The Australia Institute
Research that matters.
> Climate & Energy.

NATIONAL ENERGY EMISSIONS AUDIT

National Energy Emissions Audit
Electricity Update

July 2019

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

Author: Hugh Saddler

ABOUT THE AUSTRALIA INSTITUTE

The Australia Institute is an independent public policy think tank based in Canberra. It is funded by donations from philanthropic trusts and individuals and commissioned research. We barrack for ideas, not political parties or candidates. Since its launch in 1994, the Institute has carried out highly influential research on a broad range of economic, social and environmental issues.

OUR PHILOSOPHY

As we begin the 21st century, new dilemmas confront our society and our planet. Unprecedented levels of consumption co-exist with extreme poverty. Through new technology we are more connected than we have ever been, yet civic engagement is declining. Environmental neglect continues despite heightened ecological awareness. A better balance is urgently needed.

The Australia Institute's directors, staff and supporters represent a broad range of views and priorities. What unites us is a belief that through a combination of research and creativity we can promote new solutions and ways of thinking.

OUR PURPOSE – 'RESEARCH THAT MATTERS'

The Institute publishes research that contributes to a more just, sustainable and peaceful society. Our goal is to gather, interpret and communicate evidence in order to both diagnose the problems we face and propose new solutions to tackle them.

The Institute is wholly independent and not affiliated with any other organisation. Donations to its Research Fund are tax deductible. Anyone wishing to donate can do so via the website at https://www.tai.org.au or by calling the Institute on 02 6130 0530. Our secure and user-friendly website allows donors to make either one-off or regular monthly donations.

Level 1, Endeavour House, 1 Franklin St
Canberra, ACT 2601
Tel: (02) 61300530
Email: mail@tai.org.au
Website: www.tai.org.au

Table of Contents

Key points

- New South Wales annual output from grid scale wind and solar generators doubled over the past fourteen months

- South Australia set to lose its top stop as the largest generator of renewable energy, with Victoria and NSW in a race to take over top state for total wind and solar generation.

- While Queensland has slower than any other NEM state to shift towards renewable generation (and is not on track to meet its target of 50% renewables by 2030) it retains its moniker as the sunshine state with the: largest solar generation output; largest share of solar rooftops; and most solar jobs.

- Current changes in the Australian electricity supply system (as it transitions from coal fired generation to wind and solar) are comparable to the rates of growth of the whole electricity supply system during the 1950s and 1960s. The transition during the 50s and 60s was larger and as transformative as the changes currently taking place.

- The new electricity generation from 1953 to 1960 in all six states were comparable in size of new generation wind and solar from 2011 to 2019.

- April to June saw a NEM-wide fall in annualised consumption supplied from the grid. This drop was mainly due to a lower supply from brown coal generators in Victoria, caused by lower output from Loy Yang A, where Unit 2 failed in mid-May, and from a decrease in both Snowy hydro and the Tasmanian hydro system, caused by low rainfall throughout eastern Australia.

- Commercial scale solar generation has also accelerated since early 2018. A significant proportion of this new grid connected solar generation, as well as some new wind generations is financially supported by power purchase agreements (PPAs) with large commercial and industrial consumers.

- Average monthly data from 2007 highlights seasonal trends in solar and wind generation. Solar generation shows little volatility in month to month output but marked and very consistent seasonal variation. Wind generation, by contrast, shows very considerable month to month variation, but a limited and inconsistent seasonal pattern.

INTRODUCTION

Welcome to the July 2019 issue of the *NEEA Electricity Update*, with data updated to the end of June 2019. The *Electricity Update* presents data on electricity demand, electricity supply, and electricity generation emissions in the National Electricity Market (NEM), plus electricity demand in the South West Interconnected System (SWIS). Since the start of 2018 there has been a marked acceleration in the commissioning and connecting to the grid of new wind and solar farms, and a corresponding increase in the growth of supply from new solar farms in particular. The majority of this growth has occurred in Queensland and New South Wales, states which had previously been lagging in the uptake of new zero emission generation. This issue takes a more detailed look at the growth of new generation in each of the four mainland states in the NEM. We also look back into the history of the Australian electricity supply system, to compare the changes in generation capacity and generation mix in the NEM with the changes to electricity supply which occurred during the 1950s, a period during which changes which were at least as fast, and arguably more far reaching than those now occurring.

OVERVIEW OF MAIN TRENDS

Demand for electricity

Annualised consumption supplied from the grid fell steadily over the three months from April to June in each of the five states making up the NEM, and also in Western Australia, as shown in Figure 1. Annual consumption in the NEM in the year to June 2019 was lower than in the year to March 2019 by 0.63 TWh, equivalent to 0.34%. When electricity supplied from rooftop solar is taken into account, the decline in annual consumption is somewhat reduced, to 0.41 TWh since March for the NEM, as shown in Figure 2.

