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Demand Response: A National Strategy to address Air Conditioner Peak Load

Prepared for the

Equipment Energy Efficiency Committee (E3)

by

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November 2006

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Summary

The Growth of Air Conditioning

Australian homes have historically been moderate users of air conditioning. However, the number of air conditioners installed in homes more than doubled between 1995 and 2005, and Australia is on the way to becoming a high air-conditioning country.

Air conditioner peak demand is one of the main factors driving capital investment in the National Electricity Market, as well as a mechanism for cross-subsidies between air conditioner users and non-users. If no action is taken, both the energy and peak demand impact of air conditioning will increase rapidly in the coming years. The National Energy Market Management Company (NEMMCO) projects that summer maximum demand in the mainland states will increase at a rate of 0.8% per annum *more* than the growth in energy consumption. This deterioration in load factor means that the benefits of market reform are being eroded, and the efficiency of capital utilisation in the electricity industry is declining, largely due to air conditioning.

Typically about 30-40% of commercial sector demand and 40%-50% of residential sector demand on summer maximum demand days is now due to air conditioning. The two loads are currently of similar magnitude, but the household air conditioner load is growing more rapidly.

Commercial air conditioner demand can be, and is being addressed by a combination of energy efficiency programs and cost-reflective electricity pricing. These strategies are less effective in the household sector. Household air conditioner peak demand is less amenable to management by building thermal performance standards or air conditioner energy efficiency programs, although these are still effective and necessary for containing energy consumption. Unlike commercial users, householders have limited exposure to electricity price signals, and have been limited in their ability to respond.

Another indirect strategy to address peak demand from household air conditioners is to work with large business users to get them to curtail demand (or increase supply) during periods of peak demand. Many utilities are developing programs of this type. However, the cost of the necessary incentive payments comes from all electricity users, not just those who contribute to the peak load, so they do not reduce inequities or change the behaviour of household air conditioner purchasers and users. Furthermore, this source of demand response is finite, and once it is fully utilised (in say 3 to 5 years time) there will be no alternative to focussing directly on the household sector

Demand Response and Policy

Demand Response (DR) is the ability of individual items of electrical equipment to automatically reduce their consumption at times of high load on the electricity system, according to rules pre-agreed between the user and the electricity supplier. The DR capability could reside in the appliance itself or in a separate controller. The critical aspect of DR is automated response. Time of use pricing and interval meters may also be present, but it is possible to develop effective DR systems which use neither, and indeed such systems are being trailed in Australia.

There are many policy and technical pathways to achieving DR, and there are hundreds of demand response programs, almost all of them different, offered by utilities in the USA. Indeed, this proliferation of approaches has meant that even successful programs are difficult to replicate outside their original areas.

The value of DR in electricity policy and planning has been widely recognised in OECD countries in recent years. The US Electricity Policy Act of 2005 elevated demand response to a national priority. It requires the Federal Energy Regulatory Commission (FERC) to publish annual reports assessing demand response potential by region. The first report, published in August 2006, concludes that 'demand response has an important role to play in both wholesale and retail markets'. The State of California is considering mandating demand response capability in new air conditioners via the building code.

Unlike the USA and Australia, the UK electricity supply system does not have a significant problem with air conditioner-induced peak loads. Nevertheless, there is considerable interest in demand response and distributed generation as direct substitutes for centralised generation as a means of maintaining system reliability, with lower capital costs and no greenhouse gas emissions. The Climate Change and Sustainable Energy Act 2006 requires the Secretary of State for Energy to publish a report on the potential contribution that is capable of 'dynamic demand technologies' (a specific type of demand response) to reducing emissions of greenhouse gases in Great Britain

The International Energy Agency (IEA) Demand Side Management/Energy Efficiency (DSM/EE) Program has a number of activities ('Tasks') with demand response elements. Australia is participating in those tasks.

In Australia, the demand response debate has largely been linked to the rollout of interval metering, although such metering is not essential to the development of demand response programs. At its February 2006 meeting, COAG endorsed the recommendations in the National Competition Policy Review:

> In recognition that past energy market reform has focussed on improving supply efficiency, COAG has agreed to improve price signals for energy consumers and investors . Actions include committing to the progressive national roll out of 'smart' electricity meters from 2007 to allow the introduction of time of day pricing and to allow users to better manage their demand for peak power only where benefits outweigh costs for residential users and in accordance with an implementation plan that has regard to costs and benefits and takes account of different market circumstances in each State and Territory.

At the Ministerial Council on Energy (MCE) meeting on 27 October 2006:

> Ministers agreed on a policy framework for pursuing a progressive roll out of smart meters, including an initial statement of functionality and a broad timeline for development of the initiative. Final and detailed policy decisions will reflect a cost-benefit analysis managed by MCE and stakeholder consultation. Further analysis of jurisdictional markets to identify implementation costs and benefits, and consultation with all stakeholders, will now commence.

Thus time-variable pricing is now directly on the national energy policy agenda, and so by implication is the means for customers to respond to price signals through the adoption of demand response.

Electricity Utility Activities

Most of the activity aimed at reducing peak load in Australia has focussed on the commercial and industrial sectors, for the obvious reasons that they are logistically easier to address than the residential sector. However, several Australian utilities are studying how domestic users react to time-variable and critical peak pricing, and a few are carrying out trials of direct load control for household air conditioners.

Some electricity suppliers are trailing in-home displays which communicate changing electricity prices, but still rely on the willingness and ability of the householders to manually reduce their demand by switching off or turning down appliances. Such programs are valuable in informing users about the price which their interval meter is charging, but rely on householders being be at home, aware of the price signals and ready to respond. They are not on their own sufficient to bring about demand response at the scale and reliability necessary for electricity system planning.

Demand response in the household sector process is far more effective and reliable if it can be automated. This can be done by incorporating the DR capabilities in the air conditioners directly but this needs to overcome the technical problem that curtailing air conditioner operation sometimes has unacceptable consequences for thermal comfort.

Alternatively, DR capabilities can be built in to other significant and potentially time-shiftable household loads, notably swimming pool pumps (present in about 10% of homes), refrigerators, freezers and electric water heaters (all of which have inbuilt thermal storage, so can withstand brief power interruptions).

The one critical element common to all these approaches is not the pricing structure or the presence of interval metering or price displays but the electrical product itself. Linking air conditioners or other controlled appliances to the other elements of the demand response system is usually the most difficult and expensive step. Also, many air conditioner models are not suitable for demand response but it is not possible to identify those in advance, so field crews make many wasted calls, further increasing program costs.

The costs of DR programs can be greatly reduced if the DR capability is incorporated in the product at the time of its manufacture or present in a low-cost user-installable controller. This would eliminate the need for a special service call when a product is installed, and possibly a further service all at the end of its life, to retrieve an expensive utility-owned controller.

If the presence and extent of the in-built DR capability is indicated on the product or its energy label, utilities can more easily promote, and purchasers can more easily identify and buy, DR-capable models. Thus the energy labelling program can be a powerful agent in the development of demand response in the household sector.

Barriers

Developing demand response in the household sector faces a number of issues and barriers:

1. Lack of standardisation, both in terminology and in technology; there are no common languages (technical or other) which all stakeholders can use;

2. Globalisation of the appliance market; air conditioners and other appliances are widely traded, so only international standards (developed internationally or through adoption of pre-existing national standard/s) can be effective. However, peak load is also emerging as a global problem, so there are strong drivers for a global response;

3. Pricing: the key to the development of demand response is price signals and pricing packages. The form of such packages, and whether they are presented in a 'DR-friendly' way – ie when the customer is in a position to decide on the purchase of DR-capable products – will be largely influenced by state regulators (or in due course, by the single Australian Energy Regulator);

4. Metering: the meter can be a key element of the household demand response system as a portal for price signals or a controller in its own right, or it can be bypassed entirely. As many utilities in Australia are rolling out 'smart' interval meters (voluntarily or under pressure from regulators) there will be a huge investment in metering technology which could either hinder or assist the development of demand response;

5. Promotion and identification of products with demand response capability. When/if these come on the market, it will be necessary for both customers and electricity suppliers to identify them, and easily understand their level of capability.

The Australian Greenhouse Office and the Energy Equipment Efficiency (E3) program have been active in this area since late 2004, under the program named 'A-HELP' (for Australian Household Electricity Load-Management Platform). The following activities correspond to the barriers and issues identified above.

1. Standardisation. At the AGO's instigation, Standards Australia has set up a new committee (EL-54) to develop an Australian Standard for *Demand Response Capability in Household Appliances*. The first part, *Classification Code for Functional Outcomes and Supporting Technologies*, is near complete. Sub-parts covering air conditioners, swimming pool equipment and water heaters are planned.

2. Globalisation. The AGO has established contact with the IEA via the Demand Side Management/Energy Efficiency (DSM/EE) program, and is using international events and meetings to promote A-HELP and engage international stakeholders. The AGO is planning to co-sponsor two special conferences on household demand response, in Europe and Asia, during 2007.

3. Pricing and
4. Metering: following COAG's agreement to request MCE to agree on common technical standards for smart meters there is a need and an opportunity to engage within government on a strategic approach to technical and other issues, to ensure that meters are at least neutral (and at best favourable) to demand response development. Without such engagement, there is a risk that key decisions would foreclose a range of pricing and demand response options.

5. Promotion and Identification. Part of the value of an Australian Standard is that the presence of standard demand response capability can eventually be indicated on product energy labels or on supporting information. This would enable electricity suppliers to offer incentives or favourable energy pricing packages for demand response-capable appliances, and would enable customers to purchase those appliances.

Ultimately, it is proposed to broaden the focus of the existing energy labelling program beyond energy efficiency to demand response, to create commercial incentive for suppliers to introduce and promote products with this capability. A degree of standardisation is essential to achieving this objective, but this needs to be balanced with the need to preserve flexibility for utilities to implement the technical solutions and programs appropriate to their circumstances.

Elements of A National Demand Response Strategy

The development of a national strategy to directly address the peak load effects of air conditioners is becoming increasingly urgent. Air conditioning use is growing rapidly in homes and small businesses, and could conceivably double within 10 years.

The following elements are proposed for that part of a national demand response strategy which addresses household electricity use, and air conditioner use in particular. Many of these elements will also apply to other electricity uses and other sectors.

1. Governments should encourage the development of electricity pricing structures which better reflect variation in the cost of supply and system constraints, eg - time of use pricing and critical period pricing.

2. The E3 Program should work with the electricity supply industry to introduce and promote the concepts of variable electricity pricing and demand management as criteria in household appliance selection and operation.

3. The E3 Program should work with the electricity supply industry to promote automated demand response as the central objective of national demand response strategy for the household sector (automated DR is where the user freely enters an arrangement with electricity utility or DR aggregator, but does not need to make an active decision about every demand response event).

4. The E3 Program should work with the electricity supply industry and with appliance manufacturers to standardise aspects of demand response capability in electrical products, with the objectives of:

- indicating levels of capability to prospective appliance purchasers and potential sponsors of demand-response capable appliances purchases (eg electricity utilities or demand response aggregators); and

- Enlarging the market for demand response capable products, by establishing consistent national standards, while retaining flexibility for electricity retailers and distributors to implement programs to suit their own requirements.

5. The energy labelling program should be extended to include information about the demand response capabilities of selected products, and to disseminate this information to prospective purchasers via the energyrating website and, ultimately, via the energy labels themselves.

6. Governments should ensure that the rollout of ‘smart’ metering assists the development of demand response in electrical products, and does not inhibit its development through inconsistent technical standards and requirements (while noting that many demand response approaches do not require either time of use pricing or ‘smart’ metering).

7. Government energy agencies should work with the Australian Energy Regulator to ensure that the development of demand response programs for electrical products is routinely considered as an alternative to electricity distribution system augmentation

8. Governments and energy regulators should consider pricing options which incorporate peak-related electricity supply costs in the purchase price of some electrical products, so that costs can be recovered (at least partially) if the purchasers of those products do not participate in time of use pricing or demand response programs.

