energetics

Australia’s emissions to 2030 and beyond to 2050

How well is Australia’s economy tracking to decarbonisation?

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Executive summary

In this report, Energetics presents both a revision of Australia's greenhouse gas emissions to 2030 and the emissions trajectory through to 2050 under 'business-as-usual' conditions (assuming no government policy changes nor technology disruptions). The extended forecast was achieved by extrapolating trends from the near 30 years of data in the national greenhouse gas inventory.

What we learn is that the nation's decarbonising electricity sector will not be enough for Australia to achieve its 2030 emissions reduction target, much less net zero emissions by 2050. In this paper we describe our approach to developing the trajectory and examine, sector by sector, the trends that are driving emissions.

Key findings include:

- While the projected emissions significantly exceed the target of being zero carbon by 2050, overall there is a downward trend.
- The bulk of the reduction in emissions is being driven by the electricity sector through the staged closure of the aging fleet of coal-fired generators and their subsequent replacement with renewable energy generation.
- Under business-as-usual, emissions from transport are expected to rise by 44% relative to 2005 and by 12% in the case of stationary energy. The growth in electric vehicles is important in constraining the increase in emissions from light vehicles, but they do nothing for heavy vehicle emissions and other transport modes.
- Land use change is the big unknown under business-as-usual. Net emissions from land use and land use change are close to zero in 2030 and beyond. However, the absolute number is misleading as it is the balance between emissions sources such as land clearing and sinks such as reafforestation. A change in any one of the sources or sinks can result in a significant shift in emissions.
- The Australian Government has expressed a desire to use the carry-over from the Kyoto Protocol to help meet the nation's commitment under the Paris Agreement. Our estimate of the carry-over is 397 Mt CO_2-e. Should Australia be permitted to apply the carry-over units, our 2030 abatement task could reduce to 187 Mt CO_2-e (for a 28% reduction target).

Australia has a major challenge to reduce net emissions to zero by 2050; a task that will only be made more difficult the longer national initiatives to decarbonise are delayed. With delays Australia will also lag other economies that promote and integrate the new, low carbon, high efficiency technologies.

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1. Australia's emissions to 2050

The most recent update of Australia's greenhouse inventory offers the opportunity to re-evaluate emissions to 2030. Further, Australia's inventory report, which began in 1990, is now approaching 30 years which presents the opportunity to project some observed trends to form a view of business-as-usual emissions out to 2050.

Figure 1 shows our estimate for Australia's business-as-usual emissions to 2050.

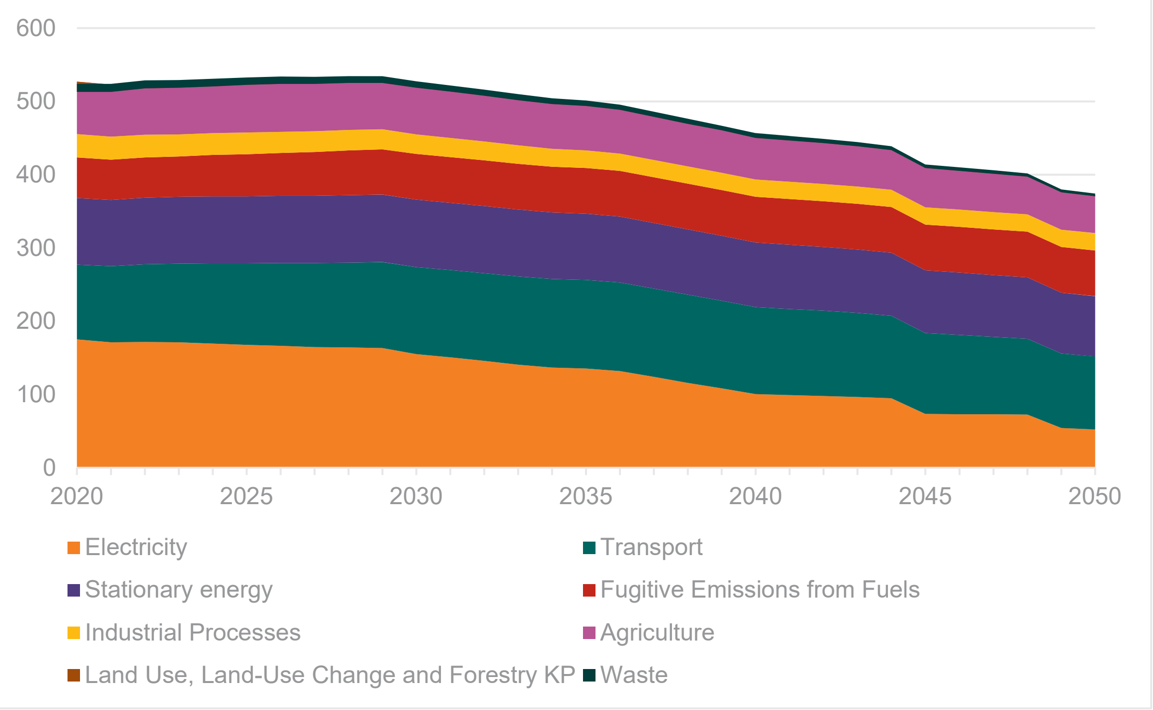

Figure 1: Australia's business-as-usual emissions to 2050 (Mt CO_2-e)

While the projected emissions significantly exceed the target of being zero carbon by 2050, they show a downward trend. The bulk of the reduction in emissions is being driven by the electricity sector through the staged closure of the aging fleet of coal-fired generators and subsequent replacement with renewable energy generation.

Australia clearly has a major challenge to reduce net emissions to zero by 2050.

Australia's emissions are summarised in Table 1 below. Aside from electricity, most sectors have slight decreases in emissions by 2050. Fugitive emissions are the exception which remain unchanged post 2030.

