DECARBONISATION FUTURES: INNOVATION SCENARIOS FOR NET ZERO EMISSIONS IN AUSTRALIA

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Overview

There is evidence that greenhouse gas (GHG) emissions from human activities have accelerated in recent years (IEA 2016) implying that significant emissions reduction may be required to limit the chances of dangerous climate change. This has significant implications for Australia given its emissions intensive economy (Denis et al 2014). In late 2016, Australia ratified the Paris Agreement, committing to achieve a 26-28 per cent reduction in GHG emissions below 2005 levels by 2030. The Paris Agreement also requires signatories to strengthen their abatement efforts over time with the overarching goal of limiting the increase in global average temperature to well below 2°C above pre-industrial levels, with efforts to limit the temperature increase to 1.5°C.

Australia's high ranking in GHG emissions per capita reflects its relatively high proportion of fossil fuels in energy consumed, high usage of relatively less efficient private transport and relatively high production of non-ferrous metals per capita. The energy sector (electricity, transport and direct combustion) is the single largest source accounting for around 71 per cent of the total 540 megatonnes (Mt) of carbon dioxide-equivalent (CO_2-e), with electricity generation accounting for the majority at 195 Mt CO_2-e (Commonwealth of Australia 2016).
The high share of GHG emissions from the energy sector is mainly due to coal-fired electricity generation which accounted for 63% of Australia's electricity generation in 2015 (OCE 2016). The dominance of coal in power generation masks Australia's rich diversity of renewable energy resources (i.e., wind, solar, geothermal, hydro, wave, tidal, bioenergy). Except for hydro and wind energy which currently account for most renewable generation, these resources are largely undeveloped and could contribute significantly to Australia's future energy supply (AEMO 2013; Geoscience Australia 2010).

Previous analyses in the Australian context have found that deep decarbonisation of the electricity supply enables other sectors (e.g. buildings and transport) to decarbonise their activities through fuel switching, (Campey et al 2017). With carbon capture and storage (CCS) technologies yet to be commercially deployed, and nuclear power generation currently prohibited by legislation, this suggests that significant deployment of renewable electricity generation will be required to achieve this goal.

The paper assesses uses scenario modelling to identify the sectors that pose the greatest challenge to Australia's emissions reduction efforts. It demonstrates in which sectors the pathways to net zero by 2050 are clear, where new innovation and solutions are still needed, and those sectors where less work has been done to develop and implement zero emissions technologies and processes.

Methods

The TIMES (The Integrated MARKAL-EFOM System) energy system modelling framework is developed and maintained by the Energy Technology Systems Analysis Programme (ETSAP) of the International Energy Agency (IEA) and has been used extensively in 20 countries. The model satisfies energy services demand at the minimum total system cost, subject to physical, technological, and policy constraints. Accordingly, the model makes simultaneous decisions regarding technology investment, primary energy supply and energy trade. Extensive documentation of the TIMES model generator is available in Loulou et al. (2016).

CSIRO in collaboration with Climate Works Australia has developed an Australian version of the TIMES model (AusTIMES). Aus-TIMES model has the following structural features:

- Coverage of all states and territories (ACT, NSW, NT, QLD, SA, TAS, VIC, WA)
- Time is represented in annual frequency (2015-2020) and then five-year time steps (2025, 2030, …, 2050)
- Demand sectors include agriculture (8 sub-sectors), mining (6 sub-sectors), manufacturing (19 sub-sectors), other industry (5 sub-sectors), commercial and services (11 building types), residential (3 building types), road transport (10 vehicle segments) and non-road transport (aviation, rail, shipping).

Four scenarios were parameterised in AusTIMES:

Base case: A scenario that projects what Australia's future emissions could be if current policy seetings remain in place. Changes in technology are based on what could be expected to occur without any deliberate interventions or action towards meeting Australia's emissions reductions goals.

Balanced: This scenario mimics the mantra of the Deep Decarbonisation Pathways Project in 2014 "…All countries decarbonise by 2050, consistent with the objective of limiting the increase in … temperature to 2°C" brought about through ambitious continuous improvement and there are no "major technological breakthroughs, major structural changes in the economy or substantial lifestyle changes."

Innovation: The cost of technologies drops at the upper bounds of current expectations, allowing technological-led disruptions to continue apace and deliver significant abatement, and still reaching net zero by 2050. There is no delay or hesitation, with action consistent with the level of abatement required throughout the time period. Given the significant cheap abatement, the uptake of abatement technologies that require very strong policy support (i.e. a very high effective carbon price) are limited (e.g. CCS). Action by suppliers (i.e. industry/providers) is elevated, driven by the need to minimise social license risks and differentiate themselves to consumers that are now paying attention.

