered from *post 1990 plantations and natural regeneration* – an increase in sequestration in 2017 of approximately 700 kt CO_2-e (over 40% increase), compared to previous reporting due to the take-up of growing plantations outstripping harvesting-related emissions, and the net regrowth of natural woody vegetation across non-harvest and otherwise protected forest lands. The resulting increase in a carbon sink was amplified by the new climate data.

The methodological changes also impacted the *land converted to grassland* sub-category, with a net reduction in emissions overall. FullCAM improvements resulted in a slowing of most regrowth activity, which reduced sequestration through the growth phase, but more significantly, resulted in re-clearing activity producing fewer emissions from a lower biomass accumulation where it has occurred. In addition to methodological changes, primary clearing of forest, which represents the most significant source of emissions in LULUCF, almost halved in 2012 compared to 2011. Re-clearing of previously cleared land also declined over the period.

Notwithstanding these methodological changes, the main drivers for the LULUCF sector, and the relative quantum of its contribution to Tasmania as a substantial net sink, remained broadly aligned with previous reporting by Point Advisory and Indufor in 2018/19. The overall effect of the recalculations on Tasmania's net emissions between 1990 and 2017, as presented in the 2017 and 2018 versions of the STGGI, is shown in Figure 8 below. Overall, it shows that between 1990 and about 2008 total net emissions had previously been understated; and from about 2012, total net emissions had been overstated.

Figure 12. Change in Tasmania's net emissions between 2017 and 2018 STGGI (for the period 1990 to 2017)



3.1.2 Energy

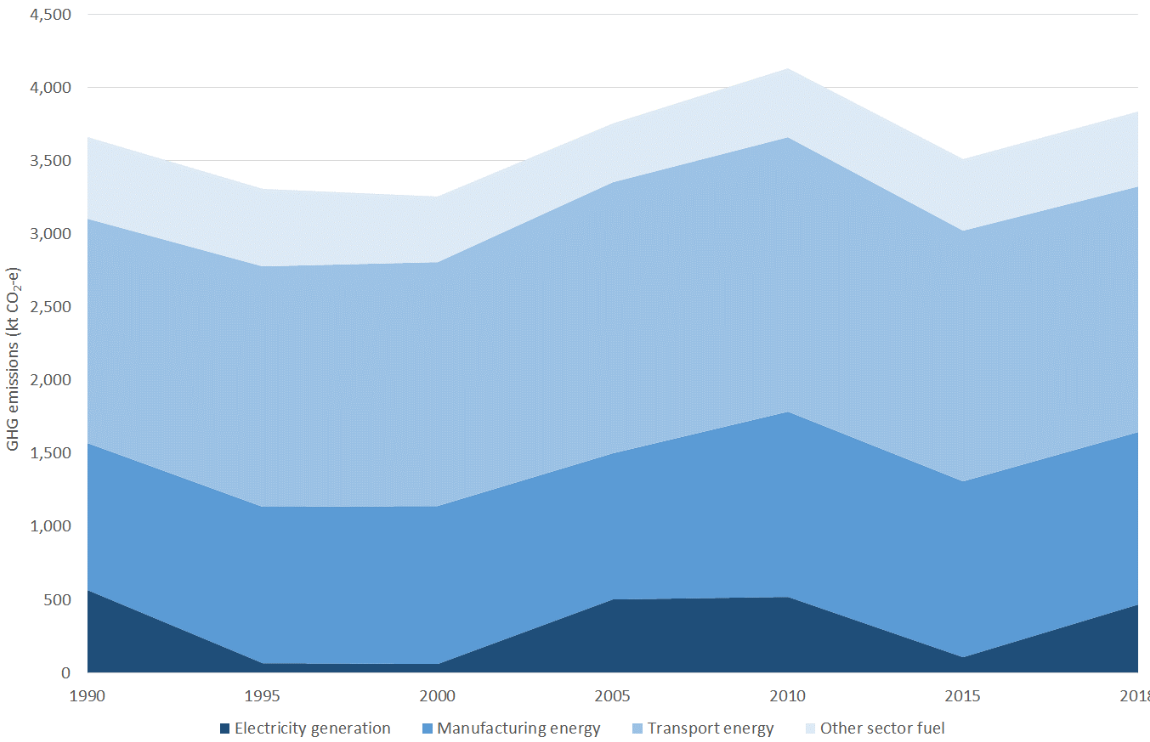
The *energy* sector is made up of many different sources, including:

- stationary energy, which includes GHG emissions from the production of electricity and other forms of energy ('energy industries') and the direct combustion of fossil fuels in industries such as manufacturing and construction; and
- transport energy, which comprises GHG emissions from air, road, rail and shipping transportation.

Figure 13 shows historic emissions for the energy sector, of which changes have primarily been driven by:

- population and economic growth;
- efficiencies in manufacturing and transport sectors; and
- the electricity generation mix.

Figure 13. Historic emissions for energy sector (1990 to 2018)



The largest contributor to emissions is from transport (primarily on-road transport), followed by manufacturing, with energy industries and other sectors roughly equal.

3.1.3 Agriculture

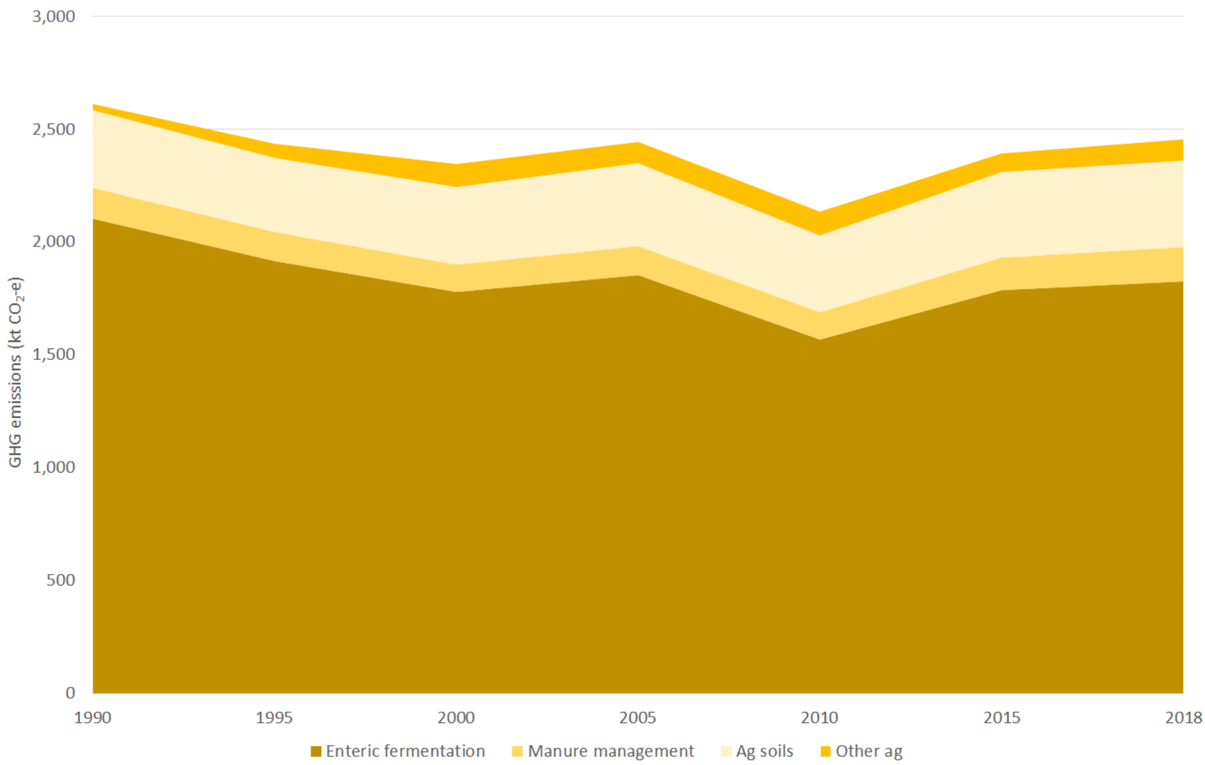
The *agriculture* sector comprises the emissions of methane and nitrous oxide from livestock, crops, and agricultural and forest soils. In 2018, Tasmania's agriculture emissions were predominately associated with enteric fermentation (71%) and agricultural soils (19%).

Enteric fermentation is a key source of Tasmania's emissions and includes emissions from:

- beef cattle on pasture (28% of agriculture sector emissions);
- dairy cattle (26% of agriculture sector emissions); and
- sheep (17% of agriculture sector emissions).

Figure 13 shows historic emissions for the agriculture sector, which have primarily been driven by changes in animal numbers, including a declining sheep flock, increasing dairy cattle herd, and relatively stable beef cattle herd over the period since 1990.

Figure 14. Historic emissions for agriculture sector (1990 to 2018)



3.1.4 Industrial processes and product use

The *industrial processes and product use* sector comprises the direct, non-energy GHG emissions from the chemical and or physical transformation of materials and emissions of synthetic gases.

In Tasmania in 2018, the major sources of emissions from industrial processes were:

- cement clinker production;
- ferromanganese production;
- aluminium production; and
- the use of hydrofluorocarbons (HFCs) for refrigeration and air-conditioning.

Overall, since 1990 the sector's total emissions have increased by 13% to 2018. The historic emissions profile is not included as for other sectors, as the data underpinning it is confidential.

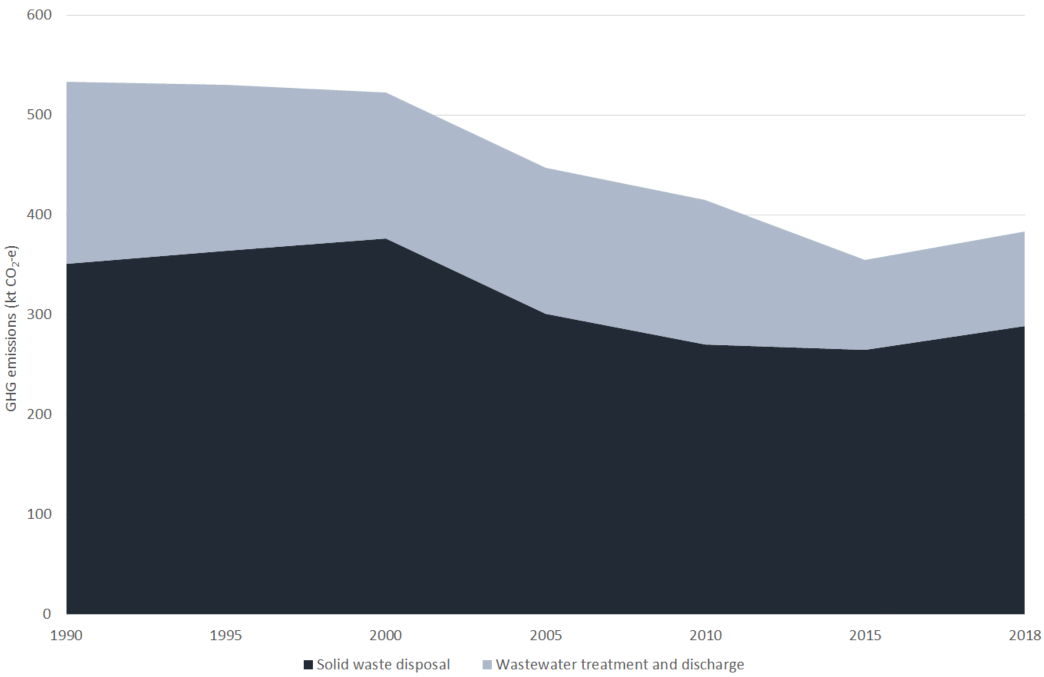
3.1.5 Waste

The *waste* sector comprises the GHG emissions from the decay of organic matter in landfill (73% of waste emissions in 2018 and the treatment of domestic and industrial wastewater (25% of waste emissions).

With regards to Tasmania's solid waste management in 2018, 26% of total solid waste generated is sent to landfill, so there are considerable opportunities to increase the diversion rate across the state. Figure 15 shows historic emissions for the waste sector, of which changes have primarily been driven by:

- population and economic growth; and
- landfill diversion rates.

Figure 15. Historic emissions for waste sector (1990 to 2018)



4 TASMANIA'S EMISSIONS PROJECTIONS TO 2050

Key points

- Under reference case conditions, Tasmania remains well below net zero emissions until 2025. However, from 2030 the State hovers very close to net zero out to 2050, and in years where there are major bushfires modelled (2035 and 2045), the State becomes a net emitter.
- Importantly the range of potential outcomes is wide, and depending on the assumptions relating to the level of post-1990 plantation activity, the rate of uptake of electric vehicles (EVs) within the passenger fleet, and growth in the agricultural sector, Tasmania's reference case emissions in 2050 could be anywhere between a net source of over 5,000 kt CO_2-e, and a net sink of around - 6,000 kt CO_2-e. It is most likely to lie somewhere in between these bounds, at around net zero.
- The balance between harvesting activity and regrowth of native forests after disturbances (including bushfires) has a high impact on Tasmania's ability to achieve net zero emissions. In the medium term (to 2050), increased levels of regeneration and replanting will result in net removals from the LULUCF sector. However, these removals are expected to gradually reduce over the longer term (i.e. out to 2100, and beyond). This means alternative strategies will most likely be needed to maintain net zero emissions for Tasmania, although modelling of the emissions profile post 2050 was outside the scope of this analysis.
- Some sectors are expected to experience significant growth in emissions, for example, emissions from the agricultural sector are expected to increase by 30% in 2050 above 2018 levels, in line with the expected increase in agricultural production, which is part of Tasmania's current economic strategy.
- In addition, despite relatively large assumed increases in the proportion of EVs in the light vehicle fleet (30%) by 2050, emissions from transport are expected to expected to remain relatively flat out to 2050, as emissions from freight are likely to increase driven by growth in the agriculture sector.
- This demonstrates that all sectors have a role to play in reducing emissions above and beyond the 'business as usual' National and State policy settings, to help Tasmania achieve net zero emissions in the medium-long term.
- Interestingly, ANZSIC sectors "E" to "S" (including industries such as "construction", "rental, hiring and retail", and "health care and social assistance") could experience significant economic expansion with limited impact on Tasmania's emissions profile. The primary emissions sources from these sectors are energy related. Assuming emissions from electricity generation will be effectively zero post 2022 (through the Tasmanian Renewable Energy Action Plan) and stationary energy emissions are relatively minor, these sectors have a low emissions intensity per dollar contributed to the Tasmanian economy.

The reference case or "business-as-usual" trajectory forecasts Tasmania's emissions by STGGI sector out to 2050. It was based on the 2018 emissions profile and an in-depth analysis of key drivers, including technological and socioeconomic dynamics, and the predicted impact of relevant national and state policies on Tasmania's emissions profile into the future.

This study assumed that, for all reference scenarios, the Australian Government would not take any **additional** climate change mitigation policy action beyond that which is currently in place or has been committed to. Therefore, if the level of ambition at the national level increased in the future, this would complement any additional actions taken by the Tasmanian Government (see Section 5 for more information on these emissions reduction opportunities), and could also improve the political feasibility of certain opportunities.

This report presents three reference case emissions scenarios (high, medium and low) to provide the Tasmanian Government with a spread of potential future emissions forecasts out to 2050. This allows the Tasmania Government to understand the inherent uncertainty associated with forecasting emissions in the long-term.

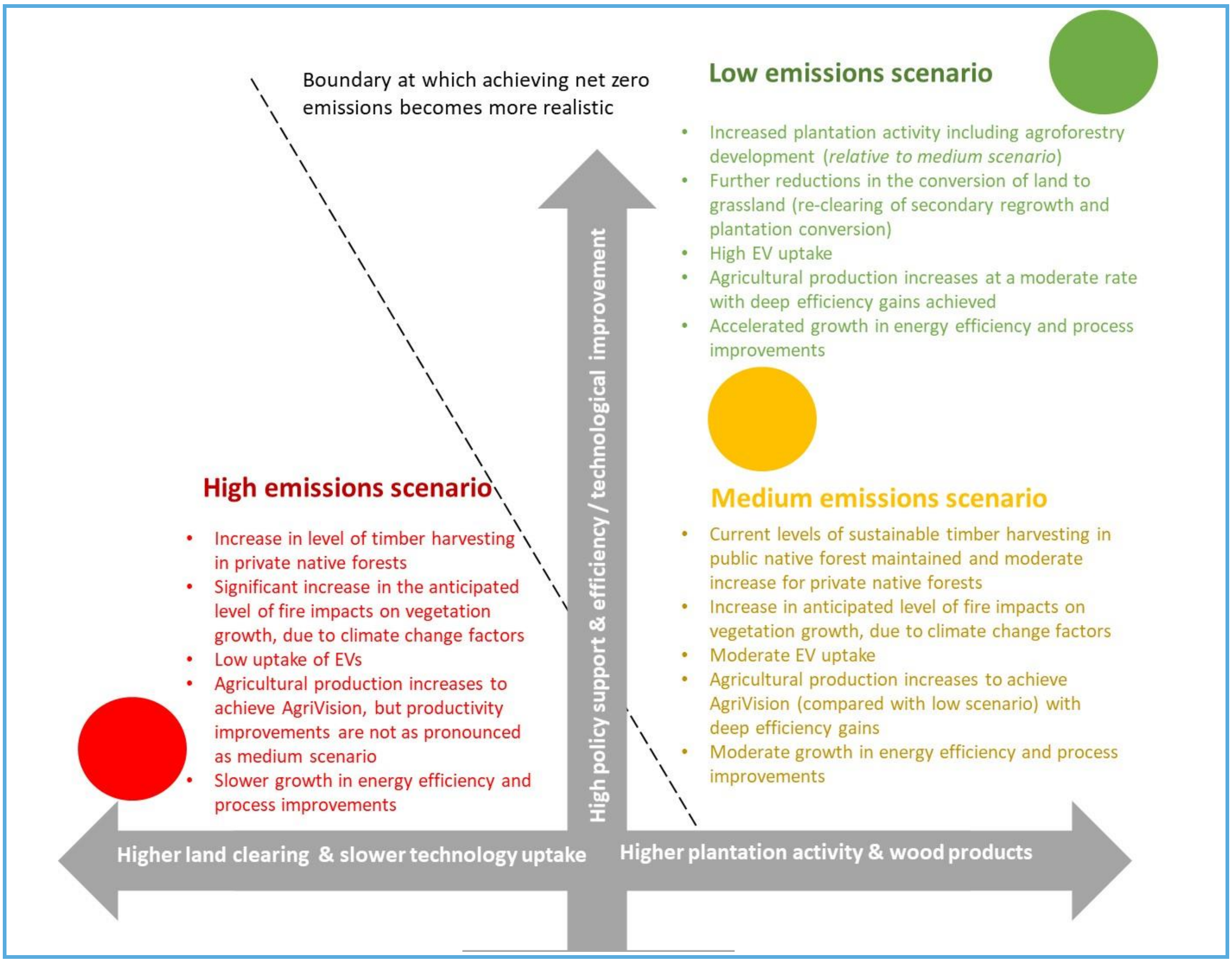
The three scenarios developed to model the reference case emissions for Tasmania exist across two fundamental dimensions:

- the degree of technological improvement and policy ambition; and

variable land-use patterns.

Figure 16 illustrates how the three scenarios interact across these two key dimensions, with the dashed line representing the conceptual boundary for achieving net zero emissions by 2050. To the right of this conceptual boundary are scenarios under which achieving net zero emissions by 2050 becomes more realistic, while on the left of the dashed line it will be significantly harder for Tasmania to achieve net zero emissions by 2050.

Figure 16. Reference case emissions scenarios and their broad characteristics[17]



Tasmania's medium reference case trajectory to 2050 across all STGGI sectors is presented in Figure 17. In this scenario, Tasmania remains well below net zero emissions out to 2025. However, from 2030 the State hovers around net zero out to 2050, and in years where there are major bushfires modelled (2035 and 2045), the State becomes a significant net source again. Therefore, although these forecasts show the State remaining close to net zero, it is important that opportunities are investigated to reduce emissions further so that maintaining net zero emissions over time is more certain.

Interestingly, total emissions for this medium emissions scenario (excluding LULUCF) stay relatively constant to 2050 (relative to 2018). This is driven by multiple factors, with the key drivers influencing the "medium" emissions scenario to 2050 being:

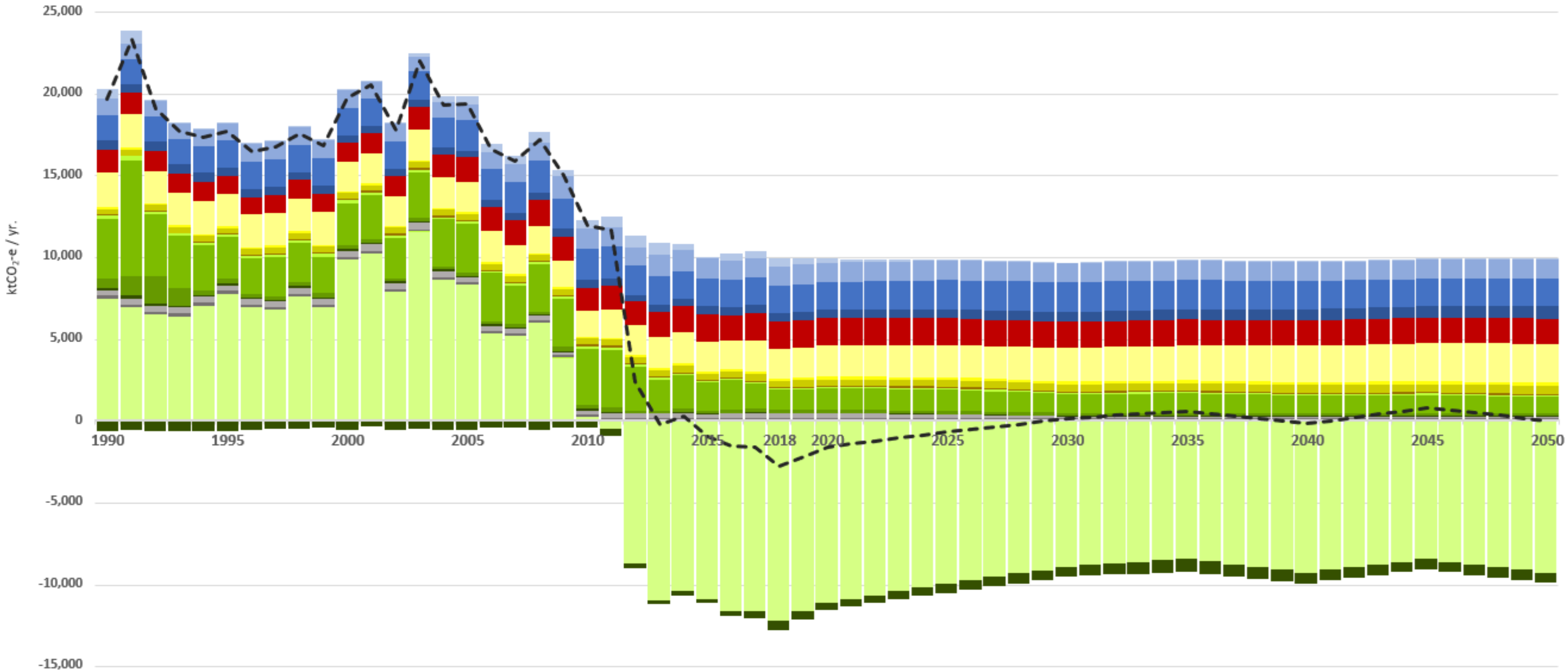
- although there is a growth in population, it is relatively small (just 8%) to 2050;

[17] This conceptual diagram was based on a similar example provided by https://www.parliament.nz/media/4449/towards-a-2050-pathway-for-new-zealand-young.pdf

- almost all electricity is generated from zero carbon sources from 2022 onwards; however, there will be some minor gas use at the Tamar Valley Power Station (TVPS) to 2050[18].
- technological improvements in the passenger transport vehicle fleet help to reduce emissions from this sector significantly, however increased emissions from freighting (linked to the achievement of AgriVision) will dampen this effect;
- agricultural emissions increase by 30%, due primarily to the Government's achievements of AgriVision and an increase in demand for meat and dairy products, however, productivity improvements such as increased milk yield and slaughter weights dampen this impact; and
- expected growth in the commercial and services sectors out to 2050 does not result in a large increase in energy related emissions because this sector has a low emissions intensity per dollar of GSP added (see Section 4.3 for more information).

[18] Note we used AEMO's 2020 forecasts (central scenario) for estimating future natural gas-powered generation in Tasmania. These align with AEMO's 2020 Integrated System Plan (ISP) which includes the achievement of Tasmanian Renewable Energy Target of 100% by 2022.

Figure 17. Medium emissions scenario, reference case emissions for Tasmania (1990 to 2050)



*** legend is provided as a colour-coded table on following page**

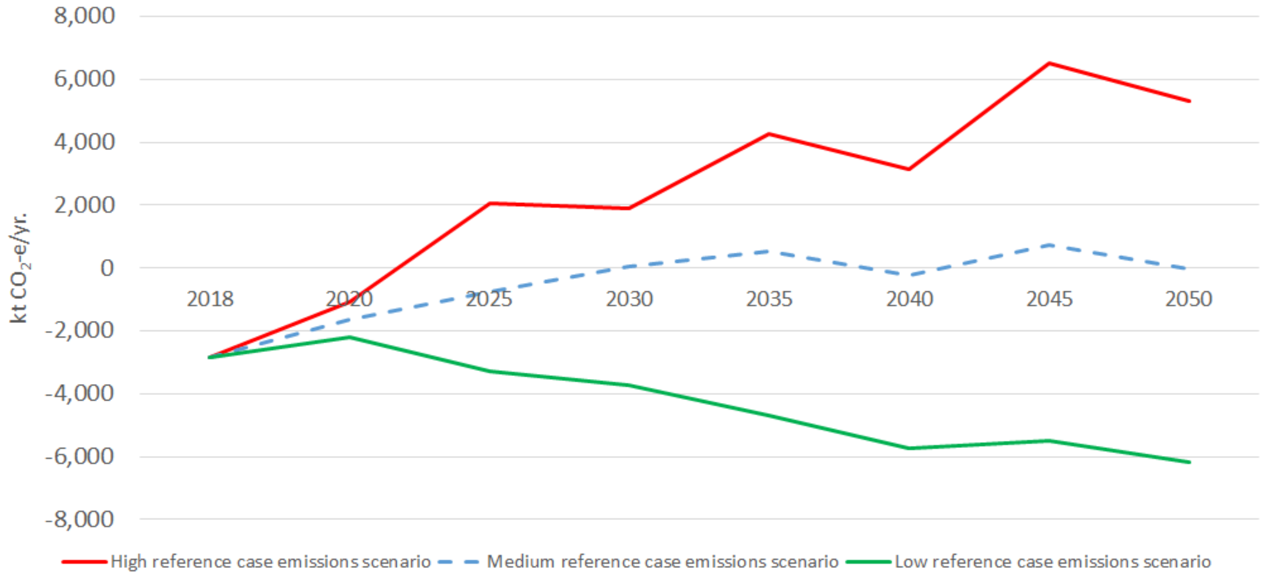
Table 4. Medium emissions scenario, reference case emissions for Tasmania (1990 to 2050)

STGGI Emissions ($ktCO_2$-e per year)	1990	1995	2000	2005	2010	2015	2018	2020	2025	2030	2035	2040	2045	2050
Net emissions (including LULUCF)	19,636	17,607	19,685	19,347	11,907	-1,047	-2,825	**-1,650**	**-753**	**67**	**548**	**-248**	**718**	**-47**
1. Energy	3,697	3,354	3,293	3,798	4,192	3,562	3,913	3,615	3,532	3,589	3,596	3,553	3,548	3,617
1. A.1 Fuel combustion - Energy industries	570	67	65	503	523	109	468	243	0	0	0	1	1	2
1. A.2 Fuel combustion - Manufacturing industries and construction	1,002	1,068	1,075	1,002	1,266	1,205	1,181	1,181	1,176	1,169	1,165	1,161	1,157	1,153
1. A.3 Fuel combustion - Transport energy	1,531	1,644	1,667	1,848	1,875	1,712	1,678	1,692	1,790	1,823	1,792	1,712	1,663	1,686
1. A.4 Fuel combustion - Other sectors	560	532	450	405	465	485	508	499	566	597	639	680	726	776
2. Industrial processes	1,417	1,114	1,172	1,489	1,434	1,702	1,648	1,704	1,614	1,595	1,574	1,560	1,549	1,531
3. Agriculture	2,613	2,436	2,345	2,446	2,133	2,392	2,454	2,523	2,633	2,735	2,851	2,965	3,075	3,182
3.A.1 Enteric fermentation	2,106	1,916	1,781	1,854	1,570	1,786	1,826	1,887	1,966	2,044	2,133	2,221	2,306	2,389
3.B. Manure Management	137	127	119	128	121	145	152	156	163	169	177	184	191	198
3.D.a.3 Agricultural soils	341	329	346	369	337	379	386	394	413	432	450	469	487	505
Other agriculture	29	63	99	95	105	82	91	86	91	91	91	91	91	91
4. Land Use, Land-Use Change and Forestry	11,375	10,171	12,350	11,163	3,728	-9,064	-11,229	-9,876	-8,873	-8,057	-7,683	-8,537	-7,666	-8,592
A. Forest land	7,410	7,705	9,796	8,262	156	-10,836	-12,168	-11,074	-9,936	-8,879	-8,397	-9,233	-8,422	-9,231
B. Cropland	215	169	157	99	147	92	76	82	81	81	81	81	81	81
C. Grassland	3,686	2,558	2,582	2,980	3,449	1,726	1,204	1,307	1,305	1,143	1,190	1,050	1,096	966
D. Wetland	539	276	235	222	248	163	221	203	203	203	203	203	203	203
E. Settlements	129	100	123	95	97	29	15	22	20	18	17	15	14	13
G. Harvested wood products	-604	-637	-543	-495	-369	-238	-577	-416	-547	-623	-776	-653	-638	-623
5. Waste	534	532	525	451	420	361	389	384	342	205	208	211	213	215
5.A. Waste - Solid waste disposal	351	364	376	301	271	265	288	284	233	84	85	86	86	87
5.D. Waste water treatment and discharge	182	166	146	146	144	90	95	94	99	101	103	105	107	108
Other waste	1	2	3	3	5	6	6	6	10	19	20	20	20	20

Figure 18 presents the high, medium and low emissions forecasts for the whole of Tasmania out to 2050, showing the wide potential variation in the reference case emissions to 2050.

