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Air-conditioning Australian households: the impact of dynamic peak pricing

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Abstract

International mandates for smart metering are enabling variable and real-time pricing regimes such as dynamic peak pricing (DPP), which charges 10-40 times the off-peak rate for electricity during short periods. This regime aims to reduce peak electricity demand (predominantly due to increasing residential air-conditioning usage) and curb greenhouse gas emissions. Although trials indicate that DPP can achieve significant demand reductions, particularly in summer, little is known about *how* or *why* households change their cooling practices in response to this strategy. This paper discusses the outcomes of a small qualitative study assessing the impact of a DPP trial on household cooling practices in the Australian state of New South Wales. The study challenges common assumptions about the necessity of air-conditioning and impact of price signals. It finds that DPP engages households as co-managers of their cooling practices through a series of notification signals

(SMS, phone, in-home display, email). Further, by linking the price signal to air-conditioning, some householders consider this practice discretionary for short periods of time. The paper concludes by warning that policy makers and utilities may serve to legitimise air-conditioning usage and/or negate demand reductions by failing to acknowledge the non-rational dynamics of DPP and household cooling practices.

Keywords

Smart metering, air-conditioning, demand management

1. Introduction

Developed nations and regions such as the United Kingdom, Europe, New Zealand, the United States of America, Canada and Australia have made bold and ambitious commitments to deploy smart metering. These include Europe's plan to rollout smart meters in every building across the Continent by 2022 (Ryberg, 2009), the UK's intention to provide smart meters and real-time in-home displays (IHDs) to every household by 2020 (DECCb, 2009) and New Zealand's plan to install 1.3 million smart meters in households within the next four years (PCE, 2009). Europe has led the way, with Italy the first European country to install smart meters on a large scale in the early 2000s and Sweden the first country to achieve 100 per cent penetration in July 2009 following a regulation driven rollout (Ryberg, 2009).

In 2007 the Australian Government followed suit, with the Council of Australian Governments (COAG, whose membership includes the prime minister and state premiers) endorsing a staged approach for the national rollout of smart electricity meters 'to areas where benefits for consumers outweigh the costs' (NERA, 2007)¹. The aim of this mandate is to curb peak electricity demand and greenhouse gas emissions, as well as improve the operating efficiency of the electricity network (NERA, 2008b).

New mechanical forms of residential heating and cooling, particularly the use of air-conditioners, are the primary cause of Australia's rising peak demand (EES, 2006; Wilkenfeld, 2004). Heating and cooling appliances also dominate household energy use (41%) and account for nearly one-fifth (19%) of residential greenhouse gas emissions (ABS, 2008a). In addition, peak electricity demand requires economically inefficient investment in new electricity infrastructure which is only used for 1–2 per cent of the year

(DPI, 2009) — a cost which is currently passed on to all electricity consumers (with or without air-conditioning), totaling millions of dollars per annum (Wilkenfeld, 2004). The impact of heating and cooling practices in Australian households is therefore interconnected and widespread, contributing to a range of resource management, economic and environmental problems which smart metering seeks to alleviate.

The decision to rollout residential smart metering in Australia has prompted a surge of demand management trials. One group of strategies involves variable (and real-time) pricing regimes, where householders are charged more for electricity during peak periods (and less during off-peak periods), which normally occur on very hot or cold days. While data from trials suggests that pricing programs are capable of curbing residential peak demand by up to 25 per cent and greenhouse gas emissions by up to 15 per cent (NERA, 2008a), very little is known about how they affect household thermal comfort practices, that is, the activities householders undertake to heat and cool their bodies and homes.

In particular, virtually nothing is known about how households use air-conditioners or, more significantly, how and to what extent the 33 per cent of Australian households *without* air-conditioning (ABS, 2008b) achieve ‘coolth’ (Prins, 1992) and avoid heat stress. As a result, policy makers and energy providers make assumptions about the necessity of air-conditioning, how it is used, and the potential vulnerabilities householders face without it. Inaccurate assumptions may lead to ineffective long-term demand management strategies that overlook the changing dynamics of household cooling practices, or serve to legitimise, promote and potentially realise such assumptions. Thus, there is an urgent need to consider *what householders actually do* in response to variable pricing programs, and how they achieve, perceive and maintain coolth.

In this paper I set out to test these assumptions in a small qualitative study of dynamic peak pricing (DPP). DPP is a variable pricing regime which charges significantly more for electricity (10-40 times) during short periods of peak demand (~4 hours). I begin by identifying the knowledge gaps regarding what householders do to achieve coolth, how householders change their (air-conditioned) cooling practices in response to variable pricing programs, and what assumptions are used to address these gaps. I outline the methods and characteristics of the study before discussing the diversity of responses to DPP reported by householders involved in the research. Finally, I identify the implications of this study for policy makers and utility providers, particularly the need to expand and test current demand management assumptions.

2. Residential air-conditioning cooling practices

Air-conditioning is now viewed as 'an essential service in modern Australia' (McCann, 2006), being considered 'vital to productivity, comfort and the simple ability to continuously occupy buildings, largely irrespective of the external weather conditions in almost every type of built environment' (McCann, 2006). Despite this view, at least three-quarters of the current Australian population has lived without air-conditioning at some point in their lives (EES, 2006). Residential air-conditioning penetration has risen to 67 per cent from just over ten per cent 40 years ago (ABS, 2008b)². Most of this growth has occurred in the last ten years where there has been a doubling of penetration (DEWHA, 2008). Cooling energy use in the residential sector is projected to increase by a factor of five from 1990 to 2020 under current trends (DEWHA, 2008) and a similar resource-intensive escalation is occurring in other OECD (2002) countries. Data from the Australian Bureau of Meteorology (BOM, 2009), which show only a small increase in temperature

(less than one degree Celsius) and very hot days across the country during this 40 year period, indicate that people are modifying their cooling practices more rapidly than the climate is changing. While the urban 'heat island' effect (Santamouris, 2007) may be exacerbating this problem in cities, changes in the temperature do not adequately explain the transforming dynamics of household cooling expectations and practices.

