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NATIONAL ENERGY EMISSIONS AUDIT

National Energy Emissions Audit
Electricity Update

September 2019

Providing a comprehensive, up-to-date indication of key electricity trends in Australia

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Key points

+ Energy productivity has increased very little since the introduction of the National Energy Productivity Plan in 2015.
+ Australia is falling further behind the main aim of the NEPP; to achieve a 40% improvement in Australia's primary energy productivity by 2030
+ Energy combustion emissions are rising, against the trend in most other OECD countries. Australia is 4th of all OECD countries in terms of increased emissions since 2005, following Turkey, South Korea and Mexico.
+ Increased combustion emissions since 2005 come predominately from transport, and from manufacturing, mining and petroleum and gas.
+ The only exception to the increasing trend is electricity generation, which has seen reduced emissions, as frequently reported by the NEEA Electricity Updates
+ The main driver of emissions reduction in electricity is the rise of large-scale wind and solar PV supported by the rise in small-scale PV, the closure of several older coal fired power stations and reduced electricity consumption
+ Electricity supplied by grid solar and wind continue to increase but in the year to August this rise was offset by a decline in hydro production

Introduction

Welcome to the September 2019 issue of the *NEEA Report.* This issue departs somewhat from the usual content by using two official documents released in the first week of September to look at the longer term trends in Australia's total energy combustion emissions. The two documents are:

- *Australian Energy Statistics 2019*, with annual data up to 2017-18.
- *Quarterly Update of Australia's National Greenhouse Gas Inventory* for March 2019.

Australian Energy Statistics constitutes the official record of how much energy Australia uses, what energy is used for, and what forms of energy are used. The 2019 publication contains annual data up to the 2017-18 year. Among other functions, these statistics are the key input to calculating Australia's annual emissions from fossil fuel combustion. They can therefore be used to estimate what these emissions were in 2017-18, well ahead of the release of the full National Greenhouse Gas Inventory for 2017-18, likely to be some time in the second quarter of 2020.

In this NEEA Report we use the *Australian Energy Statistics 2019* data to estimate Australia's total energy combustion emissions up to 2017-18, i.e. emissions including those sources which the NEEA cannot cover because of the lack of monthly data. Using this estimate as a base, together with more limited data in the March 2019 *Quarterly Update*, we also estimate energy combustion emissions for the full 2018-19 year, and present graphs of the ten year trend in energy combustion emissions by major economic sector and by major fossil fuel type.

We also include a new analysis of the relative contributions of the three main factors causing the reduction in emissions for electricity generation in the National Electricity Market. The Report ends with the usual monthly *Electricity Update* summary to the end of 2019.

An update on Australia’s energy consumption and total energy combustion greenhouse gas emissions

Trends in national energy consumption and energy productivity

Looking first at energy consumption, Figure 1 shows the trends in Australia’s total primary energy consumption and total final energy consumption since 2007-08, and also shows the trend in final energy consumption per capita. The term primary energy refers to the energy content of fossil fuels, as extracted from the ground, before undergoing conversion processes to make them suitable for use by final consumers of energy. The most important forms of primary energy are coal, crude oil and raw natural gas. A considerable fraction of the energy content of primary fuels is lost in the process of converting them to the various forms of final energy, as supplied to consumers, in the form, most importantly, of electricity, petroleum products and pipeline gas. By definition, then, final energy consumption is less than primary energy consumption. By far the largest component of the gap between primary and final energy is the energy used in converting the fuel used in thermal power stations to electricity.

Figure 1 shows that final energy consumption has grown significantly since 2008. In only two years, 2009 and 2015, was annual final energy consumption less than in the previous year. Final energy consumption per capita has consequently hardly changed since 2008. Primary energy consumption, on the other hand, has grown much more slowly. This difference has been almost entirely caused by the changes in electricity generation in the NEM, which the *NEEA Report* (and its predecessor) has been describing each month since 2012. The main changes have been the closure of a number of older, less efficiency coal fired power stations (meaning less primary energy consumption per unit of electricity generated), culminating with the closure of Hazelwood in 2017, and, the rapid growth in renewable electricity generation. Renewable generation reduces reported primary energy consumption because the electricity generated is defined as primary energy, meaning that there is no energy used in the conversion process. The reason for this energy accounting convention is a simple pragmatic one: the total kinetic energy contained in the air flowing through a wind turbine or radiation falling on a solar cell has no alternative use, unlike, say a molecule of gas burned in a gas turbine. Hence the notional primary energy content of moving air or radiation from the sun, while it has important technical implications for designers and operators of wind and solar farms, has no economic value, and hence nothing useful is to be gained by including such information in energy statistics. This reporting convention does, however, have implications when seeking to understand the place of renewable energy within the total energy mix.

