Economic modelling of Australian emissions reduction pathways

CPD submission to the Climate Change Authority

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The Centre for Policy Development welcomes the proposals by the Climate Change Authority for the economic modelling to underpin its advice on the 2035 emissions reduction target. In our June 2023 submission to the CCA on "setting, tracking, and achieving Australia's emissions reduction targets" we made several suggestions around economic modelling, and we are glad for the opportunity to provide more detailed input. In this submission, we present recommendations responding to all six questions in the CCA's consultation paper – including our views on how to reflect the economic benefits that arise from accelerated decarbonisation of Australia and the world. We would be happy to discuss these recommendations further with the CCA.

Toby Phillips and Mara Hammerle

Question	CPD recommendations
Q1 & Q6 – *What outcomes should the CCA model?*	1. The CCA should include an additional modelling question: "What are the likely impacts on Australian households, as well as on different types of households, for different emissions pathways to net zero?" 2. Economic modelling by the CCA should consider the impacts of the net zero transition on macroeconomic outcomes (like inflation and employment) both in the short and long run. 3. The CCA should model changes in both domestic emissions and global emissions that arise from efforts to decarbonise Australia's economy. 4. The CCA should incorporate analysis of the impacts of physical risks from climate change.
Q2 – *Which models should the CCA use?*	5. CCA analysis should include distributional implications for different household groups (using either GTEM or other models). 6. CCA analysis could use macroeconomic models to examine inflationary impacts.
Q3 – *Global scenarios*	7. The CCA could use a "disorderly" transition scenario by the Network for Greening the Financial System to model a low ambition global emissions pathway.
Q4 – *Domestic scenarios*	8. For domestic emissions scenarios, the CCA should model four possibilities: (1) current ambition; (2) 1.5°C of warming; (3) Australia as a green export "superpower"; and (4) the fastest possible "warp speed" renewable deployment.
Q5 – *Reflecting the benefits*	9. The CCA should use a social cost of carbon to reflect costs arising in scenarios with slower emissions reductions. 10. CCA economic modelling should reflect a high probability of extremely quick declines in technology costs for renewables. 11. Modelling should assume a relatively lower cost-of-capital in scenarios where Australia decarbonises faster, compared to a less ambitious decarbonisation scenario.

Q1. What are your views on the two modelling questions? Are there other questions the authority should explore through economic modelling to inform its advice?

Q6. Are there any other issues the authority should consider as part of its modelling exercise?

Recommendation 1: The CCA should include an additional modelling question: "What are the likely impacts on Australian households, as well as on different types of households, for different emissions pathways to net zero?"

CPD recommends the inclusion of an additional question: "What are the likely impacts on Australian households, as well as on different types of households, for different emissions pathways to net zero?" We commend the CCA on highlighting the importance of understanding the socioeconomic impacts of the net zero transition. However, it is unclear why these impacts could not be understood using economic modelling, when the potential to do this exists (see our answer to Q2 for suggestions). Such modelling would add to the qualitative findings that are identified through other means, allowing for an improved understanding of the impacts on socioeconomic factors for different emissions pathways.

This aside, CPD welcomes the two questions that the CCA proposes for economic modelling. It will be important to consider both the short and long term impacts of the net zero transition, as well as the impacts on different industries.

Alongside the socioeconomic impacts of different emissions pathways, other areas of worthwhile exploration would be on the inflationary impacts of different emissions pathways, and the impacts of Australian actions on both domestic and global emissions. To increase understanding of socioeconomic impacts, the CCA should also consider impacts on physical risks for different emissions pathways.

Recommendation 2: Economic modelling by the CCA should consider the impacts of the net zero transition on macroeconomic outcomes (like inflation and employment) both in the short and long run.

A rapid transition to net zero may have impacts on macroeconomic outcomes like inflation. Despite the fact that a rapid transition will lead to better economic outcomes than a disorderly transition, it will still involve economic disruption including possible inflationary pressures over the short-to-medium term (the next 10-15 years).

