ENERGET1°C5

Net zero ambitions

Now comes the hard part

Dr Gordon Weiss | 25 May 2023

1.0 Where we are today

Australia has committed to reducing its emissions by 43% by 2030 and reaching net zero emissions by 2050, as part of its obligations under the Paris Agreement. This target was legislated by the Albanese Government in 2022, after it won the 2022 federal election on a platform of stronger climate action.

Australia's emissions reduction target has been a source of political controversy and instability for over a decade. Different parties and factions have held different views on how to balance economic interests and environmental responsibilities. The new target was welcomed by many stakeholders, including business groups, unions, farmers, and environmentalists, who see it as an opportunity to end the "climate wars" and provide certainty and confidence for investors and consumers[1]. The target is a significant improvement on the previous target of 28% by 2030, which was set by the Abbott government in 2015 and maintained by subsequent governments until 2021.

However, setting a target is the easy part. The hard part is achieving the target. This paper examines this second point - the challenges faced by Australia in achieving its greenhouse emissions target.

1.1 Headwinds – Australia is not on track to meet its target

Despite actions taken by governments in Australia, the nation is not on track to meet its 43% reduction target[2]. The most recent *Annual Climate Change Statement*[3] outlines the issues.

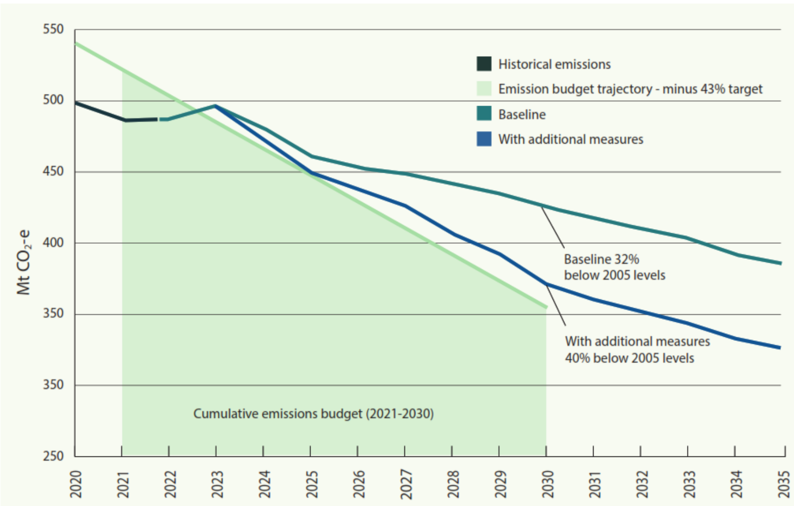

Figure 1: Australia's emissions projections baseline and 'with additional measures' scenario, 2020 to 2035, Mt CO_2-e[4]

[1] Australia Legislates Emissions Reduction Targets | Prime Minister of Australia (pm.gov.au)
[2] Federal government releases first 'climate change statement', but Australia remains behind on emissions targets - ABC News
[3] DCCEEW | Annual Climate Change Statement
[4] DCCEEW | Annual Climate Change Statement

Figure 1 shows Australia's projected emissions for two scenarios. The baseline scenario largely reflects policies and actions implemented by previous governments and points to a 32% reduction in emissions compared to 2005 levels by 2030 in line with the nation's previous emissions reduction target.

The impact of certain additional measures proposed by the current Australian Government is also shown in Figure 1. These measures were outlined in the then Labor Opposition's *Powering Australia* report[5]. The two major additional measures are achieving an 82% national renewable electricity target by 2030 and implementing the Safeguard Mechanism reforms. The Government's projection suggests that Australia is on track to reduce emissions by 40% on 2005 levels by 2030 through these two measures. With other measures in *Powering Australia* such as some elements of the *Powering the Regions Fund*, the *National Electric Vehicle Strategy*, and the *National Energy Performance Strategy*, the Government claims it is confident of achieving the 43% emissions reduction by 2030.

A look at the trends in Australia's emissions in recent times highlights the task ahead. A summary of the insights is below. More details are in the Appendix.

1.2 Emissions: past, present, and future

In the period from 2012 to 2022, Australia's annual emissions fell by 94 Mt CO_2-e per year, a reduction of 16%. Two thirds of the reduction in emissions came from land use changes (LULUCF), with most of the remainder coming from decarbonisation of electricity. Emissions from stationary energy rose by 16 Mt CO_2-e per year over the period. The average rate of emissions reduction was 9.4 Mt CO_2-e per year. This needs to increase to at least 17 Mt CO_2-e per year, on average, for the next eight years to 2030. The start has not been good, with Australia's emissions rising slightly from 2021 to 2022.

The Australian Government looks to the electricity sector to deliver an average emissions reduction of 11 Mt CO_2-e per year, a 60% uplift on the annual reduction observed for the past decade. The evidence suggests that this will not be realised. In addition, beyond reductions in the electricity sector, it is not clear where emissions abatement will come from. The Safeguard Mechanism reforms place an obligation on large emitters to reduce their emissions. However, there must still be technologies or other measures available to these large emitters in the period to 2030 to reduce their emissions. Analysis by Energetics suggests that this is not the case.

So, Australia will struggle to achieve a 43% reduction in emissions by 2030. Further, certain major barriers that will prevent Australia from reducing its emissions cannot be overcome through government actions but are linked to technical and engineering limitations, cost pressures and supply chain constraints.

However, the challenge to stop and then reverse the impacts that humans are having on Earth's climate is a multi-decadal task with different actions spanning different time periods. Ambition must not wavier despite the task becoming more difficult.

[5] Powering Australia | energy.gov.au

2.0 Headwinds

In this paper, we explain why Australia won't meet the 2030 emissions reduction target. This section provides a summary of our conclusions. The evidence and the analysis are presented in the Appendix.

2.1 Electricity

The 43% emissions reduction target is underpinned by 82% renewable electricity supply. Energetics firmly believes that an 82% renewable electricity supply (or for that matter a 100% renewable electricity supply) is achievable. However, that is not the question being explored here but rather whether an 82% renewable electricity supply can be realised by 2030.

AEMO examined operating the NEM at 100% renewable penetration. They were concerned about instantaneous high variable renewables penetration as a way point on the journey to a network that is 100% renewable[6]. *The Engineering Roadmap to 100% Renewables*[6] report noted that operating a gigawatt-scale power system at 100% instantaneous renewable generation is a feat unparalleled worldwide; and that the inverters used in a 100% instantaneous renewable network don't inherently deliver the stabilising attributes that traditional synchronous generators provide to the power system.

AEMO found that it is possible for Australia's electricity supply to be 100% renewable and certainly 82% renewable as required by the 43% emissions reduction target. It requires a substantial investment in variable renewable generators and utility scale and distributed energy storage.

But whether it can be done is only half the issue.

Achieving the 82% renewables penetration requires a significant uplift in the pace of the decarbonisation of the power system. Yet the sector is facing headwinds in its quest for additional wind and solar PV generation. They include:

- Uncertainty around the closure of coal-fired power stations
- Slowing investment in renewable generation
- Delays to key additions to the transmission infrastructure
- Community opposition slowing new wind farms and transmission lines
- Long-term storage projects are unlikely to be completed in time
- Rising costs of renewable energy generation.

The barriers discussed above will make it highly unlikely that Australia will achieve 82% renewable energy penetration. Predicting how far short Australia falls of the 82% target is difficult. We discuss possible scenarios in a later section.

2.2 The Safeguard Mechanism and stationary energy

The reformed Safeguard Mechanism (SGM) is expected to make an important contribution to achieving the 43% emissions reduction target. Unfortunately, on-site options for reducing the use of stationary energy at covered facilities are limited in the period to 2030. The scale of many on-site abatement project options such as electrification of LNG train compressors, electrification of materials movement in mining operations, and mechanical vapour recompression in alumina refineries means that it can take several years to implement. This will limit their potential impact in the period to 2030.

Further, the widespread adoption of electrification is challenging because even if it was technically and economically feasible to implement electrification in the period to 2030, it would impose more load on an already constrained electricity system.

In the absence of on-site opportunities, the covered facilities will be forced to acquire and surrender Australian Carbon Credit Units (ACCUs). This is not a desirable outcome as biosequestration is not a long-term option for carbon removal – there are constraints to the quantity of historical and current emissions that can be stored in biomass and uncertainties in the science. Further, reforestation and afforestation for reasons of carbon removal constrains future use of the land for other purposes. Finally, there is a five-year delay between planting trees and realising significant carbon sequestration due to the growth profile of trees.

The use of ACCUs to realise a short term target is challenging unless we are confident that there will always be a plentiful source of ACCUs to offset the hard-to-abate sectors in the years approaching 2050.

2.3 Other measures

The most recent projection (see Figure 1) has Australia's emissions reduction still falling short of the amount required to achieve the 43% reduction target even after the 82% renewable energy target is realised and the reforms to the SGM achieve the desired emissions reduction. The *Powering Australia Plan*[5] includes several measures to reduce emissions from transport. They can be broadly grouped into measures such as consultation and strategies leading to the development of fuel efficiency standards for light vehicles; and measures to stimulate the purchase of electric vehicles. We find that the measures in *Powering Australia* aimed at reducing emissions due to transport are unlikely to have sufficient impact before 2030 to contribute much to closing the gap to the 43% target.

2.4 How far short?

The primary source of emissions reduction is the achievement of 82% renewable electricity generation, and this is increasingly unlikely to be achieved by 2030. Emissions reduction to 2030 will also come from facilities covered by the Safeguard Mechanism, but there are limited technological options available in the period to 2030 for sites to reduce their on-site emissions. The facilities will be forced to acquire and surrender ACCUs.

Here we look at some potential emissions trajectories to 2030 to show the extent of the shortfall against the 2030 target.

Realistic abatement from the electricity sector

The most recent projection sees emissions from power generation falling by 93 Mt CO_2-e to around 46 Mt CO_2-e. We present evidence in the Appendix of this report that indicates that the desired extent of decarbonisation of electricity will not be attained.

Figure 2 gives some clues as to the reduction in emissions for the electricity sector that can be reached. The figure shows a steady reduction in emissions from the sector since 2016. This would be due to a combination of reductions in demand and reduction in emissions intensity. It also compares the most recent Government projection of emissions from the sector and the projection of the trend seen since 2016. If this trend continues to 2030 then the emissions in 2030 will be 107 Mt CO_2-e, and the reduction in emissions will be 64 Mt CO_2-e.

Given the focus on decarbonising power generation, the reduction in emissions is likely to end up between 64 Mt CO_2-e and 93 Mt CO_2-e. The emissions reduction target required emissions from the electricity sector to fall by 110 Mt CO2-e, and so the likely outcome will fall short by between 17 Mt CO_2-e and 46 Mt CO_2-e.

