



Australian  
National  
University



Australian  
National  
University

Institute for  
Climate, Energy &  
Disaster Solutions

# Australian Energy Emissions Monitor

August 2022

Dr Hugh Saddler

Institute for Climate, Energy & Disaster Solutions

[iceds@anu.edu.au](mailto:iceds@anu.edu.au)

The Australian National University

Canberra ACT 2600 Australia

[www.iceds.anu.edu.au](http://www.iceds.anu.edu.au)

CRICOS Provider No. 00120C

# Australian Energy Emissions Monitor

## Contents

Key Points.....	3
Introduction to the August 2022 issue .....	4
How does a 43% by 2030 emissions reduction target relate to Australia's energy emissions?.....	5
High energy prices.....	7
AEMO's 2022 Integrated System Plan .....	11
Appendix: Notes on methodology and data sources .....	13

## Key Points

- This issue focuses on two topical issues affecting energy systems and energy consumers: the commitment of the Labor government to reduce Australia's total greenhouse gas emissions to 43% below their level in 2005, and the very high prices for petroleum fuels, gas and electricity over recent months.
- The unanimous agreement of energy ministers on 12 August, to amend the National Energy Objective to include an emissions reduction objective was, in the words of the meeting Communique, "answering the call that has been there for too long".
- Relative to 2005, energy combustion emissions have increased from 58% to over 73% of Australia's total net emissions. The major part of the 43% reduction will have to come from energy combustion emissions.
- Nationally, emissions from electricity generation have fallen by 13% since 2005. However, emissions from use of petroleum fuels and natural gas have both increased. In absolute terms, road transport has always been the largest end use source of energy emissions, but the largest source of increased emissions by far has been mining, which has increased greenhouse emissions by 140% since 2005. Emissions from use of natural gas by final consumers have fallen, but there has been a very large increase in emissions from gas used to produce LNG for export.
- The next section of this issue presents graphs showing just how large the increase in wholesale prices of electricity, petroleum products and natural gas over recent months has been.
- It also includes graphs which plot, on a weekly basis for the National Energy Market (NEM) as a whole, average spot prices together with the shares of wind and gas generation in total electricity supply over each week. A strong correlation between high prices and higher shares of gas generation is apparent, while an equally strong inverse relationship between price and wind generation share is also easy to see.
- Finally, the release by the Australian Energy Market Operator (AEMO) in July of its final 2022 Integrated System Plan provides the opportunity to include a short overview summary of the purpose of the Plan and what it contains.

## Introduction to the August 2022 issue

Welcome to the August 2022 issue of the *Australian Energy Emissions Monitor*, which is a bi-monthly publication of the ANU Institute for Climate, Energy and Disaster Solutions (ICEDS), 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.

This issue opens with a discussion of the challenge presented to energy suppliers and consumers by the requirement to reduce Australia's greenhouse gas emission in 2030 to a level 43% below the level in 2005. Since energy combustion accounted for 73% of Australia's total greenhouse gas emissions in 2019-20 (which is Australia's most recently completed National Greenhouse Gas Inventory), it will also have to be the major source of emission reductions. While electricity generation emissions are now lower than they were in 2005, emissions from other parts of the energy system are higher, presenting a serious challenge to suppliers and users of both petroleum products and natural gas.

This issue also includes graphs showing the very large increases in wholesale prices of electricity, petroleum fuels and gas over the past six months. These are presented for information only and are not accompanied by any analytical discussion. A further set of graphs (the same data set presented in three different formats) shows the relationship over the period from late March to late July 2022 between NEM spot prices and the respective shares of wind and gas generation. Visually, the graphs show that prices appear to be higher when the share of gas generation is high and the share of wind generation is low, and conversely then the gas share is low and the wind share high. No statistical analysis of the data has been undertaken.

Finally, a very short overview of AEMO's recently released final 2022 Integrated System Plan for the National Electricity Market is included. This is particularly pertinent to the Labor government's planned Rewiring the Nation Corporation.

As always, the aim of AEEM is to provide accurate background information to the current policy debates. 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)

## How does a 43% by 2030 emissions reduction target relate to Australia's energy emissions?

The previous issue of the *Monitor* started with looking at energy emissions in the context of the government having just changed. This issue starts with an update of the same two graphs, in the context of the new government's emissions reduction target bill having just been passed in the House of Representatives.

