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Power down II

The continuing decline in Australia's electricity demand

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Summary

In *Power Down*, Australia Institute Paper 14, the most important factors accounting for the change in demand for electricity in Australia over recent years were identified as:

- the impact of (mainly regulatory) energy efficiency programs;
- structural change in the economy away from electricity-intensive industries; and
- since 2010, the response of electricity consumers — especially residential consumers — to higher electricity prices.

This paper uses the same analytical approach as *Power Down* and covers the same period, starting in 2005-06, but with a one-year extension to 2013-14. It differs, however, in focussing specifically on quantities of electricity used in consumers' premises – in electricity industry terminology, consumption behind the meter. The paper includes an estimate of how much of the electricity generated by rooftop photovoltaic installations is consumed behind the meter. However, unlike *Power Down*, this paper is not concerned with how total photovoltaic generation, as well as electricity supplied by other generators embedded within distribution networks, is affecting electricity supplied by major power stations in the National Electricity Market (NEM). This paper also updates and extends the analysis by:

- disaggregating data by states (and the ACT) in the NEM; and
- separating residential demand from demand by general business, i.e. business other than large industry, and analysing each separately.

The paper notes that in 2014 large industry accounted for 25.4% of total electricity used by consumers in the NEM, general business for 46.4%, and residential consumers for 28.2%. The overall finding is that demand in the NEM by each of the three major groups of electricity consumers has been falling since 2010, though at different rates.

The large industry group of electricity consumer consists of 93 establishments, selected as a consistent set by the Australian Energy Market Operator (AEMO) for the purpose of its forecasting work. It has always been the case that most change in total demand by large industry results from discrete investment and operational decisions by just a few of these establishments. Demand grew for a few years after 2006, but since then has fallen as a result of a small number of plant closures, which were described in *Power Down*. Since June 2014 the Point Henry aluminium smelter in Victoria has closed, but new demand has come on line in Queensland.

Electricity demand by general business has also fallen since around 2011 in the NEM as a whole and in all NEM states and the ACT. The ratio of business electricity demand to economic activity, most commonly measured as gross state product (GSP), is often called the electricity intensity of economic activity. This ratio has been falling steadily since 2007, and at a remarkably similar rate in all states. Analysing changes since 2006 in the previously steady rate of growth in business electricity demand, the paper finds that regulation based energy efficiency measures account for an important part of the slowing demand growth since 2007. A one-off response to higher prices in 2011 was also found, as previously described in *Power Down*. However, a significant proportion of the decline in demand growth cannot be explained by either of these factors. The paper concludes that this represents the aggregate effect of a wide variety of actions taken by businesses to improve their individual energy use efficiency. Such changes are not captured by the national aggregate estimates of electricity savings attributable to regulated increases in equipment and building efficiency. This conclusion is supported by the analysis of trends since 2010 in electricity related emissions reported, through the National Greenhouse and Energy Reporting System (NGERS), by major service sector businesses, such as banks, retail chains, and property

groups. Most report a steady decline in their emissions from electricity use over the period from 2010 to 2014.

Total electricity demand by residential consumers increased until 2010, but has fallen sharply since then. When expressed as demand per residential customer (i.e. per household), demand is constant until 2010 (meaning that total demand grew at the same rate as population), but has fallen precipitously since then. By 2014 average electricity demand per household was between 10-15% lower than in 2010, and the trends were almost identical in all five states and the ACT. The paper finds that the major causes of the fall in demand are regulated energy efficiency measures and the response to higher electricity prices. A small contribution is made by electricity generated by rooftop photovoltaic systems that is consumed behind the meter, i.e. electricity used *in situ* without being exported to the local network.

The fall in demand per household has an important mitigating impact on the effect of increased electricity prices on annual household electricity expenditure. If demand per household had been at the same level in 2014 as in 2010, the total annual residential expenditure on electricity across the whole NEM would have been $2.5 billion higher, which equates to $295 per household. In fact, without the changes in energy efficiency and electricity use behaviours and practices, which households have made, electricity consumption per household would have been appreciably higher in 2014 than in 2010. $2.5 billion therefore represents a substantial under-estimate of the total benefit Australian households have received by changing the ways they use electricity. On the other side of the coin, this figure represents a loss in revenue affecting all parts of the electricity supply industry.

Looking at future electricity demand, the paper explains that modelling of the regulatory measures affecting the energy efficiency of appliances, equipment, and buildings indicates that annual savings — relative to a 2006 base year — will continue to increase for some years to come. The rate of increase will slow, however, as stocks of shorter-lived appliances, such as televisions, are completely turned over and entirely replaced by more efficient models.

There is currently a wide array of proposals to continue driving energy efficiency improvement, both by increasing the stringency of minimum energy performance standards (MEPS) for many categories of appliances and equipment already covered, and by extending MEPS to currently unregulated equipment types. Each of the new proposals, if implemented, would extend the growth in energy savings and thereby help to moderate growth in demand for electricity. However, none of these proposals has been implemented since September 2013, despite the fact that it has been demonstrated that they would be of strong economic benefit to consumers and help the country to reduce its greenhouse gas emissions at net negative cost. The reason is that, in the name of reducing “red tape”, the Australian Government has specified that every new regulation introduced must be offset by the abolition of another regulation within the same program. Unsurprisingly, the presence of this requirement to find regulations that can be abolished is proving a near insurmountable obstacle to further upgrades in the energy efficiency of appliances and equipment across all sectors of the economy. In addition, the paper describes a different set of problems, lying with the states as much as the national government, which have resulted in widespread non-compliance with the regulated energy efficiency requirements for new buildings.

The paper concludes that, although increased energy efficiency has been the most important contributor to the large reduction in growth of electricity demand witnessed in Australia over the past few years, further improvements in efficiency are now in serious jeopardy. Unless the regulations are progressively upgraded in line with technical advances, demand reduction will end when the entire stock of buildings and equipment meets the current energy efficiency requirements. Demand for electricity is then likely to resume unnecessarily

stronger growth, driven by growth in both the economy and the population, alongside lost opportunities for increased energy efficiency.

Introduction

Power Down, Australia Institute Paper 14, analysed the changes in electricity demand in Australia's National Electricity Market (NEM) between 2006 and 2013. Since 2010, electricity demand has been characterised by an entirely unprecedented steady fall in the total quantity of electricity consumed each year. *Power Down* concluded that a number of different factors had contributed to this reduction in demand; the factors include, but are not confined to:

- national regulations mandating the increased energy efficiency of new appliances, equipment and buildings;
- a change in the behaviour of electricity consumers since 2010;
- the closure of a small number of large electricity consuming manufacturing facilities; and
- the growth in electricity supplied from rooftop photovoltaic installations.

This paper both updates and extends that analysis, bringing in data from an additional year, 2014, and using additional data sources to separate consumption by residential consumers from consumption by business customers with small and medium demand levels, termed in this paper general business. (Note that the terms "small" and "medium" refer to the level of consumption at an individual site, not to the total consumption of a business across the country; many big businesses such as major banks and retail chains use large amounts of electricity, but in the form of relatively small quantities at many locations across the country, each of which is classified as a medium or small consumer.)

Like *Power Down*, this paper looks only at electricity in the National Electricity Market – the NEM – for the very pragmatic reason that the detailed data needed to support the analysis are not available for electricity used outside the NEM. The NEM covers all electricity consumers connected to the national grid, which stretches from far north Queensland to Tasmania and far west SA. Electricity consumers outside the NEM are those in WA and the NT, together with a small number in isolated far inland areas of the eastern states, mostly in Queensland and SA. Restricting the analysis to the NEM is not a great drawback, since in 2013-14 electricity consumption in the NEM accounted for about 88 percent of total national electricity consumption.

This paper differs from *Power Down* in that it focuses specifically on quantities of electricity used in consumers' premises – in electricity industry terminology, consumption behind the meter. *Power Down* looked more broadly at quantities of electricity supplied by major generators to the wholesale market, as well as at actual consumption by final consumers. This paper does not, therefore, examine the effect on large generators of the growth in rooftop photovoltaic (PV) installations and other forms of distributed generation.