Figure 1

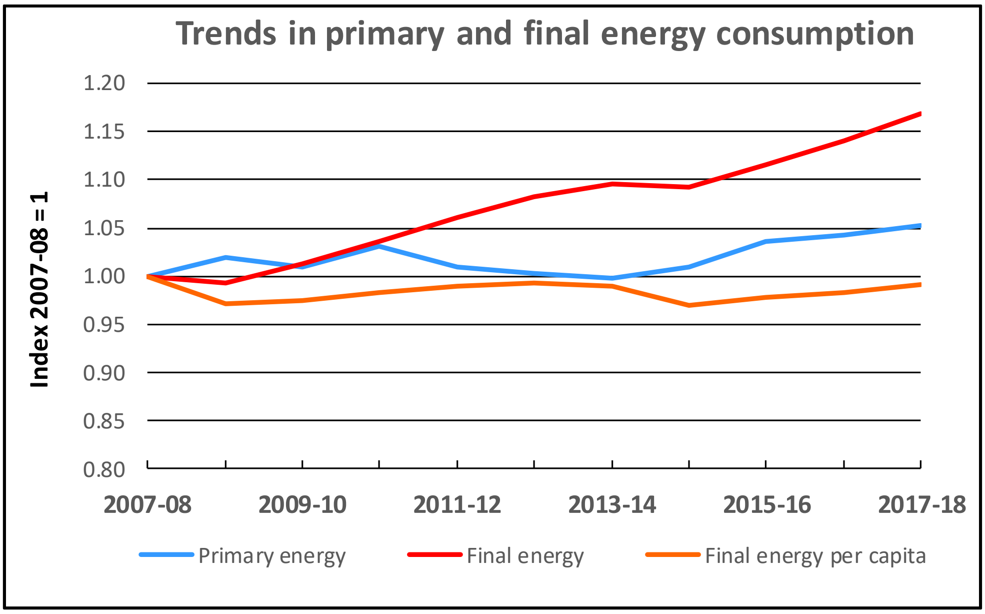


Figure 2

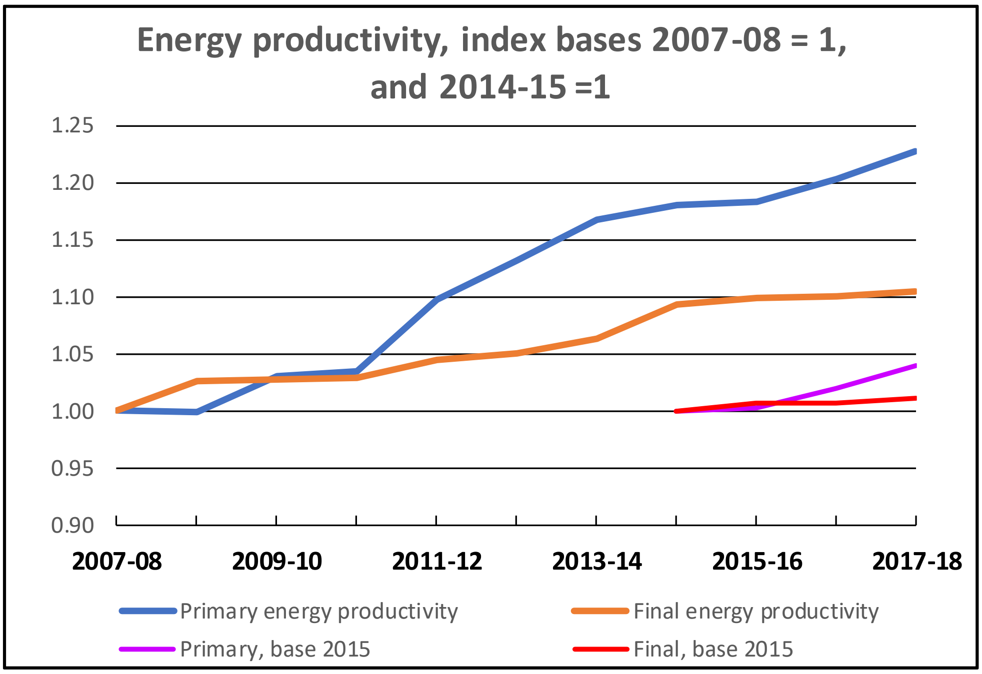


Figure 2 shows indices of energy productivity, defined as dollars of Gross Domestic Product per unit of energy used. As the data shown in Figure 1 would suggest, primary energy productivity has grown considerably faster than final energy productivity. This is particularly the case for the three years from 2015 to 2018, when final energy productivity increased by just 1.1% over the period, while primary energy productivity increased by 3.9%. This larger increase in primary energy productivity was entirely caused by the growth in wind and solar generation. It is, in effect, an artefact of the accounting convention used for energy statistics. It had nothing to do with productivity, as normally understood, which requires reducing the inputs (in this case energy) needed to achieve a given increase in economic output.

The relevance of 2015 is that it is the starting date for the National Energy Productivity Plan (NEPP), which was adopted by the COAG Energy Council in that year, with the aim of achieving a 40% improvement in Australia's primary energy productivity by 2030. A quick read of the