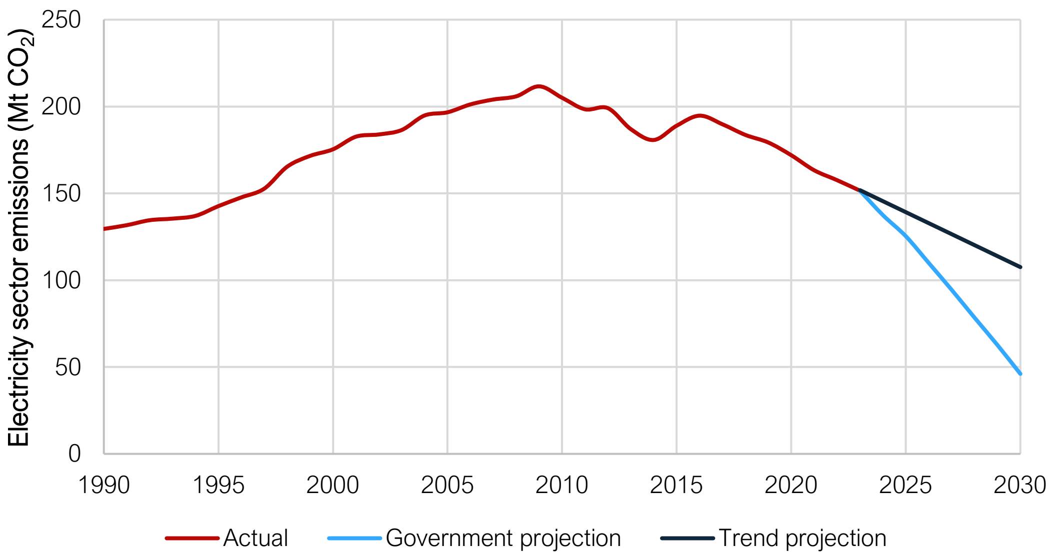

Figure 2: Projections of emissions from the electricity sector[7]

Potential impact of the Safeguard Mechanism

The *2022 Annual Climate Change Statement* suggested that the reforms to the SGM would deliver 46 Mt CO_2-e of additional abatement beyond business as usual. Emissions from entities covered by the SGM largely correspond to Australia's fugitive emissions and emissions from stationary energy which means that both must fall significantly if the SGM is to deliver the necessary abatement (without recourse to offsets). The Australian Government expects emissions from stationary energy to remain steady in the years to 2030 and for fugitive emissions to rise by 2 Mt CO_2-e. The government is anticipating that because of the reforms to the SGM, a series of large-scale abatement measures will be implemented at large facilities. Energetics questions whether these savings can be delivered in the six years to 2030.

On the other hand, a more focused effort to reduce the demand for stationary energy at large facilities could double the rate of improvement to stationary energy productivity. Stationary energy productivity is the ratio between value added and stationary energy used. This will leave the SGM short by some 31 Mt CO_2-e of emissions reduction delivered through on-site activities. See the appendix for details.

In all, the reduction in emissions could fall short by up to 80 Mt CO_2-e although the actual figure is expected to be less than that. So, what can be done to find up to an additional 80 odd Mt CO_2-e of abatement necessary to meet the 2030 emissions reduction target of a 43% reduction in emissions relative to 2005?

That is a key question for Australia.

[7] Source: Energetics analysis of Australian National Greenhouse Accounts data

3.0 What can a government do?

There are actions that governments can take to increase the likelihood of reaching their emissions reduction target. These actions include:

- **Strengthening the policy framework**: Fixing the 43% reduction target in law and tightening the Safeguard Mechanism.
- **Supporting renewable energy**: The decarbonisation of Australia's electricity supply was driven by the Renewable Energy Target. The RET schemes will continue to operate until 2030 and encourage investment in large-scale renewable power stations to achieve 33,000 gigawatt hours of additional renewable electricity generation by 2020 (Large-scale Renewable Energy Target) and encourage the installation of small-scale renewables, such as household solar rooftop panels and solar hot water systems (Small-scale Renewable Energy Scheme). Current investments in renewable energy are supported by electricity consumers through the widespread adoption of power purchase agreements (PPA)[8]. A PPA offers surety of future power and renewable energy certificate prices and therefore reduced energy price risk. The renewable energy industry has called for extensions to the RET to accelerate the decarbonisation of electricity in Australia[9].
- **Carbon pricing mechanisms**: The enhanced Safeguard Mechanism (SGM) effectively introduces a large carbon market into Australia[10]. The SGM requires large greenhouse gas emitters in Australia to reduce their emissions in line with the national target. If their own emissions exceed their target, they must purchase and surrender Australian Carbon Credit Units (ACCU) so that their net emissions (actual emissions less ACCUs surrendered) are below the target.
- **Promote new technologies**: Governments in Australia have been supporting innovation and research in clean energy technologies, such as hydrogen, carbon capture and storage, battery development and low-emissions agriculture through agencies such as the Australian Renewable Energy Agency (ARENA) and the Australian Research Council (ARC).

Australia is doing many of the actions needed to achieve the emission reduction target. What else is needed?

3.1 Let's talk about the challenges and the options

A national conversation should start with a realistic look at the cost of renewable electricity. Analysis of the levelised cost of electricity suggests that renewable electricity is the cheapest. Reports by the CSIRO (Gencost)[11] and Lazard[12] clearly support the view that renewable electricity (and even firmed renewable electricity) is the lowest cost option. However, that has not been the reality on the ground where recent rises in electricity retail costs swamp the longer-term drift down of prices experienced a few years ago[13].

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[8] *Corporate Renewable PPA Deal Tracker | Energetics*
[9] *Extend the RET: Wind industry giants call for reboot of federal renewables incentive | RenewEconomy*
[10] *Safeguard Mechanism Reforms (dcceew.gov.au)*
[11] *GenCost: annual electricity cost estimates for Australia - CSIRO*
[12] *2023 Levelized Cost Of Energy+ | Lazard*
[13] *Inquiry into the National Electricity Market: June 2023 Report (accc.gov.au)*

Oosthuizen et al (2022)[14] determined the effect of the increasing renewable electricity share on retail electricity prices for 34 OECD countries, considering the change in market structure for 23 EU countries. Their results showed that the influence of the renewable energy share in the energy mix on retail electricity prices is positive and statistically significant ie rising renewable share results in higher prices.

Forbes[15] also examined the paradox of falling renewable costs and rising electricity prices. It highlighted the complexity of an electricity grid and how falling wholesale electricity prices (driven by variable renewable generators) should not necessarily cause overall electricity prices to fall as the wholesale cost is less than 50% of the overall cost.

The constraints that are slowing the deployment of variable renewable generation have been highlighted in this report. Constraints don't just apply to the installation of variable renewable generators but also extend to the deployment of necessary transmission lines and energy storage for firming. Relieving these constraints is possible but will come at a cost. One way or another, this cost is funded by electricity users, and could see higher electricity prices.

Net Zero Australia's mobilisation report[16] suggests that the net zero transition will cost Australia a cumulative total of around $1.5 trillion in the period from 2020 to 2030. That figure represents around 6% of the cumulative GDP over the same period. While many of the initiatives in Net Zero Australia's mobilisation plan offer economic benefits over the long term and were already in train, the redirection of 6% of GDP to the net zero transition will be a significant economic disruption.

3.2 Remember the first (or is that the forgotten) fuel

The International Energy Agency (IEA) begins its 2022 report into the status of energy efficiency with the following quote in the Abstract:

> *This year record-high consumer energy bills and securing reliable access to supply are urgent political and economic imperatives for almost all governments. In response to the energy crisis countries are prioritising energy efficiency action due to its ability to simultaneously meet affordability, supply security and climate goals[17].*

The IEA sees accelerated action on energy efficiency and that related avoided energy demand measures can reduce final energy demand by around 5% in 2030 while the global economy grows by 40%. This corresponds to an annual 5.6% improvement in economy-wide energy productivity. Stated policies will result in a 2.4% annual improvement in energy productivity. So the IEA believes that a doubling in the improvement of energy productivity is possible. The question is where to direct the efforts. Figure 3, from the IEA, provides some direction. It shows that the largest emissions reductions will come from improving the energy performance of transport (ie electric vehicles and improvements in fuel efficiency for remaining petroleum powered vehicles).

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[14] Anna Maria Oosthuizen, Roula Inglesi-Lotz, George Alex Thopil, "The relationship between renewable energy and retail electricity prices: Panel evidence from OECD countries", Energy, Volume 238, Part B, 2022, *https://doi.org/10.1016/j.energy.2021.121790*
[15] *The Paradox of Declining Renewable Costs and Rising Electricity Prices (forbes.com)*
[16] *How to make net zero happen - Net Zero Australia final report 12 July.pdf*
[17] *Energy Efficiency 2022 (windows.net)*

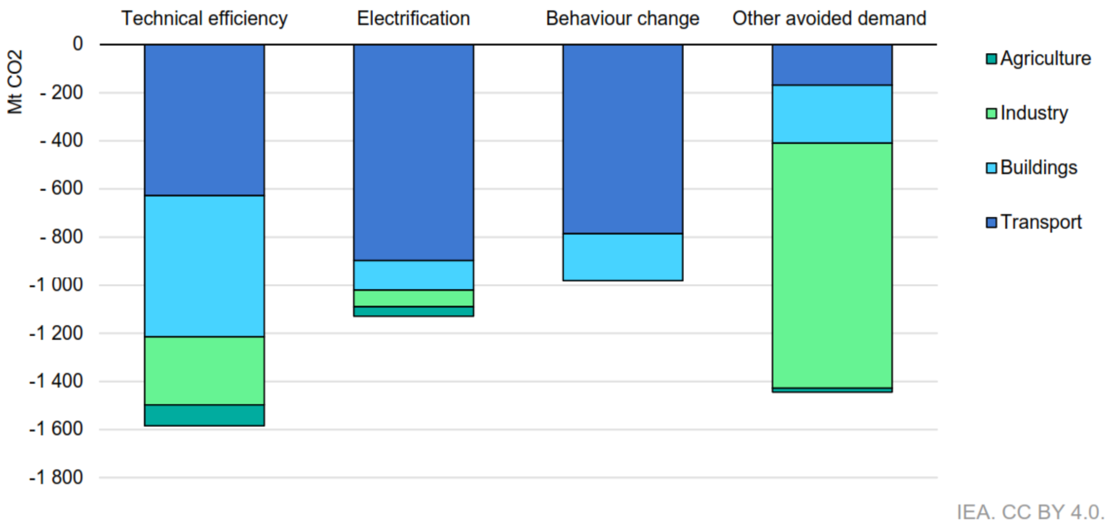

Figure 3: Emissions reduction by efficiency-related mitigation measures in the IEA's Net Zero Scenario 2020-2030[17]

Significant savings can also be delivered by improvements to the energy performance of industry. But in the IEA's latest report into the status of energy efficiency, the IEA reported disappointing progress with respect to energy efficiency improvements in industry. The IEA noted that industrial demand is pushing global energy consumption higher as intensity progress slows. This is certainly the case in Australia.

The other avoided energy demand shown in Figure 3 comes from measures such as digitalisation such as smart controls and the application of data science and AI, material efficiency including the increased recycling of plastics and scrap steel and fuel switching such as electrification of process heating[18]. These technologies are available today, and unlike the "big bang" measures such as electrification of LNG trains discussed earlier are much easier to implement. Many industrial processes involve chemical reactions and high-temperature heat that cannot be fully decarbonised with current commercially available technology. The IEA reports that around 60% of heavy industry emission reductions by 2050 come from technologies that have been proven to work but are not currently market ready[19]. However, many of the measures based on digitisation, material efficiency and fuel switching can be implemented immediately.

An effective Energy Management System (EMS) such as one compliant with ISO 50001[20] will aid the deployment of measures aimed at improving energy performance. Based on an extensive literature review, Prasetya et al[21] found significant improvements in energy performance and reduced emissions with the implementation of an EMS. There was also a positive correlation between improvement energy performance and total energy cost savings. In a comparison of the potentials of companies with an EMS and companies without an EMS, Knayer and Kryvinska[22] found a positive effect of the EMS on energy efficiency in general and on individual measures such as lighting technology, energy monitoring and peak load management.

The message here is that faced with a requirement to reduce energy use or emissions such as those facilities covered by the SGM, business should consider implementing an energy management system and use the EMS to improve the energy efficiency of a facility.

[18] 7th Annual Global Conference on Energy Efficiency (windows.net)
[19] Industry – Analysis - IEA
[20] ISO - ISO 50001 — Energy management
[21] B Prasetya et al 2021 IOP Conf. Ser.: Earth Environ. Sci. 926 012077
[22] Knayer, T., Kryvinska, N. The influence of energy management systems on the progress of efficient energy use in cross-cutting technologies in companies. *Energy Efficiency* **16**, 12 (2023). https://doi.org/10.1007/s12053-023-10086-9

3.3 Understand the issues

The transition to net zero emissions will be costly. We have already mentioned the Net Zero Australia's mobilisation report[23] and its suggestion that the cost will be $1.5 trillion in the period 2020 to 2030. That is for a managed transition. A disorderly transition is likely to be more costly.

