GRATTAN Institute

December 2013

Shock to the system

Dealing with falling electricity demand

Tony Wood and Lucy Carter

Grattan Institute Report No. 2013-15, December 2013

This report was written by Tony Wood, Grattan Institute Energy Program Director, and Lucy Carter, Energy Fellow. Cameron Harrison and James Button provided extensive research assistance and made substantial contributions to the report.

We would like to thank the members of Grattan Institute's Energy Reference Group for their helpful comments, as well as numerous industry participants and officials for their input.

The opinions in this report are those of the authors and do not necessarily represent the views of Grattan Institute's founding members, affiliates, individual board members or reference group members. Any remaining errors or omissions are the responsibility of the authors.

Grattan Institute is an independent think-tank focused on Australian public policy. Our work is independent, practical and rigorous. We aim to improve policy outcomes by engaging with both decision-makers and the community.

For further information on the Institute's programs, or to join our mailing list, please go to: http://www.grattan.edu.au/

This report may be cited as:
Wood, T., Carter, L., and Harrison, C., 2013, *Shock to the system: dealing with falling electricity demand,* Grattan Institute

ISBN: 978-1-925015-50-8

Overview

Electricity use in Australia is falling. From the 1960s to the end of the 20th century, electricity consumption increased at an average annual rate of six per cent. Investment in power stations and electricity networks also rose steadily. Since 2009, however, eastern states' electricity production has fallen and in Western Australia growth has plateaued since 2011.

Yet this extraordinary fall in demand has not led to a fall in price, as would occur in a conventional market. Since 2006 the average household has reduced power use by more than seven per cent. But in that period the average household power bill has risen more than 85 per cent: from $890 to $1660 a year. One reason is that Australians are funding billions of dollars of infrastructure that falling consumption has made redundant. These price rises are unsustainable, but who will pay for the correction: power companies, governments or – once again – consumers?

Falling consumption has several causes. Customers are responding to high prices by reducing use or switching to a new breed of more energy-efficient appliances. The cost of solar energy has fallen: a million households now have solar PV panels on their roofs. The economy has become less energy intensive as the manufacturing sector has declined.

The nature of Australia's energy market means that these changes are not leading to lower prices. Electricity generators operate in a free market: when consumption falls they must produce power at a lower price in order to sell it, or reduce production. But network businesses – which carry power from the generator to the business or home and which take about 45 per cent of a household's electricity bill – are regulated monopolies not subject to market forces.

For years, regulators have allowed these companies to earn excessive profits by setting tariffs that are too high given the low risk they face as monopolies. Some states have also allowed the companies to overinvest in infrastructure. This was less of a problem when demand was rising and higher costs were spread over a larger volume of sales. But when electricity use falls, the high cost of the network is spread over a smaller volume and customers pay more. Continually rising prices could induce them to disconnect from the network. Enough disconnections would trigger a crisis that insiders call the 'death spiral'.

To prevent this from happening governments must:

- Ensure that network companies make future investments that better match future power needs.
- Begin the hard task of reforming network tariffs so that prices companies charge reflect the costs they incur.
- Review the value of network assets to decide who should pay for any write-down of surplus infrastructure.

These solutions are neither simple nor painless. But consumers deserve a better system. A future Grattan Institute report will produce recommendations for how that can be achieved.

Table of contents

1. Electricity use is declining

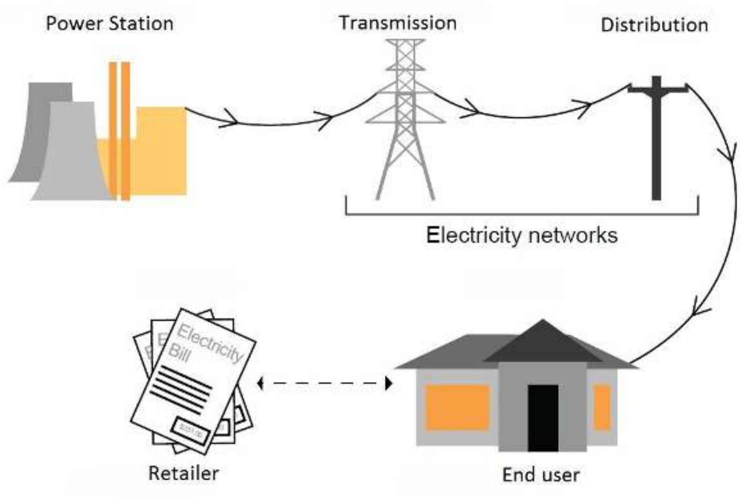
1.1 The structure of the electricity industry

Australia's electricity system contains four kinds of businesses that operate in different kinds of markets, as shown in Figure 1.1.

- Power stations, owned by generation businesses, produce electricity.
- Transmission businesses own the high-voltage 'poles and wires' that carry electricity across large distances to local markets.
- Distribution companies carry power across low-voltage networks to businesses and homes. Transmission and distribution companies are known as network businesses.
- Electricity retailers manage customers' electricity accounts and are responsible for buying enough power from generators to supply homes and businesses.

The generators and retailers compete for business and are exposed to risk if the volume or price of electricity falls. In that way competition protects consumers. But it doesn't make economic sense to have multiple physical networks competing to deliver electricity, so network businesses have a monopoly. An independent regulator sets prices that should be fair for both network businesses and consumers.

Figure 1.1: Electricity market: Power station to end user



Source: Grattan Institute

1.2 Trends in electricity consumption

Since 2009-10, electricity consumption in Australia's largest interconnected electricity market, the National Electricity Market (NEM), has fallen by 4.5 per cent. This fall in electricity consumption is unprecedented.[1]

[1] AEMO (2013b)

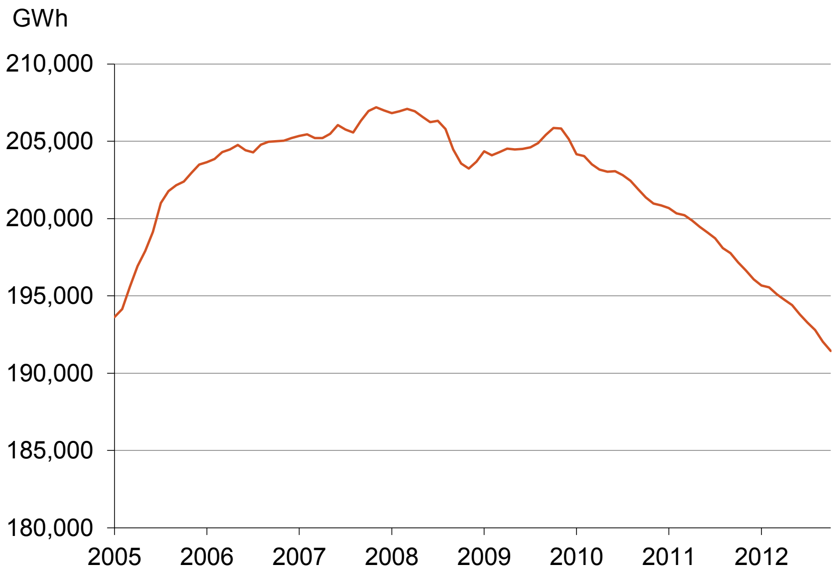
The NEM is an interconnected system of 'poles and wires' that delivers electricity to users in the southern and eastern states of Australia. It spans New South Wales and the Australian Capital Territory, Queensland, South Australia, Tasmania and Victoria.

Around 26 per cent of this power is sold to households, with the rest sold to commercial and industrial users.[2] Figures 1.2 and 1.3 show total energy supplied to the grid by generators. Electricity demand in the NEM reached an all-time high of 206,900 gigawatt hours in 2008-09.[3] By contrast for the year 2012-13, the total electricity demand was 193,500 gigawatt hours.[4]

Figure 1.2 shows the fall in consumption by charting year-to-date electricity use in the NEM. The figure shows 'sent out' electricity, which is the amount produced by power stations and transported through the network.

The change in consumption patterns has not been confined to the NEM. The South West Interconnected System (SWIS) is Australia's second largest network and supplies power to major population centres in the south-west of Western Australia.

Figure 1.2: NEM 12-month rolling total of electricity demand, 2005 to 2013



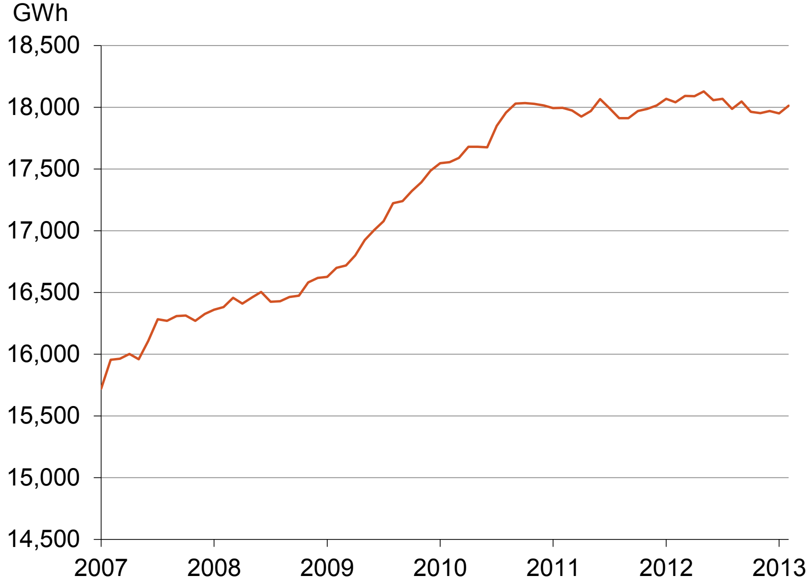
Source: AEMO (1998-2013)

Western Australia has been in the midst of a resources boom, with growth in gross state product increasing at a rate of five per cent a year over the decade to June 2013.[5]

Despite this, electricity use in the SWIS has been flat for the past several years, as Figure 1.3 shows.

