The impact of climate change on electricity demand in the Australian national electricity market

Bell, William

University of Queensland

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William Paul Bell
Craig Froome
Phillip Wild

Energy Economics and Management Group

The University of Queensland
Australia

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Energy Economics and Management Group

Postal address:	School of Economics, The University of Queensland St Lucia, Brisbane QLD 4072, Australia
Phone:	+61 7 3346 0594 or +61 7 3365 6780
Fax:	+61 7 3365 7299
E-mail:	webeemg@uq.edu.au
Website:	http://www.uq.edu.au/eemg/

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4. THE IMPACT OF CLIMATE CHANGE ON ELECTRICITY DEMAND: REVIEW

William Paul Bell, Craig Froome, Phillip Wild, Liam Wagner
The University of Queensland

There has been an increase in demand for electricity for over two decades. However there are many countervailing trends in the demand for electricity. For instance there is uneven population growth across Australia, which will increase demand unevenly. The growth in the uptake of air conditioners is nearing a plateau, which will reduce the rate of increase in electricity demand. The price for electricity has increased rapidly over the last 10 years, which may see people become sensitive to price, so a price elasticity of demand starts to slow the rate of increase in demand. There are education campaigns to make people aware of their electricity use, which will reduce the rate of increase. Finally, there is climate change affecting both temperature and humidity, which could provide a countervailing effect on demand for electricity where an increase in temperature increases the use of air conditioners and a decrease in humidity decreases demand for air conditioners. The aforementioned countervailing trends make temporal and geographic modelling of demand essential to make predictions.

This chapter discusses the aforementioned trends in demand to expose any maladaptive policy and to inform the development of a model of demand to produce demand profiles.

4.1 Demand profiles

For this project, the demand profile is the electricity demanded in MWh for each hour of the day for 20 years from 2010 to 2030. There is a demand profile for each of the nodes on the NEM grid. Appendix B shows the 11 nodes in Queensland's transmission line topology. These nodes serve three functions:

- demand - the node represents an area or region of demand;
- supply - the node represents the connection point for generators; and
- transmission - two nodes represent the connection points.

Geographically the demand is an area, the generators are points and the transmission lines are lines. These three topologies have a bearing on the use of the climate change projections. In addition, for demand, there is a requirement to relate population projections to these nodes. The population and climate change projections are used to create a demand profile for each of the 53 nodes on the NEM. The 53 nodes of the NEM are shown in Appendix B for QLD, NSW, VIC, SA and TAS. Note that the nodes for ACT are incorporated within the node structure of NSW. These figures represent the topology of the network rather than geographic distance.

Notably, the nodes Bayswater, Murray and Hazelwood are supply only nodes without any demand. Additionally, there are three pseudo demand nodes at Moreton North, Wollongong and Tumut, which are required for modelling the demand from the pumped hydro storage at Wivenhoe, Shoalhaven and Tumut respectively. Furthermore, in Appendix B for Queensland the node called 'South West' is to be re-designated by Powerlink (2011 App. C) as two nodes being Bulli and South West.

However this project will continue to use the topology in Appendix B that is with the single node 'South West' without Bulli, for two reasons:

- there lacks historical data on the two nodes to calibrate the models; and
- the project has a tight deadline.

4.2 Short-run and long-run drivers for electricity demand

Yates and Mendis (2009, p. 111) consider short-run drivers for demand due to weather and long-run driver due to climate change. For instance, in the short-run people can turn on fans or air conditions to meet changes in weather conditions and in the long-run people can buy air conditioners or install insulation to meet climate change.

Yates and Mendis (2009, p. 111) consider the following short-run electricity demand drivers:

- weather – air temperature, wind speed, air humidity and radiation;
- indoor environmental factors – indoor air temperature, wind speed and humidity;
- time of the day;
- day of the week;
- holidays;
- seasons;
- durations of extreme heat days;
- urban heat island effects;
- utilisation of appliances;
- person's financial position; and
- personal factors – clothing, physical activity and acclimatisation.

Yates and Mendis (2009, p. 112) consider the following long-run drivers:

- climate change;
- population growth composition and geographic distribution;
- real price of electricity;
- the price of electricity relative to the price of gas;
- economic growth;
- real income and employment status;
- interest rates;
- renewal of building stock;
- households and floor space per capita;
- previous years consumption; and
- commercial and industrial electricity use.

There is extensive literature in short-run electricity demand forecasting. However, Taylor and Buizza (2003) state that there is no consensus as to the best approach to electricity demand forecasting citing three different approaches. Harvey and Koopman (1993) forecast hourly demand using time-varying splines, Ramanathan et al. (1997) use multiple regression models and Hippert et al. (2001) use artificial neural networks for short-run forecasting. For this project, regression is chosen because it is the most commonly understood method.

There is a much less extensive literature on long-run electricity demand projections. In addition, Yates and Mendis (2009, p. 113) consider that there are the following difficulties in producing long-run projections:

- limitations in climate change projections;
- limitations in demand modelling;
- limitations in data; and
- lack of industry sector studies.

However this project must extend the literature on short-run electricity demand forecasting to form long-run electricity demand projections. The method essentially involves using the existing literature to form a short-run forecasting model of electricity demand, then using the short-run forecasting model on simulated weather profiles of the years from 2010 to 2030. The simulated weather profiles are generated using the project's baseline weather year incremented by climate change projections. These resulting demand projections are factored for long-run derivers of electricity demand, such as population growth.