In the near future, the net zero transition will require considerable movement of resources such as labour away from other parts of the economy, which may cause supply chain issues that ripple out through economic systems. Other supply chain issues may arise from the large increase in demand for specific technologies and critical minerals. Ambitious action means high rates of turnover of capital stock across the economy – requiring something in the order of ~5% of global GDP over a sustained period of time.[1]

In the long-term, after investment expenditure in the transition has stabilised and the necessary infrastructure has been built, inflationary pressures are likely to subside. Higher levels of renewable energy may even have a long-term disinflationary effect due to their relatively low marginal costs, and this should also be reflected in the CCA's advice.

Recommendation 3: The CCA should model changes in both domestic emissions and global emissions that arise from efforts to decarbonise Australia's economy.

Alongside impacts on domestic emissions, the CCA should also seek to identify the overall impacts on global emissions from Australian efforts to decarbonise. Australia could make large contributions to global emissions reductions by exporting clean products. The decarbonisation opportunities embodied in clean products are very large; for example, scope 3 emissions from offshore processing of Australian iron ore exports are estimated at around 900 million tonnes CO_2-e, near double Australian domestic emissions.[2] The development of a large green iron industry in Australia could thus contribute considerably to global emissions reductions – much more than Australia's domestic NDC. The same opportunity is present across a range of other possible energy-intensive export supply chains, including ammonia/fertiliser and alumina/aluminium.

This type of analysis would require understanding global demand for specific Australian export commodities. The Mission Possible Project includes projections of global production levels and price curves for green export commodities, and other exercises such as Beyond Zero Emissions' "Export Powerhouse" report includes scenarios of different levels of export demand.[3]

Recommendation 4: The CCA should incorporate analysis of the impacts of physical risks from climate change.

The CCA should also consider the physical risk implications of climate change in economic modelling. Physical risks are complex because they are expected to increase in the future in a non-linear fashion and can vary greatly between geographical areas.[4] But their incidence has important social and economic effects. For instance, low-income households often live in areas that are at greater risk of natural disasters and that are facing increasingly high insurance costs as a result.[5]

The costs of natural disasters are continuing to increase rapidly around the world, due to the worsening impacts of climate change. Outcomes that the CCA could estimate include disruptions to output and consumption, foregone income, and increases in coping costs (such as pressures on mental health services). Outcomes will also differ by industry, based on exposure to the natural disaster.

At a minimum, the CCA could include a social cost of carbon in assessing top-line economic outcomes (see recommendation 7 below).

Q2. What are the strengths or limitations of these models (GTEM, AusTIMES, LUTO) the authority should keep in mind when interpreting their outputs? Are there other models that would provide valuable insights into the questions the authority is trying to answer?

Recommendation 5: CCA analysis should include distributional implications for different household groups (using either GTEM or other models).

Quantitative analysis of the socioeconomic impacts of the net zero transition would add to qualitative insights. To conduct this analysis, the CCA could use three possible methods:

1. The CCA could modify GTEM so that it includes multiple distinct households.
2. The CCA could feed the results of GTEM in different years into Treasury's Price Revenue Incidence Simulation Model suite (PRISMOD and PRISMOD.DIST).[6]
3. The CCA could use the CGE model ORANI-E to model the distributional implications.

It is possible to use GTEM – a model proposed for use by the CCA – to examine broad socioeconomic impacts, such as on employment per capita and real household disposable income per capita. CSIRO conducted such an analysis to examine climate risk by state and under different transition trajectories.[7] It should also be possible to modify GTEM to include distinct households, using a similar method as has been previously done for the model GTAP.[8] This would enable analysis of distributional implications, based on factors such as different income groups, where people live, and whether they are skilled or unskilled workers.

An alternative is to feed the results of GTEM into Treasury's PRISMOD suite.[9] This would require running GTEM, before inputting the results for each time period into PRISMOD to understand impacts on the prices of different goods and services and further into PRISMOD.DIST for the distributional analysis.