9. The AGO should develop and strengthen contacts with energy agencies and product suppliers in other countries, and with international agencies and standards bodies, to facilitate the development of demand response standards for internationally traded products.

Milestones and Timelines

Developing a large scale demand response capability on the household appliance stock in Australia is a long term project. It is also involves a larger number of unknown factors and a wider group of stakeholders than the more conventional energy labelling and MEPS projects with which the E3 is by now very experience.

The AGO has undertaken considerable preparatory work in the last two years, in identifying the issues and bringing together the stakeholders. The following objectives are achievable in the next three years.

- In 2007: the publication of an Australian Standard *Classification code for demand response capabilities and supporting technologies for electrical products* (a Draft is likely to be released for public comment by the end of 2007, subject to agreement by the Standards committee concerned);

- 2007: AGO to co-sponsor (with IEA, APEC or other bodies) and organise two special meetings on international demand response standards air conditioners and other appliances;

- 2007: preparation of additional parts of the Australian Standard covering technical requirements for demand response capability in air conditioners, swimming pool pump controllers and water heaters;

- 2007: development of 'special profiles' incorporating the technical requirements of utilities currently intending to roll out large scale DR programs;

- 2008: adaptation of energy labelling requirements for air conditioners, to allow for voluntary inclusion of demand response profiles. This is likely to coincide with the need to revise the air conditioner labelling algorithms to reflect the impacts of the 2008 MEPS levels;

- 2008: development of 'standard profiles' incorporating basic technical requirements for DR, which could form the basis of international standards;

- 2009: sales and installation of first products (air conditioners, swimming pool pump controllers) with unbuilt DR capability.

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Glossary

AC	Air Conditioner: a device that controls the temperature, humidity, cleanliness and flow of air within a building
APEC	Asia-Pacific Economic Cooperation
AREMA	Air Conditioning and Refrigeration Equipment Manufacturers Association of Australia
Cooler	A device that reduces sensible or latent heat, but is not an air conditioner
CPP	Critical Peak Pricing; an electricity price structure which allows exceptionally high prices to be charged for limited periods, for a limited number of times per year
DR	Demand Response: the automated change in a product's operating mode in response to an external signal or change in the operating environment
DM, DSM	Demand Management, or Demand Side Management: the management of the pattern of demand on the electricity system, with the emphasis on time of demand rather than on total energy consumption
E3	Equipment Energy Efficiency (Program or Committee)
ESC	Essential Services Commission (Victoria)
ESCOSA	Essential Services Commission of South Australia
Evaporative cooler	A device that cools by humidifying and directing a flow of air
HERS	Home Energy Rating Scheme: a system of rating the insulation and other aspects of thermal performance of dwellings. Variations include *NatHERS* (national), *ACTHERS* (ACT) and *FirstRate* (Victoria)
IHD	In-home Display
kVA	kilovolt-ampere; commonly used rating the instantaneous load that electrical equipment places on the supply system. The power rating of a device in kW is the product of the kVA rating and the power factor. Electricity supply almost always deviates from the ideal power factor of 1, due to the characteristics of the end user devices connected to the supply system
MCE	Ministerial Council on Energy
MEPS	Minimum Energy Performance Standards
NEM	National Electricity Market - covers all of Australia except WA and NT
NEMMCO	National Electricity Market Management Company
TOU	Time of Use: an electricity price structure which allows for prices to vary with the time of day, week or season according to a regular pattern.

1. Factors driving peak load

1.1 Air Conditioner Sales and Ownership

Categories of air conditioning

'Air conditioning' generally means the close control of the temperature, humidity, cleanliness and circulation of air in the interior of a building. This definition excludes evaporative cooling, where temperature and humidity are not independently controlled. However, evaporative coolers compete with air conditioners for the cooling market in some parts of Australia, and are an important element of a demand management strategy.

Air conditioners may be categorised in a number of ways:

- by whether they are capable of cooling only, or of heating as well and if the latter, whether they heat by a vapour compression cycle ('reverse cycle' or 'heat pump') or by resistance heaters or gas;[1]

- whether conditioned air is distributed from a central point via ducts ('ducted' or 'central' systems) or directly into the spaces being served ('room air conditioners');

- whether the compressors, condensers, evaporators and fans are in a single unit ('window-wall') or 'split' between an outdoor unit and one or more indoor units.

From the viewpoint of the electricity system, the critical feature of an air conditioner is the power demand it places on the system at the time of peak load, irrespective of whether it is a split or a ducted system, or whether it can heat as well as cool. In the residential sector this load is typically in the range 3 to 4 kVA for smaller units and up 6 to 8 kVA for larger whole-house units (IE 2003). This compares with less than 1 kVA for even a large evaporative cooler.

Ownership

The use of air conditioning is growing rapidly in Australia, especially in residential and small commercial buildings, and the rate of growth has accelerated sharply in the past few years. The number of air conditioners installed in Australian households increased by a factor of over 2.5 in just one decade (Table 1). Most of this was due to the increase in the percentage of households owning at least one air conditioners (the 'penetration rate'), but growth in the number of households and in the average number of air conditioner per household also contributed significantly. [2]

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[1] Electric resistance heating is rare in air conditioners sold in Australia, but is still used sometimes for boosting the heating performance of heat pumps sold for use in very cold climates. About 10% of ducted systems sold in Australia use gas as the fuel source for the heating cycle.

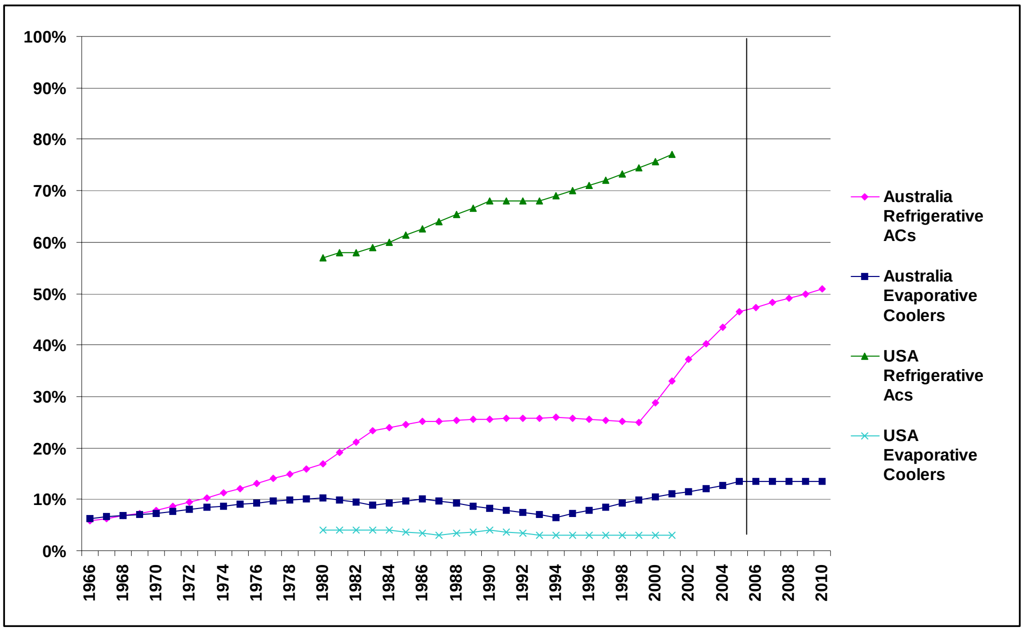
[2] The penetration rate is the proportion of households possessing at least one unit of that appliance, and cannot be higher than 100%. The ownership rate is the average number of appliances held by owning households, and cannot be lower than 1. Some of the uncertainty in the historical statistics stems from the ABS's failure to distinguish between air conditioning and evaporative cooling,

Table 1 Factors increasing air conditioners in use, 1995 to 2005

	1995	2005	Increase factor
% of households owning ACs	25.7%	46.5%	1.81
ACs per AC-owning household	1.1	1.3	1.18
Households ('000)	6737	8001	1.19
ACs in use	1905	4834	2.54

It is estimated that in 2005 nearly 47% of Australian households had air conditioning and 13% had evaporative cooling (Figure 1). The States and Territories have different levels of penetration, largely because of their differing climates. The hotter, dryer states (SA, WA and Victoria) have high levels of ownership for both air conditioners and evaporative coolers, whereas the more humid States (NSW and Queensland) have lower air conditioner penetration and very low levels of evaporative cooler use. Air conditioner penetration is projected to grow significantly in all States, reaching 51% in 2010 and 60% in 2020. These levels are still well below those in the USA.

Figure 1 Share of Australian households with air conditioning or evaporative cooling – historical and projected



Source: Australian data from EES (2006); US data from Energy Information Administration

Sales

Australia-wide sales of air conditioners and evaporative coolers totalled about 730,000 units in 1998 and 1999 before dropping back to about 640,000 units in 2000 and rising to over 1.1 million units in 2004 (EES 2006). Evaporative coolers sales were less volatile, averaging 60,000 to 65,000 units each year.

Large annual variations in air conditioner annual sales are not uncommon. Air conditioners have historically been seasonal and impulse purchases, and if the early part of the summer is hot then sales for that year tend to be higher. The sharp upturn in sales and penetration rates after 2000 coincides with a run of four exceptionally hot summers after two relatively cool ones (Figure 2). Air conditioners are becoming less of an impulse purchase and there are signs that the dynamics of the market are changing permanently, for the following reasons:

- Rising household incomes: Australia has had 15 years of uninterrupted economic growth, enabling households to increase consumption of all services, including thermal comfort;
- Falling real air conditioner prices: as the share of products imported from China and other Asian countries has risen, the real average price of products has fallen;
- Falling real electricity prices (in most States), and the absence of price signals indicating the high marginal cost of supply during summer peak demand periods;
- Decades of promotion of reverse cycle air conditioners by some electricity utilities as a counter to gas heating;
- Increasing noise, air pollution and perceived crime risk in inner city areas, making it less attractive to open windows and rely on natural ventilation, even in low-rise housing;
- The increasing number of high rise apartments, many with poorly shaded and/or west-facing glazing, and less able to rely on natural ventilation and openable windows due to their layout, safety concerns or wind velocity and exposure problems;
- The increasing tendency for project home builders to install air conditioning (or to provide a 3-phase power outlet to facilitate later installation) as a marketing edge;
- The combination of declining block sizes and increasing house floor areas is reducing the scope to optimise orientation and to retain mature tree cover in new subdivisions. This increases the proportion of new houses that rely on air conditioning for summer comfort because they are poorly orientated and shaded, even if they have reasonable levels of insulation;
- The fact that the most of the highest housing growth areas are in the hinterlands of the large coastal cities, where local micro-climates are several degrees hotter than the coastal suburbs of the same cities;
- Changes in home financing, which enable homebuilders to increase their mortgages to cover expenditure on fixed equipment such as air conditioners, whether at the time of construction or later;
- Ageing of the population: older are less tolerant to heat stress, and tend to spend more time at home, so increasing the need for thermal comfort; and