Figure 1

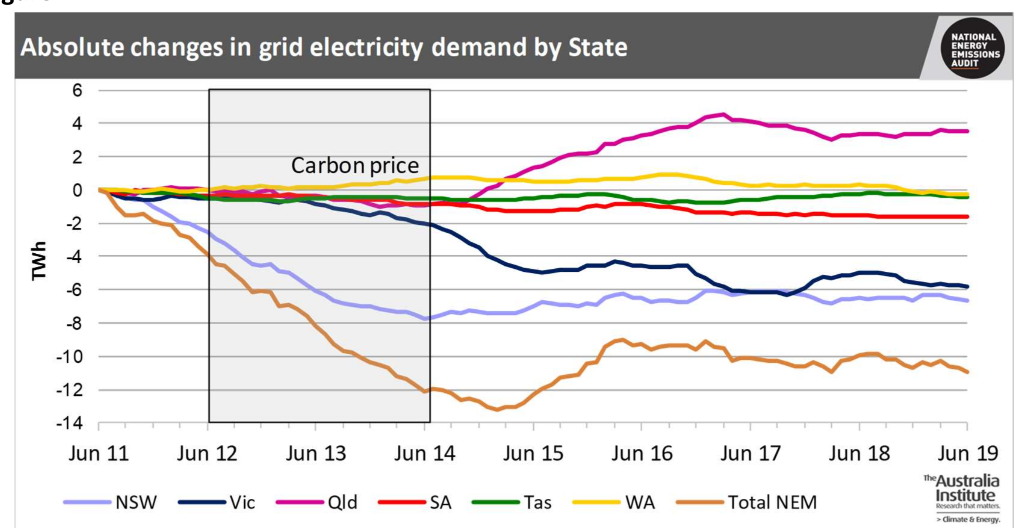
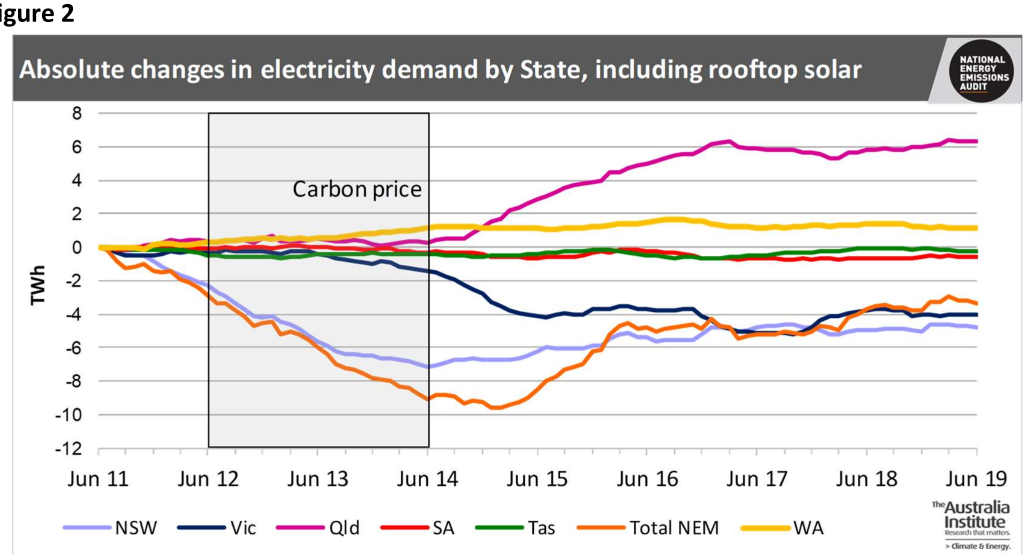


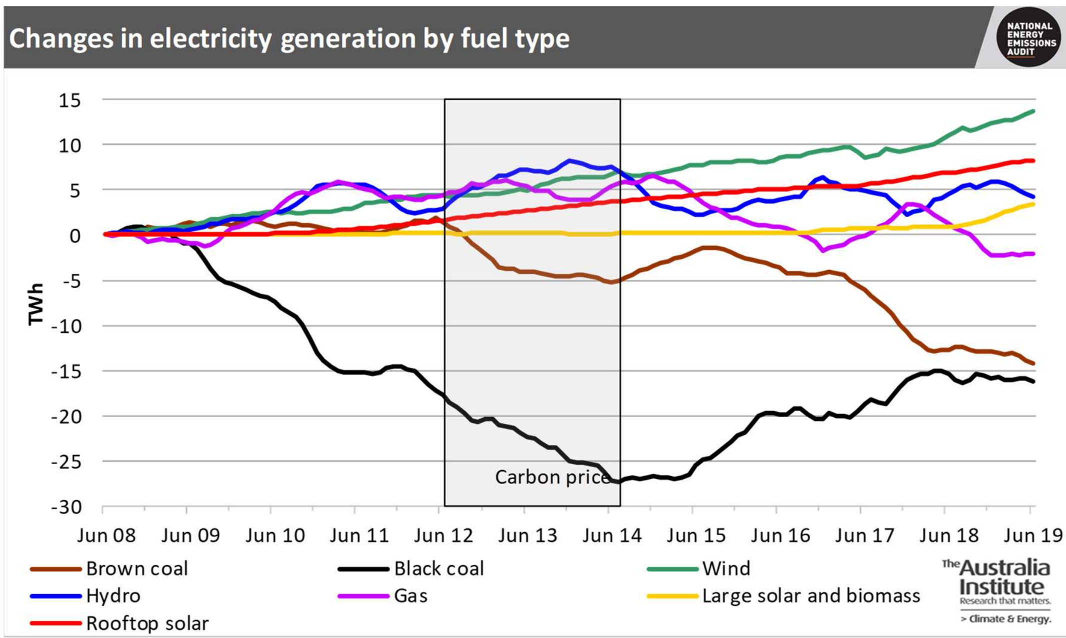
Figure 2



Generation and emissions

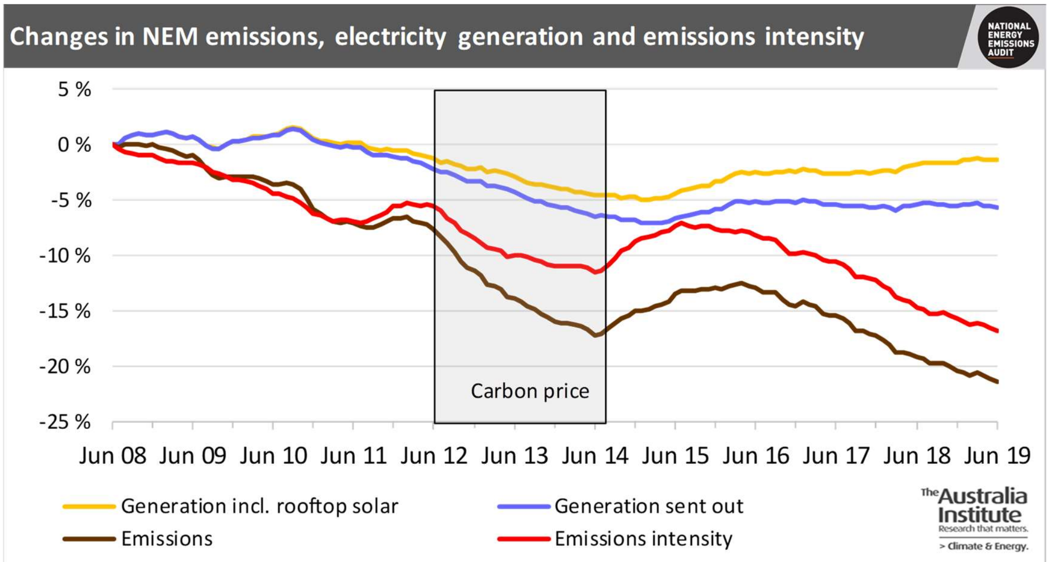
Figure 3 shows that most of the reduction in grid supplied electricity is the result of lower supply from brown coal generators in Victoria, and also in reduced hydro generation. Most of the reduction in brown coal generation is caused by lower output from Loy Yang A, where Unit 2 failed in mid-May and is expected to be out of service until December, and also from Loy Yang B. There has also been a sharp reduction in output from both Snowy hydro and the Tasmanian hydro system, caused by low rainfall throughout eastern Australia. By contrast supply from both wind and grid connected solar generators grew strongly. Gas generation was almost unchanged, though at the lowest level since early 2007. The result has been continued reductions in both the average emissions intensity of NEM generation and also total emissions from NEM generation, as shown in Figure 4.