It is therefore essential that policy makers understand where the roadblocks are. It is no use establishing a policy framework to drive investment in new renewable generation if a shortage of transmission infrastructure constrains the output of renewable generators. Similarly, it is of limited value to force the approval of the required transmission infrastructure against the strong opposition of local stakeholders if a lack of skilled workers mean that the transmission lines cannot be built in a timely manner, or if private investors are reluctant to invest in projects that lack local support.

Unfortunately, the recognition of the major constraints that are slowing the transition to net zero emissions may bring with it the need for a different narrative – one focused on 2035 (and 2040). This is not to say that the 2030 target is not important. Australia must continue to pursue the 2030 target provided this does not result in the loss of stakeholder support due to economic and social disruption.

3.4 Step outside the comfort zone

Plan A, as outlined in the *2022 Annual Climate Change Statement* and *Powering Australia* is unlikely to deliver the necessary abatement to reach to 43% reduction target. In this paper, we have presented evidence to support this assertion. There are several other factors which further reinforce this conclusion.

Australia is not alone in pursing the net zero transition, and evidence has been presented in this paper that points to upward pressure on the cost of the clean energy transition. There has been much discussion of new mines to extract the minerals critical to the clean energy transition and constructing new factories to make the solar panels, wind turbines and other necessary components. These will take several years to realise and, in the meantime, the global demand for minerals and equipment will continue to rise. Further, there are a range of exciting technologies (eg sodium ion batteries, perovskite solar panels) that could significantly reduce the cost of the transition over the longer term. This reinforces the view that the cost of abatement in the period to 2030 will be much higher than the cost of abatement in the next decade.

One of the factors contributing to the delay in achieving the necessary abatement is the time taken to implement major projects such as the construction of transmission lines. Australia has a robust system of regulatory controls to minimise the adverse social and environmental impacts of major developments. One question for Australia is whether it is willing to relax some of the controls around major projects to accelerate the clean energy transition (or at least, stop it from slowing down any further).

Finally, project proponents and other stakeholders have flagged the shortage of appropriate skills - a global problem, affecting multiple industry sectors[24, 25, 26, 27]. The issue for Australia is not just introducing more appropriately skilled workers into the economy but ensuring they are directed towards the net zero transition rather than responding to other demands such as the construction of additional housing[28, 29]. Further, moves to increase skills training now will take half a decade to

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[23] How to make net zero happen - Net Zero Australia final report 12 July.pdf
[24] Skill shortages and labour market tightness: a global perspective | National Skills Commission
[25] Tech Skills Shortage Puts World-Leading Ambition At Risk, Report Warns (forbes.com)
[26] 3 Strategies to Overcome The Future Skills Shortage (forbes.com)
[27] MPI - Mining's inability to attract talent an existential crisis: report (mpirecruitment.au)
[28] Powering the transition: The net-zero workforce challenge (2023) © CEDA 2023
[29] Carbon challenge: Skills shortage could be the biggest threat to the green boom (afr.com)

impact the pool of skilled workers available to projects aimed at reducing Australia's emissions – again too late to benefit the 2030 target.

So, what is Plan B? There are several options:

- Use the power of government to direct the resources of the economy towards the clean energy transition – the so-called "War Economy" approach. Such an approach can overcome some domestic barriers (eg protests by landowners to installation of power lines) but brings economic and political costs. It will also require a significant acceleration in the deployment of major projects which will result in adverse environmental and social outcomes. Disruption to the economy driven by governments pursing an unachievable target may see governments in Australia lose their mandate to pursue any significant emissions reductions. Most importantly, actions by governments in Australia cannot effectively address constraints that are global in nature.
- Acknowledge that the targets to 2030 cannot be achieved in an economically and politically sustainable manner but focus national resources on advancing low-emissions technologies for the next decade. Examples of these emerging technologies include new types of batteries, more efficient, lower cost electrolysers for green hydrogen production, and new industrial process could lead to low-cost abatement in the next decade. This will require a major and sustained uplift in investment in research and development compared to the norm for Australia.

There has been much discussion about the use of small modular nuclear reactors (SMR) to support variable renewable generators. Former Chief Scientist Alan Finkel[30] argues the opportunity to be one for a later stage in the transition, and not for consideration in the short term. He stated "There are no SMRs operating in the UK, Europe, Canada, the US or any other OECD country. Nor are any SMRs under construction or approved in an OECD country. There is no data to support any claims about how much SMRs will cost when deployed as operating power stations. Still, introducing nuclear power when we can, starting in the 2040s, would bring benefits".

3.5 But don't lose sight of the end game

Updated emissions reduction pledges submitted by countries ahead of the COP26 in Glasgow saw a strengthening of global ambition compared to the 2015 Paris pledges. However, studies have found that limiting global warming to below 1.5 °C this century will require countries to increase ambition for 2030 and beyond. Iyer et al[31] found that increasing near-term ambition through 2030 will be crucial to limiting peak temperature changes. The current levels of commitment could still deliver end-of-century temperature change of less than 1.5 °C but would result in higher temperature overshoot over decades leading up to the end of the century.

The IPCC has also modelled global pathways that limit warming to 1.5°C with a probability above 50% with no or limited overshoot, and found that more rapid and deeper near-term emissions reductions through to 2030 are required[32]. This will also see less net negative CO_2 emissions and less carbon dioxide removal in the longer term compared to than pathways that return warming to 1.5°C after a high overshoot.

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[30] Updated, 8.4.2024. *Finkel, A | Here's why there is no nuclear option for Australia to reach net zero*

[31] Iyer, G., Ou, Y., Edmonds, J. *et al.* Ratcheting of climate pledges needed to limit peak global warming. *Nat. Clim. Chang.* **12**, 1129–1135 (2022). ***https://doi.org/10.1038/s41558-022-01508-0***

[32] IPCC, 2022: Summary for Policymakers [P.R. Shukla, J. Skea, A. Reisinger, R. Slade, R. Fradera, M. Pathak, A. Al Khourdajie, M. Belkacemi, R. van Diemen, A. Hasija, G. Lisboa, S. Luz, J. Malley, D. McCollum, S. Some, P. Vyas, (eds.)]. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.001.

Climate science says that 3°C of global warming will move society into a dangerously uncertain future[33, 34]. In fact, global temperature rises of 2°C will have significant adverse impacts on society[35].

Some experts and advocates argue that Australia's target is still not ambitious enough to meet its share of the global effort to limit warming to well below 2ºC above pre-industrial levels, as required under the Paris Agreement. They call for a higher target of 75% by 2035, which would require a faster transition away from fossil fuels and more investment in renewable energy and low-carbon technologies.[36] The social and economic impacts of higher global temperatures resulting from excessive emissions are not discussed in this report although we touch on them in a latter section.

But whether it is a 43% target or a higher (75%) target, the challenge remains, and Australia needs to reassess its approach to achieving its emissions abatement target.

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[33] *This is what 3°C of global warming looks like (economist.com)*
[34] *COP26: what would the world be like at 3°C of warming and how would it be different from 1.5°C? (theconversation.com)*
[35] *Why 2C of global warming is so much worse than 1.5C | World Economic Forum (weforum.org)*
[36] *No time to lose: emissions projections for industry, transport and fossil fuels show where Australia needs to lift | Climate Council*

Appendices

Appendix A: Emissions: past, present, and future

In its first Annual Progress Report[37], the Climate Change Authority (CCA) noted that:

> *Achieving Australia's 2030 and 2050 targets means sustaining and stepping up its decarbonisation rate to at least 17 Mt $CO_{2\text{-}e}$ per year, on average, for the next eight years to 2030. That means continuing with the progress of previous years and adding more. Compared to now, on average emissions need to be 17 Mt $CO_{2\text{-}e}$ lower in year one, 34 Mt $CO_{2\text{-}e}$ lower in year two, and so on until the end of the decade.*

Figure 4 taken from the Climate Change Authority's report shows that Australia has not started well. The figure shows the contributions to the slight rise in national emissions between 2020 and 2021.

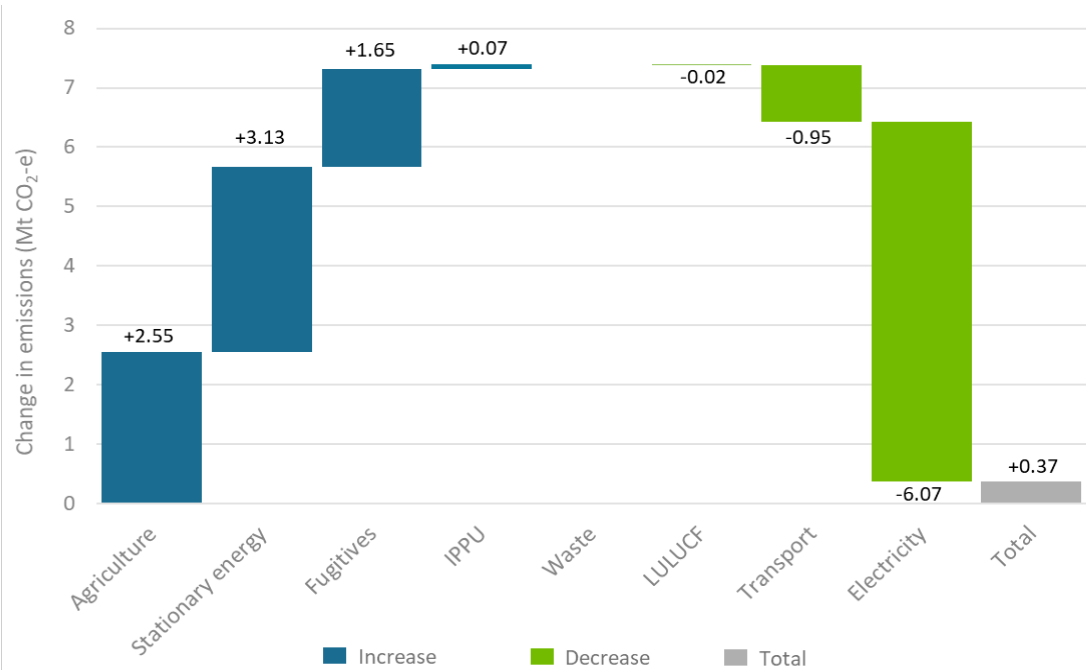

Figure 4: Emissions change from 2020–21 to 2021–22 by sector

Emissions increased between 2020–21 and 2021–22 which makes the emissions reduction requirement in future years even greater. But more important are the sources of the contributions to the slight increase in emissions. The figure shows how emissions from agriculture, stationary energy (primarily heating) and fugitive emissions rose while emissions from transport and the electricity sector fell. The CCA reported that emissions declined in the transport sector due to the policy and behavioural responses to the global pandemic, and that "*this decline in transport*

[37] *Microsoft Word - First Annual Progress Report - final word version (climatechangeauthority.gov.au)*

emissions is not expected to continue without significant policy, behavioural or technological change". So we are left with emissions from electricity decreasing over time and most other emissions sources usually increasing over time.

We see the same result in the change in emissions over the past decade. Figure 5 shows the contributions to the reduction in emissions in the decade to 2022. Much of the emissions reduction came from land use changes (LULUCF). Emissions from the electricity sector also fell but at just over half the rate of the reduction in emissions from the land use sector. Transport contributed a slight fall but since most occurred between 2019 and 2020, the pandemic lockdowns are the most likely cause.