[2] BREE (2013)
[3] The decline in total electricity demand exceeds the decline in final consumption. Electricity demand and final consumption figures may differ due to transmission and distribution losses and other losses such as the 'auxiliary load' of power consumed by generators.
[4] AEMO (2013b)
[5] ABS (2013a)

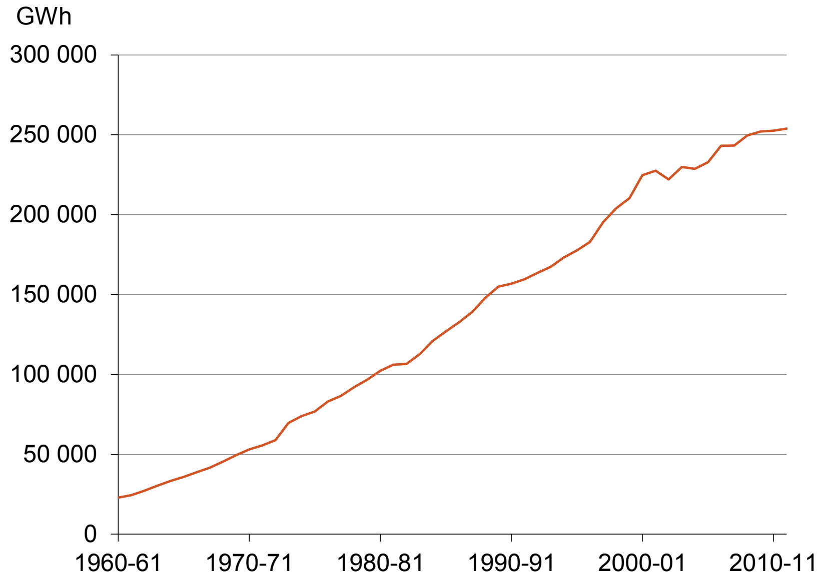
Figure 1.3: SWIS 12-month rolling total of electricity demand, 2007 to 2013



Source: IMO (2013)

Declining electricity use is new for Australia's power sector. As Figure 1.4 shows, between 1961 and 2002 there was no year in which electricity consumption declined.

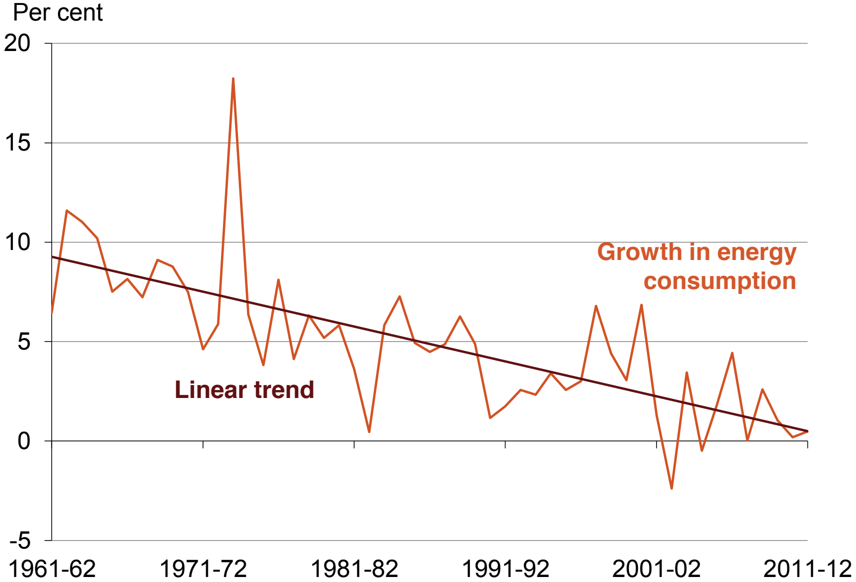
Figure 1.4: Australian consumption of electricity, 1960 to 2012



Note: BREE estimates of consumption include power supplied through the NEM and SWIS and from outside these networks. This data provides an indication of long-term trends in consumption but relies on a number of data sources.
Source: BREE (2013)

Nevertheless, a long-term trend of slowing growth in network electricity consumption is evident. As Figure 1.5 shows, over the past 50 years the rate of electricity growth has slowed. If the historical trend continues, energy consumption will enter a period of sustained contraction.

Figure 1.5: Growth in electricity consumption in Australia, 1961 to 2012



Note: BREE estimates of consumption include power supplied through the NEM and SWIS and from outside these networks. This data provides an indication of long-term trends in consumption but relies on a number of data sources.
Source: BREE (2013)

The 50-year decline in the electricity growth rate supports the view that the recent fall in electricity consumption is not simply a passing deviation from a long-term growth trend.

The recent decline in consumption is a surprise. Even some market specialists did not anticipate it. The Australian Energy Market Operator (AEMO) releases annual forecasts of energy consumption. In its *2010 Electricity Statement of Opportunities*, AEMO's medium-case forecast for electricity consumption in the NEM predicted consumption of 216,600 gigawatt hours in 2012-13.[6] The forecast implied an expected annual average growth rate of about three per cent a year from 2009-10 to 2012-13.

But in 2013, AEMO reported that actual consumption for 2012-13 was 188,900 – suggesting electricity consumption from the NEM has actually fallen by about 1.6 per cent a year since 2009-10.[7] Forecasting demand is not easy and AEMO was not alone in failing to anticipate a number of factors that have contributed to the fall in demand.

1.3 Reasons for falling consumption

A comprehensive analysis of the causes of these electricity consumption patterns is beyond the scope of this report. Yet consumption trends need to be understood in order to appreciate why slow growth and even declining electricity use may be the new normal for Australia's power networks.

In June 2012, Australia's Commonwealth Government implemented an economy wide price on carbon emissions. It was estimated that the carbon price would increase household electricity bills by around nine per cent, which would provide

[6] AEMO (2010)
[7] AEMO (2013a)

consumers with an incentive to reduce their electricity consumption.[8]

However, the declining growth of electricity demand in Australia's power networks predates the introduction of the carbon price. As such, the trend in falling demand is likely to continue even if, as promised, the newly-elected Commonwealth Government repeals existing carbon pricing legislation.

The effect of the carbon price on electricity demand is beyond the scope of this report. Falling demand is an issue that governments must address, irrespective of the policy mechanisms that will be used to meet Australia's international commitments to reduce carbon emissions.

In homes around Australia, electricity consumption has been declining due to changes in consumer behaviour, more energy-efficient appliances, and higher energy efficiency standards on new homes. Widespread uptake of rooftop solar systems has reduced the amount of electricity sourced from the power network.

Improvements in the efficiency of appliances - in particular refrigerators, air conditioners and televisions - have contributed significantly to households consuming less energy. In part, this reflects changes in consumer attitudes. Recent increases in electricity prices, coupled with concerns about the effects of climate change, have made customers more conservative in their power use.

[8] Department of Climate Change and Energy Efficiency (2011)

For example, the Australian Bureau of Statistics' surveyed households in 2012 and found that 21 per cent intended to make an improvement to their home to improve energy efficiency. A year later, a follow-up survey found that 31 per cent of households had actually made an improvement – a higher percentage than had planned to make an improvement.[9]

The increasing use of 'smart' electricity meters has also helped households to manage their power consumption. By providing consumers with more information on how they use power, smart meters can empower households to reduce their consumption.

The reduction in household electricity consumption has also been influenced by government policies targeting the energy efficiency of appliances (see Box 1.1). For example, the Minimum Energy Performance Standards program specifies minimum levels of energy efficiency that appliances, lighting and electrical equipment must exceed before being offered for sale in Australia. Mandatory energy rating label requirements assist consumers to identify more energy efficient products.[10] These standards are regularly reviewed to keep up with advances in technology.

Savings from energy efficient lighting can substantially contribute to reducing household electricity use. Globally a fifth of electricity use is for lighting households, businesses and other organisations.[11] Old incandescent light bulbs turn only two per cent of their power into light. Fluorescent lamps improve on the performance of incandescent globes, but modern LED (light-

[9] ABS (2012)
[10] Equipment Energy Efficiency (2013)
[11] Kramer (2010) cited in Kim, *et al.* (2012)

emitting diode) lights use 80 per cent less power than an average fluorescent lamp.[12]

Box 1.1: How changes in television technology cut power use

Five years ago, a household buying a new television may have purchased a plasma screen television. Since that time the far more energy-efficient LCD (liquid-crystal display) and LED (light-emitting diode) televisions have become increasingly popular.