Figure 3



The remainder of this issue of *NEEA Electricity Update* takes a more detailed, state by state look at the growth in renewable generation.

Figure 4



A DETAILED LOOK AT GROWTH IN "NEW" RENEWABLE GENERATION

Growth in capacity in the NEM as a whole

Figure 5 shows the growth in capacity of wind and solar generators supplying electricity through the NEM grid since July 2007. Figure 6 shows the capacity of rooftop solar generation, meaning solar generation supplying electricity directly to consumers and connected to local distribution networks through consumer meters.

Some of the output from rooftop solar systems is directly consumed "behind the meter" by the consumer, while some is exported into the local distribution network. However, all of the output from rooftop systems offsets the volume of electricity which would otherwise be supplied to the relevant distribution network from the NEM grid, and therefore directly affects the quantity of electrical energy that large, grid connected generators are required to supply. It can be seen that growth in capacity of wind and rooftop solar has been relatively steady for some years, though it has accelerated in the last year or so. By contrast, nearly all the growth in grid connected solar generation has occurred since the beginning of 2018.

Figure 5

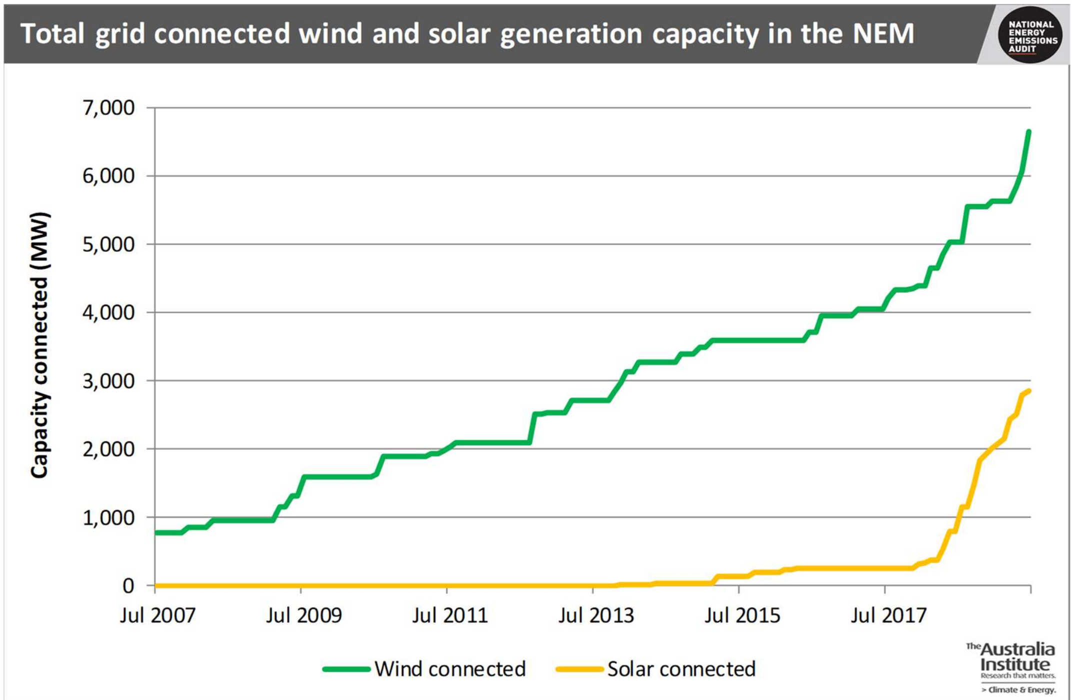
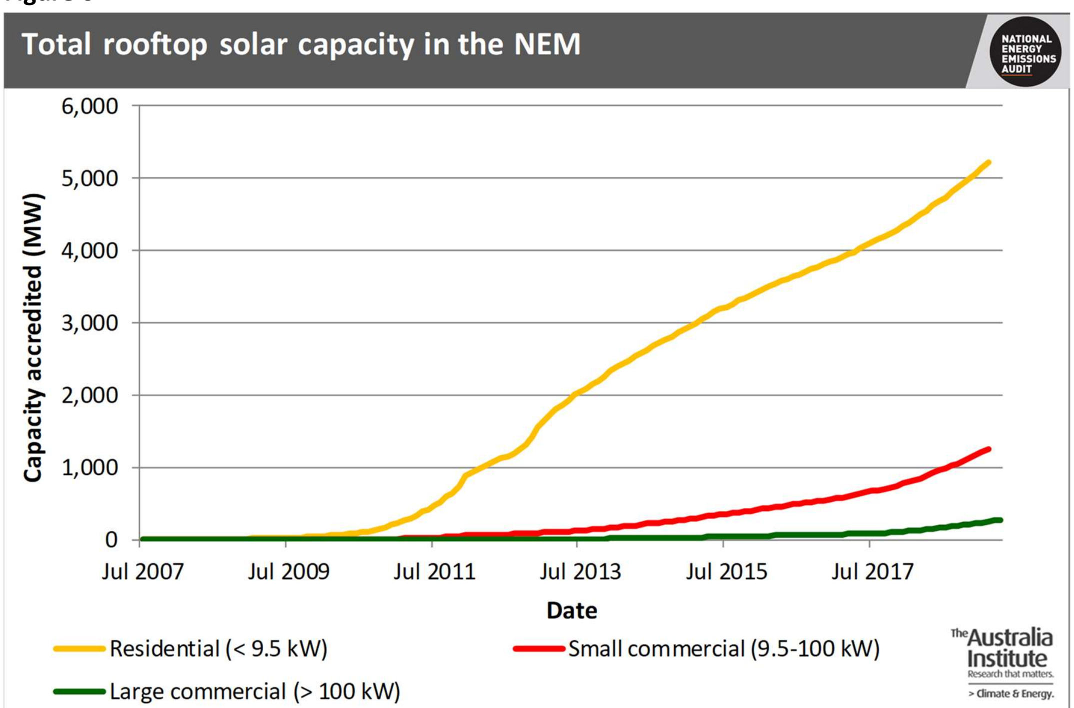


Figure 6



There has also been an acceleration in the installation of commercial scale solar generation over the same period. It is noteworthy that a significant proportion of new grid connected solar generation, together with some new wind generations, is financially supported by power purchase agreements (PPAs) with large commercial and industrial consumers. A growing number of commercial consumers are choosing to source some or all of their electricity from renewable generators, for reasons of cost, as much as out of environmental concerns. PPAs are an attractive option for such consumers if they do not occupy buildings with large roof areas.