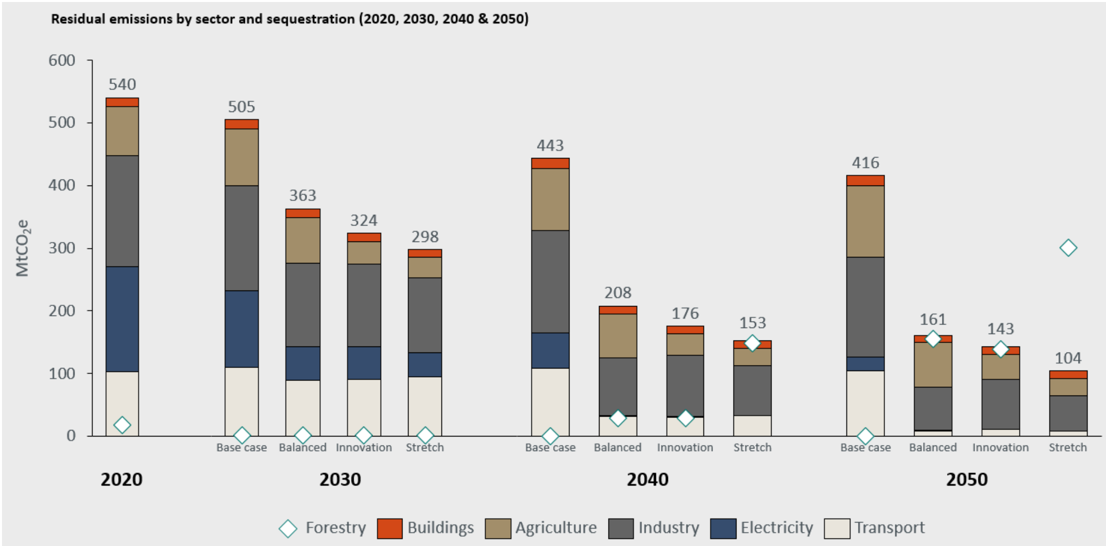
Stretch 1.5: The ambition rises to limiting the increase in temperature to 1.5°C by mid century. Australia contributes through the combination of society, policy makers and technology providers all working in unison towards this shared, universally accepted goal. There is no delay or hesitation, with action consistent with the level of abatement required throughout the time period. Any and all technological breakthroughs eventuate and are available (to the best of our current knowledge) in the magnitude necessary to reach this climate goal.

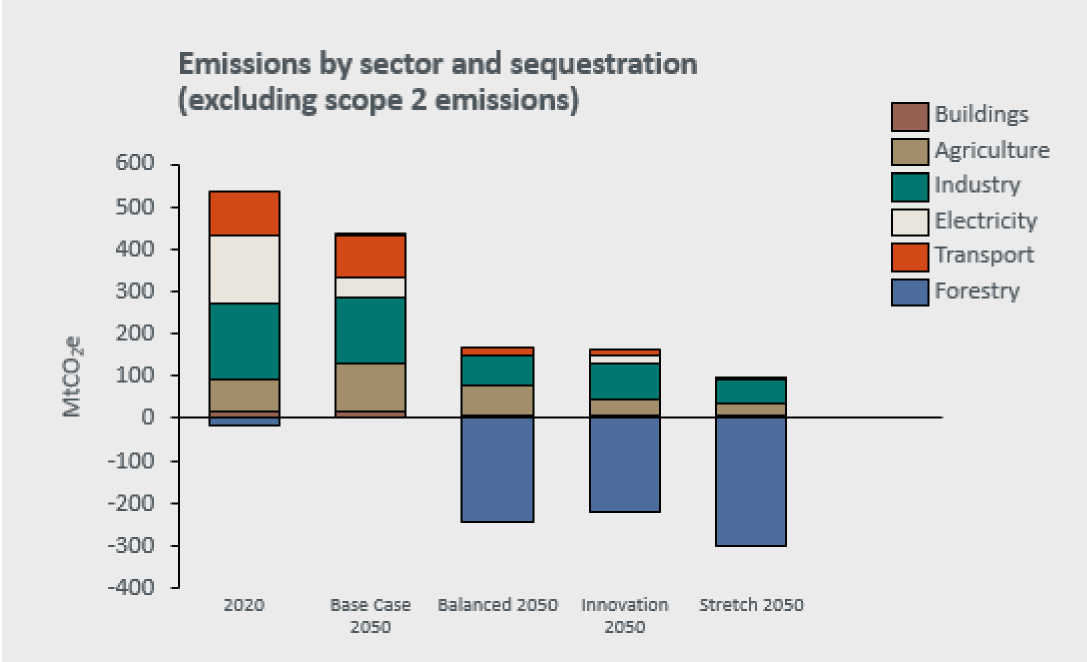
Results

Each of the scenarios consistent with a net-zero emissions pathway see reductions across all sectors of the economy, with some variance in magnitude between scenarios. This contrasts with Base Case, which undergoes much lower abatement in the absence of any meaningful technology, policy, or society effort to reduce emissions. Here, emissions decline by just over 20% relative by 2050, despite significant decarbonisation in the electricity sector. These results reinforce the importance of concerted action on emissions reduction, with *Stretch* benefiting from strong settings in all drivers.

The transition in the electricity sector is a consistent trend, and is almost fully decarbonised by 2040 as renewables approach 100% of generation in most scenarios, while Base Case also sees significant emissions reductions. This, along with high uptake of electric vehicles and other low-carbon fuels, leads to deep reductions in transport emissions.

Agriculture and industry are the most difficult sectors to decarbonise completely, with a relatively large residual emissions challenge in 2050. The combination of strong technology, policy and society drivers in Stretch unlocks further abatement potential in these sectors.





To reach net-zero emissions, action will be required across all sectors of the economy. Emissions decline significantly across all scenarios, with a large amount of this occurring by 2030 largely due to decarbonisation of electricity generation. This transition is also observed in the Base Case, albeit slower relative to other scenarios. By 2040, electricity emissions are near-zero, while transport emissions have also declined substantially due largely to the electrification of road vehicles. Industry and agriculture have also declined by 2040, with Stretch able to reach net-zero emissions with just over 150 $MtCO_2$-e of forestry. The years to 2050 see additional abatement in transport, industry and agriculture, although some emissions persist in these sectors, which must be offset with sequestration to reach net-zero emissions.

Conclusions

To meet its Paris Agreement commitments, Australia must achieve significant reductions in GHG emissions given its emissions intensive economy. Previous analysis for Australia have found that a key element in energy sector abatement is a deep decarbonisation of the electricity supply, as it enables other energy sub-sectors to decarbonise their activities as well through fuel switching. The Australian implementation of the TIMES model is well suited to extending our understanding of this relationship given its detailed representation of the energy sub-sectors.

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