original document supporting the NEPP reveals that it consists of 34 measures. Measure 14 is "Improve light vehicle efficiency". As regular readers of the *NEEA Report* will be aware, after four years, this measure has gone nowhere. Most of the other 34 are in a similar condition. It will therefore be interesting to see the outcome of the first detailed review of the program, which is supposed to be published "before 2020".

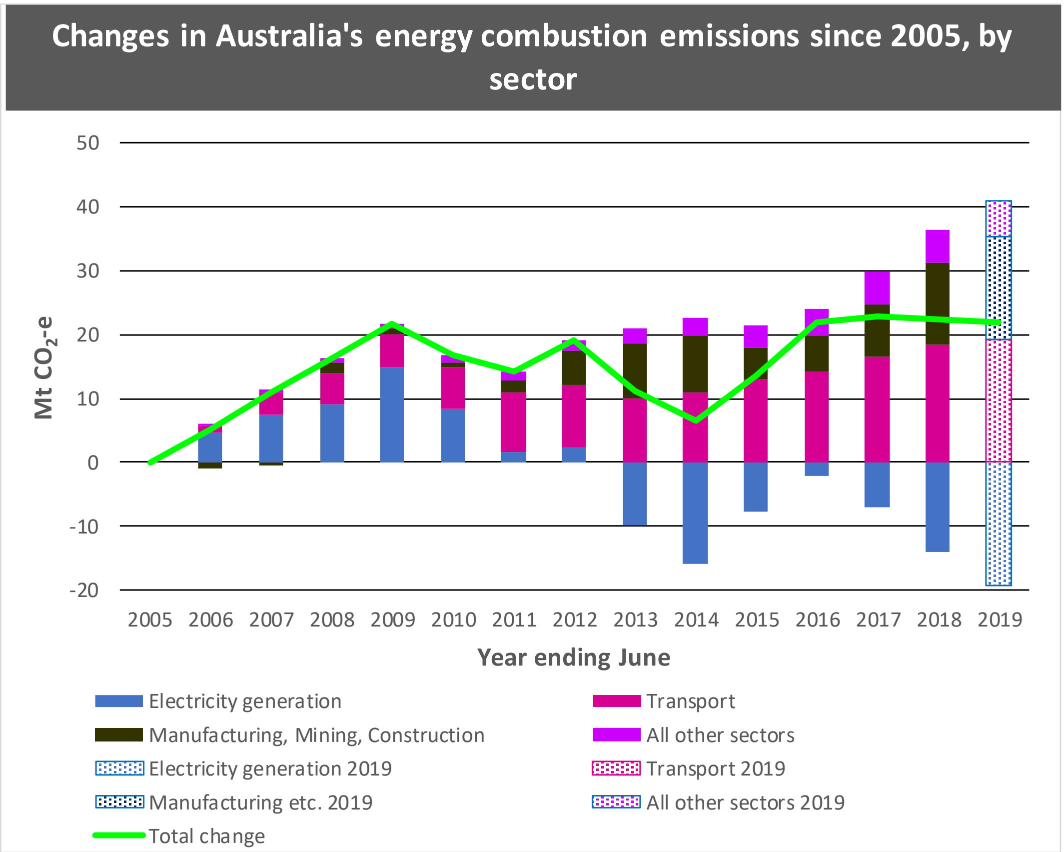
Trends in national energy combustion emissions

The new 2017-18 energy consumption data have been used to estimate Australia's complete energy combustion emissions until 2018. Figure 3 shows changes in energy combustion emissions by major sector since 2005, the base year for Australia's emissions reduction required under the Paris Agreement. Figures up to 2016-17 are from the National Greenhouse Gas Inventory, Emissions for 2017-18, calculated using the new *Australian Energy Statistics* data, have been projected forward to 2018-19, with the aid of data contained in the government's most recent *Quarterly Update of Australia's National Greenhouse Gas Inventory*, which was released in early September, with data up to March 2019.