Total electricity supplied in the NEM

Figure 7 shows moving annual total electricity supplied by wind and solar generation, including rooftop solar generation, in the NEM. Figure 8 shows the same data, but expressed as a fraction of total moving annual sent out generation in the NEM. Figure 9 shows generation in each month, but expressed not in terms of energy supplied but as the average trading interval (30 minute) output during each month, thereby normalising for differences in the number of days in the month. Figure 10 also shows average monthly "new" renewable generation, and in addition shows average monthly total NEM generation, plus the share of this total supplied each month by "new" renewable generation. Note that the NEM total includes output from rooftop solar installations as well as all output from generators connected to the NEM transmission system. This total shows a very distinct and very consistent seasonal pattern, with two minima each year, in April and September, and two maxima, in January and July.

Figure 7

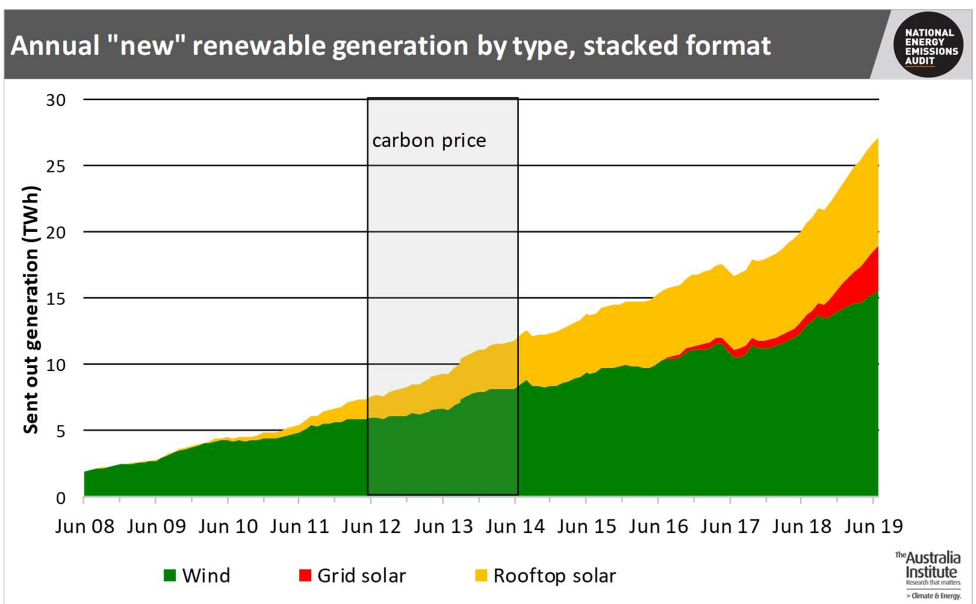
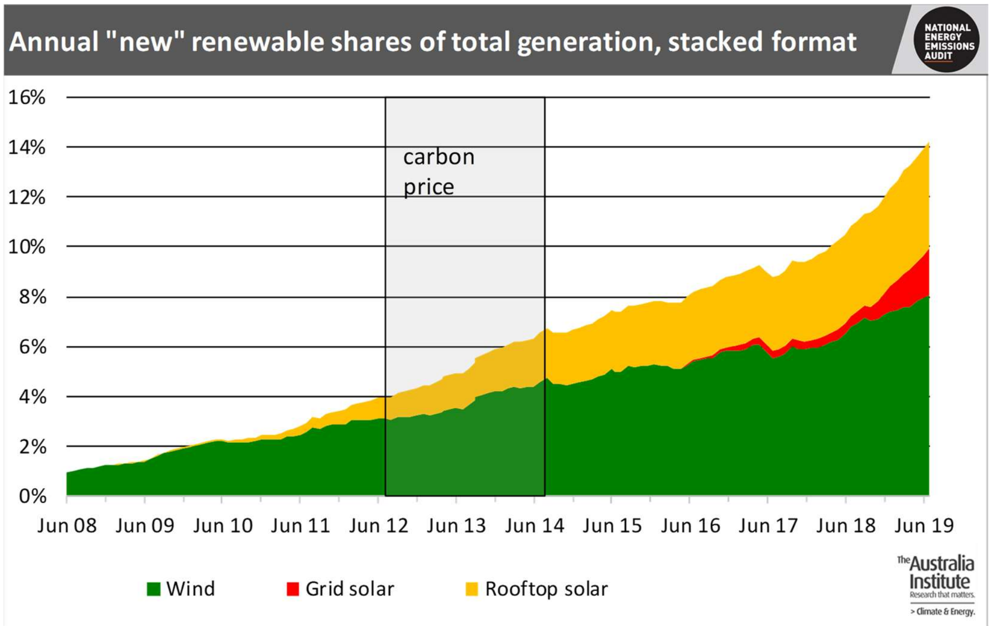


Figure 8



Presenting the data in this average monthly format makes it easier to see the marked and very consistent seasonal variation in output from solar generation, with relatively little volatility in month to month output. Wind generation, by contrast, shows very considerable month to month variation, but a limited and inconsistent seasonal pattern, though output tends to be somewhat higher in August/September and lower in May/June. The combination of higher average wind speeds, medium level solar radiation input, and low total consumption/ generation make September the month each year in which "new" renewable generation usually achieves its highest annual share of total generation, although average generation for the month as a whole may be slightly higher in either August or October, as seen in Figure 10 for August 2017 and October 2018.