Before proceeding to a more detailed examination of current greenhouse gas emission levels, it is important to also record one other important decision likely to affect the future of electricity supply in the NEM. This was the decision of Commonwealth, state and territory ministers to, in the words of the meeting Communique "fast track an emissions objective into the National Energy Objectives". The National Energy Objective (NEO), as it is currently worded, is:

*to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to: price, quality, safety and reliability and security of supply of electricity.*

The importance of the NEO is that it is intended to provide overarching guidance to the AEMC in how it decides to amend the National Electricity Rules over time (which the record show that it clearly does). It is also intended to (and does) influence both the AER and AEMO in how they apply and implement the Rules.

The Communique goes on to observe, correctly, that its decision is "answering the call that has been there for too long". The NEO was formulated in the 1990s, as a key step in the long process of setting up the NEM. Almost ever since, there have been attempts to persuade Ministers to amend it by adding an environmental objective. Until now, change has always been opposed by the major electricity supply industry businesses and by the key industry administrative and regulatory bodies. Several proposals were put forward, and ignored or

rejected, during the years of the Howard governments. Later, in 2008-09 the Rudd government asked the AEMC to consider whether a change to the NEO was needed to allow more effective implementation of the government's proposed climate change policies. The Commission concluded that no change was required. In 2016 the energy ministers appointed a three-person expert panel to review governance arrangements for Australian energy markets. Again, the recommendation was that no change was required.

Given this history, the change now agreed by all ministers is a significant signal, together with the Commonwealth legislation, that Australia is at last seeking to move forward in seriously addressing climate change

Returning to the topic of current and future energy combustion emissions, the emissions data in Figures 1 and 2, the most up to date available as at early August, shows monthly NEM electricity generation emissions to the end of July, petroleum emissions in eastern Australia to the end of May and gas emissions to the end of April only.

As expected, they show that while electricity emissions continue to fall, emissions from use of petroleum fuels and gas are gradually increasing, though consumption of petroleum fuels has not yet returned to its pre-pandemic level.

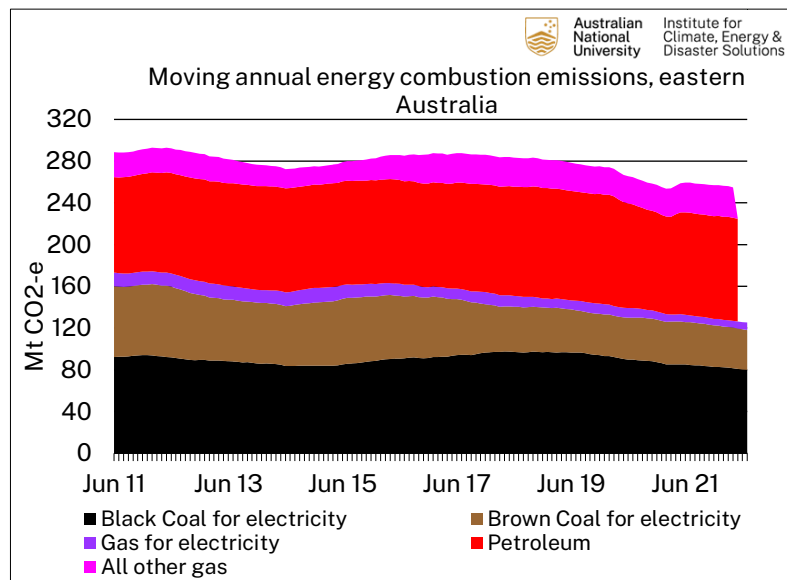
The emissions reduction target in the government's legislation is set against emission levels in 2005, in accordance with the Paris Agreement. This opening section of AEEM provides an overview of what a 43% reduction would mean if implemented *pro rata* for emissions

NEM electricity generation emissions were 177 Mt CO<sub>2</sub>-e in 2005. They reached a financial year peak of 187 Mt in the year to June 2008. Over the following eight years NEM emissions levelled out, then fell and increased again, with the effect of the on/off price on emissions. The subsidiary peak level in 2016 was below the 2008 level, because by then the effect of growing generation from wind and rooftop solar was becoming significant. Since 2016 emissions have fallen steadily, reaching 126 Mt in 2022, which is 29% below the 2005 level. And just

over 32% below the 2008 peak. Over the six years between 2016 and 2022 NEM emissions fell at an average rate of about 6 Mt CO<sub>2</sub>-e per year. A reduction of 43%, relative to 2005, would require NEM emissions over the eight years between now and then to fall at only half that rate - about 3 Mt per year.

