



National Energy Emissions Audit

Report

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Providing a comprehensive, up-to-date indication of trends in Australia’s energy combustion emissions

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## Key points

* All the net reduction in national emissions between 2005 and 2020 were contributed by the land sector. Emissions from energy combustion, which in 2020 accounted for 72% of total emissions, were 2.0% higher than in 2005.
* Total energy emissions to the end of August 2021, as estimated by NEEA, again increased, as growing consumption of petroleum fuels more than offset continued steady reduction in electricity generation emissions.
* The lockdowns in New South Wales and Victoria are the likely cause of small temporary reductions in total emissions, because of reduced urban road transport activity. This is certain to again reverse by the end of the year as the lockdowns are lifted. There remains no indication that a prolonged reduction in petroleum emissions will emerge, in the absence of significant transport policy changes.
* Moving annual generation in the NEM to the end of September 2021 recorded further falls in both coal and gas generation, in both absolute terms and as a share of total generation; gas generation fell to its lowest levels since mid-2006.
* Total annual renewable generation, including rooftop solar, passed the 30% share mark in July and is continuing to grow strongly. The coal share fell to below 63%.
* In South Australia, the share of wind and solar in total generation has also passed 63%, with gas down to 37%.

## Introduction

Welcome to the October 2021 issue of the NEEA Report. This issue starts with an overview of trends in Australia’s greenhouse gas emissions since 2005, excluding emissions relating to the land sector. This is followed by the regular update of energy combustion emissions as estimated by NEEA.

## Total Australian emissions, excluding land sector

In seeking to defend its position on greenhouse gas emissions, the Australian Government consistently cites the reduction in Australia’s emissions since 2005. The significance of 2005 is that it is the base or reference year for Australia’s Paris Agreement undertaking. The government states, accurately, that estimated total emissions in 2019-20 were 20% below emissions in 2004-05. However, as Figure 1 shows, if land sector emissions are excluded, emissions from all other sources in 2020 were actually 0.3% higher than in 2005.

In other words, all the net reduction in national emissions between 2005 and 2020 were contributed by the land sector. Emissions from energy combustion, which in 2020 accounted for 72% of total emissions, were 2.0% higher than in 2005, as shown in Figure 2.

Figure 1



Figure 2 also shows that, year-on-year, energy combustion emissions have only decreased on three occasions since 2005:

* In 2010 they fell for one year because of the impact of the global financial crisis.
* In 2013 and 2014 they fell because of the carbon price imposed on emissions from combustion of coal and gas.
* In 2020 they fell because of the severe impact on aviation and road transport during the first four months of pandemic lockdown.

This is of course an appalling performance record to be taking to the COP26 Conference in Glasgow.

Figure 2



## Update on energy consumption and emissions

Figure 3 shows total annual energy combustion emissions, by major source, as estimated by the NEEA, and Figure 4 shows each of the five sources separately. Electricity generation data is to the end of September 2021, gas and petroleum data to the end of August 2021.

Figure 3



Figure 4



Figure 4 shows just the changes in emissions, making them much easier to see. As discussed in the previous NEEA report, the sharp fall in annualised emissions over the year February 2020 to February 2021, attributable to reduced road and air transport during lockdowns, was reversed in subsequent months. With the reimposition of lockdowns in New South Wales and Victoria in July, the trend of petroleum emissions again changed, but decreased consumption of petrol and diesel by cars and light commercial vehicles was largely offset by strong growth in bulk diesel consumption, presumably largely in et mining industry. A further strong reversal can be expected by the end of 2021, following the lifting of lockdowns. There remains no indication that a prolonged reduction in petroleum emissions will emerge in the absence of significant transport policy changes.

Another point to note is that the total reduction in energy combustion emissions between 2011 and 2020, as calculated by the NEEA, is larger than the negligibly small reductions in total national energy combustion emissions. The difference is caused by the large increase in emissions from gas use in Western Australia, mainly for electricity generation used by the mining and minerals processing industries, and for the production of LNG. The previous NEEA report included an examination of the large volume of gas consumption, and consequent emissions, associated with the LNG industry.

## Electricity generation, consumption and emissions in the NEM

Figure 5 shows changes in generation and emissions, relative to their levels in the year to June 2008. It can be seen that both total emissions and emissions intensity are continuing to fall. In the year to September 2021, total emissions arising from NEM generators were 30% lower than their maximum level, which was reached exactly thirteen years earlier, in the year to September 2008. Total annual coal generation was 27% below the maximum level, which was reached in the year to January 2009, and has been falling month-by-month for several years. As a share of annual total generation in the NEM, combined black and brown coal generation fell to 68.3% in the year to September 2021, and, as a share of all electricity supplied, including rooftop solar, it was 62.9%. Since gas generation has also been falling, to 6.2%, the lowest level since 2006, moving annual total renewable generation is now clearly above 30%, as shown in Figure 6. It can be seen that annual output from rooftop solar has now exceeded annual hydro generation, following wind generation which overtook hydro just over two years ago.

Figure 5



Figure 6



In southern Australia, the early spring months of September and October often experience extended periods of windy weather. Combined with steadily lengthening days, higher sun angles and mild ambient temperatures, this means that spring is the period when combined wind and solar generation reach their maximum share of generation. In South Australia and Queensland, which are the states with the highest shares of rooftop solar generation, this also means that the total requirement for grid generation falls to its minimum annual level. New NEM records for both of these parameters are certain to be set before the end of November. In this issue of the NEEA report, we look at relevant recent developments in South Australia, where (excluding Tasmania) the shift to zero emission generation is furthest advanced.