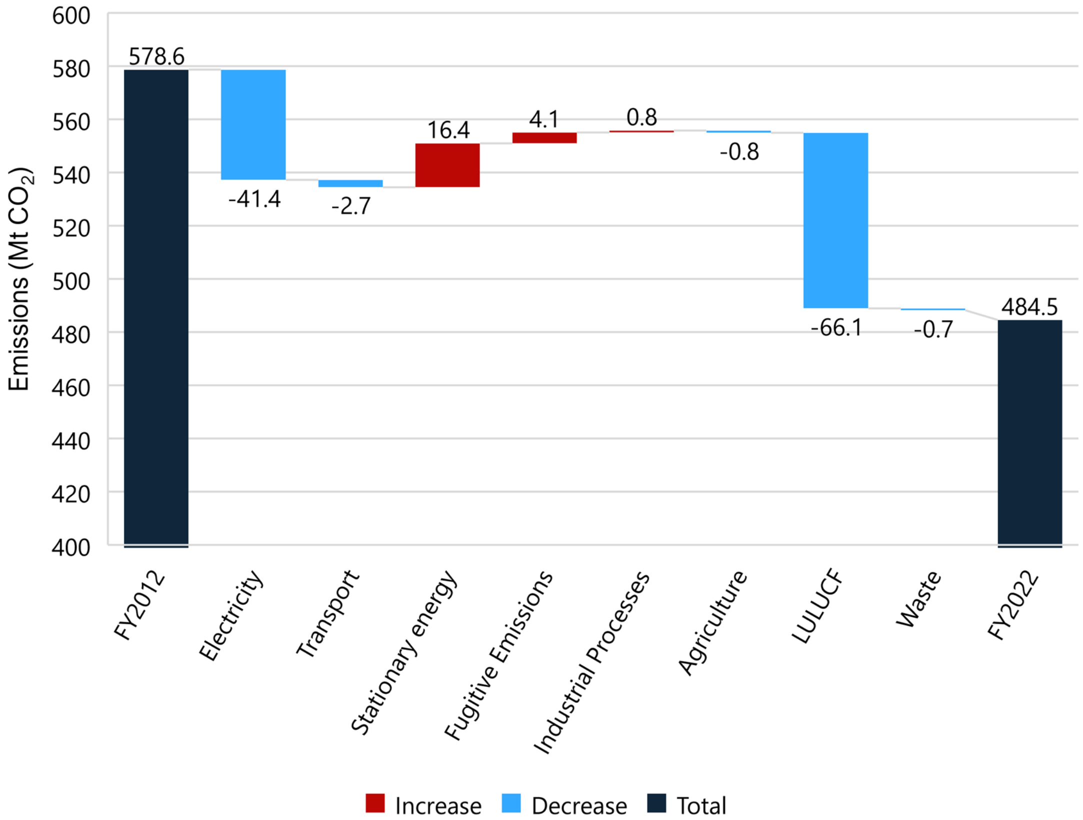

Figure 5: Change in Australia's emissions from 2012 to 2022[38]

The CCA called for a 17 Mt CO_2-e per year reduction in emissions on average, for the next eight years to 2030 if the 43% reduction target is to be realised. Actual reductions for the decade to 2022 averaged 9.4 Mt CO_2-e per year. The average reduction falls to 2.8 Mt CO_2-e per year if the contribution of LULUCF is omitted.

Given the required increase in emissions abatement in the period to 2030 if Australia is to reach its target, we are left with three questions:

1. Can the rate of decarbonisation of the electricity sector be significantly accelerated so that emissions from the sector fall more rapidly?
2. Can emissions from other sectors be reduced or at least stabilised so that the electricity sector and LULUCF sector don't need to do everything?
3. Are the observed reductions in emissions due to the LULUCF sector sustainable and should LULUCF measures (i.e., biosequestration) be used to meet the 43% reduction target?

In the context of these three questions, a look at the forecasts of emissions to 2030 developed by the Australian Government is revealing. Figure 6 and Figure 7, taken from the 2022 Annual

[38] Source: Energetics' analysis of Australia's National Greenhouse Accounts data

Climate Change Statement[3] show the how Australia is expected to achieve the 43% emissions reduction. Combining information in the two figures, we can say that the electricity sector is required to deliver emissions reduction of 11 Mt CO_2-e per year on average, a 160% uplift on the annual reduction observed for the past decade.

Further, it is not clear where the remainder of the of emissions abatement will come from. The Safeguard Mechanism reforms place an obligation on large emitters to reduce their emissions. However, there must still be technologies or other measures available to these large emitters in the period to 2030 to reduce their emissions. Analysis by Energetics suggests that this is not the case.

These points are taken up in the next section.

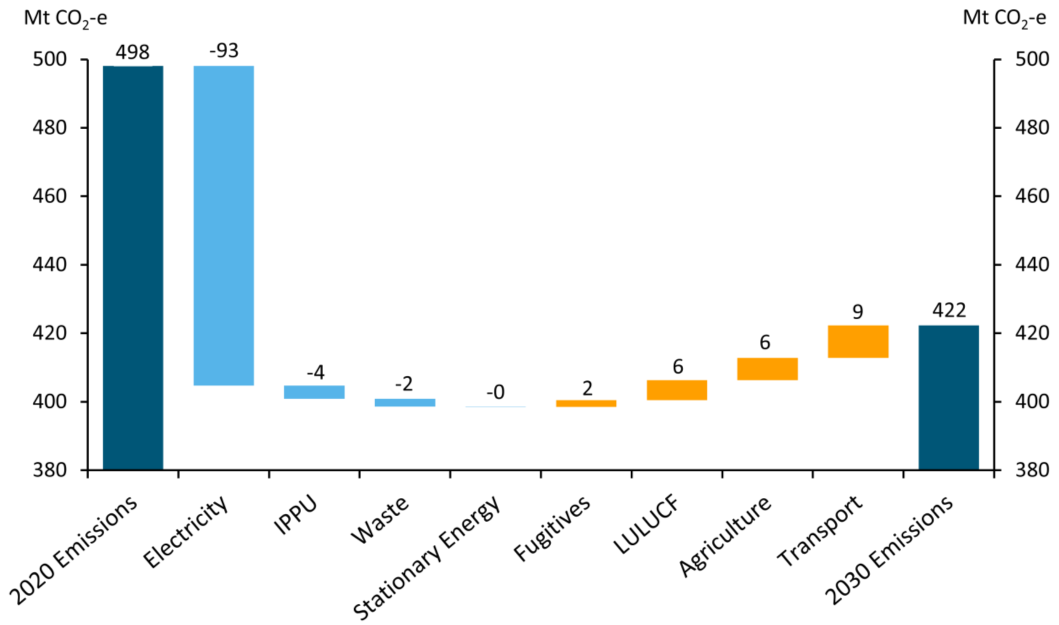

Figure 6: Change in Australia's baseline scenario emissions from 2020 to 2030, Mt CO_2-e

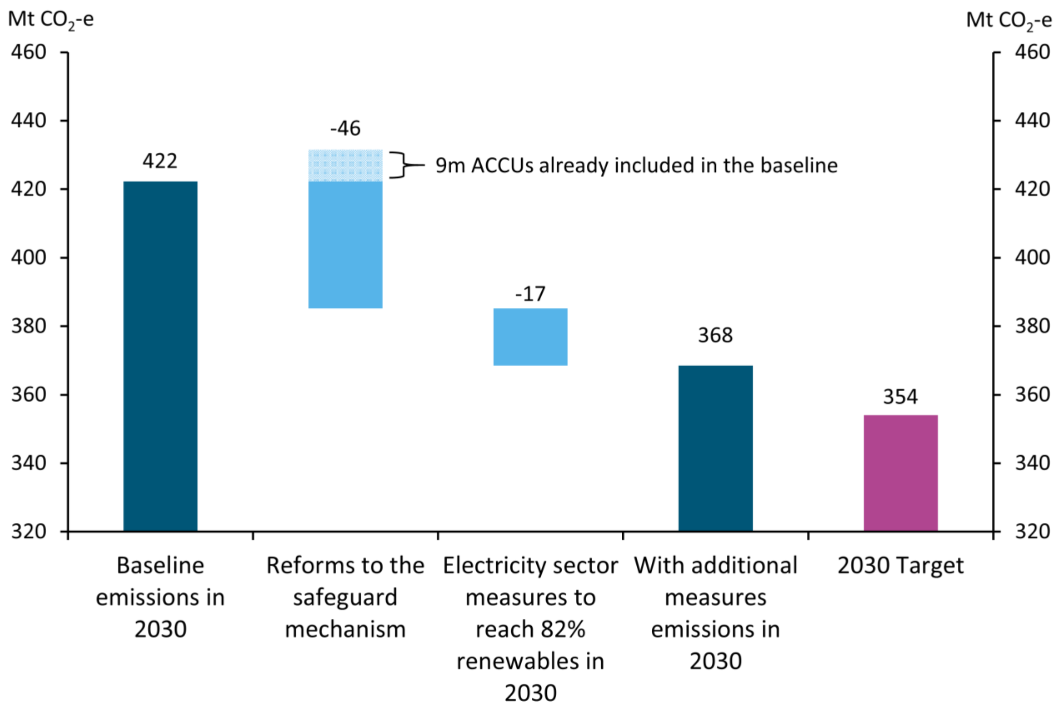

Figure 7: Change in Australia's emissions from the baseline to the 'with additional measures' scenario in 2030, Mt CO_2-e

Appendix B: Headwinds

Much has been said about the slowing of investment in the decarbonisation of the electricity sector. In the previous section, we outlined how decarbonisation of electricity was to deliver the major share of the emissions reduction require to meet the 2030 target. However, it is not the only necessary source of emissions reduction, and in this section, we discuss the issues facing these other sectors.

Decarbonisation of the electricity sector

This section looks at likelihood of realising 82% renewable (RE) penetration by 2030. It explains how operating a network with 82% RE generation is technically feasible. However, it is not realistic to expect Australia's networks to evolve sufficiently quickly to realise the goal due to a range of barriers and constraints – the headwinds.

Is it possible?

The 43% emissions reduction target is underpinned by 82% renewable electricity supply, Energetics firmly believes that an 82% renewable electricity supply (or for that matter a 100% renewable electricity supply) is both desirable and achievable. However, that is not the question being explored here but rather it is whether an 82% renewable electricity supply can be realised by 2030.

The feasibility of an electricity network containing a high or total renewables component has been discussed extensively. Comprehensive analysis by Gilmore, Nelson and Nolan[39,40] showed that a network with a high penetration of renewables will require pumped hydro and battery storage to address short-term mismatches between renewable resource availability and electricity demand, these alone may be unable to cost effectively address renewable energy droughts. However, some form of zero-emissions fuel-based power generation technology will probably be required. While the latter could be very costly to operate, their likely infrequent use may make them a cost-effective form of insurance. Gilmore et al also highlighted the need for a robust and extensive transmission system to geographically distribute renewable generators and reduce the likelihood of instances of low renewable power generation across the whole system.

Net Zero Australia[41] found that for Australia to reach net zero emissions, the nation must grow renewables as the main energy source and support the renewable energy supplies with a large fleet of batteries, pumped hydro and gas-fired firming. It will also be necessary to greatly expand the energy transmission and distribution networks. A capital investment of the order of $7-9 trillion will be required between now and 2060. This represents an investment of around 10% of national GDP per year until 2060 based on the current GDP. NZA describe this as being a "*transformation unprecedented in scale and pace*". We note though that some of the $7-9 trillion expenditure includes asset renewable that is required irrespective of the electricity generation technology.

AEMO's 2022 Integrated System Plan[42] outlines the scale of the challenge to transform Australia's electricity supply. While it is focused on the NEM, the outcomes are applicable to all the nation's networks. The organisation recognises two concurrent transformations as the electrification of the economy is occurring while switching to firmed renewables. This will see a near doubling of electricity demand in the NEM to approximately 320 TWh per year up from just under 180 TWh today. This doubling of demand is in response to the electrification of transport, industry, office and homes as gas, petrol and other fuels are replaced by electricity.