When delving deeper, a range of inter-related social, cultural, technical, economic and institutional factors emerge. Several consultants argue that the affordability and accessibility of air-conditioning has contributed greatly to this appliance's widescale diffusion and increasing usage, along with rising household incomes (EES, 2006; Wilkenfeld, 2004). However, the trend towards air-conditioning as the dominant form of coolth has also emerged from modifications to the built environment. For example, air-conditioners, or outlets for them, are being offered as 'standard' products by project home builders to gain a marketing edge (Wilkenfeld, 2004). In addition, declining block sizes and increasing floor areas are reducing scope to optimise orientation and retain mature tree cover in new subdivisions. There is also an increasing number of high rise apartments with poor shading and glazing which are less able to rely on natural ventilation (Wilkenfeld, 2004).

Compounding these issues is the growing number of Australian households, and their collective consumption of energy resources. Like many developed nations, the average number of people per household is diminishing (Linacre, 2007). Between 1990 and 2020, the number of occupied residential households has been forecast to increase by 61 per cent, in combination with a 145 per cent increase in total residential floor area — representing more space to be cooled (DEWHA, 2008). During this period, a 56 per cent increase in

residential sector energy consumption is projected, with a higher proportion met by Australia's predominantly greenhouse-intensive fossil-fueled electricity. Building shell performance standards, now implemented across Australia, only affect two per cent of total stock per annum, and have so far only managed to slow (rather than reverse or stabilise) the escalating resource consumption associated with new air-conditioned cooling (and heating) practices (DEWHA, 2008; Wilkenfeld, 2007).

In addition, there are less understood social and cultural dynamics which are contributing to cooling expectations, such as the air-conditioner's role as a status symbol. For example, the emerging social practice of pre-cooling (and pre-heating) prior to the arrival of guests is evident in a number of international studies (Agbemabiese et al., 1996; Gram-Hanssen, 2008; Haruyuki and Lutzenhiser, 1992; Wilhite and Ling, 1992; Wilhite et al., 1996). Wilhite and Ling (1992), in their ethnographic study of heating practices in Norway, found that 'for a guest in a home to give any signs that they are uncomfortably cold is a serious disgrace to the host.' Similarly, Haruyuki and Lutzenhiser (1992) argue that the diffusion of central heating and cooling systems in Japan has led to an association between social politeness and residential air-conditioned spaces. In their research, 30 per cent of the sample group cooled their rooms only for visitors or members of the family (Haruyuki and Lutzenhiser, 1992). Given the rapid diffusion of air-conditioning in Australian households, it is possible that such expectations are becoming established, leading to changing social expectations associated with 'being a good host'.

Similarly, there is enormous variation in definitions of a 'comfortable' environment which cannot be accounted for by physiological variables alone (Chappells and Shove, 2004). For example, thermal comfort researchers have found that occupants are willing to accept a

wider range of temperatures when buildings are naturally heated or cooled (Brager et al., 2004; de Dear, 2007; de Dear and Brager, 2002; Nicol and Roaf, 2007). In contrast, most respondents in climate controlled environments report being uncomfortable outside the narrow range of temperatures prioritised by comfort standards such as the American Society of Heating, Refrigeration and Air-Conditioning Engineers' Standard 55: Thermal Environment Conditions for Human Occupancy (ASHRAE, 2004). The narrowing of temperature tolerances in air-conditioned office environments is attributed to the addictive nature of homogenous and static indoor climatic regimes (Brager and de Dear, 2003; Prins, 1992), as well as occupants' inability to control their own environment, for example, by opening a window (Brager et al., 2004). These studies clearly demonstrate the interrelated dynamics between changing household infrastructures, technologies and new expectations of comfort.

Other social and cultural factors potentially contributing to the uptake of, and resistance to, air-conditioning are less understood, such as diffusion through social networks and social benchmarking (Christakis and Fowler, 2009), understandings of health and hygiene (Crowley, 2001), changing clothing conventions, the decline of the afternoon siesta (Shove, 2003), preferences for particular types of 'air' (Heschong, 1979), desires and beliefs about homogenous and natural environments (Lovins, 1992), understandings of waste and necessity (Prins, 1992), and dislike of temperature extremes (between the indoors and outdoors) (Williamson et al., 1991). Such factors have led international researchers to discover a wide diversity of household cooling practices and reasons for undertaking them, most of which are poorly understood in an Australian context.

The range of socio-technical factors contributing to changing household cooling practices raises a series of critical questions regarding variable pricing programs. Firstly, what assumptions are being made by demand managers about the necessity of air-conditioning and how do these shape householders' cooling practices? Secondly, what do we know about these programs' impact on household cooling practices? And lastly, what medium and long-term impact can these programs have in the complex and changing context described above? Without understanding and addressing these dynamics, predictions of increasing air-conditioning usage, greenhouse gas emissions and peak electricity demand are likely to eventuate (Akmal and Riwoe, 2005; DEWHA, 2008), thereby negating efficiency benefits and demand reductions achieved through smart metering (and other) policies and programs.

3. Smart metering variable pricing programs

Electricity utilities and policy makers are primarily introducing variable pricing strategies to reduce peaks or 'hot spots' in demand (Guy and Marvin, 1996; Moss, 2004). In Australia, peak electricity demand generally occurs on hot summer afternoons and evenings when people return home to switch on air-conditioners and appliances whilst commercial sector demand is still operating. The recent surge of air-conditioner penetration has led to major infrastructural and generation challenges for utilities, who are forced to 'upsized' their capacity to cope with these short bursts of demand (NERA, 2008b)³.