Alternatively, many researchers employ extensions of the ORANI model to examine the distributional impacts of climate change mitigation policies.[10] Researchers calibrate the ORANI model by using a Social Accounting Matrix (SAM) database with a household sector that contains multiple households. This method replaces calibration via an Input-Output database with a single representative household. A SAM-based model explicitly tracks how income is generated by production activities and is distributed and redistributed between different social groups and institutions.[11] In the context of climate change, researchers can use an extension called ORANI-E. Here, the model's database includes further details on energy production and consumption and the theoretical equations allow for higher levels of substitution between sources of energy production and consumption.[12]

Recommendation 6: CCA analysis could use macroeconomic models to examine inflationary impacts.

As discussed above, the CCA should give due consideration to modelling how the net zero transition will influence macroeconomic outcomes over time. One way of estimating this relationship is to base analysis on past changes in the renewable energy mix. For example, some researchers use time series data to examine the relationship between renewable energy and inflation.[13] These types of methods however are unlikely to produce valid results for future renewable energy mixes, as the proportion of renewable energy in energy grids will be considerably higher in the future than in the past. Alternatively, other researchers have examined the relationship between renewable energy and inflation by using dynamic stochastic general equilibrium modelling.[14]

Many economic modellers are updating their approaches to better account for transformational changes to the energy mix. For instance, CPD is currently working on a project with the developer of G-cubed to model the impacts of an exogenous energy price shock on inflation and GDP in Australia and understand how the impacts differ depending on future energy generation scenarios. G-cubed was designed to draw on the benefits of both CGE models and macroeconomic models. It enables an understanding of the impacts of monetary and fiscal authorities in the short to medium run.

Q3. Do you think the proposed global action pathways provide an appropriate context for assessing potential Australian emissions pathways? Are there alternatives you think are higher priority pathways to consider? Are the IPCC, IEA and GLOBIOM assumptions appropriate for the proposed scenarios?

Recommendation 7: The CCA could use a "disorderly" transition scenario by the Network for Greening the Financial System to model a low ambition global emissions pathway.

The CCA's proposed low ambition global scenario seems to involve modelling a 2°C-aligned pathway for global action, with a 1.5°C scenario to reflect increasing global action.

For a scenario consistent with less ambitious and coordinated action, the CCA should still assume that the global community achieves outcomes that are close to the goals of the Paris Agreement. For instance, instead of a 2°C scenario, the CCA could use one of the "disorderly" transition scenarios developed by the NGFS. These scenarios assume that the overall Paris Agreement objective of keeping global warming to well below 2°C will be achieved, however the pathway will not be orderly. The "Divergent Net Zero" scenario is consistent with reaching net-zero by 2050 and at least a 50% chance of limiting global warming to below 1.5°C by 2100, however there are higher costs because of differing policies across sectors and a faster phase-out of fossil fuels. The "Delayed Transition" scenario is consistent with a well-below 2°C scenario (with a likelihood of 67%) but assumes global per-annum emissions start falling after 2030.[15]

CPD agrees with the proposal to model a 1.5°C scenario to characterise strong global action. Depending on what parameters the CCA wants to vary in their modelling exercise, the IEA 1.5C scenario could be supplemented with scenarios such as the NGFS "Net Zero 2050" scenario (with macroeconomic outcomes like inflation, cost of capital, and aggregate demand) or the UN PRI Inevitable Policy Response (IPR) "1.5°C Required Policy Scenario".[16]

Q4. What potential Australian emissions pathways or scenarios do you think would provide the most valuable modelling insights and inputs to support the authority's advice?

Recommendation 8: For domestic emissions scenarios, the CCA should model four possibilities: (1) current ambition; (2) 1.5°C of warming; (3) Australia as a green export "superpower"; and (4) the fastest possible "warp speed" renewable deployment.