At the same time, the NEM is decarbonising with around 60% of capacity withdrawn by 2030. AEMO sees this capacity being replaced by variable renewable generators and utility scale and

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[39] *No.2022-04-RE-droughts-modelling-Griffith.pdf*
[40] *Microsoft Word - Firming technologies to deliver 100 percent RE.docx (energy.gov.au)*
[41] *Net Zero Australia - Net Zero Australia*
[42] 2022 Integrated System Plan for the National Electricity Market, June 2022, Australian Energy Market Operator Limited

distributed storage including virtual power plants (VPPs). Figure 8 shows the extent of the changes, highlighting the substantial increases in renewable generation, especially wind and behind the meter solar PV, and the rise of storage. RE generation capacity is required to double in the seven years to 2030. This prompted the Energy and Climate Change Minister, Chris Bowen to explain how this required installing about forty 7MW wind turbines every month until 2030, and 22,000 500W solar panels every day for the next eight years, or 60 million by 2030.[43] The Minister also flagged other issues such a labour constraints and supply chain disruptions. These are explored in more detail below.

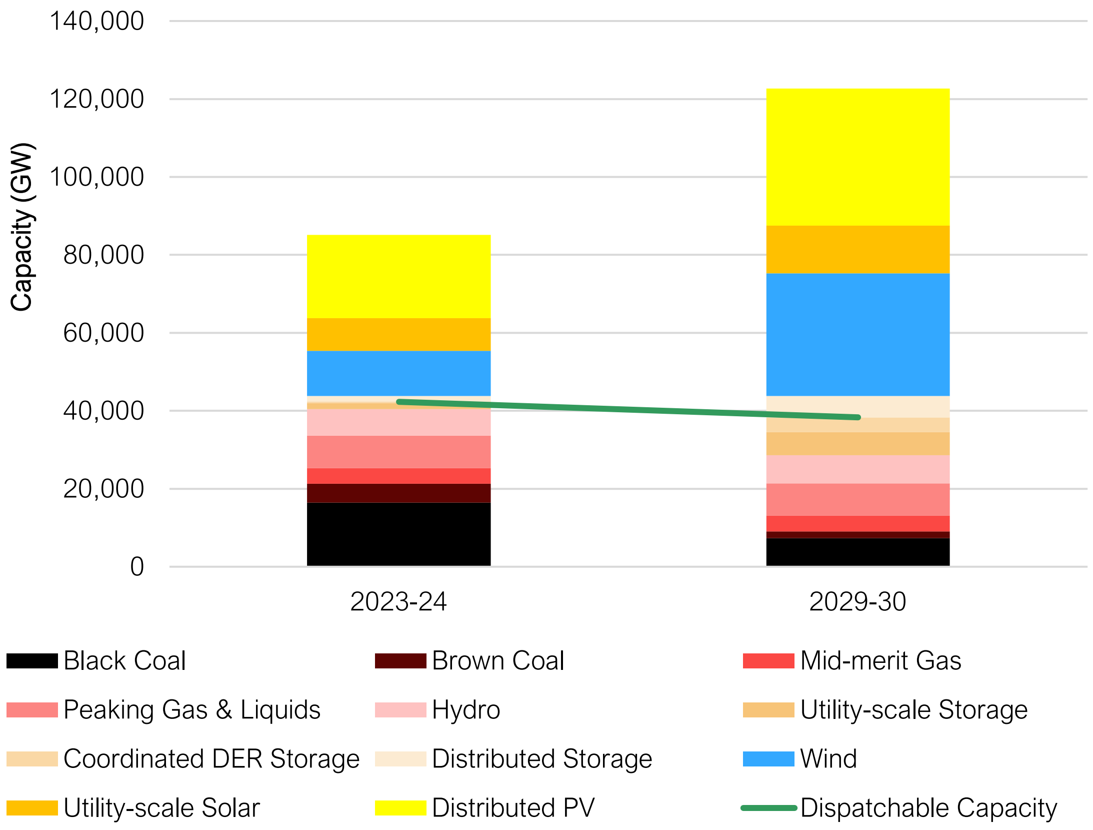

Figure 8: Forecast NEM capacity to 2030, Step Change scenario[44]

The combined capacity of the variable renewables in 2030 significantly exceeds the current average demand of the NEM which means that there will be periods when the output of the RE generators can meet the NEM demand i.e., the NEM will be operating at 100% renewable penetration.

AEMO has explored the question of operating the NEM at 100% renewable penetration. They were concerned about instantaneous high variable renewables penetration as a way point on the journey to a network that is 100% renewable.[45] AEMO sees Australia's energy future being built on low-cost renewable energy, firming technologies like pumped hydro, batteries, and gas generation, to smooth out the peaks and fill in the gaps from that variable renewable energy, an expanded and updated transmission and distribution network, and finally, power systems capable of running, at times, entirely on renewable energy. Their Engineering Roadmap to 100% Renewables[6] report focused primarily on the fourth point. It looked at what needs to be done, from an engineering perspective, to enable Australia's main interconnected power system to run reliably and securely at times without fossil fuel generators. AEMO is seeking to define the necessary engineering changes now because they see that by 2025 there are likely to be sufficient renewable generators in the NEM to, at times, meet 100% of demand. AEMO notes that operating a gigawatt-scale power system at 100% instantaneous renewable generation is a

[43] *The staggering numbers behind Australia's 82 per cent renewables target | RenewEconomy*
[44] Source: 2022 Integrated System Plan for the National Electricity Market, June 2022, AEMO
[45] Engineering Roadmap to 100% Renewables, December 2022, Australian Energy Market Operator Limited

feat unparalleled worldwide, and that the inverters used in a 100% instantaneous renewable network don't inherently deliver all the same stabilising attributes that traditional synchronous generators provide to the power system.

So, in summary, it is possible for Australia's electricity supply to be 100% renewable and certainly 82% renewable as required by the 43% emissions reduction target. It just requires a substantial investment in variable renewable generators and utility scale and distributed energy storage. But whether it can be done is only half the issue.

But how fast can it happen?

> *The unfolding fourth energy transition-from energy supply dominated by fossil fuels to a world relying on non fossil fuels and generating electricity by harnessing renewable energy flows-is both desirable (above all on environmental and strategic grounds) and (given the finite nature of fossil resources) inevitable-but it is imperative to realize that the process will be considerably more difficult than is commonly realized, and that neither its pace nor its compositional and operational details are yet clear.*[46]

This quote, from the Czech-Canadian scientist and policy analyst Vaclav Smil, highlights the challenge faced by the Australian Government as it pursues the 82% renewable target. The feasibility of achieving 82% renewable by 2030 is explored in this section. We then look at the impact that a shortfall in renewable electricity will have on Australia's emission reduction pathway.

We begin with a simple graph shown in Figure 9 below that effectively captures the required rate of change. It shows the historical emissions from the electricity sector and indicative emissions for the sector should the 82% renewables target be achieved by 2030. As with the emissions productivity discussed earlier, the graph below shows the significant uplift in the rate of decarbonisation of the power system that is required.

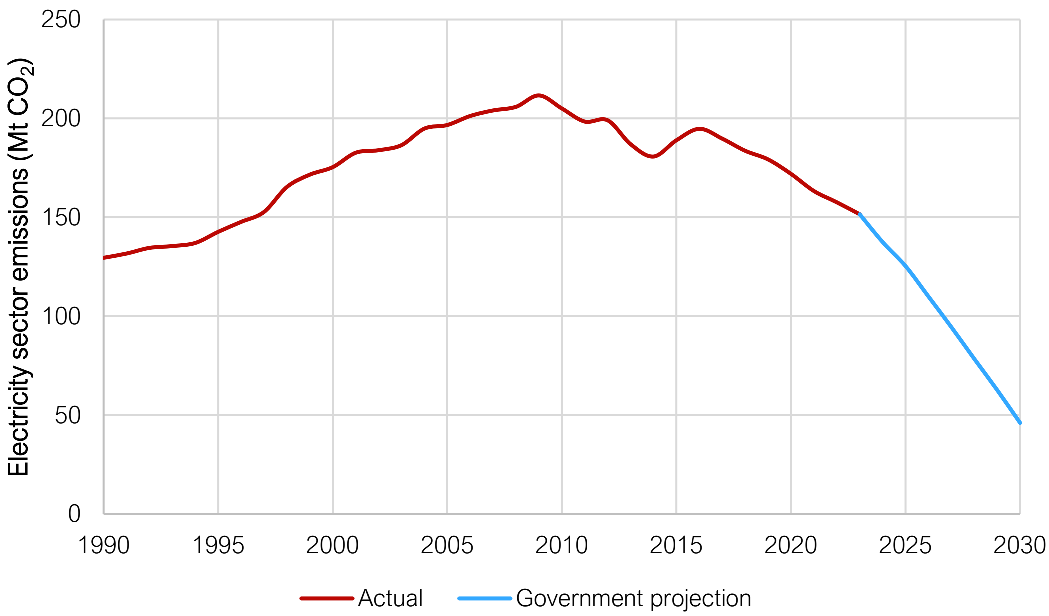

Figure 9: Historical and target emissions from the electricity sector[47]

The signs are not good. Australia evolution to 82% renewables penetration is experiencing significant headwinds. Some examples follow.

Uncertainty around the closure of coal-fired power stations: Eraring Power Station is Australia's largest coal fired power station and was scheduled to close in 2025. The retiring of Eraring would

[46] Vaclav Smil 2017, Energy Transitions: Global and National Perspectives, 2nd Edition
[47] Source: Energetics analysis of Australian National Greenhouse Accounts data

create significant space to be filled by new RE generation in the NSW renewable energy zones (REZs). However, the NSW Government has flagged that the NSW energy transition roadmap will require $10bn in urgent investment.[48] Further, two of NSW's REZs are now likely to be developed later than previously announced. The delays in the REZs are linked to an extension to consultation, amid heightened sensitivity about securing landowner approval to build high-voltage transmission infrastructure. Transmission lines are shaping as the biggest bottleneck in the transition of Australia's generation fleet. away from its traditional reliance on coal, but many landowners remain strongly opposed to new developments, The delays to the development of the REZs has prompted the NSW Government to explore options for keeping Eraring operating for longer.[49] Such delays and uncertainties increase the risk of investment in RE generation and make investors more cautious.

Slowing investment in renewable generation: Reflecting a more challenging environment for investments in RE generation, the Clean Energy Finance Corporation (CEFC) has flagged that Australia is "well behind the pace" to achieve 82% RE generation by 2030.[50] The CEFC reinforced comments from the Energy and Climate Change Minister when the CEFC CEO said that a major wind farm needs to be built each month until the end of the decade to achieve the 82% target. This corresponds to an annual RE build of 3.6GW. The figure below, taken from the latest quarterly report of the Clean Energy Council shows how the 12-month rolling average of new investments is currently running at below 1 GW per year, and trending in the wrong direction.

Figure 10: Financially committed generation projects and capacity, quarterly[51]

Several commentators have noted that the US Inflation Reduction Act (IRA) offers significant support for the clean energy transition in the USA, and this is pulling interest in renewable investments away from other jurisdictions such as Australia and Europe.[52]

"A slowdown in the rate of new projects reaching financial close is at odds with our need to accelerate deployment. While energy investors are enthusiastic about investing in clean energy in Australia, there are a variety of headwinds that are undermining confidence at present."

This includes the global competition for clean energy as many countries follow the US Inflation Reduction Act and dramatically increase the scale and incentives for clean energy, challenges with the grid, supply chain and workforce constraints and planning and approvals regimes in need of reform.[53]

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[48] NSW energy transition needs $10bn as delays strike | The Australian
[49] NSW renewable zones face delays and cost blowouts as questions hang over Eraring | RenewEconomy
[50] Australia 'behind the pace' on 2030 renewables target: CEFC | The Australian
[51] Source: Renewable-Projects-Quarterly-Report-Q2-2023.pdf (cleanenergycouncil.org.au)
[52] Australia regretting belated transition as IRA sparks global race for renewables – pv magazine International (pv-magazine.com)
[53] Clean energy construction peaks as investment pipeline battles headwinds | Clean Energy Council

Key additions to the transmission infrastructure are delayed: AEMO has flagged an urgent need for more than $12 billion of investment in new transmission lines to ensure electricity supply is secure in the coming decade. The five projects are all currently being assessed for regulatory approval or should begin that process soon. Collectively, the projects are estimated to cost $12.8 billion, and are considered fundamental to support future electricity generation and storage options. [54] The situation on the ground is challenging.

