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A few words.

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Dear Commissioners,

AGL Energy welcomes the opportunity to make a submission on the Issues Paper – *Power of choice – giving consumers options in the way they use electricity*. As one of Australia's largest energy retailers and leading investor in renewable energy, AGL Energy (AGL) recognises the importance of improving Australia's energy efficiency over the next decade, given Australia's bipartisan commitment to a 5% greenhouse gas reduction target by 2020.

AGL operates across the supply chain and has investments in coal-fired, gas-fired, renewable and embedded electricity generation. AGL is Australia's largest private owner, operator and developer of renewable generation in Australia with over 1,000 MW of renewable capacity. AGL is also a significant retailer of energy with over 3 million electricity and gas customers. The diversity of this portfolio has allowed AGL to develop a detailed understanding of the risks and opportunities presented by greater demand side participation.

AGL considers that the broad objective of the Commission within the context of this Issues Paper should relate to ensuring that policy settings achieve allocative efficiency (pricing efficiency). Assuming appropriate price signals emerge in the market, AGL believes that markets will respond and deploy technologies and capital to facilitate greater demand side participation. Specific to energy efficiency, AGL recognises that additional non-pricing approaches may be required to achieve an energy efficiency step-change due to barriers being non-price related (e.g. split incentives). AGL believes that complementary energy efficiency policies should be targeted at overcoming institutional and cultural barriers preventing allocative economic efficiency.

Key experiences and observations

Based upon offering a range of services and continually seeking new opportunities to strengthen the position of AGL as a holistic energy services provider, AGL has identified a number of persisting issues that inhibit greater adoption of demand side participation and energy efficiency in both the residential and C&I sectors.

Residential sector

Observations and experiences in the residential sector relate to three key areas, firstly retail price regulation, secondly the operation of state-based energy savings schemes, and finally the continuing uptake of low-efficiency appliances. The persistence of retail price regulation in competitive markets continues to be one of the key barriers to improved demand side participation and energy efficiency outcomes for the residential sector. Regulated tariffs impact in two key ways:

- <u>Muted price signal</u> – unless consumers are exposed to price signals that inform consumption behaviour and purchasing decisions, empowering users to be more energy efficient is unlikely to be fully obtained.

- <u>Curtailment of innovation</u> – without sufficient freedom to price energy, energy service providers are constrained to the nature of further incentives and offers that they can make to entice and retain customers.

Most importantly, the continued regulation of retail prices prevents retailers from developing innovative dynamic pricing structures which aim to overcome the allocative inefficiency which results from variable demand. It is not realistic to talk about reforms to the electricity system involving new technologies (e.g. smart meters) when the very value they provide cannot be extracted due to rigid pricing structures enforced through ongoing retail price regulation.

In order to achieve energy efficiencies and greater participation in energy markets by residential customers, most jurisdictions have introduced energy efficiency initiatives, with Victoria, NSW and South Australia introducing schemes predicated on retailers having liability for providing energy efficiency initiatives - known as white certificate schemes. These market based schemes are applicable to domestic households, as well as industrial and commercial customers in the case of NSW. The Schemes posing mandatory obligations on AGL include:

1. Victorian energy Saver Incentive, under the Victorian Energy Efficiency Target (VEET) Act 2007

2. SA Residential Energy Efficiency Scheme (REES), following amendments to the Electricity Act 1996 and Gas Act 1997

3. NSW Energy Savings Scheme (ESS) under the amended Electricity Supply Act 1995

Whilst each of these schemes in isolation have addressed a number of barriers to energy efficiency in the residential sector, by virtue of being multiple regulations interfacing with the singular wholesale market, they currently are not benefiting from the potential economies of scale that could be achieve by a singular, nationally consistent scheme. Slightly different rules and features increase complexity and consequently make it administratively more difficult and therefore costly for scheme participants; primarily retailers.

Finally, the Minimum Energy Performance Standards (MEPS) has been a strong initiative by governments, which AGL considers is broadly recognised by consumers. However, it is considered that equating a MEPS energy rating to electricity bills is not occurring. This is possibly due to the apparent low costs driver and immaterial view consumers have of the impact an appliance may have on electricity bills. Demand side participation and customer choice in energy markets cannot be implemented in isolation of information relevant to the energy consuming capital stock.

Commercial and industrial sector

Either through mandated obligations, or through interests in environmental performance, AGL has assisted many C&I energy users to identify opportunities to improve energy efficiency. However, simply identifying opportunities does not equate to implementation of improvements.

AGL has observed that owing to either the insignificant cost savings (Australia's electricity prices are still some of the lowest in the OECD), or the requirement to reserve capital for the most productive uses, it is frequently difficult for an energy efficiency project to gain financial support within an organisation. Required payback periods, combined with internal hurdle rates in the order of 15% or more, result in many energy efficiency projects being shelved.

Recommended initiatives

AGL's observations are consistent with the barriers and issues identified in the Issues Paper. The following recommendations are aimed at addressing information gaps, capital constraints and split-incentives.

Introduction of price monitoring

Policy makers should remove retail price regulation where competition has been demonstrated to be effective and introduce price monitoring. The continued regulation of retail pricing is a barrier to four key macroeconomic objectives: economic growth; innovation; environmental outcomes and new investment. Simshauser and Laochumnanvanit[1] noted that there is a direct correlation between market participation (i.e. churn), available headroom and historical price regulation outcomes. Their study also found that the NSW experience is a critical example where from 2004-2007 inappropriate price regulation essentially paralysed the competitive market, with switching rates as low as 5%. In addition, AGL agrees with the AEMC's comment that "the removal of price caps where competition is effective will be important for promoting investment in this sector."[2] AGL believes that the AEMC has a critical role in working with the Ministerial Council on Energy (*MCE*) in developing time frames for the completion of the outstanding reviews of effective competition (including in NSW and Queensland) and continuing to inform the MCE of the real and non-trivial costs associated with the continued regulation of retail prices where competition has been demonstrated to be effective.