## Update on South Australia

Figure 7 shows the changes in electricity supply in south Australia over the past thirteen years, expressed in moving annual energy units (TWh). Figure 8 expresses the mix in terms of shares of total supply.

Figure 7



In the year to the end of September 2021, renewable generation, including rooftop solar, accounted for over 62% of all electricity supplied in South Australia. This is a much higher share of total supply in South Australia than in any of the other three mainland states in the NEM; Victoria was the next highest at just under 35%. Moreover, unlike Victoria, where hydro contributed just under 6% of total supply, all renewable generation in South Australia is variable (non-dispatchable). In addition, rooftop solar contributed over 15% of total supply, which is considerable higher than the share of just under 9% in Queensland, the next highest NEM state.

Figure 8



These statistics have required the South Australian electricity supply system to become a leader in confronting the challenges of integrated variable generation resources into grid electricity supply. One of the biggest of these challenges has been deciding on how to ensure that grid security is maintained at all times. Following the traumatic experience of the system black out, now just over five years ago, AEMO adopted a policy of specifying minimum levels of conventional synchronous generation to be online at all times. In practice, this meant minimum levels of power supply from local gas generators and minimum numbers of individual gas power station units on-line. This in turn meant that AEMO often required wind generators to curtail their output to allow “space” for gas generation. Obviously, this imposed financial costs on wind generators and pushed up electricity cost for consumers.

ElectraNet, the local transmission service provider, responded to this problem by deciding to install four synchronous condensers at two key locations in the state grid, in order to provide the required levels of system strength and inertia to the South Australian grid. All four of these machines have now been installed and commissioned, which means that during coming months are likely to see further increase in the share of renewable supply in South Australia, over and above the expected seasonal shift.

One distinct indicator of the impact of rooftop solar in particular, is the low demand for grid supplied electricity in the middle of the day whenever there is sunny weather. Figure 9 is an update of a graph from last year, with one more year of data. It shows minimum annual grid demand for each year, and whether the minimum occurred during daylight hours or overnight. It shows that the transition for overnight to daytime minimum occurred eight years ago, and that system minimum demand is getting smaller every year, as rooftop solar capacity continues its rapid growth. Although not graphed here, all the other three mainland NEM regions have also now transitioned to daytime annual minimum annual system demand. During 202-21 the minimum occurred on 25 May 2021 in Queensland, 11 April 2021 in New South Wales and 25 December 2020 in Victoria.

Figure 9



The coal-based electricity generation system, which remains the basis of the NEM despite the growth in renewable generation, was built on the assumption that minimum daily demand always occurs overnight, and various marketing strategies, notably off-peak electric storage water heating, were designed to support this daily pattern of demand. As we have previously discussed, daytime minimum grid demand is eroding the profitability of coal generation and may increase maintenance costs. Low minimum demand also imposed challenges for grid operation, as explained by AEMO here: <https://www.aemo.com.au/learn/energy-explained/energy-101/energy-explained-minimum-operational-demand>

Another crucial issue with heavy reliance of wind and solar generation is the challenge of supplying demand for electricity during prolonged periods of calm, overcast weather. In southern Australia, such periods occur during the winter months, when average demand for electricity is higher, as discussed in the last NEEA report. Daily demand for electricity was compared with daily generation by wind and solar over each of the four winters from 2018 to 2021 inclusive, as installed wind and solar generation grew steadily in South Australia. Analysis of the data was based on the shortfall between average daily demand and average daily generation by wind and solar; such shortfalls are currently supplied by gas generators and imports over the interconnectors from Victoria. It was found that the number of days over each winter on which shortfalls exceeded defined average sizes (1,500 MW, 1,000 MW and 800 MW were used) decreased from 2018 to 2021. More importantly, the duration of periods on which successive days recorded shortfalls above these defined level fell sharply. In 2021 there was one period of four successive days with a shortfall above 800 MW, and none longer. In 2018 there were six such periods, including one of 11 days duration. Such a trend is of course heavily dependent on year-to-year variations in winter weather conditions, but these results suggest that the need for very large capacity of long duration storage or large volumes of back-up gas generation will be less than opponents of the energy transition often suggest.

Far more detailed and sophisticated examination of these effects is undoubtedly the basis of AEMO’s consistent conclusion, in its successive Integrated System Plans, that the requirement for gas generation capacity in coming years will be much less than the government members and supporters often claim.

## Appendix: Notes on methodology

Data on annual consumption of electricity, and seasonal peak demand, are for each of the six states. All other data are for the states constituting the National Electricity Market (NEM) only, i.e., they exclude Western Australia and the Northern Territory. All data are reported as annual moving averages. This approach removes the impact of seasonal changes on the reported data. Annualised data reported in *NEEA Electricity Update* 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. Auxiliary loads are very large: in 2011 they amounted to 6.3% of total electricity generated and currently about 5.6%. Most of this load is at coal fired power stations, where it can be as high as 10% of electricity generated at an old brown coal power station and 7% at a black coal fired power station. Auxiliary loads are much lower at gas fired power stations, and close to zero at hydro, wind and solar power stations. Both demand and generation, as shown in the *Electricity Update* 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.

Generation is similarly defined to include only electricity supplied by large generators connected to the transmission grid. It 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. 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. That effect can be clearly seen in the regular total generation graph; the gap between the red line – electricity sent out to the grid from large grid connected power stations – and the yellow line – that electricity plus estimated electricity generated by distributed solar systems – is the electricity supplied by those systems.