Looking at Figure 3, it can be seen how emissions from electricity generation rose to a peak in 2009 and since then have, with various ups and downs, decreased, as shown in each month in the *NEEA Report*. Note that this graph includes emissions from generation in Western Australia and the Northern Territory. These add about 12% to total generation, but a smaller share of emissions, since generation in Western Australia is based much less on coal (currently roughly 40%), and much more on gas, than generation in the NEM.

Emissions from transport have been rising steadily, as also reported regularly, though, interestingly, the data indicate that the rate of increase may be slowing. This also has been discussed in recent *NEEA Reports* in the context of speculating about the slow down in growth of diesel consumption.

Figure 3

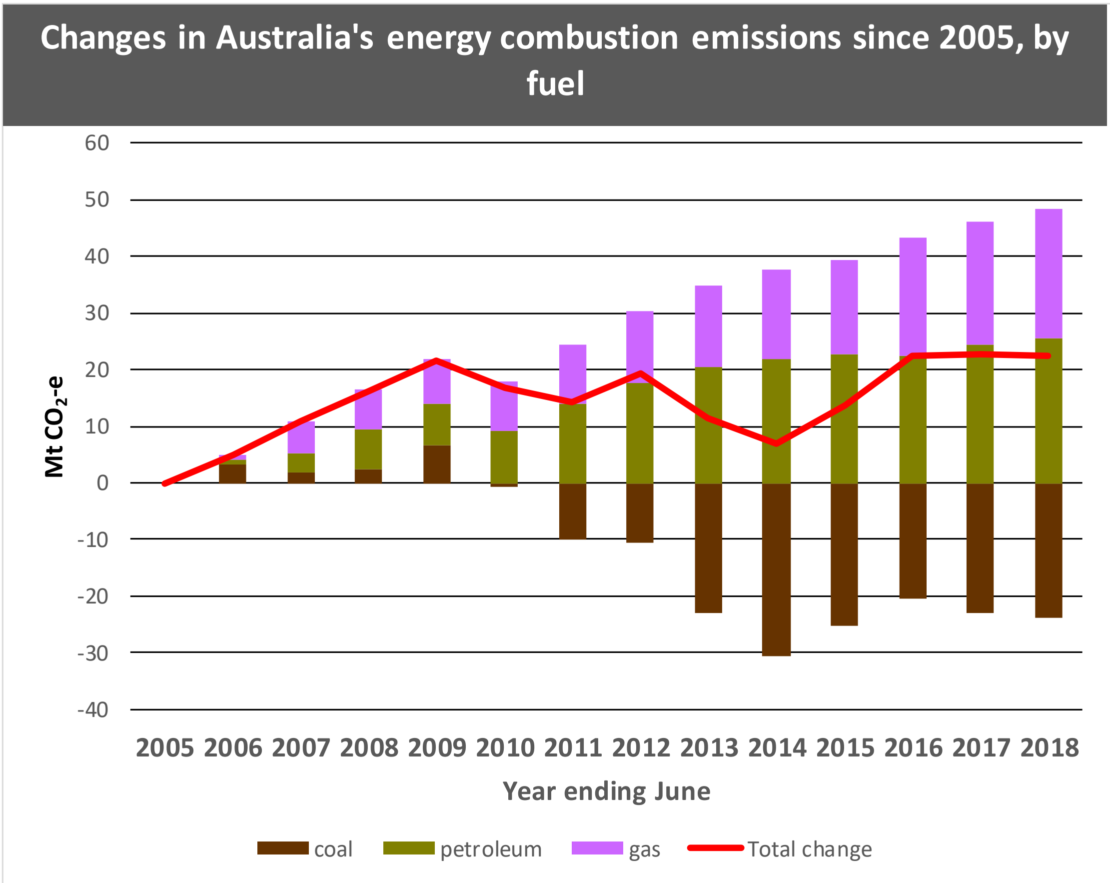


The third sector covers manufacturing, mining (including gas processing) and construction together, while the fourth sector comprises agriculture, the services sector, i.e. commercial/ institutional buildings, and residential. In both of these sectors most energy combustion is used to supply useful energy in the form of heat, for which the main fuel is gas, with some coal. However, in agriculture, mining and construction, most energy is provided by diesel for use in mobile machinery. The large and growing volume of gas used (mainly in gas turbines) to power the production of LNG is also included. It can be seen that emissions in the manufacturing and mining sectors have grown quite fast in the last few years. This is almost entirely attributable to emissions from gas used to produce LNG and diesel used for mining. Energy supplied by gas and coal to provide heat energy in manufacturing, although still considerably larger than energy used in the minerals industries, has been falling steadily since 2012-13.

