Multi-sector modelling

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Agenda

- Overview of methodology
  - AusTIMES model
  - Scenario settings
- Key model drivers
  - Carbon budgets
  - Hydrogen
  - Carbon forestry

Methodology overview

TIMES model

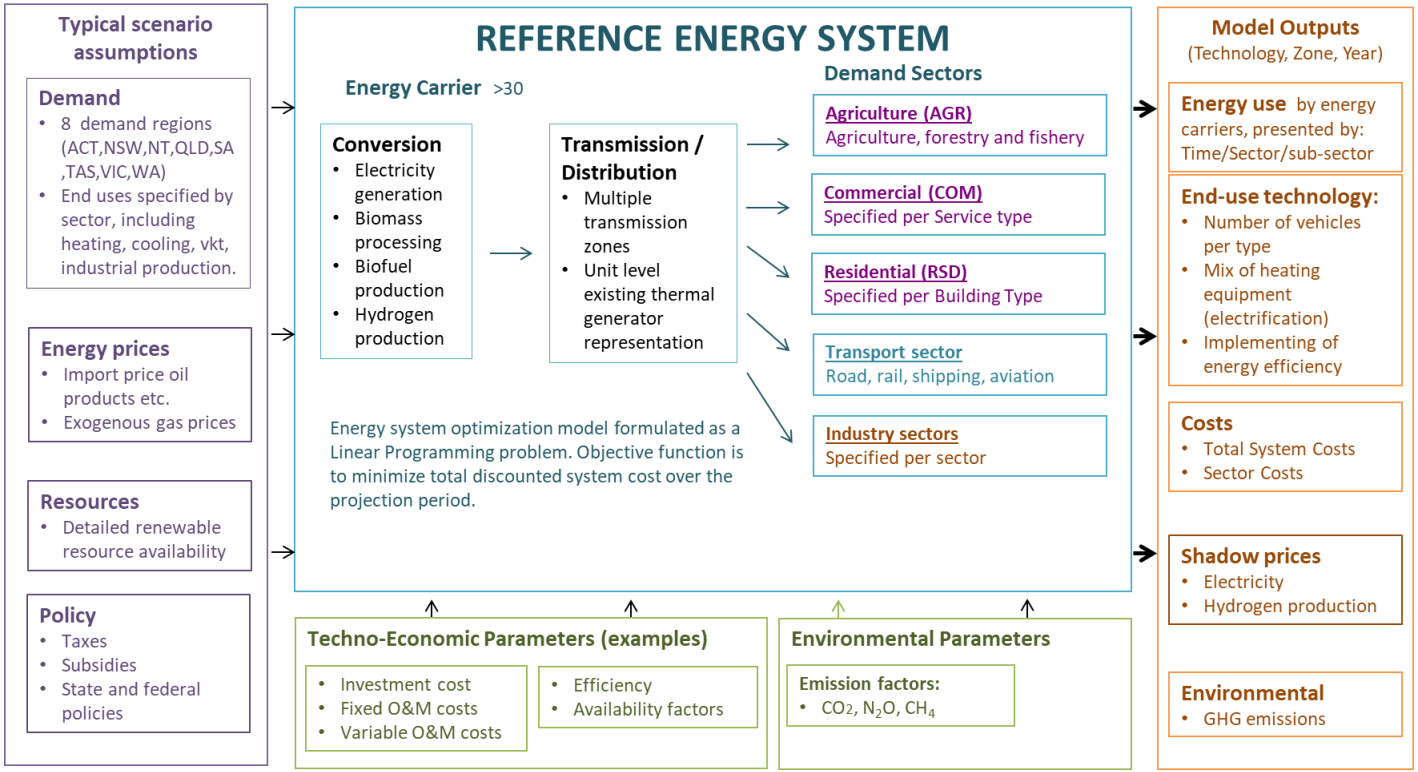
- The TIMES (The Integrated MARKAL-EFOM System) modelling framework is developed and maintained by the International Energy Agency (IEA) and has been used extensively in 20 countries.

- Extensive documentation of the TIMES model generator is available here:
  https://iea-etsap.org/index.php/documentation

- 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.

- CSIRO and ClimateWorks Australia have co-developed AusTIMES.

AusTIMES overview



Scenario settings

- Scenario settings - informed by the latest IASR consultation feedback.
- These scenario definitions have been translated to model-specific assumptions and aligned to complementary work where possible.
- Preliminary runs are underway following multiple rounds of feedback on draft assumptions with AEMO and iterations are continuing.