In addition, the impact of major bushfires (modelled as occurring indicatively every 10 years from 2025 onwards) tends to create the sawtooth pattern most evident in the high level emissions scenario reference case (assumptions underpinning this are described in detail in Section 4.2.1).

Figure 18. Comparison of Low, Medium and High reference case emissions to 2050



4.1 Overall drivers of change in emissions across low, medium and high reference case scenarios

The following sections provide a summary of drivers of change across reference case emissions scenarios to 2050, for the LULUCF, transport and agriculture sectors specifically, as they have the largest overall impact on Tasmania's emissions profile into the future.

LULUCF

The high points of the LULUCF emissions profile, in 2025, 2035 and 2045 are attributable to the assumed seven-fold increase in emissions from these modelled bushfire events compared to recent annual averages; and the assumption that up to 5% of the area burned in these fire events will be forest land converted to another land use.

These assumptions are based on the expectation of increasing impacts of climate change and bushfires over time, encompassing a provision for both land use change *and* the short term to long term forest degradation that may result after major fire events. Notwithstanding the physiological capacity for many native forest species and forest ecosystems to recover and regenerate after fire events, we note that major fires can negatively impact on carbon sequestration for an extended period. The following evidence is provided for this:

- McIntosh et al. (2020) reported the limitation of fires on carbon accumulation is evident in areas of Tasmania and the southeast Australian mainland affected by the 2019/20 bushfires; and "*while not all burnt eucalypts are killed by fire, the overall effect of crown fires is to halt landscape-scale [carbon] accumulation or reverse it*".[19]
- Looking at trends in northeast Victoria, Bowman et al. (2014) reported that since 2002, 85% of the Alps bioregion has been burnt by several very large fires; and their results indicate that without interventions to reduce fire severity, interactions between flammability of regenerating stands and increased extreme fire weather "will eliminate much of the remaining mature alpine ash forest".[20] International studies have further highlighted these anticipated impacts.

[19] McIntosh, Peter D., Hardcastle, James L., Klöffel, Tobias, Moroni, Martin, and Santini, Talitha C. (2020). Can carbon sequestration in Tasmanian "wet" eucalypt forests be used to mitigate climate change? Forest succession, the buffering effects of soils, and landscape processes must be taken into account. *International Journal of Forestry Research* 2020 6509659

[20] Bowman, D.M.J.S., Murphy, B.P., Neyland, D.L.J., Williamson, G.J. and Prior, L.D. (2014), Abrupt fire regime change may cause landscape-wide loss of mature obligate seeder forests. *Glob Change Biol*, 20: 1008-1015.

- Enright et al (2015), reported on the "interval squeeze", in which altered fire regimes and demographic responses around the world (including Australia) are interacting to threaten woody species persistence as climate changes, and they projected an increase in woody plant extinction risk and changes in ecosystem structure, composition, and carbon storage, especially in regions projected to become both warmer and drier.[21]

Therefore, we have assumed some quantum of loss of forest, or at least loss of forest growth, due to anticipated type change.

The major drivers of the difference between the high and low scenarios compared with the medium case are outlined below and in Appendix 1 for LULUCF specifically (as the key sector driving the wide range of outcomes):

- LULUCF sector emissions:
  - High emissions scenario:
    - Reduces the LULUCF net sink in 2050 by around 20% to -6,447 kt CO_2-e.
    - Incorporates an increase in the level of harvesting in private native forests, which is currently at historically low levels compared to previous periods. The scope for timber harvesting levels in public native forests to increase is limited by the determination of sustainable yield supply for the next 90 years; whereas, the current level of harvesting in private native forests is well below historical averages.
    - Other key assumptions underpinning the high emissions scenario include further conversion of post-1990 plantations to other land uses and a lower level of post-1990 plantation activity; a decrease in the level of value-added wood products manufacturing in Tasmania; and major bushfire events releasing up to 10 times the level of average annual fire related emissions from the land use sector.
  - Low emissions scenario:
    - In comparison to the medium emissions scenario reference case, the low reference case scenario increases the LULUCF net sink in 2050 by around 34% to -11,639 kt CO_2-e.
    - Harvesting levels in private native forests were assumed to remain constant at 2018 levels, which would result in a modest increase in carbon removals for forest land remaining forest land compared with the medium emissions scenario reference case.
    - The total area of post-1990 plantations, incorporating farm forestry and agroforestry, is assumed to increase by around 5% per year, to realise additional plantings totalling 30,000 ha by 2050.
    - Other key assumptions underpinning the low emissions scenario include further reductions in the level of forest land conversion to other land uses, notably grassland; and, a decrease of 10% in the level of value-added wood products manufacturing in Tasmania.

Transport

- Transport sector emissions
  - High emissions scenario: emissions in 2050 are 1.7 times that of the medium case. This is largely driven by much lower electric vehicle (EV) adoption rates, higher population growth and a larger relative freight task.
  - Low emissions scenario: under this scenario, emissions in 2050 are approximately 94% lower than the medium case. This is largely driven by higher EV adoption rates (100% versus 30% for the medium case[22]), improved ICE fuel efficiency rates across both light and heavy vehicle fleets, and a decline in population.

Agriculture

- Agriculture sectors emissions:
  - High emissions scenario: emissions in 2050 are 23% higher than the medium emissions scenario. This is largely driven by higher animal numbers required to grow the gross value of Tasmania's agricultural production to $10 billion, in line with the AgriVision 2050 growth target, and lower production efficiencies under the high emissions scenario compared with the medium emissions scenario.

[21] Enright, N.J., Fontaine, J.B., Bowman, D.M., Bradstock, R.A. and Williams, R.J. (2015), Interval squeeze: altered fire regimes and demographic responses interact to threaten woody species persistence as climate changes. *Frontiers in Ecology and the Environment*, 13: 265-272.
[22] In line with AEMO's step change and central scenarios respectively for EVs (passenger and LCV) in Tasmania

- Low emissions scenario: emissions in 2050 are 4% lower than the medium case. This is largely driven by slightly lower animal numbers compared with the medium emissions scenario, and the AgriVision 2050 growth target being only 85% realised.

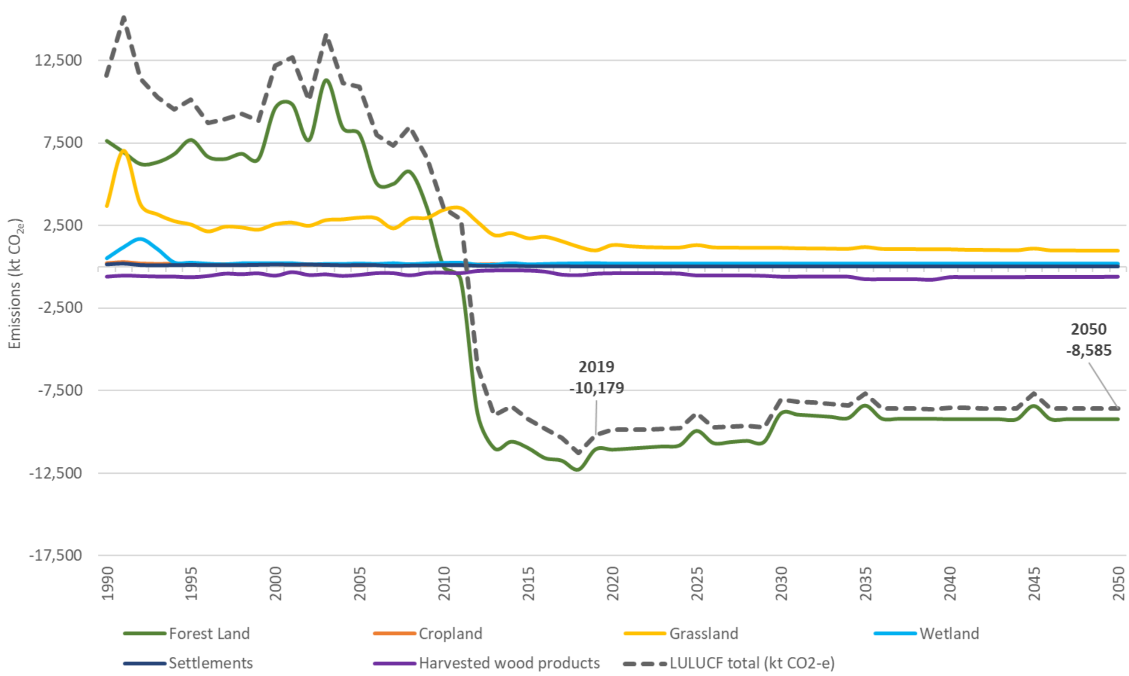
4.2 Reference case emissions by sector

The sub-sections below present an overview of the reference case emissions for each sector of Tasmania's STGGI.

4.2.1 LULUCF

The medium reference case to 2050 for the *LULUCF* sector in Tasmania is set out below. The emissions forecast under this scenario is for the LULUCF sector to remain a relatively large sink, sequestering around 8,500 kt CO_2-e in 2050 (i.e. net removals of emissions).

Figure 19. Medium emissions scenario reference case – emissions from LULUCF (2018 to 2050)



The medium emissions scenario reference case presents emissions estimates that are based on current policy settings, as well as published industry forecasts (for example, reports on the sustainable supply of timber from forestry operations in native forests and plantations), and historical trends (most notably trends over the past 5-10 years) for land use change and other key contributors to the LULUCF sector.

In relation to policy settings for forestry and timber production, it is important to recognise the extensive regulatory framework in place in Tasmania to ensure there a sustainable forestry industry as a key economic driver for the State. The regulatory framework incorporates the Regional Forest Agreement (RFA) between the Tasmanian Government and the Australian Government. A key commitment of the RFA is that the State will maintain a forest management system. The three key elements of the forest management system are[23]:

- Comprehensive, Adequate and Representative (CAR) Reserve System – Tasmania maintains a CAR Reserves Estate of around 3.4 million hectares, which covers more than 50% of the State. ·Around Half of Tasmania's forests – approximately 1.79 million hectares – are protected in reserves.
- Ecologically Sustainable Forest Management (ESFM) – this commitment is delivered through Tasmania's Independent Regulator of Forest Practices (the Forest Practices Authority), who regulate the forest practices system (with legislative power through the *Forest Practices Act* 1985).
- Permanent Native Forest Estate Policy – Tasmania maintains a significant permanent native forest estate (extending over 3 million hectares). The Permanent Native Forest Estate Policy prohibits broad scale clearing and

[23] Current policy settings and data from the Tasmanian Government: https://www.stategrowth.tas.gov.au/energy_and_resources/forestry (accessed May 2021)

conversion of native forest, other than in limited prescribed circumstances. Broad scale clearing and conversion has ceased on public land; and the extent and rate of clearing on private land is constrained by the policy.

- Permanent Timber Production Zone (PTPZ) land – The total extent of PTPZ land is around 812 000 hectares– of this, less than half (46%) contains native forest available for wood production. Harvesting occurs on less than 1.5% of this available productive land, or less than 1% of the entire PTPZ area (based on area harvested in 2019/20).

Recognising the extensive regulatory framework for forestry in Tasmania, this review of the State's emissions pathway incorporates projections of forest industry activity based on current and recent levels of production (over last five years) and industry reports on sustainable production levels through to 2050 and beyond.

Based on STT's sustainable high quality eucalypt sawlog supply outlook, the predicted yields from timber harvesting in Tasmania's Permanent Timber Production Zone (PTPZ) land are forecast to remain at current levels until 2022; then there will be a step down in harvesting levels in native forest over the next 5 years to 2027; followed by another step down in 2028 to just over half (around 53%) of the current level of predicted yield. [24] The supply of high quality eucalypt sawlogs during this progressive step down in supply will be augmented by significant additional quantities of high quality eucalypt sawlogs from eucalypt plantations. . Considering this from a GHG emissions accounting perspective, timber harvesting in native forests will influence the *forest land remaining forest land* sub-category; while timber harvesting in eucalypt plantations, mostly established after 1990, will influence GHG emissions in the *land converted to forest land* (*plantations and natural regeneration*) sub-category.

This trend in relation to *the forest land remaining forest land* sub-category is expected to reach a stage where a significant proportion of *harvested native forests* will effectively be 'unharvested' and accounted for in the same way as *other native forests* (in which there is no timber harvesting); which is treated in the National Greenhouse Accounts as in equilibrium, i.e. no net sequestration or emissions. As Tasmania's wet eucalypt forests grow older and senesce, they will, without disturbance, transition to rainforest and become a net emitter of CO_2. Therefore, with planned step downs in sustainable timber supply from public native forests, and in the absence of other forms of disturbance (such as bushfires), the capacity for Tasmania's native forest estate (forest land) to sequester carbon will tend to contract gradually over time. This is subject to the impact of bushfires, which can result in forest type changes such as rainforest to wet eucalypt forest or a change in dominant species. The potential impact of bushfires is discussed further below.

Potential impact of bushfires

The impact of bushfires on Tasmania's emission levels is largely captured in STGGI reporting under two key LULUCF sub-categories; firstly, through emissions attributed to the combustion of vegetation fuels (predominantly from the *Forest Land remaining Forest Land* subcategory, and other land uses); and secondly, through any subsequent conversion of land use if the pre-existing forest land (or other forms of vegetated land) is not restored over time.

The average annual impact of bushfires and prescribed burning on LULUCF sector emissions can be calculated using historical data and this provides an approach to modelling impacts for 'average' years to date. However, in relation to modelling the impact of major or catastrophic bushfires into the future and in the context of climate change, 'looking backwards' may not be the best guide to the future.

This project has not identified a source of published forecast data that was suitable as a proxy for forecasting fires on forest land across Tasmania. Hence for this project, new assumptions were made about the frequency of major bushfires and the impact of these bushfires on relevant LULUCF emissions reporting categories. These assumptions reflect trends observed in historic data, e.g. the *State of the Forests Tasmania 2017* report, which presented data on areas burned over the past 70 years and shows that major fire events have resulted in between 100,000 and 175,000 hectares of forested land burnt per season. This project also considered relevant research on the modelled impact of climate change on climatic conditions and the risk of fires, including the Tasmanian Government's *Climate Action 21: Tasmania's Climate Change Action Plan 2017-2021*, which observed that Tasmania is expecting to experience longer fire seasons with more frequent and intense bushfire events.

Furthermore, recently published research by Macintosh et al. (2020) on carbon sequestration in Tasmania's "wet" eucalypt forests has highlighted the risk of major fire events in these forest types, as a result at least in part to the increase in forest fuel levels since the 1820s, following European settlement and the cessation of low intensity burning

[24] Sustainable Timber Tasmania, 2017. Sustainable high quality eucalypt sawlog supply from Tasmania's Permanent Timber Production Zone Land, Review No. 5, July 2017.

by Aboriginal populations[25]. Their research notes the largest fire recorded in Tasmania was in 1898 when over 1 million ha and possibly up to 2 million ha of land in the southwest burned. Other very large fires were in 1934 when 800,000–900,000 ha burned; and in 1967 when approximately 250,000 ha burned. More recently, there were over 2,400 recorded lightning strikes in Tasmania in 2018/19 that caused 72 vegetation fires extending over 205,000 ha including approximately 100,000 ha of wet eucalypt forests and 7,000 ha of rainforest[26].

In the context of this observed variation in bushfire impacts over time, and the complexity of climate change impacts, there is clearly uncertainty around the timing and scale of major fires into the future. This represents a limitation in the LULUCF modelling of fire impacts over the next 30+ years to 2050, which has been addressed in two ways.

Firstly, the modelling for this analysis incorporated low, medium, and high scenarios, which are intended to provide a range of possible outcomes. In relation to fire impacts, the key assumptions are outlined below.

Table 5. Key assumptions relating to fire impacts on LULUCF scenarios (2018 – 2050)

Scenarios	Year-on-year change in area burnt and level of emissions from fire (bushfire & prescribed burning) (%)	Indicative area equivalent for total area burnt each year (ha)	Scale of major fire events every 10 years (indicatively 2025, 2035, 2045) (%)	Indicative area equivalent for major fire events (indicatively 2025, 2035, 2045) (ha)
Medium	+10% on past 5 years	60,000 ha/year	500% above average	300,000 ha
Low	+10% on past 5 years	60,000 ha/year	300% above average	200,000 ha
High	+30% on past 5 years	70,000 ha/year	800% above average	500,000 ha

All three of these scenarios incorporate the assumption of a major fire event (assumed indicatively as every 10 years) that is larger than the largest fire events over the past 70 years; and incorporate annual, ongoing fire impacts that apply a consistently higher average impact than seen over the past five years.

However, these assumptions do not encompass a scenario in which a mega fire covering 1 million ha or more would burn through a much larger proportion of Tasmania's forest estate. This scenario is addressed at least in part through the Australian Government's provisions for 'natural disturbances'.

In accordance with agreed international conventions, the Australian Government has established natural disturbance provisions to place an upper limit (or cap) on the impact of bushfires on the national greenhouse gas inventory[27]. This effectively means that Australia, with States and Territories incorporated, can exclude the impact of major fires on annual accounts, provided the area burned is restored over an allocated period – and if not, the land use conversion and associated emissions are then recorded in the inventory. This means that if Tasmania were to experience a mega fire of historic proportions, such as those seen in Victoria in 2009 and NSW and Victoria in 2019/20, the State and the Australian Government have provisions to excise the burnt areas from the inventory and monitor their regeneration and recovery over time, ahead of reincorporating back into the national inventory.

It is important to highlight that all the emissions from major bushfires will be 'seen by the atmosphere' – that is, they will have a direct emissions impact on the atmosphere and contribute to climate change in this way. However, from the perspective of emissions reporting and future STGGI reports, the rules make provision to exclude the impact of major fires above certain thresholds. This is important for mitigating the risk of a large spike in LULUCF emissions seen in Tasmania's STGGI accounts.

Plantations

The reference case emissions for LULUCF incorporates two categories of plantations: the pre-1990 plantations and post-1990 plantations. Emissions and removals from pre-1990 plantations are recorded under *forest land remaining forest land*, while for post-1990 plantations, they are recorded under *plantations and natural regeneration*.

[25] McIntosh PD, Hardcastle JL, Klöffel T, Moroni M, Santini TC, 2020. Can Carbon Sequestration in Tasmanian "Wet" Eucalypt Forests Be Used to Mitigate Climate Change? Forest Succession, the Buffering Effects of Soils, and Landscape Processes Must Be Taken into Account. *International Journal of Forestry Research*, Volume 2020, Article ID 6509659, 16 pages. https://doi.org/10.1155/2020/6509659

[26] Ibid.

[27] As described in Australia's National Greenhouse Accounts, "at the national level, emissions from the area burned are assessed on a year by year basis for extreme fire events where outcomes at the national level were beyond the control of authorities to manage. This is done by comparing each year's data with a threshold level or 'margin' based on two standard deviations above the mean of gross annual emissions from all fires and after iteratively excluding outliers. The national natural disturbance threshold is calculated for the calibration period of 2000–2012". National Inventory Report 2018, Volume 2, p47.

Pre-1990 plantations

In Tasmania, the pre-1990 plantation estate comprising around 15,000 ha[28], which is a relatively small proportion (5%) of the total area of forestry plantations across the state (around 310,000 ha). Softwoods (predominantly radiata pine) account for most of the pre-1990 plantation estate, while most of hardwood plantations (eucalypt species) were established from the mid-1990s onwards.

Like other states, the pre-1990 softwood plantation estate in Tasmania is in a mature phase of development with regular cycles of harvesting followed by replanting, and relatively low levels of conversion to other land uses. While there has been no new softwood plantation development over the past eight years, Point Advisory and Indufor would expect most of the existing estate to be replanted for the second and subsequent rotations.

Pre-1990 plantations have generally contributed net removals to Tasmania's emissions profile, of up to 15% in 1995, but over the past 30 years the proportion of net removals in the total LULUCF sector profile has averaged around 4%; and its contribution has reduced over the past 10 years as the impact of post-1990 plantations has increased.

For the medium emissions scenario reference case, the sector trends for emissions for pre-1990 plantations are based on ABARES' projections for plantation log supply, specifically the softwood plantation trends for Tasmania. STGGI data on recent levels of emissions for this sub-category were extrapolated based on the ABARES trends for softwood plantations. Projected net emissions from pre-1990 plantations are based on the assumptions that all plantations will be replanted after harvesting, and emissions will vary mainly in accordance with the age class and forecast fluctuations in softwood plantation log production.

Post-1990 plantations

The post-1990 plantations account for the balance of Tasmania's plantation estate, and total around 295,000 ha; of which around 234,000 ha are hardwood plantations[29]. Most of these plantations were established in the mid/late 1990s and the 2000s; with no substantive increase in the total plantation area since 2008-09. However, since that time, there has been an increasing level of harvest in the post-1990 plantations, with the total volume of hardwood plantation logs harvested in 2018-19 representing a three-fold increase on 2008-09. Most of the harvested plantations have been replanted and are regrowing in a second rotation; however, there has been some conversion of post-1990 plantations to other land uses, and industry estimates indicate a current loss of around 1,000 ha/year in Tasmania.

Over the past decade, the plantations and natural regeneration sub-category has become a key component of Tasmania's LULUCF emissions profile, contributing in the order of 20% to 40% to net removals over this period. The contribution represents net removals arising from plantation growth (removals) after harvesting related activity (emissions), and the annual contribution reflects variability in the total levels of harvesting and the age class profile of the whole post-1990 plantation estate.

For the medium emissions scenario reference case, the sector trends for emissions for post-1990 plantations assume that most of the existing plantation estate will be replanted after harvesting, i.e. maintained in the same land use; but there will be a loss of around 1,000 ha per year (-0.5%) for the next nine years to 2030. STGGI data on recent levels of emissions for the plantations and natural regeneration sub-category were extrapolated and applied to this projection for plantation area, out to 2050. missions will vary mainly in accordance with the age class and forecast fluctuations in hardwood plantation log production.

Harvested wood products

The *harvested wood products* category comprises carbon pools of wood products with service life in Australia. It is a separate category from others that report the losses in carbon stocks from harvesting activities; that is, *forest land remaining forest land* and *land converted to forest land*. Harvested wood products include both nationally produced and imported materials, excluding those that are disposed to a waste stream (landfill) and exported products.

In Tasmania, harvested wood products account for a relatively small proportion of the LULUCF net removals – indicatively, 1-4% of net removals over the past decade. This is despite Tasmania having a range of policies and programs aimed at directing more of its timber harvesting into long term and higher value timber products, for example, sawn timber, veneers and plywood products, and more recently CLT products. The State Government has contributed support through policy settings and funding allocations over time. Notwithstanding these contributions, the overall contribution of harvested wood products to Tasmania's LULUCF sector profile has remained modest. This is

[28] Forest Practices Authority (2017) *State of the forests Tasmania 2017*. Online: https://www.fpa.tas.gov.au/__data/assets/pdf_file/0005/163418/State_of_the_Forests_Report_2017_-_erratum_Feb_2018.pdf

[29] ABARES (2021) *Australian plantation statistics 2020 update*. Online: https://www.agriculture.gov.au/abares/forestsaustralia/plantation-inventory-and-statistics

consistent with the LULUCF sector profile in other states and territories, and generally relates to the much larger contributions made by the forest land remaining forest land sub-category and land use change dynamics.

Under the medium emissions reference case, the contribution of harvested wood products is not expected to increase substantially, unless there was a substantial increase in timber harvesting and most of the wood product was directed to long- and very long-term products, including structural timbers, furniture timbers and engineered wood products.

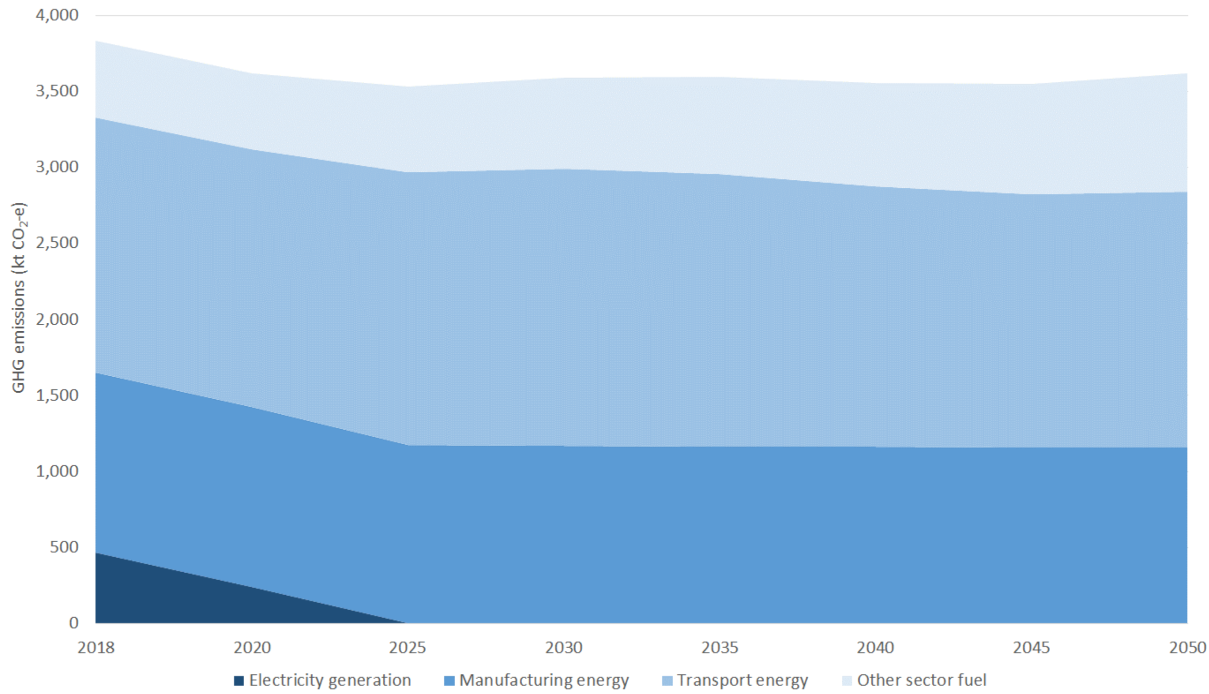
4.2.2 Energy

Under the medium emissions scenario reference case, emissions from the energy sector are forecast to be approximately 3,500 kt CO_2-e in 2050 (Figure 20), a decrease of 11% below 2018 levels.