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[1] AGL Working Paper available at http://www.aglblog.com.au/wp-content/uploads/2011/01/No.20-Domino-Effect1.pdf

[2] AEMC (2011), "Strategic Priorities Discussion Paper" page 38

Facilitation of dynamic pricing

AGL notes that one of the issues raised by the *Discussion Paper* relates to the responsiveness of energy users to higher prices. AGL has completed a number of research projects on this topic. In particular, a working paper by Simshauser and Downer[3] examined how the introduction of dynamic pricing would impact on electricity demand (particularly at peak times). The study demonstrated that an 8.2 percentage point improvement in the load curve could be achieved with the introduction of dynamic pricing. The paper's modelling showed that a flattening of the household load curve from 38.5% to 50%, indicated a reduction in unit costs of about $32/MWh, and if applied unilaterally across the four primary NEM states, a reduction in costs of some $1.6 billion pa in the household sector alone. The conclusions from this research are clear: the introduction of smart metering and dynamic pricing (with appropriate policies in place to ensure customers in hardship are not adversely affected) should be prioritised by energy policy makers. A copy of this paper is attached to this submission.

Clarification of contestable participants

One of the critical issues identified by the AEMC's *Issues Paper* relates to the distinction between regulated and non-regulated activities in the context of demand side participation. AGL is concerned that businesses which operate primarily as regulated network operators are increasingly engaging in activities that are contestable. Where appropriately ring-fenced, this is not likely to create significant concerns. However, it is unclear that regulated income is not being used to fund business development activities in these emerging contestable markets. AGL firmly believes that only contestable businesses should be in contact with customers to provide demand side participation services. Regulated businesses by definition provide a monopoly service and have no need to be in contact with the customer in relation to new products and services. AGL strongly supports the AEMC ensuring that businesses with regulated revenues are appropriately ring-fenced from any activities that require 'involvement' with the customer.

National Energy Savings Scheme

AGL considers that a singular, national energy savings scheme (NESS) should be a keystone feature of the policy framework for ensuring greater participation by energy users. This scheme would adopt features of all three of the state-based schemes and be cross-sectoral, to capture energy efficiency opportunities in both the residential and C&I markets. As the entities with the strongest interface with energy consumers, AGL considers that retailers are best placed to participate in the NESS as liable entities required to drive energy efficiency uptake.

Aside from the states of Victoria, South Australia and New South Wales already implementing similar programs, it is noted the Queensland Parliament Environment and Resources Committee has recommended that the state government explores the feasibility of a Queensland energy saving scheme consistent with schemes operating in the other jurisdictions. The Queensland Committee also recommended that the Queensland Government canvas through

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[3] AGL Working paper available at: http://www.aglblog.com.au/wp-content/uploads/2011/03/No.24-Limited-Form-Dynamic-Pricing.pdf

the MCE the feasibility of a national scheme. The efficiencies of a single scheme would be significant for retailers.

The NESS would address key issues observed in the energy efficiency market place by AGL including:

- Information asymmetries – mandating the undertaking of energy efficiency measures will ensure energy service providers deliver information to consumers.

- Capital constraints – the financial incentive under the NESS would assist in reducing the costs and capital constraints for the C&I sector. Application of the NESS to appliance purchases (as in NSW) would also assist the residential sector.

- Behavioural barriers – the financial incentive of the NESS provides opportunity for energy service providers to influence decision-making processes and energy consumption behaviour.

Provided the correct features are established, the NESS could also feature access to lower-cost capital for C&I projects that are longer-lived and have payback period beyond two years. Shortcomings on the implementation of similar existing programs would be addressed, as the mandated involvement of retailers and other energy service providers would provide a significantly stronger interface between the energy efficiency project proponent, and the assistance available under the NESS.

AGL is of the view that energy efficiency will become more economically attractive to customers as the ETS commences and energy prices rise. Work undertaken by AGL economists has demonstrated that electricity prices within QLD and NSW could be double FY08 levels by FY15[4]. If this analysis proves accurate, energy efficiency and demand side participation are likely to become more prominent due to core underlying economic incentives increasing.

Enhancement of MEPS

AGL believes efficiencies can also be achieved through enhancement of MEPS. Although appliances are ranked by the energy efficiency "star rating" the minimum standards could be ramped up considerably. At present the appliance market still features energy inefficient products, which at time of purchase often steer consumers away from more efficient products. AGL believes that minimum standards for appliances should be introduced for specific energy intensive appliances. The introduction of such a standard would further facilitate the development of Australian manufacturing in highly energy efficient products.

Importantly, information gaps could be overcome by incorporating energy consuming capital stock industries within the AEMC's consideration of improving information to facilitate greater demand side participation. Energy appliance retailers are a critical "channel" for information related to the efficiency of products.

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[4] Simshauser, P., Nelson, T., & Doan, T. (2011). The Boomerang Paradox, Part I: How a nation's wealth is creating fuel poverty. *The Electricity Journal* , 72-91

Distributed/ Cogeneration

AGL believes that currently there are few incentives for distributed generation and co-generation units. AGL is of the view that incentives should be introduced to bridge any gap between network regulation, demand management and participation in wholesale market. Incentives are especially needed for co-generation to units to accessing the pool price at times of high demand.

Clarification of responsibilities for policy development

Clarification of responsibilities for policies related to consumers participation in energy markets in a Federalist system of government is critical. Energy policy within Australia often suffers due to a lack of coordination between the States and the Commonwealth. This is not unsurprising given our Federalist system of government. However, the AEMC could play a significant role in highlighting through the Ministerial Council on Energy the perverse outcomes that occur when policies are implemented without mutual consideration or coordination. The growth in incentives for small scale solar PV generation in recent years is a crucial example of how uncoordinated policy can lead to perverse policy outcomes. In a recent paper, Nelson, Simshauser and Kelley[5] highlighted the regressive nature of Feed-in Tariffs and IPART[6] in its recent draft pricing determination highlighted the problems associated with multiple support mechanisms for solar PV leading to higher overall electricity prices. In this context, AGL believes that renewable energy policy should be the responsibility of the Commonwealth and State Governments should gradually remove support mechanisms such as State-based Feed-in tariffs.

Should you have any questions or comments, please contact me on (02) 9921 2516 or at tanelson@agl.com.au.