Scenario	NET ZERO	SUSTAINABLE GROWTH	RAPID DECARBONISATION	EXPORT SUPERPOWER
Economic growth and population outlook*	Moderate ~2.2% p.a. increase in GDP, ~1.1% p.a. increase in population	Moderate ~2.2% p.a. increase in GDP, ~1.1% p.a. increase in population	High ~2.5% p.a. increase in GDP, ~1.3% p.a. increase in population	High ~2.7% p.a. increase in GDP, ~1.4% p.a. increase in population
Energy efficiency improvement	Moderate	High	High	High
DSP	Moderate	High	High	High
Distributed PV (per capita uptake tendency)	Moderate	High	High	High
Battery storage installed capacity	Moderate	High	High	High
Battery storage aggregation / VPP deployment by 2050	Moderate	High	High	High
Battery Electric Vehicle (BEV) uptake	Moderate	High	High	High*
BEV charging time switch to coordinated dynamic charging by 2030	Moderate	High	High	Moderate/High
Electrification of other sectors	Moderate	Moderate/High	High	Moderate/High
Hydrogen uptake in the end-use sectors	Minimal	Minimal	Minimal	Large NEM-connected export and domestic consumption
Generator and storage build costs	CSIRO GenCost 2021 Central	CSIRO GenCost 2021 High VRE	CSIRO GenCost 2021 High VRE	CSIRO GenCost 2021 High VRE
Generator retirements	In line with expected closure years, or earlier if economic or driven by decarbonisation objectives beyond 2030.	In line with expected closure year, or earlier if economic or driven by decarbonisation objectives	In line with expected closure year, or earlier if economic or driven by decarbonisation objectives	In line with expected closure year, or earlier if economic or driven by decarbonisation objectives
Relative project finance costs	In line with current long-term financing costs appropriate for a private enterprise	As per Central	As per Central	As per Central

Carbon budget methodology

- The mean temperature rise by 2100 specified for each scenario implies a remaining carbon budget, highlighted in the adjacent table
- The carbon budgets for Australia have been determined from the most recent global literature and contemporary expertise

Key sources:

1. Australia's Paris Agreement Pathways: Updating the Climate Change Authority's 2014 Emissions Reduction Targets; The Climate Targets Panel, January 2021
2. IPCC SR15 Chapter 2, 'Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development'; Table 2.2

Scenario	NET ZERO	SUSTAINABLE GROWTH	RAPID DECARBONISATION	EXPORT SUPERPOWER
Shared Socioeconomic Pathway (SSP)[1]	SSP2	SSP1	SSP1	SSP1
International Energy Agency (IEA) 2020 World Energy Outlook (WEO) scenario	Stated Policy Scenario (STEPS)	Sustainable Development Scenario (SDS)	Net Zero Emissions by 2050 case (NZE2050)	Net Zero Emissions by 2050 case (NZE2050)
Representative Concentration Pathway (RCP) (mean temperature rise by 2100)	RCP4.5 **(~2.6°C)**	RCP2.6 **(~1.8°C)**	RCP1.9 **(<1.5°C)**	RCP1.9 **(<1.5°C)**
Decarbonisation target	26-28% reduction by 2030 Economy-wide net zero target by 2050.	Consistent with limiting temperature rise to 2 degrees. Economy-wide before 2050	Consistent with limiting temperature rise to 1.5 degrees. Economy-wide net zero by early 2040s	Consistent with limiting temperature rise to 1.5 degrees. Economy-wide net zero by early 2040s
Carbon budget, MtCO2-e remaining 2021-2050	N/A*	6,161 (67% chance)[1]	3,521 (50% chance)[1]	3,521 (50% chance)[1]

* Note: The emissions trajectory in Net Zero scenario is primarily bound by the decarbonisation targets specified in 2030 and 2050. Secondary check for compatibility with RCP4.5 implies a budget of ~21,400 @ 67% chance [Extrapolated from SR15 table 2.2 assuming ~150GtCO2 for each 0.1C]