In 2009, the Commonwealth Government introduced efficiency and minimum energy performance requirements for televisions. Over the first 18 months of that program, the energy efficiency of new products improved by 20 per cent.

About three million televisions are sold in Australia every year. By 2011, the market was dominated by LCD and LED televisions, with plasma technology making up only 20 per cent of the market. As households begin to replace their old televisions, they will make significant energy savings.

Origin has estimated that households can save up to $149 a year by replacing their two-star rated plasma TV with a five-star rated LCD television.

For new homes and renovations, more stringent energy efficiency standards for building have helped to reduce electricity consumption. Following changes to the National Construction Code in 2010, state governments introduced mandatory six-star efficiency ratings for new houses.[13] Ratings are determined based on building materials, glazing and sealing of the building. The choice of domestic services - hot water, insulation and artificial lighting - are also considered as part of the rating.[14] A house built to the 6-star standards will use roughly 20 to 25 per cent less energy on heating and cooling compared to a 5-star rated house of equivalent size.[15]

In addition to changes inside the home, a rapid uptake of rooftop solar systems has reduced demand for electricity from the network. The number of rooftop solar systems has soared from about 8000 in 2007 to more than one million today.[16] The main drivers of this rapid growth have been generous subsidies from state governments and the rapidly falling cost of rooftop solar modules.[17]

Beyond households use, many businesses have also reduced power consumption in response to the same drivers of rising power prices and concerns about carbon emissions. Business leaders recognise that energy efficiency can drive significant cost savings, particularly in the context of rapidly rising prices.[18]

Falling electricity consumption has also been the result of structural changes in the Australian economy. In particular, structural changes in the manufacturing sector, one of Australia's most electricity-intensive sectors, have contributed to lower

[12] Ibid.

[13] Commonwealth Government Department of Industry (2013)
[14] Australian Building Codes Board (2013)
[15] Western Australia Department of Commerce (2012)
[16] Climate Commission (2013)
[17] Ibid.
[18] Webb, *et al.* (2010)

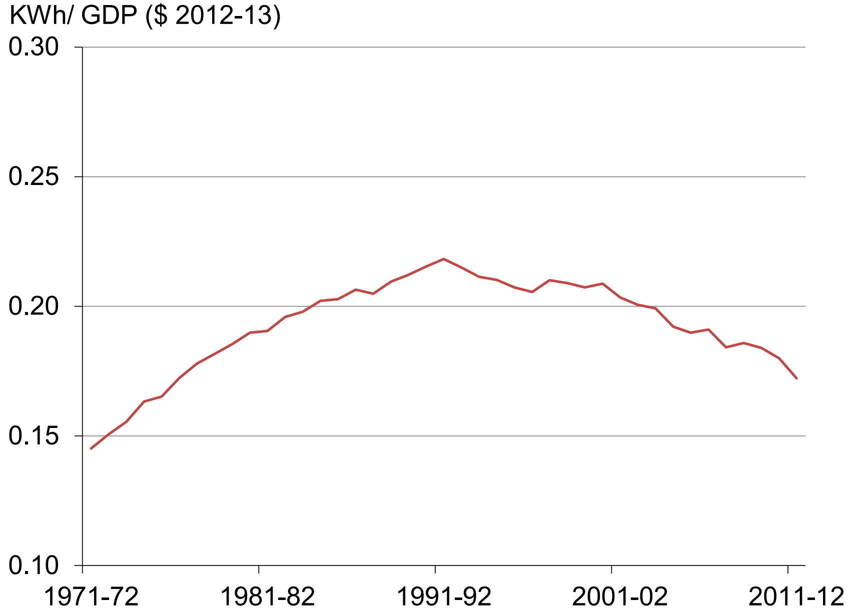
electricity consumption. In total, the Australian manufacturing sector grew by 24 per cent between 1990 and 2013, but it did not keep pace with growth in the rest of the economy. Over the same period, the share of economic output attributable to the manufacturing sector declined from 13 per cent to six per cent.[19]

The reduction of manufacturing output contributed to a decline in the electricity intensity of the Australian economy. As Figure 1.6 shows, the amount of electricity used per unit of economic output in Australia reached a peak in the early 1990s and declined steadily over the two decades since.

Changes in the types of manufacturing occurring in Australia have also led to the sector using less electricity. Over the past two decades, the sector has seen a substantial shift from labour intensive and low-skilled manufacturing, to higher-skilled sectors.[20] This change has involved a shift away from some industries, such as aluminium production, which are very high users of electricity.

For example, the Kurri Kurri aluminium smelter in the New South Wales Hunter Valley closed in 2012. This one facility closure removed around 300 megawatts of consumption – equivalent to around two per cent of electricity generation capacity in New South Wales.[21] Other industrial plants that had been planned may no longer go ahead.[22] AEMO consumption data suggests that electricity consumption by large industrial users fell by over four

Figure 1.6: Electricity consumption per dollar of gross domestic product



Source: ABS (2013b) and BREE (2013)

per cent between 2011-12 and 2012-13.[23] At the same time, existing manufacturing firms are using less electricity per unit of output.[24]

[19] ABS (2013b)
[20] Minifie, *et al.* (2013)
[21] Orchison (2013)
[22] AEMO (2013b)
[23] AEMO (2012) & AEMO (2013b)
[24] Grattan analysis based on ABS (2013b) and BREE (2013)

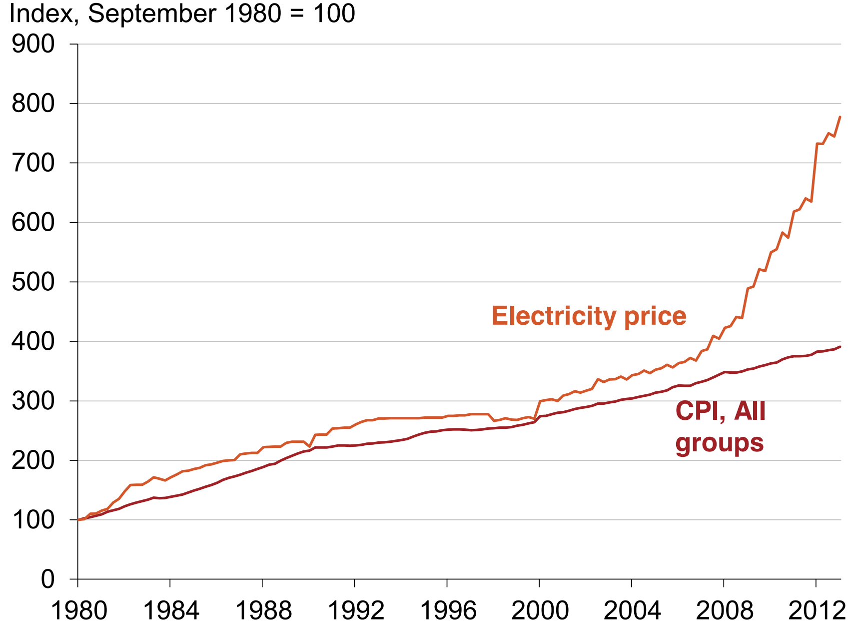
2. Bad news for power bills

In conventional economics, when demand for a product declines, the market for that product is left oversupplied. In response, the price should fall as producers seek to sell their product and maintain profits.

But the opposite has happened in Australia's electricity markets. As electricity consumption has fallen, electricity prices have continued to rise. In fact, after they grew in line with the rate of inflation for several decades, the rate of their growth has accelerated since about 2007, as Figure 2.1shows.

The result is that users have been using less electricity, but paying higher bills. Between 2006 and 2013, the average Australian household reduced power consumption by more than seven per cent, from 6100 to 5600 kilowatt hours a year. Over the same period, the average annual household power bill increased by more than 85 per cent: from $890 to $1660 a year (in real terms in $2012-13, this is an increase of around 60 per cent from $1040 to $1660 per household).[25]

Figure 2.1: Rise in electricity prices in comparison to rise in CPI

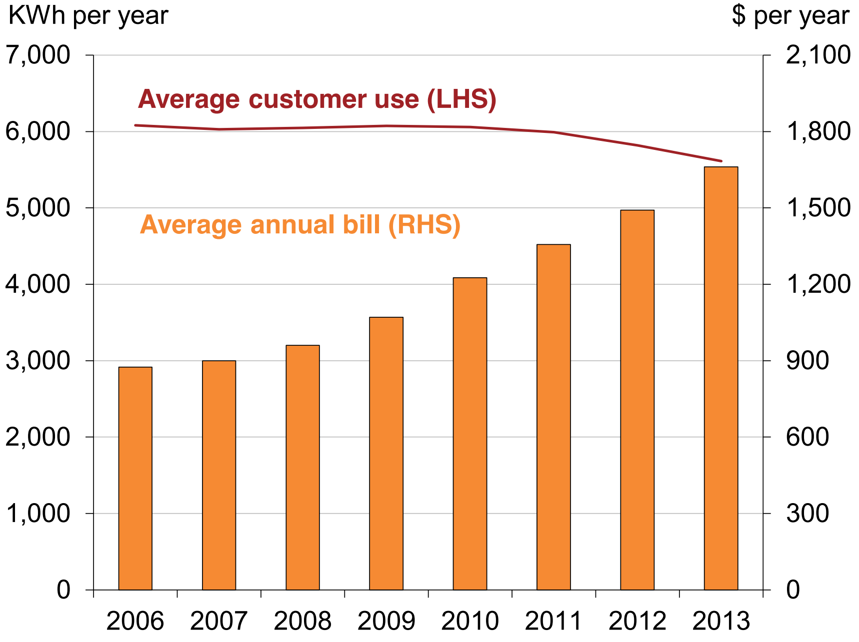


Source: ABS (2013c)

Figure 2.2 shows how household power bills in both the NEM and the SWIS have continued to grow at an average rate of more than nine per cent a year, even as households have progressively used less power.