Yours sincerely,

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Head of Economic Policy & Sustainability

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[5] Nelson, T., Simshauser, P. & Kelley, S. (2011), "Australian residential solar PV feed-in tariffs: industry stimulus or regressive form of taxation", *Economic Analysis and Policy,* in-press

[6] Available at: www.ipart.nsw.gov.au

Limited-form dynamic pricing: applying shock therapy to peak demand growth

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Abstract
Australia's recent electricity market reforms were met with remarkable success, but gains in the wholesale market have been largely exhausted. Above trend-growth investment across the energy supply chain is now driving retail prices to levels that triggered the sectoral assault in the first place. This pressure should initiate the last piece of the reform puzzle; removing price regulation, installing smart meters and implementing limited-form dynamic pricing to halt the primary cause of the problem; rapidly rising peak demand. We find that such a change can lead to non-trivial reductions in household peak demand, with our sample load factor improving by 8.2 percentage points.

Keywords: Electricity Prices, Dynamic Pricing, Smart Meters, Smart Grid.
JEL Codes: D61, L94, L11 and Q40.

1. Introduction

One of the most pronounced thematics associated with retail tariff levels in the National Electricity Market (NEM) has been the sudden change in trajectory. Taking the Queensland (QLD) region as a typical example, with few exceptions, electricity tariffs fell in real terms between 1955 and 2007. Over that 53-year period, tariff increases averaged just 68% of the Consumer Price Index (CPI).[1]

A notable exception to this was between 1982 and 1986. Core inflation was running at more than 8%, while QLD tariffs increased by 1.5+ times CPI. This coincided with startling growth in the power system's capital stock, rising as it did from $7.0 billion to $12.1 billion (in 2011 dollars) in the space of just five years.[2] This was driven by a 57% increase in generating and network plant capacity to 4,800MW (esaa, 1994). While the timing of events differed at the margins, similar patterns emerged in New South Wales (NSW), Victoria (VIC) and South Australia (SA). Once these 'build-out plans' were completed, a period of 'harvesting prior investments' ensued with real electricity tariffs reducing dramatically across Eastern Australia through to about 2007.

At first glance, one could be forgiven for thinking we are once again in *an exception period*. Tariffs are now rising at multiples of CPI. Network capital expenditure over the five-year period to 2015 in QLD and NSW alone is forecast to exceed $31.5 billion, compared to $7 billion during 2001-2005.[3] And generation plant capacity in the broader NEM has expanded by 21% to 44,800MW over the last five years.[4]

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[1] See Simshauser and Laochumnanvanit (2011 at Figure 1) for the real price of electricity from 1955-2007.

[2] Capital stock derived from esaa (1994) and inflation data from ABS.

[3] Simshauser, Nelson and Doan (2011 at p.86).

[4] esaa (2005, 2010) at Appendix I.

There are commonalities between the sharp run-up in the outlook for tariffs in 1982, and in 2008. Both periods involved above-trend growth in the capital stock in response to rising demand and asset replacement. But key differences also exist which tend to imply that the current round of tariff increases may not be followed by a 'harvesting period'. First, the 1980s investment cycle, undertaken in response to high demand forecasts, grossly exceeded actual requirements with the benefit of hindsight. As a result, tariff increases in subsequent periods decelerated below CPI as excess capacity was, over time, productively utilised. Second, the outlook for key commodity input costs (viz. fuel) was stable, if not declining, due to pronounced productivity gains in the mining sector. Third, expansion of the capital stock was accompanied by material technological enhancements, including a shift to much larger, more fuel efficient, and more reliable turbogenerators. Structural enhancements also included greater interconnection, and the addition of sizeable mining and manufacturing loads, which in the event reduced the highly volatile household loads from 40% to about 30% of aggregate demand. The new mining and manufacturing loads were desirable due to their flat and predictable shape, enabling the electricity industry on the East Coast to expand its fleet of low-cost base load machines, thereby spreading the heavy fixed costs of the entire industry across greater units of output, thus producing a lower overall system average cost.

The outlook for the 2010s feels different. Generation and network capacity additions do not appear to be grossly exceeding growth in energy demand, and so a harvest period seems unlikely. Inputs to the industry are experiencing heightened volatility; turbine prices, the cost of capital, labour construction costs, copper, steel, and above all, coal and gas.[5] This latest expansion will also involve changes to the power generating technologies deployed, but in the main it will come at a cost penalty, driven by requisite environmental objectives. And finally, like 1982, demand has been demonstrably rising, but unlike 1982, load growth is not structurally advantageous. New incremental load, increasingly driven by households and non-industrial enterprises, is extremely peaky, not the flat and predictable industrial loads of the 1980s.

In reviewing the factors present in the 2010s, for policy makers the obvious candidate capable of further microeconomic reform is the demand-side, and in particular peak demand. The perennial underperformer in most energy market reforms, demand-side participation represents an important frontier for policy makers because the principle means by which to do so, shifting from mechanical to digital metering, is now possible and economical (Faruqui and Sergici, 2010). Other factors impacting retail tariffs, outlined above, are simply the out-workings of properly functioning markets. Trivial 'Demand Response' in a rising cost environment, is not.

Household energy consumption in Australia, as with the United States, now represents about ⅓ of aggregate energy demand. But the contribution of household peak demand is entirely out-of-step. In some regions and segments, peak demand is running at almost twice the growth rate of underlying energy demand, driven by rising disposable incomes, larger household floor space, and plunging appliance costs. That peak demand is rising so fast is hardly surprising given households are equipped with century old metering infrastructure which is unable to distinguish time-of-use (TOU). Consequently, TOU pricing has not been technically feasible, and where digital meters do exist such as in VIC, it is not yet politically feasible. Either way, households have no incentive to adjust peak demand since the primary driver to do so, price, is absent.

The purpose of this article is to analyse a subset of the gains associated with shifting to digital meters and limited-form dynamic pricing, and to examine the ethical considerations of such a reform. This paper is structured as follows. In Section 2, an historical analysis of household electricity costs is presented. Section 3 illustrates the cost consequences of declining load factors. Section 4 provides a brief overview of smart meters and the smart grid. Section 5 examines

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[5] The coal and gas industries are increasingly seeking to export their commodities to the seaborne market, thus creating export price-parity pressure for domestic fuel users.

dominant thought on electricity demand. In Section 6, results from limited-form dynamic pricing pilots are presented. Section 7 then presents simulated modelling results of limited-form dynamic pricing to a sample of 3000 NEM customers with digital meters. Section 8 considers the ethics of shifting from average to dynamic pricing. Our policy recommendations follow in Section 9.