The key drivers of change that impact Tasmania's reference case energy emissions to 2050 include:

- Increasing penetration of EVs across the passenger, commercial and heavy vehicle fleet, from 0% in 2018 to approximately 30% by 2050.
- Increasing rooftop PV and energy efficiency measures which are projected to have a dampening effect on stationary energy consumption. Our forecasts were based on the Australian Energy Market Operator (AEMO)'s 2020 Integrated System Plan (ISP) as the basis for growth to 2040[30] and extrapolated these trends to 2050.
- Government policy and programs including primarily the Tasmania First Energy Policy, which will result in Tasmanian electricity being close to net zero emissions from 2022 onwards. However, there will continue to be some minor gas use at the Tamar Valley Power Station (TVPS) to 2050.
- Increasing population and economic growth.
- Growth in the agricultural sector which in turn is expected to result in an increase in activity in the food processing, beverages and tobacco sub-sector.
- Emissions from the pulp, paper and print sub-sector are expected to decrease following a global decline in print newspaper and magazine sales, while most other sectors remain fairly constant in line with historical trends.

Figure 20. Medium emissions scenario reference case – emissions from energy (2018 to 2050)[31]



4.2.3 Agriculture

Under the medium emissions scenario reference case, emissions from the agriculture sector are forecast to be approximately 3,000 kt CO_2-e in 2050 (Figure 21), an increase of 30% above 2018 levels, underpinned by rising food demand and prices both in Australia and internationally.

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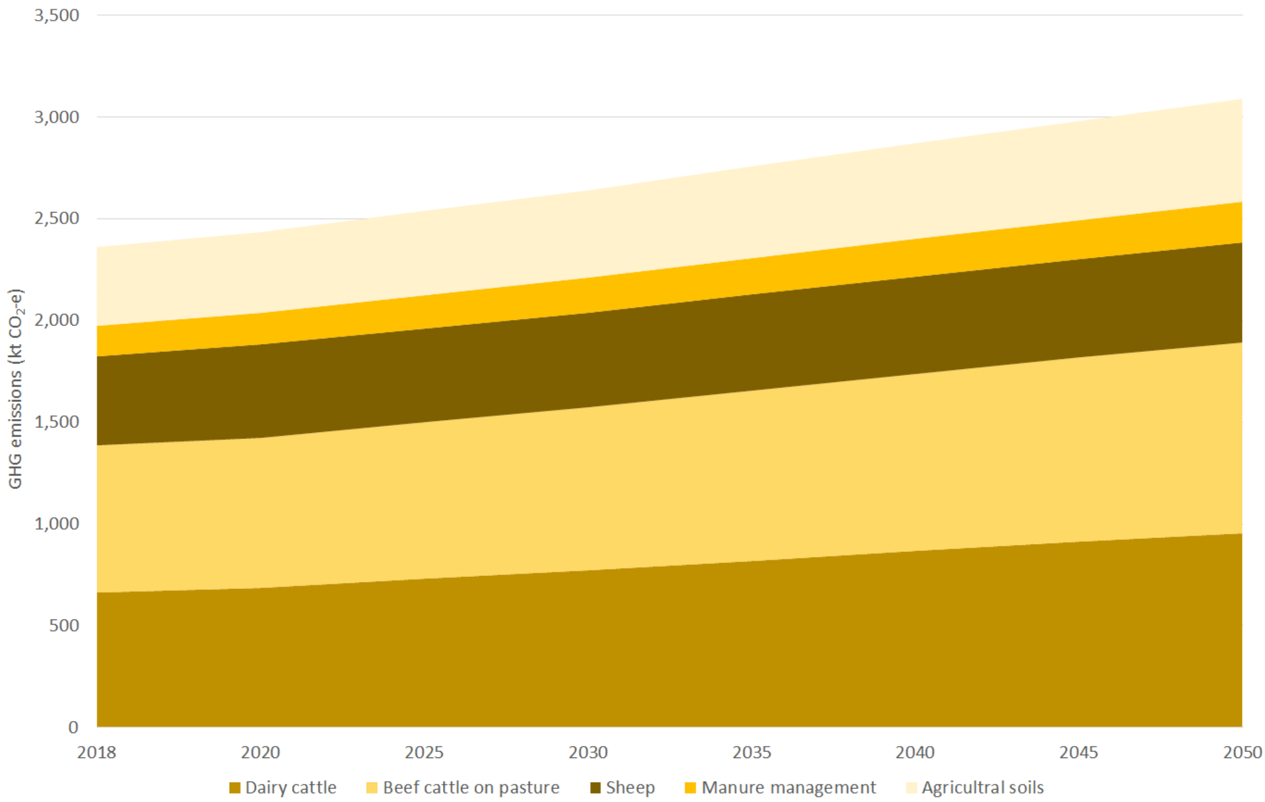
[30] https://aemo.com.au/en/energy-systems/major-publications/integrated-system-plan-isp/2020-integrated-system-plan-isp

[31] Note that there are minor emissions associated with electricity generation to 2050, however because of their magnitude they are not visible in this graph.

The key drivers of change that impact Tasmania's reference case agricultural emissions to 2050 include:

- Tasmanian Government policy and programs including the AgriVision 2050 target of growing the gross value of agricultural production to $10 billion by 2050 (or just over $4 billion in real terms). The achievement of this target is supported by complementary policies and programs such as Tasmania's Sustainable Agri-Food Plan 2019-23[32], the Pipeline to Prosperity program[33], and the White Paper on the Competitiveness of Tasmanian Agriculture for 2050[34].
- Changes in demand for agricultural products. Overall, stronger global economic growth will translate to higher per person incomes in most of Australia's export markets, driving stronger demand for agricultural products, including meat and dairy. Although globally there is a trend towards veganism and vegetarianism, Tasmania's position as a premium provider of meat and dairy goods is expected to limit the impact of this trend on demand for Tasmanian agricultural goods to 2050[35].
- Reductions in the enteric emissions intensity as a result of production efficiencies. For example, over the past thirty years, milk yields per cow have increased significantly, and there has been a corresponding reduction in the emissions intensity per litre of milk[36]. This is because the selection of cattle for increased milk yields tends to lower enteric methane emissions per litre of milk.

Figure 21. Medium emissions scenario reference case – emissions from agriculture (2018 to 2050)



4.2.4 Industrial processes and product use

Under the medium emissions scenario reference case, emissions from the industrial processes and product use sector are forecast to be approximately 1,500 kt CO_2-e in 2050 (Figure 22), a decrease of 8% below 2018 levels.

The reference case modelling for industrial processes and product use assumes relatively static emissions to 2050 based on historic trends (using the historical low and high emissions to indicate the range of scenarios into the future).

[32] https://dpipwe.tas.gov.au/Documents/Tasmanian%20Sustainable%20Agri-Food%20Plan%202019-23.pdf

[33] https://www.tasmanianirrigation.com.au/pipeline-to-prosperity

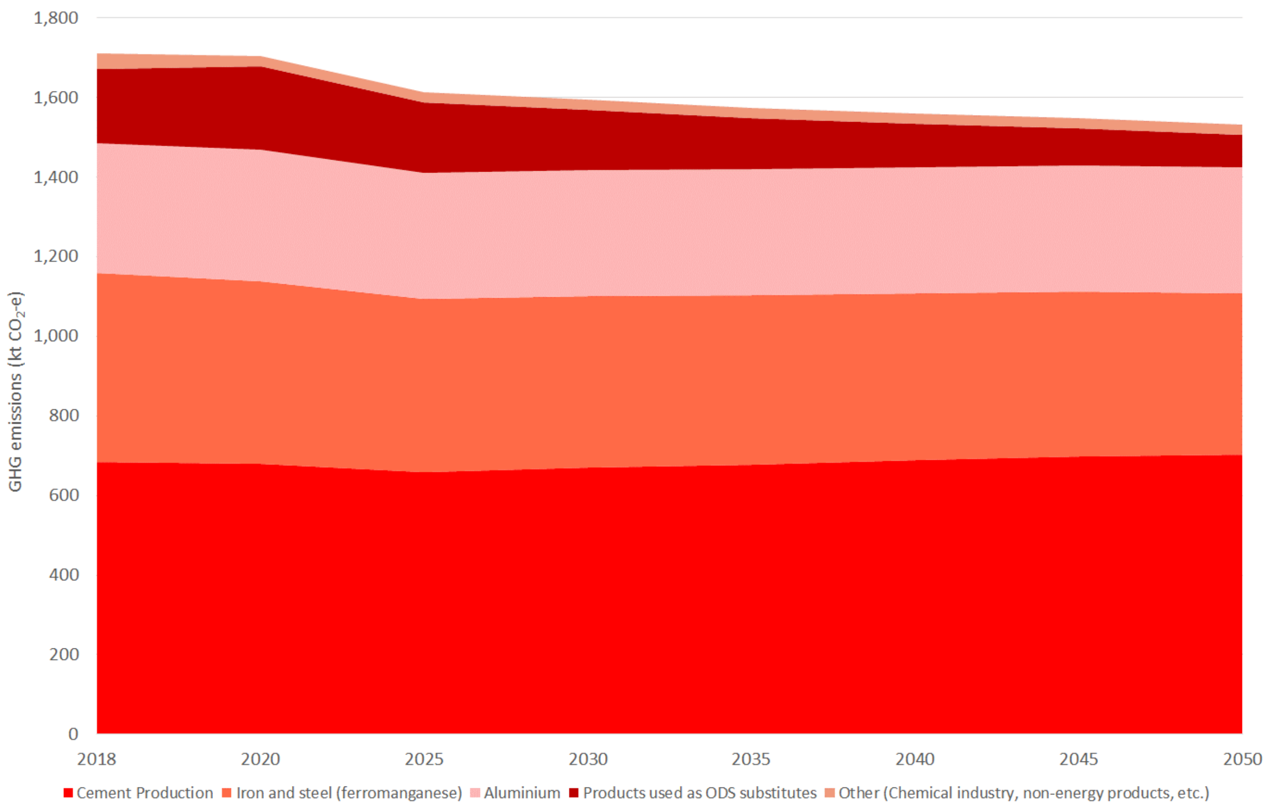
[34] https://dpipwe.tas.gov.au/Documents/Competitiveness%20of%20Tas%20Ag%20for%202050%20Discussion%20Paper.pdf

[35] Based on feedback from representatives from DPIPWE.

[36] Moate Peter J., Deighton Matthew H., Williams S. Richard O., Pryce Jennie E., Hayes Ben J., Jacobs Joe L., Eckard Richard J., Hannah Murray C., Wales William J. (2015) Reducing the carbon footprint of Australian milk production by mitigation of enteric methane emissions. Animal Production Science 56, 1017-1034.

The exception is for emissions of HFCs, which will be subject to a legislated phase out to 2036 and beyond. Developed countries are obligated to phase-down their production and importations of HFCs by 85% between 2019 and 2036.

Figure 22. Medium emissions scenario reference case - emissions from industrial processes and product use (2018 to 2050)

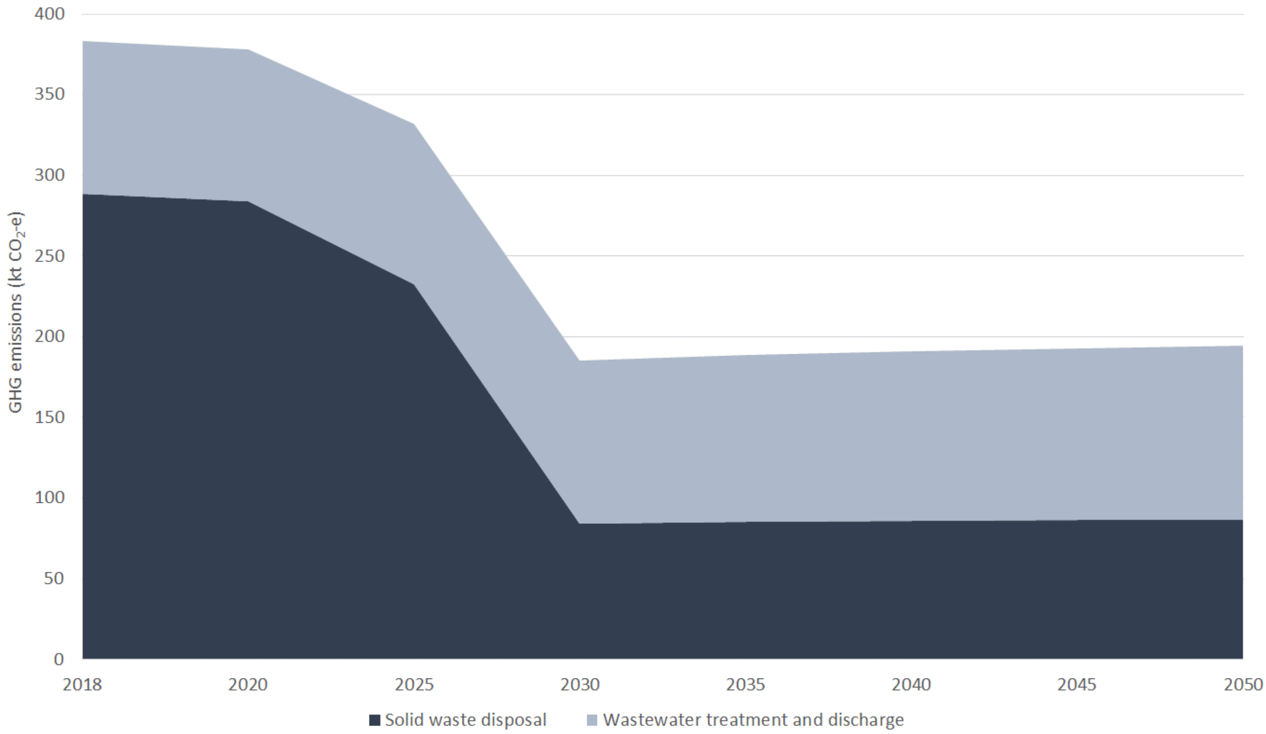


4.2.5 Waste

The key drivers of Tasmania's reference case solid waste emissions include a growing population out to 2050 which will put upward pressure on emissions. This will be dampened by the introduction of a state-wide landfill levy this year (as a result of the implementation of the draft Tasmanian Waste Action Plan), and corresponding increased rates of waste diversion from landfill.

Under the medium emissions scenario reference case, emissions are projected to be about 200 kt CO_2-e in 2050 (Figure 23), which is 45% lower than 2018. There is a steep decrease in emissions from 2018 to 2030 due to increasing diversion rates of organic waste from landfill driven primarily by the state-wide landfill level and targets outlined in the draft Tasmanian Waste Action Plan.

Figure 23. Medium emissions scenario reference case – emissions from waste (2018 to 2050)



4.3 Economic analysis of reference case emissions trajectories

4.3.1 Overview

A goal of this project was to understand how to grow Tasmania's economy without increasing emissions. It was therefore necessary to develop an understanding of the current emissions intensity of different sectors of Tasmania's economy, especially those with growth potential, so that emissions reduction opportunities could be planned in ways that supports ongoing economic growth.

To do this, a model linking high-level economic sectors to STGGI emissions sources was developed. This enabled the modelling of changes to Tasmania's economy across sectors out to 2050 under reference case conditions (Table 6), noting that many confounding factors are likely to impact these theoretical projections.

Further detail on this economic modelling approach is provided in section 2.3 of this report.

4.3.2 Sectoral economic analysis

The following points provide a summary of some of the key insights into how Tasmania's economy may change and the resulting impacts on emissions out to 2050.

- **Certain sectors will experience significant growth with a relatively low impact on Tasmania's emissions profile:** The Australian and New Zealand Standard Industrial Classification (ANZSIC) codes for GSP sectors F to S (which comprise, for example, administrative, commercial and financial businesses) have a low emissions intensity per dollar added to the economy (approximately 0.03 tonnes (t) of CO_2-e are added with every $1,000 of economic activity). In 2017/18, the gross value of the commercial and institutional sub-sector was $17.4 billion, and overall this analysis shows that these sectors may grow in value by 2.5 times (in real terms) by 2050. However, because of the low emissions intensity of these sectors, this will not have a large impact on Tasmania's emissions profile.
- Another example is the construction sub-sector which adds just 0.1 t CO_2-e with every $1,000 of economic activity, and is expected to grow by up to 3 times the 2018 sector value by 2050 (in real terms). Note that this intensity only factors in energy consumed during construction activities, rather than embodied carbon of construction materials.

- **The agriculture sector will experience large growth and will have a significant impact on emissions**: The agriculture sector has a relatively large emission intensity per dollar added to the economy (just over 1.3 t CO_2-e for every $1,000 of economic activity), driven primarily by enteric methane emissions from ruminants.
- **The mining and manufacturing sectors are not expected to grow significantly out to 2050**: Despite the relatively lower forecasted growth, mining and manufacturing have a relatively large emission intensity per dollar added to the economy (0.9 t CO_2-e for every $1,000 of economic activity).
- **The LULUCF sector currently sequesters carbon from the atmosphere while contributing to Tasmania's GSP:** this analysis has found indicatively 22 t CO_2-e are sequestered for every $1,000 of economic activity within this sector. However, it is important to recognise the relationship between economic activity in the LULUCF sector and carbon sequestration in forests and wood products is not linear nor positively correlated. For example, under some strategies to increase carbon sequestration (e.g. further reductions in timber harvesting levels in public or private native forests), carbon sequestration and emission removals may increase in the short-term, but economic activity would decline (due to a loss of wood products manufacturing and associated jobs). Furthermore, over time, the reduction in timber harvesting levels will result in a reduction in carbon sequestration rates, as there is less regeneration and regrowth of forests after planned disturbance, and less storage of carbon in wood products. In this context, the amount of carbon sequestration depends on many factors, most notably forest management practices, the incidence of bushfires, downstream processing, and the type of wood products produced.
- For certain important emissions sources including cement, aluminium and ferromanganese production, the gross value added to Tasmania's GSP is not available, as the ABS does not publish figures at the required level of disaggregation. Therefore, it was not possible to develop specific forecasts of industry value to 2050 using historic trends for these industries. In addition, although historic production volumes were available, future changes in production volumes are hard to predict and subject to many economic drivers. This means the value added and emissions associated with these activities is not possible to predict either. In addition, as Tasmania is a relatively small economy, any closure (or opening) of large plants, smelters or mines is likely to have a relatively large impact on the GSP and emissions. Therefore, the reference case modelling for these industries assumes minor growth in value to 2050, in line with historic trends.
- Although the value of Tasmania's aquaculture sub-sector is expected to increase into the future with the State's salmon output potentially doubling over the next decade, this sector did not meet the emissions materiality threshold used in this analysis, and as such, it can be expected to grow in value without having a significant impact on Tasmania's STGGI accounts.

Table 6 summarises the approach used for forecasting how Tasmania's sectoral value may change to 2050, including the expected growth in 2050 relative to 2018. The "Real GSP growth by 2050 – multiplier" column refers to the expected ratio of the value of the sector in 2050 compared with 2018. This value was derived using the assumptions outlined in the table regarding the drivers of forecast value change to 2050, which took into account both historic trends and industry specific growth plans for each sector.

Table 6. Drivers of expected sectoral value growth to 2050

ANZSIC code and GSP sector	GVA in 2018 (million)	Emissions intensity in 2018 (kg CO_2-e/$)	Discussion on the drivers of forecast value change to 2050 (medium scenario)	Real GSP growth by 2050 (compared to 2018) – multiplier
Agriculture, forestry and fishing (A)	$2,972 <u>Sub-sector value</u> Agriculture: ~$1,600[37] Fishing: ~$1,070[38] Forestry: ~$230[39]	1.3 for agriculture and fisheries combined, -22 for forestry	**Agriculture** Sectoral specific value growth based on state specific economic forecasts (AgriVision 2050) using projections to 2050 developed by the Centre for International Economics (CIE) 2015[40] as a basis. These projections show that on the demand side, stronger global economic growth will translate to higher per person incomes in most of Australia's	2.5

[37] Based on gross value for agriculture reported in 2017/18 AgriFood scorecard: https://dpipwe.tas.gov.au/Documents/Agri-Food%20SCORECARD%202017-18.PDF

[38] Based on gross value for seafood reported in 2017/18 AgriFood scorecard: https://dpipwe.tas.gov.au/Documents/Agri-Food%20SCORECARD%202017-18.PDF

[39] Based on the difference between total GVA for the whole sector and the values provided for agriculture and fishing in the 2017/18 AgriFood scorecard

[40] https://www.climatechangeauthority.gov.au/sites/default/files/2020-06/Target-Progress-Review/Australian%20agricltuure%20emission%20projections%20to%202050/Australian%20Agricultural%20Emissions%20Projections%20to%202050.pdf

ANZSIC code and GSP sector	GVA in 2018 (million)	Emissions intensity in 2018 (kg CO_2-e/$)	Discussion on the drivers of forecast value change to 2050 (medium scenario)	Real GSP growth by 2050 (compared to 2018) – multiplier
			export markets, driving stronger demand for agricultural products. **Forestry** Following substantial industry restructuring between 2009 and 2012, Tasmania's forestry sector has seen a stabilisation of log supply from native forests, a steady profile of softwood logs from pre-1990 plantations and a substantial increase in plantation hardwood logs from post-1990 plantations. A large proportion of the plantation hardwood logs are exported, which represents a key driver of sectoral value growth. However, there is also an increasing focus on domestic processing and value adding, as reflected in the development of new processing plants, including the establishment of the Cross Laminated Timber Panel (CLTP) production facility proposed for the state's north west near Wynyard[41]; which has received significant State Government support to facilitate this type of investment. In 2017, the Ministerial Advisory Council on Forestry published *A Strategic Growth Plan for Tasmanian Forests, Fine Timber and Wood Fibre Industry*, with the growth objective of doubling the industry value-add to $1.2 billion in real terms by 2036[42]. With this strategic direction, there is a clear driver for further increases in downstream processing, to increase value adding for forestry products. However, it should be noted the State Government has provided significant funding support with this aim over the past couple of decades, and it is apparent there are market factors that can limit value growth, including demand in international markets for exports and the competitiveness of wood product imports. **Fishing** Tasmania's aquaculture industry is set for further growth, with several major new projects under consideration which could potentially double the state's salmon output over the next decade. This trend has been forecast to continue at a moderately reduced rate post 2030.	
Mining (B)	$1,080	0.18	Extrapolation of historic sectoral sector GVA trends, using Tasmania specific GSP data from 1990 to 2019[43], to derive mean annual growth rate.	1.5
Manufacturing (C)	$1,929	1.29	Limited growth in this sector is forecast, with an assumed CAGR of 0.21% per year. The key drivers of change in this sector would be an opening or closure of a large facility. However, based on feedback from Reference Group members, it is very difficult to predict if and when this would happen. Therefore, we have assumed that no major manufacturing plants will close or, if they do, it is assumed they are replaced with new plants with similar growth and emissions profiles.	1.1

[41] https://www.cltptasmania.com/why-cltp

[42] https://www.stategrowth.tas.gov.au/__data/assets/pdf_file/0004/148855/Strategic_Growth_Plan.PDF

[43] Note 2020 GVA excluded from analysis because of COVID impacts

ANZSIC code and GSP sector	GVA in 2018 (million)	Emissions intensity in 2018 (kg CO_2-e/$)	Discussion on the drivers of forecast value change to 2050 (medium scenario)	Real GSP growth by 2050 (compared to 2018) – multiplier
			One exception is the assumed increase in the volume of harvested wood products, transformed through the manufacturing process out to 2050 (20% greater than 2018 levels). As long-term commodity prices were not available, prices were assumed to remain constant. Therefore, the analysis forecast a minimal increase in manufacturing from 2018 value levels.	
Electricity, gas, water and waste services (D)	$990	0.8	Used the forecasted growth in electricity demand to 2050 (AEMO's 2020 ISP) as a proxy for growth in this GSP sector.	1.4
Construct-ion (E)	$1,963	0.1	Extrapolation of historical sector GVA trends, using Tasmania specific GSP data from 1990 to 2019, to derive mean annual growth rate.	3.0
Wholesale trade (F)	$927	0.03	Extrapolation of historic sectoral sector GVA trends, using Tasmania specific GSP data from 1990 to 2019, to derive mean annual growth rate.	1.8
Retail trade (G)	$1,443			2.9
Accomm-odation and food services (H)	$777			1.7
Transport, postal and warehous-ing (I)	$1,278			1.8
Information media and telecomms (J)	$969		Uses the 4% average annual growth rate provided by ACS Australia's Digital Pulse for Tasmania's ICT employment forecasts to 2025, as a proxy to forecast sectoral growth. This is lower than 5.5% annual historic growth rate, but deemed more appropriate in long-term.	3.5
Financial and insurance services (K)	$1,755		Extrapolation of historic sectoral sector GVA trends, using Tasmania specific GSP data from 1990 to 2019, to derive mean annual growth rate.	2.0
Rental, hiring and real estate services (L)	$528			3.2
Profession-al, scientific and technical services (M)	$909			2.6
Administ-rative and support services (N)	$539			2.0
Public administ-ration and safety (O)	$1,918			2.4
Education and training (P)	$1,842			1.5
Health care and social assistance (Q)	$3,678		Historically this sector has grown by 3.8% per year, and this growth is expected to continue. Therefore, forecasts were based on the extrapolation of historic sectoral sector GVA trends, using Tasmania specific	3.5

ANZSIC code and GSP sector	GVA in 2018 (million)	Emissions intensity in 2018 (kg CO_2-e/$)	Discussion on the drivers of forecast value change to 2050 (medium scenario)	Real GSP growth by 2050 (compared to 2018) – multiplier
			GSP data from 1990 to 2019, to derive mean annual growth rate.	
Arts and recreation services (R)	$321		Extrapolation of historic sectoral sector GVA trends, using Tasmania specific GSP data from 1990 to 2019, to derive mean annual growth rate.	1.7
Other services (S)	$500			1.3

5 OPPORTUNITIES TO REDUCE EMISSIONS

Key points

- Tasmania can achieve significant emissions reductions out to 2050 through opportunities that are expected to be moderately to highly achievable, including:
  - reducing emissions related to energy used in manufacturing through demand management and energy efficiency measures, and through fuel switching, making greater use of bio-energy and the use of renewable hydrogen;
  - driving a higher uptake of electric vehicles in the passenger fleet through the strategic development of a network of public charging stations;
  - lowering methane emissions from livestock through feeding seaweed supplements such as that currently being trialled by SeaForest and Fonterra in Tasmania, which will depend on successful commercialisation of the technology;
  - increasing the plantation estate and expansion of agroforestry plantings over the next 10 years; and
  - increasing the proportion of forestry logs directed to long-term wood products.
- A number of opportunities with significant emissions reduction potential are somewhat more complex and uncertain, including:
  - soil carbon sequestration via regenerative agriculture practices, which would require transaction costs for participating in the Climate Solution Fund to be reduced in the Tasmanian context before it would be achievable for the state.
  - low-emissions ferromanganese production and aluminium smelting, which would have the added benefit of improving the international competitiveness of Tasmanian manufacturers.
- Importantly, our modelling indicates that Tasmania can maintain net zero emissions in the long term if low emissions development is maintained across a broad range of industry sectors. In the case of the forestry sector, timber harvesting levels would remain at close to current levels across the public native forest estates, with some scope to increase harvest levels in private native forests (recognising that harvesting levels in public forests will be maintained in line with the long-term sustainable yield).

5.1 Abatement potential in 2050

A total of 26 emissions reduction opportunities were identified and investigated in detail across all sectors of the STGGI reports. These opportunities vary in their level of technological development, cost to implement, and likely acceptability to the Tasmanian Government and public.

It is important to note these opportunities are presented as *technical* emissions reduction opportunities over which the Tasmanian Government has some degree of control or influence (such as improvements in industrial energy efficiency or feeding methane inhibitors such as *Asparagopsis taxiformis* to ruminant animals). These opportunities will require some degree of policy development to drive earlier adoption[44], and possible mechanisms are suggested throughout the analysis to help the Tasmanian Government in progressing the next phase of policy development following the delivery of this project. Examples of these policy mechanisms include:

- regulation (e.g. minimum efficiency standards);
- incentives (e.g. providing grant funding for energy upgrades);

[44] It should be noted that several of the identified opportunities are expected to eventually occur in the absence of government intervention, driven by market forces. In the context of the modelling in this report, these opportunities exist because government has an ability to bring these emissions reductions forward so they occur sooner than they would under a 'no intervention' scenario.