Emissions from gas used in residential and commercial buildings have been growing much more slowly over the last few years. Note that almost two thirds of all gas consumption in the residential and commercial sectors occurs in Victoria. It seems likely that relatively slow growth in consumption and emissions is caused, at least in part, by improvements in building energy efficiency. Although much slower than would be economically optimal, given the price of gas (and electricity), these improvements are more extensive than energy efficiency improvements in many other parts of the economy.

Figure 4 shows the shares of energy combustion emissions contributed by each of the three main types of fossil fuels. The trend in coal consumption is dominated by the reduction in coal consumption for electricity generation. In 2004-05 electricity generation accounted for 91% of all coal consumption, and in 2017-18 for 89%, as coal consumption in manufacturing fell somewhat more slowly than in electricity generation.

Figure 4

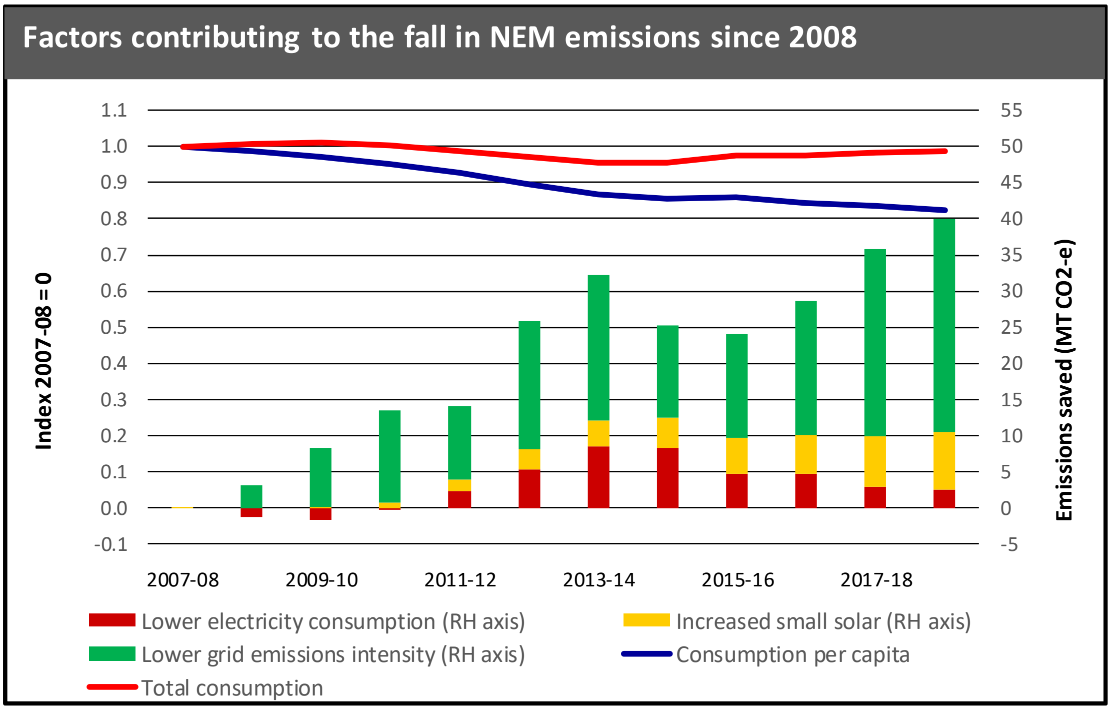


As would be expected, emissions from consumption of both petroleum fuels and gas have increased steadily since 2005. Transport dominates petroleum consumption, but petroleum fuels are also very important in mining, agriculture and construction, which, together with transport, are responsible for all the growth in consumption and emissions. Petroleum consumption in manufacturing is also quite large, but is almost entirely confined to oil refining and the associated petrochemical industries, and has decreased quite significantly since 2005.