Figure 9

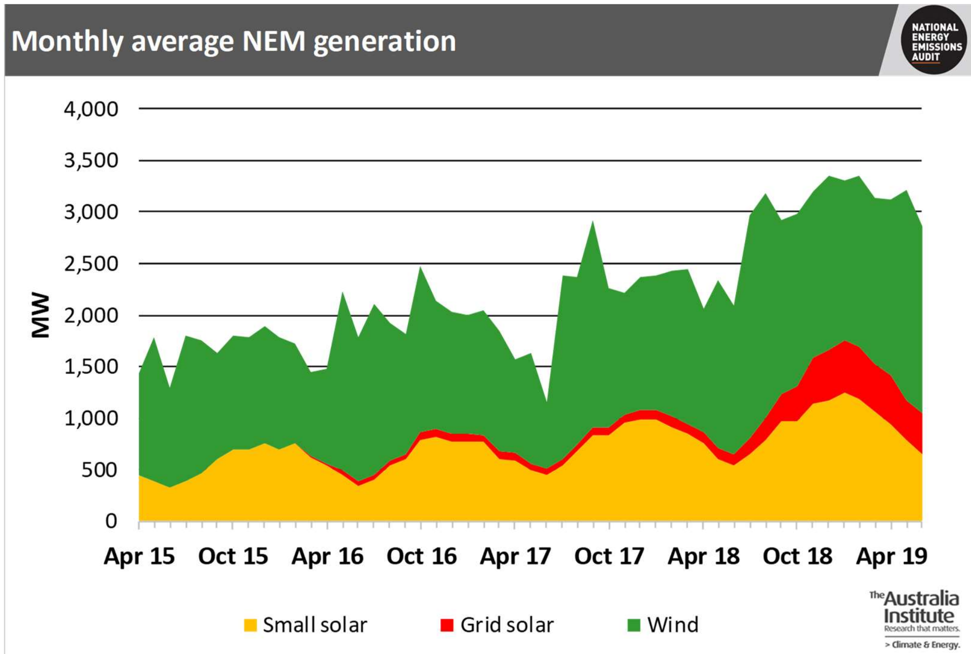
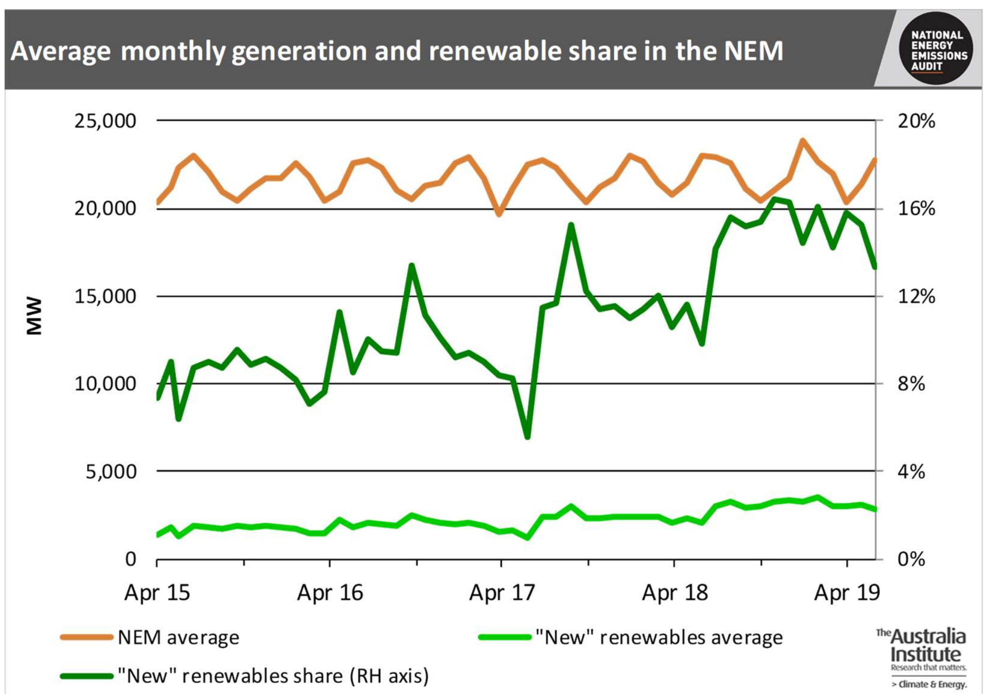


Figure 10



Another feature of the wind capacity currently operating is there appears to be a fairly high level of correlation, at a day to day level, between output from the generators in South Australia and Victoria, a characteristic which undoubtedly contributes to the large month to month variations in total output seen in Figure 9. Output from wind generators in New South Wales and Tasmania also appears to be correlated, though less strongly. The apparently different patterns of variation in output between solar and wind has important implications of the design of the evolving NEM electricity system. The characteristics of the firming capacity needed to offset variations in wind generation output over periods of more than a day will quite be quite different from those needed to offset variations over similar periods in solar generation.

“New” renewable generation supplied at the regional level

Figures 11 to 14 show total “new” renewable generation supplied in each of the four mainland states (NEM regions). It can be seen that South Australia is still the state with the highest volumes at both the grid level and in total, when rooftop solar is also included. However, output is growing fastest in New South Wales, where annual output from grid scale wind and solar generators has doubled over the past fourteen months, and Victoria. It seems certain that both will soon overtake South Australia in terms of total wind and solar generation. Queensland has been much slower than any other state to shift towards renewable generation. However, in January it overtook New South Wales as the state with the largest output of grid solar generation and it has always generated more rooftop solar than any other state.

Figures 15 to 18 show the same annual renewable generation data, but expressed as shares of total generation in each state. The shares are of course much higher in South Australia than in any of the other three states, because total generation is so much lower in South Australia. It is of course the high share of renewable generation, rather than the absolute quantity, which places South Australia on the cutting edge of incorporating variable renewable generation into existing electricity grids. On average, over the year to June 2019, total grid solar and wind generation in the state was greater than demand for electricity from the grid (not including rooftop solar generation in either generation or supply) during 1,080 30 minute trading intervals, equal to 6.2% of all trading intervals in the year. This number would have been higher were it not for the fact that on a number of occasions during the year the grid operator, AEMO, considered it necessary to curtail output from some wind generators, that is, to instruct the operators of those windfarms to reduce output. AEMO takes such action when it feels necessary to do so in order to maintain the stability of the electricity supply system as a whole at prudent levels.