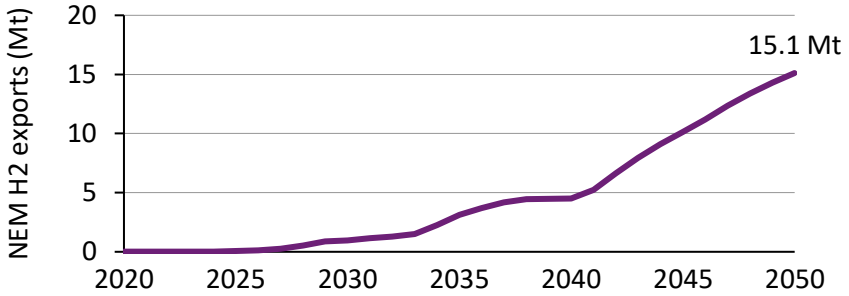
Hydrogen demand methodology

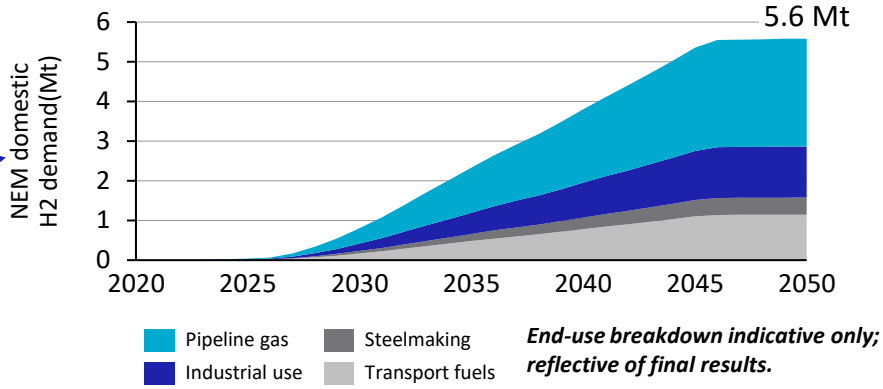
Exogenous:

- Total hydrogen export volume
- Total hydrogen-based steelmaking volume
- Other domestic end-uses of hydrogen (industry and buildings)

Endogenous:

- Fuel switching of natural gas to hydrogen in:
  - Residential & commercial buildings
  - Petroleum refining, alumina production, chemical manufacturing & other industry
- Hydrogen demand in transport
- Hydrogen for electricity generation





End-use breakdown indicative only; not reflective of final results.

Hydrogen production

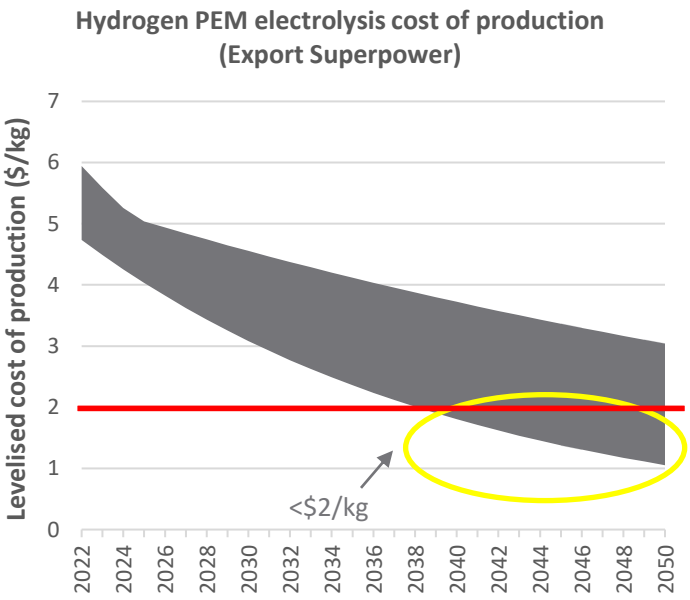
3 Thermochemical pathways: Uses a fossil fuel feedstock to create hydrogen.

- This process must be paired with carbon capture & storage (CCS) to produce clean hydrogen.
- Mature technologies include steam methane reforming (SMR) which relies on natural gas as an input and coal gasification.

2 Electrochemical pathways: Involves the use of an electrical current to split water into hydrogen and oxygen.

- Requires the use of low or zero emissions electricity.
- Mature technologies include polymer electrolyte membrane (PEM) and alkaline electrolysis (AE).