Such a rate of reduction is eminently achievable and, indeed, all the scenarios modelled by AEMO for the 2022 *Integrated System Plan* (ISP) anticipate a fast rate of emissions reduction.

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

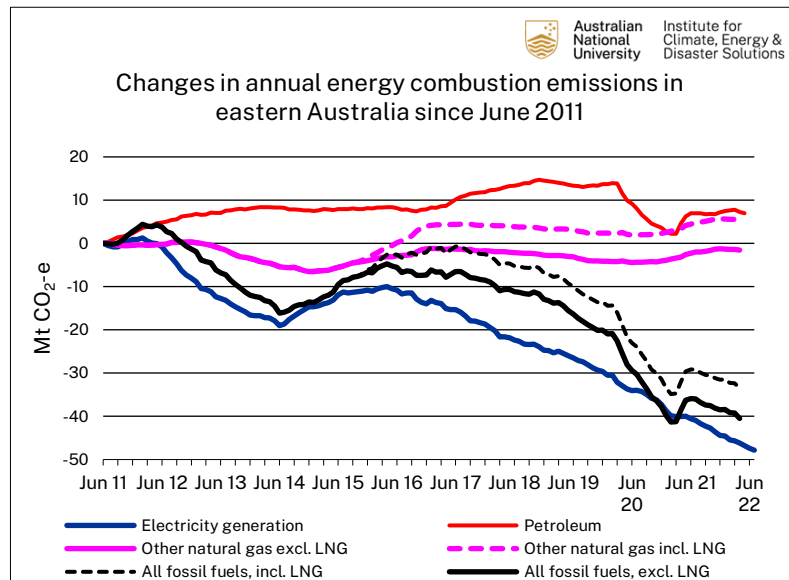


For emissions from petroleum fuels, on the other hand, the challenge is far greater, as every issue of AEEM has emphasised. Official National Greenhouse Gas Inventory data for Australia as a whole show that between 2005 and 2020 (the most recent year for which Inventory data are available) emissions from consumption of petroleum fuels increased by 17%, equal to 16.0 Mt CO<sub>2</sub>-e.

Road transport accounted for 59% of total emissions in 2020 and contributed 68% of the total emissions increase between 2005 and

2020. Road transport emissions increased by 11% from 2005 to 2020. Other transport (mainly domestic aviation) recorded an increase which was more than three times larger in relative terms, though smaller in absolute terms. However, aviation emissions in total are much smaller than road transport emissions. The largest source of increased emissions between 2005 and 2020 was mining, which in relative terms increased its emissions by an astonishing 137%. In 2020, mining contributed 14% of Australia's total petroleum emissions, but 68% of the increase in emissions between 2005 and 2020. Coal mining alone contributed 30% of the total emissions increase, though only 7% of the total emissions in 2020. Given that petroleum emissions accounted for 27% of Australia's total greenhouse gas emissions in 2020, it is very hard to see how the 2030 target can be achieved without drastic reductions in emissions from both road transport and the mining industry. Figure 2 shows that annualised consumption of petroleum products is still below the level it reached in 2019 because the annual total still includes a number of months with partial lockdowns and border closures. Monthly data in Figure 3 below, however, shows that by May (the most recent available month) emissions had returned to pre-pandemic levels.

Figure 2: Changes in moving annual energy combustion emissions, 2011-21



As Figure 2 shows, consumption of natural gas, and resultant emissions, in eastern Australia, have been fairly constant for a number of years, excluding consumption and emissions from the operation of the three LNG plants at Gladstone, in Queensland, and the associated consumption and gas powering compressors, pumps and other equipment in the gas fields supplying the LNG plants. Emissions from consumption of gas by final consumers, i.e. excluding electricity generation, are much less than emissions from either electricity generation or consumption of petroleum fuels – about 22 Mt CO<sub>2</sub>-e p.a., compared with about 130 Mt from petroleum fuels and 126 Mt from electricity generation.

