Australian National University

Australian National University Institute for Climate, Energy & Disaster Solutions

Australian Energy Emissions Monitor

April 2022

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CRICOS Provider No. 00120C

Australian Energy Emissions Monitor

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Key Points

- Following the publication, at the beginning of April, of the Mitigation volume of the IPCC's Sixth Assessment Report, it is timely to assess progress in reducing energy combustion emissions, which are by far Australia's largest source of emissions. The five states of eastern Australia collectively reached their peak energy emissions ten years ago, in early 2012, since then they have fallen by 12%. All of this reduction is attributable to the 29% fall in electricity generation emissions since 2008; emissions from petroleum products and gas have both increased.
- In Western Australia, by contrast, energy emissions continue to increase, because growth in emissions from petroleum products and gas has outweighed very modest decreases in electricity generation emissions.
- The National Electricity Market is thus the only source of significant energy emissions reduction in Australia. In the year to March 2022, grid scale renewable generation was just under 25% of total generation, and all renewable generation, including rooftop solar was just under 34%.
- As a special feature, this issue of the *Monitor* looks at the electricity system transition in each state on a year by year basis. Unsurprisingly, South Australia leads, reaching a 62% share of all generation in 2020-21. Victoria was next on 30%, then NSW on 23% and Queensland on 17%. All these figures include the contribution of rooftop solar. Emissions reductions from their historic peaks, mostly in 2008 or 2009, show a similar pattern: largest in SA and smallest in Queensland, where electricity generation and consumption continued to increase until 2017-18.
- Victoria and South Australia, the two states with the largest renewables shares and the largest emissions reductions, had average wholesale prices 25% lower than the other two states in 2020-21, and futures markets currently expect these lower prices to continue for at least another two years.
- In Western Australia, like Queensland, continuing growth in electricity consumption means that emissions reductions from electricity generation in 2020-21 were only 16% below the peak in 2016-17. Unlike Queensland, however, WA lags in uptake of grid scale solar generation, with output in 2020-21 less than 5% of grid solar generation in the NEM, despite the enormous solar resource in the state.

Introduction to the April 2022 issue

Welcome to the April 2022 issue of the *Australian Energy Emissions Monitor*, which is a bi-monthly publication of the ANU Institute for Climate, Energy and Disaster Solutions, providing timely analysis of the most recent trends in energy related greenhouse gas emissions. The publication is intended as a service to Australia's energy community.

The main feature of this issue is a broader look at the progress (and indeed lack of progress) in reducing energy emissions of Australia as a whole. For the first time it includes near complete data on WA. It also includes a more detailed look at the progress each state is making in transitioning its electricity supply system towards zero emissions.

The aim of the *Monitor* is to estimate and report on Australia's energy combustion emissions as soon as reasonably possible after data sufficient to do so becomes publicly available. This timing has consistently been 6 to 8 weeks after the last day of the month to which the emissions estimates relate. Energy combustion remains by far the largest contributor to Australia's total greenhouse gas emissions (72% in 2020) and is the main opportunity to rapidly reduce emissions. Minimising the lag between when emissions occur and when they are reported allows faster and more complete understanding of how Australia's emissions are tracking, and what changes are needed to achieve faster emissions reductions.

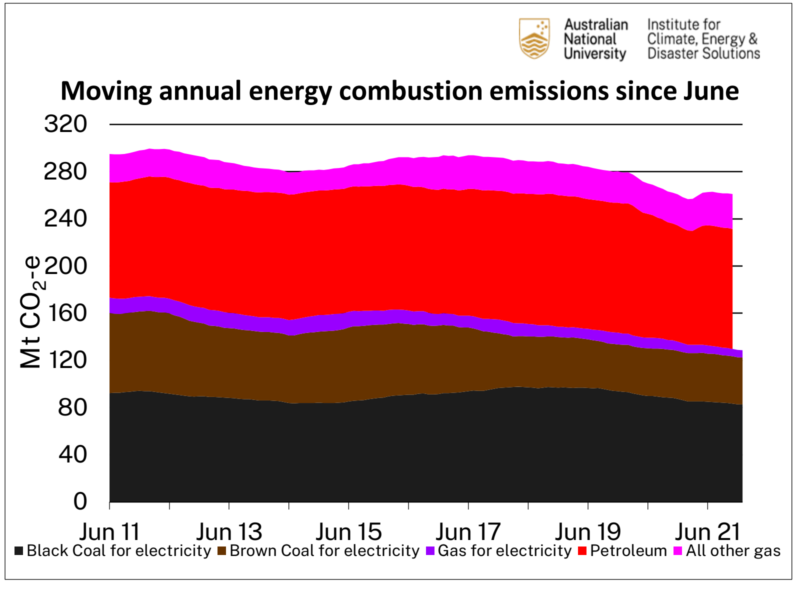
The main data presented in each issue of the *Monitor* covers around 80% of Australia's energy combustion emissions, with data on the remaining 20% of energy related emissions not available within the window of a 6 to 8 week lag, and some not publicly available at all. The additional data on WA, included in this issue, comes from a variety of other less detailed and less up to date sources, which are described more fully below. More detailed information on which emissions are reported in each issue of the *Monitor* and which are not, and on data sources and methodology, are in the Appendix. The underlying data is provided in a separate online document alongside the report.

Hugh Saddler (author and analyst) and Frank Jotzo (Head of Energy, ICEDS)

Is Australia decarbonising its energy supply?