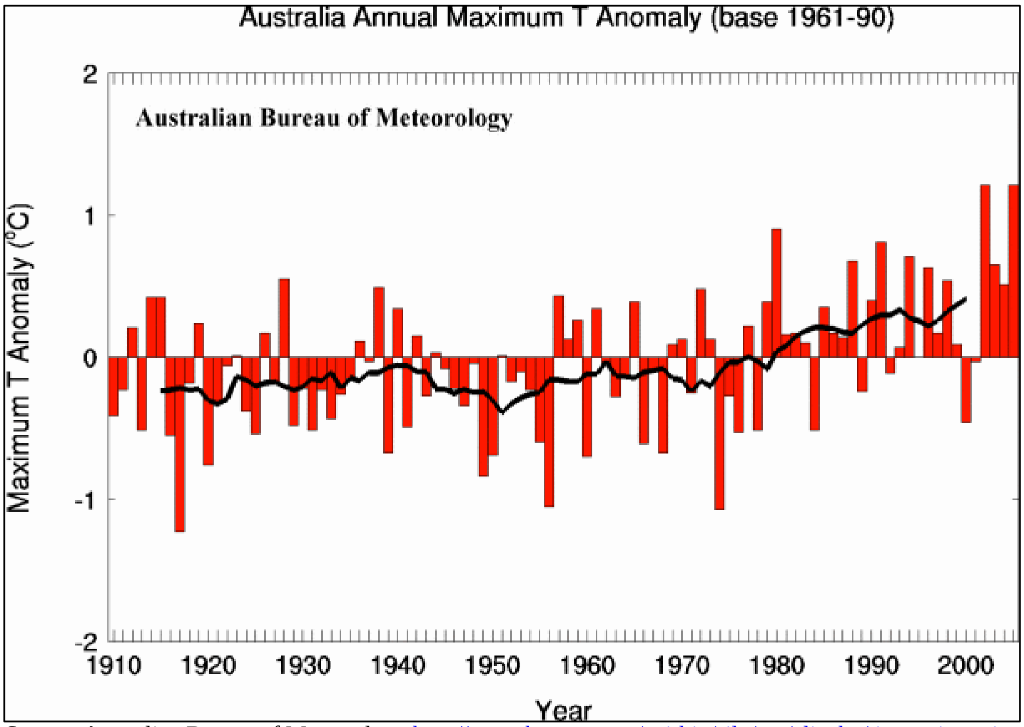
- Global warming: summer average temperatures have been rising in Australia, as in many other parts of the world (Figure 2).

Given these drivers it is little wonder that an increasing proportion of existing dwellings are acquiring air conditioning, and more new houses are being equipped with air conditioning at the time of construction – especially as the capital cost can be rolled into the mortgage, and the real costs of peak demand to the electricity system are hidden.

Most of the air conditioners sold are replacing existing units or as the first air conditioner in an existing home, rather than for installation at the time of new construction. However, even where no air conditioner is installed at the time of construction, the period to the installation of the first air conditioner appears to be getting shorter.

The preferred types of air conditioner purchased are also changing. Split systems dominate the market, and the market share of window/wall systems is falling rapidly. Buyers have also come to prefer reverse cycle systems which can heat as well as cool. The decline of the window/wall segment also led to the end of small air conditioner manufacturing in Australia. All split and window/wall units are imported, mainly from Asia, but Australian manufacturers retain a significant share of the ducted market.

Figure 2 Trends in Australian Average Maximum Temperatures, 1910 - 2005



Source: Australian Bureau of Meteorology http://www.bom.gov.au/cgi-bin/silo/reg/cli_chg/timeseries.cgi

Potential for further increases in air conditioning

As much as air conditioning penetration has increased in the last decade, it is still well below the USA level (Figure 1). Increasing penetration is likely to be the strongest driver for increasing the use of air conditioning in Australia, but by no means the only one. All else being equal, air conditioner use will also increase if dwellings become larger, if more rooms are air conditioned and if the frequency and duration of use increase.

A single window-wall air conditioner or single split systems can only fully serve one space, although it can partly cool other spaces via open doors or common walls. The installation of two or more split or window-wall units can cool more rooms, but true whole-house air conditioning requires outlets in each room, achievable with a 'multi-split' configuration (one central condenser unit serving several evaporator units) or with air-ducted systems.

Recent research in SA indicates that households with non-ducted systems typically cool 2 to 3 rooms, whereas ducted systems serve 5 to 6 rooms (MTR 2004). The average number of rooms served per SA household with air conditioning is 3.2, whereas the average per household with ducted air conditioning is 5.7 rooms. This suggests that there is still considerable scope for growth in the use of air conditioning, even in one of the most saturated markets in Australia, through the increase in the number of rooms.

As the purchase price and running cost premium of air conditioners over evaporative coolers declines, the takeup of air conditioning may well will increase further. It also illustrates the size of the evaporative cooler market that may be vulnerable to air conditioning, especially if the electricity supply costs of air conditioning continue to be subsidised.

Other factors contributing to growing air conditioner use are increasing average dwelling sizes, and the probability that global warming will increase the frequency of very hot days in summer. SA respondents report using their air conditioners an average of 11.5 days month during summer at present, so there is significant scope for increasing frequency of use.

Given the projections for growth in the number of households and in the penetration of air conditioner ownership, the likely growth in floor areas cooled and frequency of use, it is probable that household demand for air conditioning in Australia will more than double in the decade 2005 to 2015.

1.2 Energy and Peak Load

Present Contribution

Historically, air conditioning has accounted for a relatively small proportion of residential sector energy use (as distinct from peak demand), but a large proportion of commercial sector energy. It is estimated that air conditioning accounts for 5% to 6% of household energy use and over 30% of commercial sector energy use (GWA 2004). The contribution of air conditioning to peak load is far higher. Analyses of the summer and winter peak loads on the NSW electricity system in 2002/03 indicate that:

- Commercial sector cooling demand on the summer peak day was over 1,000 MW, accounting for about 32% of commercial sector demand, and over 8% of total system demand;

- Residential sector cooling demand was almost as great (980 MW at 4pm), accounting for about 39% of residential sector demand, and nearly 8% of total system demand;

- Cooling accounted for at least 16% of the system peak demand (12,456 MW) and probably more, since there would also have been significant air conditioner use in the industrial sector, which is more difficult to identify (GWA 2004).

In the commercial sector, the air conditioner share of peak demand is comparable to the energy share on an annual basis, so the 'load factor' of air conditioning is similar to that of other electric uses. In the residential sector however, air conditioners contribute only 5 to 6% of energy but nearly 40% of peak day demand – in other words they have a very low load factor. This makes the residential air conditioning load very costly for the electricity supply system.

Colebourne (2003) makes the following points with regard to the residential air conditioner load served by the EnergyAustralia (EA) network (covering most of Sydney, the NSW Central Coast, Newcastle and the Hunter Valley):

- The load factor of domestic air conditioners is only about 7%;

- On hot days the average demand of air conditioned dwellings more than doubles, at a time when network capacity is lower;

- Residential customers with air conditioners consume 40% more energy than average non-air conditioner customers, but contribute 200-250% more to the peak on summer days;

- It is estimated that every air-conditioned household received an annual cross-subsidy of $86 from non-air conditioner households (equivalent to $70 per non-air conditioner household, for a total annual cross-subsidy of over $50 M).

The peak load contribution of household AC is proportionally even higher in the Integral Energy (IE) network area, which serves western Sydney, the Blue Mountains and Wollongong, and the resulting cross-subsidy from non-AC users to AC users is estimated at $80-110 M per year (IE 2003).

The situation in other States is similar. An analysis of the relationship between system load curves and temperature in Victoria found that air conditioning is an even higher contributor to system peak demand, with state system peak loads on hot days up to 40% higher than on non-cooling days (Shevlin 2004). VENCorp projects a 2600 MW increase in temperature-sensitive summer load between 2001 and 2011 (Page 2004).

Taking the IE and EA figures as a guide, the total cross-subsidy from the 4.1 million non-AC households in the national electricity market (NEM) area to the 2.7 million AC-owning households could be in the range $300-500 M annually. Apart from the equity implications, this underpricing of the costs of supply is a serious distortion in the economics of the NEM, as is apparent from the National Electricity Market Management Company (NEMMCO) *Statement of Opportunities* (NEMMCO 2006).

Projected Increases in Demand

Table 2 summaries the projected growth in energy and demand in the main NEM regions. Peak demand growth is projected to significantly exceed energy growth in the regions with the highest penetration of household air conditioning - NSW, Victoria and SA. Although the Statement of Opportunities does not analyse end uses, it is obvious from the deteriorating load factor and growing temperature-sensitivity of demand projected for the largest AC markets that air conditioning will account for a growing share of the summer peak day system peak, and so drive network capital expenditures.

Table 2 Projected energy and demand factors in National Energy Market regions

National Electricity Market region	Projected 10-yr annual growth rates		Projected summer max demand 2006/07 MW				Demand-side Management (c)	
	Energy	Summer Maximum Demand	Average weather	Extreme weather	Excess demand	Increase over average	MW	% of excess demand
Queensland	3.5%	3.6%	9167	9974	507	5.5%	96(a)	19%
NSW	1.7%	2.7%	13780	14750	970	7.0%	21(b)	2%
Victoria (a)	0.8%	1.9%	9421	10234	813	8.6%	283(b)	27%
SA (a)	0.8%	1.6%	3222	3441	219	6.8%		
Tasmania	1.5%	1.6%	1438	1456	18	1.3%	0	0%

Source: NEMMCO (2006) (a) Less than in previous year's Statement of Opportunities. (b) More than previous year (c) Considered by NEMMCO as demand reductions available with high probability.

Boxed Example

Extreme Summer Day, 2030 – Two scenarios

1. All air conditioners on. Simultaneous hot spells in 3 NEM regions (SA, Victoria and NSW). Load shedding or very high capital costs to accommodate demand.

2. Demand response programs in place. Pool pumps switched first, then air conditioners cycled. If frequency drops, large number of auto-response refrigerators begin to cycle. If that is not enough, some air conditioners switched off to save local subs before problems spread.

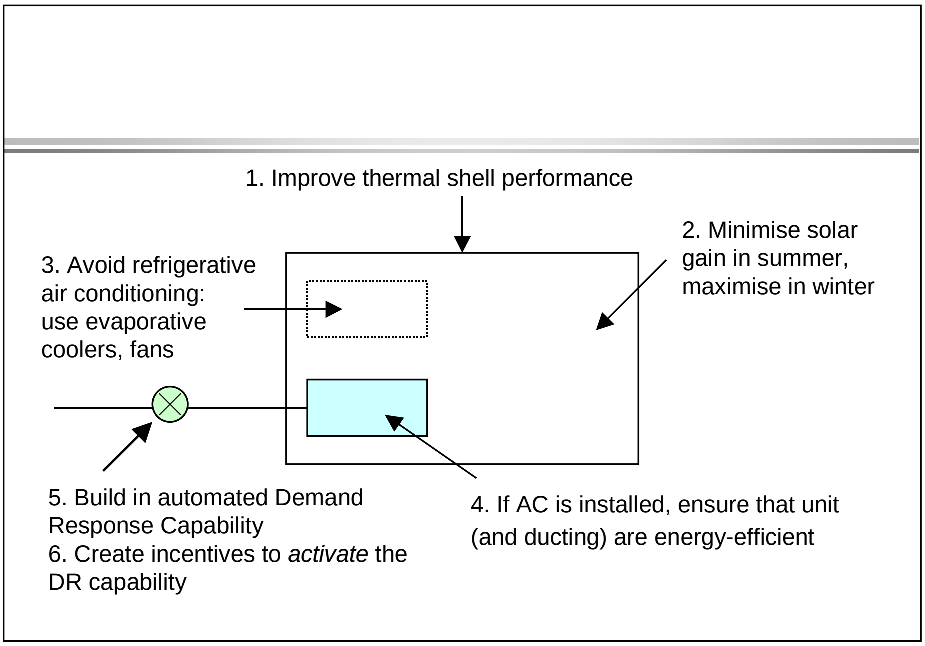
2 Strategies for Addressing Peak Load

2.1 Energy Efficiency and Related Strategies

Australian governments were made acutely aware of the peak load implications of household air conditioning during the summers of 2003-04 and 2004-05, when some cities experienced localised blackouts on days of extreme heat. (The summer of 2005-06 was relatively trouble free, since the most extreme days fell on weekends or public holidays when the business load was low).