Manufacturing industry, residential buildings, and commercial buildings account for almost all natural gas consumption. There is considerable interest in reducing emissions from natural gas consumption by replacing it with electricity. In early August the ACT government formally announced that it would be introducing a policy to prohibit reticulated gas connections to all new buildings, and would also be encouraging owners and operators of both residential

and commercial buildings to replace existing gas appliances with electric alternatives. For manufacturing, “green” hydrogen is seen as a potential alternative, but probably in the somewhat longer term.

## High energy prices

Over the last few months, consumer prices for petroleum fuels, natural gas and electricity have all been at their highest ever levels in terms of nominal dollars, and amongst the highest, at least for some years, in constant dollar terms. The next three graphs show quarterly spot wholesale prices for natural gas in the four main eastern Australia markets, daily terminal gate wholesale prices for petrol and diesel, and median monthly NEM spot wholesale prices in each of the five NEM regions (states).

Figure 3 shows very clearly the effect of the halving in excise at the beginning of April, and also suggests that prices may have peaked towards the end of June. Note that terminal gate prices function as maximum wholesale prices, and many transactions between wholesalers and retailers and also with large final consumers occur at discounts off terminal gate prices. Figure 4 shows monthly emissions arising from wholesale sales of the main petroleum products. Emissions are of course proportional to the volumes sold and used, and show, up to the end of May, no obvious impact of higher prices on consumption. This may well be because wholesale transactions precede retail sales and may well reflect volumes contracted before retailers knew whether higher prices would affect volumes sold.

Figure 3: National average daily terminal gate petroleum prices

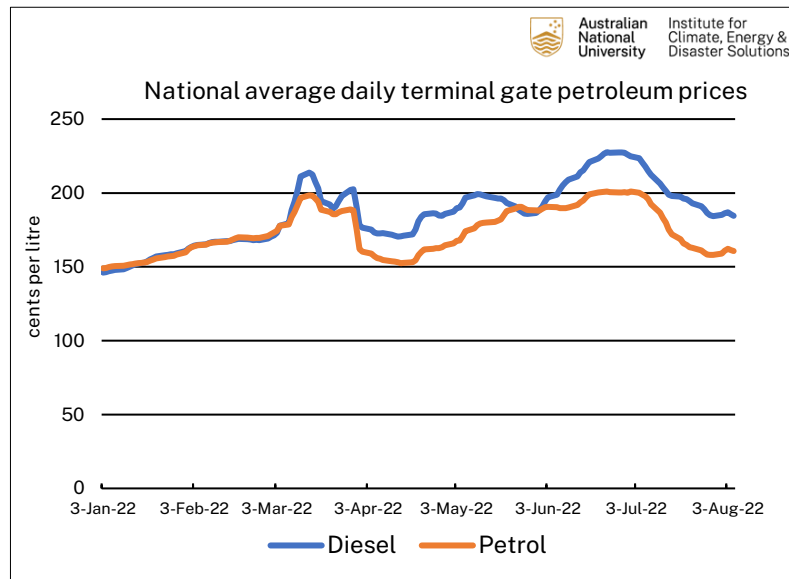


Figure 4: Emissions from petroleum fuels (based on monthly sales data)