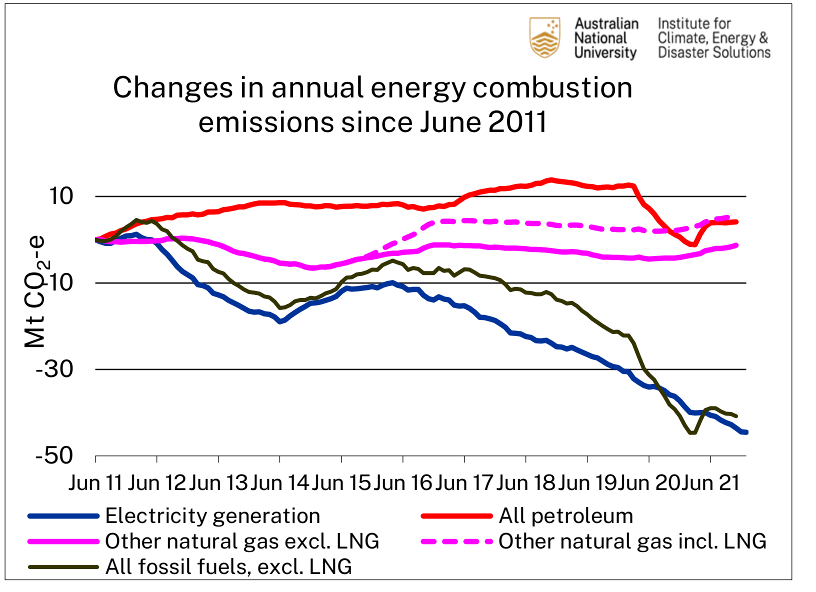
Figures 1 and 2 show total annual energy combustion emissions by major energy source in the five states, plus the ACT, of eastern Australia. Figure 1 shows total emissions while Figure 2 shows changes in emissions since June 2011. These are the same as Figures 1 and 2 of the two previous *Monitor* issues, with one change – petroleum emissions in WA and the NT are excluded. Both Figures 1 and 2 therefore show energy emissions in eastern Australia.

Figure 1: Moving annual energy combustion emissions, eastern Australia, 2011-21



Between the year ending June 2011 and the year ending January 2022, total energy combustion emissions fell by 34 Mt CO_2-e, equivalent to just under 11%. The decrease since 2005, reference year for the Paris Agreement, will be less, since energy emissions increased between 2005 and 2011. Figure 2 shows that this decrease is entirely attributable to the electricity system transition towards zero emission generation. Emissions from use of petroleum and gas, other than for electricity generation, both increased. Figure 2 also shows that, as at the year to January 2022, annual emissions from use of petroleum fuels had not returned to their pre-pandemic level. More detailed data, not shown separately in these graphs, makes it clear that this is mainly attributable to domestic aviation, which, in terms of fuel consumption, appears to still be some way below its pre-pandemic level.

Figure 2: Changes in moving annual energy combustion emissions in eastern Australia since 2011

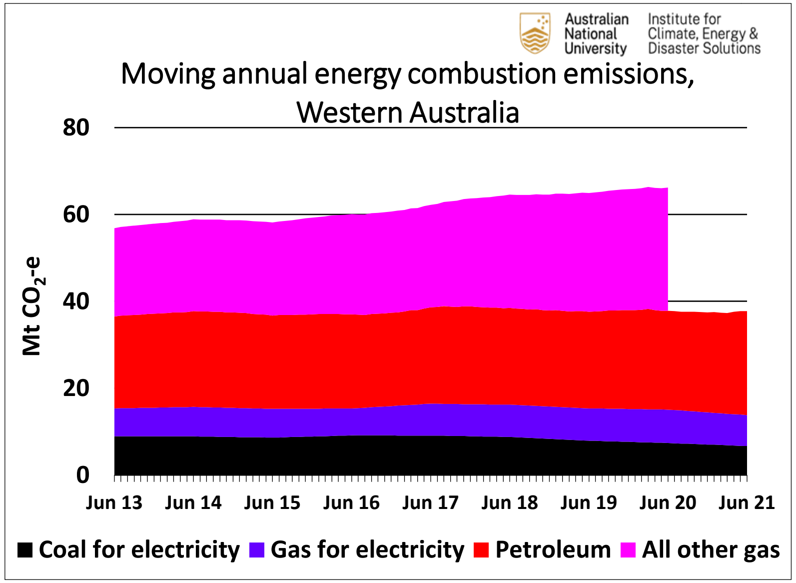


While not unexpected, the recent Budget decision to address the shock of sharply higher global oil prices by borrowing more public money to offset the higher cost of petroleum fuels used for road transport, is yet a further demonstration of the complete absence of any long term plans to transition road transport away from its complete dependence on highly polluting imported crude oil and petroleum products.

It is a striking fact that each of the five states and one territory in eastern Australia has made a public commitment to achieving large emission reductions, in most cases relative to 2005. On the basis of the data shown here, each state has an enormous task to achieve these targets. It is essential that policy and programs shift rapidly away from focussing almost exclusively on electricity generation, and pay at least as much attention to emissions from use of both petroleum products and gas.

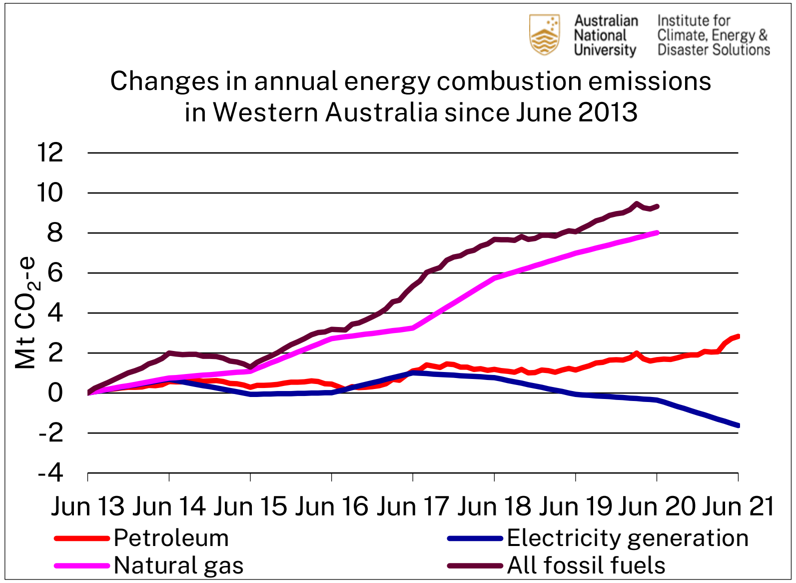
Figures 3 and 4 show total annual energy combustion emissions by major energy source, and changes in emissions since 2013, in Western Australia. These graphs have been compiled from several different sources and, as can be seen, are available only from 2013 and extend only to June 2020 in the case of gas and June 2021 in the case of electricity generation. Moreover, both gas and electricity emissions are derived from annual only data, with monthly changes calculated by simple linear interpolation.