4.3 Weather and other short-run drivers for electricity demand

Equation (4-1) shows the short-run factors or weather variables driving demand that are readily modelled from the previous section and based on Ramanathan et al. (1997, p. 163).

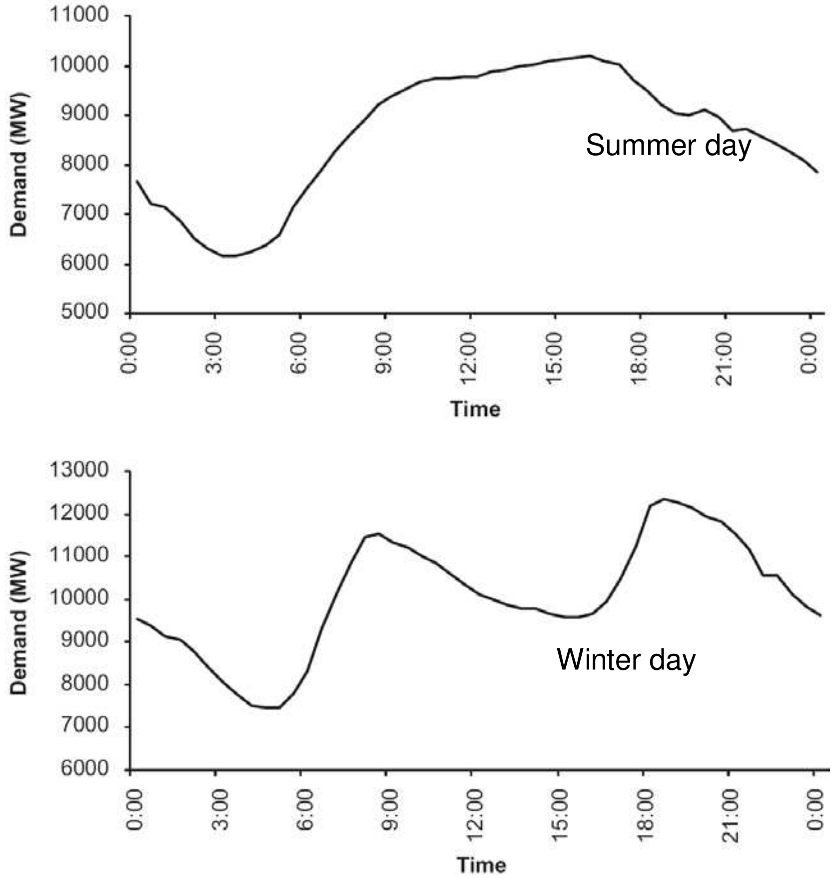
$$d_{(s,\ dow,\ t,\ h,\ n)} = f(T,p,w,r)_{(s,\ dow,\ t,\ h,\ n)} + AR$$

Where
- d = demand
- s = season
- dow = day of week
- t = hour
- h = holiday
- n = node
- f = function
- T = temperature
- p = per cent humidity
- w = wind speed
- r = radiation
- AR = autoregressive term

Equation (4-1)

The subscripts in Equation (4-1) mean that there is a separate equation for each season, either summer or winter, for each day of the week, for each hour of the day, for whether the day is a holiday or not and for each node. Figure 4-1 shows the typical demand profiles for summer and winter days. In summer, people start to use the air conditioners about mid-morning and continue using air conditioners until late afternoon. In winter, people use the heating early in the morning and later evening but tend to switch off the heating during the middle of the day. This difference in profile illustrates the importance of capturing the typical summer and winter day in Equation (4-1).

Figure 4-1 Examples of the NSW intraday demand for a typical summer and winter day



(Source: Thatcher 2007, p. 1649)

Equation (4-1) ignores a *person's financial position* and *personal factors* as the equation models an aggregation of all the consumers on a node. Equation (4-1) captures the *utilisation of appliances*, in particular air conditioners, by using the variables for time of day and temperature. Equation (4-1) partially captures the *urban heat island effects* using the node variable. The *durations of extreme heat days* affect the use of air conditioners as buildings retain heat from the previous day. The auto regressive term in Equation (4-1) captures this residual heat effect. The auto regressive term simply means that today's demand for electricity is related to yesterday's demand for electricity, which is related to the demand for electricity of the day before yesterday, and so on but the relationship dissipates over time.

There is a possibility that the environment variables are highly correlated or synchronised, so a subset of the variables, that are the most uncorrelated, are selected to form the regression to model the demand for electricity. The process is known as *principle component analysis* of historical demand. For instance, the effect of the following four variables on demand for electricity may be adequately modelled with just three of the variables: population, number of air conditioners owned, number of households and climate change.

Table 4-1 cites results from Preston and Jones (2006) who forecast the increase in peak demand under given temperature increases for Adelaide, Brisbane, Melbourne and Sydney. The response to an increase in temperature varies greatly between the metropolitan centres, which stresses the importance of modelling demand for each node.