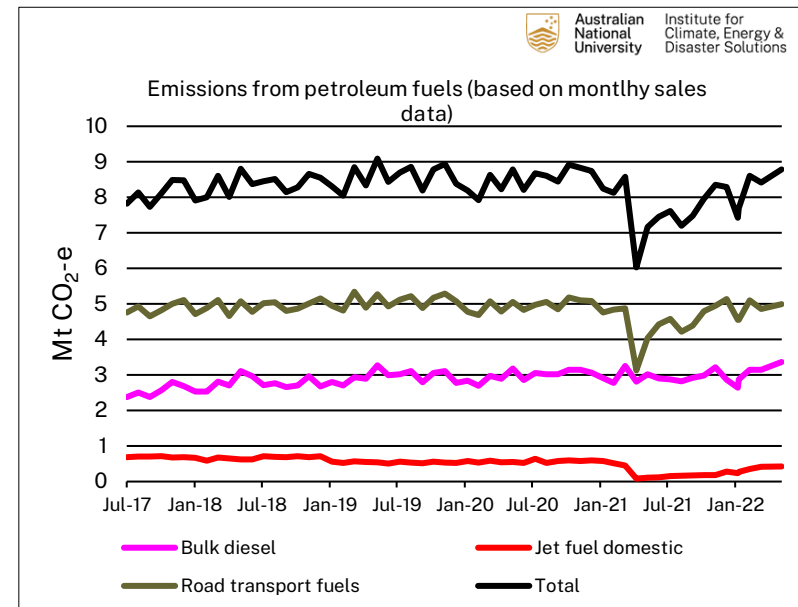
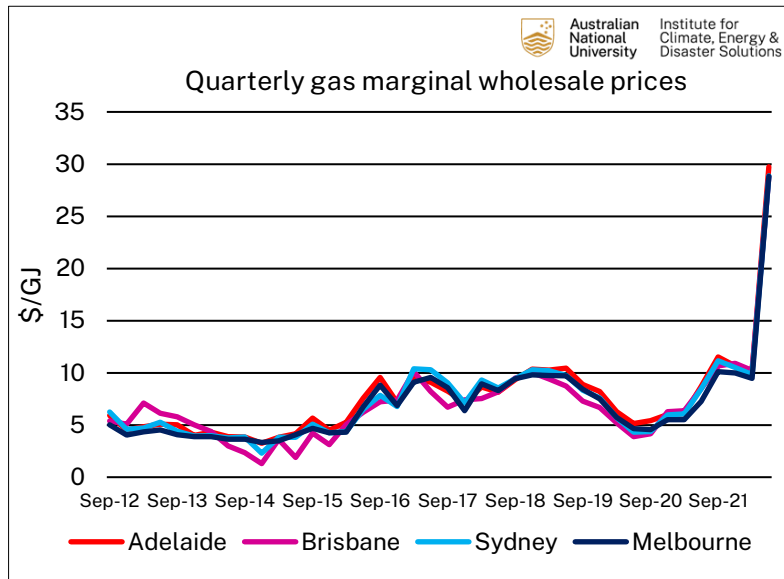


Figure 5 shows wholesale gas prices, published regularly by the AER up to the June quarter. The huge rise in price this year is very obvious, as is the fact that prices in all four markets move closely together, because the Queensland gas fields are the marginal source of supply for all of eastern Australia. Gas sales/consumption volume data are currently available only up to late April, and show no evidence of any effect of higher prices on consumption.



Figure 5: Quarterly gas marginal wholesale prices



Finally, Figure 6 shows wholesale electricity prices in the NEM and, in terms of general shape, bears a close resemblance to Figure 5. NEM prices are set every 5 minutes and are strongly influenced not only by the marginal costs at coal and gas fuelled power stations (the marginal cost of renewable generation being close to zero at all times), but also by the bidding behaviour of suppliers of dispatchable capacity (meaning not only the owners/operators of coal and gas fuelled power stations, but also the owners/operators of hydro power stations). Bidding behaviour is in turn affected by the availability of capacity. As discussed in the June *Monitor*, unavailability of large shares of coal generation capacity was recognised as one factor contributing to the initial large price increase in April and May.