Rather than addressing the complex and inter-related bundle of factors contributing to changing expectations of coolth discussed in Section 2, variable pricing regimes aim to 'shift' or 'shed' household electricity demand during periods of peak demand. The use of pricing tariffs to achieve this aim is based on a series of assumptions originating from the

discipline of economics, which propose that householders conduct (or need to be encouraged to conduct) micro cost-benefit analyses about their daily electricity consumption behaviours (Borenstein et al., 2002; Gellings, 1994). This 'rational actor' understanding of consumption assumes that individuals act freely and in a self-interested manner based on the information available to them in order to maximise their own wealth (utility) and avoid unnecessary labour (Jackson, 2005). The idea that choices may in some way be embedded into or emerge out of social, cultural or technical systems is overlooked.

New pricing tariffs for electricity which are premised on this rational action framework have been, or are being, trialed and implemented in nearly every state and territory around Australia using smart metering (NERA, 2008a). DPP, also known as critical peak pricing (CPP), is one such pricing scheme which is generally characterised by a series of 'events' (up to 12) throughout the year where the price of household electricity rises by 10-40 times for a short period (~4 hours) for participating households. A range of communication methods are used (SMS, email, phone message, IHD⁴), to notify householders of an event within 24 hours of when it will occur. The aim is to encourage households to reduce their electricity demand during the DPP period or shift it to an off-peak period. Rates are lower at other times of the day to compensate for the high price charged during DPP events (NERA, 2008b).

As a result of DPP and other variable pricing trials in Australia and internationally, there is a surge of data being produced and analysed on changing demand patterns in response to price. While some qualitative research has been conducted, this has mainly focused on the types of energy-saving behaviours householders have engaged in (Oliphant, 1999), market-based surveys (normally kept confidential by utility companies), and surveys of

householder attitudes and opinions towards demand management programs (Jelly, 2008). Overlooked is an understanding of *if, how* and/or *why* cooling (and other household) practices are changing in response to these programs.

Results of trials indicate that DPP can achieve average peak demand reductions of up to 25 per cent in Australian trials when used in conjunction with an IHD (NERA, 2008a) and, in the best-case international example, an average reduction of 26 per cent was achieved on weekdays in summer months when combined with an IHD and time switch controls (TSCs)⁵ (Braithwait, 2000). Internationally, DPP has resulted primarily in load shifting (transfer of electricity-consuming practices to other times of the day) rather than conservation, while in Australia, conservation has dominated existing trials (NERA, 2008b). It is assumed that DPP is more effective than other variable pricing tariffs (such as time-of-use (TOU)⁶ pricing) because it charges disproportionately more for electricity during the peak period. However, the quantitative findings from Australian and international trials suggest that the response may be more complex.

In particular, the results of national and international DPP trials indicate that the response is weather dependent and seasonal. Nearly all DPP trials found a correlation between high temperatures and higher demand responses and, to a lesser degree, low temperatures and higher responses (see tables 1-2). This suggests that consumption is more elastic with extreme weather conditions, or in the height of summer and winter. Given that the demand response to DPP across international trials is highly weather dependent and, particularly in the Australian trials, less likely to be transferred to other times of the day, there is evidence to suggest that cooling services — the most energy-intensive practices undertaken during hot weather — are somewhat discretionary for short periods of time (see tables 1-2). In

conventional terms, householders are choosing to tolerate a higher temperature than they would have previously in order to avoid a price increase in their electricity usage.

Table 1: Demand response from international residential smart metering variable pricing trials

Name of trial	Delivered by	Location	Strategy	Number involved	Overall demand response
Californian Statewide Pricing Pilot (CRA, 2005)	Pacific Gas and Electric Company, San Diego Gas and Electric and Southern California Edison	California, USA	DPP	606	<ul style="list-style-type: none"> • Summer critical peak days – 7.61-15.83% peak demand reduction (dependent on climatic region) and 2.4% reduction in overall consumption • Winter critical peak days – 3.39-4.25% peak demand reduction (dependent on climatic region) and 0.62% reduction in overall consumption • Summer non-critical peak days – 4.71% reduction in peak demand and 0.17% increase in overall consumption • Winter non-critical peak days – 1.38% reduction in peak demand and 0.02% reduction in overall consumption
Californian Statewide Pricing Pilot (RMI, 2006)	Pacific Gas and Electric Company, San Diego Gas and Electric and Southern California Edison	California, USA	Automated load control (DLC) technologies and DPP	250	<ul style="list-style-type: none"> • 20-60% peak load reduction
Ontario Smart Price Pilot (OEB, 2007)	Ontario Energy Board	Ontario, Canada	DPP	124	<ul style="list-style-type: none"> • Critical peak days – 17.5% reduction in peak • Non-critical peak days – 8.5% reduction in peak • Overall consumption reduction of 7.4%
USA east-coast utility TOU trial (Braithwait, 2000)	N/A	USA	TOU, DPP, IHD and timer technology	N/A	<ul style="list-style-type: none"> • Average 26% reduction in peak demand usage on weekdays during hottest summer month • 5% reduction in overall consumption during summer

Table 2: Demand response from Australian residential smart metering variable pricing trials

Name of Trial	Delivered by	Location	Type of mechanism	Number involved	Demand response
EnergyAustralia Strategic Pricing Trial (Collins, 2009; NERA, 2008a)	EnergyAustralia	Sydney, New South Wales (NSW)	TOU and DPP, IHD (various combinations)	756	<ul style="list-style-type: none"> • 23–25% reduction during DPP events (30% in winter and 36% in summer) • Conservation of energy dominated deferral effect. Preliminary results indicate conservation effect of 7-15% on summer DPP days • 11–13% information-only response (notification only)
Integral Energy Pricing Trial (NERA, 2008a)	Integral Energy	Western Sydney, NSW	TOU and DPP, IHD (various combinations)	900	<ul style="list-style-type: none"> • Conservation of energy dominated deferral effect. Preliminary results indicate a conservation effect of 7-15% on summer DPP days. • 5% additional reduction in peak demand for households with IHD • Other results N/A
CountryEnergy Home Energy Efficiency Trial, HEE (NERA, 2008a)	CountryEnergy	Queanbeyan and Jerrabomberra, NSW	DPP, IHD	150	<ul style="list-style-type: none"> • 25% DPP reduction in peak demand in summer and winter. • Overall consumption reduction of 8%