Figure 3: Moving annual energy combustion emissions, Western Australia, 2013-19



A number of different data sources have been used to compile these graphs. Petroleum data are extracted from the monthly Australian Petroleum Statistics, and calculated by the application of standard default emissions factors for each petroleum product, just as for all other petroleum emissions shown in the *Monitor*. Electricity generation emissions are sourced directly from public electricity generation and emissions National Greenhouse and Energy Reporting Scheme (NGERS) data for so-called designated generation facilities. These are effectively all generators except rooftop solar system which supply at least some electricity into the transmission or distribution networks. The type of fuel used by each reporting generator is specified, making it a straightforward task to calculate total emissions from coal, gas and petroleum product fuelled generators (the latter are extremely small). 2012-13 is the first year for which these data were made available, and hence defines the initial year. National Greenhouse Gas Inventory (NGGI) data were the source for total natural gas emissions. NGERS data for gas emissions from electricity generation were subtracted from the annual totals, to give emissions from all other natural gas combustion. However, the most recent state level NGGI data is for 2019, so a figure for 2020 was estimated from total gas consumption data for WA in *Australian Energy Statistics*.

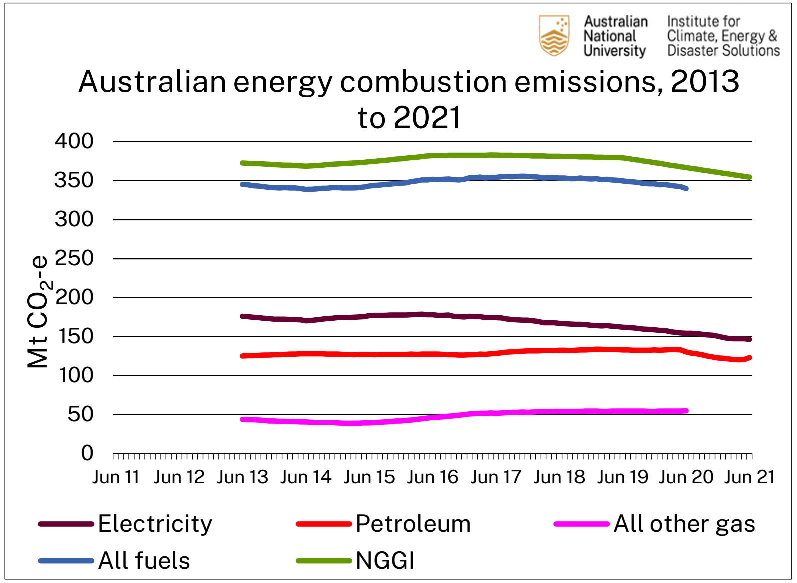
Figure 4: Changes in moving annual energy combustion emissions in Western Australia since 2013



During the six years between 2013 and 2020, Western Australia's energy combustion emissions increased by over 16%. By far the largest source of the increase was gas used to process gas to LNG for export, as the Gorgon Wheatstone and Prelude LNG projects all came on-stream during that period, more than doubling LNG production capacity in the state. There was also a significant increase in consumption of bulk diesel, presumably mainly associated with the mining industry. Road transport fuel consumption also increased, though more slowly and, since WA did not experience lockdowns, there was no reduction in road transport fuel consumption during 2020 and 2021, unlike the eastern states. Also unlike these states, WA has no explicit emissions reduction target.

Finally, in this section, Figure 5 shows the combination of emissions shown in Figures 1 and 3, i.e. for energy combustion emissions for all states and territories except the NT. It also includes Australia's total annual energy combustion emissions, as reported in the NGGI, up to 2019, and on to June 2021 in the *NGGI Quarterly Updates*.

Figure 5: Moving annual energy combustion emissions, all states and territories except the NT



Total Australian energy combustion emissions in 2021 were 7.2% less than the historic maximum level, reached in 2009, but only 1.8% below the 2005 level. In 2005 energy combustion emissions accounted for 58% of total national emissions. In 2021 the energy combustion share was 71%.

Quick update on the NEM

The previous section has demonstrated that electricity generation in the NEM is the only part of Australia's total energy system that is achieving significant emissions reductions. Figures 6 and 7 update NEM data to the end of March 2022. Figure 6 shows that the share of renewable generation continues to increase and the share of coal generation and total emissions both continue to decrease.