Key data sources and general approach

Two key data sources provide the foundation for the analysis. The first source is the *2015 National Electricity Forecasting Report* (NEFR) produced by the Australian Electricity Market Operator (AEMO)[1]; the organisation responsible for operating the NEM. The 2013 version of this report was the principal source of data used in *Power Down*. The second data source is Regulatory Information Notice (RIN) response reports to the Australian Energy Regulator (AER), furnished on an annual basis by each transmission and distribution network business in the NEM[2]. The AER requires all businesses to report using the same standard reporting template. The data which the AER requires coves a very wide range of matters relating to

[1] Australian Energy Market Operator (2015) *National Electricity Forecasting Report (NEFR) 2015*. http://www.aemo.com.au/Electricity/Planning/Forecasting/National-Electricity-Forecasting-Report

[2] Australian Energy Regulator, 2015. Network performance reports. http://www.aer.gov.au/node/483

both the technical and the financial performance of the network businesses. The data used in this report is that contained on the single sheet, *Operational Data*, of the large template workbook. Like the AEMO data, this AER data is annual, starting in 2006. A minor complication is that the Victorian network businesses report on a calendar year basis, while businesses in the other five NEM jurisdictions (including the ACT) report on a financial year basis. All analysis in this report is undertaken on a whole-of-NEM basis; the approximation of linear interpolation is used to include the Victorian data.

Explanation of the trends in demand revealed by the analysis of electricity data makes use of key data published by the Australian Bureau of Statistics, including state population, Gross State Product and the Consumer Price Index.

The AER RIN data include quantities of electricity supplied by each distribution network business to residential consumers and quantities supplied to all other consumers. It also includes quantities of electricity received by each network business from generators located on the premises of residential consumers and, separately, from other generators located within the network, termed embedded generators. This means that the generators are connected into the distribution network, not into the high voltage transmission network. These embedded generators may be either generators located on the premises of non-residential consumers, e.g. industrial cogeneration plants, or small stand-alone generators, e.g. small hydro plants on large irrigation storage dams and landfill gas generators at landfill sites. Like the AEMO data, the AER data is also annual, starting in 2005-06.

By combining data from AEMO and AER it is possible to allocate total electricity supplied to consumers into three groups:

- large industry, as defined by AEMO,
- all other non-residential consumers, termed general business, and
- residential consumers.

The strength of the analysis described in *Power Down* was limited by the necessity, imposed by data availability, of analysing electricity demand by residential and general business consumers as a single combined total. It is obvious that there are large differences between the average residential consumer of electricity and the average business consumer, such as the functions for which they use electricity, and the size and nature of opportunities to respond to higher electricity prices. Separating the two groups of consumers provides the opportunity to improve understanding of the factors driving reduced demand for electricity.

Data on electricity consumptions savings related to the use of electrical appliances and equipment are an updated version of the same data used in *Power Down*, sourced from George Wilkenfeld & Associates[3]. All the savings estimates were made on an *ex ante* basis. For the analysis in this paper, use was also made of unpublished *ex post* data on new sales and average energy consumption for a small number of residential electricity using items, including compact fluorescent and other types of lamps that replaced incandescent lamps. All savings estimates were allocated to either residential or general business consumption, based on the category of appliance or equipment; for example, televisions were allocated to the residential sector and electric motors to business. The savings resulting from building energy efficiency regulations and programs are sourced from pitt&sherry, also as in Power Down[4]. The measures and programs are in all cases explicitly identified as being related to

[3] George Wilkenfeld & Associates, 2014. *Impacts of the E3 program: projected energy cost and emissions savings.* http://www.energyrating.gov.au/program-publications/?_wpnonce=b9c739ea70&er_doc_submitted_query=1&er_doc_year=2014&er_doc_category=&er_doc_subcategory=&er_doc_query=&publicationPageNumber=3

[4] The report is no longer available on an Australian Government website, but can be found at http://www.pittsh.com.au/assets/files/CE%20Showcase/Quantitative%20Assessment%20of%20Buildings%20Measures.pdf

either residential buildings or commercial buildings, so allocation of savings is straightforward.

Overview of trends in electricity consumption by major consumer groups

Figure 1 shows trends in electricity consumption in total and by each of the three consuming groups since 2005-06. It is difficult to see trends in this form of presentation, but is a convenient way to show the relative size of the three groups of consumption. Consumption is defined as electricity supplied through the meter; it does not include electricity consumed "behind the meter", i.e. produced and consumed without leaving the site. Behind the meter consumption contributes to meeting a consumer's requirements for electricity, but from the perspective of a network service provider or an electricity retailer it looks like a reduction in demand. Trends are more easily seen in Figure 2, where they are expressed as absolute changes from the starting year. It shows that, in absolute terms, residential demand has been the largest contributor to the fall in demand over recent years. Figure 3 shows that the reduction in demand by the residential sector has also been the largest in relative terms. Demand by each of the three consumer groups will now be discussed in more detail.

Figure 1: Consumption of electricity in the NEM, by consumer group

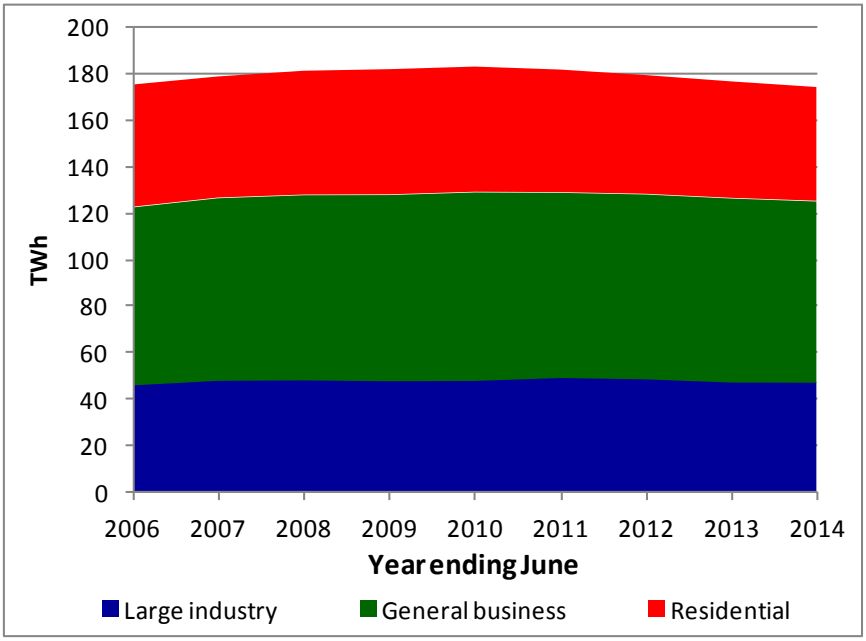


Figure 2: Absolute changes in electricity demand since 2005-06, by consumer group

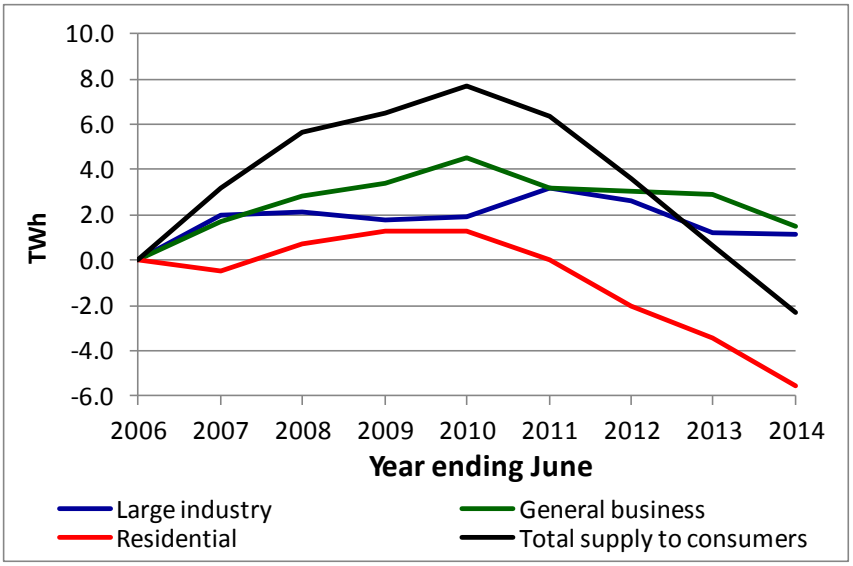
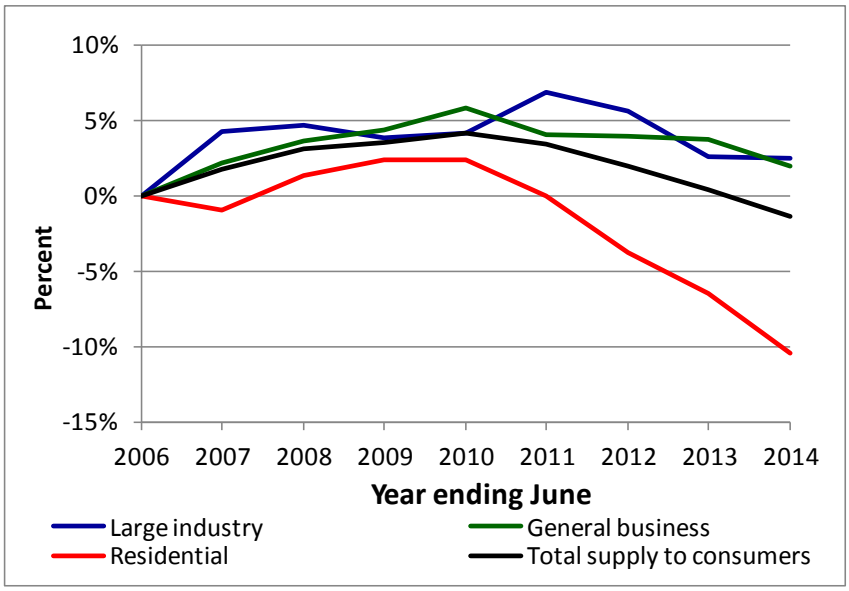