While there is clear evidence to suggest that DPP is capable of achieving significant load shifting and conservation, these trials continue to leave unanswered important questions about the changing nature of demand. For example, we are yet to understand *why* householders respond more in summer than they do in winter. Does this mean that air-conditioning is not as ‘essential’ as it might first appear? Are heating expectations simply more deeply entrenched? Or are there other dynamics not yet understood? By designing variable pricing programs in a way which ‘avoids significant impacts on comfort and lifestyle’ (Reidy, 2006), and by assuming that air-conditioning is ‘an essential service’ in maintaining that comfort and lifestyle (McCann, 2006), we may be overlooking alternative and more effective ways of addressing this complex problem, or dismissing programs such

as DPP for their assumed negative impact on non-negotiable and necessary air-conditioning services.

More significantly, we may undermine the effectiveness of reducing peak demand. For example, assumptions about how and why people use their air-conditioner has led some demand managers to promote pre-cooling prior to DPP events (CountryEnergy, 2004), potentially encouraging a practice of overcompensation, whereby householders who otherwise might not have used their air-conditioning decide to switch it on ‘just in case’. Promoting pre-cooling is a ‘double win’ for energy retailer-distributor businesses: more electricity is consumed, but peak demand is reduced (Strengers, 2010). However, just as the promotion of energy-efficient air-conditioners ‘fails to engage with the big questions of what our needs are and how they are constructed and reproduced’, thereby ‘internatlis(ing) and tak(ing) for granted those features of indoor climate that are the most problematic’ (Shove, 2004), so too may the promotion of pre-cooling inadvertently contribute to the normalisation of this appliance and the practices it facilitates.

4. A case study of DPP: overview and methods

In late 2008, a qualitative study of EnergyAustralia’s DPP trial was conducted to understand householders’ current cooling (and other household) practices and how they change in response to this pricing tariff. The trial was the longest and largest in Australia at the time, running for two years from 2006 to 2008. It took place in EnergyAustralia’s electricity distribution area covering Sydney and the central coast and Hunter regions of New South Wales (NSW) (EA, 2007), and was part of this utility’s broader Strategic Pricing Study (Amos, 2008) involving 756 residential and 544 commercial retail electricity customers (Miller, 2007).

Residential participants were divided into a control group; TOU tariff group; DPP 20 group with a DPP rate of approximately AU\$1 per kWh (around 20 times the off-peak rate) and an IHD; DPP 40 group with a DPP rate of approximately AU\$2 per kWh (around 40 times the off-peak rate) both with and without an IHD; and an information-only group, which received notification of a DPP event without any tariff change (See Table 3; Amos, 2008). Households volunteered to join the two-year trial and were considered representative of EnergyAustralia’s customer base. All participants received AU\$100 credit on their electricity bill for joining the trial and AU\$200 for completing it as an incentive to take part (Amos, 2008).

Table 3: EnergyAustralia’s residential pricing trial

Stratification	Experiment group					
	Control Group	Information-only	Seasonal TOU	DPP 20 with IHD	DPP 40 with IHD	DPP 40 without IHD
Annual Consumption of household (kWh)						
2000-5400	33	33	36	56	47	47
5401-9000	33	33	36	56	47	47
9001-40,000	33	33	369	56	47	47
Total households	99	99	108	168	141	141

Adapted from Amos, 2008

EnergyAustralia called a maximum of 12 DPP events per year for each year of the trial, which were half an hour to four hours in duration (Miller, 2007). Householders were notified within 24 hours of when an event would occur, with a minimum of two hours notice. Notification was delivered through a Landis & Gyr ecoMeter IHD (where applicable; see Figure 1 & Table 3), SMS, automated phone message and/or email as elected by participants. During an event, the DPP tariff would apply. The 309 residential DPP households with an IHD also received real-time electricity consumption feedback

(kilowatt hours, greenhouse gas emissions and cost). Their IHD displayed a series of ‘traffic lights’, which were used to provide households with notification of tariff changes, where green corresponded to an off-peak rate, orange to a shoulder rate and red to a DPP event (see Figure 1).

Figure 1: Landys & Gyr ecoMeter IHD displaying a green ‘traffic light’

Source: <http://www.ecometer.com.au/>

Overall, EnergyAustralia’s residential pricing trial was successful, with demand reductions of 36 per cent in summer and 30 per cent in winter for DPP 20 and 40 tariff groups both with and without an IHD, or 23 per cent across all seasons for households without an IHD (see Table 4; Collins, 2009). The IHD only enhanced the response by two per cent (leading to a 25 per cent reduction in these households), suggesting that information feedback did not play a substantial role in the response. However, the information-only group, which received communication of a DPP event without a tariff increase, reduced their demand by 13 per cent in summer and 11 per cent in winter, suggesting that notification of a DPP event was significant to the response (see Table 4). A limitation of these results is that the trial period was considered climatically mild for the region, with summer temperatures rarely exceeding 40 degrees Celsius.

Table 4: Demand reductions resulting from EnergyAustralia’s residential pricing trial

Seasons	Experiment group				
	Information-only	Seasonal TOU	DPP 20 with IHD	DPP 40 with IHD	DPP 40 without IHD
Summer	-13%	-24%	-36%		
Winter	-11%	-6%	-30%		
Overall (all)	-11%	N/A	-25%	-25%	-23%

Twenty-three households on the DPP 20 or 40 tariff participated in a qualitative study of this pricing trial (identified by number throughout this paper) towards the conclusion of the trial period in late 2008. Of these households, 12 had an IHD which they had been using for up to two years⁷. Households were randomly recruited via a letter sent to all DPP 20 and 40 participants. A broad range of household types self-selected for this study, including single-person households of varying ages, young couples, young families, elderly couples, and families with teenage or adult children. Noticeably absent were recent migrants and non-family households (e.g. student households). Housing types were predominantly detached or semi-detached dwellings located in urban or suburban locations around Sydney and the Hunter (coastal) region of NSW. Seventeen of the 23 households had some form of air-conditioning in their homes.