Figure 6: Changes in generation shares and emissions in the NEM

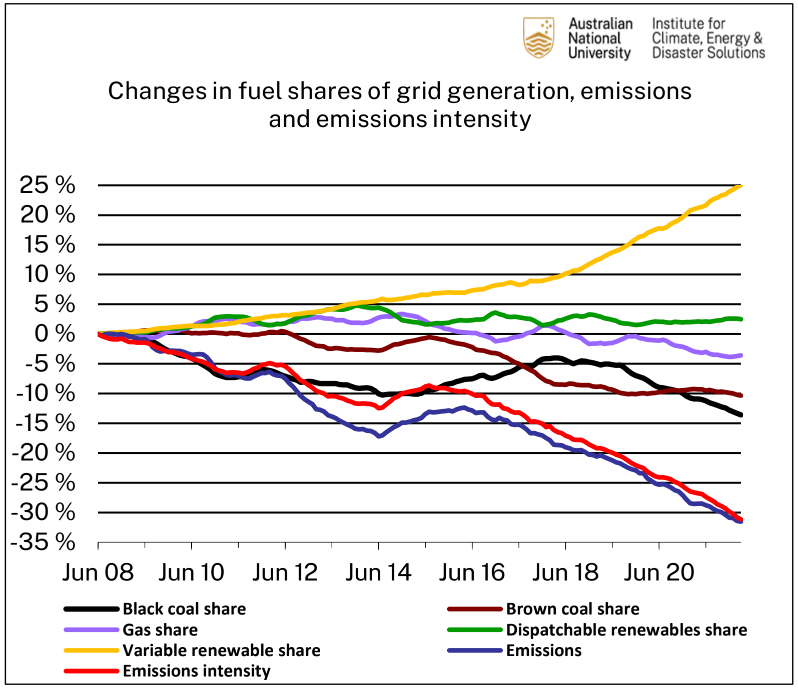


Figure 7 shows that coal generation is now only just above 60% of total sent out generation, including supply from rooftop solar, while renewable generation is now almost 34%, as can be seen more clearly in Figure 8. Figure 7 also shows the steady fall in gas generation over the past five years. Figure 9 shows that generation in South Australia, for a long time more dependent on gas than any other state in the NEM, has made an important contribution to the total gas generation decrease. In December, the monthly average daily renewable generation reached 75% of total electricity consumption, and in February 2022 it reached 73%.The consequent reduction in (synchronous) gas generation is a tribute to the way that all parts of the electricity supply industry in the state have worked with AEMO to change the system, so that it can continue to provide a secure and reliable supply of electricity without the need to specify large minimum shares of synchronous generation, previously provided by gas, and, until 2016, coal fired generators. Key changes already made include the installation of batteries and synchronous condensers, and AEMO and the industry are doing a great deal of planning for a shift to grid forming inverters, which will be key components of a 100% renewable electricity system.

Figure 7: Shares of annual generation in the NEM

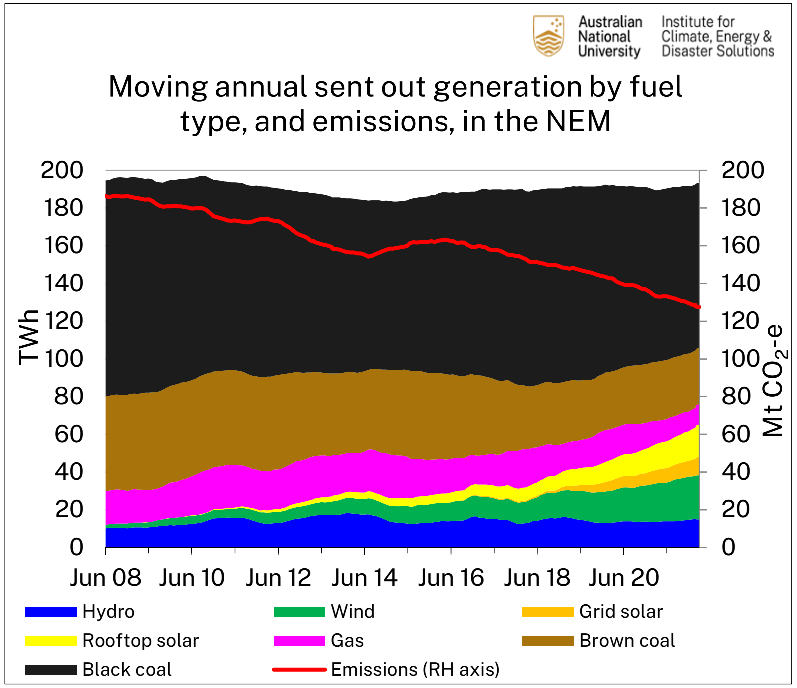


Figure 8: Moving annual shares of renewable generation in the NEM

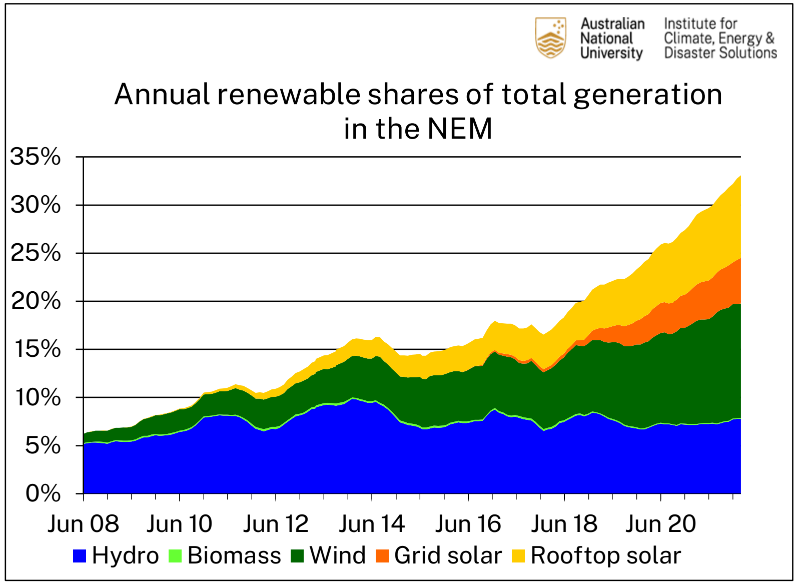
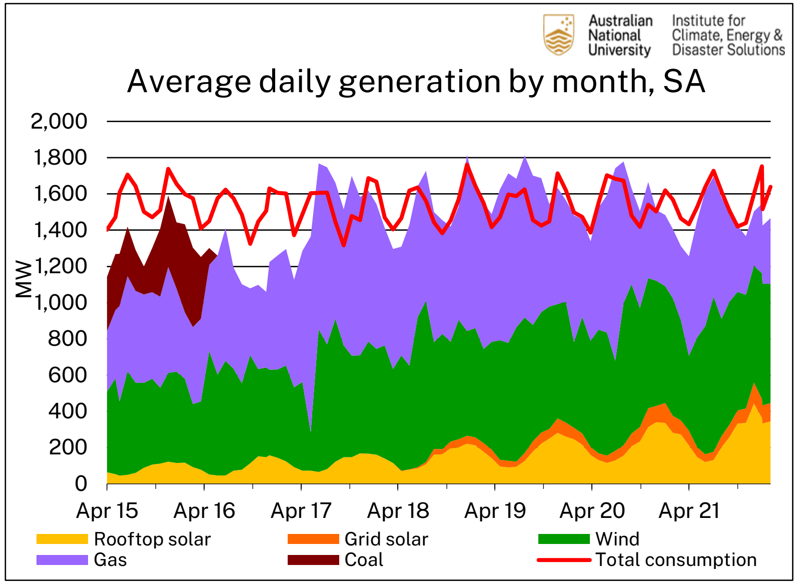