Table 1: Australia's emissions to 2050 (Mt CO_2-e)

Sector	2020	2030	2040	2050
Electricity	175	155	100	52
Transport	102	118	119	100
Stationary energy	90	92	88	82

Fugitive emissions from fuels	55	62	62	62
Industrial processes	32	27	24	24
Agriculture	72	65	58	51
Land Use, Land-Use Change and Forestry (LULUCF)	-14	-1	-1	-1
Waste	11	9	6	4
Total	**524**	**528**	**457**	**374**

These results can also be used to assess Australia's position relative to its 2020 Kyoto Protocol target and the 2030 Paris Agreement target.

For Kyoto, in the most recent projection of Australia's emissions[1], the Department of Energy and the Environment reported that Australia's emissions reduction task including the impact of voluntary actions was -240 Mt CO_2-e. In other words, that Australia's reduction in abatement exceeded the target. Application of the carryover from 2008–2012 commitment period of -128 Mt CO_2-e resulted in a total emissions reduction carryover of -367 Mt CO_2-e.

Our forecast of emissions to 2020 shows a slight decrease compared to the values determined by the Department of Energy and the Environment. Our estimate of emissions in 2018[2] is approximately the same as the Department's earlier forecast. The cumulative impact is a decrease in the cumulative emissions to 2020 of 30 Mt CO_2-e compared to the Department's most recent results.

The Australian Government has expressed a desire to use the carry-over from the Kyoto Protocol to help meet our commitment under the Paris Agreement. We estimate that the carry-over will be 397 Mt CO_2-e.

The Department also reported that the cumulative emissions reduction task in the period covered by the Paris Agreement is 695 Mt CO_2-e for a 26% reduction relative to 2005 and 762 Mt CO_2-e for a 28% reduction. We estimate that the business as usual cumulative emissions to 2030 are 178 Mt CO_2-e less than the figure presented by the Department. Applying this result means that the respective abatement tasks are 517 Mt CO_2-e and 584 Mt CO_2-e respectively.

Should Australia be permitted to apply the carry-over units, its abatement task could be as small as 120 Mt CO_2-e.

[1] ***https://www.environment.gov.au/system/files/resources/128ae060-ac07-4874-857e-dced2ca22347/files/australias-emissions-projections-2018.pdf***
[2] Emissions for 2018 were determined by consideration of actual emissions in the first three quarters of 2018 rather than projection of trends from 1990.

2. Modelling emissions to 2050

Transport

We extrapolate the observed relationship between GDP and transport energy use. Trends for light vehicles and all other transport are shown in Figure 2 below. No trends in the emissions intensity of transport fuel were observed.

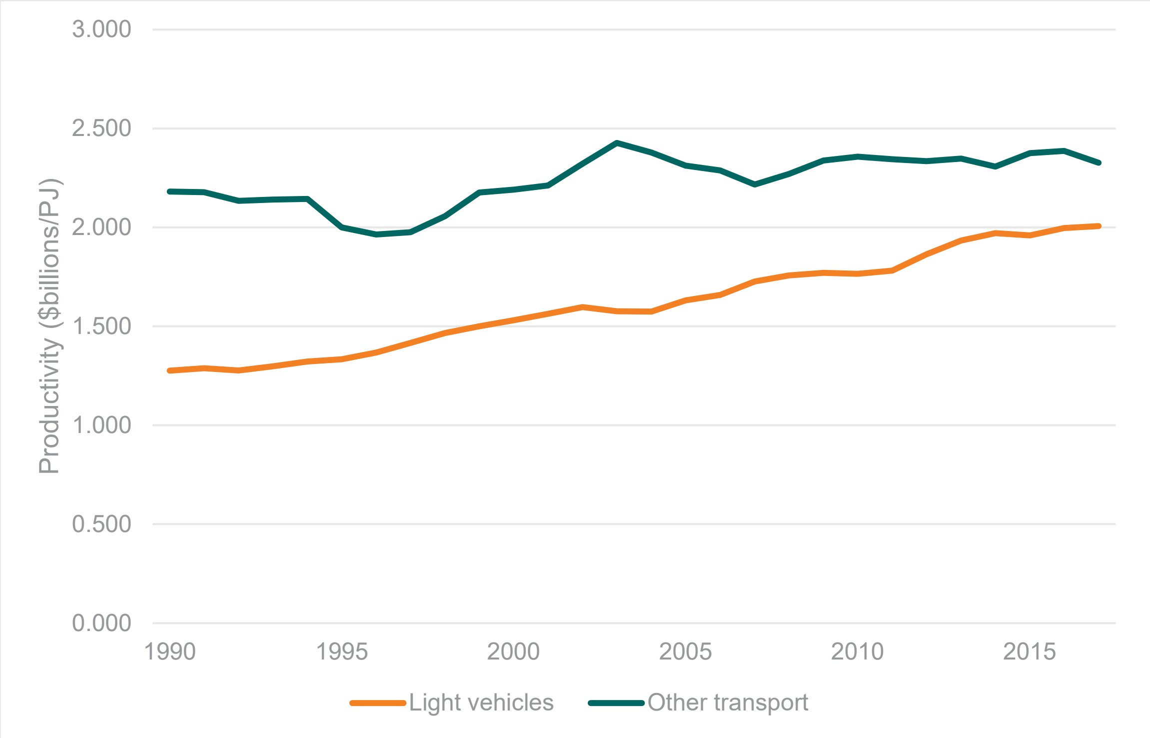

Figure 2: Energy productivity of transport

Electric vehicles are expected to disrupt these trends. The forecast rise of electric vehicles (EVs) in the period from 2025 to 2050 will result in a significant reduction in traditional fuels used by the transport sector and a corresponding reduction in emissions. The overall impact of electric vehicles however depends on the emissions intensity of electricity used by EVs. This is discussed in the section below that looks at the forecast of emissions from the electricity sector.