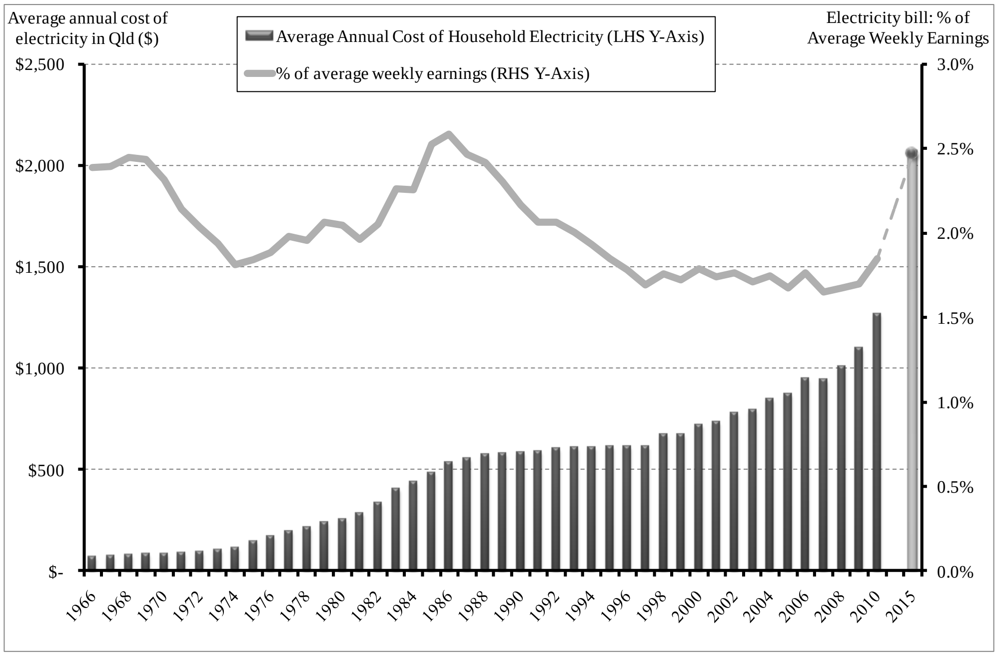
2. History of household electricity costs

We compiled 45 years of electricity price, consumption and earnings data for residential customers in QLD. This enabled us to generate an 'average annual household electricity bill' time series, represented by the bar series in Figure 1. Consumption has increased from about 2MWh in 1966 to about 7.5MWh in 2010, and price has increased from about $20/MWh in 1966 to $186/MWh in 2010. Accordingly, average household electricity costs have risen from $68 pa to about $1270 in 2010

The use of average weekly earnings data enables us to derive the relative proportion of household income represented by an electricity bill, depicted by the lines series. In the 1960s, electricity costs represented 2.4% of household income before falling sharply in the early-1970s. The effects of the OPEC oil price shock led to rising electricity costs. And as noted earlier, this was heightened with the expansion of the power system between 1982 and 1986, peaking at 2.6% of income. The harvest period then followed with electricity costs falling to 1.7% of income through to 2007.

In Figure 1, we have also plotted a forecast electricity bill for the future year 2015 using pricing data from Simshauser, Nelson and Doan (2011a) while increasing household incomes by 4.0% pa. Our forecast bill is $2,066, based on 7.5MWh and $275/MWh. Crucially, at this level, electricity will once again represent 2.5% of average household income.

Figure 1: Average annual electricity bill vs. average weekly earnings



Source: esaa, ABS, AGL Energy Ltd.

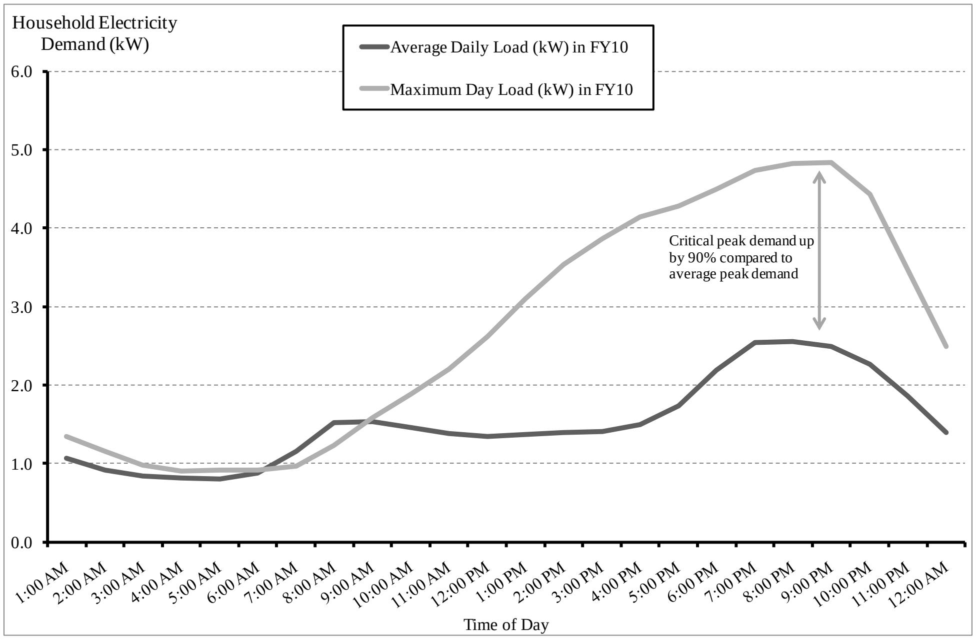
The last time electricity costs represented 2.5% of household income, a wave of microeconomic reform was triggered by the federal government. Ten years later, state-owned monopoly electricity commissions were restructured, market institutions implemented and the NEM was formed with a focus on productive, allocative and dynamic efficiency gains. If electricity is once again set to rise to 2.5% of household income, it would seem logical to presume that further reform will be originated by policy makers. As Simshauser and Laochumnanvanit (2011) noted, the wholesale market has been subjected to a comprehensive assault, but the retail market remains largely untapped. The areas which stand out are metering, metering services, Demand Response, and pricing structures.