- investment (e.g. providing preferential finance or underwriting for clean energy projects); and
- information (e.g. education and capacity building programs).

Figure 24 provides a summary of the abatement potential of each opportunity in 2050, and their estimated achievability (based on technical viability, economic impact and policy alignment) in the Tasmanian context, rated from high (left-hand side of figure) to low (right-hand side).

Opportunities that are considered moderately or highly 'achievable' for Tasmania over the next 10 years, while also delivering relatively large emissions reductions include:

- **Feeding methane inhibitors to produce low methane livestock**: Although feeding these supplements may represent a net cost (see Appendix 2.5 for further for cost estimates), this will be relatively low as a proportion of the total value of agriculture in 2050 (approximately $4.4 billion in real terms in 2050). In addition, there is the potential that feeding these supplements may result in productivity benefits in terms of increased liveweight gain per tonne dry matter intake, and reduced feeding requirements which may offset this cost (although this is not yet proven at a commercial scale). Therefore, with current policy settings focused on growing the value of Tasmania's agricultural production, it is anticipated that the political appetite to partially or fully fund the roll-out of a program to support this opportunity could be relatively high.
- **Driving higher uptake of electric vehicles within Tasmania's passenger vehicle fleet, decarbonising the heavy transport fleet via EVs, hydrogen and/or drop-in hydrocarbon fuels**[45] **and introducing light vehicle CO_2 emissions standards** (noting that this would require a change in the Australian Government position on these standards).
- **Reducing energy-related emissions from manufacturing through demand management and energy efficiency, and through fuel switching with both electricity and bioenergy** (noting that Bioenergy Australia released a report[46] in 2018 which shows that Australia is lagging behind the developed world in bioenergy development, and Tasmania is lagging behind the nation, despite having significant bioenergy feedstocks available for use[47]).

In addition, there are opportunities that are considered moderately achievable but would result in less abatement, such as:

- **Increasing the proportion of forestry logs directed to long term wood products**, and increased domestic processing of forestry logs, which the State Government has supported over many years through policy settings and funding allocations to facilitate investment in the State. However, the contribution of carbon storage in long term wood products to the total LULUCF emissions scenario reference case is relatively modest overall compared to net removals in *forest land remaining forest land*, and emissions from *land converted to grassland*.
- **Increasing the size of the plantation estate (including agroforestry plantings)**, which has also received considerable State government support over time and is directly aligned with the Australian Government's 2018 policy to grow Australia's renewable timber and wood-fibre industry[48]. However, beyond the development and promotion of these policy settings and some specific funding allocations, the State government has limited influence over land use decisions by landowners, who are typically influenced mainly by market dynamics relating to land prices underpinned by agricultural and forestry commodity prices.
- **Fuel switching across the stationary energy sector** using renewable hydrogen, biogas and/or synthetic gas in place of natural gas and LPG.

The third grouping of opportunities incorporates those that may result in the largest abatement but are relatively complex and uncertain, which means they have a low to medium 'achievability' rating. These opportunities, which are not included in the 'best-fit' emissions reduction pathway include:

- **Reducing the conversion of forest land to other land uses:** The *land converted to grassland* sub-category accounts for the largest source of GHG emissions in the LULUCF sector, and while annual emissions from this sub-category have reduced markedly and steadily the early 1990s, in 2019 they still accounted for around 12% of net emissions from the sector. Primary conversion of native forest (for agriculture or other purposes) was the

[45] Renewable hydrocarbon biofuels (also called green or drop-in biofuels) are fuels produced from biomass sources through a variety of biological, thermal, and chemical processes. These products are chemically identical to petroleum gasoline, diesel, or jet fuel.

[46] https://s3-ap-southeast-2.amazonaws.com/piano.revolutionise.com.au/news/vabsvwo5pa8jnsgs.pdf

[47] https://www.pft.tas.gov.au/__data/assets/pdf_file/0006/134664/Rothe_Moroni_-_2015_Biomass_Bioenergy_-_Current_and_potential_use_of_forest_biomass_for_engy_in_Tasmania.pdf

[48] Australian Government 2018. *Growing a better Australia: A billion trees for jobs and growth*. An Australian Government Plan.

primary source of these emissions in the early 1990s, but is now negligible. Since the 2000s, the main source is re-clearing of secondary regrowth or the conversion of plantations to other land uses. Reducing the extent of this re-clearing of secondary regrowth and conversion of plantations to other land uses would most likely require the Tasmanian or Australian Governments to provide or facilitate grants and incentives to encourage the retention of existing forest land. However, there may be perceived constraints on agricultural enterprise and expansion, representing an opportunity cost to farmers. Although under all reference case scenarios out to 2050 there was excess carrying capacity available for pasture-based livestock systems, it is important to note that this is theoretical and even if there is sufficient land to support livestock, individual landowners may still decide to clear regrowth vegetation where they can or convert plantation forest to other land use. Beyond the development and promotion of policy settings that encourage the retention of carbon stocks in the land sector, the State government has limited influence over land use decisions by landowners, who are typically influenced mainly by market dynamics relating to land prices underpinned by agricultural and forestry commodity prices.

- **Use cement substitutes / low-emissions cement variants:** Although this opportunity would be compatible with net zero by 2050 targets set by a number of global cement producers, including the parent companies of Australian cement producers, consideration will need to be given t to a range of community and supply chain impacts if clinker production was reduced in Tasmania. For example, state-wide freight volumes could be impacted which may impact freighting costs for other manufacturers in the state. This comment applies for all large manufacturers across Tasmania.
- **Soil carbon sequestration via regenerative agriculture practices**: This would require transaction costs for participating in the Climate Solution Fund to be reduced in the Tasmanian context before it would be achievable for the state.
- **Low-emissions ferromanganese production and aluminium smelting**: These opportunities are very technologically uncertain, but would have the added benefit of improving the international competitiveness of Tasmanian manufacturers.

Figure 25 illustrates the anticipated implementation timeframes for the various opportunities, with the size of the bubbles indicating their abatement potential in 2050.

Figure 24. Quantum and achievability of Tasmania's GHG abatement opportunities

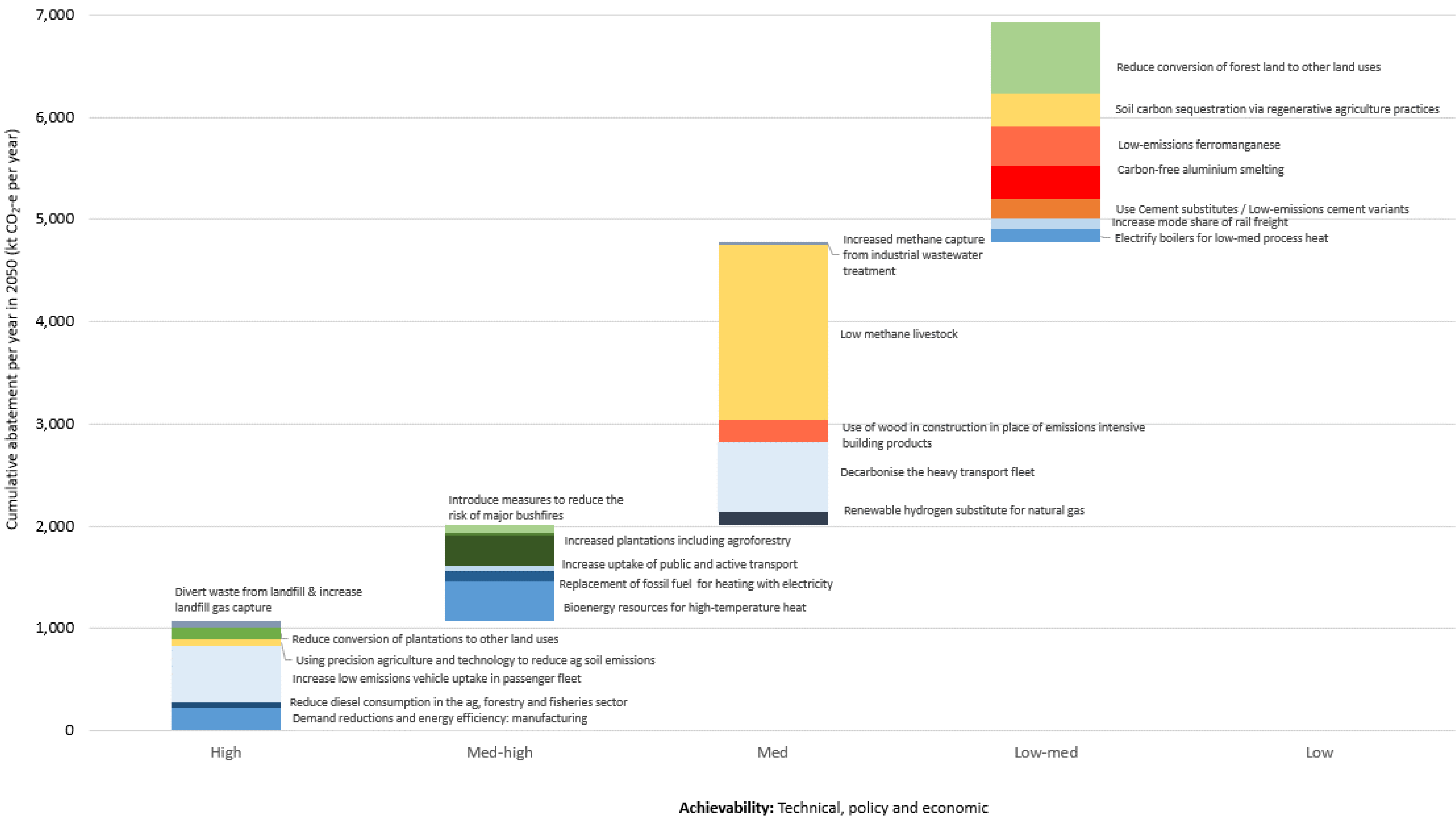
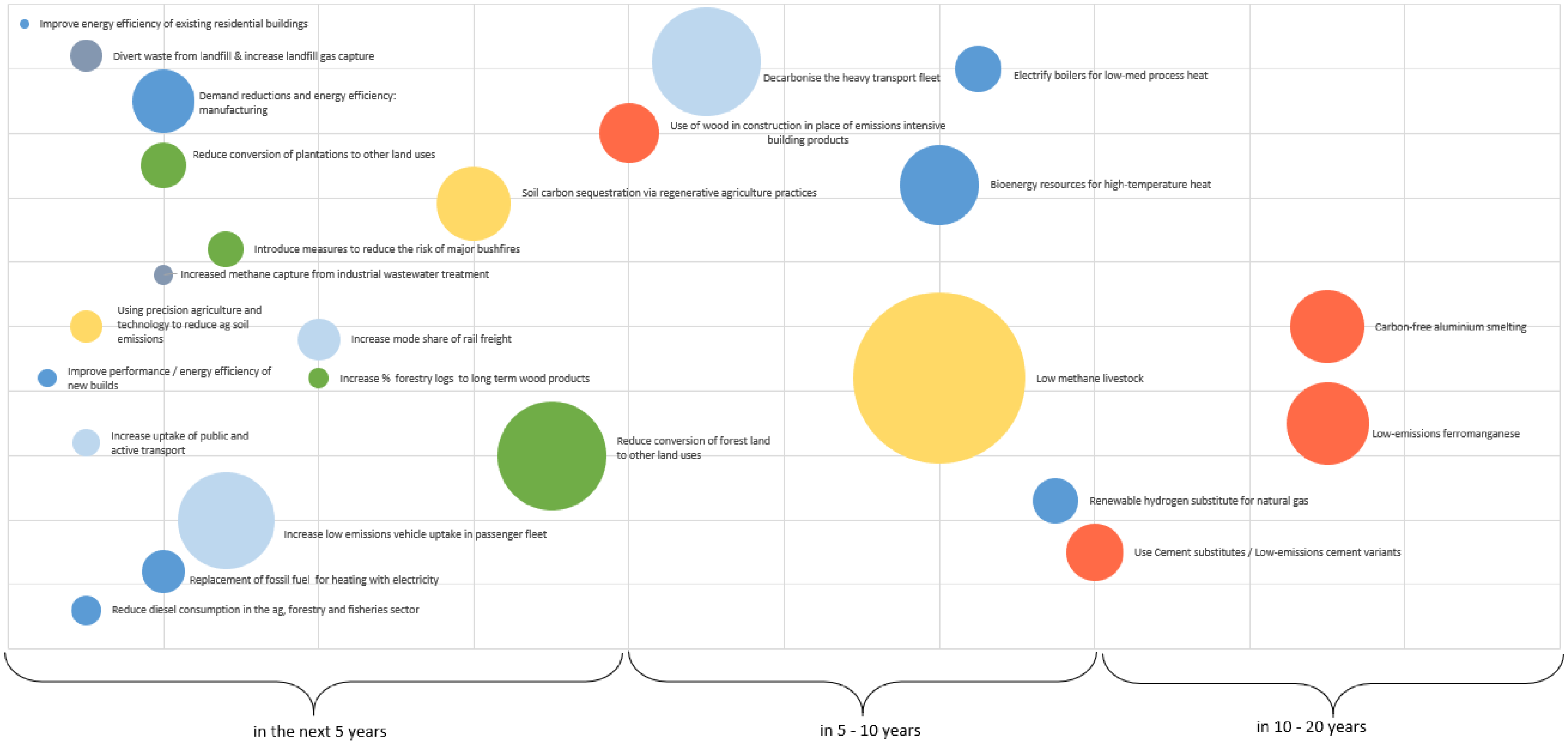


Figure 25. Quantum of abatement from all opportunities and their likely implementation timeframes (for illustrative purposes)



5.2 Sectoral emissions reduction opportunities

This section provides a detailed analysis of the opportunities presented in Figure 24, including the key assumptions and drivers, the quantum of abatement, and the level of achievability.

5.2.1 LULUCF

Table 7. LULUCF opportunities summary

Opportunity description	Key assumptions and drivers	Annual emissions reductions in 2050 (kt CO_2-e/yr)	Overall achievability rating
Option 1: Reduce conversion of forest land to other land uses	**Adoption rate considerations** 1. This opportunity would likely require stronger incentives to reduce the extent of re-clearing of forest vegetation (excluding plantations) – with the assumption of reducing existing grassland conversion rates by around -7.5% per year, compared to the recent trend of around -5% per year. It is important to note that primary conversion of native forest has reduced to negligible levels since the early 1990s, and the scope remaining is limited to re-clearing of secondary regrowth on agricultural land, which has also reduced markedly over the past 15 years. 2. This option does not generally result in any additional timber production, as farmers typically clear forest land for access to land and agricultural productivity gains, rather than timber extraction. 3. This option also incorporates an active forest restoration program for any areas of forest land burned by bushfire. This results in an assumed 3% reduction in the major fire impacts on forests (through reduced conversion of forest land to grassland). **Year of implementation**: Assumed to be rolled out from 2021 onwards.	Approx. 685	Low-Medium *Economic achievability: Low* *Technical achievability: Med* *Policy achievability: Low*
Option 2: Reduce conversion of plantations to other land uses	**Adoption rate considerations** Industry reports and Project Reference Group insights have observed an ongoing decline in post-1990 plantation areas of approx. 1,000 ha per year; relative to a total plantation estate of around 310,000 ha in Tasmania, including around 233,000 ha of post-1990 hardwood plantations. Conversion of existing plantations to other land uses will generally lead to increased emissions, as plantation-based carbon stocks are converted to (generally lower) carbon stocks on other land uses. Policy drivers and other incentives may be required to address market factors that would otherwise encourage private landholders to convert plantations post-harvest.	Approx. 123	High *Economic achievability: Med* *Technical achievability: High* *Policy achievability: High*

Opportunity description	Key assumptions and drivers	Annual emissions reductions in 2050 (kt CO_2-e/yr)	Overall achievability rating
	This option assumes that plantation owners will replant all existing plantations after harvesting (compared with the reference case which assumed a -0.5% decrease per year in the total plantation area from 2021 until 2030). This would effectively reduce the conversion of plantations by around 10,000 ha across the state (around 3% of total plantation estate). For this option to be realised, landholders would need to be sufficiently encouraged to replant, based on a range of expectations, including obtaining the same or higher yields (potentially through improved seed stock and genetic improvements), improved market access (including roading/port access to those markets), and ongoing demand that will underpin acceptable prices. The State Government has provided policy enablers and significant funding support over time, and the Australian Government has also provided support, including through the ERF for eligible plantation projects (conversion of short rotation to long rotation plantations). Further encouragement for private landholders may need to come from the private sector including demand for wood products and processing investments. **Year of implementation**: Assumed to be rolled out from 2021 onwards.		
Option 3: Increase plantations including agroforestry	**Adoption rate considerations** This opportunity is based on plans to establish agroforestry models on up to 10% of agricultural land, such that it does not impact on farm productivity, which is estimated to be around 30,000 ha in total - resulting in a 10-15% uplift in the total area of new plantations in Tasmania. It is envisaged these plantings would comprise both softwood and hardwood plantations, established to produce saw logs as well as pulp logs and wood fibre. This option would require increased promotion and incentives for agroforestry development, recognising that agroforestry would have lower removal rates than industrial plantations (therefore lower emission reduction impacts in the short-to-medium term). Timber plantations are typically established with around 1,000-1,400 trees per ha, while agroforestry systems would typically have 300-600 trees per ha. This option aligns with Australia's National Forest Industries Plan (2018), which calls for a substantial increase in new plantation development across Australia (an additional 400,000+ ha by 2030), and for increased focus on farm forestry / agroforestry and community engagement. This plan aligns Commonwealth and State government interests directed to facilitating investment in new plantation development, to address the lack of new plantation establishment over the past 10 years and support the expansion of the national plantation estate for benefits including carbon sequestration.	Approx. 300	Medium-High *Economic achievability: Med* *Technical achievability: High* *Policy achievability: Med*

Opportunity description	Key assumptions and drivers	Annual emissions reductions in 2050 (kt CO_2-e/yr)	Overall achievability rating
	If a bioenergy market were established in Tasmania, to reduce fossil fuel emissions, this could lead to improved management of shelterbelts by providing a market for pre-commercial thinning and harvest slash not financially viable on farms currently. **Year of implementation and adoption rates**: Assume this opportunity is rolled out from 2021 to increase the total area of post-1990 plantations by 10% by 2050. This amount equates to a CAGR of approx. 0.4%[49].		
Option 4: Increase proportion of forestry logs directed to long term wood products, and increased domestic processing	**Adoption rate considerations** This opportunity is directly aligned with the Strategic Growth Plan for the Tasmanian Forests, Fine Timber and Wood Fibre Industry (2017). On this basis, and the broader benefits of increased value adding within Tasmania, the feasibility of this opportunity is high (provided industry investment follows to increase processing capacity). The potential impact is low-medium, recognising the uplift would start from a low base currently. In addition, the Project Reference Group has highlighted the need to consider substitution impacts, e.g. engineered wood products (such as cross laminated timber, CLT) substituting for emissions-intensive products like concrete. Substitution for construction materials is addressed directly in the 'Industrial processes' sector. Stronger encouragement for investment in domestic processing of wood products (e.g. the CTLP facility near Burnie) may result in an increase of forestry logs directed to long term wood products of between 25% to 50% over the next 20 years. This increase in logs directed to long term wood products will increase the carbon stored in Harvested Wood Products, which acts as a sink for CO_2 emissions. **Year of implementation and adoption rates**: Assumed this option is rolled out from 2021 onwards; and there is a 2% increase in allocation to long term wood products by 2030, and 3% by 2050	Approx. 25	Med-High *Economic achievability: Low* *Technical achievability: Med* *Policy achievability: High*
Option 5: Introduce measures to reduce the risk of major bushfires	**Adoption rate considerations** This opportunity relates to and reflects concerns about the increasing risk of bushfire impacts, due to climate change trends and other factors. The feasibility of increasing protection measures, e.g., increased prescribed burning and firebreak maintenance programs, is considered medium-high.	Approx. 70	Medium-High *Economic achievability: Med* *Technical achievability: High*

[49] Based on an increase of around 30,000 ha in the total area of post 1990 plantations in Tasmania, currently being around 233,000 ha in 2019/20; and calculated as: (e.g. ((263,000 ha/233,000 ha)^(1/30 years))-1).

Opportunity description	Key assumptions and drivers	Annual emissions reductions in 2050 (kt CO_2-e/yr)	Overall achievability rating
	On this basis, this option proposes an increased level of prescribed burning of up to 20,000 ha per year compared with the reference case. The potential impact could be high but is moderated by national carbon accounting rules and protocols which have existing limits and caps on the impact of bushfire on GHG inventory accounts. This option is based on recognition that climate change is contributing to the potential for increasing risk of bushfires over the next 30 years to 2050; and a 'mega-fire' (stand replacing fires at the landscape level) could significantly disrupt or destroy large parts of Tasmania's net sink in native forests. **Year of implementation and adoption rates**: These measures are assumed to reduce bushfire impacts by 2% of attributable emissions annually from 2025; reduce the total extent of major bushfires in 2025, 2035 and 2045, from 500% to 150% of average annual impacts; and reduce the proportion of major fire impacts resulting in conversion to grassland from 5% to 2%.		*Policy achievability: Med*

5.2.2 Transport energy

Table 8. Transport energy opportunities summary

Opportunity description	Key assumptions and drivers	Emissions reductions in 2050 (kt CO_2-e/yr)	Overall achievability rating
Option 1: Drive low emissions passenger vehicle uptake (via EVs, biofuels) and reduce internal combustion engine (ICE) vehicle emissions	• Adoption rate: Assume that this action results in 5% uptake of EVs by 2030, up to 90% by 2050 (compared with 30% for reference case). • Year of implementation: Assumed to be rolled out from 2025. • Efficiency improvements: For ICEs, 40% improvement on vehicle fuel economy (compared with reference case). For EVs, biofuels, 100% improvement on baseline.	Approx. 550	High *Economic achievability: Med* *Technical achievability: High* *Policy achievability: High*
Option 2: Decarbonise the heavy transport fleet via hybrid electric vehicles (HEVs), hydrogen fuel cell	• Adoption rate: Assume that this action results in 15% uptake of EVs, HFCVs and drop-in hydrocarbons by 2030, up to 80% by 2050 (compared with 27% for reference case). • Year of implementation: Assumed to be rolled out from 2025. • Efficiency improvements: For ICEs, 40% improvement on vehicle fuel economy (compared with reference case). For EVs, biofuels, 100% improvement on baseline.	Approx. 690	Medium *Economic achievability: Med* *Technical achievability: Med*

Opportunity description	Key assumptions and drivers	Emissions reductions in 2050 (kt CO_2-e/yr)	Overall achievability rating
vehicles (HFCVs) and drop-in hydrocarbon fuels			*Policy achievability: Med*
Option 3: Increase mode share of rail freight	• Adoption rate: Rail freight mode share increases from 22% in 2018 to 35% in 2050 (tonne km basis). • Year of implementation: Assumed to be rolled out from 2025. • Efficiency improvements: A switch from road freight to rail freight results in an 85% reduction in the emissions intensity per tonne km (based on the 2018 STGGI emissions, and the 2016/17 Tasmanian Freight Survey, most recent available)	Approx. 100	Medium-low *Economic achievability: Low* *Technical achievability: High* *Policy achievability: Low*
Option 4: Increase uptake of public and active transport	• Adoption rate: Growth in public transport and active transport use from around 3% in 2018 to 10% by 2050, Tasmania wide. This represents a mode shift from private transport. • Year of implementation: Assumed to be rolled out from 2025. • Efficiency improvements: Assumed to be 100% reduction on baseline emissions.	Approx. 50	Medium-high *Economic achievability: Low* *Technical achievability: High* *Policy achievability: High*

5.2.3 Stationary energy

Table 9. Stationary energy opportunities

Opportunity description	Key assumptions and drivers	Emissions reductions in 2050 (kt CO_2-e/yr)	Overall achievability rating
Option 1: Reduce energy demand of manufacturing processes through demand management and energy efficiency measures	• Adoption rate: 80% by 2050 across all manufacturing industries and construction. • Year of implementation: Assumed to be rolled out from 2025. • Efficiency improvements: Assumption that energy reductions of 25% are achieved at sites that implement these demand reduction measures. This is in line with work carried out by the NZ Productivity Commission for the Low Emissions Economy analysis.	Approx. 230	High *Economic achievability: High* *Technical achievability: High* *Policy achievability: Med*
Option 2: Fuel switching: Electrification of boilers	• Adoption rate: The adoption rate for fuel switching for low/med-temp process heat manufacturers increases to 60% by 2050, from 0% in 2030. • Year of implementation: Assumed to be rolled out from 2030. • Efficiency improvements: Assumed to be 100% reduction on baseline emissions.	Approx. 125	Medium-low *Economic achievability: Low* *Technical achievability: Med* *Policy achievability: Med*

Opportunity description	Key assumptions and drivers	Emissions reductions in 2050 (kt CO_2-e/yr)	Overall achievability rating
for low-med process heat[50]			
Option 3: Fuel switching and co-firing: Use of biomass resources for high-temp process heat	• Adoption rate: The adoption rate for fuel switching for med-high-temp process heat manufacturers increases to 60% by 2050, from 0% in 2030. Requires approximately 900,000 tonnes biomass (forest residues – waste material) by 2050. Manufacturing sectors targeted include the cement, iron ore pellet production, and the aluminium smelting sectors. • Year of implementation: Assumed to be rolled out from 2030. • Efficiency improvements: Assumed to be 100% reduction on baseline emissions.	Approx. 370	Medium-High *Economic achievability: Low* *Technical achievability: High* *Policy achievability: High*
Option 4: Improve energy efficiency of existing residential building stock	• Adoption rate: Assume that this is rolled out to approximately 24% of households (low-income households <$999 per week) built before 2020, by 2050 (approx. 35,000 households). • Year of implementation: Assumed to be rolled out from 2025. • Efficiency improvements: 60% improvement on baseline. This is based on improving from a 2-star NatHERS rating (assumed that Tasmanian households are currently at this level) to 5 stars.	Approx. 5	Medium *Economic achievability: Low* *Technical achievability: High* *Policy achievability: Med*
Option 5: Improve energy performance of new buildings, both residential and commercial	• Percentage of residential and commercial buildings that are new (built after 2020) in 2050 (50%)[51] • Adoption rate: Rolled out across all new households and commercial buildings. • Year of implementation: Assumed to be rolled out from 2025. • Efficiency improvements: 17% improvement on baseline for residential, and 33% savings for commercial.	Approx. 20	Medium-high *Economic achievability: Med* *Technical achievability: High* *Policy achievability: Med*
Option 6: Replace natural gas, LPG and inefficient wood heaters with electric heaters and modern pellet fires	• Adoption rate: Assume that this is rolled out to approximately 80% of households and businesses by 2050. • Year of implementation: Assumed to be rolled out from 2025. • Efficiency improvements: 100% improvement on baseline.	Approx. 100	Medium-High *Economic achievability: Med* *Technical achievability: High* *Policy achievability: Med*
Option 7: Use precision agriculture to reduce stationary diesel consumption in the ag,	• Adoption rate: Assume that this is rolled out to approximately 90% of farms by 2050. This would cover an area of around 1 million ha, and the number of farms involved could be up to 1800[53]. Improvements would roll out on a continuous basis and would most likely be adopted by the larger, already more efficient farms first. • Year of implementation: Assumed to be rolled out from 2025.	Approx. 55	High *Economic achievability: High* *Technical achievability: High* *Policy achievability: Med*

[50] In addition to electrification of low/medium-temperature process heat manufacturing, there may be an opportunity to use biomass for some of these processes. The viability of biomass for lower heat is already demonstrated through uses such as pellet fires for home heating. In terms of emissions impact, there is no difference between use of electricity or biomass.