Figure 3: Relative changes in electricity demand since 2005-06, by consumer group



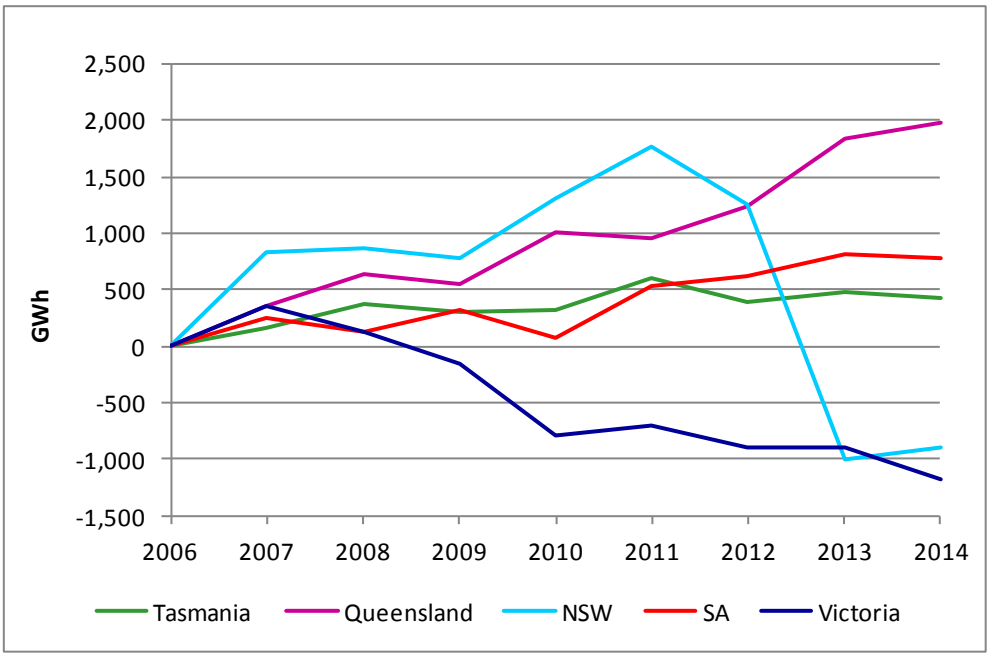
Large industry

Large industry is defined by AEMO to include all sites with a maximum power demand of greater than 10 MW. The operators of all these sites were asked individually by AEMO, as part of its preparation of the *2015 National Electricity Forecasting Report*, to provide their expectations about future electricity demand[5]. The total number of sites was 93. A maximum demand of 10 MW would be equivalent to annual electrical energy consumption of around 70 GWh, assuming a capacity factor of 80%, which would be expected at a large industrial facility. As can be seen in Figure 3, demand by large industry has fallen since 2011. The causes of this fall are well understood, and were discussed in *Power Down*: the closure of the Kurri Kurri aluminium smelter and the reduction in production at the Port Kembla steelworks. The Sydney desalination plant was also shut down in July 2012, as the reservoirs supplying Sydney's water were filled by prolonged heavy rain. All of these demand

[5] Australian Energy Market Operator (2015). *Op. Cit*.

reductions were in NSW, and are clearly seen in Figure 4. More recently the closure of the Point Henry aluminium smelter in Victoria has reduced demand in that state. Point Henry was roughly the same size and same vintage (over 40 years old) as Kurri Kurri and its closure reduced demand by about the same amount, around 3 TWh annually.

Figure 4: Absolute change in large industry electricity demand since 2005-06, by state



In an attempt to gain further understanding of the demand growth in NSW up to 2011, and also the faster demand growth in Queensland, an examination was made of the year-by-year trend in Scope 2 emissions publicly reported under the National Greenhouse and Energy Reporting Scheme (NGERS)[6]. Scope 2 emissions are those emissions associated with the generation of electricity used by the reporting businesses. This means that reported emissions are proportional to electricity consumed, though the proportionality factor varies with the source of electricity, and so is particularly high in Victoria and almost zero in Tasmania. The first year for which data are available is 2008-09.

Several companies with large Scope 2 emissions and major operations in NSW show significant increases in Scope 2 emission between the 2008-09 and 2010-11 NGERS public reports. They include Rio Tinto and Pechiney (Tomago aluminium smelter), Hydro Aluminium Kurri Kurri (Kurri Kurri aluminium smelter), BlueScope Steel (Port Kembla steelworks), Pratt Industries (Tumut pulp mill), Norske Skog (Albury newsprint mill), and Newcrest Mining (Cadia gold mine). Since then there have been very large reductions by Kurri Kurri and BlueScope steel, and also Norske Skog, which installed a large cogeneration plant on-site, greatly reducing the quantity of electricity it takes from the NEM (and, by doing so, greatly reducing its greenhouse gas emissions). For Queensland, the NGERS data provide less help in identifying particular sources of the growth in large industry demand. It is plausible to speculate, however, that the rapid growth in coal mine production has contributed, because most mines are large users of electricity.

These examples confirm, as has always been the case, that major changes in total demand by the large industry group of electricity consumers can result from discrete investment and operational decisions by just a few of the 93 establishments included in this consumer

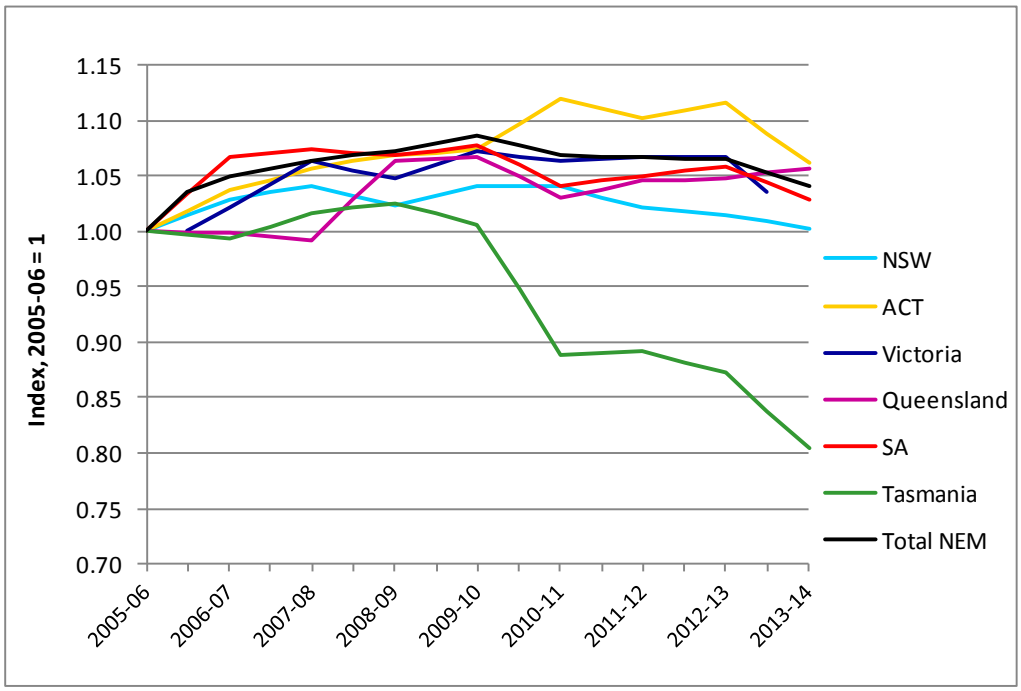
[6] Clean Energy Regulator, 2014. http://www.cleanenergyregulator.gov.au/NGER/Published-information/Published-NGER-data/Reported-greenhouse-and-energy-information-by-year

category. As discussed in *Power Down*, demand from large industry was a major driver of growth in demand for electricity for many decades, as a succession of major mineral and natural resource processing plants were built and subsequently expanded. This stage in Australia's economic development may now be coming to an end; if correct, this would mean a cessation of growth in demand for electricity, and quite possibly a gradual reduction in demand as businesses act to increase the efficiency with which they use electricity. That is the expectation of AEMO, as set out in its *National Electricity Forecasting Report* (with the single exception of expected significant growth in demand, eventually amounting to as much as 10 TWh annually, for the extraction and transport of gas from the extensive coal seam gas fields.) What is quite clear, however, is that widespread industrial closures are emphatically not, as is sometimes claimed, a major reason for the absolute fall in demand for electricity since 2010.