Table 4-1 Effect of temperature change on peak demand for electricity in four capital cities

ΔT (°C)	Projected impact on peak electricity demand
<1	Melbourne and Sydney decreases up to 1% Adelaide and Brisbane increases 2–5%
1-2	Melbourne and Sydney decreases 1% Adelaide and Brisbane increases 4–10%
2-3	Adelaide, Brisbane and Melbourne increases 3–15% Sydney decreases 1%
3-4	Adelaide, Brisbane and Melbourne increases 5–20% Sydney decreases 1%
4-5	Adelaide, Brisbane and Melbourne increases 9–25% Sydney decreases 0.5%
>5	Sydney decreases 0% Adelaide, Brisbane and Melbourne increases 10–25%

(Source: Preston & Jones 2006, p. 29)

Table 4-2 show the increase in peak demand for a one degree increase in temperature in the states NSW, VIC, QLD and SA.

Table 4-2 Projected increase in peak demand for a one degree increase in temperature

Region	Change in peak regional electricity demand
NSW	–2.1% ±1.0%
VIC	–0.1% ±0.7%
QLD	+1.1% ±1.4%
SA	+4.6% ±2.7%

(Source: Thatcher 2007, p. 1655)

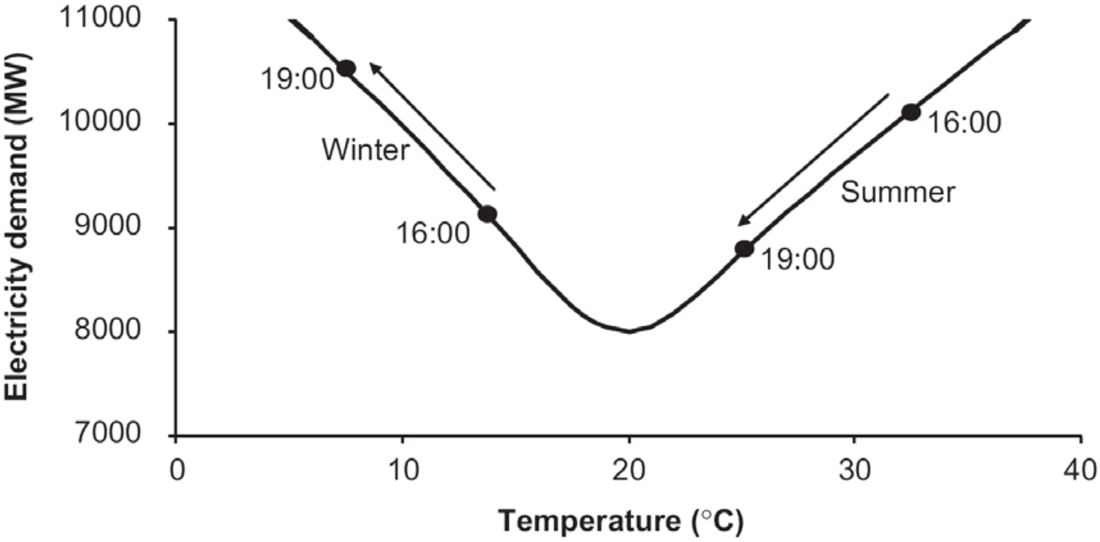
When comparing Table 4-1 and Table 4-2 it indicates a discrepancy between the change in peak demand between the capital city and the state. The *urban heat island effect* can partially explain why demand in a capital city would differ to the state. This discrepancy adds weight to the need to model demand for each node rather than aggregate by state. Unfortunately, the demand profiles of the years 2006 to 2011 from AEMO (2011a) are aggregated by state. However, the demand profiles for each node are available via company websites and annual reports.

Furthermore, these large increases in peak demand have traditionally been met by increased investment in generation, transmission and distribution even though the peaks are for relative short periods. The consequence is a considerable increase to electricity bills to meet peak demand, which lasts for a relatively short duration. Chapters 6 and 10 discuss methods to defer investment in generation, transmission and distribution.

Howden and Crimp (2001) and Thatcher (2007) use Heating Degree Days (HDD) and Cooling Degree Days (CDD) to model the effect of temperature on peak demand. This degree day technique provides a better modelling technique than the season variable in Equation (4-1), as the degree day technique accommodates unseasonal days. For instance, with regards to the profile in Figure 4-1 there are very cold summer's days that could have the winter's day demand profile and very hot winter's days that could have the summer's day demand profile.

Figure 4-2 shows a schematic that illustrates the degree day concept where in summer at high temperatures the demand at 16:00 is greater than at 19:00 and in winter at low temperatures the situation is reversed. This technique can be applied to any hot or cold day but a base temperature (T_b) is required to determine whether a day is a HDD or a CCD. In Figure 4-2, the base temperature appears about 20°C.

Figure 4-2 Relationship between electricity demand and temperature at different time



(Source: Thatcher 2007, p. 1650)

Table 4-3 shows that the base temperature varies amongst the capital cities and state and between capital city and home state, which adds further weight to developing demand profiles for each node. As expected, the base temperatures forms some indication of acclimatisation, for instance the base temperature for Brisbane is higher than Melbourne, which indicates that somebody in Melbourne is more likely to switch on an air conditioner at lower temperature than somebody in Brisbane and that somebody in Brisbane is more likely to switch on heating at a higher temperature than somebody in Melbourne.