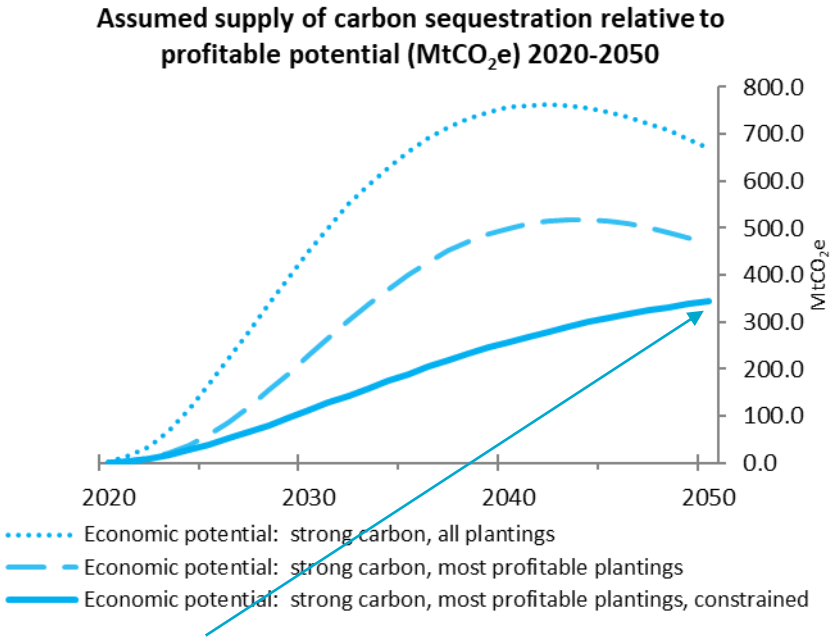
While the model has all options included, it is expected that the majority of production comes from PEM electrolysis as it is zero emissions and has flexibility in production.



Carbon forestry methodology

- *Carbon forestry* refers to sequestration of emissions through terrestrial forestation (plantations).
- Sequestration is necessary to offset the residual emissions across the economy to achieve a 'net zero by 20xx' target while some sectors continue to emit (in sectors where zero emissions abatement solutions are still under development).
- Furthermore, sequestration works to reduce emissions in interim years in order to stay within the cumulative emissions budget.
- The quantity of sequestration available is based upon on a constrained share of the 'most profitable plantings' - plantings that are at least five times as profitable as the next most economic land use. Food/fibre production, water resources, biodiversity services & energy production are also modelled.
- The quantity required for the scenarios to reach net zero are iterated alongside other abatement options to achieve the net-zero targets set out in the scenario specification, and to stay within the carbon budget.

Source: CSIRO's Land Use Trade-offs (LUTO) model as described in Bryan, B. A. et al. 2016, 'Land-use and sustainability under intersecting global change and domestic policy scenarios: Trajectories for Australia to 2050', Global Environmental Change, vol. 38, pp. 130-152.
Analysis undertaken for ClimateWorks Australia 2015, Pathways to Deep Decarbonisation in 2050: How Australia can prosper in a low carbon world



Note: 344 Mt $C0_2e$ would equate to approximately 24 Mha.

Example outcomes

- *Well below 2 degree scenario*

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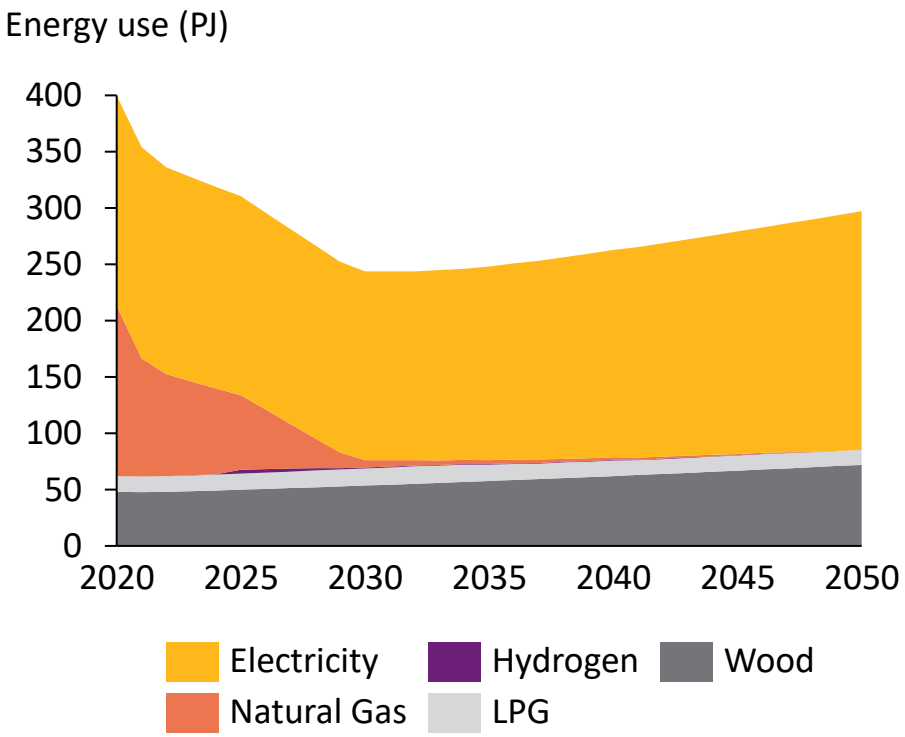
Residential sector

Key assumptions:

- Abatement options available
  - Energy efficiency
  - Electrification
  - Hydrogen fuel switching
- Relative importance
  - 10% of Australia's emissions (including end use electricity)
    Source: CWA analysis of 2018 OCE and NGGI
- Drivers
  - Population growth (number of dwellings)
  - The emissions trajectory of the building sector is strongly linked to electrification and the transition to renewable electricity generation
- Relationship to other forecasts
  - Uptake of rooftop PV/batteries consistent with ISP adoption modelling



PRELIMINARY

Commercial sector

Overall, abatement options and relationship with other sectors and forecasts are similar to the residential sector.