General business

Figure 3 shows that electricity demand by general business grew slightly up until 2010; since when, it has gradually fallen. This pattern is replicated at the individual state level, as seen in Figure 5. This shows the changes on an index number basis, which places small states on the same scale as large states, in relative terms. In absolute terms, the changes in NSW and Victoria are of course very much larger than the changes in Tasmania and the ACT.

Figure 5: Relative changes in General business electricity demand since 2005-06, by state

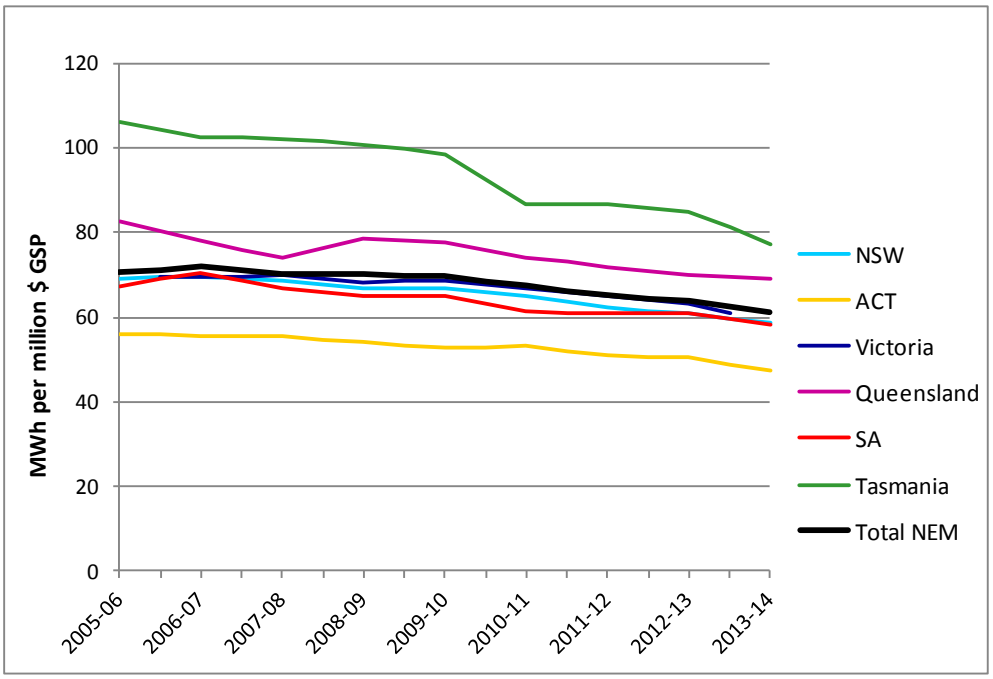


As a historical generalisation, demand for electricity by business consumers has been closely related to the total level of economic activity, most often measured at the national level as Gross Domestic Product (GDP) and at the level of individual states and territories as Gross State Product (GSP)[7]. This relationship is no surprise; whatever the level of electricity consumption per unit of output, i.e. electricity intensity, there is always a close relationship between electricity consumption and output in the short term, irrespective of the absolute electricity intensity of the business concerned. In the longer term, businesses can reduce electricity consumption per unit of output by increasing the efficiency with which they use

[7] Australian Bureau of Statistics, 2014. *Australian National Accounts: State Accounts, 2013-14*, Cat. No. 5220.0

electricity. The ratio of general business electricity consumption to real GSP is shown in Figure 6.

Figure 6: General business electricity demand per unit of Gross State Product since 2005-06, by state (MWh per million $ real GSP)



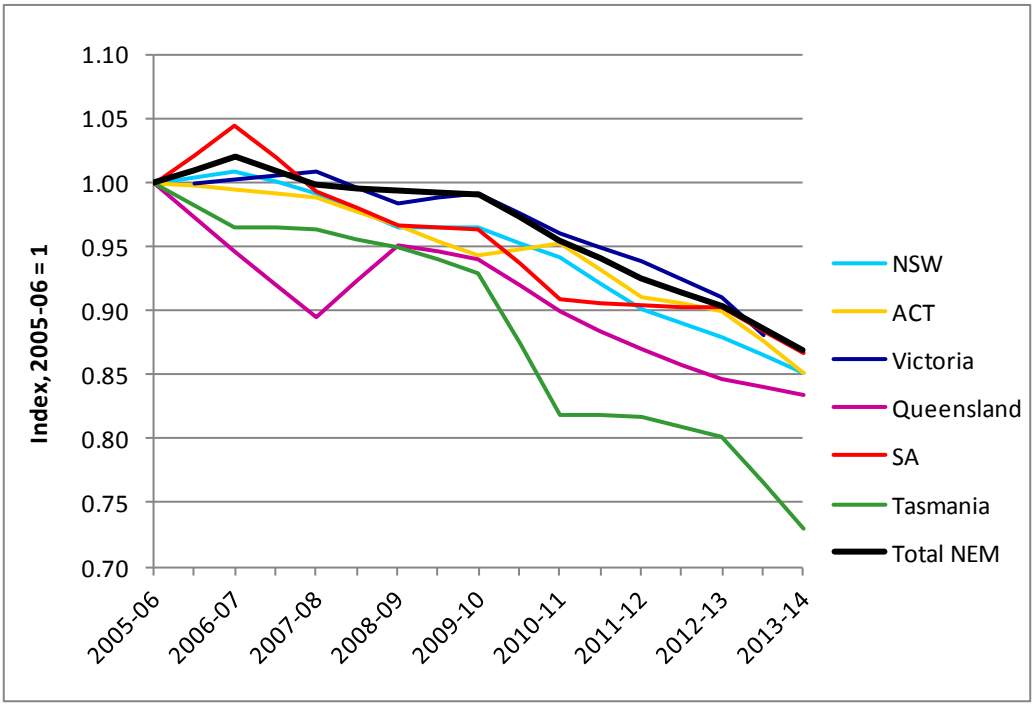
It is important to understand that, although general business accounts for only about two thirds of total business electricity consumption, it accounts for the great majority of GSP, including all of the service sectors, construction, most of agriculture and much of manufacturing. Hence, while electricity consumption per dollar of GSP is not a reliable measure of the electricity intensity of each state economy as a whole, because of the disproportionate impact a handful of very large electricity consuming businesses can have on total electricity consumption in the state, changes in this ratio are a good measure of changes in the electricity intensity of general business consumers.

Figure 6 shows some interesting differences between states in the level of general business electricity consumption per dollar of GSP. These differences are most likely to be related to differences in economic structure. This is clearly the case with the ACT, which has no mining and virtually no manufacturing or agriculture. There is obviously very little difference between NSW, Victoria and SA in terms of electricity intensity; in terms of economic structure, value added in manufacturing accounted for a slightly higher share of GSP in Victoria and SA than was the case in NSW. In Queensland, mining is a much higher share of GSP and manufacturing a somewhat lower share than any of these three states, and services a much lower share than in either NSW or Victoria. These structural differences are a probable share of the somewhat higher electricity intensity of general business in Queensland. Tasmania is the most extreme outlier. It has much the same share of manufacturing in GSP as NSW. However, until quite recently, gas was not available at all in Tasmania, and availability is still limited. It is therefore likely that electricity is used in Tasmanian industry for some activities that use gas in the mainland states. It is also possible that lack of gas access has led some manufacturing businesses not to locate in Tasmania when they might otherwise have done so; that is, Tasmania's economic structure may be slightly skewed towards business activities that preferentially use electricity.

Irrespective of these differences, the more important point is that electricity consumption per unit of economic activity has been steadily declining in all states, as can be seen most clearly

in Figure 7. Moreover, when allowance is made for the fact that the Queensland numbers are artificially low, the rate at which electricity consumption per dollar of GSP has fallen is much the same in every state. In other words, general business electricity consumption is growing more slowly than real GSP right across the NEM. Over the whole period since 2006 electricity consumption per dollar of real GSP had decreased at about the same rate as the economy has grown, with the consequence that total consumption has remained roughly constant. In 2005-06, total electricity demand by general business in the NEM was 77.1 MWh per million dollars of combined GSP. By 2013-14 it has fallen to 63.6 MWh per million dollars.