[25] Wood (2012)

Figure 2.2: Average customer electricity use compared to average annual customer bill



Source: Grattan analysis based on AEMO (1998-2013), IMO (2013), ABS (2013c) and BREE (2013)

2.1 Why are bills rising?

The reason electricity bills have grown in the face of falling consumption lies in the structure of the electricity market and the way it is regulated. The final price customers pay for electricity through their power bills has three parts. Customers pay for the cost of generating electricity at a power station (including the cost of compliance with environmental regulations and climate change policies), the cost to transport electricity through the transmission and distribution networks, and a retail margin. The last is the cost paid to retailers for buying electricity on behalf of customers and managing customers' accounts.

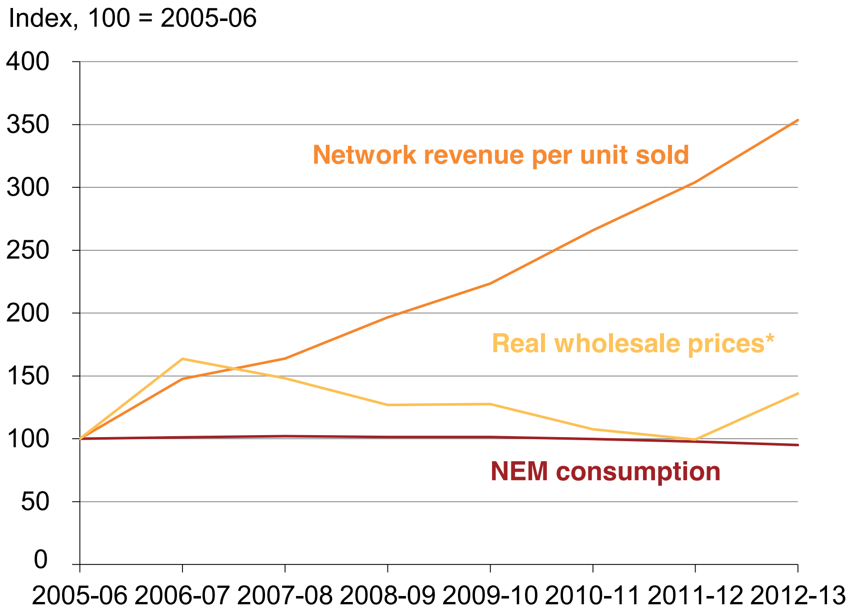
Generators face competition

Electricity generators and retail businesses both operate in competitive markets. Therefore, the prices these businesses receive fall in response to falling electricity demand. As consumers use less electricity, power stations produce less. Figure 2.3 shows how wholesale price of electricity (the price paid to power stations) has decreased as electricity demand in the NEM has fallen.

The biggest losers have been black coal power stations. In the past few months, two large, state-owned black coal generators in New South Wales, the Bayswater and Liddell power stations, have operated at around 60 and 45 per cent capacity, respectively.[26] In 2008-09, their average operating loads were about 65 per cent of capacity.[27]

[26] Pitt&Sherry (2013)
[27] Macquarie Generation (2009)

Figure 2.3: NEM electricity consumption, network revenue per unit sold, and wholesale electricity price, 2005-06 to 2012-13



*Note: *Real wholesale prices are adjusted for the carbon price in 2012-13*

Source: Grattan Analysis based on AEMO (1998-2013) and regulatory determinations.

The cost of such redundant power generation capacity may be substantial. AGL, a large power retailer and generator, has estimated that the NEM has more than 9000 megawatts of excess power generation capacity – around a sixth of the market capacity.[28] When prices fall, leading to potential loss in value of power stations, it is the asset owners who carry the risk.

Network businesses do not

Businesses responsible for transmission and distribution – known as network businesses - are different. They are regulated monopolies. A regulator determines how much revenue each is permitted to earn. In the NEM, that is the Australian Energy Regulator; in Western Australia's SWIS, the Economic Regulation Authority.

The regulator determines the revenue the network businesses are allowed to collect over a five-year period. It makes the calculation based on the companies' existing infrastructure, required investments in new infrastructure and other operating costs. To collect the allowed revenue, the businesses set prices, which generally include both a small fixed charge and a charge that varies with consumption. When power consumption falls, network businesses do not drop their prices but may actually increase them, to ensure they collect the allowed amount of revenue. In that case, the cost of falling consumption is borne by other users of the network, not the companies.

For example, if a large industrial customer closes a factory, the network charges that were being paid by that business would have to be recovered from other users of the network, who would pay more.

[28] AGL (2013)

Falling consumption has made a moderate contribution to price rises in recent years, but its contribution to future price rises could grow substantially.

A bigger problem over the last decade is that some network businesses have spent too much on their network assets. At the same time, their allowed returns have been higher than they should have been. Grattan Institute's 2012 report, *Putting the customer back in front* shows how regulatory incentives for network businesses have led to excessive investment.[29] Better incentives, particularly for state government-owned distribution businesses in New South Wales, Queensland and Tasmania, could lead to lower spending on networks and save household customers around $100 a year.

In recent years, these factors have combined to drive electricity cost increases. Figure 2.4 shows how the average amount of revenue per unit of energy sold in each state has increased, in real terms, between 2005-06 and 2012-13.

Under the regulatory arrangements governing Australia's power networks, the owners of transmission and distribution businesses do not bear the risk of falling asset prices as a result of lower levels of electricity consumption. Power users carry the risk, in the form of higher bills.

In other words, the impact of falling electricity consumption on these regulated businesses is not just a problem for the businesses themselves. It is a critical issue for keeping power prices low, and it is therefore a critical issue for governments.

[29] Wood (2012)

Figure 2.4: Average revenue per kilowatt hour of electricity sold by state, between 2005-06 and 2012-13 ($2012-13)

Note: Caution should be taken when interpreting changes in Tasmania. Due to data limitations we have assumed constant revenue for Aurora Energy.

Source: Grattan Analysis based on AEMO (1998-2013), IMO (2013) and regulatory determinations (see References for regulatory determinations)

3. The problem for networks

The regulations that govern what transmission and distribution businesses can charge consumers are designed to prevent the former taking advantage of their position as monopoly businesses. In the NEM and the SWIS, businesses are allowed to recover the costs they incur to build and maintain the power network, plus earn a return on their investment.

Regulated asset owners therefore face very little commercial risk. Accordingly, the returns they are allowed to earn are low relative to the returns of businesses that do face commercial market risks.

When electricity use was consistently growing, these arrangements worked quite well. The value of a network business's infrastructure – known as the regulated asset base – would increase each year to reflect new investment.

In the past, as electricity use grew, the businesses would build more assets to accommodate growth. Because this cost was shared over a higher volume of consumption, there was no real increase in the price of electricity.

Falling electricity use, however, creates serious problems for the regulatory model. In particular, the arrangements do not cope well with the mismatch between rising asset values and falling consumption. Further, changes in the way that customers are using electricity mean that some users are not paying a fair share of the rising costs.

3.1 Peak demand and the risk of redundant assets

If electricity consumption is falling, then some of the assets that network businesses have built to meet past usage needs may become redundant.

The 'capacity' of a network is the amount of electricity it can carry at any point in time. Because networks do not store electricity, they must have sufficient capacity to deliver power to meet customers' needs at the point when electricity use is at its highest. This point is called 'peak demand', and it is critical to the running of the electricity system.

If the network has insufficient capacity to meet peak demand, the system is likely to fail and cause blackouts. Blackouts are expensive, and extremely unpopular with businesses and residential customers. They damage the reputations of power companies. Because they are most likely to occur at times of peak demand, the electricity network must be built to deliver power at any moment through the year as if it were the annual half hour of peak demand.

In most Australian states, that half hour comes on a hot weekday evening in summer, when factories and businesses have not yet shut for the day, people are switching on air conditioners and other appliances, and output from rooftop solar systems is low. (An exception is Tasmania, where milder summers and colder winters mean that peak demand usually occurs in winter, when a lot of users are simultaneously running heaters.)