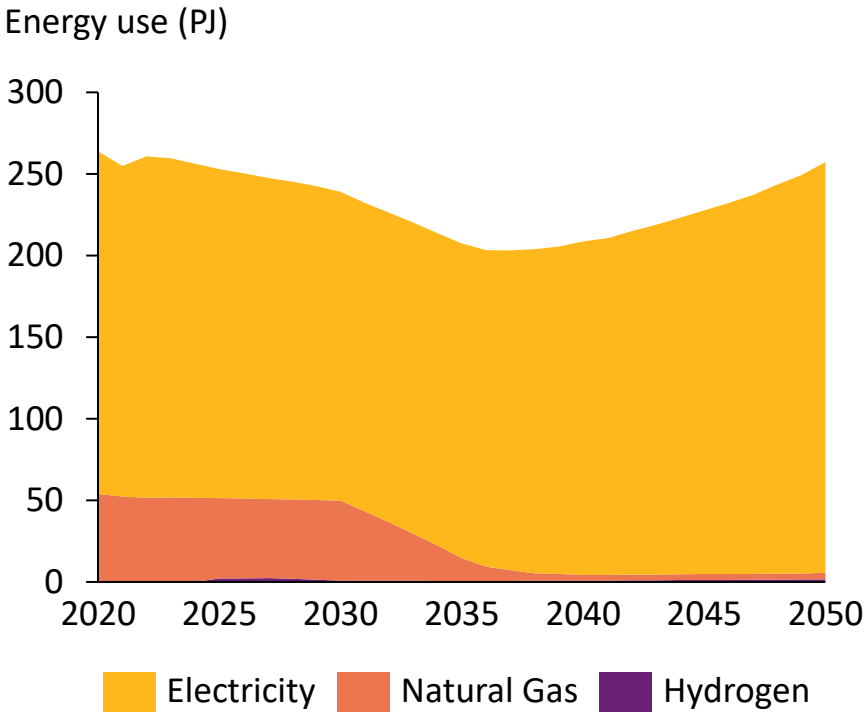
Commercial buildings constitutes also ~10% of Australia's emissions (including end use electricity)

Source: CWA analysis of 2018 OCE and NGGI

Key differences:

- The activity driver being economic activity (m^2 floor space) and
- longer equipment lifetime and higher replacement costs.

- Relationship to other forecasts
  - Uptake of rooftop PV/batteries consistent with ISP adoption modelling