[51] https://www.asbec.asn.au/wordpress/wp-content/uploads/2018/10/180703-ASBEC-CWA-Built-to-Perform-Zero-Carbon-Ready-Building-Code-web.pdf

[53] based on 2018 farm numbers: http://www.agriculture.gov.au/abares/research-topics/aboutmyregion/tas#agricultural-sector

Opportunity description	Key assumptions and drivers	Emissions reductions in 2050 (kt CO_2-e/yr)	Overall achievability rating
forestry and fisheries sector[52]	• Efficiency improvements: Overall productivity is assumed to increase by 10% across all farm types (based on results for dairy and vegetable farms[54]). Key drivers of diesel reduction are the roll-out of precision agriculture technologies, and the use of electric pumps rather than diesel for irrigation, combined with increased pump efficiency.		
Option 8: Fuel switching across the stationary energy sector using renewable hydrogen, biogas and/or synthetic gas in place of natural gas and LPG	• Adoption rate: Assume that this is rolled out to offset 80% of all residual natural gas /LPG across all stationary energy sectors in Tasmania by 2050 (following the implementation of opportunities 1,2 and 3). This option has links with the Tasmanian Renewable Hydrogen Action Plan and the Renewable Energy Action Plan. • Year of implementation: Assumed to be rolled out from 2030. • Efficiency improvements: 100% improvement on baseline.	Approx. 145	Medium *Economic achievability: Low* *Technical achievability: Med* *Policy achievability: High*

5.2.4 Agriculture

Table 10. Agricultural opportunities summary

Opportunity description	Key assumptions and drivers	Emissions reductions in 2050 (kt CO_2-e/yr)	Overall achievability rating
Option 1: Low methane livestock via feed supplements that inhibit enteric methane fermentation	• Adoption rate: Assume that this action rolls out to 20% of ruminants from 2030, increasing to 90% by 2050. This is considered conservative because of the 2030 carbon neutrality targets for the beef industry made by Meat & Livestock Australia, and because of the promising outcomes of commercial trials for *Asparagopsis taxiformis*[55]. • Year of implementation: Assumed to be rolled out from 2030. • Efficiency improvements: 80% reduction in enteric methane emissions.	Approx. 1700	Medium *Economic achievability: Med* *Technical achievability: Med* *Policy achievability: Med*

[52] This is the same option in terms of technology change as for Option 2 under the Agricultural opportunities in Table 10, as the roll-out of precision agriculture impacts both energy consumption and agricultural soil emissions. This highlights the overlaps and co-benefits linked across sectors.

[54] https://crdc.com.au/sites/default/files/P2D%20Ecomomic%20impact%20of%20digital%20ag%20-%20AFI%20Final%20Report.pdf

[55] https://www.csiro.au/en/research/animals/livestock/futurefeed

Opportunity description	Key assumptions and drivers	Emissions reductions in 2050 (kt CO_2-e/yr)	Overall achievability rating
Option 2: Use precision agriculture to reduce agricultural soil emissions	• Adoption rate: Assume that this is rolled out to approximately 90% of farms by 2050. This would cover an area of around 1 million ha, and the number of farms involved could be up to 1800[56]. Improvements would roll out on a continuous basis and would most likely be adopted by the larger, already more efficient farms first. • Year of implementation: Assumed to be rolled out from 2025. • Efficiency improvements: Promote improved pasture and feed management for livestock, improved yields for crops, and reductions in fertiliser use (14%) as a result of these efficiencies, reducing soil N_2O emissions.	Approx. 70	High *Economic achievability: High* *Technical achievability: High* *Policy achievability: Med*
Option 3: Soil carbon sequestration via regenerative agriculture practices	• Adoption rate: Assume that this action rolls out to 5% of agricultural soils (beef, dairy, sheep land - ha) by 2050. Note that this is considered appropriate, as although this opportunity is one of the top five priorities in the Australian Government's First Low Emissions Technology Statement 2020, it is still not cost effective for a majority of landowners. The King Review recommended establishing a scheme to subsidise the costs of directly measuring the abatement associated with certain types of project activities, particularly the sequestration of carbon in agricultural soils. • Year of implementation: Assumed to be rolled out from 2025. • Efficiency improvements: Total tonnes CO_2-e sequestered is 5.9 tonnes/ha. This is an average of two reports, ranging from 1.8 to 10 tonnes CO_2-e sequestered/ha[57].	Approx. 320	Low-med *Economic achievability: Low* *Technical achievability: Low* *Policy achievability: High*

5.2.5 Industrial processes

Table 11. Industrial process opportunities summary

Opportunity description	Key assumptions and drivers	Emissions reductions in 2050 (kt CO_2-e/yr)	Overall achievability rating
Option 1: Use cement substitutes / low-	• Adoption rate: It is assumed that this opportunity is rolled out to 10% of sector in 2035, and 30% of sector by 2050[58]. • Year of implementation: Assumed to be rolled out from 2030.	Approx. 190	Low-med *Economic achievability: Med*

[56] based on 2018 farm numbers: http://www.agriculture.gov.au/abares/research-topics/aboutmyregion/tas#agricultural-sector

[57] https://iopscience.iop.org/article/10.1088/1755-1315/25/1/012004/pdf, https://www.agriinvestor.com/tasmanian-soil-carbon-project-aims-to-build-data-for-investor-confidence/

[58] As per the UK cement industry's 2050 emissions reduction strategy (https://cement.mineralproducts.org/documents/MPA_Cement_2050_Strategy.pdf)

Opportunity description	Key assumptions and drivers	Emissions reductions in 2050 (kt CO_2-e/yr)	Overall achievability rating
emissions cement variants	• Efficiency improvements: 25% improvement on baseline.		*Technical achievability: Med* *Policy achievability: Low*
Option 2: Use of wood in construction in place of emissions intensive building products	• Adoption rate: It is assumed that this opportunity is rolled out to 15% of sector by 2030, and 30% of sector by 2050. This option helps to reduce emissions by both designing large structures to use concrete more efficiently and replacing cement with timber. This option would require approximately 470,000 m^3 of sawn timber / engineered wood products by the construction industry by 2050. • Year of implementation: Assumed to be rolled out from 2025. • Efficiency improvements: 100% improvement on baseline. This will have significant emissions benefits due to a reduction in embodied carbon in the long-term wood product versus cement, and less lifecycle emissions as a result of reduced insulation and maintenance needs. This trend continues to 2050.	Approx. 210	Medium *Economic achievability: Low* *Technical achievability: High* *Policy achievability: Med*
Option 3: Carbon-free aluminium smelting	• Adoption rate: It is assumed that this opportunity is rolled out to 100% of sector from 2030. • Year of implementation: Assumed to be rolled out from 2030. • Efficiency improvements: 100% improvement on baseline. *Note that Bell Bay's owner Rio Tinto has formed a joint venture with Alcoa, Apple and the Government of Quebec supported by the Government of Canada which looks to scale up and demonstrate the economic viability of an alternative process for making aluminium that does not release CO2 as part of the underlying chemical reaction. The joint venture is called Elysis and last year completed the construction of its industrial research and development centre in Quebec. Therefore, innovative electrode technologies may be available to produce low emissions aluminium at scale in the next 5-10 years and given Rio Tinto's ownership of Bell Bay, it could be one of the smelters well placed to utilise these technologies but retrofitting would be required.*	Approx. 310	Low-medium *Economic achievability: Low* *Technical achievability: Med* *Policy achievability: Med*
Option 4: Low-emissions ferromanganese	• Adoption rate: It is assumed that 100% of the coking coal used in ferromanganese production could be substituted by bio-coke (charcoal) and through the use of green hydrogen as a substitute coking coal (via direct reduction). The demand to supply this opportunity could reach up to 450,000 tonnes of biomass by 2050[59]. • Year of implementation: Assumed to be rolled out from 2040. • Efficiency improvements: 100% improvement on baseline.	Approx. 390	Low-medium *Economic achievability: Low* *Technical achievability: Low* *Policy achievability: High*

[59] Analysis undertaken for this opportunity and "*Option 3. Fuel switching and co-firing: Use of biomass resources for high-temp process heat*", shows that it is likely there will sufficient forest residue feedstock for both of these opportunities to be rolled out if required.

5.2.6 Waste

Table 12. Waste opportunities summary

Opportunity description	Key assumptions and drivers	Emissions reductions in 2050 (kt CO_2-e/yr)	Overall achievability rating
Option 1: Reduce waste to landfill and deployment of additional landfill gas capture technology	• Adoption rate: It is assumed that this opportunity results in overall recovery rates of 40% by 2025 (same as reference case) and 80% by 2030 (same as reference case), but increases to 95% by 2050 (assumed constant at 80% in reference case). With regard to landfill gas capture, Assume that this opportunity doubles landfill gas capture rates to 16% by 2050. • Year of implementation: Assumed to be rolled out from 2025. • Efficiency improvements: % reduction in landfill gas emissions from diversion of organics to composting / AD.	Approx. 60	High *Economic achievability: High* *Technical achievability: High* *Policy achievability: High*
Option 2: Increase methane capture from industrial wastewater treatment	• Adoption rate: It is assumed that the number of industrial wastewater treatment plants capturing and combusting methane gas increases from 29% to 100% by 2050. • Year of implementation: Assumed to be rolled out from 2025. • Efficiency improvements: 100% improvement on baseline.	Approx. 20	Medium *Economic achievability: Low* *Technical achievability: High* *Policy achievability: Med*

6 AN EMISSIONS REDUCTION PATHWAY FOR TASMANIA

Key points

- Under the "best-fit" emissions reduction pathway, Tasmania maintains net zero emissions comfortably from now until 2050, with the state acting as a net sink of over 4,500 kt CO_2-e per annum in 2050.
- The best-fit emission reduction pathway excludes technologically uncertain opportunities such as low emissions ferromanganese and carbon-free aluminium smelting. However, if they become viable this would reduce Tasmanian's emissions even further.
- Concerted effort will be required to roll out emissions reduction actions and investments but, even with this, the impact on economic growth potential would be minimal, including for agriculture and forestry, with both sectors modelled to continue growing to 2050.
- Of the 26 opportunities modelled for this project, 16 were selected to sit within the best-fit emissions reduction pathway. Of these, ten directly reduce fossil fuel-related emissions, while the remaining seven reduce biogenic carbon emissions. While it is important to reduce emissions across all sectors of the economy, reducing fossil fuel emissions is considered to be critical as long-term stabilisation of the global climate cannot be achieved unless these emissions are almost entirely eliminated.

6.1 Modelled best-fit emissions reduction pathway

As described in Section 5, different opportunities have varying levels of achievability based on many factors including:

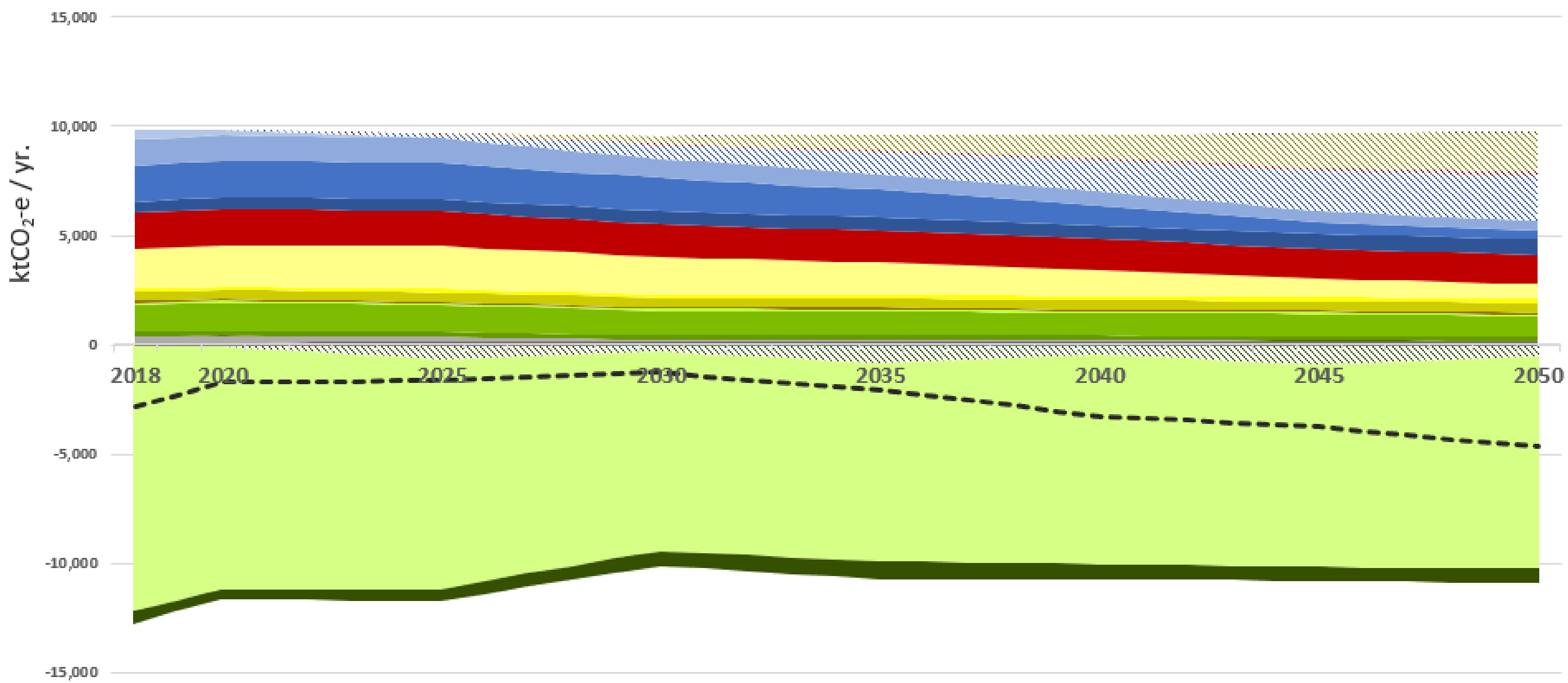
- **Economic considerations**: For example, increasing the amount of plantations and domestic wood processing may require a significant investment in ports, roads and wood processing facilities in some regions of Tasmania.
- **Technical barriers:** For example, the carbon-free aluminium smelting opportunity presents a high degree of uncertainty relating to the required technology development and its economic viability. Barring any breakthroughs in production technologies, the potential for significant reductions in GHG emissions from aluminium production in Tasmania seems limited in the short to medium term.
- **Authorising environment:** For example, policymakers may be reluctant to support the cement substitutes opportunity, which may reduce jobs within this sector of the Tasmanian economy.

A **best-fit emissions reduction pathway** to 2050 was developed (Figure 26), which includes opportunities that are considered to be the most reasonable and realistic for Tasmania against the medium emissions scenario reference case. In the diagram, the dotted line represents net emissions.

Of the 26 opportunities modelled for this project, 16 were selected to sit within the best-fit emissions reduction pathway. Of these 16, ten directly reduce fossil fuel CO_2 emissions, while the remaining seven reduce biogenic carbon emissions. While it is important to reduce emissions across all sectors of the economy, reducing fossil fuel emissions is considered to be critical as long-term stabilisation of the global climate cannot be achieved unless these emissions are almost entirely eliminated.

This best fit pathway would see Tasmania maintaining net zero emissions easily from now until 2050, with the state acting as a net sink of over 4,500 kt CO_2-e per annum in 2050. Of this impact, 12% is from carbon sequestration opportunities in the LULUCF sector, and the remainder is direct emissions reductions.

Figure 26. Best-fit emissions reduction pathway to 2050 (medium emissions scenario)



*** legend is provided as a colour-coded table on following page**

STGGI Emissions (ktCO$_2$-e per year) (S)	2018	2020	2025	2030	2035	2040	2045	2050
Total net emissions	**-2,825**	**-1,750**	**-1,637**	**-1,288**	**-2,093**	**-3,274**	**-3,777**	**-4,701**
1. Energy	3,913	3,592	3,343	2,988	2,622	2,156	1,734	1,556
1. A.1 Fuel combustion - Energy industries	468	241	0	0	0	1	1	2
1. A.2 Fuel combustion - Manufacturing industries and construction	1,181	1,166	1,124	873	745	629	484	427
1. A.3 Fuel combustion - Transport energy	1,678	1,687	1,659	1,532	1,267	888	569	403
1. A.4 Fuel combustion - Other sectors	508	498	560	583	610	639	680	725
2. Industrial processes	1,648	1,704	1,581	1,494	1,447	1,405	1,365	1,320
3. Agriculture	2,454	2,520	2,624	2,390	2,131	1,935	1,541	1,399
3.A.1 Enteric fermentation	1,826	1,887	1,966	1,717	1,451	1,244	830	669
3.B. Manure Management	152	156	163	169	177	184	191	198
3.D.a.3 Agricultural soils	386	391	404	414	413	416	429	441
4. Land Use, Land-Use Change and Forestry	-11,229	-9,951	-9,522	-8,362	-8,498	-8,959	-8,590	-9,131
A. Forest land	-12,168	-11,128	-10,492	-9,130	-9,095	-9,584	-9,221	-9,686
B. Cropland	76	82	81	81	81	81	81	81
C. Grassland	1,204	1,307	1,237	1,116	1,106	1,006	998	907
D. Wetland	221	203	203	203	203	203	203	203
E. Settlements	15	22	20	18	17	15	14	13
G. Harvested wood products	-577	-436	-571	-650	-810	-680	-664	-649
5. Waste	389	384	336	202	205	189	172	155
5.A. Waste - Solid waste disposal	288	284	227	81	82	64	46	27
5.D. Waste water treatment and discharge	95	94	99	101	103	105	107	108
Other waste	6	6	10	19	20	20	20	20

This best-fit emissions reduction pathway includes the below opportunities.

Table 13. Best-fit emissions pathway opportunities with roll-out dates

Opportunity	Year rolled out
1. Energy	
1. A.2 Fuel combustion - Manufacturing industries and construction	
Demand reduction measures for manufacturing	2025
Fuel switching: boiler electrification	2030
Fuel switching: Biomass	2030
1. A.3 Fuel combustion - Transport energy	
Drive low emissions passenger vehicle uptake (via EVs, biofuels) and reduce internal combustion engine (ICE) vehicle emissions	2025
Decarbonise heavy vehicles via HEVs, HFCVs and bioenergy	2025
Increase uptake of public and active transport	2025
1. A.4 Fuel combustion - Other sectors	
Reduction of stationary diesel consumption in the ag, forestry and fisheries sector through precision agriculture and improved irrigation processes	2025
Fuel combustion – all stationary energy sectors	
Fuel switching: renewable hydrogen, biogas & synthetic gas substitute for other stationary uses of natural gas & LPG	2030
2. Industrial processes	
Use of wood in construction in place of emissions intensive building products	2025
3. Agriculture	
Low methane livestock	2030
Reducing agricultural soil emissions through precision agriculture	2025
4. Land Use, Land-Use Change and Forestry	
Reduce conversion of plantations to other land uses	2021
Increased plantations including agro-forestry	2021
Increase proportion of forestry logs directed to long term wood products, and increased domestic processing	2021
Introduce measures to reduce the risk of major bushfires	2021
5. Waste	
Reduce organic waste to landfill	2025

Uncertainty considerations

Under the best-fit pathway, emissions are expected to remain comfortably below net zero out to 2050. However, there is a risk of major bushfires occurring over the next 30 years, with climate change one of the main contributors to this risk; potentially at a higher frequency and with greater severity than seen over the past 30+ years.

Bushfires will impact on Tasmania's emissions profile in multiple ways. These include the direct emissions from the fire event, and the risk of a consequent change in land use, for example if forest land is burned and not fully restored to forest or its previous productive capacity. The emissions modelling conducted for this report incorporates assumptions about these types of impacts. For example, the modelling for this project assumed major fire events may occur indicatively every 10 years, and these events could exceed the largest area of bushfire impacts in any given year over the past 70+ years (noting the largest areas burned in any given year over this period has been around 200,000 ha).In addition, the forecasts include an assumption that up to 5% of the area burned in major fire events may not be restored to forest land, and is therefore converted to other land uses (e.g. grassland). This estimate reflects the view that after major fire events, forest lands will generally tend to recover over time through regeneration and regrowth – but not necessarily with the same species composition or growth rates as previously, and there is a risk that not all the forest land recovers, or recovers to the pre-fire productive capacity, due to intensive impacts and potential for successive fire events to lead to forest type changes.

However, there is considerable uncertainty around forecasting emissions from bushfire impacts. This analysis has not attempted to capture and model the complexity of a range of interrelated factors that contribute to the incidence and scale of fires, including fuel loads and climatic conditions at points of ignition. Furthermore, estimating the potential changes in forest growth rates and sequestration rates after major fire events under a range of future scenarios would require more comprehensive forest modelling and complex scenario analysis that was beyond the scope of this report.

That said, this project analysis shows the impact that bushfires could have on Tasmania's emissions profile, but also highlights the uncertainty associated with forecasting these impacts.

6.2 Sectoral economic analysis of best-fit emissions reduction pathway

Point Advisory analysed, at a high level, the impact of the best-fit pathway on the different sectors of Tasmania's economy (as defined by the ANZSIC economic divisions).

This was undertaken through a qualitative cost-benefit assessment, rather than through quantitative analysis (which would include the calculation of Net Present Value of each option, and was outside the scope of work). In addition, this analysis did not include dynamic CGE modelling, which would provide more certainty over the expected economic impacts of the emissions reduction pathways over time. However, CGE modelling on the emissions pathway has been undertaken as part of a separate scope of work (undertaken by Victoria University and Point Advisory), and the outputs of this analysis have been used as inputs to that modelling.

The qualitative cost-benefit assessment was based on the information gathered through both the 2018/19 project and new resources (where available). Our analysis showed that the transition to a net zero carbon economy could deliver economic benefits across most sectors including agriculture, forestry and aquaculture, and manufacturing[60].

Appendix 2 provides the detailed analysis across each sector of Tasmania's economy for each emissions reduction opportunity identified for the state.

6.2.1 Agriculture, forestry and fishing (A)

The agriculture, forestry and fishing industry was estimated to be the biggest winner in terms of economic benefits. The opportunities that drive this are outlined below, and ordered in terms of highest to lowest contribution:

- **Reducing agricultural soil emissions through the roll-out of precision agriculture:** This opportunity could result in productivity improvements for both livestock and non-livestock based agricultural enterprises (assumed to improve productivity across farms by 10% - see Table 10 for more detail). These would result in additional production volumes which would most likely lead to an increase of value added by the agriculture industry (commodity prices being equal).
- **Low methane livestock:** Feeding seaweed-based supplements could result in productivity improvements for beef, dairy and sheep farmers (productivity gain assumed to be 5%) as result of improved conversion of energy otherwise lost as methane emissions[61], resulting in increased value for the agriculture industry.
- **Use of biomass resources for high-temp process heat:** This opportunity could result in an additional revenue stream for the forestry industry as a result of the sale of Tasmanian sourced forest residues[62] to the manufacturing industry.
- **Reducing the conversion of plantations to other land uses, and increased plantations including agroforestry:** These options would result in both an increase in the value of plantation logs harvested from hardwood and softwood plantation logs, by 10% above the reference case, from 2035 onwards.

6.2.2 Electricity, gas, water and waste services (D)

Emissions reduction opportunities in the best-fit pathway could result in a minor decline in value in this sector by 2050. Some opportunities will result in an increase in value for the electricity sector, while others represent a decrease. The resulting sectoral decline in value will be the balance of these trends. The opportunities that drive this include:

- **Manufacturing energy demand reduction:** This opportunity results in reduced demand for electricity and so could reduce the value added by the electricity sector to Tasmania's GSP. This however delivers a corresponding benefit to manufacturing industries, ensuring their competitiveness on the national and international markets (see below).
- **Electrification of boilers for low-med process heat for manufacturing:** This opportunity results in increased demand for electricity and so could increase the value added by the electricity sector to Tasmania's GSP. This is a

[60] Note that transfer effects between industries (i.e. an industry benefitting from a transfer of activity from another industry) have been identified where possible but may not be exhaustive.

[61] The metabolic conversion of methane represents up to 15 per cent of feed energy and feed expenses, and is a loss of economic potential. Consequently, although as yet unquantified, the reduction of methane emissions has a potential economic benefit for producers and a metabolic benefit for the animal, via an improved conversion of energy otherwise lost as methane emissions. https://www.csiro.au/en/research/animals/livestock/futurefeed

[62] The sale price of biomass for bioenergy was assumed to be $9.15 per GJ: https://www.productivity.govt.nz/sites/default/files/Productivity%20Commission_Low-emissions%20economy_Final%20Report_FINAL.pdf

transfer of value from the current fuel distribution (gas) to the electricity sector. Assuming current fuel is imported, this could be a net gain for Tasmania.

- **Drive higher uptake of electric vehicles within Tasmania's passenger vehicle fleet**: This opportunity results in additional electricity consumption above the baseline to charge EVs. This could increase the value added by the electricity sector by 2050. This is a transfer of value from the vehicle fuel distribution industry – assuming that no petrol refining occurs in Tasmania, this is likely to be almost an overall economic net gain for Tasmania, as a result of reduction in imported fuel.
- **Decarbonisation of the heavy transport fleet through EVs, Hydrogen FCVs and bioenergy**: As for passenger vehicles, this opportunity results in additional electricity consumption above the baseline to charge heavy EVs. This could increase the value added by the electricity sector by 2050. The same remark as above applies. In addition, there will be likely be additional revenue generated through fees for selling hydrogen and /or biofuels produced within Tasmania (in place of imported transport fuels). The increase in value is uncertain at this stage, but will become clearer as the renewable hydrogen and biofuel industry becomes more progressed in Tasmania in the coming years.

In addition, the production of renewable hydrogen domestically in Tasmania will require a large increase in electricity generation, which will add value to the electricity sector. This increase in generation will be supported by the Tasmanian Renewable Energy Target (TRET) which will double renewable generation to 200% of Tasmania's current needs by 2040.

6.2.3 Manufacturing (C)

Manufacturing opportunities could add additional value to this sector by 2050. The opportunities include:

- **Increasing the total supply of logs for downstream manufacturing, but reducing the conversion of plantations to other land uses, and increased plantations including agroforestry:** These options are estimated to result in an increase in the value of domestic wood products manufacturing by indicatively 7% from 2035 onwards.
- **Increasing the proportion of forestry logs directed to domestic processing and long-term wood products:** This option is based on increasing the proportion of forestry logs directed to long term wood products from 25% to 50% over the next 20 years.
- **Energy efficiency and demand management** will also lead to energy savings for manufacturers, lowering overheads and improving competitiveness, which could in turn drive increases in production volumes. However, due to the very specific nature of potential energy savings and the investments required to achieve them, this analysis did not attempt to forecast increases in the value added by these opportunities.
- In addition, **the local production of renewable hydrogen, biogas and synthetic gas** could lead to an increase in value for the manufacturing sector also. However, given the very early stage and uncertainty surrounding the development of such local production, this benefit could not be quantified.

6.2.4 Other sectors

Outside the key sectors of the economy described above, the opportunities included in the best-fit emissions pathway are unlikely to have a material impact on GSP sectors E to S (see Table 6 for a description of these sectors). This is mostly because these sectors are downstream to the sectors targeted by the opportunities. This does not necessarily mean that there will be no impact on these sectors, but they are difficult to anticipate. Impacts may include:

- Investment in energy efficiency measures, delivering a return on investment over several years - government may want to consider what support programs may be required to assist industry.
- Erosion or gain in competitiveness depending on price movements in key inputs (electricity, other types of energy, cement and construction material) and the ability for the industry to transfer any price impact to the end customers or absorb it through efficiency gains.

Dynamic modelling was not part of this scope of work, but the following considerations relating to the secondary impacts of opportunities identified have informed this analysis:

Construction industry (E)

- The “use of wood in construction in place of emissions intensive building products” opportunity may result in a decrease in material costs for the industry, assumed to be 10% by switching from cement to timber[63], thus assuming that the reduction in construction costs would, in time, be passed on to final customers. However, the implementation of the opportunity is unlikely to impact the value-add of the industry significantly.

Transport, postal and warehousing (I)

- Transport will be impacted by transport fuel decarbonisation and switch to a more efficient and electric fleet; this is however likely to be done in a cost-effective manner and following international trends.
- Warehousing is unlikely to be affected materially by any of the actions envisaged, except some cost-effective energy efficiency measures which would increase operational efficiency.

Services industries (sectors F to S, except transport - I)

- As electricity production is already largely decarbonised in Tasmania, these sectors are unlikely to be impacted by any of the opportunities considered, except some cost-effective energy efficiency measures, and some possible flow-on impact from transport (likely to be limited, even for retailers and wholesalers, if the adjustment is smooth rather than sudden).