There have long been energy efficiency programs focussed on improving building thermal performance (options 1 and 2 on Figure 3) and on increasing the energy efficiency of air conditioners sold (option 4). While these are worthwhile measures and cost-effective in their own right, their effect on peak load is limited.

Figure 3 Policy Response Options for Containing Air Conditioner Peak Load



Building thermal performance regulations mainly target steady state heat loss or gain, and the design changes they promote are less effective in limiting the demand for intermittent cooling. Another limitation is that less than 2% of the housing stock is built new or radically refurbished each year, so the rate of improvement in thermal performance is slow. For example, an increase in the thermal performance level of the entire housing stock in the state of Victoria to ‘5 star’ standard from the present 2.2 star average (measured using the AccuRate thermal simulation model) would have reduced the peak load in the residential sector in 2002 by about 530 MW on extreme days (EES 2006). The 5 star level was adopted as a minimum requirement for new homes built after June 2005. At a 2% annual housing stock replacement rate, the peak load reduction from higher thermal performance standards grows by only about 10MW per year. The difference between average summer peak day and extreme day demand in Victoria is already estimated at about 813 MW (Table 2), so at this rate relying on thermal performance alone to manage peak load would take 80 to 100 years.

Active discouragement of air conditioners would also help. Properly designed 5 star homes should not need air conditioning. However, there are currently no programs aimed at avoiding the installation of air conditioning, even in houses that are designed well enough to not need it, or in areas where evaporative cooling would be suitable (option 3). To be effective, a program of this type would need to based on price – eg by rolling in the peak demand costs into an up-front charge payable at the time of air conditioner purchase. Once installed, an air conditioner will almost certainly be used, even if comfort conditions are such that the householder would normally tolerate them.

Increasing the energy efficiency of air conditioners themselves (option 4) can work more rapidly than building standards, since about 6 to 8 times as many air conditioners are installed as homes built each year. Although air conditioner energy-efficiency has improved markedly since the introduction of energy labelling and Minimum Energy Performance Standards (MEPS), and MEPS levels are due to become significantly more stringent in 2008, the effect on peak load is limited.

Manufacturers are likely to achieve the target efficiencies by increasing cooling output rather than by reducing motor power, since claiming a higher cooling output has more commercial value. If the more efficient air conditioner is used in a thermally efficient home (where air conditioning should not be necessary) and it is well controlled, this should reduce both energy and peak demand. If not, then the motor demand at peak periods will be the same but cooling output will be higher.

The recognition that existing policies are not adequate on their own has led to the serious consideration of programs that directly target the operation of air conditioners at peak times (options 5 and 6). This means the development of a demand response capability (DRC) in air conditioners, so that householders – or better still, the air conditioners themselves – can respond to price and other signals.

2.2 Demand Response

Principles

While improving the thermal performance of housing and increasing the energy-efficiency of air conditioners will have some impact on air conditioner peak demand, the magnitude is difficult to predict, and could fall away sharply at the times of critical peak demand, when it is needed the most.

Managing the demand on the electricity system at times of peak load is the most direct way to address the air conditioner peak load issue. Many Australian utilities are already working with large business users to get them to curtail demand (or increase supply) during such periods. However, the cost of the necessary incentive payments comes from all electricity users, not just those who contribute to the peak load, so these schemes do not reduce inequities or change the behaviour of household air conditioner purchasers and users. Furthermore, this source of demand response is finite, and once it is fully utilised (in say 3 to 5 years time) there will be no alternative to focussing directly on the household sector.

The barriers to introducing demand response to the household sector are considerable. Once it is achieved, however, the following options become possible:

- demand response in air conditioning directly; this needs to overcome the technical problem that curtailing air conditioner operation sometimes has unacceptable consequences for thermal comfort; or

- demand response in other significant and potentially time-shiftable household loads, notably swimming pool pumps (present in about 10% of homes), or refrigerators, freezers and electric water heaters (all of which have inbuilt thermal storage, so can withstand brief power interruptions).

Some electricity suppliers are trailing systems which communicate changing electricity prices to households via in-home displays or – in the case of critical peak pricing – via telephone or SMS. These programs are valuable in informing users about changing energy prices, but their effectiveness in reducing demand depends on householders being at home, aware of the price signals and willing and able to respond by manually switching off or turning down appliances. In fact, price information may be counter-productive if it leads users to think that energy is cheaper than they expected, even at peak periods.[3]

The response process is far more effective and reliable if it can be automated. 'Demand Response Capability' (DRC) is the ability of individual items of electrical equipment to automatically reduce their consumption at times of high load on the electricity system, according to rules pre-agreed between the user and the electricity supplier. DRC could reside in the appliance itself, in an external controller (such as a 'smart' meter), or shared between the two. There are many technical pathways to achieving this, and none have made much headway due to lack of standardisation and high cost.

The essential building blocks of demand response programs are:

- A financial incentive to users to participate. This may be the wish to avoid high energy prices, or a direct incentive in the form of annual payments or payments per interruption episode. The incentive must obviously be high enough to ensure a useful level of participation, but not so high that the cost to the program sponsor outweighs the benefits. It is also common for utilities to reduce the risk to participants by offering over-ride or opt-out provisions - eg users can manually restart their air conditioner in the event that it is cycled off, but lose some financial benefit - but these can greatly reduce the program's effectiveness.

- Means for the energy supplier to communicate (with the user or directly with the product) when a peak load event is impending, and to communicate which of the pre-agreed responses will be or should be invoked.

[3] This may in fact have occurred in some trials, where household without in-home displays showed a greater demand reduction than households with.

- A range of pre-agreed decision points and response options: for air conditioning these could include complete interruption, cycling (eg limiting operation to 10 minutes out of every 30 during the peak event) or an increase in thermostat settings. The response options could be limited to one product only (typically the air conditioner) or decided at the time across other interruptible loads such as pool pumps and water heaters. The benefit of signalling directly with AC equipment is that fan operation (typically powered by a 0.1 – 0.3 kW motors) can continue even while the compressor motor (typically 1.5 – 3.0 kW) is off. For more advanced air conditioners, such as those with DC motors ('inverter' models) the optimum response could be left to the machine itself. For example, it could be programmed to optimise cooling while limiting total power to 0.5 kW during periods when it detects a 'critical price' signal from the supplier.

- The participation of the regulator. Given that electricity prices, metering and continuity of supply to residential and smaller business consumers is subject to regulatory control in every jurisdiction, as is the mode of recovery of network costs and DM program costs, the approval of the regulator is essential.

The principles of demand response are similar irrespective of the customer class. However, the demand management of household appliances and equipment is far more complex, since it potentially involves millions of dispersed decision-makers and appliances. For this reason most electricity utilities have concentrated their efforts on larger industrial and commercial users, who can take large blocks of load off line or switch to back-up generation on request or in response to electricity price signals.

Cost-reflective pricing alone does not constitute a demand response program. It can signal to consumers the value of demand response, help recover supply costs more equitably from those who contribute most to them, and can motivate customers to consider demand response options if those are available. However, it is necessary to offer a practical means for customers to contain the costs of their individual energy use, and this distinguishes a demand response objectives from cost-recovery. Pricing is a necessary but not sufficient condition for demand response.

Utilities may have no interest in demand response if their infrastructure is not constrained, if they are shielded from the volatility of the wholesale market and if they are in a position to recover their costs. Indeed, regulated distributors may have a commercial incentive to invest more in distribution infrastructure in order to increase their earnings, so they may be interested in time of use pricing without necessarily encouraging demand response.

Demand Response, Energy Efficiency and Greenhouse

The term 'demand management' usually covers all efforts to influence the use of energy, including both the efficiency of energy consumption and the time of use. The main objective of demand response is to reduce the demand on the electricity supply system at times of high price, congestion or stress. If this energy use is permanently foregone and is not made up at other times, there is a reduction in energy use and hence greenhouse gas emissions.

In some cases demand response results in shifting energy use from peak periods to other times. Indeed, demand response programs which give advance notice of interruption may prompt energy use which may not have occurred otherwise – for example, pre-cooling of buildings in case they are occupied at the time of the impending interruption or high-price period.

This could result in a net increase in greenhouse gas emissions if more energy is used, or if electricity generation outside peak hours is more CO_2-intensive than during peak hours. This may be the case if peak energy is generated from hydro or gas and baseload energy is generated from coal.

Ultimately, the rationale for demand response is not environmental but economic: greatly increasing the efficiency of capital utilisation. In many cases there is also a public safety dimension, through reduced risk of catastrophic failure of electricity supply.

2.3 International developments

The United States

Many electricity suppliers in the USA have implemented successful demand management programs for large users, often at the direction of their State public utilities commissions (eg Smith et al 2004). To recruit large users to participate in such programs it is necessary to offer a financial benefit that exceeds the cost in lost production, reduced amenity (eg through temporary shut-down of large central air conditioners), the costs of operating standby plant and the additional wear and tear of plant restarts after interruptions.

Almost all large electricity users purchase under contracts with time of use and/or peak demand pricing features, so it is relatively straightforward to determine their load profile and the value of load withdrawals. Also, there is usually a range of communications channels available – from telephone to wireless to internet-based systems – by which the utilities can signal impending peak load events and interruptions, customers can signal their intention to participate or not (if the agreement allows them a choice) and utilities can monitor customer behaviour.

Many electricity utilities in the USA also offer demand management programs to residential and small business customers, and in some cases have been doing so for decades. The programs cover a wide range of approaches and targets, in terms of:

- Housing types: most utilities target single-family residences, while east coast utilities also target multi-family apartment blocks (where setup costs per unit are significantly lower);

- Automation of response: in some cases customers are informed about price peaks but the response is left to them, while in others the utility can directly control aspects of equipment operation (eg air conditioner cycling or thermostat set points);

- The level of information given to individual customer about their energy use and load patterns, and about individual demand response events.

Despite the large number of trials and actual programs, the level of success has been mixed (Agnew et al (2004) Masiello et al (2004)). A recent survey of 40 US and Canadian utilities found that about a third offered programs under which residential consumers could have part of their load – mostly the air conditioners - controlled to some extent by the utility (Gunn 2006). The rate of participation varied widely: less than 5% of eligible customers for a third of the programs, between 5% and 20% for third and over 25% for the rest.

The US Electricity Policy Act of 2005 (passed 8 August 2005) elevated demand response to a national priority. Section 1252 of the Act required the Federal Energy Regulatory Commission (FERC) to publish annual reports assessing demand response potential by region. Congress directed that this report be prepared and published not later than one year after the date of enactment of the EPAct 2005, and specifically to identify and review the following for the electric power industry:

- saturation and penetration rate of advanced meters and communications technologies, devices and systems;
- existing demand response programs and time-based rate programs;
- the annual resource contribution of demand resources;
- the potential for demand response as a quantifiable, reliable resource for regional planning purposes;
- steps taken to ensure that, in regional transmission planning and operations, demand resources are provided equitable treatment as a quantifiable, reliable resource relative to the resource obligations of any load-serving entity, transmission provider, or transmitting party; and
- regulatory barriers to improved customer participation in demand response, peak reduction and critical period pricing programs.

The first report concludes that:

> Based on the results of the FERC Survey, input from interested persons, and an extensive examination of regional and national trends in electric demand response programs policy, Commission staff concludes that demand response has an important role to play in both wholesale and retail markets. The potential immediate reduction in peak electric demand that could be achieved from existing demand response resources is between three and seven percent of peak electric demand in most regions. However, the technologies needed to support significant deployment of electric demand response resources, such as advanced metering, have little market penetration.
>
> Demand response deserves serious attention. Staff recommends that the Commission: (1) explore how to better accommodate demand response in wholesale markets; (2) explore how to coordinate with utilities, state commissions and other interested parties on demand response in wholesale and retail markets; and (3) consider specific proposals for compatible regulatory approaches, including how to eliminate regulatory barriers to improved participation in demand response, peak reduction and critical peak pricing

> programs. Staff also encourages states to continue to consider ways to actively encourage demand response at the retail level. In particular, staff recommends that the Commission and states work cooperatively in finding demand response solutions. (FERC 2006)

The State of California

The major California electricity utilities (Pacific Gas & Electric, Southern California Edison and the Sacramento Municipal Utilities District), the California Energy Commission and the California Public Utilities Commission have been particularly active recently in the development of demand management, including demand response programs (although more utilities in the Midwest offer load control programs, and states such as Pennsylvania have a far higher penetration of advanced meters). California is exceptional in that it is considering mandating demand response technology.