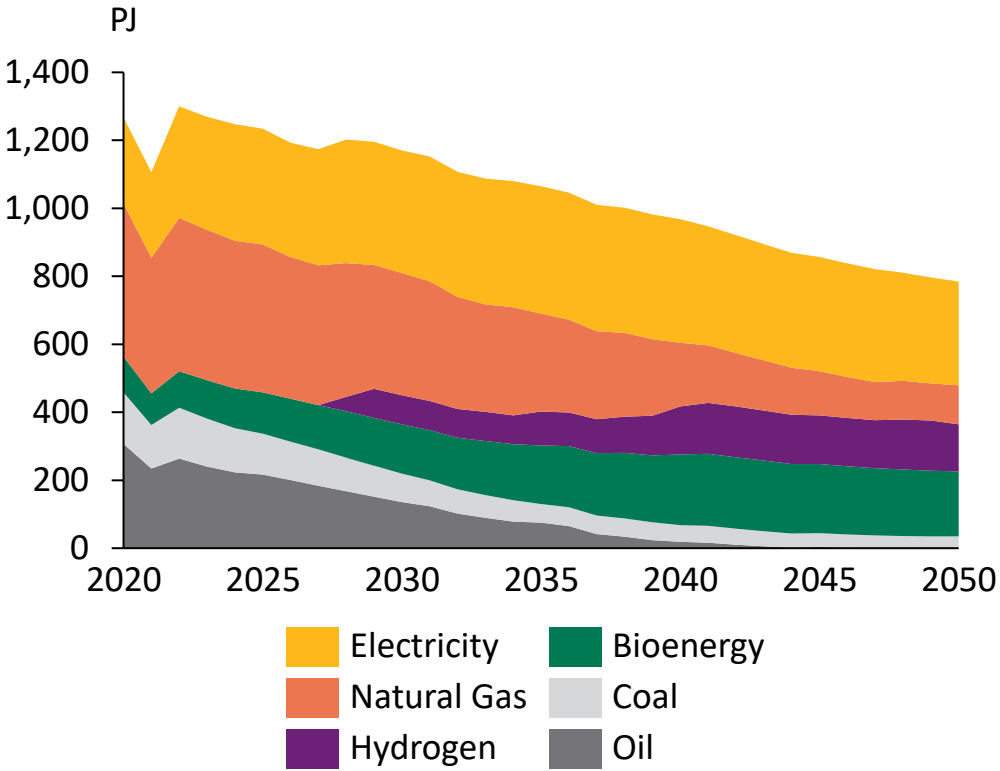


PRELIMINARY

Industrial sector

Key assumptions:

- Abatement options available
  - Energy & materials efficiency
  - Electrification
  - Fuel switching (bioenergy & hydrogen)
  - Targeted solutions to reduce non-energy emissions
- Relative importance
  - Industry accounts for 47% of Australia's emissions (including end use electricity)
    Source: CWA analysis of 2018 OCE and NGGI
  - Just under half of all emissions in industry are from non-energy sources
- Key activity drivers are general economic activity, large industrial loads and export commodity demand



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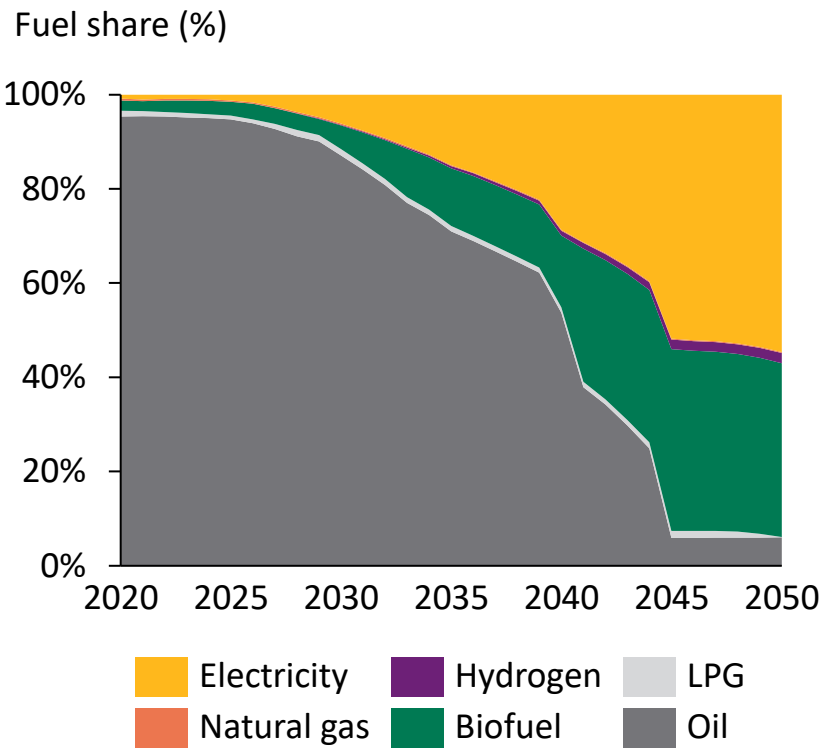
Transport sector

- Key assumptions:
  - Activity drivers (population, economic activity)
  - Zero emission vehicles
  - Biofuels, hydrogen, electricity
  - ICE vehicle retirement
- Relationship to other forecasts
  - CSIRO Consumer Adoption Model forecasts are used as an input to benchmark the forecasts, particularly for road transport