3. The cost consequence of a declining power system load factor

A recent survey by the NSW energy regulator found that average household consumption in that state had declined by 5% over the five years to FY10, but aggregate peak demand had increased by 10%, from 13,200MW to 14,580MW. In Queensland, average annual household energy demand has not moved materially since the late-1990s, but the number of households has increased by 34% while peak load had risen by 104% (Simshauser et al, 2011a).

To illustrate the source of the problem at the household level, Simshauser and Laochumnanvanit (2011) analysed 3000 NSW residential customers who had an interval meter (which records half-hourly data). The granularity of this data allowed an examination of the shape or 'peakiness' of household demand. 52.5 million FY10 meter readings from the 3000 customers were condensed into two household load curves, which has been reproduced in Figure 2; the first being average daily demand, and the second being demand on a 'critical event day', where temperatures reached 40°C.[6] On this critical event, household peak demand is up by 90%.

Figure 2: Daily average demand vs. critical event demand from 3000 households



Source: Simshauser & Laochumnanvanit (2011).

Simshauser and Laochumnanvanit (2011) noted that electricity cannot be stored and therefore there is no inventory from which to draw upon during peak periods, and unlike time-delays with transport congestion, electricity congestion can only be solved through blackouts, which is politically unacceptable. As a result, network infrastructure and generating plant capacity must expand to meet projected instantaneous peak demand (plus a margin for forecast errors and plant outages). The capital cost of doing so is non-trivial. SSC (2010) recently noted that $900 million of capital invested in the distribution network in southeast QLD is used for just 3½ days pa. To put this into context, the total capital stock of the southeast QLD grid is $8 billion, and thus

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[6] The households in Figure 2 consume an average of about 6.7MWh per annum (below the regional average of about 7.5MWh). Nonetheless, it is the shape of the load curve that is of relevance to our analysis.

12.5% of the network is provided for use on 3½ days pa. Clearly for network companies to stay in business, investment costs must be recovered. But with most households equipped with mechanical meters, this is done via average tariffs. This raises a rather obvious issue for consumers going forward. Peak demand is rising rapidly, causing more investment. Average tariffs are rising to recover the cost. While there is evidence to suggest annual consumption is moderating in response, peak demand is not. As peak demand keeps rising, new capacity must be built to keep the power grid stable. The cost of this capacity must then be recovered, leading to yet further price increases. In short, increasing the average tariff is *not* dealing to the 'moment of scarcity'. Average tariffs are evidently substantially below the available consumer surplus on critical event days. As US energy economist Ahmad Faruqui (2010a, pp 4-5) elegantly observed:

> *"In just about any market-driven economy, prices play a central role in allocating scarce resources such as capital, labour, fuel, and other raw materials. Suppose the [flat tariff principles currently used in the electricity industry] were accepted by policymakers in the halls of government, who then proceed to apply them to the entire U.S. economy... Parking meters in inner cities would charge the same hourly rate all day long, every day of the year, instead of the current system where meters commonly do not charge after work hours or on weekends. The consequence would be that motorists would have a tough time finding parking during working hours... Airline prices would be the same regardless of when you booked your flight or when you flew. Business travellers needing to book a seat at the last minute would be disappointed and vacationers looking for special deals would find none... The same uniformity would be applied to hotel rates and car rentals. It would not matter whether you checked in on a weekday or a weekend. Grocery shoppers would expect to pay the same price for produce regardless of whether it is in-season or out-of-season. When filling up for gas at the pump, motorists would pay the same price year round. And so on. Would prices for various goods and services be higher or lower, on average, in this alternative reality we have just sketched? The alternative reality would be characterized by excess capacity and poor load factor, because prices would no longer be used to spread out periods of intense demand. As a result, the alternative reality would be a world of higher prices."*

Faruqui's (2010a) *poor load factor* concept can be illustrated by reference to southeast QLD electricity demand. In Simshauser et al. (2011a, 2011b), a series of forecast electricity prices was provided for the future year 2015. We have reproduced the QLD 'high gas' scenario in Figure 3, represented by the left-hand bar.[7] Given a forecast load factor of 38.5% for QLD households, this resulted in a tariff of 27.6c/kWh or $276/MWh and at 7.5MWh of consumption, a household bill of $2,066 per annum. We have produced a second scenario where the load factor is assumed to increase from 38.5% to 50.0%, an improvement of 11.5 percentage points which as we will see later requires a concerted effort.[8]

In order to generate the 50% load factor scenario, we used the NEMESYS model to determine generation fuel and capacity costs. NEMESYS is a dynamic, partial equilibrium model of the power system with half-hourly resolution and price formation based on a uniform, first price auction consistent with the NEM design. The NEMESYS model assumes perfect competition and essentially free entry to install any combination of capacity that satisfies differentiable equilibrium conditions. The lumpiness of new capacity is a constraint; firms may chose either 300MW CCGT base load plant or a 150MW OCGT plant based on conventional 'E Frame' gas turbine technology; a technology widely available from the main plant manufacturers. The

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[7] In this scenario, gas prices were assumed to rise to a 'netback price' of $6.75/GJ compared to a domestic gas extraction cost plus margin of $3.60/GJ.