In 2004 and 2005 the three utilities conducted a trial of the Automated Demand Response System (ADRS) program, which is based on 'GoodWatts, an advanced, two-way, realtime, comprehensive home energy management system.' (Wang & Swisher 2006). Participants can set climate control and pool or spa pump run time preferences via the internet, and view these settings at any time. Participants can also monitor whole-house and end-use specific demand, and energy price variations, including critical price events. The average load reduction achieved on 'event days' varied between 1 and 2 kW, with air conditioners contributing most of the load reduction and swimming pool pumps the rest (although pumps made up half the load reduction on non-event days).

The California utilities are now factoring demand response into their forward strategies alongside energy efficiency programs (Ceniceros & Vincent, 2006), even though the rates of growth in maximum demand are relatively modest (1.5 - 1.6% per annum) compared with projected growth rates of 1.6 - 3.9% in mainland Australia (Table 2). The California Public Utilities Commission (CPUC) Energy Action Plan II states that in 2003 about 12,000 MW of load reduction were achieved from energy efficiency programs, and plans to obtain an additional 5,000 MW of load reductions by 2013 (CPUC 2005).

California is now proposing to mandate demand response capability for new heating and cooling equipment, using the building code ('Title 24'). It is proposed to do this with Programmable Communicating Thermostat (PCTs), which are to have the following capabilities:

- A clock mechanism that allows the building occupant to set back the temperature set points for at least four periods within 24 hours;

- A non-removable communications device compatible with the default statewide demand response communications system to be operated by the utilities (the technical details of which are to still be determined);

- The ability to respond to price events, by adjusting the thermostat setpoint by up to 4ºF (up in cooling mode and down in heating mode) for the duration specified in the signal;

- Programmability: allowing the customer to change the default response prices and thermostat settings at any time, including during price events;

- Emergency response: changing the setpoint by the number of degrees or to a specific temperature setpoint as specified in the emergency signal, which cannot be over-ridden (this would in effect allow air conditioners to be switched off by setting the thermostat setpoint equal to the outside temperature);

- Give users information regarding communications system connection status, type of event (price or emergency), and other maintenance-related information, using a display on the PCT or on a separate standalone indicator.

If enacted, this would mandate a standardised demand response capability for air conditioners, by preferring one of a wide range of possible technological pathways. The mandated point of contact between the electricity supply system would be the air conditioner thermostat. This approach is far more suited to the type of air conditioner and the pattern of use common in California – central air conditioners in use for most of the day – rather than in Australia – split systems generally in use only for part of the day. It also relies on the fact that the regulators – the CEC and the CPUC – retain a higher degree of operational influence over the utilities than is the case in Australia.

United Kingdom

Unlike the USA and Australia, the UK electricity supply system does not have a significant problem with air conditioner-induced peak loads. Nevertheless, there is considerable interest in demand response and distributed generation as direct substitutes for centralised generation as a means of maintaining system reliability, but with far lower capital costs and no greenhouse gas emissions.

The Market Transformation Program (MTP) of the UK Department of Environment, Food and Rural Affairs (DEFRA) is funding research on the automatic cycling of household products in response to changes in grid frequency, starting with refrigerators (Short & Leach 2006). Devices with similar capabilities have also been developed at the Pacific Northwest National Laboratory in the USA.[4]

The Climate Change and Sustainable Energy Act 2006 (enacted 21 June 2006) contains the following provisions:

> **18. Reduction of greenhouse gas emissions: report regarding dynamic demand technologies**
>
> (1) The Secretary of State must, not later than 12 months after this section comes into force, publish a report on the contribution that is capable of being made by

[4] http://availabletechnologies.pnl.gov/technology.asp?id=61 accessed September 2006

dynamic demand technologies to reducing emissions of greenhouse gases in Great Britain

(2) The report must state the view of the Secretary of State as to whether it is appropriate to take any steps to promote the use of such technologies, and, if it is, what those steps are.

(3) In forming the view mentioned in subsection (2) the Secretary of State must have regard, in particular, to any matters which would prohibit or inhibit the use of any dynamic demand technology in any circumstance in which its use could be expected to make a contribution to reducing emissions of greenhouse gases in Great Britain; and the report must state the matters to which he has had regard.

(4) In this section-
"dynamic demand technology" means any technology which enables-
(a) the consumption of electricity, at a particular time, by a device connected to a network, or
(b) the generation of electricity, at a particular time, by an electricity microgenerating system connected to a network,
to be controlled or adjusted automatically by reference to, or to matters relating to, the frequency of alternating current on the network at that time"

International Energy Agency

The International Energy Agency (IEA) Demand Side Management/Energy Efficiency (DSM/EE) Program has a number of activities ('Tasks') with demand response elements:

- Task II – Communication Technologies for DSM (completed task)
- Task VIII – Demand Side Bidding in a Competitive (completed task)
- Task XI – Time of Use Pricing and Energy Use for Demand Management Delivery
- Task XIII – Demand Response Resources
- Task XV – Network Driven DSM

Australia is represented on the DSM/EE Program Executive Committee and is actively involved in all tasks, and an Australian consultant is the operating agent for Task XV, the objectives of which are:[5]

> '…identifying the most appropriate and cost-effective DSM measures to relieve electricity network constraints, whether these constraints are time related (eg occurring at times of the network system peak) or location-related (eg associated with particular lines or substations) or both. All types of constraint will be addressed, including capacity limitations, voltage fluctuations, reliability issues, etc. Such network-driven DSM measures are often more cost-effective, and may

[5] Dr Harry Schaap is a Vice Chairman of the Executive Committee and Dr David Crossley is the operating agent for Task XV, the other members of which are France, Spain and the USA.

also have lower environmental impacts, than network augmentation (ie building 'poles and wires').

In addition to relieving network constraints, DSM can also provide services for electricity network system operators, achieving peak load reductions with various response times for network operational support. Task XV also covers DSM activities which provide network operational services.'[6]

[6] http://dsm.iea.org/NewDSM/Work/Tasks/15/task15.asp accessed October 2006

3 Demand Management in Australia

3.1 Utility trials

Most of the activity aimed at reducing peak load in Australia has focussed on the commercial and industrial sectors, for the obvious reasons that they are logistically easier to address than the residential sector.

However, some Australian utilities have already carried out trials of direct load control for household air conditioners. In 2001/02 Integral Energy, the distributor serving western Sydney, conducted a trial of interruptible tariffs jointly with the NSW Sustainable Energy Development Authority (SEDA).

Customers in the target area were offered a financial incentive to participate, subject to their air conditioners having an auto restart capability. Two communication systems were trailed: a pager system, and frequency injection. A controller and 'smart' meter was installed at the customer's switchboard. The duration of interruption was limited to 30 minutes, but the interrupt also affected the fan.

The trial was successful at the technical level, for both methods of communication, but the economic benefit to the utility was not clearly demonstrated. In particular, the administrative costs were high. These could be reduced if there were direct linkage to the metering and billing system (BES 2003).

After some years of inactivity, there has been a resurgence of electricity utility interest in demand response at the household level in the last few years, led by distributors rather than retailers. The activities under way at the end of 2006 are summarised in Table 3. All of these are trials – no distributor in Australia has so far offered a demand response tariff or contract to all household customers in its service area.

Table 3 Recent and Continuing Household Demand Response Investigations

Utility	Number of Participants	Dynamic price info to participants	Communication with appliance	Appliance control
Country Energy, NSW	150	Advance notice of CPP by messaging, IHDs etc	None	Manual Any appliance
Integral Energy, NSW	21	Advance notice of CPP	Ripple control	On/off cycling Air conditioners
EnergyAustralia, NSW	1300	Advance notice of CPP by messaging, IHDs etc	None	Manual Any appliance
Energex, Qld	370	Indication of CPP	Ripple control	On/off cycling Any appliance
ETSA, SA	2000	None	FM radio	Variable cycling Air conditioners

It is apparent that the approaches differ from one another in key respects:

- The degree to which customers are involved in managing their appliances when energy prices are high and/or the distribution system is constrained. This ranges from complete responsibility (ie it is the customer's responsibility to respond to messages and indications on the in-home displays (IHDs) in the Country Energy and EnergyAustralia trials) to no involvement at all (ETSA);

- The equipment required: some approaches require both a communicating interval meter and an in-home display, while others require neither but rely on equipment which directly controls the appliance;

- 'Firmness', or the likelihood that a signal from the distributor will result in demand response. This is lowest for manual systems, where all action relies on the user (Country Energy and EnergyAustralia) and highest for systems where there is direct control of the air conditioner (ETSA and Integral). The Energex model, which relies on the user to plug in the controlling device, is somewhere in between.

At this stage none of the trails have concluded with firm recommendations for further action, or in demand-related tariffs or contracts for general offer.

The eventual results of the trials, however, will have major implications for whether a national approach to demand response emerges, and the supporting technologies - interval meters, in-home displays and/or air-conditioner controllers.

Given the diversity of approaches it is likely that different distributors will offer different tariffs and contracts, and that different States will mandate or constrain options in different ways.

The only elements common to all approaches are the appliances themselves: if all the effort on the distributor's part fails to produce a reduction in demand from the appliances, then the program has no effect on the magnitude of peak demand, although it can help the distributor recover the costs of meeting that demand more equitably.

For approaches which rely on manual switching or set-back by the users in response to a price signal, no special appliances or end-use equipment are necessary. For programs that rely on direct appliance control, however, the characteristics of the appliance become crucial. The Equipment Energy Efficiency Program, which has mandatory influence over many aspects of appliance performance and point-of-sale information disclosure, is obviously a key participant in automated demand response programs.

3.2 Other participants

Equipment Suppliers and Industry Associations

There are many parties, in addition to the electricity distributors, with a commercial interest in the emerging approaches to demand response in Australia.

The suppliers of interval meters and in-home displays are promoting approaches which use their products. The suppliers of the ripple control switches used in the Energex trail and the controllers used in the ETSA trial also have an interest.

The air conditioning industry is sensitive to the contribution of their products to peak demand, and well aware that management of the peak demand issue is essential to the continued growth of their market. In early 2005, with the encouragement of the AGO, the air conditioner industry association, AREMA, set up an informal working group with the electricity distributors. This now meets regularly to exchange information on demand response trials and in particular to resolve technical issues relating to the control of air conditioners.

So far this grouping has produced a guide to assist utilities to apply ripple control technology to the cycling of air conditioners (AREMA 2005) and has assisted ETSA with the development of an 'emulator' which keeps the fan on indoor split units operating while the power supply to the outdoor unit is interrupted. These is effective across a range of brands and models, so demonstrating the value of non-proprietary approaches and 'open' rather than 'closed' standards and technologies.

Demand Response Aggregators

There is only one Demand Response Aggregator in Australia at present. Its business is to approach Commercial and Industrial electricity users and make commercial agreements regarding load curtailment and on-site generation at time of peal demand. The aggregator then 'packages' the load response for sale to entities to whom it has value: electricity distributors and electricity retailers. The aggregator works with users whose individual loads and curtailment potential is too small to be of direct interest to the buyers, but where the aggregated load has a high commercial value.