Table 4-3 Comparing base temperature in degrees Celsius for cities and states

City	T_b	T_b	State
Brisbane	18.6	19.70	QLD
Sydney	17.5	19.16	NSW
Melbourne	16.9	16.94	VIC
Adelaide	16.8	18.08	SA
(Source: Howden & Crimp 2001, p. 656)		*(Source: Thatcher 2007, p. 1653)*	

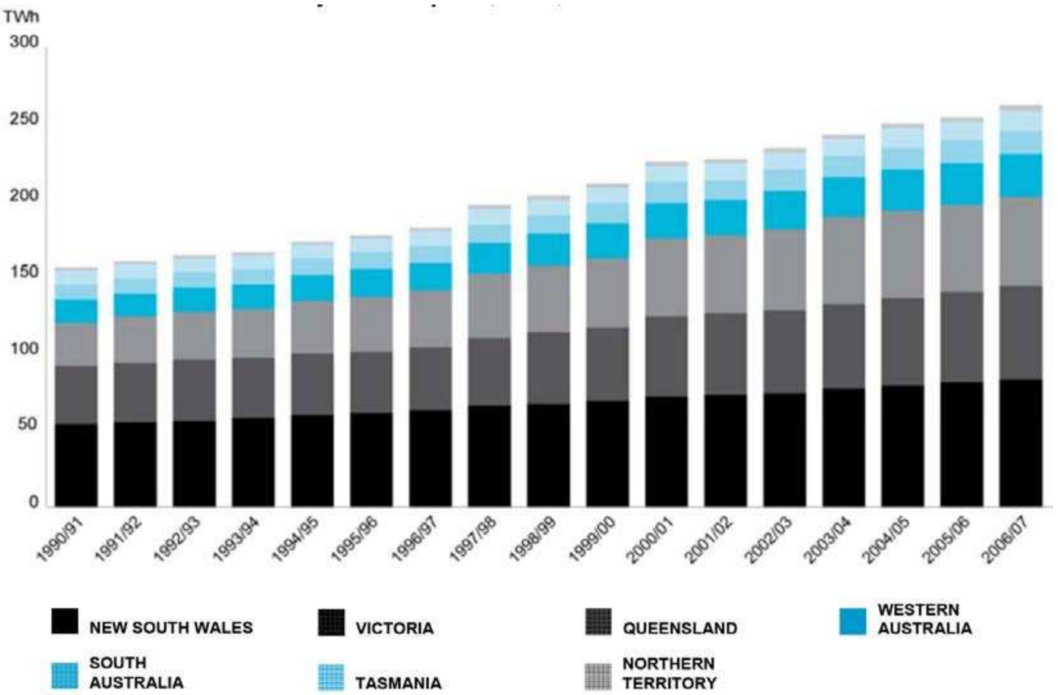
As previously discussed, Equation (4-1) fails to accommodate personal acclimatisation but the degree day technique using base temperatures accommodates personal acclimatisation to a location. So, there are two reasons to adopt the degree day technique over the season variable in Equation (1), being accommodating unseasonal days and acclimatisation to the local climate.

Howden and Crimp (2001) and Thatcher (2007) include a measure for humidity. Howden and Crimp (2001) found that the inclusion of humidity improved the models' predictive performance for Brisbane for both CDD and HDD and for Melbourne for CDD only. However the measure for temperature proved a sufficient variable to model demand for both CDD and HDD for both Sydney and Adelaide.

4.4 Climate and population as long-run drivers for electricity demand

Figure 4-3 shows the demand for electricity increasing from 1990 to 2006 by 67%. The Chairman of the AEMC (Tamblyn 2008) expects this tend to continue, requiring further investment in generation, transmission and distribution, which is discussed in Chapter 6.

Figure 4-3 Electricity consumption, TWh, 1990-91 to 2006-07



(Source: Tamblyn 2008, p. 15)

Some of this increase in demand is due to population growth and climate change. The mechanism for population growth increasing demand for electricity is obvious but the mechanism for climate change increasing demand for electricity is more indirect. For instance, warmer temperatures encourage people to install more air conditioners and use the air conditions more often. Both population growth and climate change are long-run demand drivers and are readily modelled.

However, the following long-run demand drivers are not so easily modelled for the 20 year duration of the project:

- public engagement and the smart grid;
- acclimatisation to climate change;
- air conditioner purchases;
- real price of electricity - price elasticity of demand;
- the price of electricity relative to the price of gas;
- real income and employment status;

- interest rates;
- economic growth;
- renewal of building stock;
- households and floor space per capita;
- previous years' consumption; and
- commercial and industrial electricity.

Chapter 2 discusses the selection of this project's *Special Report on Emission Scenario* (SRES) A1FI and three Global Climate Models (GCMs) used to produce the climate change projections for the *'Worst case'*, *'Most likely case'* and *'Best case'*. These three climate projections are used to produce demand profiles in conjunction with population projections.

This section discusses the three Australian Bureau of Statistics (ABS 2008) population projections used in this project. The ABS (2008, p. 3) states, *"Three main series of projections, Series A, B and C, have been selected from a possible 72 individual combinations of the various assumptions. Series B largely reflects current trends in fertility, life expectancy at birth, net overseas migration and net interstate migration, whereas Series A and Series C are based on high and low assumptions for each of these variables respectively".*

Table 4-4 shows the population projection assumptions and the expected increases in population from 2006 to 2030. The projected population percentage increase provides an indication of the expected increase in demand for electricity from population growth.