6.3 Benefits from the low-emissions transition

In addition to the economic benefits detailed previously, broader economic co-benefits associated with a transition to net zero emissions include:

- Improvements in energy efficiency and productivity leading to reduced costs for energy users and a relative “insulation” from fluctuations in commodity prices.
- An earlier transition to a low carbon economy minimises the risk of stranded assets - particularly for Tasmania’s manufacturing sector as international demand for low-emission products and services increases.
- The positioning of Tasmania as a key player in the renewable hydrogen space through the Tasmanian Renewable Hydrogen Action Plan could help ensure that Tasmania is well placed to benefit from emerging hydrogen technologies. This could create opportunities including fuelling the heavy vehicle fleet in Tasmania with locally produced hydrogen and enabling commercial exportation of renewable hydrogen by 2030.
- The creation of additional investment opportunities in specific activities in Tasmania. For example, the relocation of Australia’s data centres to Tasmania due to its affordable low-carbon electricity and milder climate requiring less cooling. While it must be acknowledged that such trends have not so far emerged, it could be assisted by Tasmania’s population growth strategy which aims to actively pursue and facilitate overseas and interstate migration to Tasmania and encourage Tasmanians living elsewhere to come home, and could specifically target migrants with relevant ICT services skills.

Other significant co-benefits that will arise from transitioning to a low-emissions economy include:

- Cleaner air and reduced rates of illness and death as a result of reduced air pollution. The shift to a low-emissions heavy vehicle fleet and reducing coal consumption for industrial process heat will help to reduce rates of asthma, lung cancer, and heart and brain problems across Tasmania.
- Cleaner water. The shift in agriculture to more efficient rates of fertiliser application through the roll-out of precision agriculture will reduce runoff from farms, and hence reduce the risk of increased algal blooms and contamination of drinking water supplies.

Furthermore, by achieving a successful transition to a low-emissions economy, Tasmania can have a positive influence on other Australian states and other countries in pursuing a low-emissions economy, by demonstrating leadership, thus creating opportunities for exports of skills and services.

[63] Previous analysis by Indufor (Forest Residues Solutions Study Stage 2 – Detailed Options Analysis, table 4-5

6.4 Implementation considerations for achieving Tasmania's best-fit emissions reduction pathway

This analysis has considered policy implications and timelines for each opportunity identified as part of the best-fit emissions reduction pathway (Table 14) to assist TCCO in progressing the implementation of opportunities to achieve the designated emissions reduction targets. Importantly, these are provided as examples of possible policy solutions, and this list is not exhaustive.

Table 14. Implementation considerations for achieving Tasmania's best-fit emissions reduction pathway

Opportunity description	Possible policy directions	Implementation considerations
1. Energy		
1. A.2 Fuel combustion - Manufacturing industries and construction		
Option 1. Reduce energy demand of manufacturing processes through demand management and energy efficiency measures	Arguably the most powerful policy for reducing these emissions is a price on carbon. However, this is unlikely to be accepted in Australia/Tasmania under the current political climate. An alternative could be to develop a loan or grants scheme to fund energy efficiency projects. The Tasmanian Government could work with the Australian Industry Group, Business Council of Australia, Energy Efficiency Council (EEC) or other similar organisations to target Tasmania's large energy users for this sort of scheme. This could take the form of a "fuel substitution scheme" (which could also be a "fuel efficiency scheme"). This could complement the *Industrial Electricity and Fuel Efficiency* method currently available under the Federal Climate Solutions Fund. In addition, the example set by the NSW Government's Net Zero Industry and Innovation program[64], could be used. Additionally, in June 2020, the AEMC implemented a rule change to the Wholesale Demand Response Mechanism[65] to facilitate wholesale demand response in the national electricity market (NEM), principally through implementing a wholesale demand response mechanism. This will assist the Tasmanian Government in supporting the roll-out of this opportunity.	If the Tasmanian Government supports the roll out of this option from 2025 as has been assumed, the Tasmanian Government could develop actions over the coming years in order to facilitate the development of a scheme to support manufacturers to undertake energy efficiency and demand management investments. In addition, actions to promote the take-up of the Federal Industrial Electricity and Fuel Efficiency method should be investigated. For example, a study aimed at understanding the barriers to industry for using this method.
Option 2. Fuel switching: boiler electrification for	There are a number of options to drive the electrification of the manufacturing industry, including regulation and further support, which	The policy actions carried out for option 1 will help build a solid base for the Tasmanian Government supporting the roll-out of this opportunity from 2030 onwards. In addition,

[64] https://energysaver.nsw.gov.au/business/reducing-emissions-nsw/net-zero-industry-and-innovation

[65] https://www.aemc.gov.au/rule-changes/wholesale-demand-response-mechanism

Opportunity description	Possible policy directions	Implementation considerations
low-med industrial process heat	may be identified as part of the Tasmanian Bioenergy Vision (due for release in 2021).	key actions identified in the upcoming Tasmanian Bioenergy Vision will support the implementation of this opportunity. As the manufacturing industry is the major user of natural gas in the state, it is our opinion that a transition out of gas needs to be orderly to avoid perverse outcomes and negative impacts on existing users. For example, in 2016 only 33 of Tas Gas Network's customers were large (i.e. use greater than 10 terajoules of gas per year), which means the impact of these customers leaving the network is significant. However, this risk can be mitigated by repurposing gas assets i.e. using these assets for renewable hydrogen distribution for the stationary energy sector (as is currently being investigated under the Tasmanian Renewable Hydrogen Action Plan). In addition, the Tasmanian Government is also working on a Future Gas Strategy and decarbonisation study which should be finalised by the end of 2021[66].
Option 3. Fuel switching: Biomass (bioenergy) resources for high-temp industrial process heat	As above considerations for options 1 and 2.	The policy actions carried out for option 1 and 2 will help build a solid base for the Tasmanian Government supporting the roll-out of this opportunity from 2030 onwards. In addition, both ARENA and the Clean Energy Finance Corporation support the use of bioenergy in Australia. For example, in 2018, ARENA partnered with MSM Milling[67] for a biomass fuel switch project in NSW to replace LPG boilers with biomass fuelled boilers using locally sourced timber residues as the fuel source. In order to support the roll-out of this opportunity from 2030 onwards, the Tasmanian Government could build a better understanding of the market for forest residues. In addition, further analysis could be conducted into the barriers for adoption. For example, the cost of collecting and transporting harvest residues has been a significant barrier to the uptake of this opportunity to date; and understanding what could be done to remove these barriers and increase adoption would be valuable.
Option 8: Fuel switching across the stationary energy sector using renewable hydrogen, biogas	The work is well underway in Tasmania to support the roll-out of this opportunity via the Tasmanian Renewable Hydrogen Action Plan. This plan includes actions such as working with the incumbent natural gas distribution network infrastructure owner to explore opportunities for hydrogen blending at 10 per cent and to investigate potential trials of	The policy actions already underway as part of the Tasmanian Renewable Hydrogen Action Plan will support the implementation of this opportunity. In addition, the findings of the Tasmanian Government's gas decarbonisation study will likely support the implementation of this opportunity.

[66] https://renewablestasmania.tas.gov.au/innovation_and_investment/future_gas_strategy_and_decarbonisation

[67] https://arena.gov.au/projects/msm-milling-biomass-fuel-switch/

Opportunity description	Possible policy directions	Implementation considerations
and/or synthetic gas in place of natural gas and LPG	higher hydrogen blends in Tasmania's hydrogen compatible gas distribution networks.	
1. A.3 Fuel combustion - Transport energy		
Option 1. Drive low emissions passenger vehicle uptake (via EVs, biofuels) and reduce ICE vehicle emissions	With regards to driving the uptake of low emissions vehicles across the state, the Tasmanian Government has already implemented the following actions to support electric vehicle uptake including: • Supporting the rollout of a statewide electric vehicle charging network, including the recently unveiled Electric Highway Tasmania, a state-wide fast and ultra-rapid electric vehicle charging network which is capable of ensuring mid-range EVs can travel almost anywhere across the state where there is a bitumen road[68]. • The target to transition the Tasmanian Government fleet to 100 per cent electric vehicles by 2030 With regards to reducing emissions from ICE vehicles, currently there are no federal standards in place limiting emissions from light vehicles. Moving unilaterally to make the fuel standards more stringent could be difficult (or even impossible) for Tasmania, given the federated nature of these standards.	Driving an increase in EV uptake in the short-term is considered to be a very important aspect of achieving net zero emissions, and the Tasmanian Government has committed considerable resources to this action over the next few years. This option assumes that the mandatory best practice light vehicle fleet standards are in place by 2025, however it does not specify if it is at the state or federal level. If Tasmania decided to pursue state based mandatory reductions there would be two types of policies that could help achieve this: "pull" and "push" policies: "Push" would be linked to specific standards, starting with roadworthy certification, emissions disclosure, etc. This would be less costly to government. "Pull" would be grants / rebates for low emissions vehicles, as well as some kind of discounting of registration cost. These would be more costly for the government.
Option 2. Decarbonise the heavy transport fleet via HEVs, HFCVs and drop-in hydrocarbon fuels	The work is well underway in Tasmania to support the roll-out of this opportunity via the Tasmanian Renewable Hydrogen Action Plan. This plan includes actions to explore opportunities to trial hydrogen fuel cell electric vehicles within government fleets to gain first-hand experience of the technology and act as a potential catalyst for broader uptake across the private sector. This opportunity will also be supported by the Bioenergy Vision for Tasmania currently under development that will likely identify key areas of opportunity for the transport sector.	This opportunity is assumed to roll-out from 2025 onwards. As the price parity of heavy EVs and HFCVs is only expected to reach that of conventional freight vehicles by 2030 or later, the Tasmanian Government can help speed up the transition through different policy options. These options include: • Advocate to the Australian Government for reduced vehicle registration duty and tax discounts for EVs. • Develop a grant scheme for incentivising the uptake of low-carbon fuels for heavy vehicles specifically. Such a scheme could be similar to the design of the Australia's Cleaner Fuels grants scheme (closed July 2015) and New Zealand's previous biodiesel grants scheme. Alternatively, this could take the form of a mandate that a percentage of all fuel sold must be hydrogen based, similar to Queensland's mandate for 0.5% of all diesel fuel sold by fuel wholesalers to be bio-diesel.

[68] https://thedriven.io/2021/02/19/tasmania-opens-electric-highway-fast-charging-network-paving-way-for-ev-rentals/

Opportunity description	Possible policy directions	Implementation considerations
		In addition, with regards to the actions being undertaken as part of the Renewable Hydrogen Action Plan, the Tasmanian Government could work with incumbent natural gas distribution network infrastructure owner to help build an understanding the appropriateness of using the incumbent natural gas distribution network infrastructure owner network for distributing hydrogen for HFCVs specifically.
Option 4. Increase uptake of public and active transport	There is a walking, cycling, parking and smart roads plan for Hobart[69] that outlines priority works plans and frameworks for active and public transport to 2030.	This opportunity is assumed to roll-out from 2025 onwards. To achieve this would require leveraging the work already done regarding the City of Hobart Transport Strategy 2018-30. Other implementation considerations include the Tasmanian Government working with local governments across the state to: • Improve the cycle and pedestrian walkways networks • Provide park and ride facilities • Provide additional public transport services • Facilitate behaviour change and awareness programs to drive additional public and active transport
2. Industrial processes		
Option 2. Use of wood in construction in place of emissions intensive building products	This option has linkages with the LULUCF sector options 2 and 3, as to ensure the long-term availability of timber in Tasmania, maintaining existing and investing in new forest plantations would be beneficial. Importantly the Tasmanian Government already has a Wood Encouragement Policy[70] in place. This Policy ensures sustainably sourced wood is fully considered, where feasible, in Tasmanian Government procurement, particularly for new buildings and refurbishment projects. It does not mandate wood, but rather seeks to ensure that wood is considered as a key design component where it represents value for money and provides appropriate functionality in addition to other criteria.	This opportunity is assumed to roll-out from 2025 onwards. To achieve this, the Tasmanian government can play a role through procurement mechanisms for construction, leveraging the existing Wood Encouragement Policy and broadening it to cover a larger set of buildings across Tasmania.
3. Agriculture		

[69] https://www.hobartcity.com.au/Council/Strategies-and-plans/City-of-Hobart-Transport-Strategy-2018-30

[70] https://www.stategrowth.tas.gov.au/__data/assets/pdf_file/0009/149868/Tasmanian_Wood_Encouragement_Policy.PDF

Opportunity description	Possible policy directions	Implementation considerations
Option 1. Low methane livestock via feed supplements that inhibit enteric methane fermentation	Future Feed - which is a partnership between the CSIRO, Meat and Livestock Australia and James Cook University - is focusing on research and development of seaweed-based supplements (*Asparagopsis*) for methane reduction for the cattle industry. In 2020, Tasmanian based start-up Sea Forest is producing commercial volumes of *Asparagopsis* in Tasmania and is currently trialling these with major milk processor Fonterra in the state[71]. However, although this opportunity is being supported by other players, unless this option demonstrates significant productivity benefits for farmers it is unlikely to be taken up. Therefore, this option may require a grant scheme that incentivises uptake across farmers in the early years.	This opportunity is assumed to roll out from 2030 onwards. Although the Tasmanian Government is unlikely to play a central role in its development, there are various options for the Tasmanian Government to support its implementation: • Provide grant funding to the University of Tasmania and Sea Forest to support the development of a Tasmanian based *Asparagopsis* market that can supply required volumes • Provide subsidies / grants to Tasmanian farmers that integrate *Asparagopsis* feed supplements in their feed rations • Fund an information campaign about the benefits of feeding *Asparagopsis* to ruminants, once the ongoing trials have proved it is commercially ready, and does not have significant risks.
Option 2. Reduce agricultural soil emissions through precision agriculture	The Tasmanian Government is already supporting the uptake of precision agriculture as part of the the Competitiveness of Tasmanian Agriculture for 2050 White Paper[72].As industry takes the lead on developing digital technologies for precision agriculture, the Tasmanian Government assists the agricultural sector and its support services to address digital skill gaps and share information and technology solutions to enable the sector to implement more efficient practices that improve agricultural productivity.	This opportunity is assumed to roll out from 2025 onwards. In order to achieve this, the Tasmanian Government can leverage the actions already being undertaken as part of the Competitiveness of Tasmanian Agriculture for 2050 White Paper, which includes the following actions: • The government, through Digital Ready for Business, will work with industry to improve awareness of the benefits of digital technologies such as blockchain that can be used to improve product traceability for biosecurity, food safety and brand protection purposes. • The government will support a Tasmanian Agri-tech Accelerator program which will help advance the development of local startups and businesses, and also attract new cutting edge and hi-tech startups to Tasmania. • The government will continue to work with the Tasmanian Spatial Information Council, Tasmanian Agricultural Productivity Group and other industry bodies to address digital skill gaps and promote digital technology solutions to improve agricultural productivity and efficiency. • The government will continue to support the development of tools and information to help with farmer decision making including for example additional enterprise suitability maps on the Land Information System Tasmania (the LIST) to support better pasture management and farm productivity. • The government, will continue to promote developments in this area through support for the Tasmanian Agricultural Productivity Group annual Precision Farming

[71] https://futurefeednews.com/tasmanian-startup-commences-trial-to-see-if-feeding-seaweed-to-cows-and-sheep-can-reduce-climate-change-emissions/

[72] https://dpipwe.tas.gov.au/Documents/Competitiveness%20of%20Tasmanian%20Agriculture%202050%20White%20Paper.pdf

Opportunity description	Possible policy directions	Implementation considerations
		Expo and Tasmanian Spatial Information Council industry events which raise awareness of on-farm application of these techniques.
4. Land Use, Land-Use Change and Forestry		
Option 2. Reduce conversion of plantations to other land uses	Australia's National Forest Industries Plan (2018) calls for a substantial increase in new plantation development across Australia (an additional 400,000+ ha by 2030), and for increased focus on farm forestry/agroforestry and community engagement. This plan aligns with Commonwealth and State government interests directed at maintaining and increasing the national plantation estate, for a range of benefits including carbon removals. This option also has policy support through the Australian Government's Emission Reduction Fund (now Climate Solutions Fund, CSF), and its Plantation Forestry method, which incorporates scope for reducing the conversion of short rotation plantations to other land uses, where they are converted to a longer rotation investment model. Please note that replanting a short rotation plantation with another short rotation plantation is not an eligible activity currently under the ERF. In relation to state policy, Tasmania has a range of initiatives to support plantation development, including the *Strategic Growth Plan for the Tasmanian Forests, Fine Timber and Wood Fibre Industry* (2017), which includes specific consideration that "the private plantation estate is currently undergoing a level of consolidation as some landowners opt to harvest their plantations to make the land available for other productive purposes. While, in the short-term, this is expected to result in a reduction in the overall size of the private plantation estate, future plantings are likely to be concentrated within productive hubs where ease of access and transport distance will help minimise cost and maximise return."[73] The Strategic Growth Plan also notes that landowners will need support in realising and maximising a return on their forest asset. In some cases, this will mean overcoming structural and operational barriers to productive utilisation of their forest estate. This may include collaborative programs to facilitate an increase in the certification of private forests. Strategies and initiatives intended to address these issues include:	Most of the current rotations of privately owned post-1990 plantations (predominantly hardwoods) will be harvested within the next 4-5 years, i.e. before 2025. Therefore, most decisions by private landowners on whether to replant their existing plantation areas, either on a short rotation or longer rotation regime, will need to be made over this period. The effects on plantation wood fibre production and associated emissions/removals will follow these decisions, i.e. through the period between 2022 and 2030 particularly. The Tasmanian government, agency organisations and industry networks should give ongoing consideration to strengthening the enabling environment for private forest investment; and as an outcome of that, realising the opportunity to reduce the conversion of plantations to other land uses, where plantation land use is a viable and attractive option from a biophysical, environmental, social and economic perspective, and where landholders are interested to convert short rotation plantations to a long rotation plantation model. Strengthening the enabling environment may comprise: - Supporting industry development programs, e.g. supporting private forest cooperatives or new bioenergy developments that will provide residue markets - Supporting private sector investment in new processing facilities and industry supply chains - Providing demonstration sites and information services for plantation silviculture. - Supporting access to carbon markets via the ERF, through current information and guidance, standards development, and engagement at the national level. Under this alternative option, any incentives would need to be allocated in the near term, to provide encouragement to existing growers from 2021 onwards that they can access markets cost effectively, with any incentives available. Therefore, the costs of supporting this opportunity would need to be borne from 2021 onwards, indicatively until 2025, by which time most of the current stands of post-1990, short rotation hardwood plantations would be harvested and decisions on replanting will be made.

[73]

Opportunity description	Possible policy directions	Implementation considerations
	- encourage landowners to recognise the future potential of the industry and the resultant benefits of growing trees and actively managing their existing native and planted forests for sustainable wood production; - Assist landowners in the development and management of plantation forests to maximise their sustainable use; and - Identify and remove impediments to the sustainable use of private native forests for production forestry.	As noted above, the effects on plantation wood fibre production and associated emissions/removals will follow these decisions, i.e. through the period between 2020 and 2030 particularly.
Option 3. Increase plantations including agroforestry	Policy options for industrial plantations are like those presented for Option 2. Australia's National Forest Industries Plan (2018) calls for a substantial increase in new plantation development across Australia (an additional 400,000+ ha by 2030), and for increased focus on farm forestry/agroforestry and community engagement. This plan aligns with Commonwealth and State government interests directed at maintaining and increasing the national plantation estate, for a range of benefits including carbon removals. In addition, Tasmania's Strategic Growth Plan for the wood fibre industry calls for a doubling of industry value added. This plan is not specific about requirements for increasing Tasmania's plantation estate. However, increasing the scale and production capacity of Tasmania's plantation estate would directly assist in building a resource base for domestic value adding of plantation logs as well as native forest hardwood timber. For agroforestry at the state level, this could include a grant scheme that incentivises this option for farmers. This grant scheme would need to ensure that higher benefits arise from grants to maintain forests, and establish agroforestry systems, than revenue earned from producing livestock/crops on grassland. In addition, practical information and demonstrations of establishing trees on farms can provide farmers with evidence of the productivity-enhancing benefits of agroforestry for livestock production. See for example Private Forests Tasmania's Tree Alliance initiative. .	As with Option 2, this opportunity would require the costs to be borne from 2021 onwards, indicatively until 2025, to facilitate the establishment of new plantations (including agroforestry systems) that can grow through the period to 2050. While successive plantations would maintain the land as 'land converted to forest land' with associated emission reduction (removal) benefits, it would be important for Tasmania's emission reduction pathway for the increased area of plantations to be established in the near term to fully realise the benefit of this action. In contrast to Option 2, the emission reduction (removals) benefit should be realised shortly thereafter, as the land converted to forest land starts to provide carbon sequestration, i.e. from 2020 onwards, and will continue to increase these removals over time. Harvesting of the additional areas of plantations (including agroforestry systems) in due course, indicatively 15-20+ years after establishment, would result in emissions that typically reduce the level of net removals. However, provided the land use is maintained thereafter, the cycle of plantation establishment and growth over time will typically lead to a balance of net removals from this land use over time.

Opportunity description	Possible policy directions	Implementation considerations
Option 4. Increase proportion of forestry logs directed to long term wood products, and increased domestic processing	This option requires stronger encouragement for investment in domestic processing of wood products (e.g. the Hermal Group's CLTP facility near Burnie). Tasmania's Strategic Growth Plan for the wood fibre industry calls for a doubling of the industry value added. Increasing Tasmania's capacity for wood product manufacturing and value adding would be directly aligned with this Growth Plan.	This opportunity is assumed to roll-out from 2030 onwards. To achieve this, the Tasmanian Government and industry organisations (such as the Tasmanian Forestry Hub) will need to maintain support for major industry value-adding initiatives, including but not limited to the investment in new manufacturing facilities for sawn timber and CLT production in northwest Tasmania. Similar efforts to establish other timber processing developments and bioenergy/biomass energy plants adjacent to existing facilities, e.g. in the Burnie region, would strengthen this option.
Option 5. Introduce measures to reduce the risk of major bushfires	Following the most recent bushfires in Tasmania in 2018/19, the Tasmanian Government commissioned an independent review by the Australasian Fire and Emergency Service Authorities Council (AFAC), which concluded, among other recommendations, that State agencies should work with government and each other to continue to pursue a whole-of-state fuel management and burning program that encompasses all land tenures, meets the range of outcomes required by the state (township protection, risk reduction and landscape-scale burns) and is inclusive of private landholders and local communities as well as all fire agencies[74]. AFAC also noted: "*With consideration of Tasmania's future climate outlook we flag that there may be a shortfall in current Parks & Wildlife Service capacity to undertake the extent of planned burning desired or required across national parks and its other estate while striving to resource priorities under the State program. As previously noted, windows of opportunity for planned burning in Tasmania are heavily constrained by a range of natural and human factors. Fuel management programs need to take into account the 'opportunity cost' associated with not completing planned burns and the impact risks of extreme bushfire events*."[75] The State government has accepted all the recommendations of this review.	This opportunity is assumed to roll out from 2021 onwards, with effect from 2025 onwards. In order to achieve this the Tasmanian Government would need to give further support for the state's Fuel Reduction Program – indicatively through recurrent expenditure allocated to the Tasmanian Fire Service, Parks & Wildlife Service and Sustainable Timber Tasmania. The emission reduction benefit would arise from avoided emissions from major bushfire events, relative to the reference case, which assumes there will be major bushfire events indicatively every 10 years, with associated emissions and some subsequent conversion of forest land. On this basis, the timeline for avoided emissions are reductions indicatively in 2025, 2035 and 2045, with relatively minor emission reduction benefits during the intervals.
5. Waste		

[74] *AFAC Independent Operational Review: A review of the management of the Tasmanian fires of December 2018 – March 2019.* Report prepared for the Tasmanian Government. Recommendation4.

[75] Ibid.

Opportunity description	Possible policy directions	Implementation considerations
Reduce organic waste to landfill	This opportunity has policy support at the Federal and State level, through the National Waste Policy 2018 and Tasmania's Draft Waste Action Plan, which includes the following actions and targets: • Introduce a waste levy by 2021 to fund waste management and resource recovery activities • Introduce a Container Refund Scheme by the end of 2022 • Ensure 100% of packaging is reusable, recyclable or compostable by 2025 • Reduce waste generated by 5% per person by 2025 and 10% by 2030 • Achieve a 40% average recovery rate from all waste streams by 2025 and 80% by 2030	This opportunity is assumed to roll out from 2025 onwards. To support and boost the beneficial impacts of the landfill levy roll-out from 2021 (considered under the reference case modelling), the Government could conduct an analysis of current local government rates for households and businesses and fund an information campaign about the new food and organics bin service (when rolled out). This campaign could be coupled with a government behaviour change program such as NSW's Love Food Hate Waste. This work would need to be carried out in partnership with the EPA and local government councils.

7 EMISSIONS REDUCTION TARGET OPTIONS ANALYSIS

Key points

- With its significant forest estate and low carbon electricity sector, Tasmania is well placed amongst Australian states and territories to achieve and maintain net zero emissions at a relatively low cost.
- Five target timeframes are proposed for consideration by the Tasmanian Government: net zero by 2030, 2035, 2040, 2045 and 2050.
- Tasmania has the opportunity to position itself as a climate change leader, at both the national and global level, by setting a target to achieve and maintain net zero emissions earlier than 2050. That said, setting a net zero by 2050 target is still aligned with climate science, and therefore robust and defensible.

7.1 Context

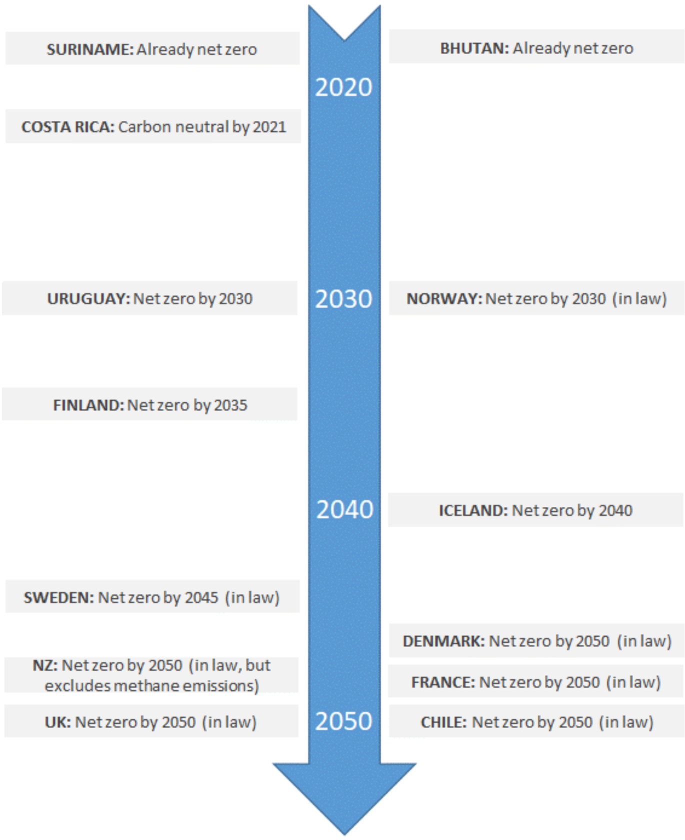
Under the existing *Climate Change (State Action) Act 2008* (the Act), Tasmania passed a legally binding target to reduce emissions by at least 60% below 1990 levels by 2050. Through the release of Climate Action 21, the Tasmanian Government has committed to a target of net zero emissions by 2050. As part of the independent review of the Act that is currently underway, the Tasmanian Government is seeking to set a more ambitious emissions reduction target for Tasmania, aligned with the goals of the Paris Agreement.

7.2 Targets set by Tasmania's peers

At the domestic level, all states and territories in Australia now have some form of net zero commitment by 2050. Most notably, Victoria has a legislated target to achieve net zero emissions by 2050, and the ACT has a net zero target by 2045. At the international level, a number of countries have set net zero emissons targets by 2050 (or earlier), including many that are enshrined in law (Figure 27).

Note that New Zealand's overall net zero emissions target for 2050 excludes methane emissions from agriculture and waste. These emissions represent over 40% of New Zealand's total emissions. They are covered by a separate target of at least 24-47% reduction below 2017 levels by 2050, with an interim target of 10% reduction by 2030.

Figure 27. Timeline of announced international net zero emissions targets[76]



7.3 Target options for Tasmania

With its significant forest estate and low carbon electricity sector, Tasmania is well placed amongst Australian states and territories to achieve net zero emissions at a relatively low cost. Our analysis indicates that under most-likely reference case assumptions, Tasmania could achieve and maintain net zero emissions much earlier than 2050, whilst continuing to grow the state's economy.