Emissions from gas consumption have increased very strongly since 2005. The largest increases have been in the gas production and processing industry, mostly to produce LNG, and in electricity generation. Gas consumption has increased more gradually in the commercial/institutional sector, at almost exactly the same rate as GDP, while residential sector consumption has increased at almost exactly the same rate as population.

Stepping back from this detail, the overall picture is clear. Australia's energy combustion emissions increased in every year between 1990 and 2009. There was a marked change in trend after 2009. Since then combustion emissions have been almost constant, with two periods of decrease, both related to generation and consumption of electricity. In 2010 and 2011 the share of coal generation fell, offset by increases in lower emissions gas and, to a lesser extent, renewable generation. At the same time, total electricity consumption also fell, triggered by consumer response to large and sudden increases in retail electricity prices. In 2013 and 2014, the imposition of a price on emissions caused another shift in the mix of generation, from coal to hydro. Removal of the price at the start of the 2015 year restored the pre-2013 generation mix. Since then the growth in wind and solar generation, together with the closure of several older coal fired power stations, culminating with Hazelwood in March 2017 has caused electricity generation emissions to fall again.

Figure 5



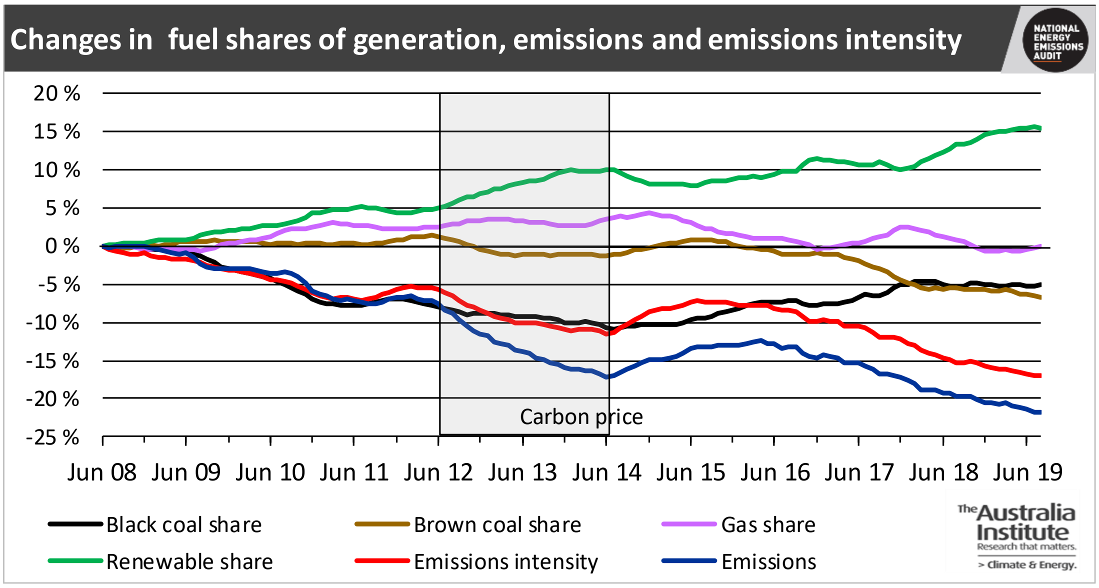
All these changes can be seen in Figure 5, a new graph which separates out the contributions of the three factors which have together caused the steady fall in emissions arising from electricity consumption in the NEM over the past ten years. It shows the separate effects of the reduced emissions intensity of grid generation and changes in consumption of electricity. It also separates out the contribution that growing supply from rooftop solar generation has made to the reduction in demand for grid electricity. The graph also shows trends in total annual consumption of electricity (grid supplied plus rooftop PV), and in consumption per capita.

A comparison of the trend in Australia's energy combustion emissions with other OECD countries is striking. Based on official UNFCCC national emissions inventory data (accessed through the World Resources Institute Climate Watch data base, https://www.climatewatchdata.org/), of all OECD countries, 27 reduced energy emissions from 2005 to 2016. 8 increased energy emissions, including Australia which had the 4th largest increase (and 5th largest in percentage terms) after Turkey, South Korea and Mexico. This applies even to major fossil fuel exporting countries, such as Canada and Russia and major coal consuming countries, such as the USA, Germany and Poland. It is not enough for Australia to rely on falling generation emissions to achieve reductions in total emissions. It must become serious about reducing transport emissions and increasing the efficiency, and hence productivity, of energy use in manufacturing, mining and all other sectors.