Figure 7: Relative changes in general business electricity demand per $ of real Gross State Product since 2005-06, by state

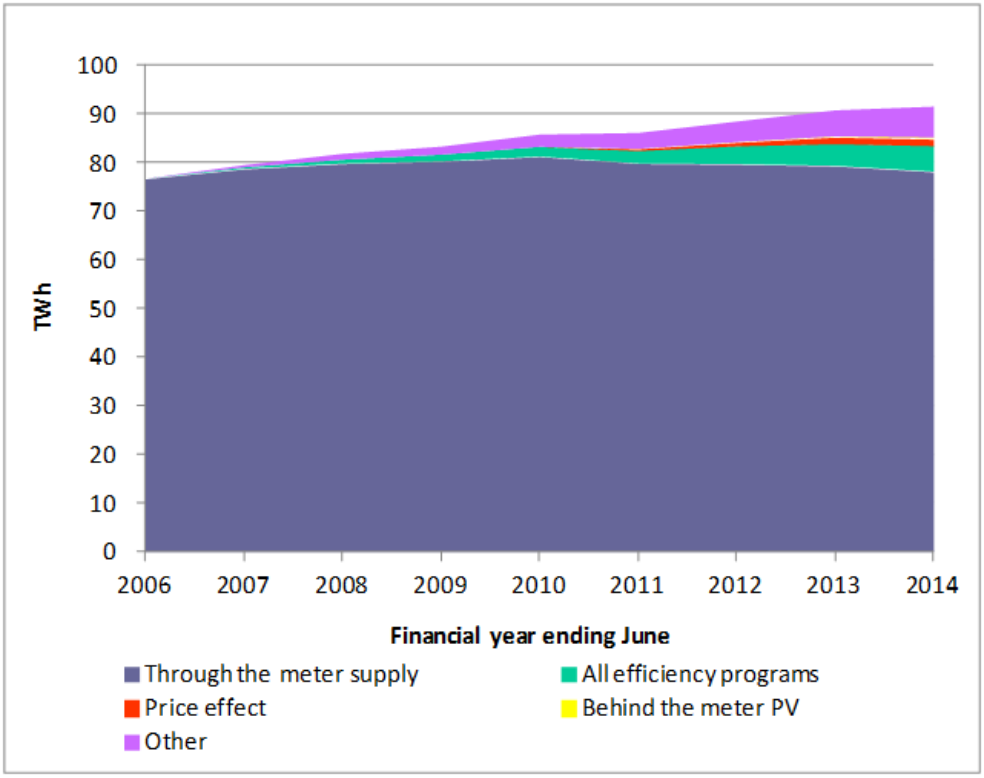


General business demand for electricity in the NEM as a whole was analysed using the approach described in *Power Down*. This involves modelling demand not for electricity supplied, but for electricity services, defined as the sum of electricity supplied through the meter plus electricity saved by the use of more efficient appliances, equipment and buildings. Starting with electricity services equal to electricity supplied in 2006, i.e. with electricity savings set at zero, electricity services increase faster than electricity supplied, as savings grow steadily. Between 2006 and 2010, a simple model of electricity services, with price elasticity of demand for services equal to –0.05 and income (GSP) elasticity equal to 0.6 gives a very good fit to general business electricity demand in the NEM as a whole. Between 2010 and 2011 there was a sharp fall in demand, which could only be explained by a sudden increase in price elasticity to –0.3. Since then, however, the further gradual decrease in demand for electricity services fits more closely with a reversion to a price elasticity value of –0.05.

Figure 8 presents the results of an analysis that estimates the contributions to the observed reductions in demand for electricity by general business consumers of two factors: increased energy efficiency and the response to higher electricity prices. Without the savings resulting from increased efficiency, electricity demand would have continued to grow throughout the entire period from 2006 to 2014. This is shown by the green wedge in Figure 8. The demand reduction induced by the response to higher electricity prices is shown by the red wedge. Had income elasticity of demand for electricity services been equal to 1.0, i.e. demand for

electricity services increased at the same rate as GSP, the additional demand which would have resulted is shown by the mauve wedge in Figure 8.

Figure 8: Contribution of identified explanatory factors to changes in General business electricity demand in the NEM since 2005-06



From a policy perspective, this last wedge is in many ways the most interesting of the three, as it is a measure of the rate at which this very large group of electricity users, accounting for the great majority of national economic activity, is becoming steadily less electricity intensive — and also, therefore, less emissions intensive.

Economy-wide changes in electricity (and energy) intensity, as seen in Figure 7, can be explained by two high level types of change:

- changes in the structure of the economy towards economic activities which are inherently less electricity intensive; and
- reductions in the electricity intensity within economic sectors.

General business electricity consumers include the very great majority of all consumers classified within the service sectors of the economy, as well as significant parts of manufacturing. Over the period from 2006 to 2014, national accounts data show that these economic sectors in total increased their share of total economic activity, i.e. they grew faster than the economy as a whole. Specifically, in the NEM states, total service sector value added increased by 24% in real terms between 2005-06 and 2013-14, whereas total economic activity increased by only 20%. This change in economic structure has therefore contributed to a reduction in the electricity intensity of the Australian economy as a whole. However, the economic output of the service sectors — and, therefore, by implication, of general business consumers — has in fact increased faster than that of the total economy. Thus, all else being equal, this structural change would be a factor working to increase electricity consumption by general business consumers faster than total economic activity. In other words, structural change would tend to make general business electricity consumption per dollar of GSP increase, rather than decrease. This is of course the opposite of what has

happened. The changes actually observed must therefore reflect reductions in electricity intensity within the various sectors covered by general business; that is, reductions in electricity intensity by general business consumers, taken as a whole.

The most recent analysis by the Office of the Chief Economist in the Department of Industry (formerly the Bureau of Energy and Resource Economics) of trends in energy intensity of the Australian economy found that the energy (not just electricity) intensity of the service sector, defined as the ratio of energy use to economic output, fell at an average rate of 1.4% per annum between 2002-03 and 2012-13[8]. The data in Figure 7 show that the reduction in electricity intensity of general business accelerated after 2010 and that the average annual rate of decrease over the whole period from 2006 to 2014 was 2.7%, at the same time as the share of electricity in total energy use by the services sector increased modestly, from 73% to 74%[9]. The Department of Industry report concludes that about a quarter of the decrease in energy intensity over the ten years can be attributed structural changes within the sector, in the form of a growing economic share of the finance, insurance, property and other business services sectors, which are less energy intensive than sectors such as wholesale and retail trade. The other three quarters of the intensity decrease is attributed to what is called, in the strict technical sense, energy intensity, meaning, in effect, increased energy use efficiency.

The energy efficiency savings shown in the green wedge in Figure 8 are those attributable to regulatory policies and programs which mandate minimum performance standards for new appliances, equipment and buildings, plus small contributions from other national programs affecting commercial buildings and one NSW state program. They do not include any of the savings made as a result of initiatives by businesses to increase the efficiency with which they use electricity – these are shown in the mauve wedge.

Some of these savings have been driven by government programs, of which the former national Energy Efficiency Opportunities (EEO) program is probably the most important. Establishment of this program by the Howard government was one of the main outcomes from its 2004 Energy White Paper. Data collected and published in a comprehensive review of program performance its first five years indicate that program participants had at that time implemented efficiency measures estimated to save around 3 or 4 TWh per year[10]. It appears that about half of these savings are in industry sectors dominated by a small number of establishments which would fall into the large user category, while the other half would fall into general business. Savings of this size would represent a material contribution to the changes in both large industry and general business electricity demand shown in Figure 2. The EEO program was terminated by Act of Parliament in September 2014 (discussed in the *Future trends and challenges* section below).

Other government programs supporting increased energy efficiency remain in place. State governments provide a diverse array of financial support programs, such as support for energy audits. Ratings schemes such as the National Australian Built Environment Rating System (NABERS) are another form of support, or an enabler, of business action. While these programs help spur business engagement and activity, the savings are the result of action by electricity consumers themselves. For example, most large commercial property businesses have for some years had programs to systematically upgrade the energy performance of buildings in their portfolio.

[8] Stanwix, G., Pham, P. and Ball, A., 2012, *End-use energy intensity in Australia*, Department of Industry and Science, Canberra. http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/energy-intensity/EndUseEnergyIntensityInAustralia.pdf

[9] Calculated from Department of Industry and Science, 2014. *Australian Energy Statistics*. http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Pages/Australian-energy-statistics.aspx

[10] Department of Industry, 2013. *Energy Efficiency Opportunities Program, the first five years: 2006-11. Overview*. https://eex.govspace.gov.au/files/2014/08/Overview-5-YR-REPORT-2.pdf

Many businesses are also reducing their consumption of purchased electricity by installing behind the meter electricity generation at their own premises in the form of either gas fuelled cogeneration or, in the last year or so, commercial-scale rooftop photovoltaics. The term "behind the meter" refers to the fact that the electricity generated is not exported out to the local network, but is used on-site to displace electricity that would otherwise have been supplied from the network. This approach is attractive for many businesses, both because of the financial and management costs of meeting the regulatory requirements for an on-site generator to be grid connected, and because of the economic benefits of avoiding electricity purchases rather than selling into the network for a price which is often a third or less of the price of purchased electricity.