Shortfalls in transmission infrastructure is Australia's biggest energy threat, and the country has a history of delays in the construction of transmission lines.[55] Currently the timing for EnergyConnect, a new interconnector being built between South Australia and NSW, has slipped by 12 months and it has seen cost overruns. The HumeLink transmission project is needed to deliver Snowy 2.0's capacity to the market, but that project has yet to be committed.[56] Further, the cost of HumeLink has grown to $3.3bn, up from an initial $1.1bn. The Australian Government is seeking to end delays to critical transmission infrastructure such as HumeLink and Marinus Link. The Government intends to establish a $20 billion fund to accelerate the roll-out of electricity transmission assets.

The issue of transmission network constraints appears to be a global one[57], which will put pressure on suppliers of equipment to meet a global demand.

Community opposition is slowing new wind farms and transmission lines: Community opposition is now impacting both new renewable energy generation projects and investment in transmission infrastructure. Developers such as Transgrid recognise the need for more community consultation and additional compensation. Both lead to increases in cost and delays in completion of the projects.

RE-Alliance[58] reported seeing examples of community resistance to new transmission infrastructure roll-out. They point to the Western Victorian Transmission Network Project being developed in Victoria in over 30 years which is meeting with significant community resistance. Same with TransGrid's Central-West Orana REZ which has seen the formation of opposition groups. RE-Alliance noted that this situation is not dissimilar to the one the wind industry found itself in about five to ten years ago, when instances of poor community engagement, inadequate benefit sharing, and a lack of awareness of local impacts led to widespread community opposition.

NSW Energy Minister Penny Sharpe has acknowledged that one of the greatest risks to developing new transmission infrastructure is the acceptance of the community or the "social licence"[59]. The national transition to renewable energy could be delayed or cost more if government and business do not focus on securing community support to build new projects and much needed transmission. Projects that lacked "a social licence" put the decarbonisation of the grid at risk.

A rising trend in local communities challenging renewable energy projects in the courts is also increasing the risk to developers, which leads to increases in costs and time to implement.[60]

Long-term storage projects are unlikely to be completed in time: In the NEM, long-term renewable energy storage means Snowy 2 and long-term energy storage is a key enabler for grids with a high penetration of renewable generation. The problems with Snowy 2 have been well covered[61,62,63,64], with the delays and increasing costs. Snowy 2 is unlikely to be operational before 2030. Further, the problems (cost and time overruns) with Snowy 2 will likely impact

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[54] *AEMO calls for urgent investment in key projects to shore up electricity supply - ABC News*
[55] *Transmission is Australia's biggest transition threat: Debelle | The Australian*
[56] *Australian energy crisis: AEMO warns on electricity reliability as projects delayed (afr.com)*
[57] *Gridlock: how a lack of power lines will delay the age of renewables | Financial Times (ft.com)*
[58] *Launching our Report: Building Trust for Transmission (re-alliance.org.au)*
[59] *NSW Energy Minister Penny Sharpe says community hostility to poles and wires a 'great risk' to energy shift (afr.com)*
[60] *Landmark nuisance case against Wind Farm creates uncertainty and risk for renewable energy operators and projects operating with emission limits - Botten Levinson Lawyers (bllawyers.com.au)*
[61] *Major Snowy 2.0 tunnelling operation on hold after NSW government intervenes - ABC News*
[62] *Snowy Hydro 2.0 pumped-hydro battery project faces a further two years of delays - ABC News*
[63] *Snowy 2.0 will not produce nearly as much electricity as claimed … we must hit the pause button - Ecogeneration*
[64] *Disastrous tunnelling delays underline folly of Snowy 2.0 pumped hydro scheme | RenewEconomy*

further investments in pumped hydro until investors can be more confident of costs and project timelines.

Costs of renewable energy generation are rising: While acknowledging that variable renewable generators still provide the lowest cost bulk energy, several reports[65,66,67,68] have highlighted upward pressure on the cost of renewable energy generation.

Achieving the 82% renewables target required a benign economic environment and few barriers to the development of the necessary infrastructure. This is no longer the case, and the barriers discussed above will make it highly unlikely (many say impossible) to achieve the 82% RE penetration. Predicting how far short of the 82% will be achieved is difficult. We discuss possible scenarios in a later section.

The Safeguard Mechanism and stationary energy

The reformed Safeguard Mechanism (SGM) is expected to make an important contribution to achieving the 43% emissions reduction target. In this section, we explain how the reformed SGM is essentially seeking to reduce emissions associated with the use of stationary energy and emissions from fugitives from Australia's large emitters. Further, on-site options for reducing the use of stationary energy at these facilities are limited in the period to 2030. In particular, the widespread adoption of electrification is challenging because even if it was technically and economically feasible to implement electrification in the period to 2030, it would just impose more load on an already constrained electricity system. In the absence of on-site opportunities, the covered facilities will be forced to acquire and surrender Australian Carbon Credit Units (ACCUs).

Emissions from covered facilities

In the most recent quarterly update of Australia' emissions[69], the Australian Government reported that emissions from stationary energy amounted to 104.0 Mt CO_2-e for the previous four quarters. Fugitive emissions contributed a further 48.8 Mt CO_2-e.

It is informative to compare these values with the total reported emissions from entities covered by the SGM. The total reported emissions amounted to 137.5 Mt CO_2-e in FY22.[70] Of these, some 7.1 Mt CO_2-e could be attributed to large transport businesses such a Qantas, Pacific National and Toll Holdings.

Most other entities that are covered by the SGM will have some emissions due to transport. However, they are not specialist transport businesses, and these emissions will be small. Emissions from certain off-grid operations will also include emissions associated with on-site power generation. However, most emissions from covered entities are due to stationary energy and fugitives so to a first approximation, the entities covered by the SGM are responsible for most of Australia's emissions from stationary energy and fugitive emissions of greenhouse gases. The changes to the SGM which impose declining baselines (emission caps) on covered entities is the mechanism to reduce emissions from stationary energy and fugitive emissions.

In this section of the report, we explore whether the declining baselines can in fact deliver the required emissions reductions in the required timeframe. The reforms to the SGM require the total emissions from covered entities to be no more than 100 Mt CO_2-e in 2030.[71] Current emissions from covered entities totalled 137.5 Mt CO_2-e in FY22 and since the Australian Government's projection for national emissions suggest that emissions from stationary energy and fugitive emissions will be largely steady to 2030, the reforms of the SGM call for a reduction in emissions of the order of 27% or 37.5 Mt CO_2-e.

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[65] *Executive summary – Renewable Energy Market Update - June 2023 – Analysis - IEA*
[66] *Cost of New Renewables Temporarily Rises as Inflation Starts to Bite | BloombergNEF (bnef.com)*
[67] *Renewable power generation costs in 2021 (irena.org)*
[68] *Wind and solar remain cheapest new sources of power, even after inflation hit | RenewEconomy*
[69] *National Greenhouse Gas Inventory Quarterly Update: December 2022 - DCCEEW*
[70] *Safeguard facility reported emissions 2021-22 (cleanenergyregulator.gov.au)*
[71] *Safeguard Mechanism Reforms (dcceew.gov.au)*

Electrification kicks the can down the road

The table below shows how around three quarters of the emissions from covered entities come from facilities in five sectors. Table 1 also some technology options that could provide significant reductions in emissions from the facilities.

Table 1: Safeguard Mechanism facilities and their share of SM emissions based on FY21 data

Sector	Number of facilities	Total emissions ($MtCO_2$-e)	Share of safeguard emissions	Options for decarbonisation
LNG	10	33.3	24%	Electrification of compression
Coal mining	59	32.0	24%	Electrification of material movement, management of fugitive emissions
Alumina	6	13.4	10%	Mechanical vapour recompression, zero or low emissions fuels for high temperature heating
Other mining	46	11.3	8%	Electrification of material movement
Iron and steel	5	9.1	7%	Iron-ore reduction via electrolysis, zero or low emissions fuels for iron ore reduction

Electrification stands out as the major opportunity but there are several challenges that need to be considered. **Electrification of compression** at LNG trains is an established technology that is used at existing LNG trains, e.g., Freeport LNG[72], and electric drives for the LNG train compressors offer several operational advantages as well as emissions reductions.[73] However, retrofitting electric drives is complex and expensive. Economic benefits offered by electric drives instead of gas turbines in new LNG trains are not so clear when an electric drive is retrofitted especially when the existing gas turbine drives are operating effectively. Further, retrofitting of electric drives would need to happen during planned shutdown periods and this complicates the timing of such projects.

Electrification of materials movement in mining is an emerging opportunity that the global mining industry is committed to and is seen as an essential part of the roadmap to zero emissions for the mining industry. However, the proposed technologies – battery electric vehicles, hydrogen fuel-cell electric vehicles or biofuels at scale will not be available until the next decade. For instance, the equipment suppliers such as Caterpillar are working with the mining industry to develop electric haul trucks[74]. But it will take several years to fully test the operation of electric mining equipment at mine sites before the industry could consider widespread adoption. Further, recent work has indicated that electrification of mining vehicles will lead to a reduction in productivity, and "*the switch to electric mining trucks was unlikely to be seamless*".[75]

Mechanical vapour recompression for alumina refineries is an example of a heat pump, where an electrically driven compressor is used to pump heat from a low temperature to a high temperature. The technical and commercial viability of MVR for alumina refineries was recently examined by ARENA.[76] They found that MVR is technically feasible and cost effective for greenfield or brownfield sites. Economic benefit for retrofits was marginal. Further, "*an overall investment of approximately $4.5B would be required to implement MVR across Australia's six*

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[72] Decarbonizing the LNG industry: Full electric solution for LNG liquefaction trains | GE Power Conversion
[73] The future is electric | LNG Industry
[74] Caterpillar And BHP Plan To Create Battery-Powered Mining Trucks - CleanTechnica
[75] Energy transition: Electric trucks will be 19 per cent less productive (afr.com)
[76] Mechanical Vapour Recompression (MVR) Technical and Commercial Feasibility Studies - A Summary Report, ARENA, November 2022

alumina refineries, together with provision of approximately 1.2 GW of firmed renewable power". That is, the deployment of MVR requires a significant expansion of renewable electricity supplies.

In fact, all electrification options such as the ones listed above require expansions to the electricity system. The previous section explained how constraints on the expansion of the electricity system will prevent the realisation of the 82% RE target and so other decarbonisation options for 2030 that require further expansion of RE generation are unlikely to offer a net reduction in emissions.

Timing is everything

It takes time and money to implement even existing low emissions technologies. A good example is MVR. The challenge is captured in this figure, taken from the ARENA report.

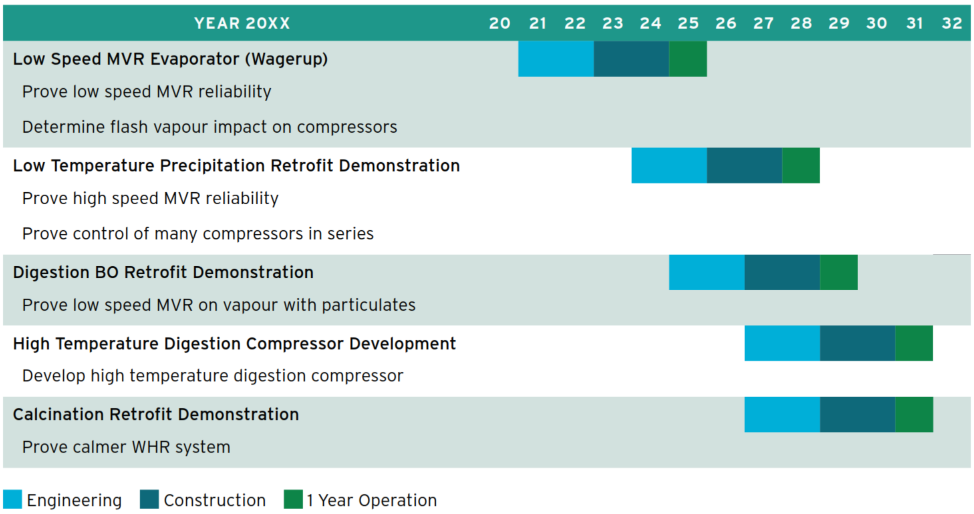

Figure 11: MVR development pathway — fast tracked

The figure shows how even the fast-track deployment of MVR will not see it deployed at scale before 2030. It is a viable low-emissions technology for the future but is not an option for reducing emissions before 2030.