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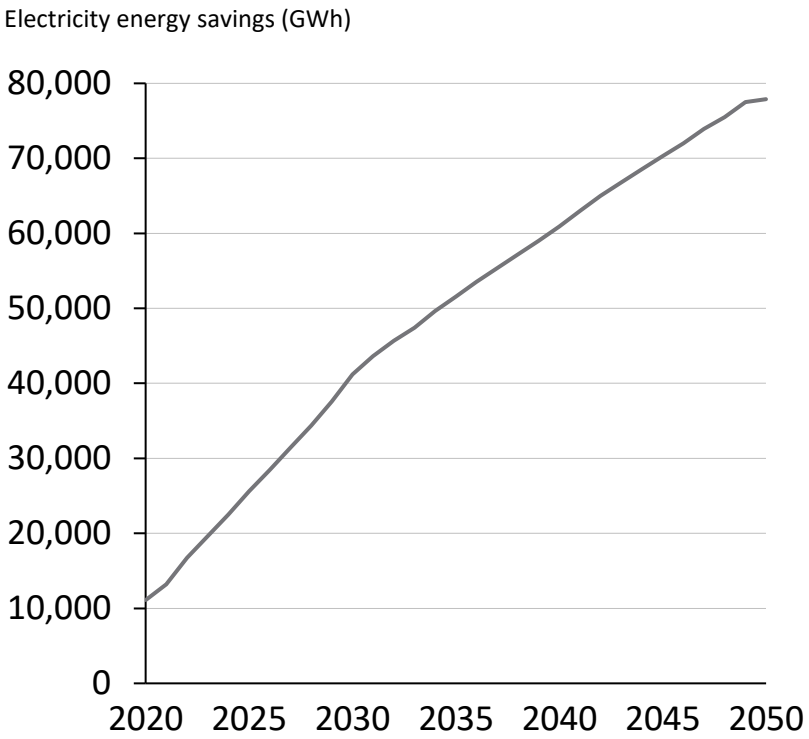
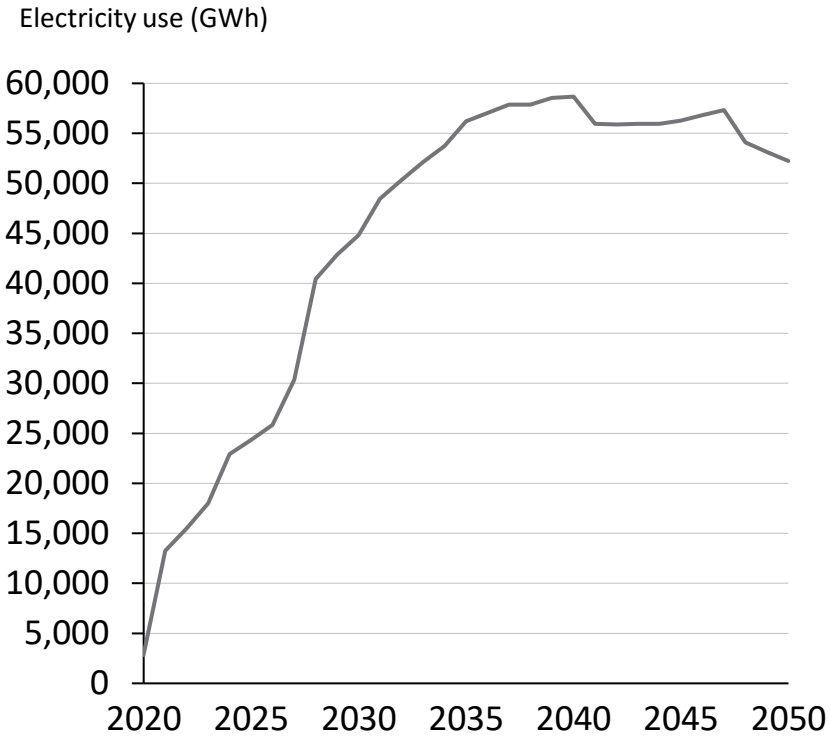
Energy Efficiency