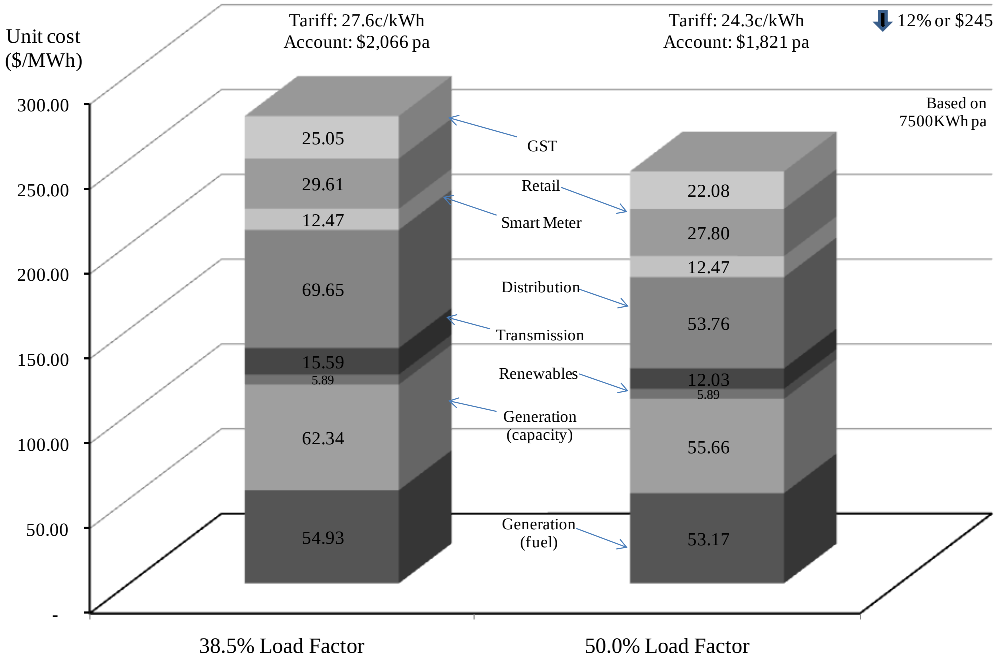
[8] We opted to hold peak demand constant for ease of modelling. While doing so exaggerates energy consumed, it has the benefit of capturing the gains in network charges whilst eliminating the requirement to revise future network capital expenditure.

NEMESYS model specifications have been documented in Simshauser (2008) and therefore we do not propose to reproduce them here.

The comparative scenario costs for generation fuel and capacity are clearly illustrated by the bottom two blocks in the Figure 3 ‘cost stack’. The higher 50% load factor scenario led to a change in the plant stock by comparison to the 38.5% scenario. While not evident in Figure 3, base plant was increased and peaking plant reduced in response. This lead to a reduction in unit fuel costs, from $54.93 to $53.17/MWh due to the higher combustion efficiency levels of base plant, and while there was a higher sunk capital cost arising from more base plant, the costs were spread across greater units of output, thereby reducing capacity costs from $62.34 to $55.66/MWh.

The transmission and distribution charges decline due to enhanced loading of the power system. Holding the relevant revenue caps constant, unit transmission costs reduced from $15.59 to $12.03/MWh, and distribution from $69.65 to $53.76/MWh. Retail costs and GST also decline in-line with revised costs. All-in-all, this scenario, while highly stylized, demonstrates that gains from a flatter load curve are substantial; -$32.67/MWh or 12%. esaa (2010) data indicates there are 7.6 million households in QLD, NSW, VIC and SA, with the four-State average consumption being 6.7MWh pa. If a $32.67/MWh reduction was achieved in all four regions, this would equate to avoided costs of $1.67 billion pa in the household sector alone. The key question that follows is whether such gains are long-run plausible?

Figure 3: QLD residential electricity bill in FY15 – low vs. high load factor



Granted, we should not expect elegant policy to be devised, implemented and then immediately downgrade load forecasts. The defrayed nature of Demand Response means that time, experience and sustained participation rates are required. But Demand Response designed during QLD’s monopoly era (i.e. electric hot water loads on ripple control) was driven in the 1980s, and by the 1990s fully 500MW or 10% of aggregate system demand *was responding*.

As a separate aside, one aspect of energy policy that is gaining increasing traction at the federal level is the concept of a ‘white certificate’ energy efficiency scheme, primarily as part of the suite of policies aimed at greenhouse gas abatement. Under such a scheme, efficiency targets would be imposed upon retailers to reduce electricity consumption of their respective customer base via changing out lights, appliances and installing other energy saving devices. Ergas (2010) observed that this should only occur where benefits exceed the cost. In relation to a federal taskforce report on implementing such a scheme, he noted that:

> *A policy is effective if it does what it sets out to do. It is economically efficient if what it sets out to do is worth doing. The [federal government energy efficiency taskforce] report's premise is that we should reduce our energy consumption; what it fails to show is that reducing energy consumption would make Australians better off. The clear implication of this is that our levels of energy use are inefficient. But for this proposition, there is no evidence [presented in the report] whatsoever...*

Analysing the cost and benefits of a white certificate scheme and its impact on carbon emissions is beyond the scope of this article. However, a reasonably predictable outcome of an energy efficiency scheme, if set in the context of limited-form dynamic pricing, will be reductions in peak demand. The evidence in Figure 3 tends to imply that the benefits of such a scheme, given load factor effects, would have a very high probability of exceeding costs.

4. The Smart Grid

In order to deal to future peak demand, a technology shift is quite essential. Whereas telephones have been revolutionised over the past 100 years to the current 3G handsets, electricity grids have remained a set of ‘dumb wires’. *The Economist* (2009) noted that Thomas Edison, who pioneered electrification in the 1880s, would be able to run the existing networks as they are based on early-1900s technology. Utilities rely on consumers to advise them when load shedding events have occurred, and the cause of outages requires extensive physical analysis by utilities.

4.1 Grid-side applications

A smart grid would encompass all kinds of grid-side applications such as digital meters and a communications network akin to the internet to the existing wires. This would enable fault-detection, identification and restoration, voltage control and feeder monitoring. Real-time monitoring of the network would enable power to be re-routed around faults thus minimising disruptions just as the internet redirects data packets under stress conditions.

Once the cost of technology is established and known, there seems to be little risk involved in capturing the benefits from grid-side applications, particularly in non-radial parts of the network. Automation of the poles & wires is well overdue. Power station control systems made very substantial gains to production, reliability and operational efficiency levels from automation and monitoring; the most visible gains were achieved throughout the 1990s with plant availability levels rising from 70-80% to the current 90%+ benchmarks (esaa, 1996, 2010). Similarly, the combustion efficiency and minimum stable loads of thermal plant have been improved materially as a result of automation.