Table 4-4 Population projection assumptions and increase from 2006 to 2030

	Total fertility rate	Net overseas migration	Life expectancy at birth		Actual Population	Projected Population	
	Babies per woman	persons	Males year	Females years	30 June 2006	30 June 2030	Increase
Series A	2.0	220 000	93.9	96.1	20,697,880	30,499,959	47%
Series B	1.8	180 000	85.0	88.0	20,697,880	28,484,167	38%
Series C	1.6	140 000	85.0	88.0	20,697,880	26,851,511	30%

(Source: ABS 2008)

However, for Series B, Table 4-5 shows that this population growth and induced growth in demand for electricity is unevenly spread across the NEM region with Queensland expecting significantly more growth and Tasmania the least growth. Additionally, there is marked difference in growth between the capital city and the balance of the state for VIC, NSW, TAS and SA. Consequently, modelling population by node would better reflect the stresses induced on the NEM by this uneven population growth.

Table 4-5 Uneven projected population growth from 2006 to 2030 across the NEM

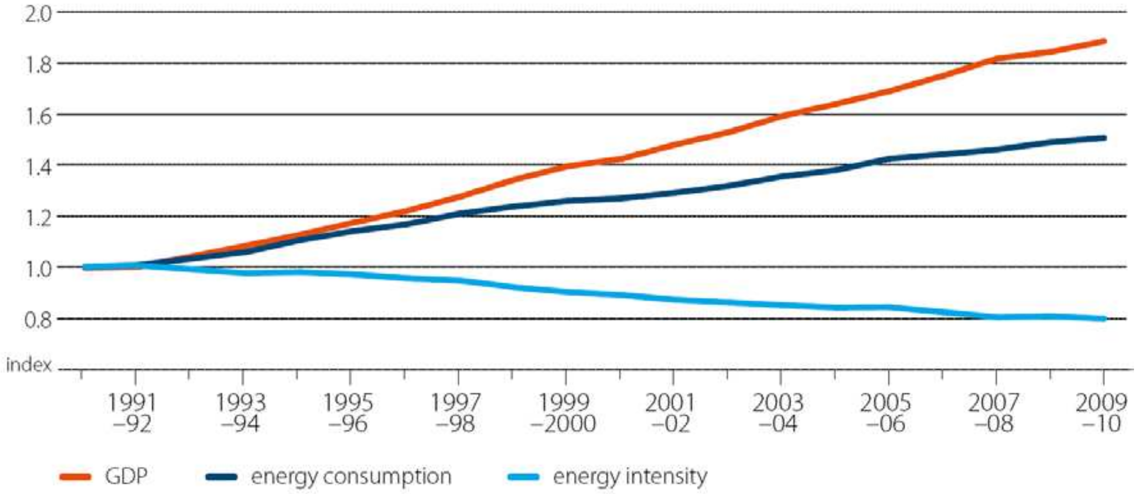
Series B	Qld	NSW	Vic	SA	Tas	ACT	NEM
State	57%	27%	36%	24%	14%	29%	36%
Capital city	57%	32%	41%	25%	22%		38%
Balance of state	57%	20%	20%	21%	8%		32%

(Source: ABS 2008)

4.5 The link between economic growth and growth in demand for electricity

Figure 4-4 shows that growth in energy consumption has remained below the growth in Gross Domestic Product (GDP) and energy-intensity has been declining. Energy-intensity is the ratio of energy used to activity in the Australian economy. Ball et al. (2011, p. 8) discuss how declining energy-intensity is a worldwide phenomenon.

Figure 4-4 Intensity of Australian energy consumption

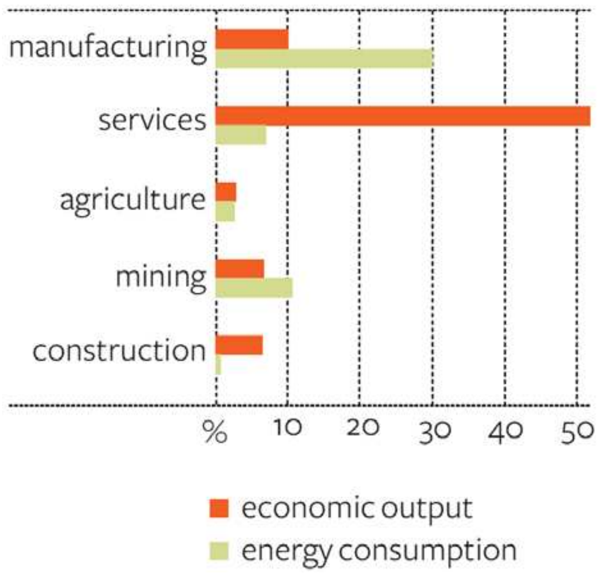


(Source: Schultz & Petchey 2011, p. 5)

Shultz and Petchey (2011, p. 5) consider the decline in energy-intensity due to two factors being the improvement in energy efficiency associated with technological advancement and a shift in industry structure toward less energy-intensive sectors. The improvement in energy efficiency is likely to continue and is further discussed in the following sections. Figure 4-5 compares the percentage share of economic output and of energy use for different industries. Manufacturing is the most energy intense industry and the service industry is one of the least intensive industries. The increase in the size of the service industry and decrease in the size of the manufacturing industry accounts for some of the decline in energy-intensity. The decline in energy-intensity requires modelling to adjust the demand profiles developed from the population and climate projections. The next section discusses why this long run trend is likely to continue.