Electrification



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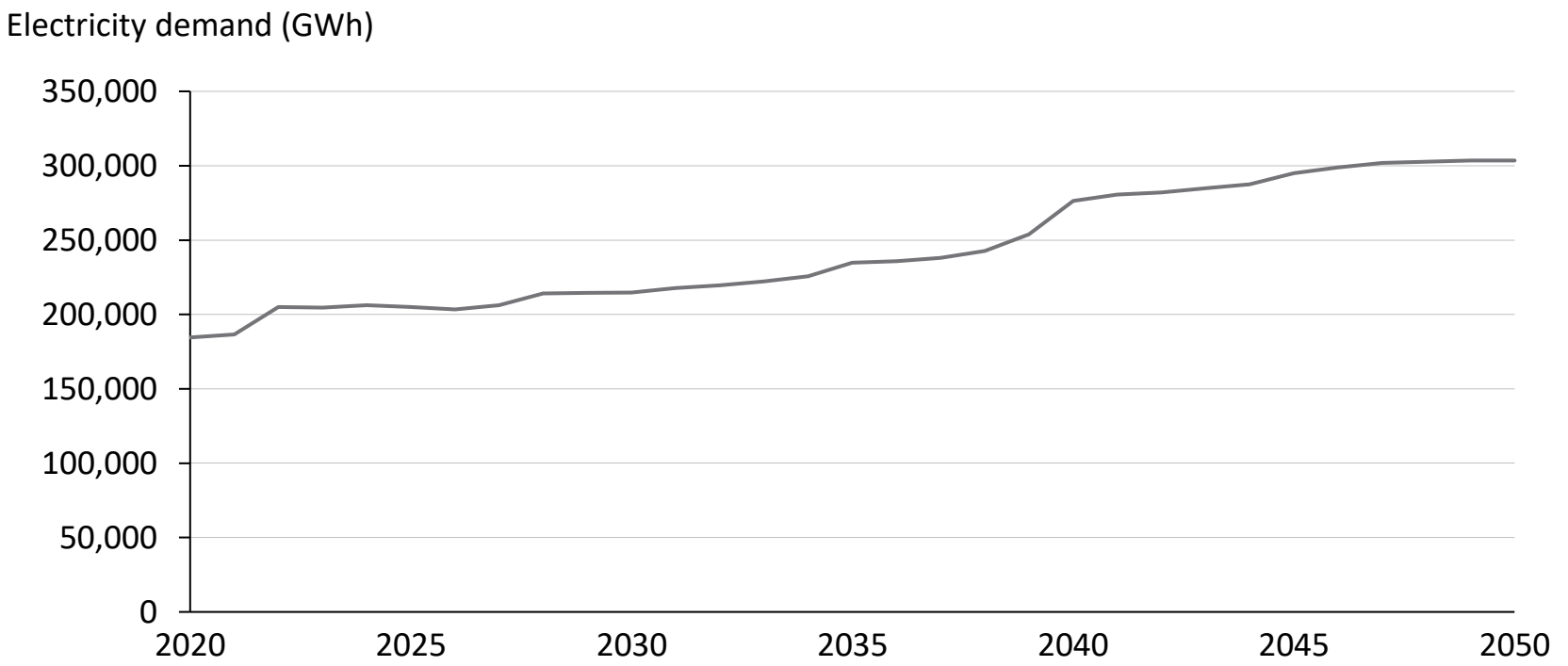
Electricity demand in the end-use sectors*



*including hydrogen production

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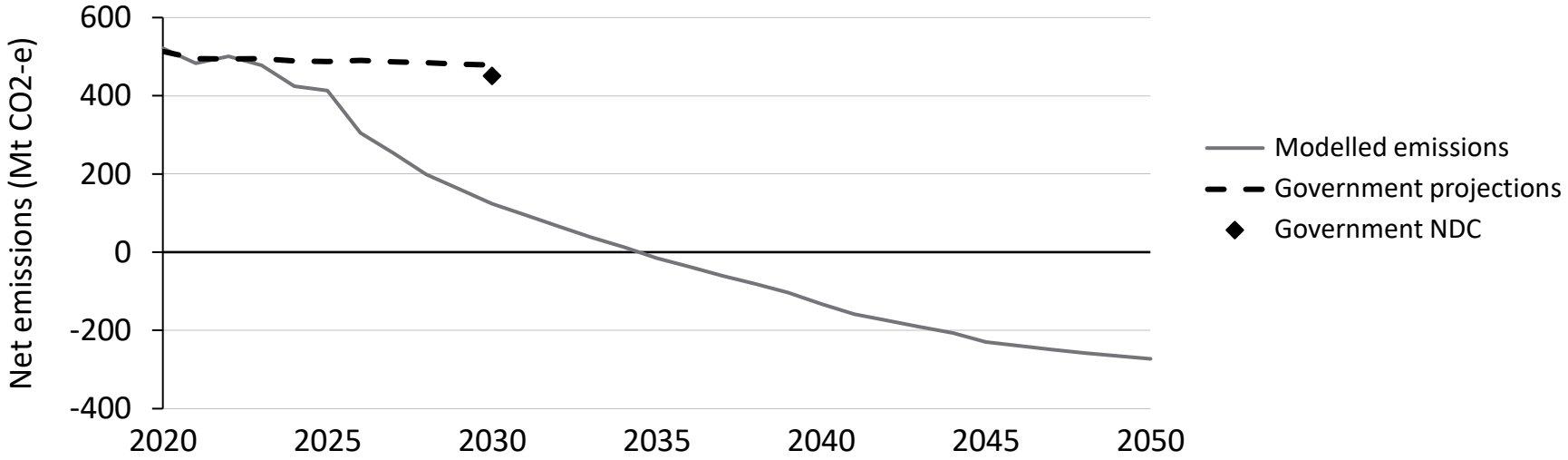
National emissions



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CSIRO

Thank you

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