The forecast of EV uptake in Australia reported by AEMO was used in our work.[3] The forecast fraction of the light vehicle fleet (cars and light commercial vehicles) that is electric is shown in Figure 3.

[3] AEMO data from "AEMO Insights: Electric Vehicles", AEMO and Energeia, August 2016 (***https://www.aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/NEFR/2016/AEMO-insights_EV_24-Aug.pdf***)

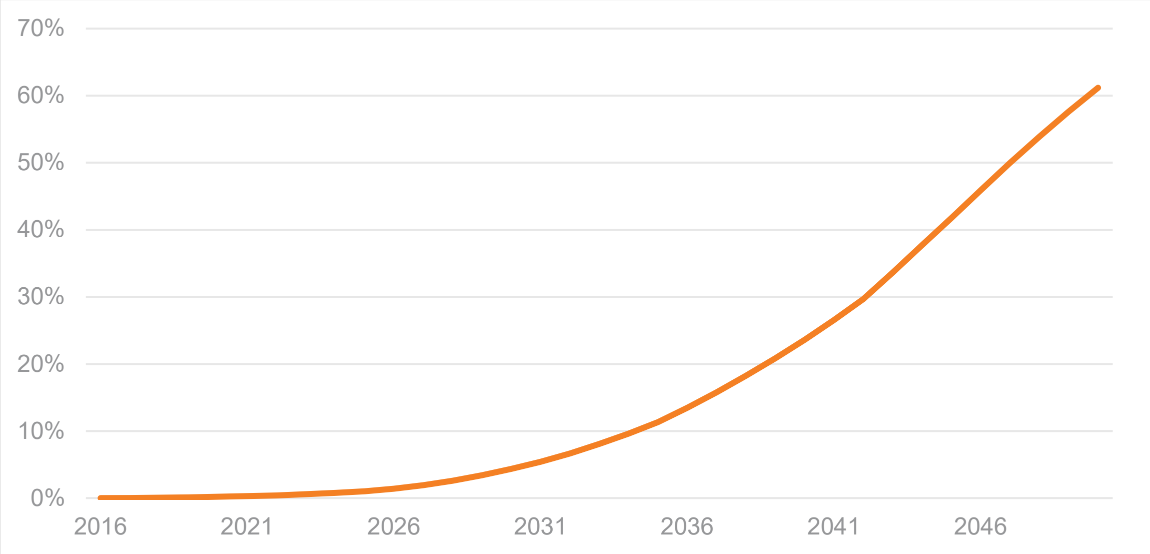

Figure 3: Forecast fraction of passenger vehicle fleet and light commercial vehicle fleet that is electric

Stationary energy

The forecast of emissions from fuel used for stationary energy is based on the long-term trends in both the productivity of stationary energy and the emissions intensity of the fuels. Figure 4 shows the trends in stationary energy productivity for the industrial, commercial and residential sectors. Overall there was a steady, albeit slow increase in stationary energy productivity for all sectors. The fall in energy productivity for the industrial sector that began in 2015 corresponded to the start-up of several LNG trains and it may just reflect the relative energy intensity of LNG production.

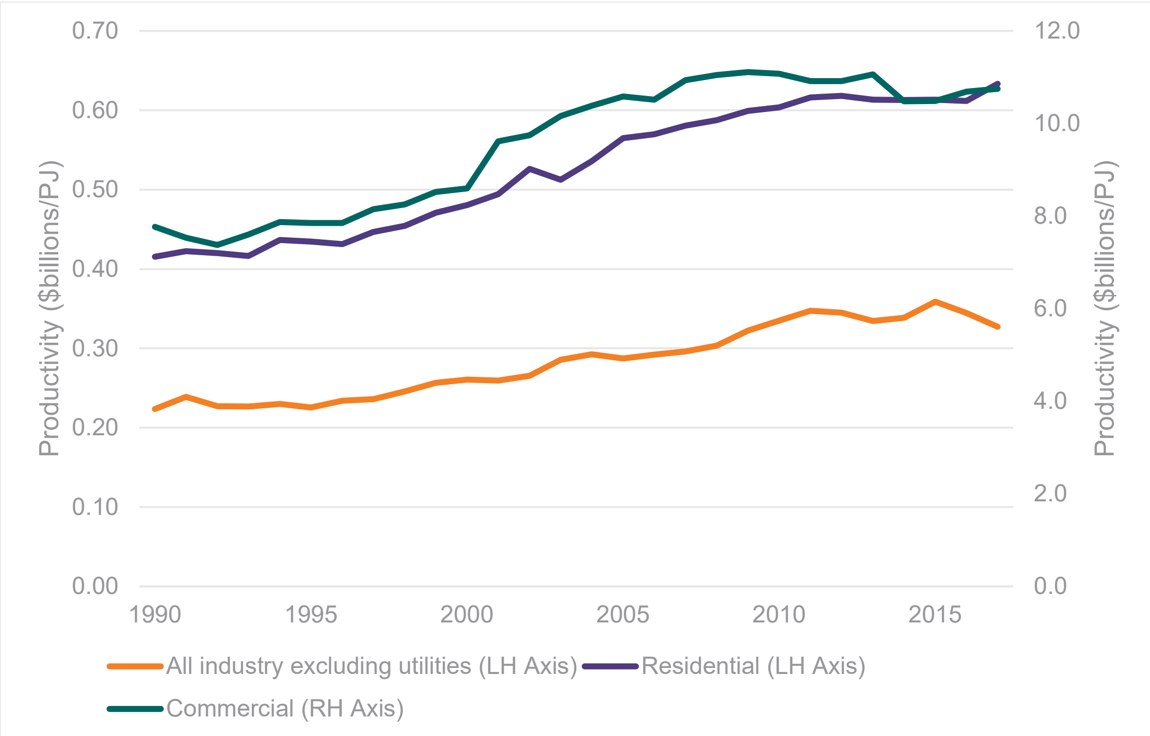

Figure 4: Energy productivity of various sectors

We projected these trends to 2050 to estimate fuel use for stationary energy in the industrial, commercial and residential sectors out to 2050. This also requires an estimate for GDP in the years to 2050 and the fraction of total GDP that is due to the industrial, commercial and residential sectors. Our forecast for GDP adapted figures used by AEMO when developing the Integrated System Plan.[4]

Our estimates for the fraction of GDP contributed by the industrial, commercial and residential sectors was derived from an analysis of Australia's national economic figures since 1990.