Figure 9: Average daily generation by month, South Australia



Electricity system transition in the NEM: state by state assessment

The first section showed that electricity generation is currently the only major source of reducing energy combustion emissions in Australia. Energy provided by direct combustion of both petroleum products and natural gas continues to be a source of increasing emissions. This section of the April Monitor looks at each of the four mainland states in the NEM individually, to assess how their electricity system transition, from coal and gas to renewable generation, is proceeding. The next and last section of this issue looks at Western Australia. Tasmania is not included, for the obvious reason that its electricity system is already effectively 100% renewable, being supplied by its fleet of legacy hydro plants, together with four windfarms commissioned over recent years and a small amount of rooftop solar. The transition in each of the four other states is described by a relatively complex graph, which shows annual data for:

- the quantities of electricity supplied in the state by each type (fuel) of generator,
- total electricity consumption (including the contribution of net imports/exports),
- annual greenhouse gas emissions, and
- annual volume weighted spot wholesale price, as calculated by the AER.

It is clear to see that both the speed and extent of the transition varies very considerably between the four states. For most of the parameters depicted in the graphs the sequence of the four Figures expresses the range from most to least progress of the state electricity system transition. South Australia is the most advanced and Queensland the least. The most obvious reason for these differences is that the first solar farm in Queensland was only commissioned in 2017 and the first wind farm in 2019, whereas in South Australia the first wind farm was commissioned in 2003 and the first in Victoria in 2004. Two other factors contributing to the slow rate of decarbonisation in Queensland have been, firstly, that it consistently exports significant volumes of electricity to NSW, made possible by its lower cost of its coal generation, and, secondly, that total state demand for electricity (including supply from rooftop solar) has been growing strongly, while in the other three states it has been either steady or falling for some years.