Methods centred on a group household interview involving as many members of the household as possible (including children) along with a household tour, observations and photography, all conducted within participants' homes. Interviews were semi-structured and conversational in format although a series of themes and questions were covered including householders' comfort practices and modifications resulting from the DPP program. Group interviews encouraged interaction between householders so that contradictions, tensions, agreements and/or disagreements about various cooling practices were drawn out. In order to represent the interaction and dialogue between householders, as well as the breadth of responses, findings are presented in a number of ways throughout this paper: firstly, as tables of quotes pertaining to a specific theme; secondly, as standalone

quotes from one householder; and thirdly, as a dialogue between the interviewer and/or multiple householders.

The whole visit to the household encompassing an interview and household tour took 45 minutes to two hours, with an average time of over an hour. The entire visit was voice-recorded with one exception due to technical problems where the interviewer took notes. Seventeen interviews were transcribed and the remainder were partially transcribed due to budget constraints. Participants were given an opportunity to review their transcripts for accuracy via email. Transcriptions were imported into qualitative analysis software (NVivo) and coded thematically using a practice theory conceptual framework (Giddens, 1984; Reckwitz, 2002; Schatzki, 2002; Strengers, 2009).

Social practice theory has been used by other researchers in recent empirical research to identify the complex dynamics shaping what people do and why they do it (Gram-Hanssen, 2007, 2008, 2010; Shove and Pantzar, 2005, 2007). While there are several interpretations and definitions of a practice, it can be loosely described as 'a "bundle" of activities, that is to say, an organized nexus of actions' (Schatzki, 2002), which is made up of a series of interconnected and mutually reinforcing components. The primary significance of practice theory for this research is that it provides a framework for shifting emphasis away from individuals and their demand, and onto the socio-technical dynamics shaping that demand (Warde, 2005). Using this conceptual starting point, I analysed the data to identify how different practice components, namely technologies and infrastructures such as air-conditioners and the built environment; common understandings about health, hygiene and cosiness; rules about 'right' and 'wrong' ways of achieving coolth and comfort; and

practical knowledge about *how* to achieve comfort (and avoid heat), intersect to transform existing practices as a result of DPP (Strengers, 2009).

5. Findings and discussion

5.1 Diverse cooling practices

While the majority of electricity-consuming practices were shifted to other times of the day in response to DPP events (such as laundering, cooking, vacuuming, clothes drying and ironing), air-conditioned cooling practices were often not. Table 5 provides a range of quotes which illustrate the diverse and malleable cooling arrangements householders engaged in during a DPP event. The quotes demonstrate the significant practical knowledge householders drew on to carry out alternative ways of cooling their bodies and homes, such as using a fan, opening a window, changing their clothing or going to the beach (see Table 5). Some households didn't feel the need to make *any* adjustments to their thermal comfort during a DPP event apart from turning the air-conditioner off, highlighting the malleability and negotiability of cooling.

Table 5: Diverse Comfort Arrangements in Response to DDP Events

If we were going through a warm period and that was also when a peak period was occurring, we would turn it off. And when the period came to an end we would then turn the air-conditioning on (6).

I'd have to make a judgment on that because I've got to live at the end of the day and I'd do it [turn the air-conditioner on] with reluctance but I would try and avoid the peak because I imagine that the reason for telling people is that they have the expectation that they're trying to reduce demand at that time and as a result of that, if I can cut back and get a benefit from it, that's what I'd do (7).

I think we're more conscious of how much it is, where before you go, 'oh I'm feeling a bit sticky, I'll whack it on'. Now we're sort of going, 'feeling a little bit sticky'... Well, I put the fan on, but even the fan isn't the first thing we look at ... we'll open the doors and then we'll walk outside or something like that, like it's not an automatic straight to the air-conditioner which before it was (8).

I think one time it was just too hot and the peak pricing was on and we took off to the beach (18).

If it's too cold I just put more clothes on. ... Well the hot days I just wear a pair of shorts (23).

If it's warmer weather I'd punch the air-conditioner up high till such time as just before the peak period's going to apply, and then I cut it back to about 19 or 20 [degrees Celsius] just to circulate (14)

When an event's called we basically go out for the four hour period. [Laughter] We switch everything off and we go out. ... We go to someone's house or we would go out for dinner (16)

Look if it gets really, really, really hot, we're about to use it, and then the red light comes on [so we don't use it] (3).

Yeah, I think there was one instance where I felt it would be good to put the air-conditioner on, but we were on a peak period and I stuck that out I think (7).

It wouldn't matter how hot it got, I don't think we'd turn it on in a peak (14)

I remember one time last year, it was at a really bad time, it was really hot and I'd just come home from work because unfortunately when I get home from work the peak hour starts ... and it was just stinking hot that day. ... I remember saying to my husband, I said 'I don't care how much money it costs, put the bloody air conditioner on!' It was just *so hot*. My little boy was screaming. ... I think it was the only time that we've ever, you know, used a big appliance while the peak pricing was on (18).

We wouldn't even have it on. We wouldn't even *contemplate* having it on (17).

While some householders talked about how they had to 'survive' or 'bide out' these periods (Table 5) most did not consider them to be a significant burden or source of discomfort:

You can always go without ...I can't ever recall being uncomfortable (6).

INTERVIEWER: Were you uncomfortable?
MAN: No. ... It wasn't happening every day.
INTERVIEWER: So it wasn't a big inconvenience for you?
MAN: No, it hasn't been. (9)

I have to say the four hours ... is not too much of a burden. In the summer,
I don't think it's a burden at all (5).