The long term drivers of increasing population and economic growth do not necessarily have to lead to an increase in demand for electricity. In other countries, particularly in Europe, these long term drivers have been managed by not using or minimising the use of electricity for heating and cooling (the largest growth demands) by using the waste heat from local electricity generation, renewable heat or the injection of renewable gas into the gas grid. These have additional benefits of decentralising energy generation close to demand, increasing the efficiency of the energy system, reducing losses and providing the opportunity for the undergrounding of electricity infrastructure – a classic case of adapting to climate change.

Figure 4-5 Shares of energy consumption and economic output 2005-06



(Source: Sandu, Suwin & Syed 2008, p. 4)

4.6 Smart meters as long run drivers for reducing electricity demand

This section discusses how smart meters providing customers with dynamic pricing can help customers reduce demand for electricity at peak times and increase public engagement in energy conservation.

Smart meters allow retailers to automatically collect high frequency data on customers' electricity usage and customers to monitor their own use of electricity. Smith and Hargroves (2007) discusses the introduction of smart meters, the ensuing public engagement and the substantial reduction in peak demand being achieved. Currently in Australia, transmission and distribution investment is made to meet the peak demand period, which is usually between 3 pm and 6 pm in most Organisation for Economic Co-Operations and Development (OECD) countries. Smith and Hargroves (2007) state that in Victoria the transmission investment is 20 per cent larger to meet peak demand for one per cent of the year. In comparison, Georgia Power and Gulf Power in Florida, USA, have installed smart meters resulting in Georgia Power's large customers reducing electricity demand by 20-30 per cent during peak times and Gulf Power achieving a 41 per cent reduction in load during peak times. Zoi (2005) reports on California's experience of tackling the growing demand for peak summer power using a deployment of smart meters with a voluntary option for real time metering that uses lower tariffs during off peak times and higher tariffs during peak times with a 'critical peak price' reserved for short periods when the electricity system is really stressed. Energy consumption during peak periods was reduced by 12-35 per cent. Most Californians now have lower electricity bills and 90 per cent of participants support the use of dynamic rates throughout the state.

The AEMC (2009, p. v) considers fixed priced tariffs for retail customers a risk to the NEM with the introduction of the RET and the Carbon Pollution Reduction Scheme (CPRS), so the AEMC (2009, p. v) recommends more flexible pricing for retail customers to reflect the movements in wholesale prices. In addition, it recommends a national customer protection scheme be setup prior to introducing flexible pricing. A flexible retail consumer price reduces the risk for the electricity companies and transfers the risk to the retail customer. However, if the retail customers lack in-house-displays for their smart meters, the customers will be unable to readily adapt to changes in price. Introducing flexible pricing before smart meters with in-house-displays could induce a negative response from customers, so hindering consumer engagement in energy conservation. For instance the World Energy Council (WEC 2010) evaluates the residential smart meter policies of Victoria and claim the lack of an in-house-display is a major source of customer dissatisfaction amongst customers with dynamic prices. Another source of dissatisfaction is the lack of provision for the most financially vulnerable. Section 9.5 discusses institutional fragmentation as a cause of the slow smart meter deployment in Australia and as a source of maladaptation to climate change.

4.7 Energy efficiency as a long run driver for reducing electricity demand

Institutional fragmentation is also hindering policies surrounding energy efficiency. Hepworth (2011a) reports how AGL and Origin Energy called for a national scheme rather than state based schemes because compliance across the different states' legislations is costly. However the National Framework for Energy Efficiency (NFEE 2007) instituted by the MCE claims significant progress. But in a submission to the NFEE (2007) consultation paper for stage 2, the National Generators Forum (NGF 2007) comments on the progress since stage 1 of the NFEE *"Progress in improving the efficiency of residential and commercial buildings can best be described as slow and uncoordinated, with a confusion of very mixed requirements at the various state levels. … Activities in areas of trade and professional training and accreditation, finance sector and government have been largely invisible from a public perspective"*. The NGF (2007) states that the proposals for stage 2 are modest and lack coordination and national consistency. So, there is disagreement between the MCE and participants in the NEM over coordination in the NEM. Section 9.6 further discusses coordination problems induced by institutional fragmentation as a cause of maladaptation to climate change.

In another submission to the consultation paper, Origin Energy (2007) calls for the NFEE to focus on non-price barriers to energy efficiency that the price signal from the CPRS is unable to address. Claiming the public good aspect of energy efficiency provides strong justification for government funding even where there are private benefits through cost savings. Origin Energy considers the following items are suitable for direct action to remove non price barriers:

- education/information campaigns;
- low interest or zero interest loans;
- minimum Energy Performance Standards (MEPS);
- phasing out electric hot water systems;
- incandescent light bulb phase out; and
- building standards.

Stevens (2008, p. 28) identifies the need for raising public awareness of electricity demand and shaping public opinion as part of an adaptive strategy but Origin Energy (2007) considers public education/information campaigns are considerably underfunded. The star rating of appliances by Equipment Energy Efficiency (E3 2011) is an example of a campaign that is visible and easy to understand, which is moot with some success and addresses information asymmetry. As discussed, the introduction of smart meters and flexible pricing has engaged customers in other countries. This public engagement by smart meters can provoke a much wider interest in the conservation of electricity to include energy efficiency.