In addition to the "current ambition" scenario, CPD recommends the CCA model three alternative options to represent different levels and types of ambition:

- Australian action consistent with 1.5°C (or 1.6°C) of global warming
- Australia as a green export "superpower" (if this is not a feature of the 1.5/1.6°C scenario)
- The fastest possible "warp speed" rate of renewable deployment

Australian action consistent with 1.5°C (or 1.6°C) of global warming

For the basic higher ambition scenario, CPD recommends the CCA model a scenario of Australian action that is consistent with 1.5°C (or 1.6°C) of warming. Based on global carbon budgets, the remaining global budget for 1.6°C would be roughly consistent with an Australian goal of 80% reduction below 2005 levels by 2035 (assuming linear emissions reduction to 2035).[17] This is a defensible approximation of "pursuing efforts" to limit warming to 1.5°C, as per the Glasgow Pact and Paris Agreement. 80% is also in the range of existing state decarbonisation targets. This should be the lowest level considered for the 2035 NDC.

While ambitious, the required emissions reductions per year would be around 27Mt CO2e per annum. This is similar to the largest historically achieved reductions (reductions between 2010-11, 2011-12, 2014-15 and 2015-16 were around 20Mt CO2e; reductions between 2019-20 were around 31Mt CO2e).[18]

Applying the same carbon budget methodology to find a linear emissions reduction pathway that is consistent with 1.5°C of warming, our rough estimates suggest this requires Australia to be net zero by 2030.[19] CPD believes the Australian economy may struggle to achieve this, which is why we suggest a 1.6°C pathway.

Australia as a green export "superpower" (if this is not a feature of the 1.5/1.6°C scenario)

In the 2023 Budget, the Commonwealth allocated funding to DCCEEW to develop a package of actions to "leverage Australia's competitive strengths in renewable energy, critical minerals and highly skilled workforce to accelerate our other clean industrial and manufacturing capabilities".

To the extent that these industries include energy-intensive commodities (iron, aluminium and ammonia), they will require massive amounts of renewable energy (see Figure 1).

Indeed, if this "superpower" vision is realised, it would involve a very specific decarbonisation pathway with significant rapid build-out of firmed, dispatchable renewables, reaching 10-20 times current levels of NEM generation over 10-15 years. This is many times more than required for AEMO's "step change" scenario and the build-out of renewables for industry would be a driver of overall grid decarbonisation.

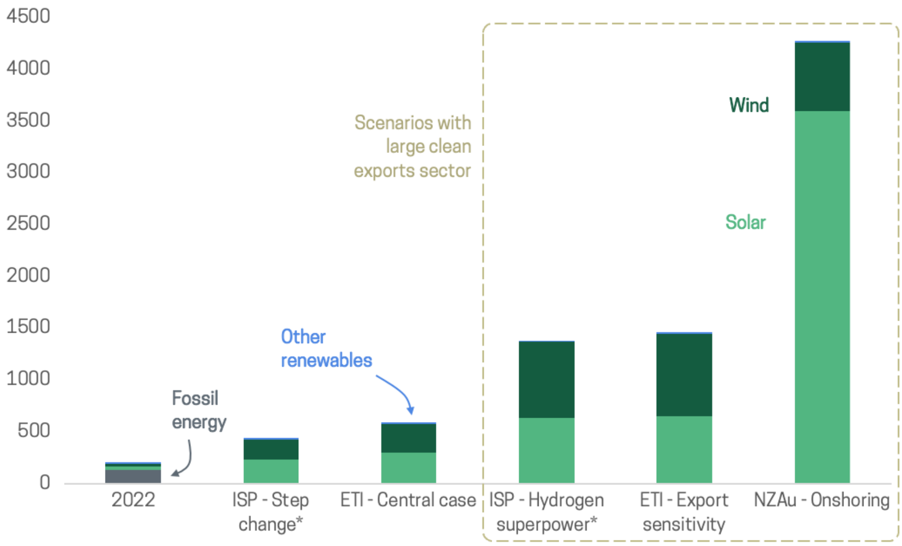
It may be that the CCA's main 1.5°C (or 1.6°C) scenario includes massive green export industries. But if it does not, CPD recommends that this scenario is modelled separately.