Available data allow estimates to be made of the consumption of electricity produced by rooftop photovoltaics on the premises of both business and residential consumers. The results are included, though barely visible, in both Figure 8 and Figure 12. However, it is not possible to estimate the growth in behind the meter supply from cogeneration. There is anecdotal evidence that this supply is growing; for example, a number of local government authorities have in recent years increased energy use efficiency at their swimming pools (often termed acquatic centres), either by installing cogeneration for the first time or upgrading old installations, but there is no comprehensive source of data on the performance of such installations. From the perspective of the network electricity supplier, behind the meter supply from cogeneration looks like any other reduction of supply through the meter caused by increased energy efficiency, which of course it is, though not a type of energy efficiency which of itself reduces consumption of electricity.

The effect of these activities at the larger end can be seen from NGERS data. The large financial institutions, retailers, property groups, hospital owners and others are all amongst the one hundred largest Scope 2 greenhouse gas emitters, not because any of the individual properties they own or lease are very large electricity consumers (as is the case for most large industrial electricity consumers) but simply because they have so many properties their portfolios. Almost all of these very large businesses reported steady falls in their Scope 2 emissions between the 2009-10 and 2013-14 reporting years, at average annual rates in the range 0 to 5% per year, notwithstanding significant turnover growth in the same period. (A few reported much larger reductions, but these are likely to have resulted from property divestment.) This group includes the largest banks, retailers, shopping centre operators, and commercial property owners, as well as Telstra, Australia Post, and the CSIRO. Over the four years the total net reduction in Scope 2 emissions reported by a group of 30 very large service sector businesses was 0.5 Mt CO_2-e, which corresponds roughly to a reduction in annual electricity consumption of 0.5 TWh. The group includes two businesses, ALDI Stores and Global Switch (a very large data centre operator), which reported significant increases in emissions, obviously a consequence of their rapid growth. A reduction of 0.5 TWh is clearly significant in the context of the absolute changes in general business electricity demand shown in Figure 2.

While it remains the case that Australia has enormous untapped potential for further increases in energy efficiency, the data suggest that significant progress in realising this potential is beginning to be made, and the effect of this progress can be seen in the changed trajectory of growth in general business demand for electricity over the past four or five years.

Residential consumers

Figure 3 shows that residential demand for electricity in the whole NEM has fallen steadily and significantly since 2010. This pattern is replicated, with small variations in timing, in every state, as Figure 9 shows. This graph shows the changes on an index number basis, which places small states on the same scale as large states, in relative terms. Figure 10

normalises the data by showing per customer residential consumption in each state. Figure 11 shows the changes in demand per customer more clearly by expressing it in index number terms. Both Figures show that per customer demand has been falling since at least 2006 (with the partial minor exception of SA), but the rate of this decline accelerated greatly after 2010.

Figure 9: Relative changes in total residential electricity demand since 2005-06, by state

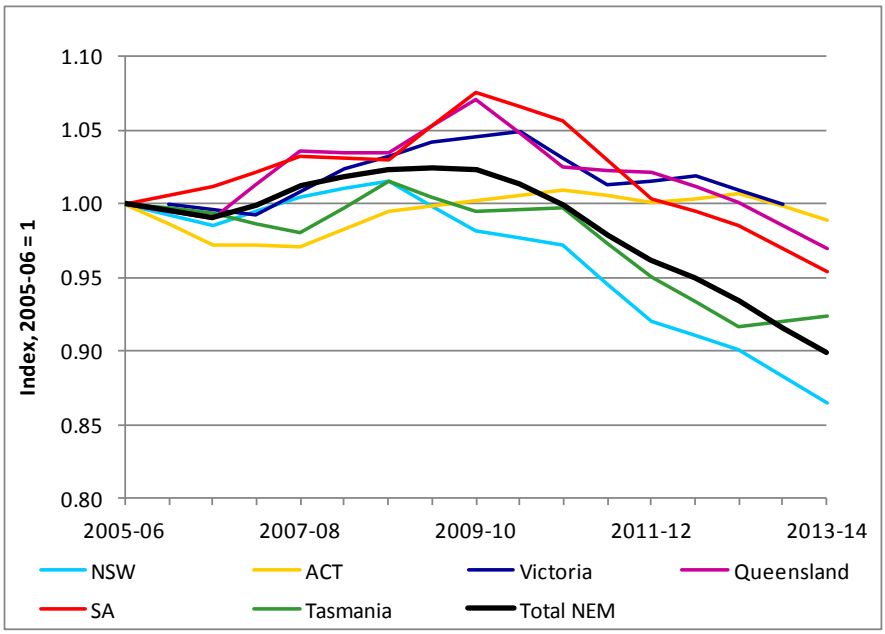
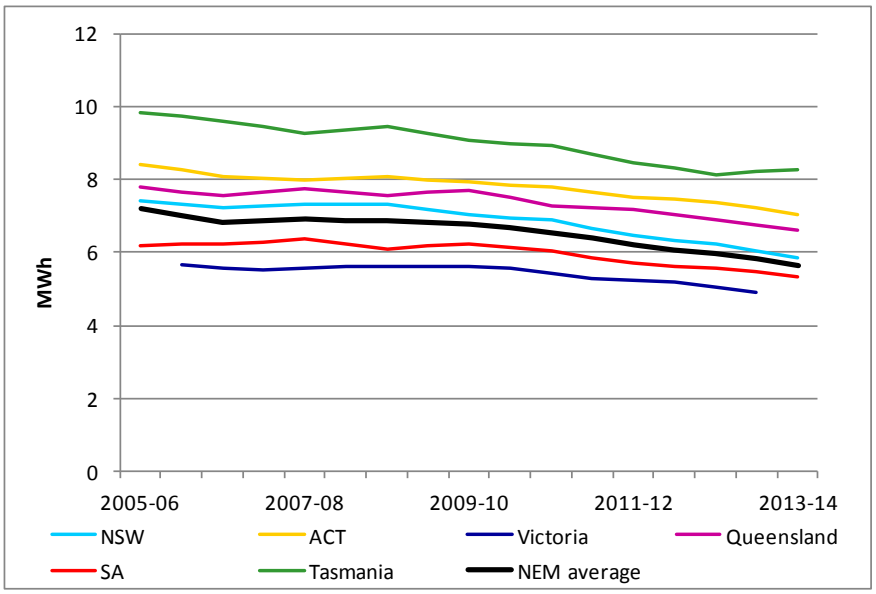


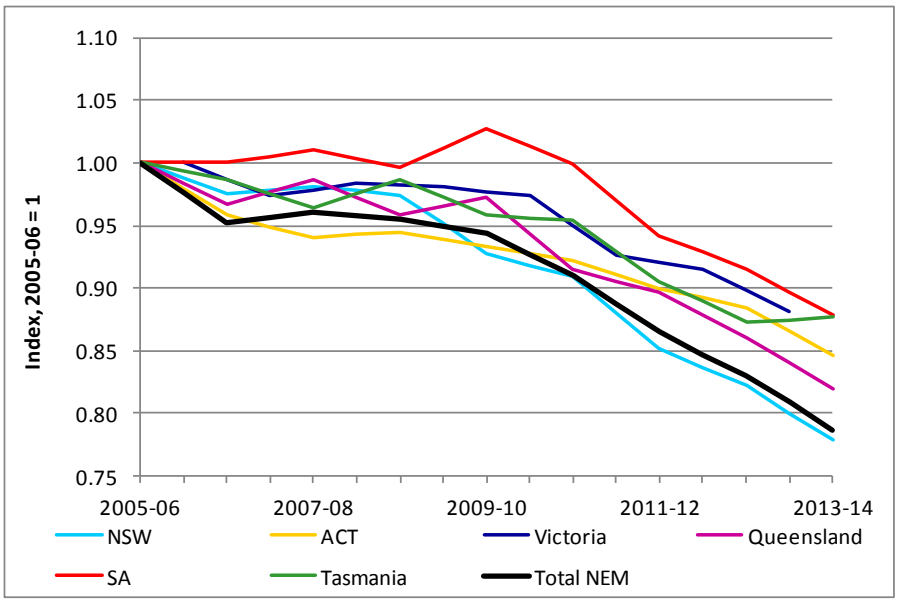
Figure 10: Residential electricity demand per customer since 2005-06, by state (MWh)



The marked differences between states are readily explained by the dual effects of their varying climates and the extent of gas use by residential consumers. At one extreme, Victoria has a relatively cold climate, and a much higher penetration of gas than any other states; well over half of all households use gas for both space heating and water heating. Consequently, average per-household electricity consumption is lower than any other state. At the other extreme, Tasmania has a somewhat colder climate than Victoria, but gas has

only become available in last few years and is used by very few households. Historically, electricity was seen as cheap and abundant. Were it not for the fact that a great many households use wood-fuelled heating, per-household electricity consumption would be even higher. All other states lie somewhere in between these poles. The ACT has colder winters than any other state/territory, but gas is quite widely used for both space heating and water heating and houses are on average better insulated than in Tasmania. On average, NSW has milder winters than its southern neighbours, but fewer households use gas and most use electricity for water heating. In Queensland, there is very little use of gas, the great majority of households use electricity for water heating, and in many parts of the state air conditioning is used for many months of the year, making it a significant consumer of electricity in total energy terms. In SA, gas is widely used for water heating and quite common also for space heating.