Electricity Update

The changing generation mix in the National Electricity Market, discussed above, is shown in Figure 6. August saw virtually no change in the trends of the preceding three or four months, with total renewable generation growing only slowly, as steadily growing wind and solar generation was largely offset by falling hydro generation. This can be clearly seen in Figure 7. The general declining trend of total emissions and emissions intensity of sent out grid generation, shown also in Figure 5 above, also continued.

Figure 6



In the year to August 2019, the total grid share of renewable generation was 17.4% and the renewable share of all generation, including rooftop solar, was 21.8%. These shares are just slightly lower than in the year to July 2019, because of the fall in hydro generation, but shares of variable renewable generation, i.e. wind and solar, were 10.6% for grid generation only, and 14.7% including rooftop solar. The steadily increasing share of variable renewable generation is shown in Figure 8. This shows very clearly how the boom in construction of solar farms, in particular, over the past two years has accelerated the rate at which electricity generation in the NEM is undergoing a transition away from conventional coal and gas generation.

Figure 7

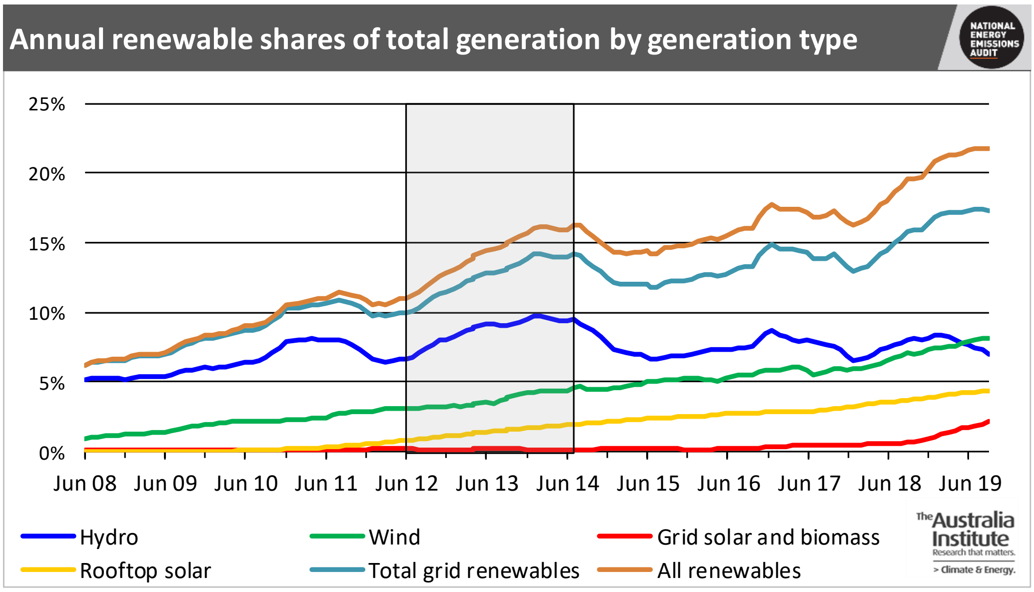