The fastest possible "warp speed" rate of renewable deployment

The value of the CCA's advice could be strengthened by critically considering how far Australia's emissions could be reduced and setting this as an upper bound for Australian ambition: the fastest possible "warp speed" scenario. This would be the absolute best case scenario and should go beyond what is currently considered possible, similar to the way the world approached development of the COVID-19 vaccine (in the US this was referred to as "Operation Warp Speed").[20]

Such analysis would demonstrate the economic benefits that could come from a paradigm shift in ambition and investment. For instance, consider a world where there is unlimited capital to fund renewables build-out, and bottlenecks around social licence and approvals are resolved. What would be the economic results of the *fastest possible* build out of renewables?

Figure 1: Comparison of annual generation required in different "export superpower" scenarios
Annual generation (GWh)



Sources: ETI: Energy Transitions Initiative (Climateworks Centre and Climate-KIC Australia, 2023); ISP: Integrated System Plan (Australian Energy Market Operator, 2022); NZAu: Net Zero Australia (University of Melbourne, University of Queensland, Princeton, Nous Group, 2023

Faster action on renewable deployment is likely to yield positive economic outcomes as it will enable Australian industry to capture a larger share of the benefits from the global clean energy transition. Modelling the superior economic benefits of the fastest possible transition will enable policymakers to view the required policies, such as a regional transition fund to assist with social licence, in context.

Regional transition support would no longer sound like retail politics, but rather an effort to resolve critical issues preventing Australia from getting to the "warp speed" scenario.

To identify the fastest possible rate of decarbonisation, CPD suggests the CCA identify the absolutely fundamental physical constraints that put a limit on renewable-build out. These might include:

- Lack of existing technologies in a proof-of-concept stage that could be scaled by 2035
- A limited or under-skilled workforce
- Upper limits in supply from global supply chains
- Time lags in land-use change limiting the development of carbon farming
- The time it takes to physically build new facilities

The upper bound target could then be developed by reducing the rate of decarbonisation to the most limiting constraint identified from the above.

This target may be net negative (that is, more ambitious than net zero). For example, after accounting for limitations in land-use change, it may not be possible for Australia to achieve more than a 120% reduction on 2005 emissions by 2035. Other constraints may be more binding; after accounting for available technologies, perhaps no more than a 90% reduction may be achievable even in the absolute best conceivable scenario.[21]

Q5. How do you think the authority should capture the potential benefits of stronger action to reduce national and global emissions in its modelling? Are some approaches better than others?

Recommendation 9: the CCA should use a social cost of carbon to reflect costs arising in scenarios with slower emissions reductions.

A simple option to analyse physical risks would be to estimate the social cost of carbon (SCC) for different emissions pathways. We recommend above that the CCA do more detailed analysis of physical risks, but at minimum it should be possible to incorporate an SCC into the analysis.

The SCC is a way to estimate the cost in monetary terms of the damage from an additional tonne of carbon emissions emitted into the environment. A credible estimate of the SCC would be anything from \$75 per tonne CO_2-e at the low end (reflecting the current SCC used by the US White House, as well as the Safeguard Mechanism ACCU price cap) to \$300 per tonne CO_2-e at the high end (reflecting recent estimates from the US EPA).[22] The SCC could also be modelled to rise over time as each additional tonne of emissions comes closer to exhausting the global carbon budget. The SCC from cumulative emissions should be added to the headline economic results from each modelling exercise, to accurately reflect the cost of additional emissions (and the economic benefit of emissions reductions).

More advanced options could involve using CGE and IO modelling to assess the socioeconomic impacts of natural disasters in Australia, such as droughts and bushfires.[23] CGE models can be used to analyse impacts of natural disasters for different geographical regions that are more or less exposed to the disasters. Wittwer and Waschik (2021) use the Dynamic VU-TERM (The Enormous Regional Model) – a CGE model – to analyse the economic impacts of drought and bushfires for different regional economies in Australia.[24] They consider factors such as regional GDP, employment, household consumption, and farm output and incomes. The model could be extended to other climate-related economic shocks using hypothetical scenarios.