Additionally, Origin Energy (2007) supports interest free loans to undertake energy efficiency projects with high upfront costs, particularly for poorer individuals or smaller businesses that have difficulty accessing finance. Section 9.1 further discusses interest free loans and peoples' expectation of a much shorter payback period on an investment than is economically optimal as justification for government intervention.

Both Origin Energy (2007) and NGF (2007) acknowledge that the MEPS established for refrigerators and freezers, electric water heaters and refrigerative air conditioners are effective and support the expansion of MEPS to include other appliances. MEPS are a successful adaption to climate change.

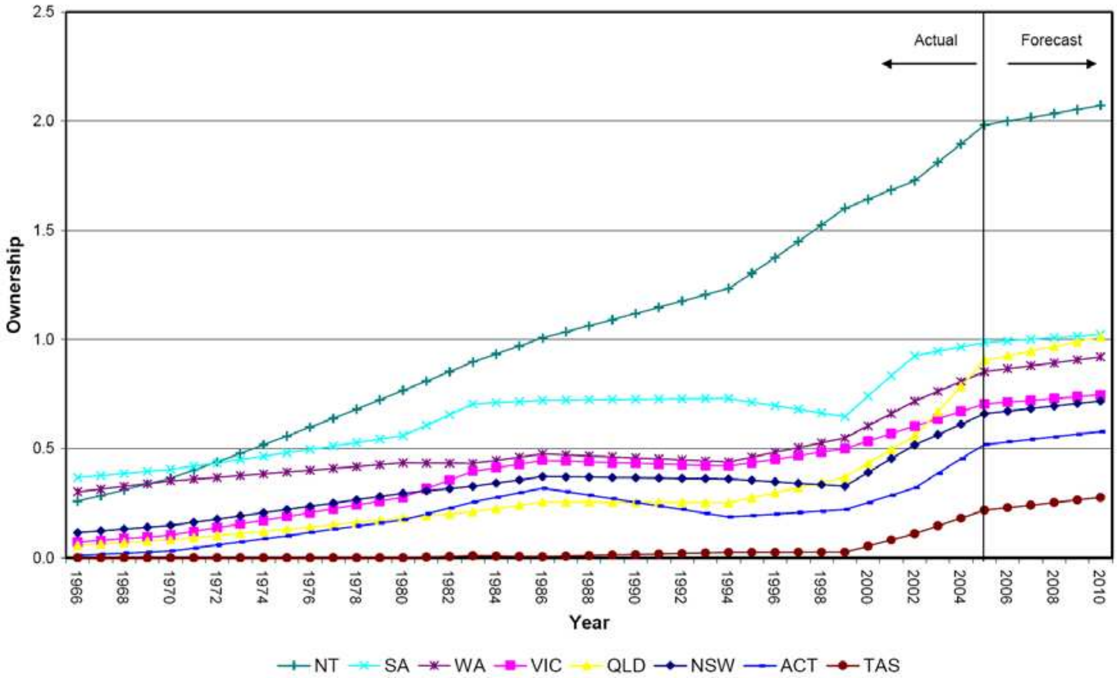
However, Origin Energy (2007) agrees but NGF disagrees with the phasing out of electrical hot water systems. NGF states that water heating accounts for 30% of household electricity use but only 6% of total stationary energy use. Additionally, NGF calls for fuller consideration of the impact of the phase out on peak and off peak electricity use, electricity costs and prices and water use. These electrical hot water systems provide a use for electricity generated during the off peak periods. There are strong financial incentives for coal generators and some gas generators to maintain this off peak load to avoid considerable shutdown and startup costs. Section 6.12 discusses the requirement to maintain this off peak load or a baseload to support coal as a potential form of maladaptation to climate change.

Both Origin Energy (2007) and NGF (2007) express concern about the phase out of incandescent light bulbs being in favour of the phase out but better consultation prior to the phase out may have prevented some adverse and unintended consequences, such as, the poor light rendition and high failure rate of substandard imported compact fluorescent lights (CFL), which caused some people to adopt halogen down lights that have higher energy use than incandescent light bulbs.

The NGF (2007) breaks down the stationary energy use by sector as household 21%, commercial 12% and industrial 67%, claiming a greater focus on energy efficiency in the industrial sector may provide greater gains rather than on the household sector. However, as mentioned, the need to meet peak load drives investment in transmission and generation rather than total energy used. For instance energy use for air conditioners as a percentage of total energy is not significant but air conditioners are primarily used during peak period, which makes the additional load significant.

The MEPS will reduce the amount of energy new air conditioners use and so reduce the demand for electricity. However, Figure 4-6 shows increases in ownership of air conditioners across all states, which will increase demand for electricity. There was a rapid growth in air conditioner ownership from 2000 to 2005 when the growth was expected to slow from 2006. This trend is consistent with a slowing increase in demand per capita for electricity over the long-run. The NT shows a considerably different trajectory to the other states but is ignored as it lies outside the NEM region.

Figure 4-6 National Ownership of Air Conditioners by State



(Source: NAEEEC 2006, p. 9)

Decentralised energy can address peak electricity demand brought about by air conditioners. In NSW, a key part of the reason for surging electricity prices is the need to build electricity assets for peak power demand, primarily electric air conditioning, for four days of the year to meet high demand on hot days. $11 billion of network assets is built to meet demand for just 100 hours a year and as much as 25% of electricity costs result from peak demand, primarily electric air conditioning, which occurs over a period of less than 40 hours a year (Dunstan & Langham 2010).