In contrast, other householders reported that DPP events hadn't affected their cooling practices very much, but most still felt it made them more 'aware' of their comfort during peak periods:

I don't think you should let your own personal comfort go, if you're trying to achieve something like that. So what I'm trying to say there is that [the peak pricing] wouldn't influence me one way or the other, but at the same time I'd be aware of it, up here [pointing to head] (20).

MAN: We have done [turned the air-conditioner off]. But if it's real stinking hot we don't. We leave it on.

WOMAN: Well, it makes you think, doesn't it love? It makes you think about the heating and cooling, whereas before you might have gone and thrown the air-conditioner on, but you sort of think, well you don't need it (11).

But then sometimes it's excessively hot and you say, well I'm going to use it.
... But it also makes you aware that there are peak times, whereas I was never aware before, that there were different times when the power went up (13).

These findings demonstrate not only a diversity of cooling arrangements in response to DPP events, but also the shifting of cooling practices across both time and space. While some householders pre-cooled their house, others used the DPP event as an excuse for a family outing or a chance to visit a friend (see Table 5). Thus, while DPP did not always result in householders modifying their cooling practices, it did place them in a contestable space, albeit for a short time period.

5.2 Ability to respond

The ability of householders to move their cooling practices to other places and times, or change them altogether, depended on their mobility, working arrangements and financial situations. Interestingly, householders who were home all day (assumed to be more vulnerable to heat (Johnston, 2009; Rayner, 2008)) were *more* able to shift their practices to other times and reported *greater* flexibility in their comfort arrangements compared to householders working full-time or often away from home. In particular, several elderly householders reported being used to 'doing without' during their lifetimes, therefore possessing a wide base of practical knowledge regarding alternative ways to stay cool. In one exception, a sick elderly home-cared woman with dementia was unable to respond to DPP events. While this research did not assess the vulnerabilities of specific demographic groups, these insights raise questions that deserve further investigation.

In particular, the findings suggest that certain demographic groups could be unnecessarily dismissed from DPP strategies because of common assumptions regarding their perceived vulnerability. For example, consumer protection organisations, such as the Consumer Action Law Centre (Rayner, 2008), St Vincent de Paul Society Victoria and the Consumer Utilities Advocacy Centre (Dufty and Johnston, 2008) are concerned that variable pricing tariffs introduced through smart metering may disadvantage low-income earners who are often at home (i.e. the unemployed, stay-at-home mothers, the elderly or the unwell). However, this study suggests that these same households may financially *gain* from variable pricing regimes, rather than experience disproportionate disadvantage, because they are more able and willing to shift their practices to alternative times of the day. Clearly further research is required to test householders' ability to respond to DPP and assess the assumed vulnerabilities they may face, some of which has begun (Johnston, 2009).

5.3 Understanding the DPP response

There are several ways of interpreting the wide diversity of cooling responses to DPP. The dominant explanation for similar trials is that householders weigh up the benefits of their practices against the high cost of electricity during DPP events and modify their demand accordingly (NERA, 2008a). There is some evidence to support this claim:

WOMAN: When it went to peak periods we were extra careful with the use of electricity. Sometimes it was from two to six [pm], so we often didn't have dinner. ...

MAN: That was \$2 an hour!

WOMAN: Yes, so we often had dinner after. Or I would prepare

something, so I could just pop it in on the gas part. ... It just takes a bit of nous to get yourself organised (10).

However, the findings also provide alternative explanations that challenge this assumption of rational action. Firstly, householders rarely identified saving money as a motivator of the practice modifications reported (even though they were explicitly asked), yet they often cut back *all* electricity consumption during a DPP event (some left the house or turned off mains power effectively instigating a self-enforced blackout). Secondly, householders often did not shift their consumption to off-peak times of the day, which would give them the same or similar benefit at a lower cost, indicating that pre-cooling was not viewed as an essential or necessary alternative. Rather, householders reported conserving a significant amount of electricity as well as shifting it — a finding consistent with the results of the wider EnergyAustralia DPP trial and other trials conducted in Australia (NERA, 2008b). This might lead us to assume that householders were environmentally motivated. However, householders rarely identified themselves as being so, questioning the assumption that ‘green’ attitudes might explain this response. Further, few householders understood peak demand, and some didn’t realise that the trial was trying to address this problem, even though a plain language explanation had been provided by EnergyAustralia, as well as for this research.

These findings do not suggest that householders were unaware that the electricity rate spiked during a DPP event, but rather that this increased cost did not feature in their explanations of how or why they responded, nor did they fully understand why it was occurring. Instead, householders reported alternative reasons for their participation and

response. Several households, specifically a retired couple, an elderly couple and a family with young children, reported joining because they thought it might be interesting and fun:

MAN: We use it as a bit of fun. ... 'Okay, it's a red light – candles everybody!' ... You know the TV's off and that sort of thing.

WOMAN: We're probably taking it to the extreme but we've made a bit of fun out of it (8).

However, in most cases, householders expressed a sense of social responsibility in responding to the DPP signal. Similar findings have been reported by demand managers running DPP trials in Australia, who describe the 'sacrifice' of air-conditioning during DPP events as a non-rational 'common good factor' (Strengers, 2010). In this trial, this response was heightened by the notification provided by EnergyAustralia regarding an upcoming DPP event, which consisted of one or more of the following: a red light and sound alert on an IHD; SMS sent to one or multiple phones; phone messages; and/or email. In most cases, householders received multiple notifications, which heightened the sense of urgency they attributed to an approaching DPP event. Examples of the seriousness associated with an impending event are provided in Table 6, where householders refer to it as a 'deadly virus', 'power surge', 'failure', 'break' or 'blackout'. In the quotes selected in Table 6, it is the notification, rather than the price signal, which creates a sense of obligation to respond.