Figure 11

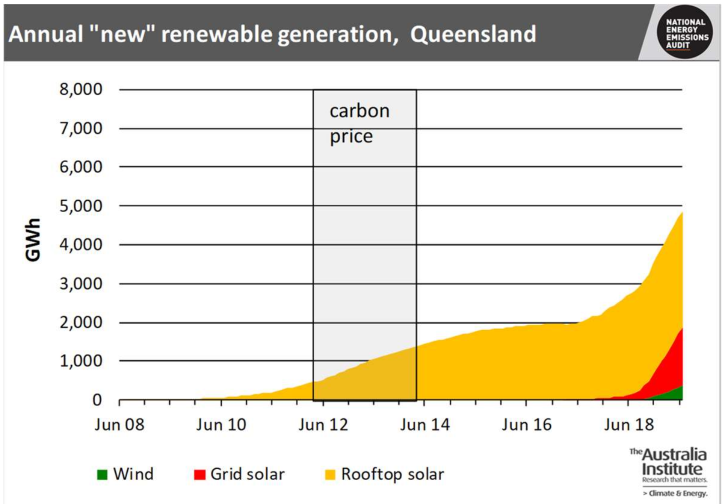


Figure 12

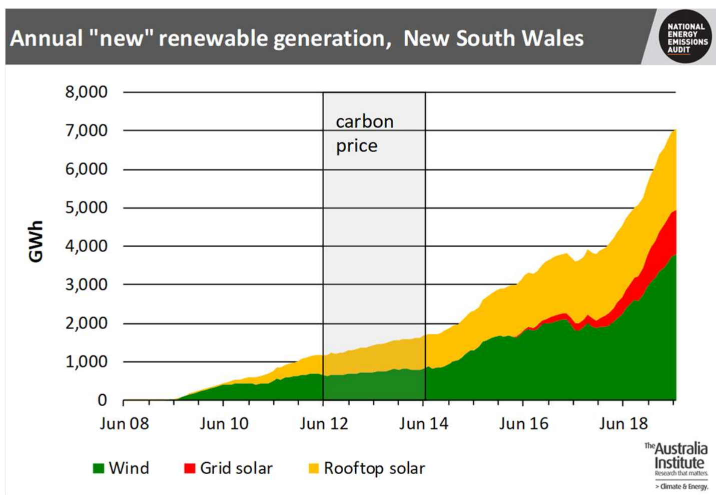


Figure 13

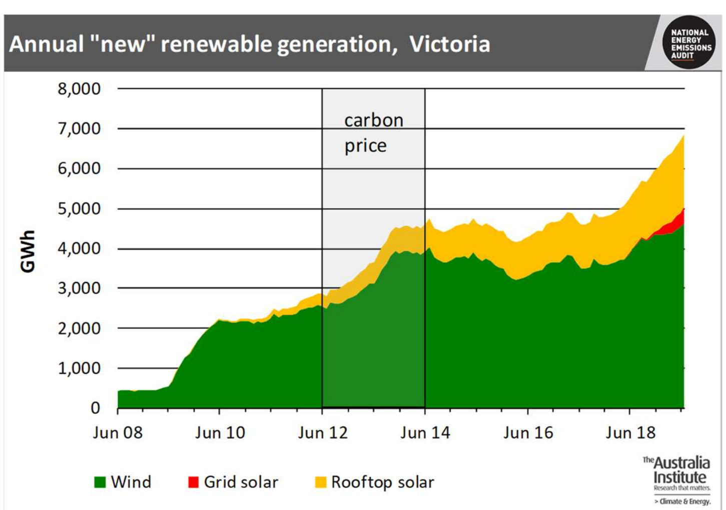


Figure 14

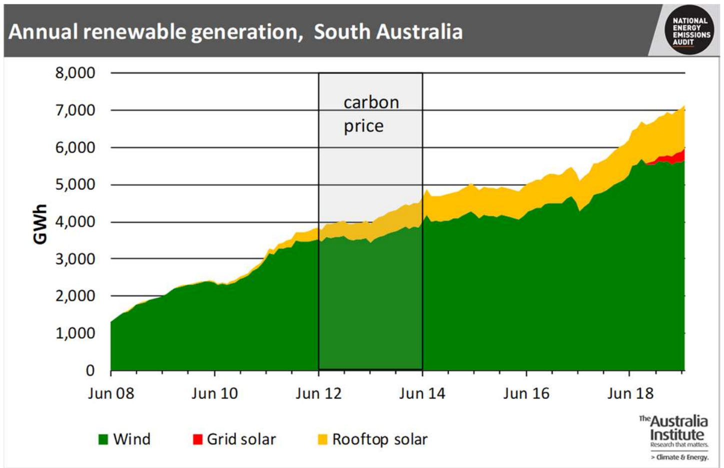


Figure 15

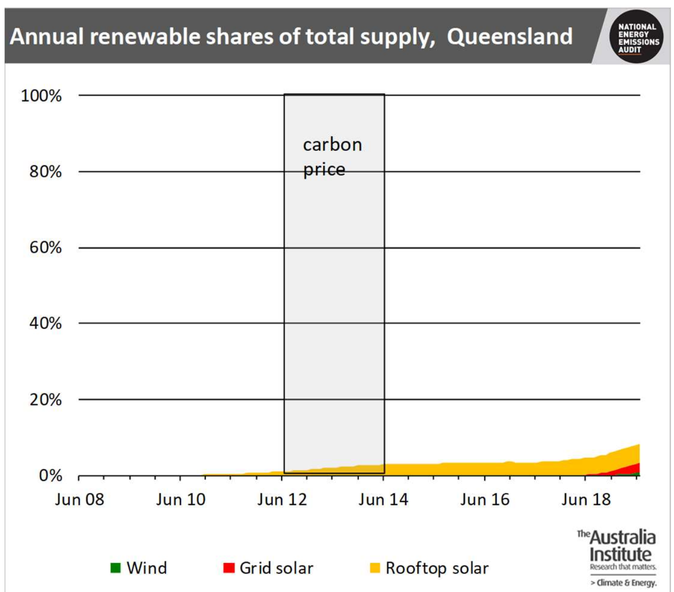


Figure 16

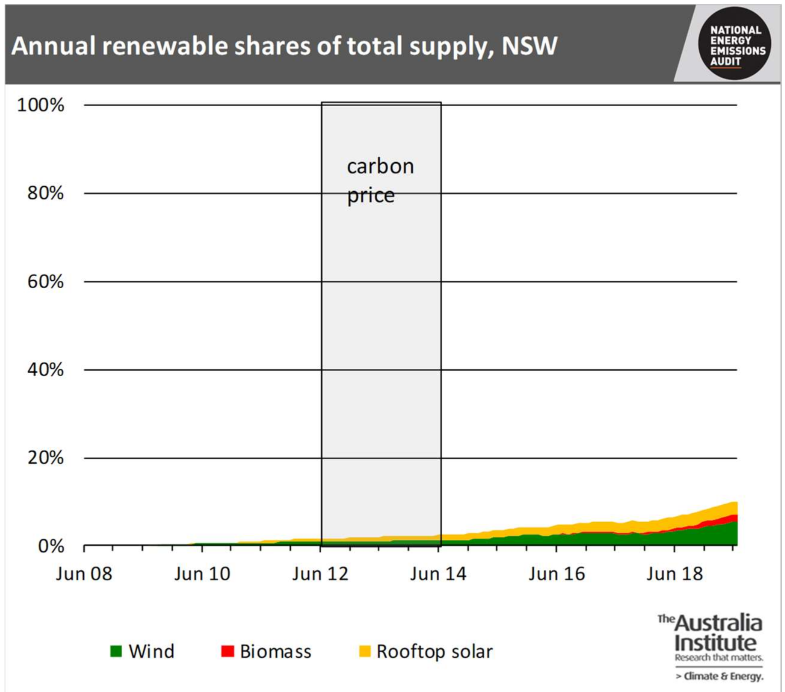


Figure 17

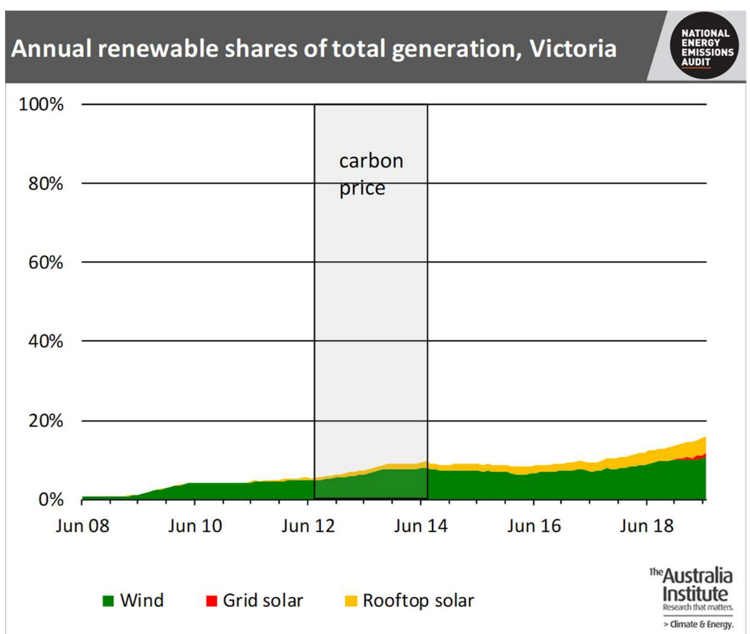
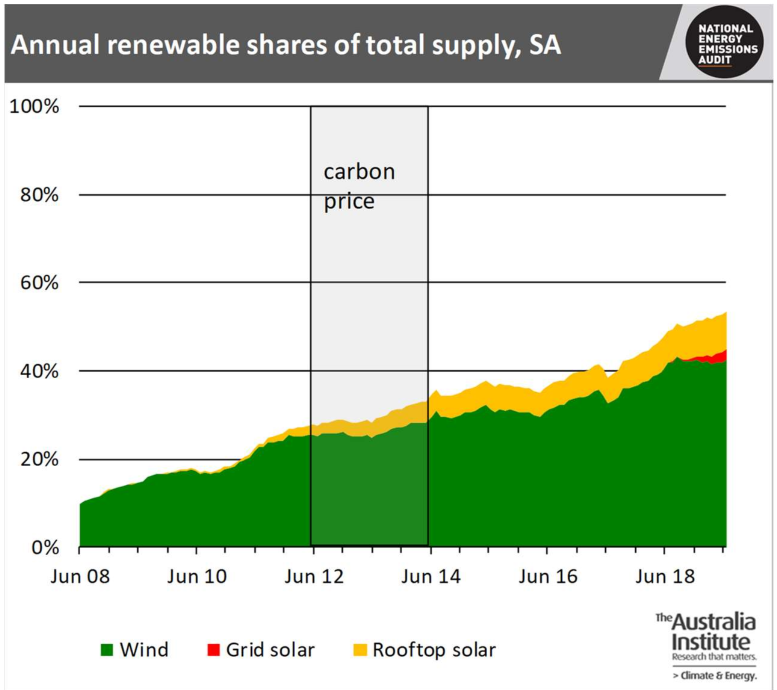


Figure 18



THE TRANSITION TO RENEWABLE GENERATION IN AN HISTORIC PERSPECTIVE

The NEEA reports have been documenting, month by month, the rapid changes currently taking place in the Australian electricity supply system, as it transitions from a system based on coal fired generation to one based on wind and solar generation. The transition involves large new investments right across the country in not only generation, but also transmission infrastructure, and changes in the way that the system is operated. Such rapid and fast-reaching changes are not, however, without precedent in the history of electricity supply in Australia, as a comparison with the rates of growth of the whole electricity supply system during the 1950s and 1960s. At the start of this period, electricity supply was a relative luxury, available almost exclusively to businesses and households located in state capital cities and a few larger regional centres, and used mainly for high value services such as lighting and electric power use by businesses. By the end of the period, the six state electricity commissions had built the state-wide electricity supply systems we now have, and made access to abundant reticulated electricity an essential service for all.

Figures 19, 20 and 21 compare the total generation and electricity supply provided by the six electricity commissions, added together, over the period from 1953 to 1961 with the capacity and generation of total wind and grid scale solar generation in the

NEM from 2011 to 2019. Figure 19 shows the growth in capacity, expressed as both the absolute increase in each year and the total capacity at the end of each year relative to capacity in the first year. Figure 20 shows similar absolute and relative increases, but for total generation in each year, rather than capacity.