Figure 5 shows how stationary energy consumption will continue to rise to 2050 in the absence of any major disruptions. In developing the forecast of emissions, we included one disruption that reduces the forecast stationary energy consumption derived from projecting business as usual trends. This disruption is the accelerated implementation of the electrification of heating - space heating in the residential and commercial sectors, and low temperature process heating in the industrial sector. ClimateWorks reported a 44PJ increase in electricity demand in 2050 as a result of electrification of heating.[5] We derived an estimate for the decrease in gas consumption for heating by assuming a typical coefficient of performance of heating (4.0) and a typical thermal efficiency of space heating (85%). This resulted in a decrease in the stationary energy consumption, as shown in Figure 5.

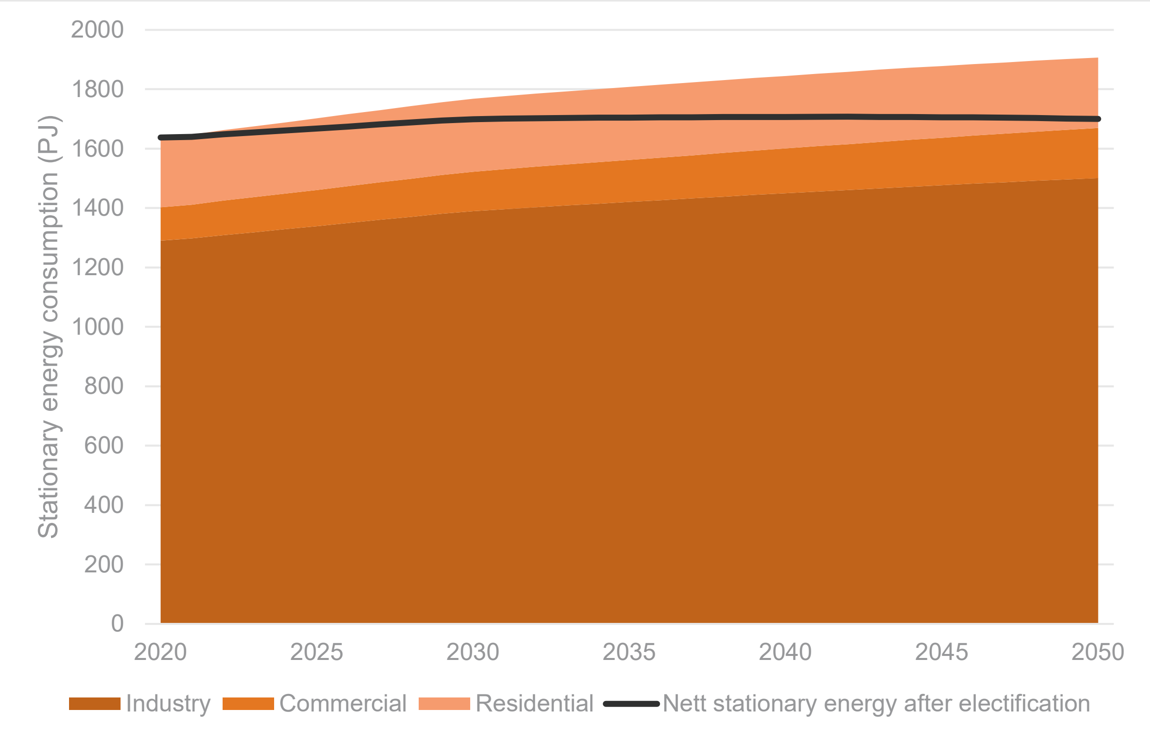

Figure 5: Stationary energy to 2050

Developing the forecast of stationary energy emissions from the forecast of consumption requires an estimate of the emissions intensity. Figure 6 shows the annual average emissions intensity of stationary energy, derived from values reported along with Australia's greenhouse gas inventory.

[4] See ***https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Integrated-System-Plan***

[5] See ***https://www.energynetworks.com.au/sites/default/files/climateworks_australia_gas-electricity_substitution_projections_to_2050_september_2016.pdf***