Figure 6: Median monthly NEM spot prices

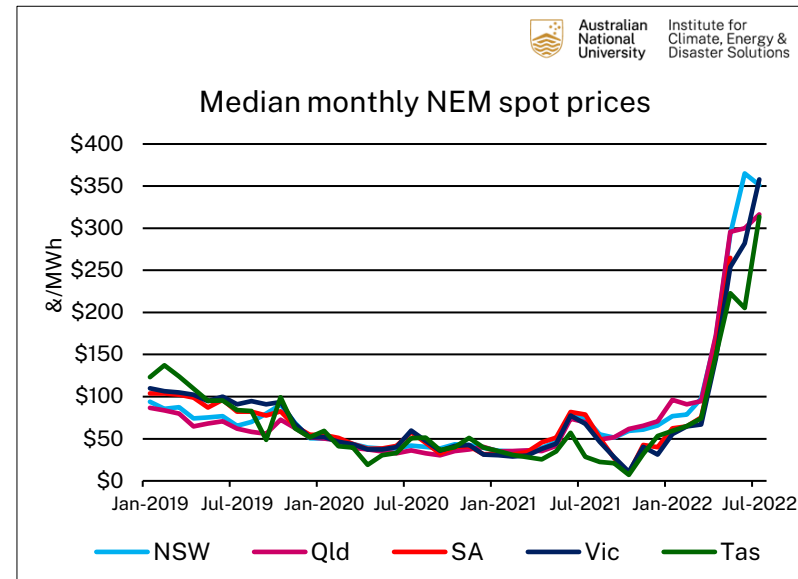


Figure 7: Average monthly availability of coal fired power stations

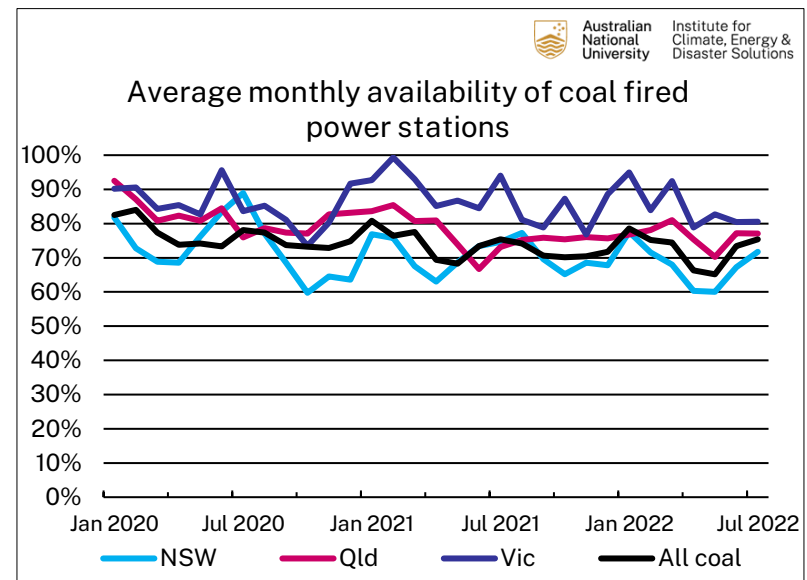


Figure 7 updates the graph of coal generation availability in each state to the end of July. It clearly shows that availability fell to very low levels in April and May, particularly in NSW and Queensland, but was not much better in June and July.

Towards the end of July, supply was boosted by a number of days with very high levels of wind generation. Availability of coal fired power stations also improved during the last few days of July and the first week of August. Both appear to have contributed to a moderation of extreme wholesale prices. That said, throughout the period gas generation, though a relatively small share of total generation, was important because of its ability to change output quickly both up and down, when needed to balance opposite changes in wind generation.

The next three graphs show different versions of the same daily data, covering median spot prices and shares of generation from each major generation source. Data are for the NEM as a whole because, as Figure 6 shows, prices in each of the five states are closely correlated. This relationship is a consequence of the capacity available for inter-regional flows through interconnectors, in many ways making the NEM a single market. Specifically, Tasmania, although it used no gas and of course no coal generation either, throughout the high price period, experienced the same extreme prices as the mainland states.