Figure 19

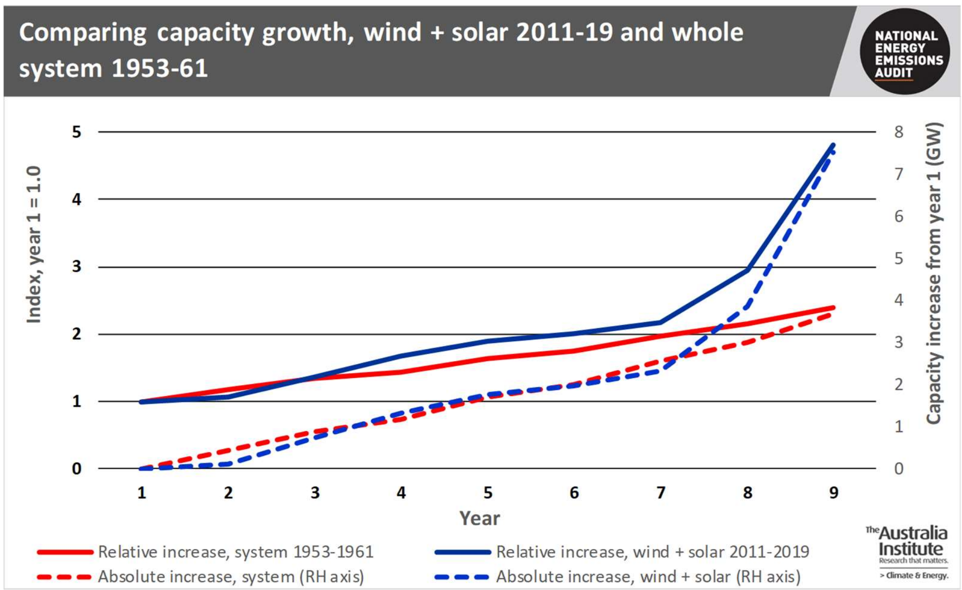


Figure 20

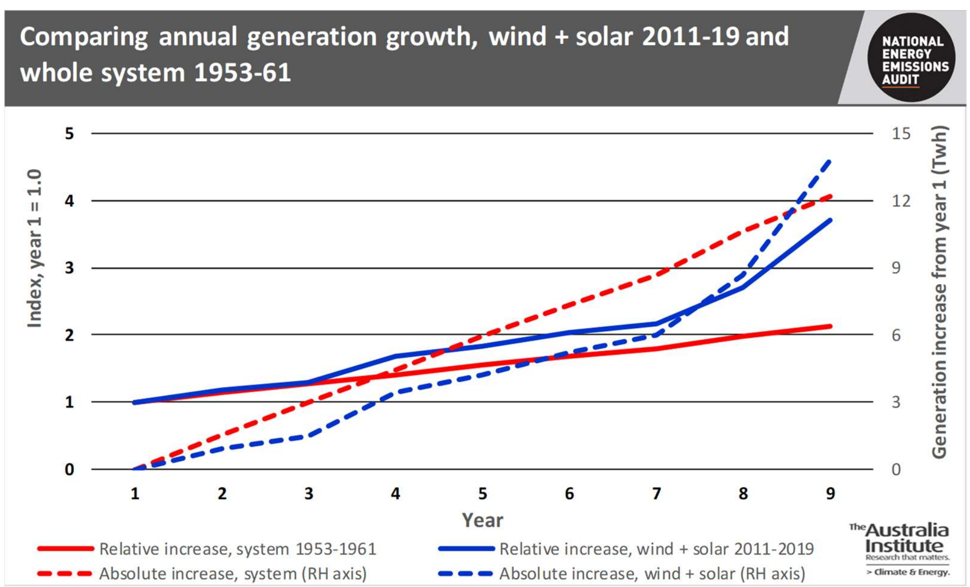
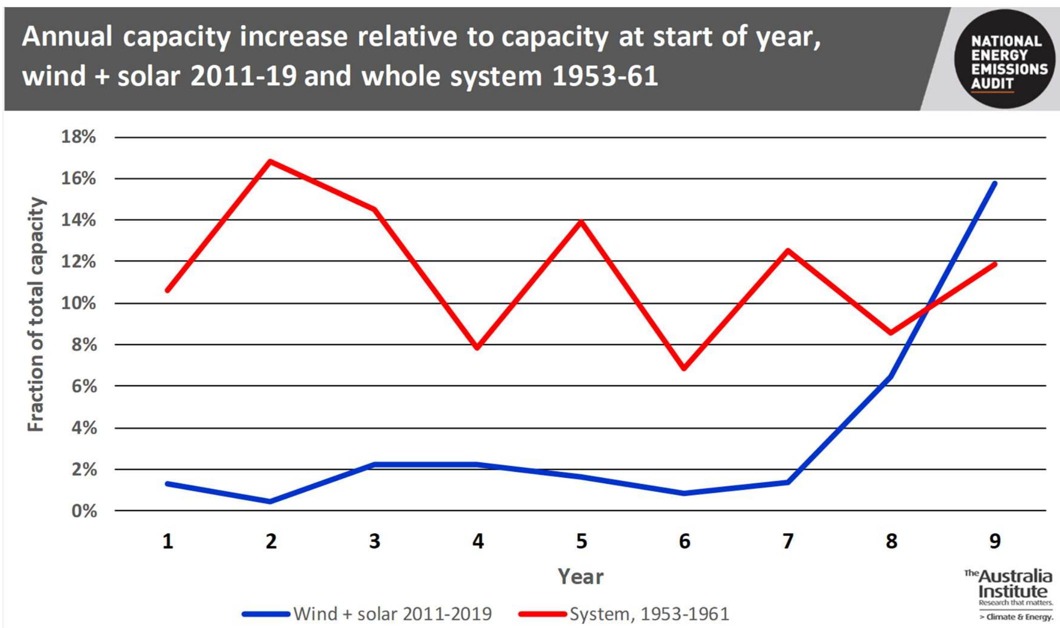


Figure 21 expresses capacity growth in each year relative to the total system capacity at the start of each year. For system growth from 1953 to 1961 the numbers graphed are simply the year by year increase represented by the red dashed line in Figure 19. However, for growth in NEM wind and solar generation from 2011 to 2019 the numbers graphed are the addition to capacity during the year, relative to the total generation capacity in the NEM, including coal, gas and hydro, at the start of each year.

It can be seen from all three graphs that, until the last couple of years, new wind and solar capacity added was only a small fraction of total capacity in place. By contrast, during the 1950s the whole system increased in size by between 8% and 16% each year. In many ways, not least because completely new high voltage transmission systems were also being built at the same time, the transition in the Australian electricity supply systems was larger and no less transformative than the transition which is happening today.

Figure 21



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.