The principle of aggregating smaller load reductions is the same for household as for business users. If the cost of household load response were low enough and the reliability high enough (without necessarily being 100%), then aggregators would enter the market to develop, purchase and package household air conditioner load response.

3.3 Pricing, metering and regulation

State Positions

The state electricity regulators have recognised, with increasing urgency, the need to address peak load investment in general and the role of air conditioning in particular. They have focussed on:

- Encouraging and sometimes requiring distributors to investigate DM opportunities before receiving regulatory approval for network extension or enhancement.

- Ensuring that distributors and retailers have an incentive to implement DM programs, or at least no disincentive, and ensuring that each party can capture sufficient share of the value of any benefit to make its participation cost-effective.

- In the case of Victoria, mandating the roll-out of interval metering for smaller users in order to, among other things, provide a platform and a framework for DM programs targeted to small users.

However, there is no uniformity of approach to this issue among the different state regulators in the NEM. One major point of difference is whether clearer electricity price signals alone would motivate suppliers to offer, and customers to take up, DM opportunities, or whether the emphasis should be on direct load control.

The Essential Services Commission of SA (ESCOSA) favours direct load control over ‘pricing based strategies’ which communicate prices but leave the response to the user (such as in-home displays):

> In order to defer augmentation costs, the demand management initiatives under consideration must be able to guarantee the load reduction at peak times. This requirement can particularly act against pricing based strategies where consumer behaviour is unpredictable (especially over long hot spells). Thus direct control of loads by a distributor appears to be one of the essential features of any demand management scheme that is designed to defer network augmentation costs. The rollout of interval meters (by themselves) does not guarantee any load reduction during peak load periods (ESCOSA 2004).

The Essential Services Commission of Victoria (ESC), on the other hand, is the first State regulator to mandate a rollout of interval meters to all electricity customers, including residential users (ESC 2004). The target is to complete the Interval Meter Rollout (IMRO) by 2011 for all users above 20 MWh per annum, which would cover most small businesses but only the largest of households.[7] For all existing consumers of less than 20 MWh per year, those with off-peak or three-phase metering are to be equipped with interval meters between 2006 and 2013. From 2008, all new and replacement services will be equipped with interval meters.

There is considerable debate over what functions the meters in the so-called Advanced Metering Infrastructure (AMI) should have, and whether the additional benefits of these functions are likely to exceed the additional costs. The Victorian Department of Infrastructure (DOI) has published a draft Functionality Specification which concentrates on communications and remote reading for AMI, and designates in-home displays and load control for air conditioners and other appliances as optional functions (DOI 2006). The only load management function to be include as a central is related to water heaters and storage space heaters, to ensure that distributors can continue to manage the existing off-peak load that has evolved in Victoria over many decades.

Charles River Associates makes the following observation on the relationship between interval meters, their communications functions and demand response:

> In scenario 1, adding communications to IMRO meters does not necessarily produce incremental DR benefits, since time-varying pricing can be supported with manually read IMRO meters, albeit with significantly delayed billing, which, some have argued, may diminish demand response. Thus, the pricing options available with and without communications functionality are largely the same. Adding communications may give enhanced demand response for IMRO customers through the use of enabling technology – smart thermostats, in-home notification devices, direct load control devices, etc. However, using the meter communication channel for these devices may not be the least cost option, and

[7] In 2004/05 the average Victorian household used 5.5 MWh (*Electricity Australia* 2006).

> there are certainly methods of providing this capability in the absence of advanced meter communications (CRA 2005).

The DOI is planning to conduct a trial of AMI technology between December 2006 and mid 2007.

COAG and MCE

The *National Competition Policy Review* (February 2006) included the following recommendation (number 2.2): ‘COAG agree to improve the price signals for energy investors and customers by:

> (a) committing to the progressive roll out of electricity smart meters to allow the introduction of time of day pricing and to allow users to respond to these prices and reduce demand for peak power;
> (b) requesting the MCE to agree on common technical standards for smart meters and implement the roll out as may be practicable from 2007 in accordance with an implementation plan that has regard to costs and benefits and takes account of different market circumstances in each state and territory; and
> (c) implementing a comprehensive and enhanced MCE work program, from 2006, to establish effective demand side response mechanisms in the electricity market, including network owner incentives, effectively valuing demand-side responses, regulation and pricing of distributed and embedded generation, and end user education.’

At its February 2006 meeting, COAG endorsed the recommendations in the National Competition Policy Review:

> In recognition that past energy market reform has focussed on improving supply efficiency, COAG has agreed to improve price signals for energy consumers and investors . Actions include committing to the progressive national roll out of 'smart' electricity meters from 2007 to allow the introduction of time of day pricing and to allow users to better manage their demand for peak power only where benefits outweigh costs for residential users and in accordance with an implementation plan that has regard to costs and benefits and takes account of different market circumstances in each State and Territory.

The matter was further considered at the meeting of the Ministerial Council on Energy (MCE) on 27 October 2006:

> Ministers agreed on a policy framework for pursuing a progressive roll out of smart meters, including an initial statement of functionality and a broad timeline for development of the initiative. Final and detailed policy decisions will reflect a cost-benefit analysis managed by MCE and stakeholder consultation. Further analysis of jurisdictional markets to identify implementation costs and benefits, and consultation with all stakeholders, will now commence.

Thus time-variable pricing is now directly on the national energy policy agenda, and so by implication is the means for customers to respond to price signals through the adoption of demand response.

However, the role of interval meters in the development of demand response is far from settled, even in Victoria, the one jurisdiction that is planning to roll them out.[8] The Energy Networks Association, the national industry body representing electricity distributors, has commented on this with some concern (ENA 2006).

3.4 Technical elements of demand response

Communications

Electrical products normally operate under user control. The user decides when they should operate and sets the level of energy service output, and usually expresses these preferences via a mediating device such as a time clock or a thermostat, so creating a disconnect between the time of decision and the actual time of operation. There may also be a geographical disconnect between the user and the product: some air conditioners offer the option of switching on and off and changing thermostat settings remotely via mobile phones or the internet. Given the widespread use of electronic controls in all household appliances, such capabilities can be added at low cost.

Users who elect to participate in automated demand response allow a ‘remote agent’, typically an electricity utility or a DR aggregator, to intervene in the control of their electrical products, and modify its operation or even turn it off entirely during ‘demand response events’. The product must somehow detect the beginning and end of the event, and the response required. In many cases the only possible response is to turn off at the start of the event and on at the end of it, but in other cases there will be a wide range of possible responses depending on the design of the product and the information it receives. For example, an air conditioner could be programmed to keep operating during normal peak price periods, to cycle on an off during critical peak price periods, which may occur only 10 times a year, and to switch off completely in an emergency where the stability of the supply system is at risk.

Technically, when to initiate and terminate demand response, and what action to take, could be communicated in a number of ways:

- The remote agent can send a signal to a controller which interrupts the power supply, and then another signal which re-connects it. This will restart the connected appliance (assuming the appliance did not interpret the original interrupt as a fault and shut itself down). The signals could be conveyed by a number of channels, including telephone landline, the GPS mobile phone network, other wireless networks or via the power line itself;

- If the appliance is pre-programmed, the remote agent can signal an impending DR event ahead of time, and the appliance will do the rest. Air conditioners could be programmed to increase cooling before the DR event so comfort conditions can be

[8] The NSW electricity distributor EnergyAustralia has independently decided to roll out interval meters in its service area, but the rate of rollout and the meter capabilities are to be decided by EA and not by regulators, as in the case of Victoria and possibly other jurisdictions.

better maintained. If the duration of the event is indicated in the original signal, no restart or end of event signal is required;

- Alternatively, the appliance can be programmed to change its behaviour in response to electricity price. The remote agent may signal price via non-communicating interval meters (where price bands may be hard-wired or only resettable when a meter reader comes by) or by communicating interval meters (where data on prices, including critical peak prices and emergencies, can be updated continuously). However, price signals can bypass the meter entirely, and be conveyed by wireless, internet or power line carrier.

- In some cases no explicit signal is necessary: the appliance directly monitors its operating environment and alters its behaviour if specified parameters move outside preset values. This is the principle behind the automatic cycling of household products in response to changes in grid frequency, which is being investigated under the Climate Change and Sustainable Energy Act 2006.

This is by no means an exhaustive list of options – many other communications modes and pathways are possible.

Control

Just as there is a wide range of communication possibilities, the control of demand response could be arranged in a number of different ways. The decision to initiate demand response could be left entirely to the external agent who sends the initiation signal, so the appliance need have no analytical capability of its own. Alternatively, the logic could reside in the electricity meter, which shuts off the supply circuit/s to the selected appliance/s once electricity prices reach a preset threshold. Another possibility is for the logic to reside in a separate controller, which switches off or adjusts a number of appliances and lights in the household according to algorithms which reflect the preferences and priorities of the householder.

'Opt-in' and 'over-ride' are also important considerations. A householders who moves into a home where demand response equipment was installed by the previous occupant may not wish to participate. Alternatively, if all air conditioners are sold with DR capability, the householder may have to contact the electricity supplier to activate the capability in order to take advantage of special tariffs or for refund of a 'demand response bond'. How appliances can be switched in or out of a demand response program, and whether this can be done remotely – saving the considerable expense of a service call – is an important aspect of control.

'Over-ride' means the ability of a householder who has opted in to nevertheless prevent or terminate an individual demand response event, if for example a member of the household is ill and uninterrupted cooling is needed. Most DR programs allow some over-ride, but differ widely on the extent (eg cooling continues but at a higher thermostat setting) and the financial disincentives (eg by charging the critical peak price or reducing an annual incentive payment).

Some DR approaches offer no possibility of over-ride. In the past, for example, when off-peak water heaters ran out of hot water during the day the household had to make do with cold water until the off-peak circuit was energised again. This became a barrier to consumer participation in this particular DR program, especially when competing gas water heaters offered uninterrupted reheating at comparable energy cost. This led to the introduction of the ‘dual element’ heater which reduced the risk of running out of hot water for the householder, but greatly increased the price risk to electricity retailers, who often found themselves in the position of purchasing electricity at peak wholesale spot prices while selling it to users at off-peak tariffs. The mode of over-ride is a critical element in both the marketing and the economics of demand management.

Standards

There are many possible ways to structure, recruit participants for and operate demand response programs, involving a range of financial incentives, communications channels and modes of control. A given air conditioning unit may not be compatible with a given DR approach, for range of technical reasons. If so, the program operator can either compensate with its own equipment and systems – thereby raising the cost – or exclude the unit from the program, so reducing the potential benefit.

DR programs which retrofit controls to existing appliances in the field will encounter a large number of unsuitable appliances, so the cost per successful application will be high. There is an opportunity to standardise key design features of new appliances, so the future cost of DR programs will be much lower. In fact, the aim should bne to build a minimum level of DR capability into every air conditioner sold, so that the costs to the utility or aggregator of including it in a DR program are very low.

It is neither necessary nor practical to make every product compatible with every possible approach, but the more standardised the elements of DR systems, the more likely that product suppliers will ensure that their products are compatible.