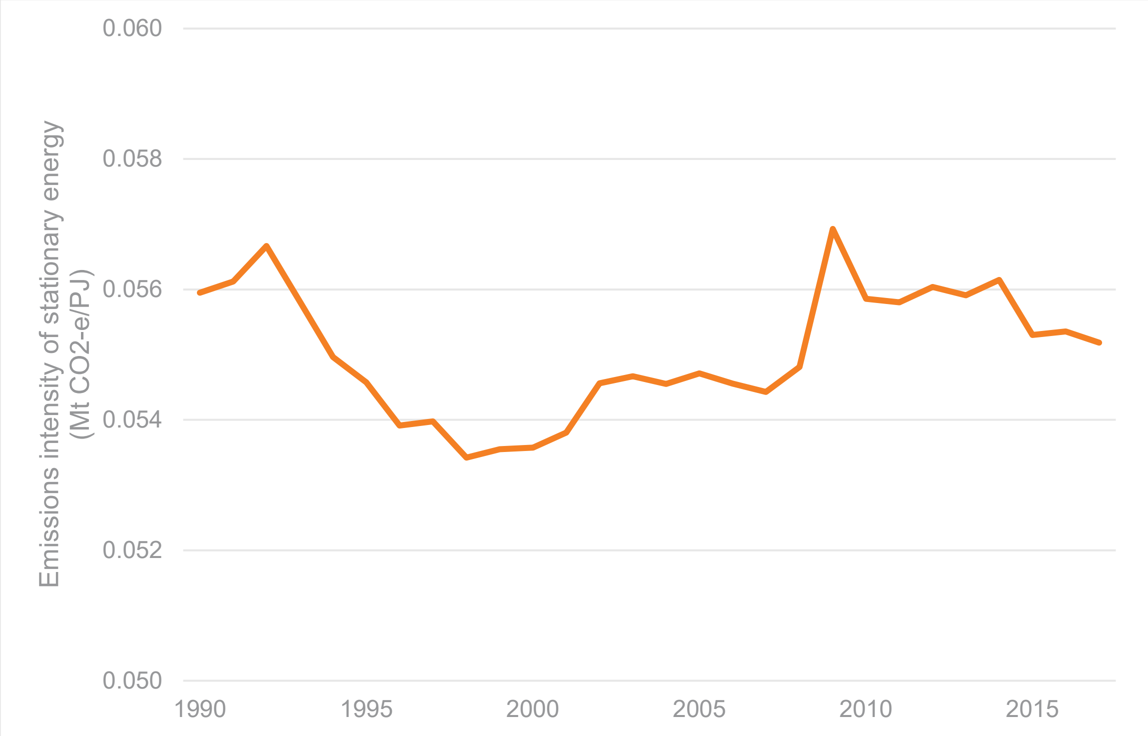

Figure 6: Emissions intensity of stationary energy

The emissions intensities shown in Figure 6 are around 10% above the emissions factor for natural gas suggesting that it is the main fuel for stationary energy applications; although some coal is used in certain applications such as alumina refining. Any of the uses of natural gas in industry are for high temperature heating and other specialist heating applications where electrification is not feasible. However renewable gas such as hydrogen or biogas provides a route to decarbonise some of these specialist or high temperature heating applications. In deriving this forecast of emissions to 2050, we have assumed that in the period to 2050, 10% of Australia's natural gas is substituted for renewable gas. This has the effect of reducing the emissions intensity of stationary energy fuel.

Electricity

Not surprisingly, forecasting emissions from the electricity sector is the most challenging. It is also the most important because the sector's contribution is the largest source of emissions.

We begin by estimating the demand for electricity, which is based on the broad trend in electricity use per unit of GDP and the forecast of national GDP. This figure is adjusted for the impact of electric vehicles and the electrification of heating. The generation fleet required to meet this demand is then determined. This analysis assumes that coal fired power stations retire as announced publicly or after 50 years of operation. Energy shortfalls are met by a combination of variable renewable generation and gas fired generation. We also account for the continuing installation of rooftop solar PV on residential, commercial and industrial buildings. Our analysis also allows for the on-going expansion of renewable generators, driven by corporate renewable Power Purchase Agreements (PPAs).

Factors driving the evolution of the generation fleet

Each year, electricity demand is derived from our estimate of electricity productivity and GDP. This is compared with the capacity of the generation fleet available at the time. If there is a shortfall, new capacity is added according to the following table. Similarly, if there is excess then capacity is withdrawn.

	2020	2030	2040		2050
Adjustments up of generation type to meet actual demand					
Natural gas	50%	33%	25%		10%
Utility scale wind and solar	50%	67%	75%		90%
Adjustments down of generation type to meet actual demand					
Coal	40%	50%	60%		60%
Natural Gas	50%	50%	40%		40%
Utility scale wind and solar	10%	0%	0%		0%
Minimum dispatchable load	50%	40%	25%		10%

There are allowances for current committed and contracted renewable generation to be delivered by 2020-21 compared with 2018 (27.1 TWh)[6] and for the impact of state-based programs such as the VRET and QRET (20 TWh). We note that there are risks in including these allowances due to the potential for double counting such as committed and contracted load being directed to the QRET or VRET. The tables below list key the assumptions used to derive our estimate for emissions from the electricity sector.

Table 2: Assumptions required to derive the forecast of residential solar PV

Year	% residential with solar PV	Average system size (kW)	Dwellings (millions)[7]	Capacity (MW)	Output (TWh)
2017	23%	3.31	7.19	5,537	7.8
2030	35%	4.50	8.77	13,813	19.5
2050	65%	7.00	11.16	50,783	71.7

Table 3: Assumptions required to derive the forecast of commercial solar PV

FY	% take-up of available roof area	Available roof area 'million m2 [8]	Capacity (MW)	Output (TWh)
2017	13%	57.6	1143	1.6
2030	21%	82.0	2635	3.7
2050	50%	124.3	9508	13.4

[6] See ***https://www.abc.net.au/news/2019-04-26/renewable-energy-investment-maybe-heading-from-boom-to-bust/11041964***
[7] The number of dwellings was derived by adjusting the number of dwellings (from ABS 2071.0 Table 19) by the latest projection of populating growth. The penetration was adjusted so that the total of residential and commercial solar PV in 2030 matches the 2017 figures plus the sum of annual expansion assumed in the NEG modelling.
[8] Energetics' estimate

Table 4: Assumptions required to derive the forecast of renewable capacity due to corporate Power Purchase Agreements

Item	Value	Notes
Projected network electricity demand by business in NEM states in 2037	131 TWh	AEMO forecast data dashboard (http://forecasting.aemo.com.au/)
Percent of electricity consumed by NEM states	84%	Australian Energy Statistics Table L. Australian consumption of electricity, by state, physical units
Projected network electricity demand by business in Australia in 2037	156 TWh	We assume that business electricity is proportional to total electricity
Projected network electricity demand by business in Australia in 2050	156 TWh	We assume that electricity demand by business is flat from 2037 to 2050
Percentage of business electricity demand covered by PPAs in 2050	50%	

Fugitives for fuels

The impact of fugitive emissions due to the production of fuels is shown in the next two graphs, along with the associated production volumes. In the case of fugitives from coal mining (Figure 7Figure 7), emissions have remained largely steady despite rising coal production.