A 2kW reverse-cycle air conditioner costs $1,500 a year to operate and yet imposes costs on the electricity network of $7,000 since it adds to peak demand (DRET 2012). These network costs are not paid by the consumer operating the air conditioner but by all NSW electricity consumers whether or not they own air conditioners. These network costs are significantly amplified by a city such as Sydney. In an alternative solution to building more network infrastructure, the Tri-generation Master Plan (Kinesis Consortium 2012) will displace 542MW of electricity peak demand, primarily electric air conditioning, which all NSW electricity consumers are currently paying for. This is equivalent to taking 271,000 - 2kW reverse-cycle air conditioners off from peak electricity demand.

The changes in building standards have engendered an improvement in new housing energy efficiency. Yates and Mendis (2009, p. 121) discuss how increased urban salinity and ground movement damage induced by climate change will accelerate building stock renewal, leading to a long-run reduction in demand for electricity. However, the projected growth in the number of households exceeds the projected growth in population, which means fewer people sharing a household and resulting in an increase in demand for electricity above population growth. Table 4-6 shows the projected growth in the number of households across the NEM from 2006 to 2030. Table 4-7 shows the projected growth in the number of households above the projected growth in population, which is significant and amenable to modelling. Table 4-7 is the difference between Table 4-6 and Table 4-5.

Table 4-6 Uneven projected household growth from 2006 to 2030 across the NEM

Series II	QLD	NSW	VIC	SA	TAS	ACT	NEM
State	68%	37%	44%	31%	22%	38%	45%
Capital city	66%	40%	50%	31%	28%		46%
Balance of state	70%	32%	31%	32%	18%		43%

(Source: ABS 2010)

Table 4-7 Projected household growth above population growth from 2006 to 2030

Series II - Series B	QLD	NSW	VIC	SA	TAS	ACT	NEM
State	11%	10%	8%	7%	8%	9%	9%
Capital city	9%	8%	9%	6%	6%		8%
Balance of state	13%	12%	11%	11%	10%		11%

The household projection assumptions in Table 4-6 are those for Series II of the ABS (2010). Series II is considered the most likely growth scenario where Series I and III represent lower and higher growth scenarios, respectively. Series I, II and III household projections use the assumptions of the Series B population projection in Table 4-4.

While the number of people per house decreases, Building Research Advisory New Zealand (BRANZ Limited 2007, pp. 28-9) discusses how there is an increase in the size of the average house in Australia where the new standard house has four bedrooms and two bathrooms. The increases in size of house will increase demand for electricity. While house size has become larger, the section size has become smaller, which increases the heat islands effect that is the reduction in greenery around a suburb to moderate temperature swings. The heat island effect will also increase the demand for electricity. But the increase in the number of swimming pools acts to moderate the heat island effect.

4.8 Higher prices and acclimatisation as long run drivers for demand

Australia still enjoys relatively low electricity prices by international standards but the commodity boom has driven prices higher for fossil fuels, which has in turn driven electricity prices higher (Garnaut 2008, pp. 469-70). At low electricity prices people are insensitive to price rises but at higher prices people become much more sensitive to prices increases to the extent that people decrease their use of electricity. The higher price example means that the price elasticity of demand for electricity has increased or is more elastic. The price elasticity of demand is the percentage increase or decrease in quantity demanded in relation to the percentage increase or decrease in price. The higher prices for electricity could see an elasticity of demand operating, which would moderate further increases in demand for electricity.

Climate change is rapid on a geological scale but slow on a human scale. Hence there is ample time for people to acclimatise to changes in climate in the same location, as opposed to people moving to a new location with a different climate and acclimatising to the new climate but taking a few years to adapt to an abrupt locational change. Peoples' ability to acclimatisation will slightly moderate the increase in demand for electricity induced by climate change.

4.9 Conclusion

The first key finding is the requirement to model demand for each node rather than by state. This finding is supported by the following five observations. There is significantly uneven projected population growth within each state, excepting QLD. Sensitivity analysis of demand to temperature shows a discrepancy between state and capital city. There is a significant difference in base temperature between the state and capital city, excepting VIC, which indicates difference in acclimatisation and heat island effects. Additionally, there are uneven weather patterns and climate change projections within each state.

This chapter provides sufficient information to model demand profiles from 2010 to 2030. Section 4.1 discusses the sensitivity analysis and research questions in which the demand profiles are used. In addition to climate change, the projected growth in population and in the number of households will have a significant effect on the NEM. One research question examines the relative impact of climate change to population change whist another question examines a sensitivity analysis of differing population growth.

The second key finding is that institutional fragmentation is hindering the deployment of smart meters and of energy efficiency equipment generally but there are some successful adaptations to climate change namely, MEPS and the E3 star rating. Furthermore, introducing smart meters with in-house-displays before introducing flexible retail pricing would be more conducive to enhancing public engagement. Sections 10.5 and 10.6 further discuss smart meter deployment and institutional fragmentation, respectively.

Additionally, finance is identified as a non-price signal barrier to the deployment of energy efficient equipment. Section 9.2 further discusses this issue.