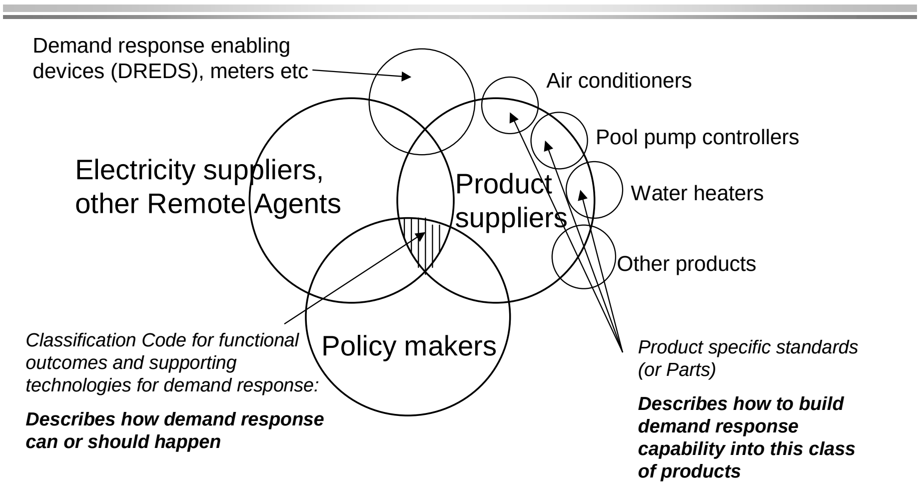
In 2006, at the request of the AGO, Standards Australia formed a new committee EL-54, *Remote Demand Management of Electrical Products*, with representation from electricity distributors, appliance manufacturers, research and professional organisations and government. The committee is in the process of preparing a new Australian Standard, a *Classification code for demand response capabilities and supporting technologies for electrical products*.

The target users of the Standards are:

- Remote Agents (mainly electricity suppliers) planning DR programs;
- Government agencies, whose interest is encouraging the development of DR programs (at the request of Energy Ministers), and who could help market DR-capable products by using the energy labelling and standards scheme; and
- Electrical product and Demand Response Enabling Device (DRED) suppliers, who have to meet the needs of electricity suppliers, governments and, of course, consumers.

At present these parties do not have a common language to discuss demand response. The purpose of the *Classification Code* is to provide the essentials of that common language. Further parts of the Standard, addressing technical issues relating to demand response for air conditioners, swimming pool pumps and water heaters are planned, and further parts will be prepared as needs are identified. (see Figure 4). Labels, marks and or other tools for marketing DR-enabled products to consumers will also be included in the Standard in due course.

Figure 4 Relationship of Classification Code to users and other possible standards



When electricity suppliers or DR aggregators plan a DR program, they will want to make sure that the electrical products and/or DREDs, will have characteristics which:

- make them compatible with their own communications and control systems, and their technical/economic drivers; eg some may want the ability to 'set and forget' DR at price levels rather than actively initiate each DR event; and
- make them marketable to their customers, by reducing buyer cost, fear and risk; this could involve the assurance of not needing to buy additional hardware, and the assurance of opt-out or over-ride capabilities, etc.

Electricity utilities can use the *Classification Code* as a guide or checklist in negotiating with potential suppliers of DR-capable products and DREDS. When the DR-capable products actually come on the market they will need to be easily identifiable to both the electricity supplier (who may give a cash incentive to buyers of those products or admit them to more favourable tariffs) and to buyers.

The most efficient way to identify DR-capable products may be through the channels with which consumers are already familiar, such as the www.energyrating.gov.au website. The lists of air conditioners could carry special symbols or logos against models which meet specific electricity suppliers' or demand response aggregators' criteria (eg ‘DR-Ready Type A’, ‘DR-Ready Type B’ etc if say, ETSA and Integral have different requirements).

It is likely that each such electricity supplier-product supplier arrangement will create a distinct ‘Type’ or ‘Profile’. One restraint on the multiplication of profiles will be that product suppliers will not want to fragment an already small market, so if too many utilities try to come up with new profiles, product suppliers will not be interested. There is an obvious first mover advantage to both electricity suppliers and product suppliers, and advantages for groups of electricity suppliers to harmonise their needs.

In due course products meeting the standard profiles could be identified on the energy label itself. A neutral terminology such as ‘DR-Ready Type A’ may be preferable to a comparative rating (eg ‘the more stars the better’) since it will be hard to determine whether ‘Type B’ offers ‘higher’ capability than ‘Type A’. There is already a commercial incentive for product suppliers to obtain a higher energy star rating, and DR labelling will add a further incentive to supply products meeting the profiles supported by the largest number of suppliers (or backed with the most valuable purchase incentives). If the one model can satisfy the requirements of more than one profile (eg ‘Type A’ *and* ‘Type B’) then it will obviously have a commercial advantage.

Since there will be a significant incentive in claiming DR-capability, it will be essential to have a clear definition of DR criteria in a Standard which can ultimately be invoked in legislation in the same way as the energy efficiency testing and labelling standards.

Initially, it may be appropriate allow voluntary labelling of DR-capability, but once this becomes a significant factor in purchase decisions (as is likely for air conditioners and pool-pump controllers), there may be a case for mandatory inclusion of the type of DR-capability, or the absence of DR-capability, on energy labels (subject to the usual cost-benefit analysis).

In addition to the ‘special profiles’ likely to be created through negotiation between specific electricity distributors and product suppliers, it would also be possible to develop a small number of discrete ‘standard profiles’, for example:

- Basic load control compatibility: this designation could be available to air conditioners which are equipped for at least one mode of communications (eg power-line carried signals, GPS or internet), and are able to cycle the compressor off without affecting fan operation and can restart automatically.

- Advanced load control compatibility: this designation could be available to air conditioners which are equipped for at least one mode of communications (eg power-line signals, internet), and are able to optimise operation within a preset kVA limit (say 0.5 kVA for a period of 1 hour), balancing compressor run time and fan operation. Inverter units would be well suited for this.

- Smart meter load control compatibility: ability to respond to control or real-time price signals received via a standard smart meter interface (assuming that a standard interface becomes part of the basic performance specification for the proposed Advanced Metering Rollout.).

The existence of ‘Standard profiles’ would create additional drivers for development of DR by building up a pool of products which could be incorporated into DR programs at minimal cost.

Existing Appliances vs New Appliances

The demand response trials implemented in Australia to date have naturally been concerned with the control of the existing stock of air conditioners. However, the lessons learned will inevitably have to be applied to new appliances as the stock turns over.

A control device that is connected (literally or figuratively) to an old air conditioner is only effective for the remaining service life of that product. When the air conditioner fails, the options are to retrieve the controller, allow it to be scrapped along with the appliance or try to ensure that if the occupant buys a new air conditioner it is compatible with the controller. Any of these options are costly for the DR program. The greater the number of new models that have compatible DR capabilities built in, the lower the ‘churn cost’ from existing participants.

Figure 5 illustrates the historical sales of household air conditioners in Australia to 2005, and projections to 2021. Sales are differentiated according to whether:

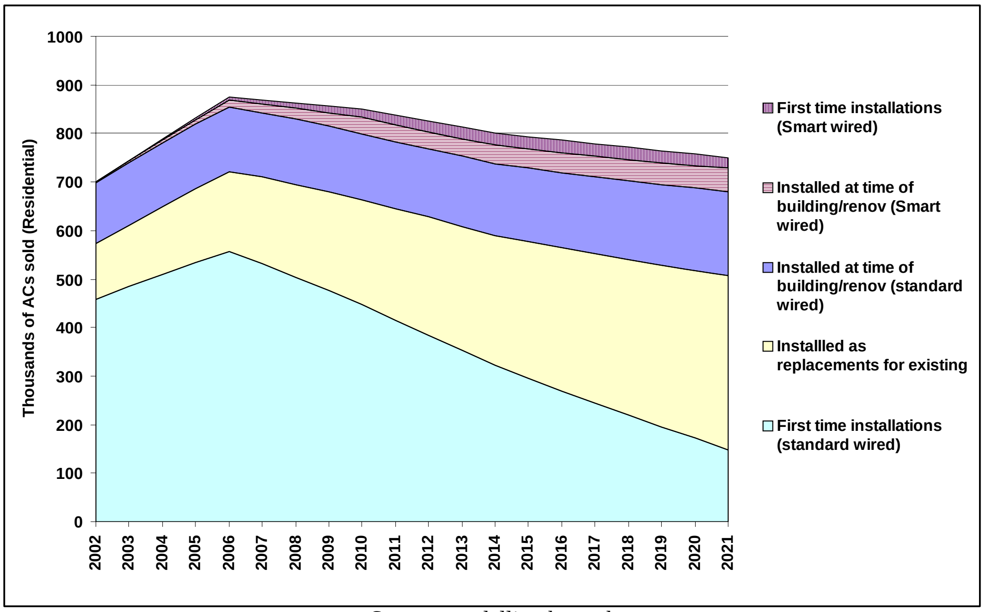
- The air conditioner replaces an existing unit or is the first installed in an existing home;
- The air conditioner is installed at the time of construction of a new home; and
- The air conditioner is installed in a dwelling with a ‘smart wired’ controller – where the control logic for DR response could conceivably be located, so that it survives individual appliances – or in a ‘standard wired’ home, where the only options are to include the DR capability in the appliance itself or to retrofit a special device.

It is apparent that the great majority of air conditioners will continue to be installed in existing homes, independently of building work, and only a small proportion will be linked to a ‘smart wired’ controller.

Figure 6 illustrates the importance of concentrating on new products as soon as possible. At the present high growth rates in ownership, nearly 1 in 6 of the entire household appliance stock is installed new each year, and in 10 years’ time only half the air conditioner in use today will still be in use.

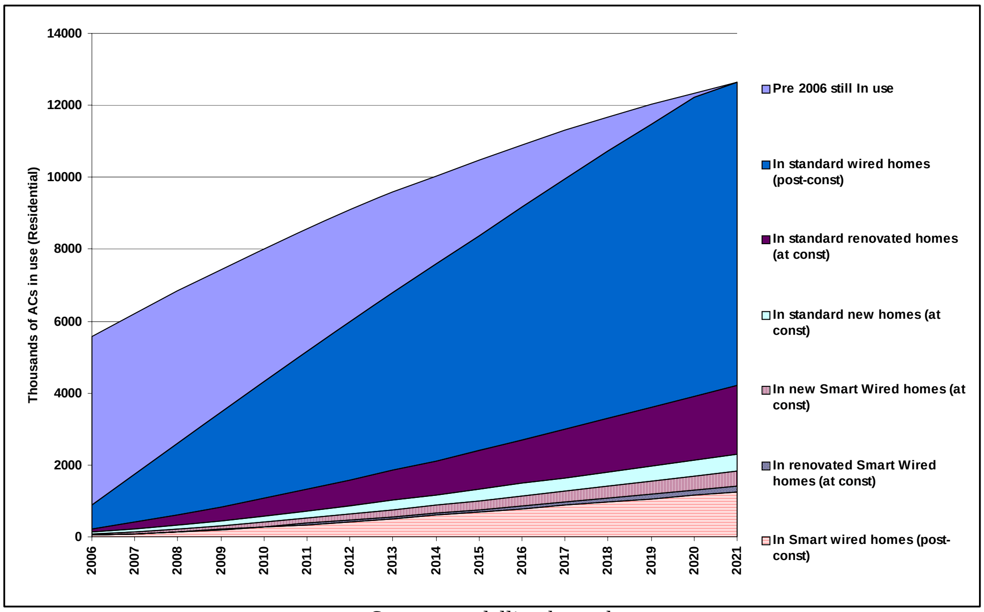
Therefore any approach to DR which concentrates solely on the existing appliance stock, without planning for the new stock, will be of limited value.

Figure 5 Projected annual new residential sector air conditioner installations, Australia



Source: modelling by author

Figure 6 Projected total residential sector air conditioner installations, Australia



Source: modelling by author

4 The way forward

4.1 Marketing Demand Response

Electricity pricing has often been criticised as a limited spur to efficient use of electricity, because customers get their bills weeks or months after the fact. Flat tariff billing is even weaker as a driver for the development of demand response, because in addition to the delay the flat tariff masks the variable costs of supply.

Real time indication and time of use pricing overcome some of these deficiencies by signalling prices closer to the time of use. However, users' ability to respond will be limited by whether they are at home, aware of the price and sufficiently motivated to respond at the time. In due course, users will probably realise they are better served by products where the response can be automated, but it could take many years before the old appliances wear out and products with the necessary characteristics can be acquired.