We have pointed to similar challenges with the other forms of large-scale electrification mentioned above. Even if the technologies are commercially available (and that is often a big ask), it can take several years to implement them due to constraints in the operation of large facilities.

Technological advancements and innovations occurring globally play a significant role in Australia's ability to achieve its emissions targets. The International Energy Agency (IEA) believes that innovation is underway in many near zero emission industrial technologies, but progress must be accelerated if targets are to be reached. [77] Many industrial processes involve chemical reactions and high-temperature heat that cannot be fully decarbonised with current commercially available technology, and that around 60% of heavy industry emission reductions by 2050 come from technologies that have been proven to work but are not currently market-ready. Examples include electrolytic reduction of iron ore, green hydrogen for ammonia production, external firing of cement kilns coupled with CCU. The IEA views the innovation efforts of recent years as promising and most key near zero emission technologies are currently expected to see commercial market penetration between the mid-2020s and the early 2030s.

In summary, large emitters in industry and resources will have several technically and commercially ready low- or zero-emissions technologies available in the next decade. However, this does not help them to meet an obligation in the years to 2030. In the absence of on-site abatement options, covered facilities will be required to use offsets to bring their net emissions

[77] *Industry – Analysis - IEA*

down to their baseline. These emissions offsets will be ACCUs[78], and offsets most likely generated from reforestation or afforestation methods. There are several concerns with this approach:

1. It goes against the first of the Oxford Offsetting Principles[79], which calls for on-site emissions avoidance ahead of the use of offsets. See Box 1 for an explanation of the Oxford Offsetting Principles.
2. Biosequestration today has the advantage of providing low-cost carbon removal now. However, biosequestration is not a long-term option for carbon removal – there are constraints on the quantity of historical and current emissions that can be stored in biomass[80] and uncertainties in the science.[81],[82],[83]
3. Reforestation and afforestation for reasons of carbon removal constrains future use of the land for other purposes. The higher the carbon price, the greater the incentive to undertake revegetation activities on more marginal land or more expensive land. Marginal land may be cheap to buy but provides less abatement due to lower rates of biomass accumulation. The latter arises primarily from constraints on water supply but could also result from constraints on nutrients. Land that has adequate water and nutrients is most likely to be agricultural land which therefore carries an opportunity cost if converted to carbon plantings or existing forest land and so is not available for revegetation methods.
4. There are problems with using vegetation methods to address short-term abatement objectives. The problem with trees is that they start small and take some time to become big – see Box 2 for more details.

Geosequestration provides the long-term storage option for carbon removal and investing in R&D to develop low cost geosequestration methods in the future may be a better option for today as it could reduce the total cost of achieving net zero emissions.

The use of ACCUs to realise a short term target is unwise unless we are confident that there will always be a plentiful source of ACCUs to offset the hard-to-abate sectors in the years approaching 2050.

Box 1 - Oxford Offsetting Principles

The Oxford Offsetting Principles are a set of guidelines for carbon offsetting that aim to achieve a net zero society. The principles are as follows:

Reduce your emissions first: This principle emphasizes the importance of reducing your own emissions before resorting to carbon offsetting. It is essential to prioritise the reduction of your own carbon footprint before considering offsetting.

Use high quality offsets: It is crucial to ensure that the offsets you use are environmentally sound, meet strict environmental standards and contribute to the overall goal of achieving net-zero emissions.

Regularly review the offset strategy as the procedures and methods (best practices) used evolve: This principle emphasises the importance of regularly reviewing your carbon offsetting strategy to ensure that it remains effective and up to date with current best practices.

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[78] While the reforms to the SGM introduced Safeguard Mechanism Credits as a second option for offsetting emissions with the SGM, Energetics does not believe that SMCs will be available in sufficient quantities to make a material difference to the challenges faced by covered entities.
[79] *The Oxford Principles for Net Zero Aligned Carbon Offsetting 2020*
[80] *RealClimate: Can planting trees save our climate?*
[81] *One of Earth's biggest carbon sinks has been overestimated | Stanford News*
[82] *Photosynthetic limits on carbon sequestration in croplands - ScienceDirect*
[83] *Hidden carbon: Fungi and their 'necromass' absorb one-third of the carbon emitted by burning fossil fuels every year (phys.org)*

Shift from offsetting through carbon reduction to offsetting through carbon removal and storage: Carbon removal and storage are considered more effective in achieving net-zero emissions than carbon reduction.

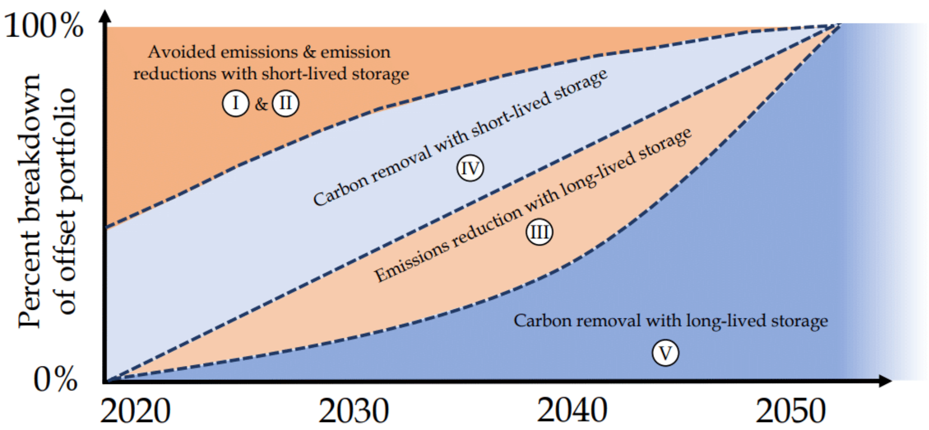

Figure 12: Breakdown of different types of offset that could be used to address unmitigable emissions between 2020 and 2050[84]

Box 2 - The problem with trees

The CSIRO developed FullCAM model[1] provides estimates of the change in the mass of carbon that accumulates on land due to a change in the vegetation cover. **Error! Reference source not found.** below shows the rate of accumulation of CO_2 per hectare for native trees planted in near Narrabri in NSW.[1]

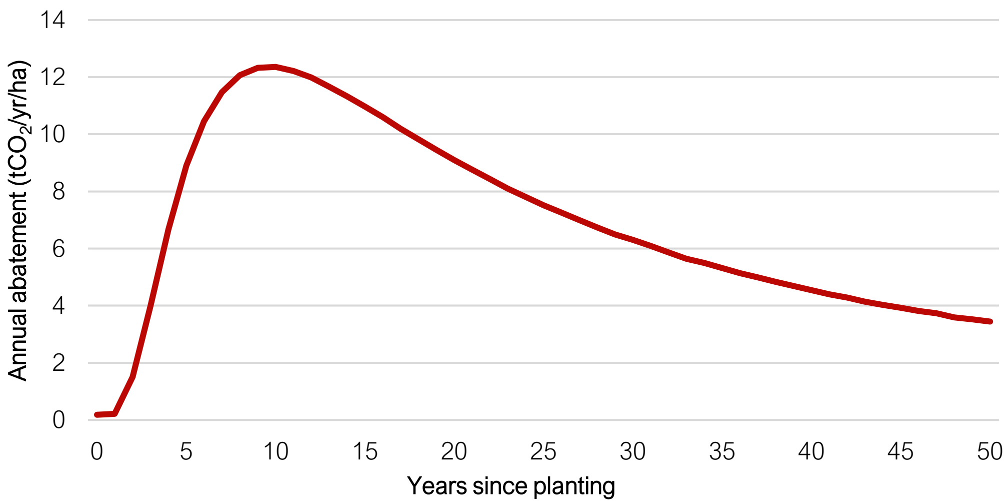

Figure 13: Rate of accumulation of CO_2 per hectare for native trees planted in northwest NSW

The plot highlights several features that are important when considering the use of land-based offsets. First, there is a delay of around three years between the planning of the tree and significant grow rates and hence abatement. Secondly, peak abatement occurs around a decade after planting. Together, these are important when considering the use of land-based offsets to meet short-term abatement targets. If organisations are forced to use reforestation or afforestation measures to create offsets to meet a target in the period before the trees reach maturity, then the volume of trees that must be planted may significantly exceed the volume needed to meet realistic longer-term targets.

[84] *Oxford Net Zero Aligned Carbon Offsetting Report 2020*.

The other "additional measures"

The most recent projection of Australia's emissions (see Figure 1) has Australia's emissions reduction still falling short of the amount required to achieve the 43% reduction target even after the 82% renewable energy target is realised and the reforms to the SGM achieve the desired emissions reduction. In this regard, the Government notes that:

> *Not all measures from the Powering Australia Plan are included – for example, the National Electric Vehicle Strategy and National Reconstruction Fund – as these policies are at earlier stages of design and consultation. It is expected that the gap in meeting the 2030 target will close as more policies are included in future projections.*[85]

So, how much abatement can these measures deliver? The minimum requirement is 14 Mt CO_2--e per year by 2030 if the 2030 target is to be met.

A look at Australia's emissions shows that emissions from transport is the third largest source of emissions and should therefore be targeted if Australia is to meet its 2030 reduction target.

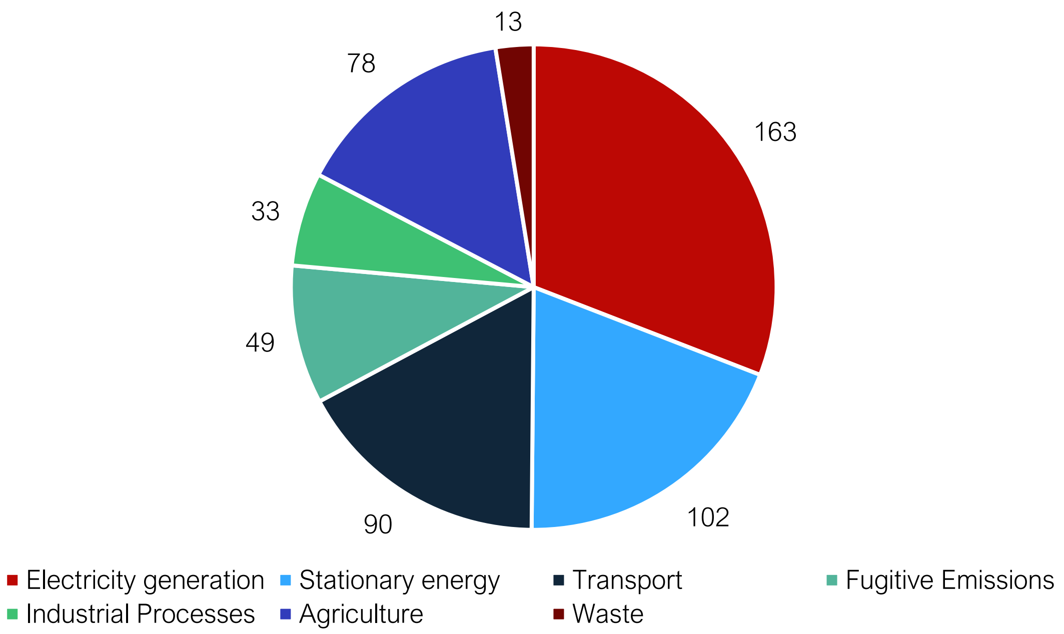

Figure 14: Australia's greenhouse gas emissions in 2021 in MT CO_2-e, excluding LULUCF at -64 Mt CO2-e (Source: Australia's National Greenhouse Accounts)

The *Powering Australia Plan*[5] includes several measures to reduce emissions from transport. They can be broadly grouped into measures such as consultation and strategies leading to the development of fuel efficiency standards for light vehicles; and measures to stimulate the purchase of electric vehicles.