Figure 11: Relative changes in residential electricity demand per customer since 2005-06, by state



Residential demand for electricity is being significantly reduced by regulated increases in the minimum efficiency levels of household appliances and equipment, and also by minimum energy performance requirements for new dwellings. The savings are appreciably larger than the corresponding savings in business electricity consumption for several reasons:

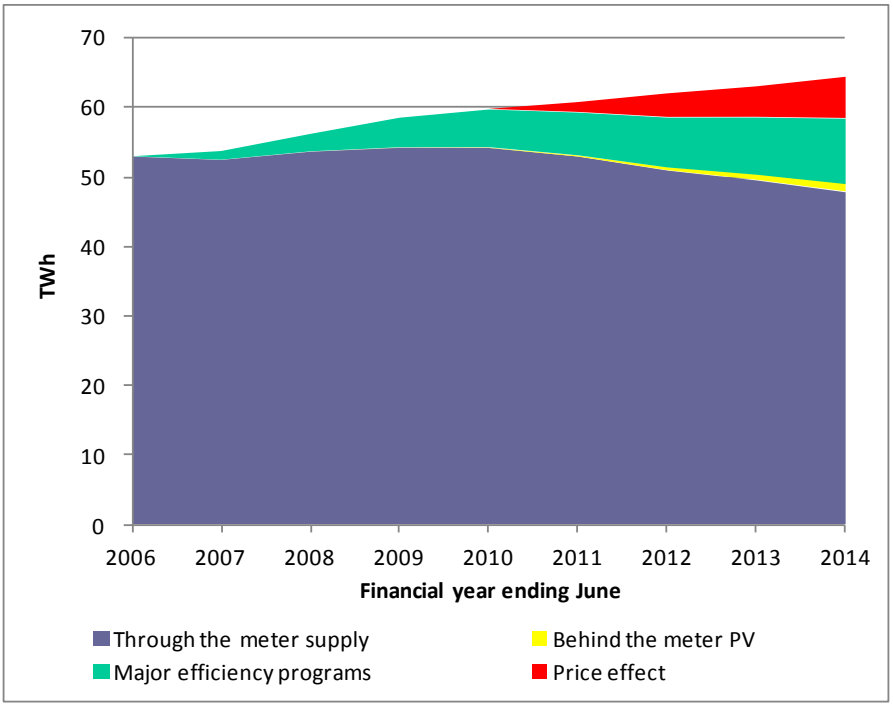
- minimum energy performance standards apply to a wider range of residential appliances and equipment, and this equipment accounts for a larger share of total household electricity consumption;
- original efficiency levels for some categories of household equipment, such as air conditioners, were lower than their commercial scale equivalent, allowing more scope for improvements; and
- the large savings resulting from the phase-out of incandescent lamps accrued almost entirely in the residential sector, because incandescent lamps were not much used in commercial buildings.

Behind the meter consumption of electricity generated by rooftop photovoltaics is also significant. Behind the meter consumption is, by definition, not metered, but it has historically been estimated as the difference between electricity exported to the network, as reported in the AER data, and total photovoltaic generation in each state, as estimated by AEMO. This assumes that all photovoltaic generation exported from customer premises is located on residential buildings. Although never precisely correct, this assumption was a reasonable

approximation until very recently. From now on, however, it seems certain that photovoltaic installations on commercial buildings will account for a steadily increasing share of total generation, much of which, for reasons previously explained, is likely to be consumed behind the meter. It will therefore be very difficult to apportion behind the meter consumption between residential and general business consumers.

Figure 12 shows the estimated contributions of both behind the meter rooftop photovoltaics and regulated energy efficiency to total electricity services used by residential customers. The additional contribution arising from household responses to higher electricity prices was estimated by fitting a simple price and income (GSP) elasticity model to the year-by-year estimate of total residential electricity services in the NEM. All analysis was undertaken on a per capita basis, so that the effect of population growth could be separated out. It was found that the use of a model in which price elasticity was zero up to 2009-10 and -0.25 thereafter, and income elasticity was 0.5 throughout, gave a very good fit to the observed data. The model was then used to estimate the electricity demand reduction resulting from higher electricity prices; this is the red wedge in Figure 12.

Figure 12: Contribution of identified explanatory factors to changes in residential electricity demand in the NEM since 2005-06



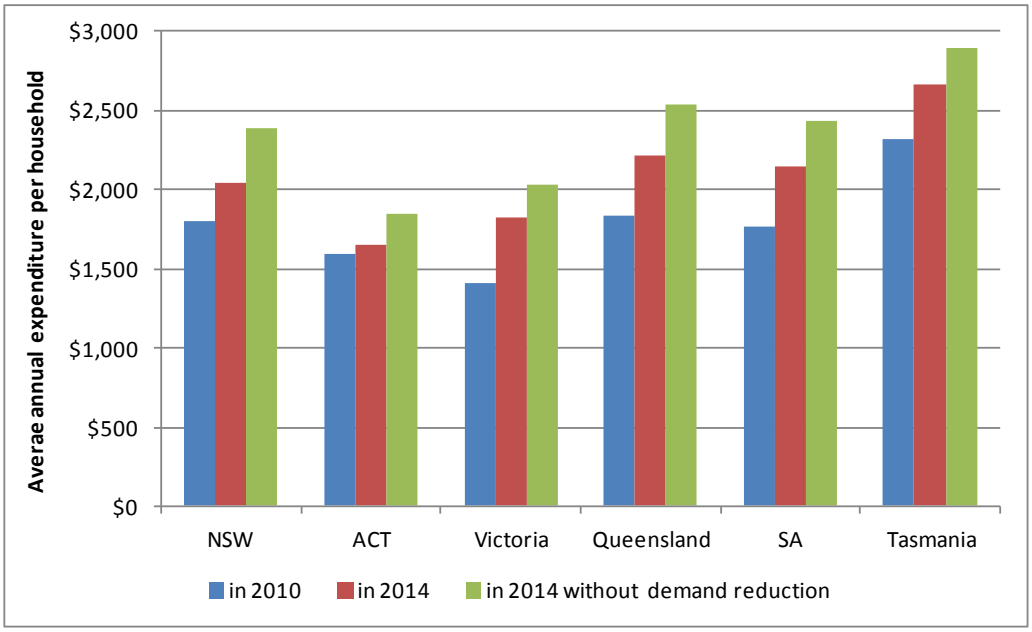
This analysis indicates that in the absence of regulated efficiency programs, behind the meter consumption of rooftop photovoltaics, and higher electricity prices, residential electricity demand in 2013-14 would have been 21% higher than in 2005-06 and 10% higher than in 2009-10, whereas in fact demand was 10% and 12% lower respectively.

By reducing their demand for electricity, households have greatly reduced the impact of higher prices. It can be calculated from CPI data that average residential electricity prices increased by 40% between 2010 and 2014 in real terms[11]. However, over the same period, the data reported in this paper on electricity supplied to residential consumers show that on average demand per household fell by 17%. This means that that average annual household expenditure on electricity increased by only 20% in real terms. Results for each of the six states and territories it the NEM are shown individually in Figure 13. If demand per

[11] Australian Bureau of Statistics, 2015. *Consumer Price Index, Australia*, Cat. No. 6401.0

household had been at the same level in 2014 as in 2010, the total annual residential expenditure on electricity across the whole NEM would have been $2.5 billion higher, which equates to $295 per household. These figures have been calculated as if electricity consumption per household had been the same in 2014 as in 2010. However, Figure 12 suggests that, without the various changes in energy efficiency and electricity use behaviours and practices, electricity consumption per household would have been appreciably higher in 2014 than in 2010. $2.5 billion therefore represents a substantial under-estimate of the total benefit Australian households have received by changing the ways they use electricity. On the other side of the coin, this figure represents a loss in revenue affecting all parts of the electricity supply industry.