The most efficient time to alert buyers to the value and the possibilities of demand response is at the time of home construction – when whole-house control systems may be installed relatively cheaply – and at the time of purchase of individual appliances, notably air conditioners, pool pump controllers and water heaters.

The key issues in marketing demand response at the point of appliance purchase are:

- What characteristics of a product constitute demand response capability?
- What is the most effective way to communicate the presence of this capability?; and
- What is the most effective way to motivate purchasers to prefer products with this capability?

Defining DR Capability

The parties with the most direct and immediate incentive to promote DR-capable products are electricity suppliers developing DR programs, and a clear vision of how DR-capable products will fit into those programs. Not surprisingly, these tend to be those in States with the highest rates of air conditioner use or the highest rates of projected growth rates in summer demand (see Table 3).

These utilities are in the best position to define the technical characteristics of DR-capable products to suit their programs, but it would help the wider development of DR if those requirements were made public. This will stimulate competition among potential suppliers of qualifying products.

The existence of an Australian Standard will also support the development of the DR market. It can offer a consistent terminology and language for defining DR-capability in products, and specific sets of attributes developed by individual electricity utilities (or DR aggregators) can be incorporated into the Standard as distinct 'profiles', subject to the agreement of the stakeholders in the Standard.

Promoting DR Capability

The Equipment Energy Efficiency Program (E3P) offers a ready made framework for promoting products with DR capability. The E3P already invokes (via State and Territory legislation) a number of Australian and New Zealand standards for the testing, performance, energy efficiency and labelling of air conditioners, largely based on international ISO standards.

Once criteria for DR capability are developed, it will be relatively straightforward to incorporate them into the existing standards. At the very least, suppliers of energy-labelled products such as air conditioners suppliers could choose to state whether their products were DR-capable, and buyers who wished to participate in their utility's local DR program could identify those products.

The next level of response may be to require disclosure the level or 'Type' of DR-capability (or possibly the level of capability) on the energy label. Ultimately, meeting a certain minimum level of DR-capability may become a mandatory requirement, like meeting a minimum level of energy-efficiency. Any mandatory requirements would of course be subject to formal benefit-cost analysis and regulation impact assessment.

The E3P has shown itself capable of successfully taking up new challenges in the past. Some years ago it moved into the area of standby energy rather than just operating energy. It is a natural progression for it to investigate the peak demand implications of air conditioners and whether these can be addressed through product design.

Complementary Market Mechanisms

Increasing the availability and sales of DR-capable air conditioners would lower the costs of implementing demand response programs, but would not of itself compel utilities to offer such programs or motivate consumers to participate. However, introducing demand response factors into the appliance purchase process would facilitate other potential measures, eg:

- Requiring AC buyers to install smart metering and to go on time of use tariffs;

- Alternatively, including a 'demand management bond' in the purchase price (say $500-$1,000, depending on maximum motor power) to be forwarded to a publicly-administered fund and to be redeemable after a specified period of participation in a utility DR program.

Measures such as these are justified on equity grounds, to ensure that new AC users do not add to the cross-subsidy burden on non-AC users, and on the grounds of increasing the security of electricity supply in a period where one of the highest risks of supply disruption is from air conditioner load. They should also have the benefit of increasing the competitiveness of demand-side responses in the national electricity market, by enabling the cost-effective aggregation and block demand bidding of AC loads.

Measures of this type would increase the efficiency of the market for air conditioning services by signalling some of the AC operating costs which are hidden at present. A large enough 'demand management bond' could also encourage buyers to:

- Delay installing an air conditioner in a new home for a season or two, which could be long enough to determine that it is not necessary;

- Consider evaporative cooling as an alternative to refrigerative air conditioning (provided the local climate is suitable).

The wide availability of products with standard DR capabilities would also encourage State regulators (or the Australian Energy Regulator) to require all distributors to consider DR programs as alternatives to investment in infrastructure to meet peak load.

International Action

Experience with demand response program in the USA suggests that the needs of local electricity suppliers and the policies of local energy regulators are the strongest drivers for the development of DR programs. The availability of local control and component suppliers also points to the development of local approaches.

It is likely that this will initially be the case in Australia as well. The control technologies which ETSA and Energex are trailing was developed in Australia, specifically to suit those utilities' systems, customer bases and regulatory constraints. In ETSA's case, these constraints include the decision *not* to roll out time of use meters.

Local approaches and 'special profiles' are effective so long as the focus remains on the introduction of DR to the existing stock of air conditioners. As the focus shifts to new appliances, however, it will be necessary to engage product suppliers, not just in Australia but beyond, since all single phase air conditioners sold in Australia are now imported.

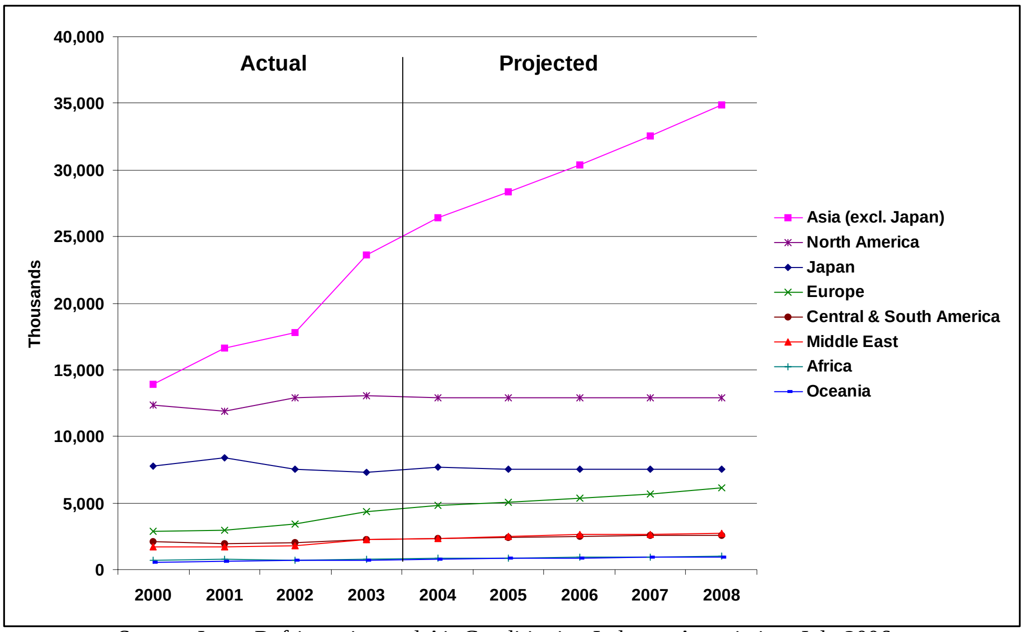
It should be possible be engage other governments and international product suppliers in co-ordinated approaches to demand response, because air conditioner peak demand is emerging as a world-wide problem.

Figure 7 illustrates the projected growth in air conditioner sales by global market region. The Asian market outside Japan (mainly China and India) is now the largest in the world and growing at 8% per annum . This region will account for half the global AC market by 2008;

In Europe, the air conditioner market is growing at 7% per annum and set to overtake the Japanese market in size by about 2010. Oceania (mainly Australia): the AC market is currently growing at over 6% per annum. Annual market growth in the other regions (Middle East, Africa and Central and South America) is projected to be in the more modest 3 to 4% range, and negligible growth is projected for the most mature air conditioner AC markets, Japan and North America.

This makes demand response for air conditioners a high priority issue for (non-Japan) Asia and Europe, as well as for Australia. The problems in Asia will become especially acute as power systems are less robust and already under stress.

Figure 7 Projections of Air Conditioner Sales by Global Markets



Source: Japan Refrigeration and Air Conditioning Industry Association, July 2006

The AGO has begin to use its links with energy agencies in other countries to start to build a concessus on demand response. Although this is at an early stage, there have been encouraging exchanges of information with agencies in Korea, California, the UK and the European Union. These will be further developed through special meetings on demand response planned for 2007.

Appliance manufacturers in Japan and other countries are already experimenting with DR-capable features in their products. There is scope to make the 'standard demand response capability profiles' in the Australian Standard accepted as the basis for international demand response standards.

4.2 Recommendations for a National Demand Response Strategy

The Strategy

The development of a national strategy to directly address the peak load effects of air conditioners is becoming increasingly urgent. Air conditioning use is growing rapidly in homes and small businesses, and could conceivably double within 10 years.

The following elements are proposed for that part of a national demand response strategy which addresses household electricity use, and air conditioner use in particular. Many of these elements will also apply to other electricity uses and other sectors.

1. Governments should encourage the development of electricity pricing structures which better reflect variation in the cost of supply and system constraints, eg - time of use pricing and critical period pricing.

2. The E3 Program should work with the electricity supply industry to introduce and promote the concepts of variable electricity pricing and demand management as criteria in household appliance selection and operation.

3. The E3 Program should work with the electricity supply industry to promote automated demand response as the central objective of national demand response strategy for the household sector (automated DR is where the user freely enters an arrangement with electricity utility or DR aggregator, but does not need to make an active decision about every demand response event).

4. The E3 Program should work with the electricity supply industry and with appliance manufacturers to standardise aspects of demand response capability in electrical products, with the objectives of:

- indicating levels of capability to prospective appliance purchasers and potential sponsors of demand-response capable appliances purchases (eg electricity utilities or demand response aggregators); and

- Enlarging the market for demand response capable products, by establishing consistent national standards, while retaining flexibility for electricity retailers and distributors to implement programs to suit their own requirements.

5. The energy labelling program should be extended to include information about the demand response capabilities of selected products, and to disseminate this information to prospective purchasers via the energyrating website and, ultimately, via the energy labels themselves.

6. Governments should ensure that the rollout of ‘smart’ metering assists the development of demand response in electrical products, and does not inhibit its development through inconsistent technical standards and requirements (while noting that many demand response approaches do not require either time of use pricing or ‘smart’ metering).

7. Government energy agencies should work with the Australian Energy Regulator to ensure that the development of demand response programs for electrical products is routinely considered as an alternative to electricity distribution system augmentation

8. Governments and energy regulators should consider pricing options which incorporate peak-related electricity supply costs in the purchase price of some electrical products, so that costs can be recovered (at least partially) if the purchasers of those products do not participate in time of use pricing or demand response programs.

9. The AGO should develop and strengthen contacts with energy agencies and product suppliers in other countries, and with international agencies and standards bodies, to facilitate the development of demand response standards for internationally traded products.

Milestones and Timelines

Developing a large scale demand response capability on the household appliance stock in Australia is a long term project. It is also involves a larger number of unknown factors and a wider group of stakeholders than the more conventional energy labelling and MEPS projects with which the E3 is by now very experience.

The AGO has undertaken considerable preparatory work in the last two years, in identifying the issues and bringing together the stakeholders. The following objectives are achievable in the next three years.

- In 2007: the publication of an Australian Standard *Classification code for demand response capabilities and supporting technologies for electrical products* (a Draft is likely to be released for public comment by the end of 2007, subject to agreement by the Standards committee concerned);

- 2007: AGO to co-sponsor (with IEA, APEC or other bodies) and organise two special meetings on international demand response standards air conditioners and other appliances;

- 2007: preparation of additional parts of the Australian Standard covering technical requirements for demand response capability in air conditioners, swimming pool pump controllers and water heaters;

- 2007: development of ‘special profiles’ incorporating the technical requirements of utilities currently intending to roll out large scale DR programs;

- 2008: adaptation of energy labelling requirements for air conditioners, to allow for voluntary inclusion of demand response profiles. This is likely to coincide with the need to revise the air conditioner labelling algorithms to reflect the impacts of the 2008 MEPS levels;

- 2008: development of ‘standard profiles’ incorporating basic technical requirements for DR, which could form the basis of international standards;

- 2009: sales and installation of first products (air conditioners, swimming pool pump controllers) with unbuilt DR capability.

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