Table 6: Notification of a DPP event

Oh gosh, everything goes off. Two mobile phones, a message on the answering machine, this thing [referring to the IHD], as soon as the time actually hits, it glows up red and it just starts beeping at you and it won't stop beeping until you press the button. ... Yeah, it just goes, everything just goes off. Like we get a fair bit of notice (18).

I don't know if you have ever heard it, but it sounds very...deadly: 'there's a deadly virus coming in, you must not use your power!' That's how it comes across the first few visits: ... 'Now listen carefully, I will only repeat this once', or something like that (6).

They sent us an email and they send me a text message on the mobile phone to tell me 'the peak period is going to be or high priced period is going to be between two and four, or two and six'. So we go around and turn off all the power points and we don't use anything (14).

Yeah, and that's one of the reasons why we have changed a lot of our things. As soon as that red light comes on, [my partner] gets her SMS message. It comes through on my phone as well but I use the work phone, not my private one. We change our dinner pattern. We have candles in our bedroom (8).

When the power surge goes on I do turn that off (5).

No, when there are power failures we wouldn't use it. ... And we try not to use it unless it really is cold (6).

Yeah, there was another time where we had a power blackout and we just said, 'let's just go to the beach' (18).

In addition to the communication householders received from their utility, householders also communicated with each other, adding to the intensity of the situation:

Oh, well the kids would get them too. Then everyone would leave messages everywhere! (21).

Some householders also reported a heightened perception that they were being monitored by EnergyAustralia during a DPP event which led to new habits:

That comes into your mind, particularly when you've had that phone call, 'oh wait a minute, they're trying to measure this now, or just to see what the rate of consumption is and they've given us the message now' — and quite

obviously when they give it to you they must be measuring — that's the day they measure it for sure, so I don't think it would change me that much, but I've got an awareness of it now. Now that I've got into the habit of doing what I do now I don't think that would leave me (20).

It's like someone looking at you all the time. It's like Big Brother watching you... and then it becomes normal. It becomes habit (4).

The self-reported observations above were not expressed negatively, as they are often portrayed in media reports of 'Big Brother' utilities (Vermeer, 2008). This is consistent with the wider EnergyAustralia trial, which found that 84 per cent of participants' expectations were either met or exceeded (Collins, 2009). Rather, the perception of being watched or monitored *encouraged* householders to modify their electricity practices and engaged them in the co-management of their cooling practices. While some researchers might call this the Hawthorne Effect (Benson, 2000) — an experimental effect which makes people more likely to respond because they understand they are part of a trial (whether they are so or not) — we could also interpret this communication as a form of engagement between EnergyAustralia and their customers, which may have heightened householders' willingness to respond.

In support of this finding, EnergyAustralia's information-only group, who received notification of a DPP event without changed tariff conditions, reduced their consumption by 13 per cent during summer DPP events across the two-year trial (Collins, 2009). While EnergyAustralia found this response more variable than participants on higher tariff charges, and while international trials indicate that this response may diminish over time

(CRA, 2005), these results suggest that notification plays a significant role in the DPP response. Furthermore, given that the purpose of the trial was to empower householders to reduce or shift their *consumption* with the right *price signals*, as opposed to modifying their *practices* with the right *notification*, developing demand management programs with the explicit aim of engaging householders as co-managers of their cooling (and other household) practices may solicit greater results.

The success of DPP may also be connected to the *direct link* householders made with their cooling (and heating) practices during a DPP event, by observing the weather conditions during which a DPP event was called: 'it's mostly if the weather is very hot or very cold, so it obviously refers to the air-conditioning and heating' (13). By linking the price signal to air-conditioning, rather than 'consumption' in general, new meanings, values and expectations were indirectly attributed to this appliance. A DPP event implicitly repositioned air-conditioning as a luxury activity during these periods, or as something that should only be used when absolutely necessary. In this sense, DPP placed air-conditioning practices in a negotiable and contestable space, albeit for a short period of time, thereby encouraging householders to reassess their cooling practices.

Similar findings have been reported by Hackett & Lutzenhiser (1991) in their research on changing householder practices resulting from a switch from master metering to individual metering in a Californian apartment block. Through quantitative meter readings and qualitative interviews, these researchers found a significant and immediate drop in consumption resulting from the change to unit-metering. This drop was virtually universal, persistent over time, and highly specific to the air-conditioner. The authors found little evidence regarding the calculation of energy costs and benefits one might expect from a

strictly economic model of consumption. Instead, they argue that the price signal generated a new form of *social responsibility* concerning residents' energy use which gave consumption an 'obligatory' quality (Hackett and Lutzenhiser, 1991). Residents identified air-conditioning as a luxury and visible appliance which they were responsible for managing in an appropriate manner within their new role as metered power consumers. The authors conclude that the metered pricing structure acted 'as a socially instituted "allocated rule"' applied to discretionary or 'luxury' practices such as air-conditioned comfort (Hackett and Lutzenhiser, 1991).

These findings suggest that understanding the resource management issue of peak demand (i.e. being informed) and weighing up the costs and benefits of the price signal (i.e. behaving 'rationally') may be *less* important than (or as important as) being engaged by the utility as co-managers of specific practices, thereby linking new social and cultural meanings to those practices at specific times. These are important considerations given that dominant smart metering rhetoric and policy making is focused on enabling customers to 'make informed choices' (NERA, 2008b), 'manage their bills' (MCE, 2008) and 'save on their energy account' (CountryEnergy, 2004). In light of these findings, alternative demand management approaches may be required that utilise alternative understandings of consumption and change.

6. Policy and utility implications

This study provides insight into the broader demand response achieved through DPP, particularly the heightened drop in energy consumption on hot days (see Section 3). While the findings cannot be generalised, they are consistent with other Australian trials (NERA, 2008a; Strengers, 2010), and suggest that a greater range of factors than normally assumed

are at play in moderating responses to DPP. In particular, this study highlights a range of alternative cooling practices that some households possess knowledge of and actively engage in, as well as several non-rational motivations for responding to DPP, such as a desire to contribute towards a loosely-defined ‘common good’. At the very least, these findings suggest that the entrenched assumptions underpinning variable pricing programs need to be expanded and extended to consider other potential theories, methods and motivations for change. More broadly, they raise a series of potential concerns for policy makers and utility providers who continue to prioritise dominant assumptions about how and why householders consume energy.