4.2 Advanced Metering Infrastructure

Until recently, customer metering at the household level had similarly changed little over the past 100 years with accumulation meters dominating the landscape. Faruqui, Sergici and Sharif (2010, p.1598) put the consequence of this technology lag into context:

> *...Imagine a world in which Joe Smith drives up to the gas pump in his large SUV, fills up his truck, and drives away without paying a dime. The gasoline is not free, but Smith won’t know how much he has purchased or how much he owes until [3] months later because he has a [quarterly] account with the gas station. When his wife drives up to the pump in the family sedan, she goes through the same procedure; as does their high school senior, who drives up to the pump in her compact coupe. The Smith’s get a combined bill and don’t know how the charges accumulated. Was it Joe’s driving, his*

> *wife's driving or their daughter's driving that accounted for the lion's share of the bill? What makes life even more interesting for the Smiths is that none of their cars have a speedometer or a gas gauge. They get no feedback at all on how to manage their gas bill. Are the Smith's living in some type of parallel universe? No, if we were to change the gas station to an electric utility, the Smith's are living in the world as we know it today... But this may be about to change. Courtesy of the digital revolution, new devices are being introduced that would allow electricity customers to know where their power is going and what they can do to control usage, lower their bills and also help reduce their carbon footprint...*

There are many adverse consequences of mechanical meters; the time taken read them, the absence of automated information flows on outages, connections and reconnections errors. But perhaps the most critical constraint of the mechanical meter is the inability to measure the shape of household load, thus negating the ability to apply TOU pricing. Without half-hourly information, the deeming process used to charge residential loads means that some households are being under-charged for consumption (e.g. wealthy households with high air-conditioning and appliance use) while other households (e.g. most low income households) are being over-charged and are in effect subsidising high-use households. Volume throughput is no longer the lead indicator of investment in the NEM; peak demand is, and only TOU pricing (as distinct from inclining block tariffs) can correct cross-subsidies with any degree of accuracy.

Digital or 'smart meters', also known as Advanced Metering Infrastructure (AMI), provide the data and communications to overcome TOU constraints. Smart meters do more than just log half-hourly consumption. In all, there are 24 individual 'services' provided by smart meters as set out by the minimum national standard.[9] These include remote reading, security, tamper detection (to detect theft), remote time synchronisation, remote connection and reconnection, load management, measurement of import and export data in the case of on-site generation, interface to Home Area Networks (HAN), loss of supply and event recording details and monitoring, and most critically, half-hourly load measurement.

At the time of writing, more than 76 million smart meters have been installed worldwide.[10] This number is forecast to rise to 302 million by 2015, running at an annual compound growth rate of 31%.[11] In California for example, Pacific Gas and Electric has already installed 7.65 million smart meters and Southern California Edison has installed over 2 million meters.[12] Locally, 500,000 Smart Meters have been rolled-out in VIC with all 2.8 million households expected to be equipped by 2013[13], and in NSW, a roll-out will be completed by about 2017. QLD and SA have not made any decision on a smart meter roll-out.

4.3 Demand-side applications

There is currently very little automated demand in households. The only widespread form of demand management comes via electric hot water heaters and swimming pool pumps in States like Queensland, where special tariffs and a separate pulse system cuts loads out during high demand.

In contrast, the smart grid would include a HAN, which is essentially the smart *wireless* technology behind the meter inside the home. This includes wireless In-Home Displays which show close to real-time household power consumption and price, thermostats that are connected between the meter and electrical appliances, with those appliances being switched on- or off

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[9] The Ministerial Council on Energy has approved a set of minimum functionality that must be provided in any smart meter roll-out in Australia.

[10] See http://www.pge.com/myhome/customerservice/smartmeter/deployment/ for details of global smart meters.

[11] The forecast of smart meters to 2015 has been drawn from www.metering.com.

[12] See http://www.sce.com/customerservice/smartconnect/about_smartconnect.htm for details.

[13] The Victorian roll-out is available at http://www.ena.asn.au/

remotely, or in the case of space heating and cooling, switched-off in short bursts or throttled-back during high price events. And over the next horizon, a HAN could also ensure that demand arising from Electric Vehicles could be adequately diversified.

But fundamentally, all roads lead back to the roll-out of smart meters as the starting point of the smart grid. Two key issues stand out; (1) ensuring product standards are enforced, and (2) the cost-benefit of wide-scale roll-outs. In VIC, the cost-benefit of the smart meter rollout has been well documented in Oakley Greenwood (2010), with a low case expected benefit of $1.8 billion exceeding costs of $1.6 billion. The low case expected benefits did not include any gains arising from a shift to dynamic pricing, which as we identified in Section 3, are potentially substantial. But as Page (2010) recently noted:

> *…To keep smart grids on track, political fortitude will be required. Politicians must be able to explain the necessity of the changes to the community and to stare down a media and oppositions that will be looking for every chance to criticize governments. We've already seen in Victoria that the rollout of the interval meter has hit trouble [due to cost increases]. It seems that the local media has decided households outlaying about a dollar a week for new technology that forms the basis of their future engagement in an energy efficient world is an unacceptable cost. The really unacceptable cost would be to leave consumers without the technology to make direct and informed decisions about energy use. Short-sighted commentary on this initiative is especially disappointing…*

5. Dominant thought on energy demand: virtually price inelastic?

Historically, 'dominant thought' on household electricity demand was that it was highly price-inelastic. Electricity price increases in Australia have been met with virtually no sustained response from households. As a result, dominant thought is probably not without foundation given the essential service characteristic of electricity. As Rochlin (2009, p.15) observed:

> *...The obligation to serve, the lack of retail price signals reflecting the variable cost of production, the inability [of households] to respond to that price signal, and the lack of exclusion have created a truly unique economic aspect of electricity: the false belief that customers would not respond to price signals. The desire for relatively stable retail prices, the high cost of [smart] metering and an assumption that consumers must have electricity have resulted in a complete failure to move price variability to the retail level...*

Demand Response, energy efficiency and the so-called 'nega-watt', long argued as the *low hanging fruit* in the context of energy market reform, has been the perennial under-performer in deregulated markets globally. Quite simply, demand-side participation over the past 12 years since industry deregulation in the NEM has been trivial. The fact that residential demand management has featured so little can be attributed to the muting of peak price signals, especially on critical event days.[14] There is also the vexed problem of split incentives around household load management; all things equal, network utilities seek to reduce demand during extreme weather events in parts of the grid that are subject to relative under-investment. Retailers seek to reduce household demand during high spot price events. These two load management 'events' (i.e. high loads in weaker parts of the grid, and high spot prices) are no doubt positively, but not perfectly correlated. Ideally, the benefits from both events should be fully captured.