Figure 10: Electricity system transition, South Australia for year ending June

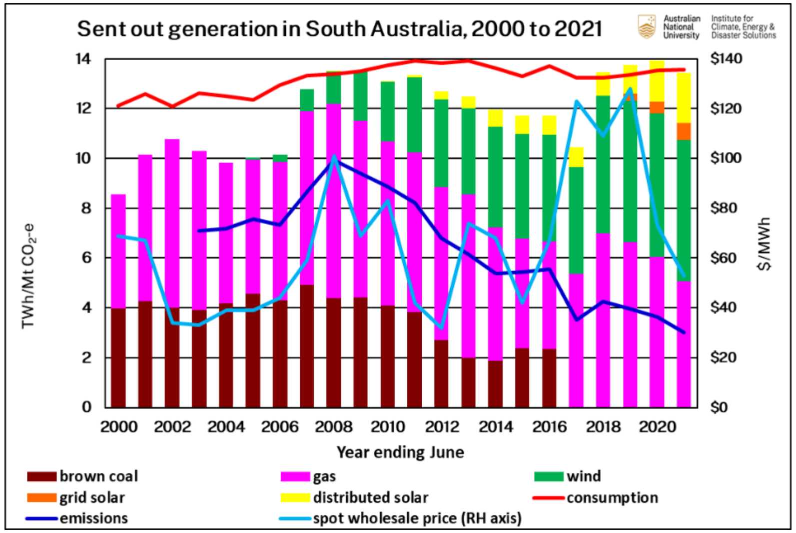


Figure 11: Electricity system transition, Victoria

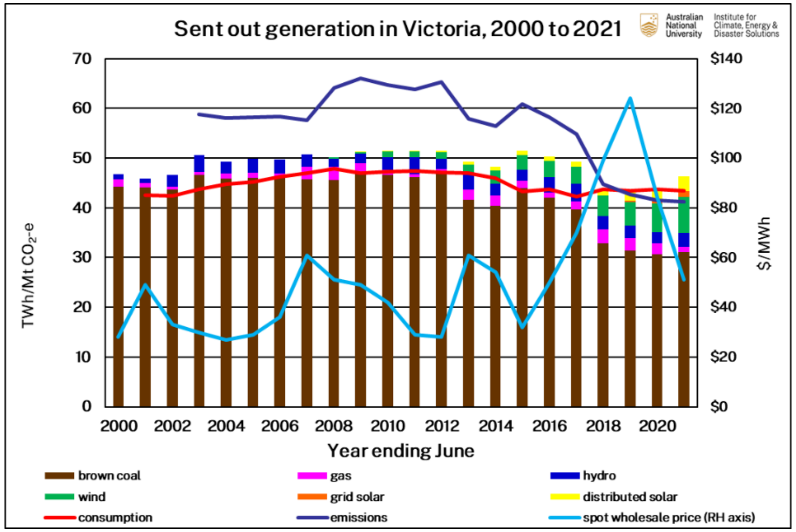


Figure 12: Electricity system transition, New South Wales

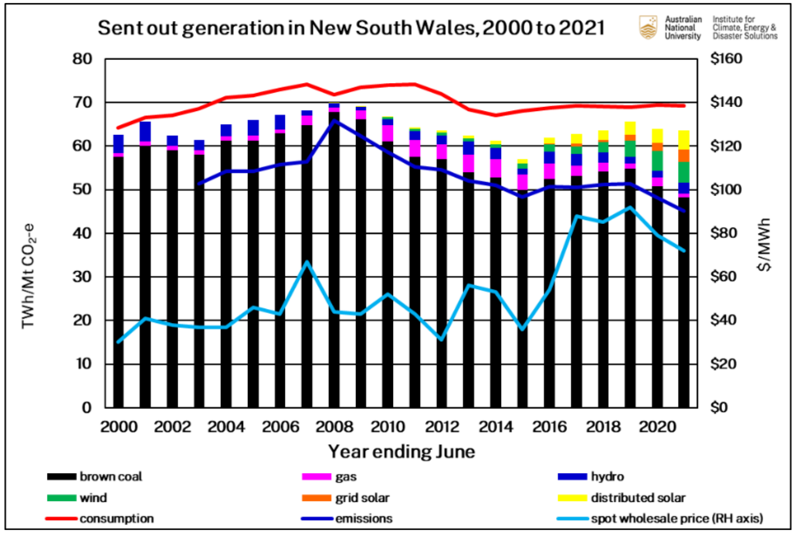
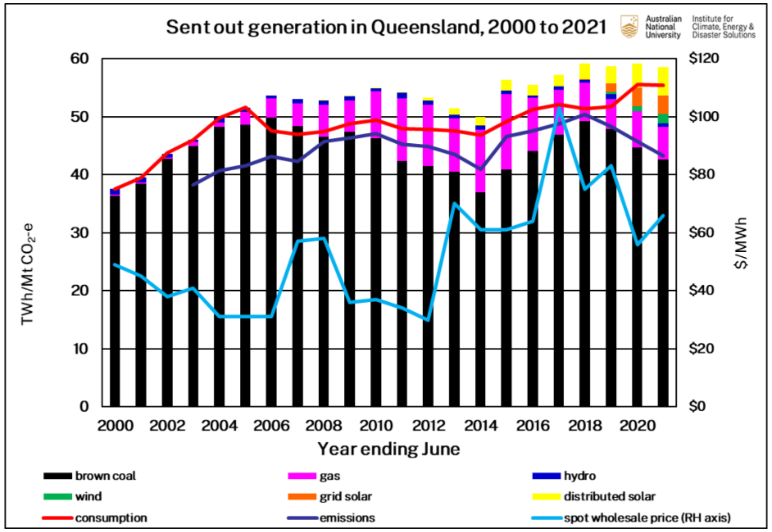


Figure 13: Electricity system transition, Queensland



As a number of commentators have observed, there is an obvious division in the NEM between the "north" (NSW and Queensland) and the "south" (Victoria, South Australia and Tasmania), in terms of their respective electricity system transitions. This division (or separation) is also seen in volume weighted average wholesale prices in 2021; in Victoria it was $51/MWh, in South Australia $53, in Queensland $66 and in New South Wales $72. This split is also seen in futures prices; AER data show, that prices for Victoria are lower than for New South Wales and Queensland in every quarter out to 2025, and that is also the case for South Australia, with the exception of one quarter in 2024.

Electricity generation and emissions in Western Australia

The electricity system in Western Australia differs from the system in eastern Australia in that the main grid, the South West Interconnected System (SWIS) supplies less than 80% of the total electricity supplied to consumers through distribution systems in the state. The remainder is supplied through the North West Interconnected System (NWIS), in the Pilbara area, and a large number of stand-alone power stations supplying mines and their associated communities in both the Pilbara and the Goldfields regions of the state. As foreshadowed in the February Monitor, the data shown in the graphs below are sourced from the NGERS designated generation facility data for generators in WA. As previously explained, these data provide as generated (not sent out) generation for all significant power stations (and many which might be considered insignificant) together with total scope 1 greenhouse gas emissions.

In addition, estimates of total, state-wide generation by rooftop solar systems have been available from the Australian Photovoltaic Institute (APVI) from 2016; these data are included in Figure 14. These data cannot be easily disaggregated to regions within the state, notably the area served by the SWIS, so are not included in Figures 15 to 17. Unfortunately, there are no complete data on the volume of electricity supplied to consumers from the distribution system, and no useful data on wholesale prices. Figures 14 to 17 therefore show only generation and emissions, and only from 2013 (2016 for rooftop solar).

Figure 14 shows that, for the state as a whole, electricity generation emissions have been falling gradually since 2017, mainly in line with the gradual fall in coal fired generation in the SWIS.