Tasmania has the opportunity to position itself as a climate change leader, at both the national and global level, by setting a target to achieve and maintain net zero emissions earlier than 2050. Five target timeframes have been suggested in Table 15, and outline the relative benefits and risks of each option. Importantly, the ability to achieve these targets is largely influenced by the LULUCF sector maintaining removals at levels broadly aligned with those seen over the past five years. It is expected that this trend will continue into the future under most-likely conditions. Importantly under the best-fit emissions reduction pathway, net zero emissions are forecasted to be achieved from now until 2050, so all targets should be achievable, provided the right policy and economic support is provided.

Table 15. Potential emissions reduction target setting options – benefits and risks

Target option	Benefits	Risks
Net zero emissions by 2030	• Would be the most ambitious state-level net zero emissions target in Australia. • Highly ambitious at the global level, outside of countries that have extensive forest resources and relatively low emissions electricity sectors.	• Could be seen as too difficult / costly to achieve, which may make stakeholders hesitant to commit. • Likely to require significant investment and research and development to support businesses to transition.

[76] Source: Based on information provided in the Energy & Climate Intelligence Unit's Net zero tracker: https://eciu.net/analysis/briefings/net-zero/net-zero-the-scorecard

Target option	Benefits	Risks
	• Aligned with climate science, and therefore robust and defensible. • First mover advantage.	
Net zero emissions by 2035	• As for 2030 target.	• As for 2030 target.
Net zero emissions by 2040	• Would be the most ambitious state-level net zero emissions target in Australia. • Ambitious at the global level. • Aligned with climate science, and therefore robust and defensible. • First mover advantage.	• Could be seen as not being ambitious enough given Tasmania's unique position of already having achieved net zero emissions since 2013, and its significant advantages compared with other states. • There is the risk that if Tasmania waits too long to set a net zero emissions targets, then the state may miss the opportunity to catalyse innovative research and development and practices, and the associated additional economic activity arising from being a global leader in new technologies and systems.
Net zero emissions by 2045	• Would be aligned with ACT's net zero emissions target so still very ambitious at the national level. • Ambitious at the global level. • Aligned with climate science, and therefore robust and defensible.	• As for 2040 target.
Net zero emissions by 2050 ***(Tasmanian Government's current emissions reduction target policy position)***	• Aligned with climate science, and therefore robust and defensible.	• As for 2040 target.

APPENDIX 1 KEY DRIVERS FOR LULUCF REFERENCE CASE FORECASTS

A summary of the key drivers for the high case and low case emissions forecasts is set out below. The ranges around these key drivers are based on a review of historical variation in emission trends, guidance from the Reference Group for this project, and Indufor perspectives on valid scenarios around the medium reference case.

Table 16. Key drivers for the Low reference case and High reference case scenarios for LULUCF sector

Key drivers for emissions forecasts	LOW reference case	HIGH reference case
1. Level of timber harvesting in public native forests compared to actual historic data and published sustainable supply forecasts for high quality eucalypt sawlogs	-5% decrease	10% increase
2. Level of timber harvesting in private native forests (which is currently at relatively low levels compared to previous periods)	no change to medium case	30% increase
3. Level of harvesting of pre-1990 plantations over the period	no change to medium case	25% increase
4. Post-1990 plantation estate over the next 10+ years, due to decisions to revert the land back to non-forest land uses	5% increase annually	-3% decrease annually
5. Average annual level of impact of bushfires and prescribed burning, compared to average levels of associated emissions over the last five years of inventory	5% increase	30% increase
6. Area burnt and levels of emissions from fire (bushfire and prescribed burning), in major events, indicatively every 10 years, compared to annual average levels	300% increase	800% increase
7. Total area of conversion of forest land to grassland	-5% decrease annually	2% increase annually
8. Proportion of forestry log products that are directed to solid wood and engineered wood products (i.e. value adding in Tasmania)	10% increase	-10% decrease

APPENDIX 2 QUALITATIVE COST-BENEFIT ANALYSIS OF OPPORTUNITIES

2.1 Context and methodology

The scope of this engagement did not include the modelling of dynamic relationships between economic aggregates and therefore, the assessment of costs and benefits should be considered as indicative of possible risks and opportunities rather than definitive. Note that CGE modelling has been undertaken as part of a seperate scope of work by the Tasmanian Government (*2021 Emissions Pathway Review CGE Modelling project*). The costs and benefits presented in the following sections were used as inputs to this CGE modelling to analyse the economic outcomes of the best-fit emissions reduction pathway. Hence the reporting of any economic outcomes should be based on the separate final report for the *2021 Emissions Pathway Review CGE Modelling project.*

Reducing carbon emissions may require investments from specific stakeholders and may deliver various levels of benefits across society. This Appendix provides a high-level (and largely qualitative) cost-benefit analysis (CBA) of each opportunity. In keeping with best practices, costs and benefits were first identified, indicating the stakeholder group(s) benefitting or bearing the cost, by comparison to the "reference case".

Benefits and costs considered were both of a financial nature (with associated cash-flows) and of a broader economic (i.e. encompassing social / environmental costs and benefits) or intangible nature (e.g. health and well-being). Wherever material and possible benefits and costs were quantified, either by estimating the potential impact of an opportunity on Tasmania's GSP (without any dynamic modelling) or the private cost/benefit to stakeholders. When no publicly available information could support such estimation, a qualitative evaluation of costs and benefits was undertaken.

For each emissions reduction opportunity we:

- Identified the key categories of stakeholders that will be impacted by the implementation of the opportunity
- Identified the likely costs associated with opportunity implementation, both quantitatively (if information was publicly available) and qualitatively
- Estimated expected benefits beyond emission reductions, in particular the reduction in cost (of energy for example) including less tangible or indirect benefits – e.g. decrease in air pollution from fossil fuel burning, health impacts, etc. These additional benefits were not quantified, except where a reduction in costs can be attributed.

Text coloured in blue indicates where there is a clear impact on Tasmania's GSP and it has been quantified as part of the economic modelling of the emissions reduction pathways to 2050.

When estimates of costs or benefits (or GSP impacts) are provided, they should be considered as *orders of magnitude based on assumptions* rather than *forecasts*. It must also be emphasised that these benefits have been modelled based on available information related to major economic sectors. Many economic impacts (benefits or costs) involve transfers between sectors or between economic agents. Depending on the value chain of the product or service concerned, such transfers may translate into net costs or benefits for the Tasmanian economy if a greater economic value added is created across the economy by the opportunity considered. This type of analysis can only be done with dynamic CGE modelling, which was beyond the scope of this engagement. Notwithstanding, wherever possible and appropriate, transfer impacts have been identified qualitatively in the table below, indicating which economic agent or sector is likely to benefit or lose, should the opportunity be implemented.

2.2 LULUCF

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
Option 1: Reduce conversion of forest land to other land uses	*Annual area impact*: 500 ha/yr *No. years*: 12 years *Total area impact*: 6,000 ha *Indicative increment*: 10% ↓ 1. *Emissions reduction benefit*: -685 kt CO_{2e}/year in 2050 (medium) 2. *Economic benefits*: Revenue stream generated through selling ACCUs generated through ERF Avoided Deforestation method (**Private:** Farmers) 3. *Environmental benefits*: Increased retention of tree cover, which can provide for habitat as well as shade benefits for soil cover, flora and fauna, and other environmental values (**Public:** Population of Tasmania)	1. The ERF Avoided Deforestation method allows landowners to generate ACCUs (with a weighted average auction price of around $16/t CO_{2e} in April 2021[77], notwithstanding compliance costs of generating ACCUs) for protecting native vegetation from being cleared. 2. Increased forested land is expected to result in biodiversity benefits, although how much benefit will depend in part on the quality of land management. The World Wildlife Fund's Living Planet report has named Eastern Australia as one of 11 deforestation hotspots in the world, with clearing for livestock being the primary cause of deforestation. This clearing has resulted in koala numbers reducing by 20% a decade since 1970. Although Tasmanian forests were not included in this deforestation analysis, the results highlight the importance of conserving Australia's forests to maintain habitat for native species, and this option will contribute to this objective to some extent, as well as ongoing emissions abatement.	1. Economic: Ongoing costs of fire management and remediation services (**Public:** Tasmanian Government; STT, DPIPWE/Parks & Wildlife Service, working with Tasmanian Fire Service (TFS) 2.Economic: Opportunity costs for livestock farmers (**Private:** Farmers)	1. This option will likely present some opportunity costs to farmers as livestock could have been run on this land if these forested areas (predominantly secondary regrowth after previous clearing) were converted to grassland (as is assumed in the reference case – see Section 4.1.1). The potential decrease in land values that farmers may face from being discouraged from clearing, particularly with re-growth, may cause some resistance from landowners. 2.Therefore, appropriate incentives would need to be provided to encourage farmers to further reduce the re-clearing of land, where they are authorised to do so, especially in times of high agricultural commodity prices. However, due to the high degree uncertainty in fluctuations to commodity prices into the future, these expected opportunity costs to farmers were not estimated.
Option 2: Reduce conversion of plantations to other land uses	*Annual area impact*: 1,000 ha/yr *No. years*: 12 years *Total area impact*: 12,000 ha *Indicative increment*: 5% ↑ 1. *Emissions reduction benefit*: -123 kt CO_{2e}/year in 2050 (low) 1.Economic: Revenue from increased sales of hardwood and softwood plantation logs, in domestic and export markets, contributing approximately $10 million to Tasmania's GSP per year in 2050 **(Private:** Land-owners)	1. This option this would result in an increase in the volume and value of plantation logs harvested from hardwood and softwood plantation logs, by 5% above the reference case, from 2035 onwards. It would also increase the value of domestic wood products manufacturing by indicatively 3-4% from 2035 onwards; recognising that, based on current markets and supply chains, a large proportion of the increased production may be exported as wood fibre material, i.e. not processed in Tasmania. 2. There may be scope to generate ACCUs under the ERF Plantation Forestry method, if the landowner has managed a short rotation plantation (for pulpwood) and, instead of converting the plantation to another land use, decides to convert to a long rotation plantation (hardwood or softwood, for sawlog products). This activity is eligible under the method, which allows landowners to generate ACCUs.	1.Economic: Potentially opportunity costs for livestock farmers, who may seek to use the plantation land for agricultural uses (**Private:** Farmers) 2.Economic: Infrastructure costs for new infrastructure that will facilitate further forest industry development, by replacing previous infrastructure that no longer accessible (e.g. Triabunna port no longer an option for woodchip exports) and creating new domestic processing opportunities for plantation wood, for ongoing benefits to the forest industry that	1. If plantations remain plantations, the primary economic cost beyond the business as usual (reference case) costs of plantation management (i.e. coppicing or replanting) would be the opportunity cost for agriculture – that is, the foregone potential for agricultural activity on land by 2050 that would have been converted under the reference case. 2. It is proposed that in broad terms, the returns from agricultural enterprises and plantation enterprises are comparable, as reflected in the mix of land uses across the state – but the plantation enterprises will typically contribute more to emission reductions (removals).

[77] Clean Energy Regulator, 2020. Auction April 2021: http://www.cleanenergyregulator.gov.au/ERF/auctions-results/april-2021 Accessed May 2021.

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
	2. Economic:: Potential revenue stream from selling ACCUs generated through the ERF Plantation Forestry method, subject to eligibility rules that would only recognise conversion from short rotation to long rotation plantations. **(Private:** Land-owners) 3.Economic: Net increase in sales and income from wood manufacturing in Tasmania (excluding export values captured above with the sales of logs) of approximately $25-30 million to Tasmania's GSP per year in 2050. This is in addition to 1 above. (**Private:** Manufacturing industry)	The Australian Government contracted the purchase of ACCUs with a weighted average auction price of around $16/tCO_{2e}$ in April 2021[78], notwithstanding compliance costs of generating ACCUs). Note the ERF Plantation Forestry method does not currently recognise eligibility for re-establishing a short rotation plantation instead of conversion to another land use. 3. Under current industry settings, it would be expected that most of the post-1990 plantation wood to be directed to export markets for wood fibre. Therefore, only a small proportion would flow through to domestic wood products manufacturing. For this analysis therefore, it was assumed this option would lead to an increase of 3-4% of the value added by the manufacturing industry to Tasmania's GSP, reflecting the increase in scale of operations and the opportunity to direct more to domestic value adding.	may reduce further conversion of plantations to other land uses Indufor & Point Advisory have estimated the potential requirement for indicatively $20-30 million for infrastructure investments to support the further industry development around port facilities (e.g., Hobart Port) and wood processing facilities that can receive and process plantation logs. (**Public-Private partnerships:** involving manufacturing industry)	3. However, it was beyond the scope of this project to conduct a detailed comparison of economic returns between agriculture and plantations across a range of sites (which differ in terms of soils, rainfall, productivity, proximity to market etc.) 4. The Tasmanian forestry industry has been working with the State Government over the past eight years to address infrastructure requirements to enable industry development and support international competitiveness. This work and associated studies are continuing. Public investments of this nature should be designed to create an enabling environment and leverage private sector investment. Hence, the costs would not be borne by government alone; but with these policy signals, the industry and private landholders may be more encouraged to maintain and grow the existing plantation estate.
Option 3: Increased plantations including agroforestry	*Annual area impact*: 2,500 ha/yr *No. years*: 12 years *Total area impact*: 30,000 ha *Indicative increment*: 10% ↑ *Note: These impacts are assumed to be fully additional to Option 2, which addresses the opportunity to reduce the conversion of existing plantations; while Option 3 is focussed on establishing new plantations, including agroforestry. In total, option 3 is expected to lead to an additional area of 30,000 ha of new plantations.*	1. This option this would result in an increase in the volume and value of plantation logs harvested from hardwood and softwood plantation logs, by an estimated 10% above the reference case, from 2035 onwards. It would also increase the value of domestic wood products manufacturing by indicatively 5% from 2035 onwards; recognising that a proportion of the increased production would be exported as wood fibre material, i.e. not processed in Tasmania. 2. Productivity gains have been seen for farms producing livestock in Tasmania due to the benefits of shade provision, with benefits assumed to begin five years after planting. However, these potential gains have not yet been incorporated in the LULUCF forecasts, due to lack of reliable data at this stage. 3. New plantations and agroforestry on previously cleared land would be eligible for generating ACCUs under the ERF	1.Economic costs of establishing new plantations: approximately $80-120 million for between 10-15,000 ha of additional plantings from 2025 onwards **(Private:** Landowners/farmers) 2.Economic costs of establishing agroforestry-based plantations: indicatively $35-50 million for between 10-15,000 ha of additional plantings (for a total of 30,000 ha for this option) from 2025 onwards **(Private:** Landowners/farmers) 3.Economic: Infrastructure costs for new infrastructure developments $20-$30 million	1. Indicatively, the cost of establishing new plantations in an intensive format (in contrast to agroforestry) would be in the order of $6,000-10,000/ha, comprising purchase of suitable land ($4,000-8,000/ha) and establishment (~$2,000/ha). For greenfield developments based on these costs, the establishment of 10-15,000 ha may cost approximately $80-120 million, over say 10 years for the program. 2. However, incorporating plantations or agroforestry into farm systems could be done on a marginal cost basis, and may feature the farmer/landholder already owning the land and allocating specific areas (e.g. up to 10%) to forestry, without overly compromising agricultural production levels. In this context,

[78] Clean Energy Regulator, 2021. Auction April 2021: http://www.cleanenergyregulator.gov.au/ERF/auctions-results/april-2021 Accessed May 2021.

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
	1. *Emissions reduction benefit*: -300 kt CO_{2e}/year in 2050 (low-medium) 1.*Economic benefits*: Revenue from increased sales of hardwood and softwood plantation logs, from 2035 onwards, contributing approximately $20 million to Tasmania's GSP per year in 2050 **(Private:** Land-owners/farmers) 2.*Productivity benefits for agroforestry:* not quantified in this review. **(Private:** farmers) 3. Economic: Potential revenue stream from selling ACCUs generated through the ERF Plantation Forestry method, or the New Farm Forestry Plantation method. **(Private:** Land-owners) 4. Economic: Revenue from increased sales of domestic wood products, approximately $35-45 million to Tasmania's GSP per year in 2050 (**Private:** Manufacturing industry)	Plantation Forestry method or the New Farm Forestry Plantation method. The Australian Government contracted the purchase of ACCUs (with a weighted average auction price of around $16/t$CO_2$ in April 2021). The plantations could be established on a short rotation regime or long rotation regime, provided they were established on previously cleared land (i.e. land use change). 4. Under current industry settings, it would be expected most of the post-1990 plantation wood to be directed to export markets for wood fibre. Therefore, only a small proportion would flow through to domestic wood products manufacturing. For this analysis therefore, it was assumed this option would lead to an increase of 7% of the value added by the wood manufacturing industry to Tasmania's GSP, reflecting the increase in scale of operations and the opportunity to direct more to domestic value adding.	(**Private:** Manufacturing industry)	establishing 10-15,000 ha through agroforestry or farm forestry (to contribute towards a target of 30,000 ha of new plantations across the state) could cost considerably less. It is envisaged this cost would be funded by private landowners. However, some public funding may be required to promote the opportunity and potentially provide some incentives to encourage planting, indicatively grant funding of ~$1000/ha, plus supporting access to carbon markets. 3. In relation to the potential for resolving market access issues, and the need for new infrastructure development, the costs are as described in Option 2. However, the scope for increased plantations including agroforestry systems is expected to be higher in the north of the state, around Bell Bay and Burnie, with closer proximity to domestic processing facilities and existing export facilities.
Option 4: Increase proportion of forestry logs directed to long term wood products, and increased domestic processing	*Annual volume impact*: 100,000 m^3 *No. years*: 12 years *Total volume impact*: 1.2 mill m^3 *Indicative increment*: 5% ↑ 1. *Emissions reduction benefit*: -25 kt CO_{2e}/year in 2050 (low) 1.Economic benefits: Revenue from additional domestic processing of long-term wood products, indicatively $45 million to Tasmania's GSP per	1. This option is based on increasing the proportion of forestry logs directed to long term wood products from 25% to 35% over the next 20 years. It is envisaged the increase would comprise mostly smaller diameter hardwood logs, including plantation logs, which are currently exported as wood fibre. 2. The economic benefit would derive from wood product manufacturing and increased value adding, notably into veneer-based products and other engineered wood products such as laminated veneer lumber and cross-laminated timber. Increased manufacturing in Tasmania	1.Economic: Private investment costs for sawmills and CLT facilities (**Private:** Manufacturing industry)	It is assumed this option would require additional domestic processing capacity in Tasmania. This would require additional investment. The Hermal Group has established a new hardwood sawmill and CLT facility at Wynard in northwest Tasmania, which is expected to contribute directly to addressing additional domestic processing and value adding. The project was described as a $190m investment, with the Tasmanian Government contributing

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
	year in 2050 (net of the concurrent value of exports for wood fibre) (**Private:** Manufacturing industry) 2.Social and economic: More jobs **(Public:** Population of Tasmania)	would increase gross revenues for wood products and increase local employment; indicatively by up to 10% in 20 years, recognising the proportional increase in economic benefits may not be as much as the volume shift (up to 10% increase in redirection of logs), due to efficiency gains and competitiveness drivers. 3. In terms of quantified economic impacts, the indicative increase in the value of plantation logs would be a minimal change in the value of logs (0%); however, the indicative net increase in the value of wood product manufacturing could be in the order of up to $45 million per year out to 2050. This is an indicative estimate only, as no relevant studies were cited in this review, and actual benefits will depend on a wide range of factors including the type of manufacturing, brand development and market access for new products, and the development of markets for existing products (e.g. wood fibre exports). 2. This option could promote the addition of jobs in the domestic wood processing industry, above reference case.		at least $13m in grants (with a $30 million loan) and training support.
Option 5: Introduce measures to reduce the risk of major bushfires	*Annual area impact*: 30,000 ha *No. years*: 10 years *Total area impact*: 300,000 ha *Indicative increment*: not assessed 1. *Emissions reduction benefit*: -72 kt CO_{2e}/year in 2050 (low) 1.Economic: More jobs in the fire management workforce **(Public:** Population of Tasmania)	1. Most likely incremental changes to the fire management workforce, but this may represent a 3% increase in the fire management workforce over time.	1.Economic: Increased fire management resources, with an estimated additional allocation of $15-20 million per year, directed principally to fuel management and land management initiatives including prescribed burning. This would incorporate an allocation for statewide coordination and indirect costs. Assuming prescribed burns can be conducted for an average of $300/ha, an additional allocation of $10 million per year would cover the costs for 30,000 ha per year. **(Public:** Tasmanian Government, including Tasmanian Fire Services and Tasmania Parks and Wildlife Service)	1.This option would require additional funding for increased fire management resource. The reported costs of prescribed burning on a per hectare basis varies considerably across sites, and between states and year to year. It depends for example, on the scale and risk levels associated with the burn operation (e.g. small burns adjacent to townships, or larger scale burns in relatively remote back valleys), the attribution of indirect costs, and recognition of burn preparation costs, which may be incurred in a different financial year to the actual planned burn; and the allocation of costs that provide benefits to fuel management and fire suppression. In that context, based on reporting by public agencies, Indufor estimates the average cost of additional prescribed burning (predominantly

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
				additional direct costs, excluding indirect costs) would be in the order of $200-300/ha.

2.3 Transport energy

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
Option 1: Drive low emissions passenger vehicle uptake (EVs) and reduce ICE vehicle emissions (biofuels)	1. Economic: Total cost of ownership (EV versus ICE) cumulative savings of ~$600 million above reference case in 2050. (**Private:** Car owners) 2.Economic: Revenue from additional electricity consumption equal to approximately $60 million to Tasmania's GSP per year in 2050. (**Private:** Electricity generators and retailers) 3. Economic: Revenue generated through selling biofuels produced within Tasmania (in place of imported transport fuels) (**Private:** Biofuel supply chain) 4. Social and economic: Health improvements through reduced air pollution.	1. Although without more detailed analysis (outside the scope of this engagement), it is difficult to quantify with certainty the net impact of this action on private motorists, it is highly likely it will have a positive net benefit by 2025, due to forecasted price parity with ICE vehicles and lower running costs. 2. and 3. This option could result in a transfer or revenue / margin if charging / distribution of fuels shifts from incumbents to other distributors. This cannot at this stage be estimated, but is likely not to result in a large impact on the GSP. However, transport fuels are currently imported, and electricity and locally produced biofuels could be substituted, adding to Tasmania's GSP. Only electricity production substitution has been estimated at this stage, biofuel production being too uncertain at this stage 4. This option will result in health benefits for the Tasmanian population resulting from a relatively larger decrease in air pollution compared with the reference case. Although these benefits could not be quantified for Tasmania specifically, in Australia, the estimated financial cost of premature deaths due to air pollution is $2.6 billion	1. Economic: Before EV price parity with ICEs, there will be a direct cost associated with the purchase of an EV, but this is included in the Total cost of ownership estimates. In addition, EV owners will need to invest in chargers for their vehicles, and these can range in cost, but typically could cost $1,000. (**Private:** Car owners) 2.Economic: Infrastructure upgrades for charging stations (**Private:** Service stations) 3. Economic: Drop in fuel excise tax revenue (**Public:** Government revenues)	1. It is assumed that EVs might reach price parity with ICEs by the mid-2020s, meaning that it is likely the public costs of establishing EV infrastructure will move to become a private investment by electricity charging facilities providers. However, if this price parity timeline moves post 2025, it is likely that the Tasmanian Government will need to remain at the forefront of driving EV uptake to achieve the emission reductions forecasted. For L2 chargers, the unit cost is approximately $13,000, while for DC fast chargers this can be as high as $79,000, assuming a blend of 90% L2 chargers and 10% DC chargers this would give the unit price per charger of $20,000. This analysis has shown that this opportunity could result in 40% more chargers required in 2050 compared with the reference case. It has been assumed that over the period from 2025 to 2050, approximately 1 charger is needed to service 30 EVs based on Energia analysis, however this number is highly uncertain. 2. The loss of revenue associated with fossil fuel sales is effectively a transfer between fuel

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
	(**Public:** Population of Tasmania)	in health costs[79]. Therefore, reducing emissions from the light vehicle fleet (and the heavy vehicle fleet) will have a positive impact on the health of Tasmania's population and hence reduce the burden of disease (although to what extent is uncertain).		retailers and retailers of electricity through charging stations and / or hydrogen fuel. The mobility energy providers may or may not be the same as current fuel retailers, and the overall private financial impact, after taking into account required investment, is very dependent on timing and highly uncertain. It has been assumed to be immaterial to the GSP (although likely to be material at each individual fuel retailer level). 3. Fossil transport fuels are taxed by the Federal government and constitute an important source of revenue, some of which can be put towards state projects and funding. A loss of fuel excise tax revenues will likely have to be compensated through other sources of revenues.
Option 2: Decarbonise the heavy transport fleet via HEVs, HFCVs and drop-in hydrocarbon biofuels	1. Economic: Post 2030, there may be total cost of ownership (EV, HFCV versus ICE) savings, however the timing for this is uncertain. (**Private:** Freight industry) 2. Economic: Revenue generated through fees for charging EVs, which could be used to fund an expansion of the charging infrastructure, and through selling hydrogen and /or biofuels produced within Tasmania (in place of imported transport fuels). (**Private:** Service stations and biofuel retailers) 3. Economic: Revenue from additional electricity consumption equal to	1. n/a 2, Revenue generated through fees for charging EVs, hydrogen fuel and biofuel sales. (**Private:** Service stations) 3. Note for the purposes of the net zero emissions modelling the differences in using electricity vs hydrogen vs biofuels are not modelled as the emissions reduction impact is the same across each. This $13 million is provided as a proxy for the potential increase in GSP value for Tasmania as a result of this opportunity being rolled out, noting that the true increase in value is uncertain at this stage, but will become clearer as the renewable hydrogen and biofuel industry becomes more progressed in Tasmania in the coming years. (**Private:** Electricity generators and fuel retailers) 4. n/a	1. Economic: Post 2030, the total cost of ownership of heavy EVs and HFCVs is expected to reach price parity with ICEs, until then it will represent a cost to the freight industry (**Private:** Freight industry) 2. Economic: Drop in fuel excise tax revenue (**Public:** Government revenues)	1.Currently the total cost of ownership for plug-in hybrid trucks and hydrogen fuel cell trucks across the US, China, Japan and Europe are significantly higher than the fossil fuel alternatives, at 220,000 AUD for diesel ICE hybrids and 680,000 AUD for hydrogen fuel cell vehicles, compared with 165,000 AUD for conventional diesel trucks[80]. As for passenger EVs, these costs are likely to come down over time, however it is likely that this will be over a longer time horizon, which is quite uncertain. Analysis by the International Council on Clean Transportation demonstrated that these technologies will see reduced cost of ownership over time, primarily because their capital technology costs decrease from 2015 through 2030. For hydrogen fuel cell vehicles (renewable), this results in a nearly halving of total cost of ownership by 2030, to almost reach price parity with diesel vehicles. For electric heavy vehicles, price parity is forecast

[79] https://www.singletonargus.com.au/story/6848064/air-pollution-causes-almost-5000-deaths-a-year/

[80] IEA (2017), The Future of Trucks, IEA, Paris https://www.iea.org/reports/the-future-of-trucks

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
	approximately $13 million to Tasmania's GSP per year in 2050. (**Private:** Electricity generators and fuel retailers) 4. Social and economic: Health improvements through reduced air pollution (**Public:** Population of Tasmania)			to be reached by 2030 [81], however it should be noted that this is highly uncertain. 2. As for option 1
Option 3: Increase mode share of rail freight	1. Economic: Increased train services revenue. (**Public:** State owned TasRail)	1. This is too prospective at this stage to quantify. Importantly, the significant costs associated with upgrades to (and compensation for) rail may outweigh its benefits if market uptake of this rail freight service offering is limited.	1. Economic: Significant investment costs (requires specific enquiries) for rail upgrades, new locomotives etc. (**Public:** State owned TasRail) 2. Economic: Transfer of revenue for the road freight to rail freight industry, compensating benefit 1 partially or totally (**Private:** Freight industry)	1. Currently, structural issues associated with Tasmania's freight network and the location of the northern ports (Burnie, Devonport and Bell Bay) limit the ability of rail services to compete with road freight for time dependent export products. Therefore, significant investment would likely be required for upgrades to the Burnie to Hobart corridor, improvement of intermodal connections such as those at Burnie Port, the Brighton Hub and Bell Bay Port, and new locomotives. While quantifying these costs was outside the scope of this engagement, the magnitude is likely to be fairly significant. For example, the Australian and Victorian governments have invested more than $4 billion in the Regional Rail Revival program, which is upgrading every regional passenger rail line in Victoria[82].
Option 4: Increase uptake of public and active transport	1. Economic: Possible cost savings compared with private transport (**Private:** Car owners); 2. Health improvements through promotion of a healthier lifestyle (active transport) and less air pollution (until EV are adopted) (**Public:** Population of Tasmania)	1. Uncertain as it depends on tariff, EV uptake, etc. Not estimated as part of this study.	1. Economic: Public expenditure on transport infrastructure and operations (**Public:** Tasmanian Government)	1. The net impact would be significant costs to government, the motivation would be that it would be recouped in the long term (for public transport) or through health improvement (active transport). It should be noted that some delivery challenges such as changes to transport services and land use planning constraints can make this opportunity difficult to achieve.