Recommendation 10: CCA economic modelling should reflect a high probability of extremely quick declines in technology costs for renewables.

The CCA should use “learning rates” to estimate future costs of technologies. Learning rates are the expected declines in cost associated with deploying technologies. However, modelling exercises have consistently underestimated technological learning rates. These exercises have therefore typically suggested a more rapid transition to clean energy would be costlier than a slower one.

Understanding and incorporating the implications of more realistic fast learning rates is very consequential. Many low-emissions technologies, including in particular technologies that are mass-produced such as solar PV, have exhibited extraordinary declines in cost. For solar PV, the learning rate is around 20% cost reduction for each doubling of installed capacity.[25] Economic modelling should recognise that learning curves are likely to be much steeper than previously expected.

Recent research that uses empirically-validated forecasts of the costs of energy technologies suggests a large economic *benefit* from rapidly transitioning to an energy system based on solar PV and wind, even before accounting for the avoided damages of climate change.[26] This is because more rapid deployment of these technologies sees their costs fall more quickly, becoming cost-competitive sooner, and reducing the total cost of the renewable energy transition. This recent research also uses probabilistic forecasting methods, providing a range of outcomes that explicitly acknowledges uncertainty for any given energy technology.

The costs of energy technologies should not be assumed to simply decline over time regardless of Australian action, but instead account for Australian activity. Especially through a “renewable superpower” pathway, Australia may be able to contribute substantially to further driving down the cost of key technologies by driving rapid deployment at scale. For example, the Australian pipeline of planned hydrogen electrolysis projects to 2030 is around 100 times current global installed capacity as of 2022.[27] Building around half of these projects could reduce the cost of producing hydrogen using electrolysers globally by nearly 70% all else equal.[28]

Recommendation 11: Modelling should assume a relatively lower cost-of-capital in scenarios where Australia decarbonises faster, compared to a less ambitious decarbonisation scenario.

Economic modelling should include a lower cost-of-capital for substantial segments of Australia’s economy in a faster climate action scenario, relative to a less ambitious climate action scenario. In modelling the previous Government’s net zero by 2050 target, Treasury suggested a 100 to 150 basis point capital risk premium would be an appropriate in-model proxy for a global response to Australia remaining a laggard on decarbonisation, with a 300 basis point increase feasible in an extreme case.[29] Similar cost-of-capital differentials could be applied in CCA economic modelling.

As a highly carbon intensive economy, Australia faces the prospect of increasing costs of financing across a wider variety of sectors if it fails to decarbonise and adapt to climate impacts. A 2021 Senate inquiry heard costs-of-capital for fossil-intensive businesses were already increasing, as investors and financial service providers priced in climate-related risks.[30]

Endnotes

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[1] Recent global estimates are that $3-6 trillion USD per year of capital investment is required to meet climate goals. This equates to approximately 5% of global GDP. See: I Andersen, 'Investment and trade to meet the Paris climate goals', UN Environment Programme, 2022.

[2] M Sandiford, 'The net-zero opportunity for Australian minerals,' in R Garnaut (ed.), *The superpower transformation*, 2022.

[3] 'Export powerhouse: Australia's $333 billion opportunity', Beyond Zero Emissions, 2021.

[4] J Woetzel et al., 'Climate risk and response: Physical hazards and socioeconomic impacts', McKinsey, 2020.

[5] *Home insurance affordability and socioeconomic equity in a changing climate*, Actuaries Institute, 2022.

[6] 'Annex A: Modelling framework', Treasury, 2020.

[7] S Whitten et al., *Exploring climate risk in Australia: The economic implications of a delayed transition to net zero emissions*, CSIRO, 2022.

[8] 'Model overview', MyGTAP, 2023.

[9] 'Annex A: Modelling framework', Treasury, 2020.