Peak demand defines how much infrastructure - poles, wires, transformers and transmission stations - a network business needs to install. This, in turn, is a major determinant of the amount that a network business must spend, which in turn determines the prices charged to customers.

In each state of the NEM, peak demand levels reached historical high points at some time between 2008-09 and 2010-11, and declined by 2012-13. In Western Australia, peak demand grew until 2011-12, but declined in 2012-13

Figure 4 shows how peak demand for the 2012-13 year compares to historical peaks in each state of Australia. The fall in peak demand ranged from three per cent in Western Australia to more than ten per cent in Tasmania.

Analysing peak demand patterns is harder than analysing consumption trends. Peak demand occurs at different times in different locations and this has different implications at different levels of the network. While transmission businesses only need to equip their big power lines to carry enough power to meet the total level of peak demand, distribution businesses must ensure that they can deliver a peak load to every street in the network.

Also, because peak demand is typically recorded on one day in summer, data can be strongly influenced by extreme weather - unusually hot temperatures in a given year can distort the data. Yet it is unlikely the decline in 2012-13 can be attributed to an abnormally cool summer period. Each of the three summer months from December 2012 to February 2013 recorded temperatures above the long-term average and January 2013 was the hottest January on record.[30]

Figure 3.1: Shortfall in 2012-13 peak demand levels, relative to historical peaks

Source: Grattan Analysis based on AEMO (1998-2013) and IMO (2013)

The problem with falling peak demand is that it may leave networks with excess capacity. The current value of regulated

[30] Bureau of Meterology (2012); Bureau of Meterology (2013a); Bureau of Meterology (2013b)

Box 3.1: Using the network more efficiently: why electric vehicles could be a game changer

Peak demand is a major driver of network costs. Network businesses must build enough assets to supply every home and business on the day of the year when electricity demand is at its maximum. This means that the network must build assets that will be surplus to requirements for 364 days of the year.

For this reason, technologies that help to reduce peak demand can materially reduce the amount that needs to be spent in the network. Further, if electricity consumption increases during off-peak periods, these users can share the cost of paying for the network, without increasing the cost to build and maintain it.

While the widespread take-up of electric vehicles might seem a long way away, they have an enormous potential to help network operators use our power system more efficiently. This could be a game changer for Australia's power system.

The first benefit of electric vehicles would come from shifting energy consumption from liquid fuels to electricity. This could reverse the trend of falling electricity consumption. As well, giving owners of electric vehicles incentives to charge vehicles at off-peak times - such as overnight – could lead to a higher volume of electricity sales but have a much smaller impact on the level of peak demand. [31] This could drive down electricity prices.

There is also potential to use electric vehicles to actively reduce peak demand levels. Electric vehicles that are connected to a charging station during a peak demand period could have their batteries drawn down to help provide power to the network. Having this capacity could reduce the need for network businesses to expand the electricity network to cope with high usage periods, which could also help to lower power prices.

It is difficult to predict if or when consumers may use electric vehicles in sufficient quantities to help manage peak demand. Accordingly, governments cannot rely on this type of technology to resolve the issues associated with falling consumption.

assets in the NEM and the SWIS is around $86.9 billion. If the fall in peak demand in each state is applied to the value of assets, it suggests that our major power networks may already contain around $4.9 billion in excess assets.

These assets are neither wanted nor needed, but they are costing consumers about $444 million a year.

[31] Cain, *et al.* (2010); ibid.

3.2 The need for new assets

A further challenge for networks is that at the same time as electricity consumption is declining, a number of changes to the network may force network businesses to invest more.

In response to the 2009 bushfires, the Victorian Government established the Powerline Bushfire Safety Taskforce to address the risk of bushfires being ignited by faulty power lines. In December 2011, the state government accepted a package of recommendations from the taskforce that is expected to cost about $700 million over ten years.[32] The risk of fire must be addressed, but replacing electrical protection devices and power lines will add to the costs that network businesses pass on to customers.

Other costs are also driving up network businesses' prices. The Victorian government's rollout of 'smart' electricity meters was a significant upgrade of metering infrastructure but cost consumers more than two billion dollars.[33]

Increased uptake of solar systems also means that some distribution businesses may need to modify or upgrade equipment to deal with power flowing from homes to the power system at certain times, rather than the other way around.

The legitimate need for network upgrades creates a challenge for the governments and policymakers that must approve the funds. While upgrades and improved safety standards may be needed, money spent on the network must be recovered from a diminishing pool of electricity sales.

3.3 Problems with cross-subsidisation

Finally, falling demand poses a challenge for the way that distribution and transmission businesses charge customers for use of their power networks.

The spending on assets of distribution and transmission businesses is closely tied to the level of peak demand in the network. Yet most customers are not charged a tariff that reflects how much they contribute to the network's peak demand level.

For many years some large commercial and industrial customers have paid a significant portion of their bills based on their peak use, to account for the large load they put on the network.

Residential customers' bills, however, are almost entirely charged at a variable rate. That is, customers pay a set price per kilowatt hour of electricity they use throughout the year. The bill is calculated by multiplying this price by the customers' total electricity consumption.

So while the cost of the network is driven by peak demand, consumers' share of the cost is based on consumption. Therefore they have little incentive to use less power at peak times, which would help networks manage costs.

In the past, the types of electricity meter that were installed at customers' homes made it necessary to charge customers based on consumption. Older style meters were not able to measure a

[32] SP AusNet (2012)
[33] Australian Associated Press (2011)

households' peak consumption level. It was also implicitly assumed that all households had similar electricity use patterns, making a household's use a good proxy for its peak demand.

Now, improvements in electricity meters make it possible to charge customers based on how much they contribute to peak load. Further, recent developments in residential electricity consumption are making it increasingly necessary to charge customers based on peak demand.

How air conditioners changed the game

Air conditioners were the first technology to dramatically change how different households contribute to peak energy costs. They are not used often, but their use on hot summer afternoons can add significantly to peak load. That means a lot of households installing air conditioners can add substantially to the peak demand of a network, and therefore to its cost.

However, these households do not pay the full cost of their contribution to peak demand because a household installing an air conditioner only increases its overall electricity consumption by a relatively small amount. As a result, the amount the consumer adds to network costs can far exceed the cost of the appliance. A report by the Committee for Economic Development of Australia noted that air conditioners purchased for $1,500 frequently impose a $7,000 cost on the energy system when their contribution to peak demand is factored in.[34]

About a decade ago, a rapid decline in the cost of air conditioners substantially increased their uptake and contributed to increases in peak demand.[35] In the decade to 2008, the rate of air conditioner ownership in Australia doubled to about 65 per cent of households.[36]

The rise of rooftop solar

More recently, increasing use of rooftop solar generators has also exacerbated the problem of using variable charges to recover network costs. A high penetration of rooftop solar systems can affect the amount of electricity flowing through a local network, as Figure 3.2 shows for a residential area in Queensland.

The problem is that high penetration of rooftop solar systems reduces consumption of electricity from the network but may not reduce use at the peak times that drive the cost of the network. This means higher costs for customers.

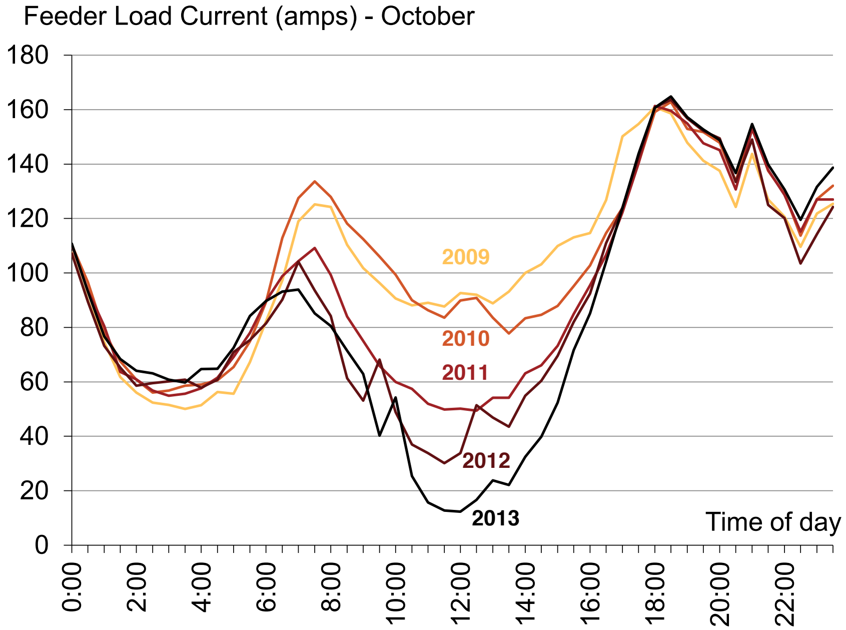
Consider the example of the Queensland local network shown in the chart above. The total amount of energy supplied to customers through the network has decreased substantially over the past five years. Yet the daily peak demand – the high point that occurs around 6 o'clock in the evening – has not fallen.

The result is that owners of rooftop solar are able to reduce the amount they pay for network charges, because they reduce their overall electricity use.