Figure 14: Electricity system transition, Western Australia

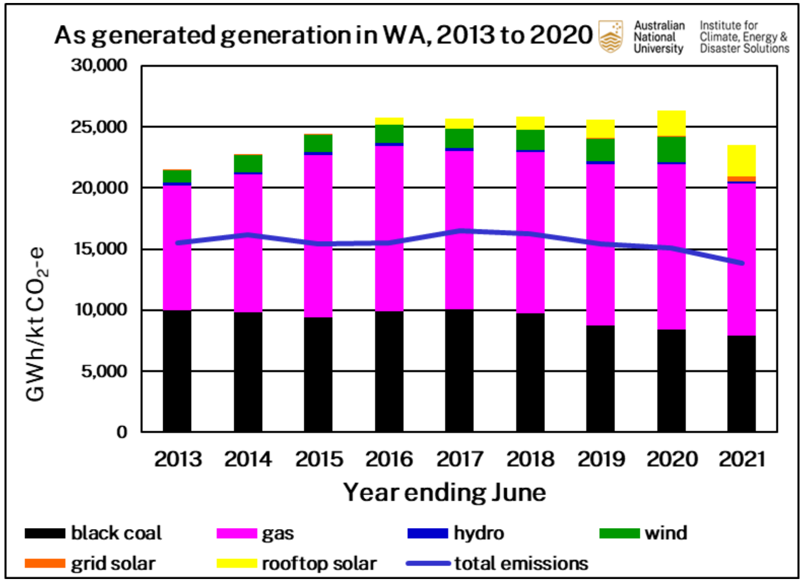


Figure 16: Electricity system transition, Western Australia NWIS

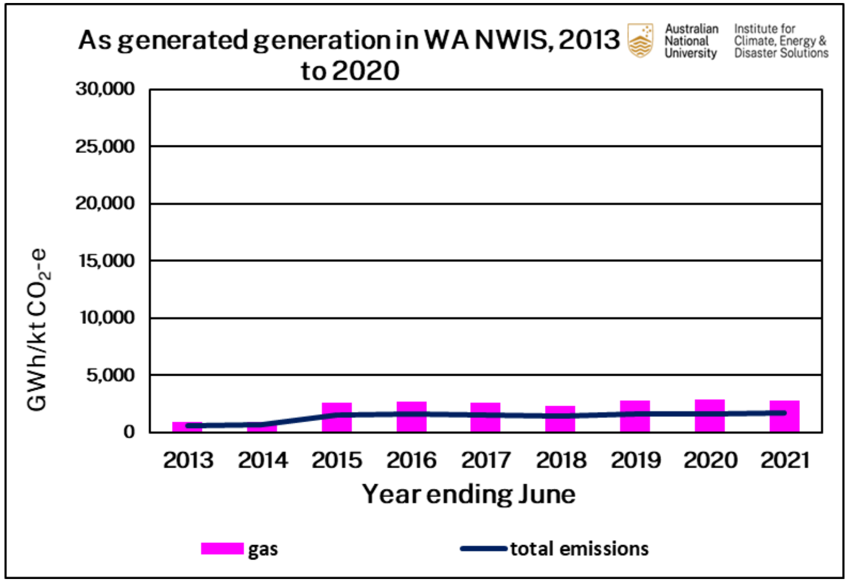


Figure 15: Electricity system transition, Western Australia SWIS

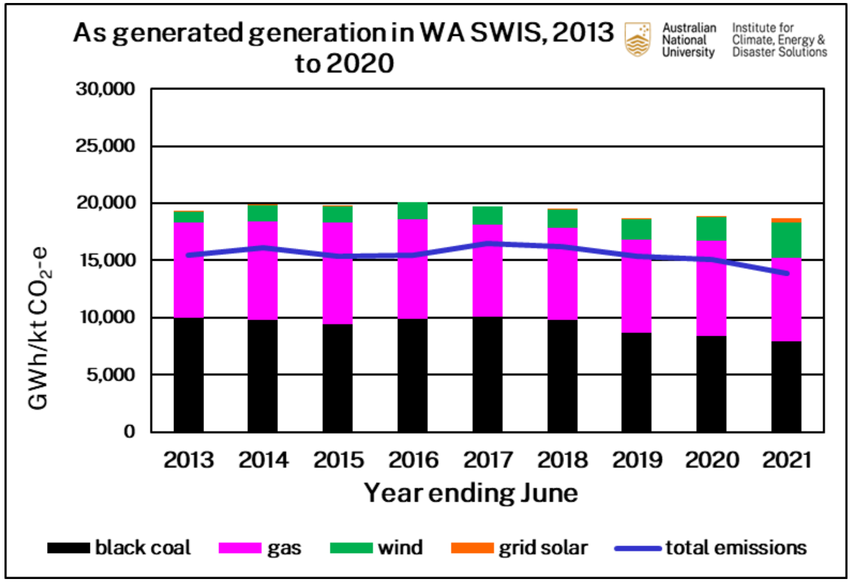
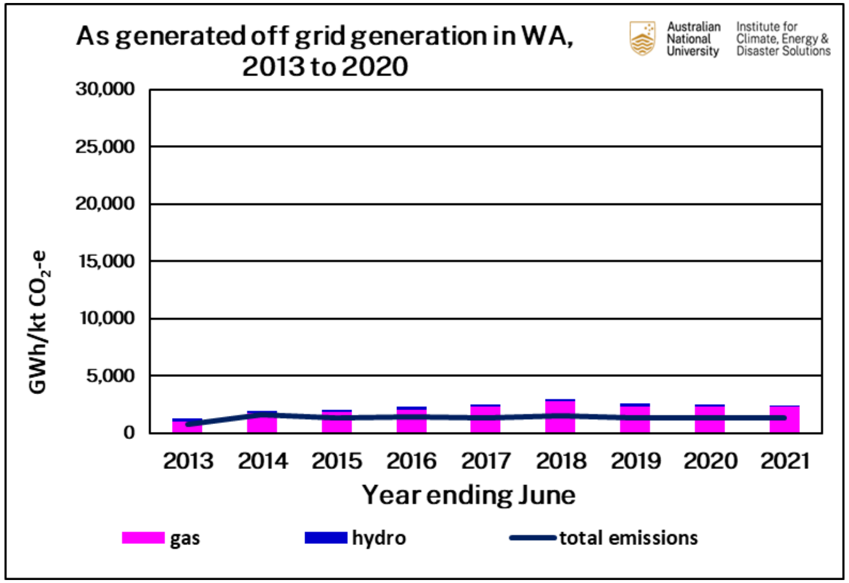


Figure 17: Electricity system transition, Western Australia stand-alone generators



The two most striking features of these data are the extremely small contribution of grid scale solar generation and the extremely large contribution of gas generation. In 2020-21, gas generation supplied more electricity in WA than in the whole of NEM, accounting for 47% on an as-generated basis, compared with just 6% in the NEM in the same year. By contrast, although WA undoubtedly has the largest solar energy potential of any state, its grid scale solar generation in 2020-21 was only 5% of grid scale solar generation in the NEM. Tasmania, with no solar farms, is the only state with less grid solar generation than WA. In addition, WA generated much less electricity from wind than either Victoria, SA or NSW, and only very slightly more than Queensland and Tasmania.