[10] D Sajeewani et al., 'Household distributional and revenue recycling effects of the carbon price in Australia', *Climate Change Economics,* 2015; AA Yusuf and BP Resosudarmo, 'On the distributional impact of a carbon tax in developing countries: the case of Indonesia', *Environmental Economics and Policy Studies,* 2015.

[11] See Sajeewani et al in footnote 10.

[12] RA McDougall, *Energy taxes and greenhouse gas emissions in Australia*, 1993.

[13] A Deka and S Dube, 'Analyzing the causal relationship between exchange rate, renewable energy and inflation of Mexico (1990-2019) with ARDL bounds test approach', *Renewable Energy Focus*, 2021; H Dinçer et al., 'Can renewable energy investments be a solution to the energy-sourced high inflation problem', in U Akkucuk (ed.), *Managing inflation and supply chain disruptions in the global economy*, 2022.

[14] A Ferrari and VN Landi, 'Will the green transition be inflationary? Expectations matter', ECB Working Paper, 2022.

[15] 'Scenarios portal', NGFS, n.d.

[16] 'Data & resources', NGFS, n.d.; 'The Inevitable Policy Response 2021: Forecast Policy Scenario and 1.5C Required Policy Scenario', UN PRI, 2021.

[17] Using a global carbon budget figure of 1013Gt for a 1.6°C scenario as per M Meinshausen et al., 'The diminishing carbon budget and Australia's contribution to limit climate change,' in R Garnaut (ed.), *The superpower transformation*, 2022. The global budget is multiplied by 0.93% (the CCA's previously established fair share value for Australia) and 5.2Gt is then subtracted from this figure to account for Australia's historical emissions for 2013-2023 as per 'Quarterly update of Australia's national greenhouse gas inventory: March 2023', DCCEEW, 2023.

[18] 'Quarterly update of Australia's national greenhouse gas inventory: March 2023', DCCEEW, 2023.

[19] Using a similar method as in endnote 20.

[20] For more on Operation Warp Speed, see Robertson & Wu (2023) *How To Replicate The Success Of Operation Warp Speed*, and D'Souza (2023) *How To Reuse the Operation Warp Speed Model*.

[21] These percentages (120% and 90%) are for illustrative purposes only.

[22] The US White House has estimated an SCC of USD $51, and the EPA has recently estimated it could be as high as USD $190 per tonne. See: E Asdourian and D Wessel, 'What is the social cost of carbon?', Brookings, 2023.

[23] G Wittwer and R Waschik, 'Estimating the economic impacts of the 2017-2019 drought and 2019-2020 bushfires on regional NSW and the rest of Australia', *Australian Journal of Agricultural and Resource Economics*, 2021; G Wittwer and M Griffith, 'Modelling drought and recovery in the southern Murray-Darling basin', *Australian Journal of Agricultural and Resource Economics*, 2011; M Horridge et al., 'The impact of the 2002-2003 drought on Australia', *Journal of Policy Modeling*, 2005.

[24] See Wittwer and Waschik (2021) from footnote 16.

[25] A Malhotra and TS Schmidt, '*Accelerating low-carbon innovation*', *Joule*, 2020.

[26] R Way et al., '*Empirically grounded technology forecasts and the energy transition*', *Joule*, 2022.

[27] The current capacity of hydrogen electrolysers in Australia is negligible. According to *Global hydrogen review 2022*, IEA, 2022, Australia's hydrogen electrolyser capacity from renewable energy is expected to be nearly 50GW by 2030 (based on the project pipeline). This is around 100x the current global capacity of 687MW (based on IEA, 'Electrolysers', 2023).

[28] Based on a learning rate of 18% from R Detz and M Weeda, *Projections of electrolyzer investment cost reduction through learning curve analysis*, TNO, 2022, and assuming six doublings of global installed capacity from 0.5GW to 32GW.

[29] *Australia's long-term emissions reduction plan*, Australian Government, 2021.

[30] *The prudential regulation of investment in Australia's export industries*, Parliament of Australia, 2021.

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