**Figure 8: Daily price and generation shares in the NEM, complete dataset**

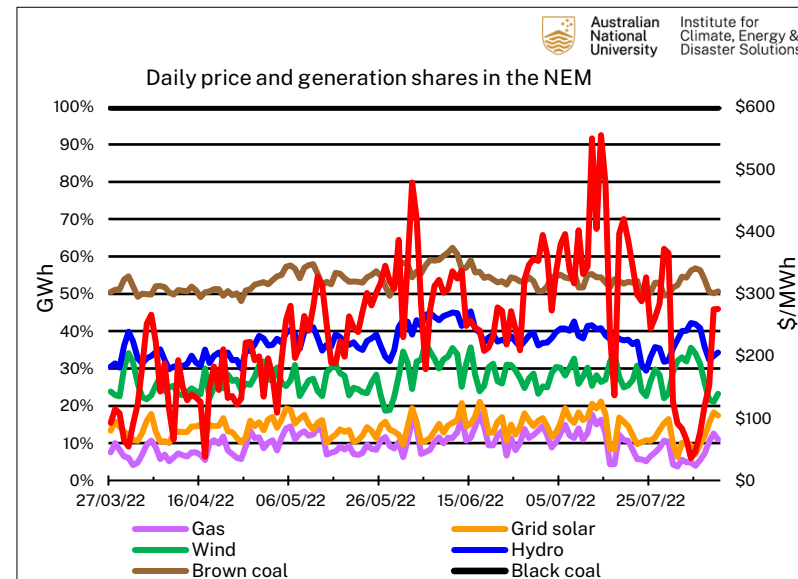
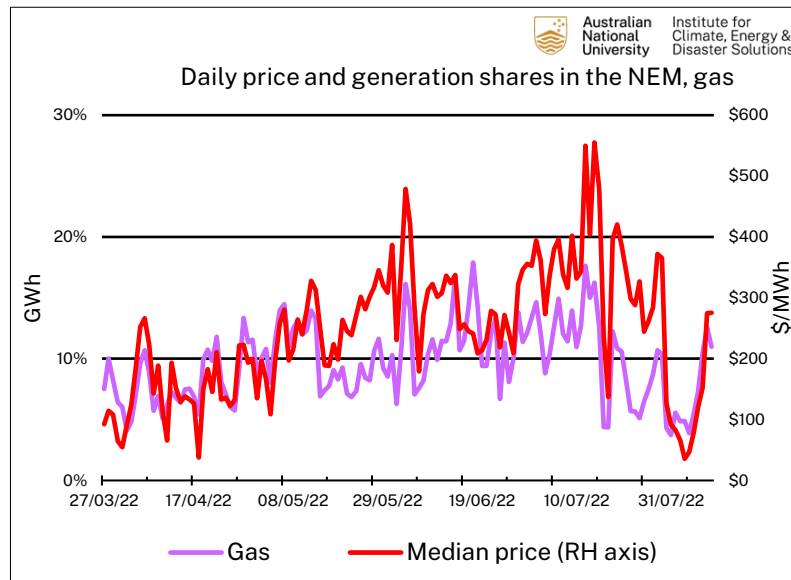
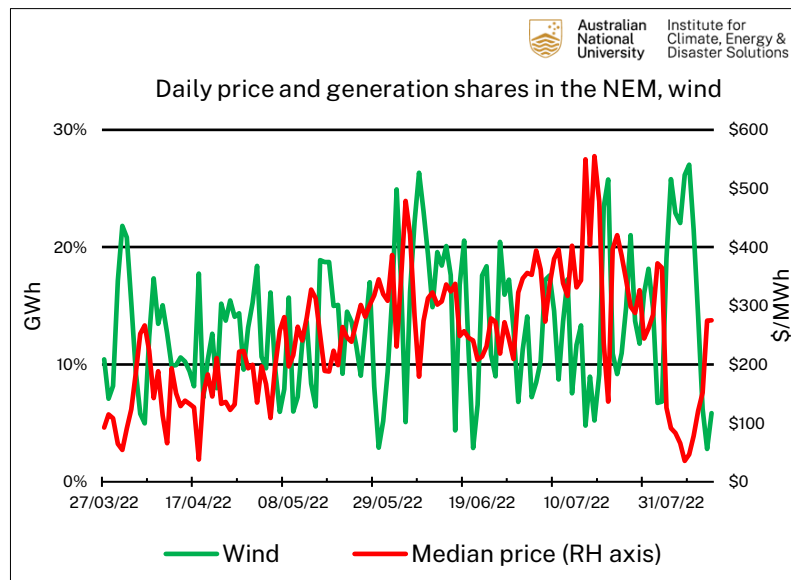


Figure 8 shows the complete dataset, Figure 9 shows price and the gas generation share and Figure 10 shows price and wind generation.

**Figure 9: Daily price and generation shares in the NEM, gas**



**Figure 10: Daily price and generation shares in the NEM, wind**



Figures 9 and 10 show, respectively, as strong positive correlation between the share of gas generation and price – a higher gas share is associated with higher spot prices in the NEM. Figure 10 shows the inverse for wind generation – higher shares of wind generation are associated with lower spot prices.