Some comments about the likely impact of emissions from transport follow.

- EVs are still more expensive to own than internal combustion engine vehicles.[86] Further, the cost of batteries has risen due to rising raw material and supply chain issues.[87] While batteries prices is still generally trending downwards, these short term impacts will slow the rate of reduction and so push out the time when EVs are cost competitive (except in the luxury market where they are already cost competitive – compare a Tesla with a Lexus, BMW or Mercedes). The cost of EVs will remain a barrier to the widespread adoption required to significantly reduce emissions from Australia's car fleet.

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[85] Australia's emissions projections 2022, Department of Climate Change, Energy, the Environment and Water, Canberra, December. CC BY 4.0

[86] *Electric cars are more expensive now, but it is possible to recoup the cost of an EV - ABC News*

[87]

- The actual emissions reduction due to a switch to an EV depends on where the electricity comes from, and until Australia's power supply has a much higher renewable component, some or all the additional power to charge EVs will come from fossil-fuel powered generators.
- Adding EVs without also adopting smart charging that uses their batteries efficiently will just put more load on already stressed power networks.
- Improving the fuel efficiency of the light vehicle fleet is a very desirable goal, and Australia is one the few advanced economies without fuel efficiency standards.[88] The nation is just starting down the path of implementing fuel efficiency standards. The challenge is timing relative to the 2030 emissions reduction target. It will take one or two years to implement any standards which will then prompt car suppliers to introduce more fuel-efficient vehicles. But the impact of those new vehicles then depends on the turn-over of the vehicle stock. The average age of cars in Australia is around 11 years[89], so it takes several years before the impact of the new efficiency standards are felt.
- The high fuel consumption and hence emissions of the Australian car fleet is in part driven by the type of car Australians prefer rather than the intrinsic fuel efficiency of the vehicles. The Australian light vehicle fleet contains a much higher proportion of SUVs and dual-cab utes than many other countries[90]. Further, the Australia Institute has identified several tax incentives that encourage small businesses in Australia to purchase large cars such as dual-cab utes.

In summary, the measures in *Powering Australia* aimed at reducing emissions due to transport are unlikely to have sufficient impact before 2030 to contribute much to closing the gap to the 43% target.

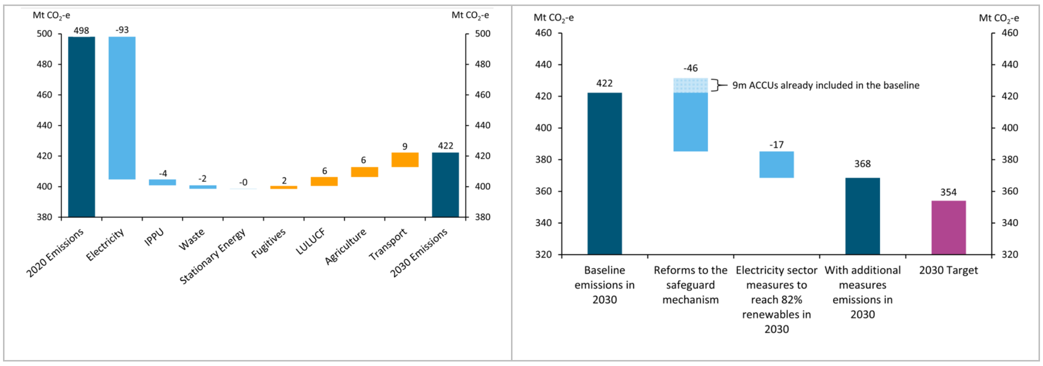
[88] *The Fuel Efficiency Standard—Cleaner, Cheaper to Run Cars for Australia—Consultation paper (infrastructure.gov.au)*
[89] *Motor Vehicle Census, Australia, 31 Jan 2021 | Australian Bureau of Statistics (abs.gov.au)*
[90] *Rise of 'fuel-guzzling' SUVs costing Australians $13bn extra at the pump per year, report finds | Transport | The Guardian*

Appendix C: How far short?

The earlier sections have looked at the view of the Australian Government on what is required to realise the 43% emissions reduction target. The primary source of emissions reduction is the achieving of 82% renewable electricity generation. We explained how it is unlikely (or impossible) to achieve 82% renewables by 2030. Emissions reduction to 2030 will also come from facilities covered by the Safeguard Mechanism. Emissions from these facilities are primarily due to the use of stationary energy and from fugitive emissions. However, there are limited technological options available in the period to 2030 for sites to reduce their on-site emissions. The facilities will be forced to acquire and surrender ACCUs. This could be difficult.

In this section we look at some potential emissions trajectories to 2030 to show the extent of the shortfall against the 2030 target. The report then explores how this could impact businesses and what options are available to mitigate any risks.

The analysis starts from Figure 6 and Figure 7, reproduced below.



The key questions are:

1. How far short of the combined 110 Mt CO_2-e reduction in emissions from electricity will more realistically be achieved?
2. Figure 7 proposes a reduction in emissions from SGM covered entities of 46 Mt CO_2-e. Existing ACCUs will be used to supply some of this net abatement. But how much of the remainder can be provided on on-site action and how much must rely on offsets.
3. Can sufficient ACCUs be created to meet SGM compliance and other demands?

For emissions from the electricity sector

The most recent projection of Australia's emissions sees emissions from power generation falling by 93 Mt CO_2-e. This figure was derived from modelling that used several important assumptions. These are outlined in the methodology reports that accompany the projections.[91] Two assumptions stand out. First, future renewable capacity was derived from the CER's pipeline of large-scale renewable projects, which describes potential renewable uptake to the mid-2020s. Beyond that, the projection assumed that the market would drive the uptake of new renewable projects. We explained above how the pipeline of new renewable projects has dried up, and so the assumption about new renewable capacity may not be realised.

Further, the modelling of emissions from electricity made assumptions about the availability of new transmission assets. The emissions projections were developed based on adopted policies and measures, and most importantly that the state renewable energy targets will be met in Queensland, Victoria, Tasmania, the Northern Territory and that the NSW Electricity Infrastructure Road Map will be realised. For reasons outlined elsewhere in this report, it is highly unlikely that the state targets will be reached.

[91] *Methodology for the 2022 projections (dcceew.gov.au)*

Figure 9 gives some clues as to the reduction in emissions for the electricity sector that can be reached. The figure shows how there a steady reduction in emissions from the sector since 2016. This would be due to a combination of reductions in demand and reduction in emissions intensity. If this trend continues to 2030 then the emissions in 2030 will be 107 Mt CO_2-e, and the reduction in emissions will be 64 Mt CO_2-e.

Given the focus on decarbonising power generation, the reduction in emissions is likely to end up being between 64 Mt CO_2-e and 93 Mt CO_2-e, i.e., falling short by between 17 Mt CO_2-e and 46 Mt CO_2-e.

For emissions from covered facilities

The 2022 Annual Climate Change Statement suggested that the reforms to the SGM would deliver 46 Mt CO_2-e of additional abatement beyond business as usual. Earlier in this paper, we argued that emissions from entities covered by the SGM largely correspond to Australia's fugitive emissions and emissions from stationary energy.

Figure 15 show the trend in the ratio between value added by industry and national consumption of stationary energy (industrial stationary energy productivity). We use historical relationship between value added and energy use as the basis for our forecasts of national emissions.

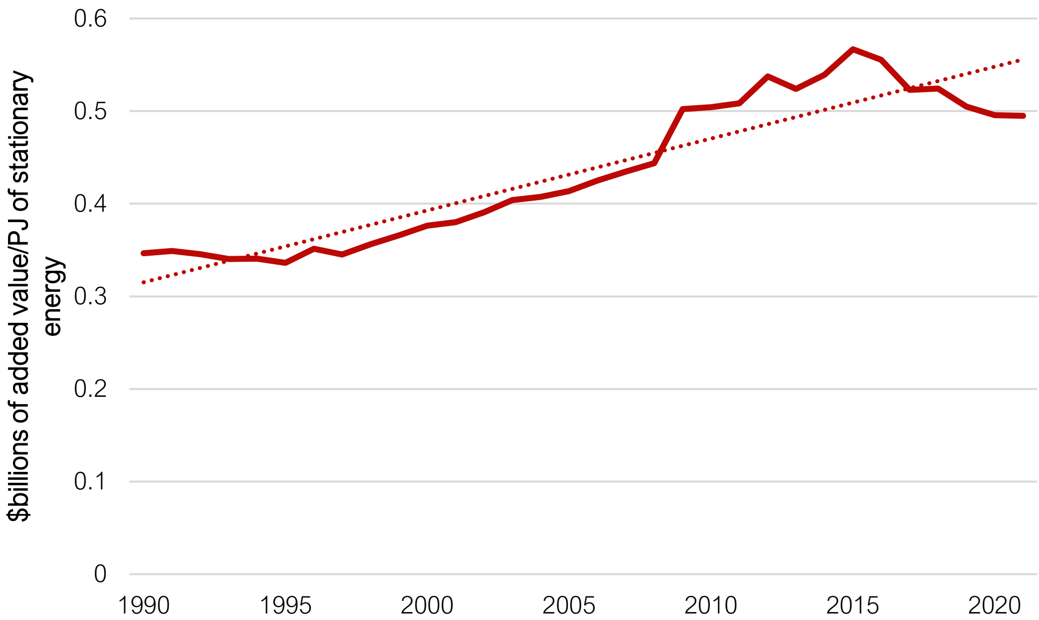


Figure 15: Value added by the industry per PJ of stationary energy consumed[92]

The graph itself is interesting. It shows that in general, the energy productivity rises at a steady rate. This reflects the on-going improvements in industrial operations through the deployment of new equipment, the construction of new facilities which are more efficient and the aggregated impact of many small improvements. However, there are three disruptions to the trend. Two correspond to major economic disruptions – the recession in the early 90's and the GFC. The third is most likely to be due to the major expansion of the LNG industry. The LNG sector is now Australia's largest emissions source of emissions after power generation.

The Australian Government expects emissions from stationary energy to remain steady in the years to 2030 and for fugitive emissions to rise by 2 Mt CO_2-e (see Figure 6). Energetics believes that the former does not fully account for business-as-usual improvements, and that by projecting the trend in Figure 15 we show that BAU emissions due to stationary energy will fall by 8 Mt CO_2-e.[93] However, this is still far short of the required reduction of 46 Mt CO_2-e.

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[92] Energetics analysis of Australian National Greenhouse Accounts and ABS data
[93] We also assume that the value added by industry rises by an average of 2.5% per year.

A tenfold increase in the rate of improvement of industrial stationary energy productivity will reduce emissions by 36 Mt CO_2-e; better but still short of the required 46 Mt CO_2-e.

Given the issues discussed in the previous chapter, where we explained that there are few options available to large facilities covered by the SGM to significantly reduce on-site emissions in the years to 2030, a tenfold increase in the rate of improvement in industrial stationary energy productive is unachievable – perhaps a doubling could be realised. A doubling of the rate of increase in productivity would see a 13.5 Mt CO_2-e reduction in emissions. This leaves the SGM short by some 31 Mt CO_2-e of emissions reduction delivered through on-site activities.

So, what can be done to find anything up to an additional 80 odd Mt CO_2-e of abatement necessary to meet the 2030 emissions reduction target of a 43% reduction in emissions relative to 2005?

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