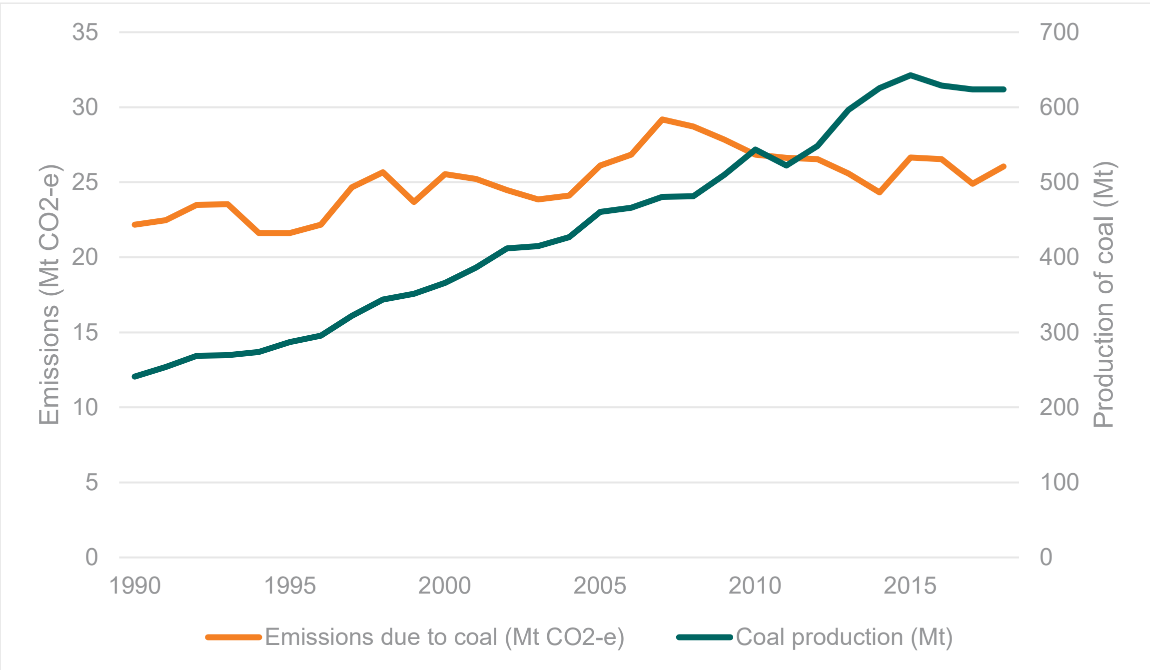

Figure 7: Fugitive emissions due to coal mining

The forecast of fugitive emissions due to coal mining in the Australian Government's most recent projection of national emissions[9] is a mine by mine estimate for all actual, proposed and closed mines, and it suggests that emissions due to coal mining will slowly rise in the period to 2030. This outcome is broadly consistent with the trend to date. The longer-term picture is less clear with many commentators predicting that Australia coal exports will fall and other saying that there will a demand for high quality Australian coal. Therefore, in the absence of more robust forecast, we use the latest forecast from the Australian government and assume that fugitive emissions from coal mining post 2040 will be constant.

Recent emissions for the production of oil and gas were dominated by the expansion of the LNG industry. Prior to the expansion of the LNG industry after 2014, fugitive emissions were steady if not slowly falling despite a rise in gas production. These trends can be seen in Figure 8.