In particular, three concerns deserve urgent reflection and attention. Firstly, there is a tension between the *intentions* and *assumptions* of DPP. While this pricing strategy *intends* to reduce and shift demand away from peak periods, it *assumes* that air-conditioning — the critical load that is trying to be curbed — is something most householders will need on very hot days. Consequently, DPP currently communicates two competing messages. On the one hand, by indirectly linking the pricing signal to air-conditioning (by calling DPP events on very hot days), there is an implicit suggestion that usage of this appliance should be curbed during a DPP event. In this sense, air-conditioning is reframed as an unnecessary, discretionary or luxury activity for short periods of time. On the other hand, by explicitly recommending that householders pre-cool their homes prior to a DPP event (see, for example, CountryEnergy, 2004), demand managers may legitimise and normalise air-conditioning uptake at all other times of the day.

From the perspective of energy retailers who, put simply, make money from selling more power, and electricity distributors, who make money out of the efficient and less ‘peaky’

use of their network, this is the desired outcome (Strengers, 2010). However, from a policy perspective, the end result of DPP may be the further escalation of energy consumption associated with household cooling practices. It is currently unclear how these competing messages will unfold if DPP becomes a more widely offered pricing scheme. However, evidently more attention should be paid to the role it, and other demand management programs, play in shaping everyday practices and the energy consumption required to maintain them.

A second concern is the potential for DPP and other demand management strategies to become increasingly ineffective within the complex and co-evolving range of factors raised in Section 3, particularly: the changing affordability and accessibility of air-conditioning; the changing size, composition and cooling arrangements of households; changing house (and clothing) fashion and design; the emergence of air-conditioning as a status symbol and socially polite practice; the homogenisation of indoor environments; and a range of other social and cultural factors not yet fully understood. In focusing on encouraging rational cost-reflective action at the individual household level, DPP and other demand management programs overlook these compounding factors, thereby potentially limiting their effectiveness.

Thirdly, there is a need to critically reengage with the reasons *why* pricing programs are effective (and ineffective), using theories, concepts and skills that extend beyond the discipline of economics. I have suggested that price signals such as DPP convey new meanings and understandings about ‘appropriate’ and ‘inappropriate’ practices and potentially realign the relationship between providers and consumers of energy through a co-management arrangement during DPP events. While similar results are being reported in

other trials (Strengers, 2010), and are alluded to in the universal weather-sensitive response to DPP (see Table 1), there is a surprising lack of research being conducted to understand these social and institutional dynamics.

7. Conclusion

In this paper I have suggested that the dominant demand management assumptions underpinning variable pricing regimes may be inaccurate and inadequate for understanding and maintaining demand reductions associated with cooling practices. Drawing on a small qualitative study of DPP, I have provided alternative explanations for understanding the weather-sensitive responses achieved through this pricing regime, and challenged the notion of air-conditioning as an essential service in Australian households. In particular, I have suggested that engaging householders as co-managers of specific household practices may be integral to a strong and maintainable demand response, and I have unearthed a wide diversity of cooling arrangements resulting from DPP that have previously been undocumented and unacknowledged.

However, it is clear that this paper raises more questions than it answers. In particular, it points to the need for a widescale and systematic study of the assumptions underpinning demand management programs such as DPP, particularly an assessment of non-rational motivations mediating the DPP response, notions of vulnerability, and critical engagement with and debate regarding the assertion that air-conditioning is a necessary service. The paper also raises broader policy and utility concerns with pricing programs that continue to prioritise these assumptions, particularly the potential for such programs to *escalate* air-conditioning usage, and the risk that demand managers will be unable to maintain demand reductions amidst the changing socio-technical context of air-conditioning expectations and

cooling practices. In light of national mandates for smart metering in Australia and internationally, these issues warrant urgent policy and research attention.

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10. Endnotes

¹ Victoria, New South Wales (NSW), Western Australia (WA), and Queensland also have their own smart electricity metering policies which involve ‘new and replacement’ smart meters, or in the case of Victoria, a state-wide roll-out which began in 2009 (MCE, 2008)

² This figure varies significantly between states which experience substantially different climatic conditions. State penetration estimations for 2009 (based on 2005 data) are NSW (57.8%), Victoria (63.1%), QLD (62.7%), SA (87.7%), WA (73.7%), Tasmania (23.9%), NT (93%), and ACT (52.6%) (EES, 2006)

³ In NSW, for example, ten per cent of the state’s generating capacity is needed for just one per cent of the time (less than 100 hours a year) and this is expected to rise to 20 per cent by 2014 Frew, W., 2006. Cool customers get \$70 a year from the hot ones. Sydney Morning Herald..

⁴ An IHD is a device which is linked to the smart meter and provides householders with user-friendly information about their consumption of household resources (electricity and/or gas and water). Most devices trialled display current and historical electricity data and graphs regarding household resource consumption (kilowatt hours (kWh)), greenhouse gas emissions and the cost of electricity.

⁵ TSCs are a device which can be attached to appliances such as air-conditioners and pool pumps to remotely turn them on and off at specified times. TSCs allow householders to maintain complete control over their own energy consumption, over-riding the time switches if they think it’s necessary. TSCs do not require a smart meter to operate.

However, they have been provided to customers as part of some smart metering trials in Queensland and internationally.

⁶ TOU pricing is typically characterised by an off-peak, shoulder and peak rate which are set at fixed periods of time and remain the same throughout the year. The cost difference between rates is typically much less than for DPP.

⁷ Specific results relating to IHD feedback are not discussed in this paper. See Strengers (2009) for further detail.