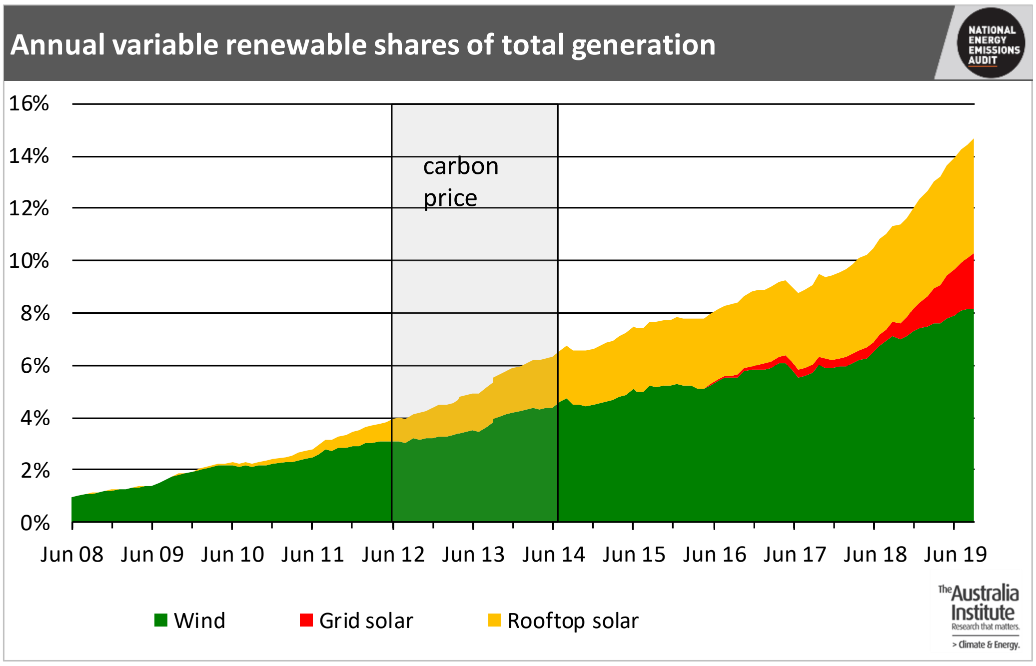
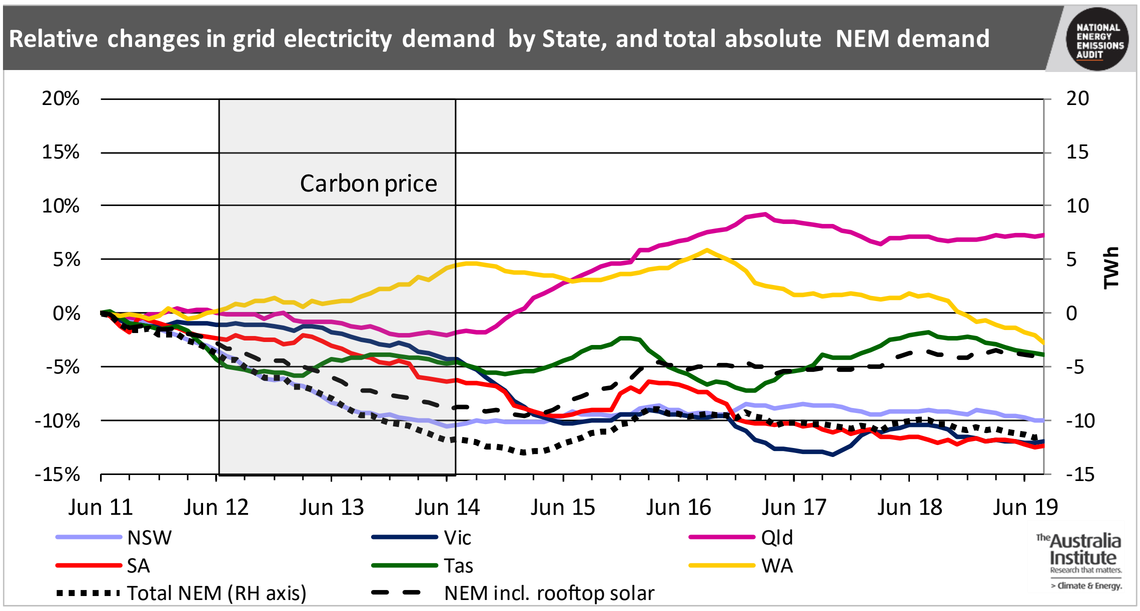


Figure 8



Turning to demand for electricity in each state in the NEM, Figure 9 shows relative changes (making it easier to see the trend in the smaller states). The trend of overall very gradual decrease in electricity supplied through the NEM grid continues, though in the year to August there was in fact an extremely small increase in consumption. The continuing decrease is more rapid in Western Australia or, to be more precise, the South West Interconnected System. Limited data (from Horizon Power annual reports) suggests that the much smaller electricity consumption in the rest of the state has been roughly constant, with some up and down year to year changes, in the last few years.

Figure 9



Relative changes in grid electricity demand by State, and total absolute NEM demand
NATIONAL ENERGY EMISSIONS AUDIT
20%
15%
10%
5%
0%
-5%
-10%
-15%
20
15
10
5
0
-5
-10
-15
TWh
Carbon price
Jun 11
Jun 12
Jun 13
Jun 14
Jun 15
Jun 16
Jun 17
Jun 18
Jun 19
NSW
Vic
Qld
SA
Tas
WA
Total NEM (RH axis)
NEM incl. rooftop solar
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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. 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 particular 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.