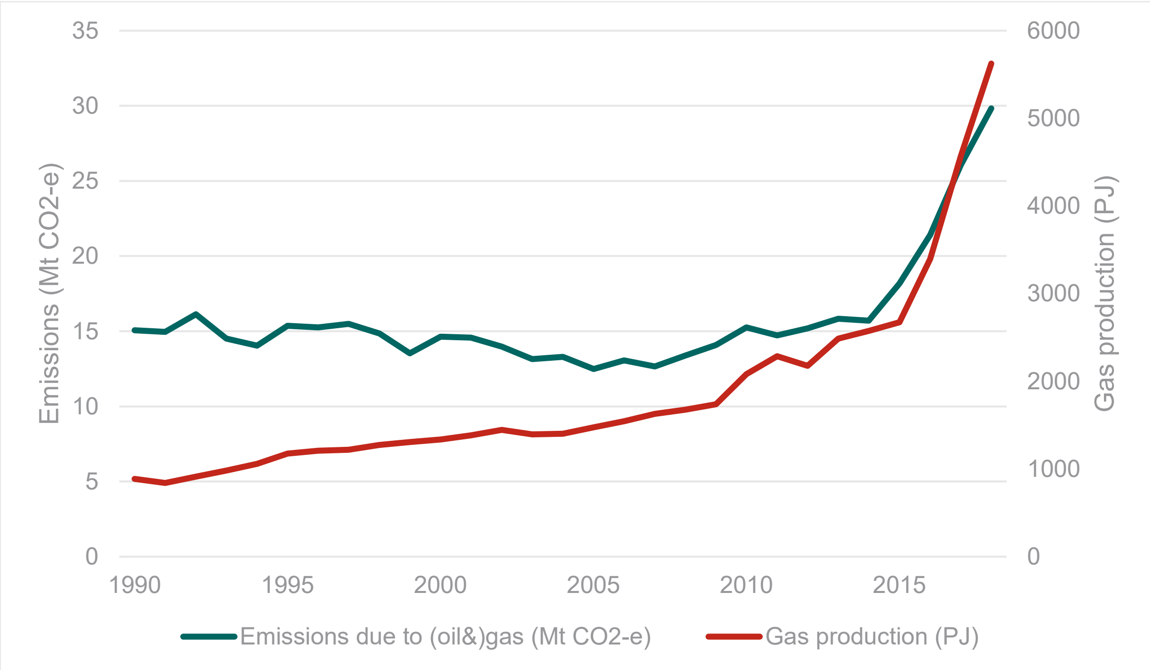

Figure 8: Fugitive emission due to gas production

The 2018 update of Australia's emissions project[9] predicts that the emissions due the production of oil and gas constant will be essentially constant after 2018 as no expansion in the LNG industry is proposed. We have used this result in our projection of Australia's emissions.

Industrial processes

Industrial emissions excluding substitutes for ODS are steady or falling. The falls in 2009 and after 2011 correspond to falls in raw steel output. Emissions from products used as substitutes for ozone depleting gases have been rising as these gases were introduced after the signing of the Montreal Protocol. The Australian Government has now prohibited the importing of these synthetic greenhouse gases

[9] *http://www.environment.gov.au/climate-change/publications/emissions-projections-2018* (Accessed 16 June 2019)

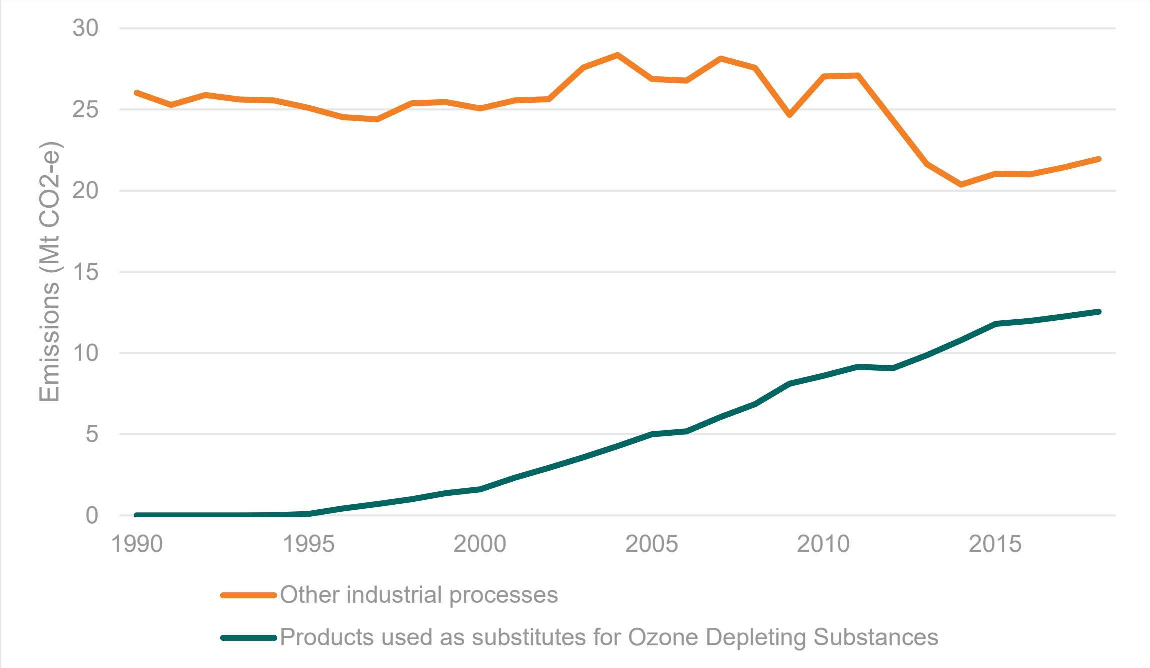

Figure 9: Emissions from industrial processes

We therefore assume that industrial emissions excluding those from substitutes for ozone depleting substances (ODS) remain constant at their 2018 value. Emissions from ODS substitutes reduce according to the agreed international phase-down of global HFC production and imports – an 85 per cent phase-down in developed countries relative to 2016 by 2036.

Emissions from other sources are assumed to be constant from 2018.

Land-Use, Land-Use Change and Forestry (LULUCF)

We use the most recent Department of Energy and the Environment projection for LULUCF emissions to 2030 and then assume the emissions after 2030 are constant.

Waste

We observed a clear declining trend in emissions from waste (see Figure 10). The decline in emissions from waste will reflect improvements in the management of waste facilities such as the diversion of certain organic waste streams and the capture and combustion of landfill gas. The reduction in emissions from waste has occurred despite rising volumes of waste due to population growth.