[34] CEDA (2012)

[35] EnergyConsult (2010)
[36] Energy Efficient Strategies (2008)

Figure 3.2: The electrical current flowing through a Queensland feeder in an area with increasing rooftop solar penetration



Note: The current on this electrical line was measured each year for five consecutive years on the second Tuesday in October.
Source: Energex (2013)

Yet the network businesses' costs will not fall because the peak demand level has not changed. In fact, the costs to service this area may actually increase as infrastructure upgrades may be required to accommodate the flow of electricity from solar systems back onto the network.

In this case, the network business is still able to recover its costs under existing regulatory arrangements. But someone must pay. Power prices will go up to account for the fall in total energy consumption and cover the cost of required network upgrades.

The structure of variable charges means that rising prices will prevent households that install solar panels from saving as much money as they had expected to save. But other users of the network will be hit harder. They will be forced to pay higher prices, without having the same means as solar panel owners to reduce their consumption.

In effect, because networks are allowed to charge revenue based on a fixed cost but individual residential consumers pay at variable rates, rooftop solar systems implicitly receive a subsidy on their network costs from other power users. This subsidy is on top of explicit subsidies that solar system owners may also receive, such as solar feed-in tariffs.

3.4 The risk of a 'death spiral'

In the short run, power users have limited capacity to reduce their consumption. A household can buy more efficient appliances and use them less often. A business can adopt 'best practice' approaches to reducing power use. But beyond these measures, it is difficult to reduce consumption further with current technology.

Over the longer term, the rising cost of electricity and expectation of even higher prices in future will drive more consumers to buy more energy efficient televisions, refrigerators or air conditioners when their appliances need to be replaced, or to install home insulation to reduce heating and cooling costs. People are also likely to build more energy efficient houses.[37]

Because of the way Australia's power networks are allowed to recover their costs, such efficiency measures can actually increase the price of power. As consumers reduce their electricity use, the same amount of revenue is recovered over fewer units of electricity being sold. Therefore, prices must rise.

Some large industrial users are also consuming less energy. The closure of large industrial plants – the Kurri Kurri aluminium smelter in 2012, for example – means that other users must pay more in power charges to allow network businesses to earn their revenue.

For residential customers, rapid uptake of air conditioners has increased peak load on the network and pushed up prices for other users. By allowing some users to reduce the amount they pay in network charges without reducing the costs they impose on the network, rooftop solar has also pushed up prices.

All these changes give customers even more incentives to reduce consumption. The possible long-term result is a 'death spiral'.

The 'death spiral' is a term used to describe the situation where declining demand, technology changes and rising prices may interact in a way that induces large numbers of consumers to disconnect from the network. In that case the whole funding model of Australia's regulated power networks is under threat.[38]

In this scenario, falling demand keeps pushing up power prices. At the same time, new technologies provide consumers with alternatives to using power from the networks. For example, customers could install larger rooftop solar systems and battery storage systems that allow them to disconnect entirely from the power network.

As growing numbers of users disconnect, consumption would fall and prices rise further, and the vicious circle this creates would increase the incentive for other users to leave the network. Networks could be left with billions worth of unused assets. Governments would face intense pressure to help bear the cost and consumers would face the cost and inconvenience of managing a 'stand-alone' power system in their business or home.

[37] Garnaut (2011)

[38] Simhauser and Nelson (2012)

4. Policy implications

The 'death spiral' is not inevitable. Rather, it describes what could happen if the way electricity networks are priced and regulated does not change.

Preventing the death spiral is in the interests of all parties. For networks, it is critical to the viability of their business models.

For consumers, network costs have been the major cause of high electricity bills. A death spiral could lead to even higher electricity bills in the short term as the fixed cost of the network is spread among fewer users. In the longer term, large-scale disconnections from the network could lock in a higher overall cost for electricity than could be supplied through an efficient network.

In that scenario, policy makers would be caught in the middle. On the one hand, loss of asset values could mean pressure on governments to compensate network owners.

On the other hand, the cost of an asset write-down would be borne by taxpayers where governments own the business and by shareholders where they have been privatised. Neither party would welcome this result.

Policy reforms in three areas are required to prevent the death spiral from occurring and to produce more efficient outcomes for the electricity system. The first two seek to stop matters from getting worse. The last considers what to do about redundant assets created by falling demand.

4.1 Ensuring cost efficient power networks

Lowering network costs to economically efficient levels would reduce price pressure on businesses and households. By making power from the network cheaper, it reduces the incentive for customers to disconnect.

Grattan Institute's 2012 report, *Putting the customer back in front*, examines four policy priorities that would, on average, save Australian households about $100 per year by reducing the element of their bills paid to distribution businesses.[39] Falling electricity demand makes the need for these reforms even more urgent.

The report recommends that to reduce electricity charges driven by the high cost of distribution services, governments should:

- Empower the Australian Energy Regulator (AER) to set the rates of return earned by network business at a lower level, to better reflect the low levels of risk faced by these businesses.
- Transfer responsibility for setting reliability standards from state governments to the Australian Energy Regulator, and make improvements to network reliability subject to a cost benefit test.

[39] Wood (2012)

- Reduce the risk of overinvestment in network assets through implementing annual reviews of distribution businesses' capital expenditure forecasts.

- Improve the corporate governance of government-owned network businesses, or privatise these businesses, to ensure they operate as efficiently as those that are privately owned.

In the past year some progress has been made on these issues. The Australian Energy Regulator has released new guidelines for setting fairer rates of return under its 'Better Regulation' reform program. The program is also running work streams to assess some of the issues leading to overinvestment in networks.

The program, however, does not address the fact that network businesses have little incentive to reduce their investment in response to falling peak demand. This is important because these businesses are best placed to forecast future demand requirements and invest in new infrastructure accordingly.

Under current regulations, network businesses have the incentive to build more infrastructure assets, and the customer bears all the risk if they become redundant. If companies carried some of the risk of falling demand, however, they would have stronger incentives to avoid over-building. In exchange, companies may expect the rate of return on these assets to be adjusted to reflect a higher level of risk. Regulators should explore this trade-off.

In relation to the second priority reform set out in Grattan's 2012 report, in September the Australian Energy Market Commission released a *Review of the national framework for distribution reliability*. In the past governments have intervened to ensure that state-owned network businesses deliver power at levels of reliability that no serious cost-benefit analysis can justify. The result is higher power bills. The Review recommends a cost-benefit test for reliability improvements, and separating the bodies responsible for providing reliability from those responsible for setting reliability targets.[40]

More recently, the Commonwealth Government has revived discussion about the privatisation of electricity networks by offering state governments financial incentives to privatise these businesses.[41]

All these steps could improve the governance and regulatory arrangements of network businesses. Yet regulatory reform can be slow. Regulators and policy makers must focus on delivering results, and not get embroiled in managing the process.

4.2 Ensuring efficient network tariffs

Consumers are faced with an increasing array of choices for how they source and consume electricity. These include the option to generate electricity on-site, rather than sourcing it all through the network.

The combination of rising prices and increasing use of 'smart' electricity meters are giving consumers both the incentive and the means to better manage their electricity consumption. Consumers are increasingly empowered to make informed trade-offs. For example, to save money on running costs, a household may

[40] AEMC (2013)
[41] Australian Associated Press (2013)

decide to spend more money to buy an energy efficient refrigerator, air conditioner or television.

Policy makers cannot predict how technology will change electricity markets in the future. Battery storage, electric vehicles and 'smart appliances' that change their usage patterns in response to the needs of the electricity system are all on the horizon.

Consumers should be given more ways to manage their electricity use. But policy makers should address deficiencies in existing tariff structures that enable and encourage some customers to reduce their electricity costs at the expense of others.

The introduction of tariffs that more accurately reflect the cost of building and running the system will lead to more economically efficient decisions by consumers. Grattan Institute Energy Program's next report will make recommendations on how this objective can be achieved. Two broad avenues, set out here, will be considered.

Network tariffs linked to peak demand, or peak customer use

Ideally, customers' tariffs for using the power network would reflect their use at the time of peak demand, rather than their overall level of consumption. This type of peak demand charge would make customers' bills more reflective of the costs they impose the network and provide an incentive to reduce consumption at peak times. However, while theoretically the most attractive option, this type of charge could be prohibitively difficult to implement.

A simpler alternative, which reflects but does not fully capture the costs of peak demand, would be to charge users based on their own peak level of energy use.

A move to demand-based tariffs would be a big change for consumers. Those who installed rooftop solar systems or large air conditioners may regard such tariffs as unfair because they would lead respectively to either lower savings or higher bills. Yet this is the inevitable and correct answer to the current subsidy problem.

Clearly, demand-based tariffs will require electricity meters that can measure a household's peak demand.

Network charges geared to peak demand would also reduce the incentive for customers to reduce their overall power consumption during non-peak periods. This could encourage customers to use more power, and slow the trend of falling electricity demand. As a consequence, this could increase carbon emissions from the electricity sector, which have been declining since 2009.[42]

However, high electricity prices are a blunt tool for reducing carbon emissions. A more efficient strategy for managing emissions is through a carbon price that encourages lower emission electricity generation and the adoption of less emission-intensive industry practices.