[81] https://www.theicct.org/sites/default/files/publications/Zero-emission-freight-trucks_ICCT-white-paper_26092017_vF.pdf

[82] https://bigbuild.vic.gov.au/projects/regional-rail-revival#:~:text=Regional%20Rail%20Revival-,Upgrading%20every%20regional%20passenger%20rail%20line%20in%20Victoria.,passenger%20rail%20line%20in%20Victoria

2.4 Stationary energy

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
Option 1: Reduce energy demand of manufacturing processes through demand management and energy efficiency measures	1. Economic: Operational energy cost savings of up to 25% per site, linked to cost 2. (**Private:** Manufacturers e.g. cement, pulp and paper, food and beverage processing, and iron ore palletisation) 2. Economic: Revenue stream from selling ACCUs generated through ERF Industrial Electricity and Fuel Efficiency method (**Private:** Manufacturers)	1. This option represents a transfer of value from electricity sector to manufacturing (see cost #2). This transfer could be passed on to customers or used to increase margins within the sector. In addition, typically, general efficiency projects in manufacturing provide a net benefit over time. However, despite this, the upfront investment and uncertainty on payback period may act as a significant barrier to uptake. 2. The Smithton abattoir boiler fuel replacement project and the Norske Skog Boyer Mill Heat recovery project are examples of Tasmanian companies having started ERF projects[83]. Overall ERF revenues are only used to offset some of the project costs.	1. Economic: Site specific demand management and energy efficiency investments (**Private:** Manufacturers) 2. Economic: Reduced revenue stream from a decrease in electricity consumption equal by approximately $160 million to Tasmania's GSP per year in 2050 (**Private:** Electricity generators and retailers). This is related to benefit 1, i.e. what is saved by the manufacturers, will be lost to electricity retailers.	1. In order to roll-out these demand reduction measures, a site-specific investment would need to be made. Before this could be quantified, it would be suggested that the sites undertake detailed energy audits to understand where savings could be made. 2. The net impact would be a loss of revenue; however, this could be compensated by higher energy retail prices, or demand increase in other sectors.
Option 2: Fuel switching: Electrification of boilers for low-med process heat	1. Economic: Revenue stream from selling ACCUs generated through ERF Industrial Electricity and Fuel Efficiency method (**Private:** Manufacturers) 2. Economic: Increased revenue stream from a growth in electricity consumption equal to approximately $60 million to Tasmania's GSP per year in 2050 (**Private:** Electricity generators and retailers)	1. Overall the revenue from ERF are only used to offset some of the project costs (see cost #1). 2. This option represents a transfer of value from natural gas sector to electricity sector (see cost #3).	1. Economic: Site specific electrification investments (**Private:** Manufacturers) 2. Economic: Increase in energy costs (**Private:** Manufacturers) 3.Reduced revenue stream for natural gas retailers. (**Private:** Tasmanian natural gas industry e.g. Tas Gas Networks)	1.and 2. It is difficult to estimate the net impact that this opportunity will have on Tasmania's manufacturers due to the highly site-specific nature of the operational savings and investments required. However, it is likely that electrification require a high upfront investment. Capital costs for replacing conventional boilers with electric heat pumps have been estimated at a very high level to be $18 million in 2030 and reach a cumulative total of $54 million in 2050. This was based on the assumptions that: - a boiler can account for 60% of site energy costs - an assumed heat pump cost of $1,200 per kW installed - Average COP is assumed to be 2 Work carried out by the NZ Productivity Commission in 2018 states that "process electrification will require the installation of heat pumps and other technologies that deliver thermal

[83] Note these are the only two projects under this method in Tasmania as of 14/03/21

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
				energy at a higher efficiency than direct electrical use to offset the relatively high cost of electricity". Currently in Tasmania, the price of electricity is approximately $66 per GJ for residential customers, while industrial and large commercial customers may pay considerably less, due to favourable contracts with electricity retailers. In comparison, the cost of natural gas is $12 per GJ for large industrial gas users (of which many of the low-medium process heat users would be), and $40 for residential and commercial customers[84]. **<u>Note</u>**: All cost estimates need to be treated as highly uncertain. This is because this process is highly site specific and process dependent. In addition, heat pumps can't be used for the whole electrification process, and other process additions would be required, such as electrical resistance heaters which in a lot of cases will have no payback period. This will need to be noted in final report. 3. This option also represents a risk of stranded assets which needs to be managed at the state level; for example, if gas assets could be repurposed or used differently e.g. for hydrogen distribution for hydrogen vehicle refuelling, this needs to be carefully considered and planned.
Option 3: Fuel switching and co-firing: Use of biomass resources for high-temp process heat	1. Economic: Revenue stream from selling ACCUs generated through ERF Industrial Electricity and Fuel Efficiency method (**Private:** Manufacturers) 2. Economic: Increased revenue stream from the use of biomass (forest residues) equal to approximately $85 million to Tasmania's GSP per year in 2050. A condition for this to be realised would be a funding program to incentivise uptake of new boiler infrastructure. Links to cost 1 & 2. (**Private:** Forestry industry)	1. n/a 2. Studies of opportunities for increased use of forest sector residues, including the Tasmanian Government's *Residues Solution Study* (2014-2016) identified a considerable quantity of processing residues and forest harvest residues across the State. This has also been confirmed again in conversations in 2021 with Tasmanian Government. However, there are practical and economic limitations on accessing these residues. In the case of processing residues, most of the current quantity have alternative markets (e.g. export wood chips or boiler fuel feedstock), and co-firing projects or new bioenergy projects would need to pay more for the delivered feedstock (including collection and transport) to redirect these flows. In the	1. Economic: Site specific investments in equipment e.g. biomass boilers (**Private:** Manufacturers) 2. Economic: Increase in energy costs (Currently in Tasmania, the price of forest residue "Other stemwood" is approximately $9 per GJ, whereas the cost of coal is $7 per GJ) (**Private:** Manufacturers) 3.Reduced revenue stream for natural gas and coal retailers. (**Private:** Tasmanian natural gas industry e.g. Tas Gas Networks)	1 and 2. It is difficult to estimate the net impact that this opportunity will have on Tasmania's manufacturers due to the highly site-specific nature of the operational savings and investments required. Capital costs to replace boilers across manufacturing sites have been estimated at a very high level to be $190 million in 2030 and reach a cumulative total of $560 million in 2050. This was based on the assumptions that: - a boiler can account for 60% of site energy costs - a biomass boiler cost of $1800 per kW installed (using Tasmanian Government cost information.) In addition, it is likely in the short-term that biomass will represent a higher cost per unit of energy delivered than coal. Currently, the price of coal is approximately $7 per GJ, whereas the cost of biomass is $9 per GJ.

[84] https://www.tasgas.com.au/residential/tariffs-charges

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
		case of harvest residues, which may be left on site, the costs of collecting and transporting green harvest residues to a centralised processing facility has proved to be a considerable limitation on its use for bioenergy around Australia to date. This opportunity assumes that high process heat users swap approximately 60% of their stationary energy requirements for biomass by 2050. This will have a large impact on the consumption of natural gas in the state.		**Note:** All cost estimates need to be treated as highly uncertain. This is because this process is highly site specific and process dependent. In addition, the costs associated with this opportunity are highly dependent on the fuel that is used in place of the fossil fuel, and so the exact fuel switching options supported by Government for different users should consider a range of other factors, including the differences in costs across various biomass / biofuels. 3. The switch mentioned in benefit 2 will have a large impact on the consumption of natural gas and coal in the state.
Option 4: Improve energy efficiency of existing residential building stock (24% of households (low-income households) built before 2020, by 2050 35,000 dwellings targeted)	1. Economic: Energy efficiency savings could reach cumulative savings for low-income households of just over $25 million by 2050. This represents a transfer in value from energy retailers to households. (**Private:** Households) 2. Social and economic: Health improvements to low-income householders as a result of improved thermal comfort levels, and could reduce reliance on public health systems (**Private:** Households)	1. Improving residential energy efficiency results in significant energy cost savings over the life of the home (which can be 100 years or more). This analysis suggests savings 60% improvement on baseline. This is based on improving from a 2-star NatHERS rating (assumed that Tasmanian households are currently at this level) to 5 stars. These upgrades can also increase the resale value or rental return of the home (if a robust rating scheme is introduced). 2. Low income households are likely to face increase health risks as a result of not being able to afford to maintain adequate thermal comfort in their homes. Health improvements lead, in turn, to reduced pressure on the public health system.	1. Economic: Installation costs (ceiling and wall insulation, double glazing) could represent a cumulative total of $600 million by 2050 for just over 35,000 households. (**Private:** Households)	1. The measures span installation of ceiling and wall insulation, and installation of double glazing. Together, these can result in a total cost of around $18,000 per dwelling.
Option 5: More stringent standards for energy performance of new buildings, both residential and commercial	1. Economic: Energy efficiency savings could reach annual savings to households and businesses of $16 million per year by 2050 and onwards. This represents a transfer in value from energy retailers to households. (**Private:** Households and building tenants)	1. Improving energy efficiency results in significant energy cost savings over the life of the building (which can be 100 years or more). This analysis suggests savings of 17% for houses and 33% for commercial buildings. These upgrades can also increase the resale value or rental return of the building (if a robust rating scheme is introduced). 2. n/a	1. Economic: Higher building costs resulting from more insulation and higher quality glazing, though payback periods can be less than 15 years. (**Private:** Households and building tenants) 2 .Reduced revenue stream for energy retailers. (**Private:** Tasmanian gas and electricity retailers	1.More stringent residential standards do bring forward additional costs to builders / owners through higher product costs (e.g. more insulation and higher quality glazing) and higher standard work (air-tightness, etc). 2. Efficiency savings will lead to reduced volumetric sales for energy providers. This may not translate directly into a loss, due to the complexity of tariffs which include infrastructure charges and various ways of maintaining overall profitability. Net impact on energy retailers was therefore not calculated.

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
	2. Social and economic: Health and comfort benefits to householders and building tenants as a result of improved thermal comfort levels, and could reduce reliance on public health systems (**Private:** Households and building tenants)			
Option 6: Replace natural gas, LPG and inefficient wood heaters with electric heaters and modern pellet fires	1. Social: Health improvements to householders and building tenants as less particulate matter from inefficient wood heaters (**Private:** Households and building tenants). 2. Environmental benefits as there would less illegal use of firewood (**Public:** Population of Tasmania)	1. As per the above, but difficult to estimate quantitatively 2. This benefit could be restricted as people are unlikely to want to give up their free source of energy i.e. illegal harvesting of firewood.	1. Economic: upgrade upfront investment cost. (**Private:** Households and building tenants)	1. Upfront investment costs in air source heat pumps up to $5,500 per unit. People will only pay for these upgrades if they see a short payback period and energy savings in the short term. This may be unlikely given the relatively low cost of wood ($15 per GJ) and natural gas ($40 per GJ) versus electricity ($66 per GJ for residential customers).
Option 7: Use precision agriculture to reduce stationary diesel consumption in the ag, forestry and fisheries sector	Note that this option applies the same technologies as for option 2 under agriculture, as the roll-out of precision agriculture impacts both energy consumption and agricultural soil emissions. The opportunity has been split in two as the impacts reduce emissions across both the stationary energy and agriculture sectors.	As for option 2 under agriculture	As for option 2 under agriculture	As for option 2 under agriculture
Option 8: Fuel switching across the stationary energy sector	1. Revenue generated through selling hydrogen fuel produced within Tasmania (in place of imported stationary energy fuels)	1. Benefit of displacing import of gas and capturing value add from the local production of renewable hydrogen, biogas and synthetic gas.	1. Economic: Infrastructure costs to develop renewable hydrogen facility. (**Private:** Manufacturing industry – hydrogen)	1. Note that these costs are likely to be significant and work is already underway via the Renewable Hydrogen Action Plan. This will include developing an electrolyser to produce the renewable hydrogen. Recent plans for 10MW electrolysers in Victoria and WA, required around $30 million in investment[85].

[85] https://www.pv-magazine-australia.com/2021/05/20/australian-first-as-sa-hydrogen-park-gets-green-light/

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
using renewable hydrogen, biogas and/or synthetic gas in place of natural gas and LPG	(**Private:** Hydrogen, biogas and synthetic gas retailers)	Given the very early stage and uncertainty surrounding the development of such local production, this benefit could not be quantified.	2.Loss of revenue for natural gas / LPG distributors, compensating some of the benefits under 2; likely to be of a lower impact to Tasmania GSP as only the retail margin is concerned (as natural gas / LPG is refined elsewhere) (**Private:** Service stations)	Noting that the Tasmanian Government has plans for up to 1000MW means this investment will be significant. In addition, it will require working with TasNetworks to assess the network requirements at identified sites including the Bell Bay Advanced Manufacturing Zone, and exploring options for minimising network costs. Water requirements will be assessed in consultation with TasWater and TasIrrigation. Port requirements for export will be assessed in consultation with TasPorts 2. The option will have a large impact on the consumption of natural gas and LPG in the state. This option also represents a risk of stranded assets which needs to be managed at the state level as for option 2.

2.5 Agriculture

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
Option 1: Low methane livestock via feed supplements that inhibit enteric methane fermentation and breeding low emitting animals	1. Economic: Livestock productivity gains from feeding methane inhibitors and breeding low emitting animals could deliver over $100 million per year in 2050 in additional revenue to Tasmania's GSP. (**Private:** Farmers) 2. Economic: Revenue generated through the sale of Tasmanian grown seaweed (Asparagopsis taxiformis). (**Private:** Seaweed retailers) 3. Environmental: Asparagopsis contributes to healthier oceans as it de-	1. It was assumed that feeding methane inhibitors and breeding low emitting animals provide a 5% productivity gain. This will increase financial returns on sold animals up to 2050. 2. This benefit will only be realised if the Tasmanian seaweed production can compete with production in SA / NSW[87], where they partner with indigenous partners to manage seaweed crops. Given the very early stage and uncertainty surrounding the development of such local production, this benefit could not be quantified. 3. n/a	1. Economic: Increased operational costs for famers for feed supplements of up to $70 million per year in 2050. (**Private:** Farmers)	1. Feed supplements for feedlot animals were based on the assumption that a supplement to reduce methane emissions will become commercially available at an annual cost of $54.75 per head of cattle and $10.95 per sheep (Cotter et al. 2015). This was the latest research available on the expected costs of feeding supplement, but note that it is our understanding that more recent papers have shown that feeding seaweed supplements has the potential to reduce feed costs[88]. However, as this is still so uncertain, we have kept the higher cost to be conservative.

[87] https://www.theland.com.au/story/7044054/seaweed-farms-to-help-reduce-cattle-methane/

[88] Roque BM, Venegas M, Kinley RD, de Nys R, Duarte TL, Yang X, et al. (2021) Red seaweed (Asparagopsis taxiformis) supplementation reduces enteric methane by over 80 percent in beef steers. PLoS ONE 16(3): e0247820. https://doi.org/10.1371/journal.pone.0247820

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
	acidifies water, stripping out carbon dioxide[86].			
Option 2: Reducing agricultural soil emissions	1. Economic: Livestock and crop productivity gains could deliver up to $370 million per year in additional revenue to Tasmania's GSP by 2050 and onwards. (**Private:** Farmers)	1.The net economic benefits being derived on-farm from precision agriculture (PA) technologies are highly situational and variable, and there is a gap in the knowledge of the potential economic costs and benefits of precision agriculture, and its impacts on the economy[89]. That said 2018 research by the Cotton Research and Development Corporation has found that the unconstrained implementation of decision agriculture would increase Australia's GDP by 1.5% on 2014/15 levels. In addition, this report found that Overall productivity increased by 10% for dairy farms and vegetables, which our team has used as proxy for all farm types across Tasmania. For changing from diesel to electric irrigation pumps, AgInnovators report that the simple payback period is 3.9 years.	1. Economic: Upfront investment costs for precision ag technologies and can vary widely. This analysis forecasted that the cumulative investment costs could range from approximately $40-135 million in 2050 (depending on the type of technologies and systems deployed). (**Private:** Farmers)	1. PA investments include purchases of equipment, installation charges, and the time and effort spent learning how to use and maintain the technologies. High investment for some precision ag technologies may act as a barrier to some farmers. There is a really wide range in regard to the demand on capital across different technologies. A range of factors affect the investment value of PA including the current farm gross margin, cost of PA equipment, the size of the farm (early adopters tend to be larger), the area and number of years over which the equipment is used and the rate at which benefits from adoption start to occur. The costing for this option was based on cost of $49,000 to $82,000 per farm using estimates from a 2014 study by CSIRO[90], converted to 2020 value, and assuming it is rolled out to 1,700 farms by 2050.
Option 3: Soil carbon sequestration via regenerative agriculture practices	1. Economic: Revenue stream from selling ACCUs generated through ERF Measurement of soil carbon sequestration in agricultural systems method (**Private:** Land-owners) 2. Economic: Crop productivity gains from enhanced soil quality[91]. (**Private:** Farmers)	1. The ERF Plantation Forestry method allows landowners to generate ACCUs (with a weighted average auction price of $16/tCO_{2e}$ in April 2021, notwithstanding compliance costs of generating ACCUs).	1. Economic: Upfront project establishment costs (**Private:** Land-owners)	1. This method will need to be amended for the Tasmanian context before the benefits will outweigh the costs. Currently it offers high transaction costs for small parcels of land – needs a robust method that enables parcels of land to be brought together under one project / audit regime, to reduce the significance of transaction costs. Note however that this barrier may be partly reduced as result of the $5000 advance to support soil method baseline sampling costs

[86] https://www.beefcentral.com/production/methane-reducing-seaweed-project-scores-1m-govt-grant-for-commercial-roll-out/

[89] https://crdc.com.au/sites/default/files/P2D%20Ecomomic%20impact%20of%20digital%20ag%20-%20AFI%20Final%20Report.pdf

[90] https://actfa.net/wp-content/uploads/2014/02/The-Economic-Benefits-of-Precision-Agriculture-Case-Studies-from-Australian-Grain-Farms.pdf

[91] https://crops.extension.iastate.edu/encyclopedia/carbon-sequestration

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
				offered by the Federal Government[92]. In addition, the CER is currently developing a new soil carbon method that will use modelled approaches to reduce overall costs of soil carbon measurement soil carbon and as such support the uptake of soil carbon projects[93].

2.6 Industrial processes

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
Option 1: Use Cement substitutes / Low-emissions cement variants	1. Economic: Energy-related advantage of geopolymer cements is that their manufacture is a low temperature process, so require 30% less fuel than traditional Portland cement. This is because the calcining process (as required by traditional Portland cement production), which requires large heat inputs, is not required. (**Private:** Cement manufacturer)	1. n/a	1. Economic: Uncertain input costs associated with procurement of fly ash required to be imported for geopolymer cement production (**Private:** Cement manufacturer) 2. Economic: Increase in input costs for the construction industry (Uncertain as to whether this will be limited to the short-term only[94]) (**Private:** construction industry) 3. Social and economic: Potential for job losses at cement clinker facility as cement clinker for Portland cement would no longer be	1. One potential cost would be an increase in input costs resulting from the switch from Portland to geopolymer cement. Portland cement is produced using limestone, while geopolymer cements can be made from fly ash (a by-product of coal-fired power stations), ground-granulated blast furnace slag (a by-product of steelmaking) and clay (metakaolin). Over a century of coal-burning has left Australia with more than 400 million tonnes of stockpiled fly ash. These stockpiles, which currently present an environmental problem, should be valued as one of Australia's most readily available mineral resources. Australia has enough fly ash resources to supply an estimated 20 years or more of domestic cement production. That said, the additional costs to import fly ash to Tasmanian from the mainland may mean this opportunity is not financially viable in the Tasmanian context. 2. Despite the fact that they are still an emerging technology, across Australia, geopolymers are already cost competitive, or close to it (10-15% above current Portland cement prices), even without a carbon price (BZE

[92] http://www.cleanenergyregulator.gov.au/ERF/Pages/Choosing%20a%20project%20type/Opportunities%20for%20the%20land%20sector/Agricultural%20methods/The-measurement-of-soil-carbon-sequestration-in-agricultural-systems-method.aspx

[93] http://www.cleanenergyregulator.gov.au/ERF/Pages/Method%20development%20tracker/Soil-carbon.aspx

[94] Despite the fact that they are still an emerging technology, geopolymers are already cost competitive, or close to it (10-15% above current Portland cement prices), even without a carbon price (BZE Report – rethinking cement), and this price difference is likely to come down in future.

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
			produced in Tasmania if this opportunity was rolled out. **(Public:** Population of Tasmania)	Report[95]), and this price difference is likely to come down in future for Australia as a whole. That said, because of Tasmania's island status, the costs for the construction industry to import geopolymer cement from the mainland could be cost prohibitive. 3. Consideration will also need to be given to the broader impacts across the community and supply chain if clinker production was stopped in Tasmania. For example, state-wide freight volumes could be impacted by this closure which could in turn impact the viability of TasRail's freight services, which could impact freighting costs for other manufacturers in the state. This statement would apply for the closure of any large manufacturing site across Tasmania.
Option 2: Use of wood in construction in place of emissions intensive building products	1. Economic: Additional revenue stream for timber products for construction, represents a value transfer from cement manufacturers to forestry (**Private:** Forestry industry (native forests and plantations)) 2. Economic: -Decrease in material costs (approx. 10% through switching to timber)[96] (**Private:** construction industry)	1. The impact would be a net benefit - increased revenue from more timber used in the construction industry. However, across the Tasmanian economy as a whole it is likely that there would be no significant net difference in value, as this opportunity involves a transfer of value from the cement industry to the forestry industry. 2. Previous analysis by Indufor (Forest Residues Solutions Study Stage 2 – Detailed Options Analysis) identified the timber cost savings for a range of buildings compared with using cement. Using the average timber cost savings (9.5%), and the 7% timber displacement rate, the construction industry could save around 1% on material costs in 2050 by switching to structural engineered wood products (CLT).	1. Economic: Decrease in revenue from a reduction in cement sales; represents a value transfer from cement manufacturers to forestry (**Private:** Cement manufacturer)	1. This will have impacts on the value added by the cement industry, as less cement is used through improved design and substitution with engineered wood products. However, as the value provided by the cement industry to Tasmania's GSP is not publicly available, it is not possible to determine the loss to the industry.
Option 3: Carbon-free aluminium smelting	1. Economic: Possible opening of new markets and additional margins (premium product) (**Private:** Aluminium manufacturers)	1. Highly speculative opportunity due to the uncertainty around investment required, technology and ability to serve export markets from Tasmania, hence potential impact on GSP was not quantified.	1. Economic: Large capital investment to retrofit Bell Bay smelter (**Private:** Aluminium manufacturers)	1. This opportunity would require a large capital investment to retrofit the Bell Bay smelter. However, as this is such an emerging technology, costs are not available. It is not envisaged that this technology would bring about productivity improvements, but could be a condition to remain competitive. Note that Bell Bay's owner Rio Tinto has formed a joint venture with Alcoa,

[95] https://bze.org.au/wp-content/uploads/2020/12/rethinking-cement-bze-report-2017.pdf

[96] Previous analysis by Indufor (Forest Residues Solutions Study Stage 2 – Detailed Options Analysis, table 4-5

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
				Apple and the Government of Quebec supported by the Government of Canada which looks to scale up and demonstrate the economic viability of an alternative process for making aluminium that does not release CO_2 as part of the underlying chemical reaction. The joint venture referred to above is called Elysis and last year completed the construction of its industrial research and development centre in Quebec. Therefore, there may be the opportunity that Rio Tinto would use Bell Bay as one of the smelters to use this technology, but retrofitting would be required, and timing is uncertain.
Option 4: Low-emissions ferromanganese (substituted by bio-coke and / or through the use of green hydrogen as a reduction agent for iron ore	1. Economic: Additional revenue stream from sale of forest residue for biocoke production, could result in $45 million per year by 2050 in additional value added to Tasmania's GSP. (**Private:** Forestry industry (native forests and plantations))	1. Revenue stream from sales of forest residue to charcoal producers / ferromanganese producers. At current biomass (assumed to be "Other stemwood") delivered costs of $100/tonne. This is a transfer from coke producers, who are assumed not to be located in Tasmania. This would reduce Tasmania's reliance on imports.	1. Economic: Increase in energy costs resulting from switching from coking coal to biocoke. (**Private:** Ferromanganese manufacturer) 2. Economic: Increase in energy costs resulting from switching from coking coal to hydrogen (**Private:** Ferromanganese manufacturer)	1. Costs of forest residues (Other stemwood) are $100/tonne, while the cost of coal is $183/tonne. However, the yield ratio of bio-coke from residues is about 8: 1, therefore switching to bio-coke could result in a large increase in fuel costs for ferromanganese producers, of up to $45 million in 2050, while the cost of coal would be around $10 million. At current bio-coke and coking coal prices, this would represent a significant net cost for ferromanganese manufacturers. Unless the costs of bio-coke (charcoal) decrease significantly, it is highly unlikely that industry will implement this opportunity. 2. Note that the production of pure renewable hydrogen based steel is not expected to be cost competitive with traditional processes until between 2030 and 2040[97] until renewable hydrogen reaches price parity with coking coal. Until then, the cost of the steel is projected to be some 60 to 90% higher than existing methods[98].

[97] https://www.forbes.com/sites/kensilverstein/2021/01/25/we-could-be-making-steel-from-green-hydrogen-using-less-coal/?sh=60a5bd073e5c

[98] https://ectltd.com.au/green-steel-articles-omit-cost/

2.7 Waste

Opportunity description	Benefits	Commentary on benefits	Costs	Commentary on costs
Option 1: Reduce waste to landfill and deployment of additional landfill gas capture technology	1. Economic: Energy substitution from capturing and combusting additional landfill gas. (**Public and private:** Landfill operators) 2. Economic: Revenue stream generated through selling ACCUs generated through ERF Landfill gas method (**Public and private:** Landfill operators)	1. Note because of the very low materiality of capturing additional landfill gas on the emissions pathways, the economic benefits have not been quantified.	1. Economic: landfill gas capture equipment cost. (**Public:** State or local government) 2. Economic: Increase in waste related expenses for Tasmanian households and businesses – cost transfer from government above. (**Private:** Households and businesses)	1 and 2. Note that any costs of this opportunity will likely be recouped as part of the state-wide landfill levy to be introduced this year. The Tasmanian Liberals have made commitments related to waste-related projects of about $14million. These include: - invest $4.5 million to improve organics collection and reprocessing infrastructure across Tasmania - invest $3 million to partner with industry to invest in a rubber crumbing plant and provide an additional $4 million over four years to help the industry transition - provide $1 million over four years to phase out single use plastics - provide $5.5 million towards the Recycling Modernisation Fund grants program to build Tasmania's plastics reprocessing capacity
Option 2: Increased methane capture from industrial wastewater treatment	1. Economic: Revenue stream generated through selling ACCUs generated through ERF via the Domestic, Commercial and Industrial Wastewater method. (**Public and private:** Wastewater treatment plant operators)	1. As more methane gas is captured and combusted, can be used to offset on-site electricity use or heat use (operational savings).	1. Economic: Upfront investment costs for additional gas capture and energy production equipment. (**Public and private:** Wastewater treatment plant operators)	1. WWTP operators in Tasmania may be willing to invest in methane capture and combustion equipment as the water sector has typically been one of the first to set net zero targets e.g. the Victorian water sector has committed to reducing its emissions by 42% by 2025 and to net-zero by 2050.