These observations show the importance, and urgency, of rapidly developing alternatives to gas generation, to provide for “firming” variable wind and solar generation in the NEM at lower cost than gas generation and avoid the exposure to volatile international gas prices.

## AEMO’s 2022 Integrated System Plan

In July, AEMO released, after a very extensive consultation process, the Final version of its 2022 Integrated System Plan (ISP), the third in the series. Since the initial ISP, developed under the leadership of former chief executive Audrey Ziebelman and released in 2018, AEMO’s ISP has become a key document for thinking about and planning how to reduce Australia’s greenhouse gas emissions.

The basis of the ISP is a set of scenarios projecting how demand for electricity and the mix of generation types required to meet this demand may change between now and 2050. The ISP uses extensive engineering and economic modelling to determine the least cost mix of transmission and related investments needed to enable the NEM to deliver secure and reliable electricity supply, at least cost and in accordance with each scenario.

At the outset of the process for developing the 2022 ISP, AEMO adopted a set of scenarios, of which one, called Progressive Change, was judged by the first consultations to be most likely. Progressive Change envisages that the shift from fossil fuel to renewable generation in the NEM will continue for the next twenty five years at about the same rate as achieved over the past five or so years. This would mean that by 2050 annual emissions from NEM generation will have fallen steadily from the current level of about 125 Mt CO<sub>2</sub>-e to about 15 Mt. However, further extensive consultations on the draft ISP earlier this year led AEMO to conclude that another scenario,

called Step Change, was now considered by industry stakeholders and experts to be the most likely. Under this scenario, emissions fall much more quickly, to around 50 Mt in 2030 (a reduction of about 70% relative to 2005 emissions), and then decline more slowly to reach close to zero by around 2040.

Needless to say, this requires a faster retirement of coal fired power stations. It expects that around 14 GW of the current 23 GW of capacity will have been withdrawn by 2030. A few years later, by 2034, only two coal fired plants will be left. Almost all demand for electricity will be supplied by wind and solar generation, including rooftop solar, and to firm this capacity a large increase in capacity of pumped hydro and batteries at various scales, and some increase in gas fired generation capacity (though not necessarily increased annual gas generation), will also be required.

The objective of the ISP is to identify the least cost development path for the transmission infrastructure which will be needed to make this change possible. Notwithstanding the identification of Step Change as the most likely scenario, AEMO models the optimal transmission development path for all four scenarios. In this context, optimal means the investment path which delivers the largest net benefits to electricity consumers. The major sources of benefit are the deferred or avoided capital cost of additional storage capacity and the avoided fuel cost of gas generation which would otherwise grow quite large in the 2040s. To put it another way, the proposed transmission investments will bring forward in time access by electricity consumers to low cost wind and solar generation. The modelling estimates the net market benefit of optimal transmission development, weighted by the assessed probability of each of the four scenarios, to be around \$28 billion.

Before Australia's electricity industry was completely restructured during the 1990s, government owned electricity commissions in each state were responsible for planning and building both generation and transmission capacity on a completely integrated basis. Between 1950 and the start of restructuring in the early 1990s, both generation capacity and annual electricity generated in Australia increased by a

factor of more than fifteen, and large numbers of small, isolated local distribution networks were connected into unitary state-wide grids. Technical advances made it more economic to meet this growing demand for electricity by building larger and more efficient power stations located adjacent to coalfields rather than close to major centres of demand, as had been the practice (except in Victoria) until the end of the 1940s. This required that the location and timing of both generation and transmission construction be closely co-ordinated, a task which would have been much more difficult in the absence of a single responsible agency in each state.

Ever since the electricity industry was restructured in the 1990s, responsibility for planning of new investments in generation and transmission has been shared between many separate organisations. The transition on which the electricity industry is now embarked is at least as momentous as the transition which occurred between the 1940s and the 1980s. Seen in this context, what the ISP seeks to do is to provide the integrated high level planning needed to allow this next profound transformation of the electricity industry to proceed as efficiently and effectively as possible, but, unlike the previous transition, not in each of the five individual states making up the NEM, but across the NEM as a whole.

## 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<sub>2</sub>-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 generators 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.