Increased use of location-based pricing

The value of certain types of technologies may be greater in different locations. Consider a household in a growing suburb

[42] CCA (2013)

where the peak demand period occurs during daylight hours. In this area, having a group of households install rooftop solar systems could be of value to the power system, as it could reduce pressure to build more 'poles and wires' to meet the growing peak demand requirement.

Conversely, for a household in an established area with falling peak demand and a peak demand period that typically occurs after nightfall, rooftop solar would be of little value to the network.

The presence of location-specific incentives is not reflected in existing network tariff structures. Their use could encourage customers to make more efficient decisions about how they source and use electricity. Again, the benefits and costs need to be fully explored.

4.3 Writing down network values

Keeping down network costs will help to keep electricity prices low and improve the competitiveness of electricity supplied through power networks against technologies that could allow consumers to bypass the network. Making tariffs reflect the cost of peak demand would provide the right pricing signals for consumers to change their electricity consumption.

However, these measures may not be enough.

The amount consumers are charged for using Australia's regulated power networks reflects the cost of previous investments. At present, consumers have no choice but to pay for these assets. However, in future they may have means to avoid doing so – through disconnecting from the network and installing rooftop solar combined with battery storage, for example. If networks were to lose significant numbers of customers in this way, spiralling prices would make their business unsustainable.

A better alternative would involve writing down the value of network assets. This would mean recognising the need for networks to compete with non-network alternatives and reducing the value of the regulated asset base accordingly.

If this were to occur, governments would need to decide who would pay for the asset write-downs. This is not a simple decision, and one that could be faced on multiple occasions in a range of jurisdictions. Consumption and peak demand are likely to continue to fall, and with them the value of the network assets.

The cost of asset write-downs will be borne by one of three players:

- **Consumers**, already paying for overvalued networks through high electricity tariffs, could pay even more. In the first instance, they would pay through higher prices. If prices reached unsustainable levels, customers disconnecting from the network could also be forced to pay substantial disconnection charges. This would cover the cost of network assets that may be made redundant as a result of a large number of disconnections, but such charges would highly unpopular.

- **Private owners** of network businesses in South Australia and Victoria could be forced to write down the value of their regulated assets. Existing regulatory frameworks do not envision this prospect, and the risk may not be reflected in the rates of return paid to the businesses. Such write-downs could be seen as a real sovereign risk and deter future investment in Australian infrastructure. It could also greatly increase the price that would have to be paid to attract investors.

- **Governments** that own network businesses in New South Wales, Queensland, Tasmania and Western Australia could be forced to write down the value of their regulated assets. In Victoria and South Australia governments could pay compensation to privately owned businesses. In either case, taxpayers would bear the cost.

Whatever solution is found, implementing changes in a timely manner will help to manage the transition and ultimately reduce the cost of any fall in the carrying value of assets.

Future Grattan Institute research will explore the relative merits of alternatives with a view to providing policy recommendations.

References

ABS (2012) *Household Energy Consumption Survey,* catalogue number 4670, Australian Bureau of Statistics

ABS (2013a) *Australian National Accounts: State Accounts,* catalogue number 5220.0, Australian Bureau of Statistics

ABS (2013b) *Australian System of National Accounts, 2012-13,* catalogue number 5204, Australian Bureau of Statistics

ABS (2013c) *Consumer Price Index,* catalogue number 6401.0, Australian Bureau of Statistics

ABS (2013d) *Energy Account, Australia,* catalogue number 4604, Australian Bureau of Statistics

AEMC (2013) *An efficient approach to distribution reliability*, Australian Energy Market Commission from http://www.aemc.gov.au/Media/docs/Information-sheet-60cbdabd-5eeb-4930-934a-69c1b02ce68e-0.PDF

AEMO (1998-2013) *Aggregrated Price and Demand Data Files*, from http://www.aemo.com.au/Electricity/Data/Price-and-Demand/Aggregated-Price-and-Demand-Data-Files

AEMO (2010) *Electricity Statement of Opportunities*, Australian Energy Market Operator from http://www.aemo.com.au/Electricity/Planning/Archive-of-previous-Planning-reports/~/media/Files/Other/planning/0410-0054%20pdf.ashx

AEMO (2012) *National Electricity Forecasting Report*, Australian Energy Market Operator from http://www.aemo.com.au/Electricity/Planning/Forecasting/~/media/Files/Other/forecasting/2012%20National%20Electricity%20Forecasting%20Report.ashx

AEMO (2013a) *Electricity Statement of Opportunities*, Australian Energy Market Operator from http://www.aemo.com.au/Electricity/Planning/~/media/Files/Other/planning/esoo/2013/2013_ESOO.ashx

AEMO (2013b) *National Electricity Forecasting Report*, Australian Energy Market Operator from http://www.aemo.com.au/Electricity/Planning/Forecasting/National-Electricity-Forecasting-Report-2013

AER (2001) *Queensland Transmission Network Revenue Cap 2002-2006/07*, Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/Powerlink%20revenue%20cap%20decision%20%281%20November%202002%29.pdf

AER (2002) *South Australian Transmission Network Revenue Cap 2003-2007/08*, Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/Decision%20%2811%20December%202002%29.pdf

AER (2003) *Tasmanian Transmission Network Revenue Cap 2004–2008/09* Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/Decision%20%2817%20December%202003%29.pdf

AER (2007a) *Application by EnergyAustralia to re-open its 2004/05-2008/09 revenue cap*, Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/AER%20-%20Revised%20decision%20on%20EnergyAustralia%27s%20revenue%20cap%20application%20-%2021%20December%202007.pdf

AER (2007b) *Powerlink Queensland transmission network revenue cap 2007–08 to 2011–12* Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/Final%20decision%20%2814%20June%202007%29_0.pdf

AER (2007c) *TransGrid 2004/05-2008/09 Revenue Cap* Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/Transgrid%20decision%20%2813%20February%202007%29.pdf

AER (2008a) *ElectraNet Transmission Determination 2008–09 to 2012–13*, Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/AER%20statement%20on%20updates%20for%20ElectraNet%20transmission%20determination%202008-09%20to%202012-13%20%28February%202009%29.pdf

AER (2008b) *SP AusNet transmission determination 2008-09 to 2013-14* Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/AER%20Final%20decision.pdf

AER (2009a) *New South Wales distribution determination 2009–10 to 2013–14* Australian Energy Regulator from

http://www.aer.gov.au/sites/default/files/NSW%20DNSPs%20final%20decision%2028%20April%202009_0.pdf
AER (2009b) *New South Wales Transmission Determination 2009–10 to 2013–14*, Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/NSW%20DNSPs%20final%20decision%2028%20April%202009.pdf
AER (2009c) *TransGrid Transmission Determination 2009–10 to 2013–14*, Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/AER%20statement%20on%20updates%20for%20TransGrid%20transmission%20determination%202009%C3%A2%E2%82%AC%E2%80%9C10%20to%202013%C3%A2%E2%82%AC%E2%80%9C14.pdf
AER (2010a) *Queensland distribution determination 2010–11 to 2014–15* Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/Queensland%20distribution%20decision%20-%20May%202010.pdf
AER (2010b) *South Australia distribution determination 2010–11 to 2014–15* Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/Final%20decision-%20SA%20distribution%20determination%202010-11%20to%202014-15.pdf
AER (2010c) *United Energy Distribution Distribution determination 2011–2015*, Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/Victorian%20distribution%20determination%20final%20decision%202011-2015%20-%20United%20Energy%20final%20determination%20%2829%20October%202010%29.pdf
AER (2012a) *CitiPower Pty Distribution determination 2011–2015* Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/CitiPower%20distribution%20determination%20amended%20in%20accordance%20with%20the%20orders%20of%20the%20Tribunal%20-%2028%20September%202012%20%282%29.pdf
AER (2012b) *Final Distribution Determination Aurora Energy Pty Ltd 2012–13 to 2016–17* Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/Final%20distribution%20determination%20for%20Aurora%20Energy.pdf
AER (2012c) *Jemena Electricity Networks (Victoria) Ltd Distribution determination 2011–2015* Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/JEN%20distribution%20determination%20amended%20in%20accordance%20with%20the%20orders%20of%20the%20Tribunal%20-%2028%20September%202012_2.pdf
AER (2012d) *Powercor Australia Ltd Distribution determination 2011–2015* Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/Powercor%20distribution%20determination%20amended%20in%20accordance%20with%20the%20orders%20of%20the%20Tribunal%20-%204%20October%202012.pdf
AER (2012e) *Powerlink Transmission determination 2012–13 to 2016–17* Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/Powerlink%20-%20Final%20decision%20-%20April%202012.pdf
AER (2013) *SPI Electricity Pty Ltd Distribution determination 2011–2015* Australian Energy Regulator from http://www.aer.gov.au/sites/default/files/SP%20AusNet%20%28SPI%20Electricity%29%20distribution%20determination%20amended%20in%20accordance%20with%20Federal%20Court%20orders-16%20August%202013%20%28mark%20up%29_0.pdf
AGL (2013) 'Analysing clean energy markets', CEC Annual Conference, Sydney, accessed 3 Dec 2013, from http://www.aglblog.com.au/wp-content/uploads/2013/07/TNPresentation.pdf
Australian Associated Press (2011) 'Smart meter roll-out rolls on', *The Age*, accessed 9 Dec 2013, from http://www.theage.com.au/victoria/smart-meter-rollout-rolls-on-20111214-1otzf.html
Australian Associated Press (2013) 'Joe Hockey offers states privatisation bonus', *The Australian,* accessed 9 Dec 2013, from http://www.theaustralian.com.au/national-affairs/joe-hockey-offers-states-privatisation-bonus/story-fn59niix-1226769632213
Australian Building Codes Board (2013) 'Energy Efficiency Provisions for Housing', accessed 5 Dec 2013, from http://www.abcb.gov.au/major-initiatives/energy-efficiency/residential-housing
BREE (2013) *Australian Energy Statistics Data*, Australian Bureau of Resources and Energy Economics, accessed 4 Dec 2013, from http://www.bree.gov.au/publications/aes-2013.html
Bureau of Meterology (2012) 'Seasonal Monthly Summary for Australia: December 2012', accessed 5 Dec 2013, from