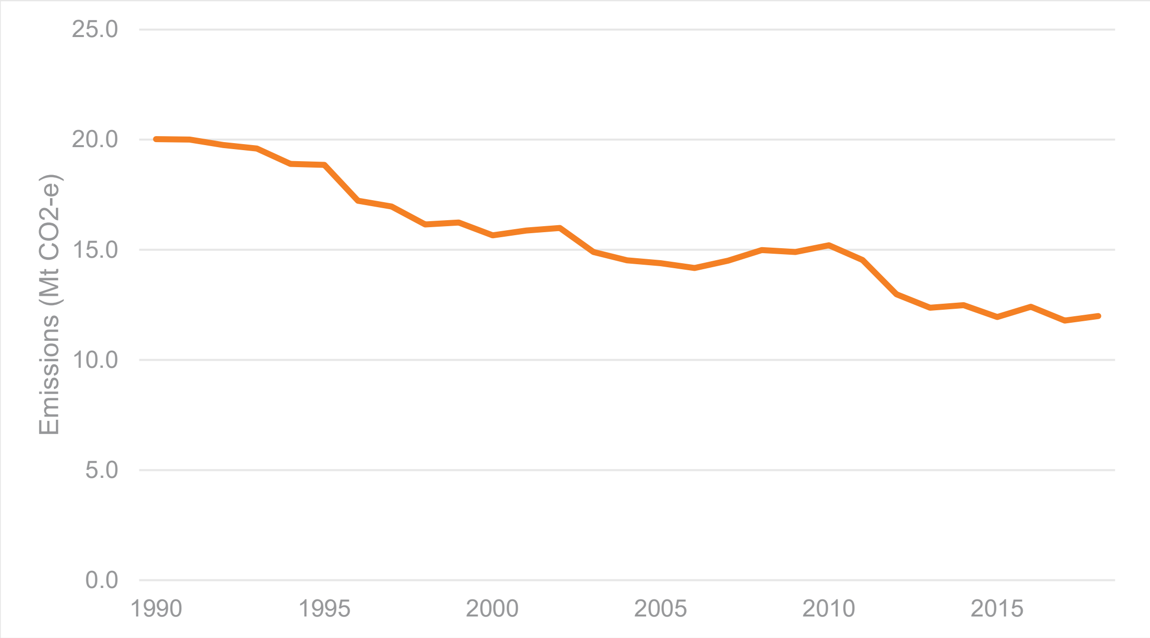

Figure 10: Emissions from waste

We assume that this trend will continue to 2050. There is considerable active research into alternative uses for waste streams (e.g. waste to energy, renewable gas generation) and more effective strategies for dealing with waste. Current government policies also support diversion from landfills which are the main source of emissions. These and other factors will contribute to the anticipated reduction with the requirement for additional policies that specifically target emissions from waste.

Agriculture

The major source of emissions from agriculture is enteric emissions from livestock, particularly cattle. The trends in emission sources from agriculture are shown in the figure below.

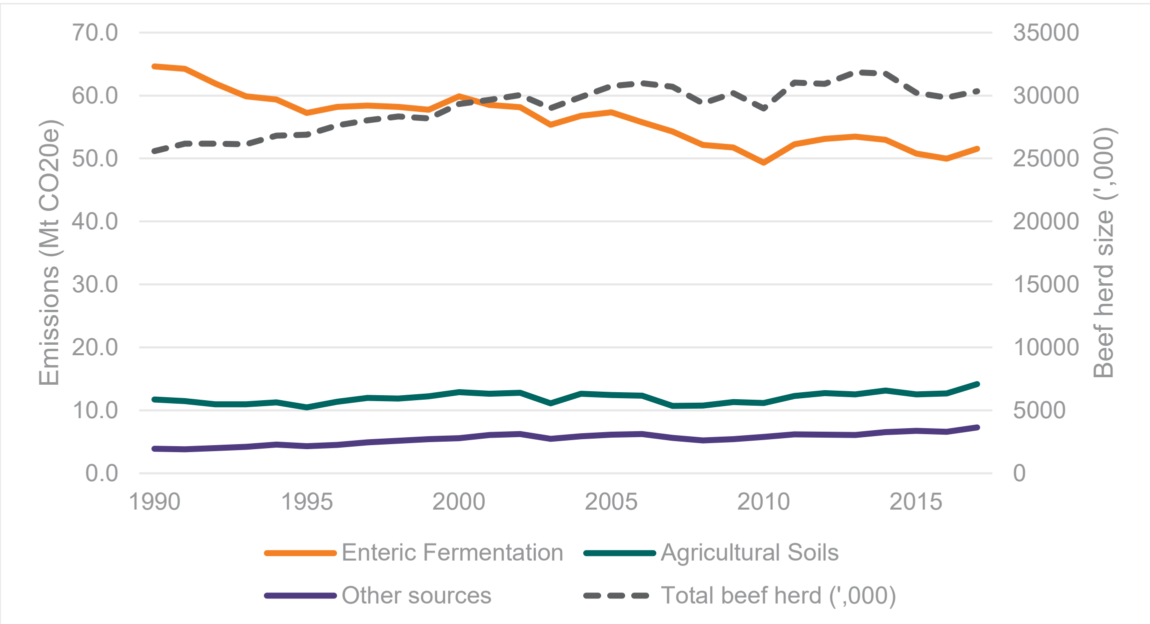

Figure 11: Emissions due to agriculture

The figure shows how emissions due to changes in soil carbon and emissions from other sources related to agriculture have been steadily rising for the past three decades. Enteric emissions have been falling despite a slow rise in the size of Australia's beef and dairy herds.

The forecast in emissions from enteric fermentation is based on the observed trend of enteric emissions with time. We assume that the rate of reduction of enteric emissions is double the historical value. We based this assumption on noting that the industry is examining a wide range of approaches to reduce enteric emissions because reducing enteric fermentation in ruminants is a way of increasing productivity.[10]

While noting that the agricultural sector is focusing on reducing emissions for its activities[11], we assume that emissions from agricultural soils and from other sources will grow in line with the trends observed since 1990.

[10] "More meat, milk and wool: less methane. Latest outcomes of research into lowering methane emissions and raising productivity in Australia's livestock industries", Meat & Livestock Australia Limited, July 2015
[11] The 2019 Australian Beef Sustainability Annual Update gives a good overview of efforts to reduce emissions from land use change, changes in soil carbon and enteric emissions due to the activities of the beef industry, in line with its target to be carbon neutral by 2030.

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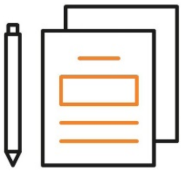

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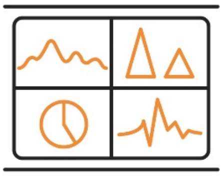

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