Gas is available to domestic consumers in WA at a lower cost than domestic gas supply in eastern Australia, because of the state government's gas reservation policy. This policy is applied to all LNG export projects, each of which owns and controls all, or almost all, of the gasfields from which it sources the gas supplied to its LNG plant. The reservation policy requires each LNG exporting project to withhold from export 15% of all the natural gas it produces from its gasfields, and offer this gas instead to the domestic market. The stated aim for the policy is to use abundant, low (or lower) cost gas to encourage value added processing of minerals and other industrial activity in the state.

The policy has been subject to considerable criticism by a wide range of economists, who argue that the benefits flowing to the Australian economy as a result of the low cost of gas to domestic manufacturers, is outweighed by the loss to the economy flowing from the reduced income of LNG producers. This critique is supported by the data shown here about what gas is actually used for in WA. In 2019-20, over 60% of the gas consumed in the domestic WA economy, i.e. excluding gas used by the gas and LNG industry itself, is used for electricity generation. It is possible that, as a result, this means that electricity consumers have access to electricity which is cheaper than it would be in the absence of the reservation policy. That is a question which could only be resolved by detailed analysis of the various costs and prices involved.

Apart from that specifically economic effect, it seems reasonable to deduce that access to low cost gas for electricity generation has been an obstacle to the wide scale adoption of grid scale solar generation in a state which is endowed with such an enormous solar resource. Low cost gas is thus one of the main reasons that WA unlike the rest of Australia, is increasing, rather than decreasing its energy combustion greenhouse gas emissions. It is ironic that the Pilbara has been identified by potential investors as an ideal location for new ultra-large scale solar generation of electricity, to be either exported directly by cable or used to make hydrogen, while existing electricity consumers in that region continue to rely on gas generation.

Appendix: Notes on methodology and data sources

Data on electricity generation and electricity consumption is for the five states constituting the National Electricity Market (NEM) only, i.e. data exclude Western Australia and the Northern Territory. All data are monthly totals, sourced from AEMO, accessed through NEM-Review. Data on gas consumption are also for the five eastern states only; sourced from the Australian Energy Regulator's weekly *Gas Market Report*. The main source of petroleum consumption data is monthly sales of petroleum products, compiled by the Department of Industry, Science, Energy and Resources and published as *Australian Petroleum Statistics*. Unlike the sources used for electricity and gas data, petroleum data covers the whole of Australia at the state level. The emission factors used for petroleum products and gas are based on *National Greenhouse Accounts Factors* and, in the case of petroleum products, are CO_2-emission factors only, because the (much smaller) emission factors for methane and nitrous oxide depend on the type of equipment in which the petroleum products are used.

Many of the graphs in *Australian Energy Emissions Monitor* are presented as moving annual totals. This approach removes the impact of seasonal changes on the reported data. Annualised data reported in *Australian Energy Emissions Monitor* will show a month-on-month increase if the most recent monthly quantity is greater than the quantity in the corresponding month one year previously. Most data are presented in the form of time series graphs, starting in June 2011, i.e. with the year ending June 2011. Some graphs start in June 2008. These starting dates have been chosen to highlight important trends, while enhancing presentational clarity.

Defining the meaning of the various terms used to describe the operation of the electricity supply system will help in understanding the data discussed.

Demand, as defined for the purpose of system operation, includes all the electricity required to be supplied through the grid level dispatch process, operated by AEMO. This includes all the electricity delivered through the transmission grid to distribution network businesses, for subsequent delivery to consumers. It also includes energy losses in the transmission system and auxiliary loads, which are the quantities of electricity consumed by the power stations themselves, mostly in electric motors which power such equipment as pumps, fans, compressors and fuel conveyors. Both demand and generation, as shown in the *Monitor* graphs, are adjusted by subtracting estimates of auxiliary loads. Thus demand, as shown, is equal to electricity supplied to distribution networks (and a handful of very large users that are connected directly to the transmission grid) plus transmission losses. Large users include the three pumped hydro schemes in the NEM, but since these both consume and generate electricity, net consumption, averaged over time, is only the difference between consumption and generation, termed round-trip losses.

Generation is defined to include only electricity supplied by large generators connected to the transmission grid. The numbers reported by AEMO are "as generated" generation, meaning the generation required to supply total demand, including auxiliary loads. However, most of the analysis and results presented in the *Monitor* show sent out generation, meaning as generated generation, minus auxiliary loads. To estimate auxiliary loads, the *Monitor* uses auxiliary load factors for each power station, published by AEMO and used in all its modelling work, including the modelling supporting the Integrated System Plan. Similarly, the Monitor uses AEMO figures for the emissions intensity (emissions per unit generated) of each power station.

Demand does not include electricity generated by rooftop PV installed by electricity consumers, irrespective of whether that electricity is used on-site ("behind the meter") by the consumer or exported into the local distribution network. This has been growing very rapidly and in the year to December 2021 totalled over 16 TWh. Also excluded is generation from landfill and sewage gas plants, and various other small generators, totalling about 2 TWh. All these types of small generator supply into their local distribution network, not the NEM grid. From the perspective of the supply system as a whole, the effect of this generation, usually termed either “embedded” or “distributed” generation, is to reduce the demand for grid supplied electricity below the level it would reach without such distributed generation.