http://www.bom.gov.au/climate/current/month/aus/archive/201212.summary.shtml
Bureau of Meterology (2013a) 'Seasonal Monthly Summary for Australia: February 2013', accessed 5 Dec 2013, from http://www.bom.gov.au/climate/current/month/aus/archive/201302.summary.shtml
Bureau of Meterology (2013b) 'Seasonal Monthly Summary for Australia: January 2013', accessed 5 Dec 2013, from http://www.bom.gov.au/climate/current/month/aus/archive/201301.summary.shtml
Cain, A., MacGill, I. and Bruce, A. (2010) 'Assessing the potential impacts of electric vehicles on the electricity distribution network ', AuSES Annual Conference, Canberra, Australia, accessed 3 Dec 2013, from http://www.ceem.unsw.edu.au/sites/default/files/uploads/publications/CainEVpaper.pdf
CEDA (2012) *Australia's Energy Options: Policy choice not economic inevitability*, Committee for Economic Development of Australia, accessed 03/12/2013, from http://www.ceda.com.au/media/275551/energynovfinal.pdf
Climate Commission (2013) *The Critial Decade: Australia's Future - Solar Energy*, Climate Commission, accessed 05/12/2013, from http://apo.org.au/sites/default/files/docs/ClimateCommission_Australias-Future-Solar-Energy_2013.pdf
Commonwealth Government Department of Industry (2013) 'Homes Improving the energy efficiency and sustainability of residential buildings', accessed 5 Dec 2013, from http://ee.ret.gov.au/energy-efficiency/homes
Department of Climate Change and Energy Efficiency (2011) *Securing a clean energy future* Commonwealth of Australia from http://www.acci.asn.au/Files/Government-Carbon-Tax-Plan
Energex (2013) *The Case for Change – The New Normal for Distribution Networks*, October 2013, Energex
Energy Efficient Strategies (2008) *Energy Use In The Australian Residential Sector*, Energy Efficient Strategies from http://ee.ret.gov.au/sites/default/files/documents/04_2013/energy-use-australian-residential-sector-1986-2020-part1.pdf
EnergyConsult (2010) *Evaluation of Energy Efficiency Policy Measures for Household Air Conditioners in Australia*, EnergyConsult from http://www.energyrating.gov.au/wp-content/uploads/Energy_Rating_Documents/Library/Cooling/Air_Conditioners/201012a-aircon-evaluation.pdf
Equipment Energy Efficiency (2013) 'Minimum Energy Performance Standards', accessed 10 Dec 2013, from http://www.energyrating.gov.au/programs/about/
ESC (2006) *Electricity Distribution Price Review 2006-10*, Essential Services Commission from http://www.royalcommission.vic.gov.au/getdoc/d09c58ae-4770-4cae-9435-586148b53398/PAL.019.001.0636
ESCOSA (2005) *2005 - 2010 Electricity Distribution Price Determination*, Essential Services Commission of South Australia from http://www.efa.com.au/Library/ESCOSA2005ElectricityDistributionPriceDetermination.pdf
Garnaut, R. (2011) *Garnaut Climate Change Review*, accessed 05/12/2013, from http://www.garnautreview.org.au/ca25734e0016a131/WebObj/GarnautClimateChangeReview-DraftReport-Ch19/$File/Garnaut%20Climate%20Change%20Review%20-%20Draft%20Report%20-%20Ch%2019.pdf
IMO (2013) *Market Data 2006 - 2013,* catalogue number http://data.imowa.com.au/#load-summary, Independent Market Operator
Independent Pricing and Regulatory Tribunal (2003) *Inclining Block Tariffs for Electricity Network Services*, Independent Pricing and Regulatory Tribunalfrom http://www.ipart.nsw.gov.au/files/0225f355-501c-4a01-890c-9f2400af557a/Inclining_Block_Tariffs_for_Electricity_Network_Services_Secretariat_Discussion_Paper_-_pdfversion_June_2003_-_website_document_ISBN_1877049654.pdf
Independent Pricing and Regulatory Tribunal (2004) *Determination - NSW Electricity Distribution Pricing 2004/05 to 2008/09*, Independent Pricing and Regulatory Tribunal from http://www.ipart.nsw.gov.au/files/753d7601-3dcb-41fc-96d5-9f2400b07829/NSW_Electricity_Distribution_Pricing_2004-05_to_2008-09_-_Final_Determinationpdf.pdf
Kim, T., Wang, W. and Li, W. (2012) *Advancement in materials for energy-saving lighting devices*, Curtin University from

http://www98.griffith.edu.au/dspace/bitstream/handle/10072/53008/83571_1.pdf?sequence=1

Macquarie Generation (2009) *Annual Report 2009*, Macquarie Generation from http://www.macgen.com.au/Resources/Documents/Annual-Reports/ar-2009.pdf

Minifie, J., Cherastidtham, I., Mullerworth, D. and Savage, J. (2013) *The mining boom: impacts and prospects*, Grattan Institute

Orchison, K. (2013) "A very big challenge", accessed 9 Dec 2013, from http://www.coolibahconsulting.com.au/TiP/author/admin/page/2/

Pitt&Sherry (2013) *Carbon Emissions Index*, Pitt&Sherry, accessed 03/12/2013, from http://www.pittsh.com.au/assets/files/Cedex/CEDEX%20December%202013%20Rev01.pdf

QCA (2005) *Final Determination: Regulation of Electricity Distribution* Queensland Competition Authority from http://www.qca.org.au/files/ACF14.pdf

Simhauser, P. and Nelson, T. (2012) *The Energy Market Death Spiral - Rethinking Customer Hardship*, AGL Applied Economic and Policy Research from http://eraa.com.au/wp-content/uploads/WorkingPaper31Summary.pdf

SP AusNet (2012) *SP AusNet 2012/13 Half Year Results*, SP AusNet from http://www.sp-ausnet.com.au/CA2575630006F222/Lookup/PresentationInvestors/$file/ReleaseandInvestorPresentation%209%20Nov%2012.pdf

Webb, S., Cruickshank, S. and Higgins, I. (2010) *Quantitiative research of CEOS/Senion level executives participating in the energy efficiency opportunities program*, OgilvyEarth, accessed 05/12/2013, from http://eex.govspace.gov.au/files/2012/01/Ogilvy-Earth-CEO-Report.pdf

Western Australia Department of Commerce (2012) 'Sustainability - 6 Star', accessed 5 Dec 2013, from http://www.buildingcommission.wa.gov.au/consumers/sustainability/6-star-energy-efficiency

Western Power (2006) *Financial Review 2006*, Western Power from http://www.westernpower.com.au/documents/reportspublications/annualReports/annualReport2006/financialReport2006.pdf

Western Power (2007) *Financial Review 2007*, Western Power from http://www.westernpower.com.au/documents/reportspublications/annualReports/annualReport2007/AR_Financials.pdf

Western Power (2008) *Financial Report 2008*, Western Power from http://www.westernpower.com.au/documents/reportspublications/annualReports/annualReport2008/ARFinancials08.pdf

Western Power (2009) *Annual Report 2009*, Western Power from http://www.westernpower.com.au/documents/reportspublications/annualReports/annualReport2009/WPAR_%20Revised.pdf

Western Power (2010) *Annual Report 2010*, Western Power from http://www.westernpower.com.au/documents/reportspublications/annualReports/annualReport2010/annual_report_2010.pdf

Western Power (2011) *Annual Report 2011*, Western Power from http://www.westernpower.com.au/documents/reportspublications/annualReports/web_annual_report_2011_updated_8_nov_2011.pdf

Western Power (2012) *Annual Report 2012*, Western Power from http://www.westernpower.com.au/documents/reportspublications/annualReports/WP%20AR%202012_Signatures%20WEB2.pdf

Western Power (2013) *Annual Report 2013*, Western Power from http://www.westernpower.com.au/documents/reportspublications/annualReports/wp-annual-report-2013.pdf

Wood, T. (2012) *Putting the customer back in front*, Grattan Institute