Figure 13: The effect of reduced household demand for electricity between 2010 and 2014 on calculated average annual household electricity expenditure



Future trends and challenges

The most striking findings of this analysis are twofold:

- The consistency across all states and territories in the NEM of the patterns of reduced electricity consumption over the past few years by both residential and general business consumers; and
- The very large part played by increased efficiency in the use of electricity, including both increases mandated by a variety of regulatory measures and programs and increases resulting from actions consumers have taken on their own account.

The modelling of the regulatory measures affecting the energy efficiency of appliances, equipment and buildings indicates that annual savings, relative to a 2006 base year, will continue to increase for some years to come. Most of these savings are derived from the regulations affecting appliances and equipment, which are strictly enforced – there have been several successful prosecutions of appliance distributors and retailers found selling non-compliant models in recent years. The rate of increase will slow, however, as stocks of shorter-lived appliances, such as televisions, are completely turned over and replaced entirely by more efficient models. Savings from the regulated building efficiency measures are smaller, both because non-compliance is widespread (see below) and because of the longer life and hence slower turnover of the building stock. Nevertheless, in later years,

savings attributable to more efficient buildings should represent a growing share of total savings.

At the time the analysis of the E3 program by George Wilkenfeld & Associates[12] was undertaken, in mid-2013, there were a number of proposed new MEPS regulations planned to be introduced over the following years. Some of these proposals involve increased stringency of MEPS on categories already covered; such upgrades to required efficiency are proposed when it is clear that technical advances embodied in products available on the world market are likely to make it cost effective for consumers to purchase more efficient models. Proposals in this category covered household refrigerators and freezers, electric storage water heaters, and household air conditioners (all of which are residential products), along with predominantly commercial and industrial products like packaged air conditioners, air conditioner liquid chillers, close control air conditioners, commercial refrigeration products, fluorescent lamp ballasts, linear fluorescent lamps, three-phase electric motors and power supply transformers.

Other proposals involved examining the use of standby power consumption on a much extended range of products, and also the introduction of MEPS for the first time on several categories of equipment, including heat pump water heaters, solar water heaters, hot water storage tanks, and battery chargers. Finally, consideration was being given to closer regulation of products that impact energy use – insulation, windows and the like. Such regulation is possible under the Greenhouse and Energy Minimum Standards (GEMS) legislation, which provides for MEPS and energy labelling regulations.

Each of the new proposals, if implemented, would extend the growth in energy savings and thereby help to moderate growth in demand for electricity. They would be of strong economic benefit to consumers and help the country to reduce its greenhouse gas emissions at net negative cost,

However, progress on these proposals has stalled. Several were well advanced along this process at the time of the 2013 election. Since then, there has been almost no obvious advance, other than the awarding in late 2014 of a consultancy contract to review the whole program. According to the June 2015 issue of the program newsletter, the review is now complete and will be considered by Commonwealth and state ministers at the Energy Council meeting towards the end of July[13].

The need for a review is unclear - all proposals for new GEMS regulations already require a rigorous assessment and public consultation process. This process includes the preparation of a Regulatory Impact Statement to provide assurance that the benefits of any proposed new regulation exceed costs for consumers and for society as a whole, and also assurance that there is no cheaper way of achieving the same outcome.

The main obstacle to introducing new MEPS, is a requirement to reduce “red tape”. The Australian Government has specified that every new regulation introduced must be offset by the abolition of another regulation – within the same program. Unsurprisingly, the presence of this requirement to find regulations that can be abolished is proving a near-insurmountable obstacle to further extensions of the coverage of MEPS to currently unregulated categories of appliances and equipment, as there are few energy standards that should be given up in order to make new energy standards for new appliances. More broadly it appears that the government’s general attitude to regulations had put a dampener on willingness even to upgrade MEPS in line with technology improvements in categories of equipment which are

[12] George Wilkenfeld & Associates, 2014. *Op. cit.*

[13] *The Efficiency Standard*, June 2015. http://www.energyrating.gov.au/for-industry/news-events/

already regulated. Further improvements in the energy efficiency of appliances and equipment across all sectors of the economy are thereby stalled.

A separate problem is affecting the realisation of energy savings implicit in the building energy regulations. The problem was highlighted in a report prepared for the South Australian, Australian and other state governments by pitt&sherry and released by the Government of South Australia on the last working day before Christmas 2014[14]. It points to widespread and widely acknowledged non-compliance with the energy efficiency regulatory requirements of the National Construction Code. The consequence is that when householders buy a new house they can have little confidence that it will perform as it is supposed to; a house that is supposed to have an Energy Efficiency Rating of six stars may in fact only rate at four stars, or even worse. This situation has arisen because of the failure of the states and territories' regulations on ensuring compliance with NCC requirements. The factors behind this failure are somewhat complex and vary in detail from state to state, but the upshot is that the energy efficiency aspects of building regulations are not at present being enforced. Builders and the various construction industry trades, can consequently get away (most often through lack of care rather than blatant disregard for requirements) with constructing non-compliant houses, apartments and commercial buildings. An obvious consequence of this situation is that the building energy savings included in the analysis in this paper may be overstated. One study was commissioned by the Commonwealth in 2012 to measure the energy performance of what were supposed to be new five-star houses. Unfortunately, it encountered technical difficulties and was unable to reach firm conclusions[15].

Finally, it should be noted that two other energy efficiency initiatives are no longer proceeding. As previously explained, the present government abolished the Energy Efficiency Opportunities (EEO) program in 2014. In moving the Second Reading of the Repeal Bill in the House of Representatives, the responsible Parliamentary Secretary, Mr Bob Baldwin, stated:

> "This government acknowledges the burden regulatory programs, such as the Energy Efficiency Opportunities Program, impose on business and has committed to cutting red tape. Repealing the Energy Efficiency Opportunities Act 2006 will save Australian businesses $17.7 million per year."[16]

The five year program review estimated that the total net annual financial saving from measures which businesses had implemented or were intending to implement was $786 million[17].

The government has also abandoned the National Energy Savings Initiative (NESI). NESI was a proposal by the previous government to establish a nationally consistent market based program to support energy efficiency improvements by residential and small business energy users. The many useful reports commissioned in the course of developing the proposal have been helpfully archived on the Industry and Science Department website[18].

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[14] Pitt&sherry, 2014. *National Energy Efficient Building Project*. https://www.sa.gov.au/topics/water-energy-and-environment/energy/government-energy-efficiency-initiatives/national-energy-efficient-building-project

[15] Ambrose, M. *et al*.., 2013. *The evaluation of the 5-star Energy Efficiency Standard for residential buildings*. CSIRO. http://www.industry.gov.au/Energy/Energy-information/Pages/default.aspx#

[16] Hansard, 15 May 2014, p. 3837. http://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;query=Id%3A%22chamber%2Fhansardr%2Fb93d9c6e-c89b-4e3b-815b-42d1e54f2e99%2F0027%22

[17] Department of Industry, 2013. *Op. cit.*

[18] http://www.industry.gov.au/Energy/Energy-information/Pages/Energy-Savings-Initiative-Reports.aspx

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Conclusion

This report has demonstrated that the two most important factors contributing to the large reduction in growth of electricity demand witnessed in Australia over the past few years have been changes in the consumer's energy using behaviour, stimulated by increased awareness of the cost of electricity since 2010, and increased electricity use efficiency of appliances, equipment and buildings.

In its June 2015 *National Electricity Forecast Report*, AEMO estimates that total demand by general business and residential consumers has been slightly higher in 2014-15 than in 2013-14. The last year in which such an increase occurred was 2008-09[19]. It would seem the adjustments in electricity using behaviour, which consumers made in response to higher electricity prices, while not being reversed, may be no longer increasing. If that is so, trends in demand for electricity services are likely to become more closely aligned with growth in population.

The reductions in electricity consumption attributable to energy efficiency, resulting from regulatory programs that mandate the minimum energy efficiency of appliances and equipment, are likely to continue growing for several years, with smaller savings from building efficiency regulations. These programs reduce electricity demand as the stocks of each regulated item category are turned over. However, unless the regulations are progressively upgraded in line with technical advances, demand reduction will end when the entire stock meets the upgraded energy efficiency requirement. Demand for electricity is then likely to resume unnecessarily stronger growth, driven by growth in both the economy and the population alongside lost opportunities for increased energy efficiency. This is the outcome which now being delivered by the current effective freeze on new MEPS regulations.

[19] Australian Energy Market Operator (2015). *Op. cit*.