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[14] There are other important factors, such as the intensely competitive nature of liberalised retail energy markets. The ability of energy retailers to initiate and fund energy efficiency and demand management programs evaporated as the intensely competitive NEM commenced. Merchant status exposes retailers to customer churn (i.e. investment stranding), and there is an absence of financial allowances in regulated price caps to recoup demand management origination costs. Interestingly, some network utilities have been successful in compounding Demand Response origination costs into regulated rate bases.

To compound matters further, the absolute cost of electricity in Australia has until recently declined in real terms. This made it difficult to engage customers in any meaningful way. A study done by QLD power company Stanwell Corporation in the late 1990s found the electricity account to be the second most boring item in household budgets; only council rates received less attention.

But, an historical view of electricity demand is not a helpful starting point for discussions on forward policy settings in light of changed economic circumstances around the rapidly rising price of electricity, changed attitudes towards climate change, and technological advances including smart meters. It is un-contentious to suggest that the future cost of electricity will exceed credible forecasts of household income growth. This may therefore provide the conditions necessary to engage households more actively in Demand Response.

While the IEA (2005) noted that despite more than 30 years of market interventions in response to energy price shocks, regulators and policy makers know surprisingly little about the consequences of intervention or the price elasticity of demand, Faruqui and Sergici (2010) noted that the first wave of household Demand Response experiments can be traced back to the late-1970 and early-1980s by the US Federal Energy Administration. Data from the top five experiments were analysed by the Electric Power Research Institute, and the results were conclusive; customers responded to time-varying prices by shifting loads into off-peaks, and results were consistent from around the country once weather conditions and the appliance stock were held constant. Demand Response was greatest in warmer climates and in all-electric homes.

A second wave of experiments is now emerging, and this growing body of evidence is pointing to the capacity and willingness of households to alter demand patterns in response to pricing structures, technology or both. A study by Reiss and White (2008), while not intended as an analysis of the price elasticity of demand, provides insight on energy consumption under extreme system conditions. Their analysis took weather-adjusted electricity consumption and billing data for 70,000 households in San Diego over a 5-year period spanning either side of the Californian energy crisis of 2000. The study had the benefit of four distinct 'period events':

1. Stable Period: prior to the energy crisis, residential tariffs were set at US$110/MWh. The 70,000 households consumed 6.1MWh pa on average (remarkably similar to East Coast Australian average retail prices and quantities at A$110 and 6.6MWh at that time).

2. Price Shock Period: the Californian energy crisis led to sharp increases in residential tariffs as wholesale electricity prices were 'passed-through' to customers. Tariffs were raised to US$230/MWh. This represented a genuine price-shock because customers received their bills with a 3-month lag and without any real warning. Demand Response over the ensuing 60-day period during the 2000 summer was marked; average household consumption declined by 13%.

3. Price Suppression Period: due to public outrage, tariffs were re-set artificially below cost at US$135/MWh by the Californian Legislature. Electricity demand rebounded 8%. The fact that demand did not rebound completely tends to indicate that there was a change in the appliance stock, dwelling improvements, or persistent changes in utilisation decisions.

4. Public Education Period: following the rebound in demand, a public campaign to reduce energy consumption was initiated at a cost of US$65 million, on advertising in television, radio, newspapers, billboards and public schools. Government officials also made dramatic television appeals. It was highly effective with demand reducing by 7%.

Additionally, Reiss and White (2008) found that approximately 40% of households were completely price inelastic despite tariff increases, and generally consumed 2.5MWh pa or less (the implication being that 2.5MWh is subsistence consumption). Approximately 33% of households reduced electricity demand by 20% or more. And finally, a substantial share of the decline in aggregate consumption following the price shock came from a minority of households who reduced their demand dramatically, presumably at considerable inconvenience. The best response came from high demand customers.

In the NEM, the size of the equivalent opportunity is significant. Figure 4 represents the analysis of 1,000 randomly selected customers in Victoria who were equipped with smart meters during FY10. It shows that fully 65% of households were high users of energy in peak periods (i.e. the top three boxes in Figure 4). Conversely, those with low peak consumption, who might be price inelastic, accounted for only 17.1% of our sample (i.e. the bottom three boxes in Figure 4).

Figure 4: Distribution of household power consumption by peak and off-peak[15]

Peak

High Usage 10+ kWh per day	**High Peak Low Off-Peak 3%**	**High Peak Medium Off-Peak 18%**	**High Peak High Off-Peak 44%**
Medium Usage 5-9 kWh per day	**Medium Peak Low Off-Peak 7%**	**Medium Peak Medium Off-Peak 10%**	**Medium Peak High Off-Peak 1%**
Low Usage 0-4 kWh per day	**Low Peak Low Off-Peak 16%**	**Low Peak Medium Off-Peak 1%**	**Low Peak High Off-Peak 0.1%**
	Low Usage 0-4 kWh per day	Medium Usage 5-9 kWh per day	High Usage 10+ kWh per day

Off-Peak

6. On limited-form dynamic pricing

So how can Demand Response be mobilsed? Faruqui, Hledik and Sergici (2009) explained the appropriate template by reference to a demand pilot in California during 2004 and 2005. The pilot was conducted with households equipped with smart meters. Consumers faced a ‘peak price’ from 2pm-7pm on weekdays with all other times set at an ‘off-peak’ or base rate. Additionally, some houses were exposed to super peak events, in which a Critical Peak Price (CPP) was applied. Super peak events could be called 24 hours in advance and a CPP would be declared, which was set at three-times the regular peak price. This describes the fundamental nature of limited-form dynamic pricing. An average annual tariff is replaced with a peak price, an off-peak price, and a limited number of *roaming* or *dynamic* CPP events, which can be called on up to 20 very hot, very cold, or supply-constrained days pa with 24 hours notice. Limited-form dynamic pricing should not be confused with ‘Real Time Pricing’ (RTP), in which the spot electricity price is directly passed-through to the (unsuspecting) consumer. The Californian limited-form dynamic pricing trial was remarkably successful:

- Households on a conventional TOU peak/off-peak tariff structure reduced their peak demand by 5% on average; and
- Households on the TOU and CPP structure reduced peak demand on critical event days by 13% on average.

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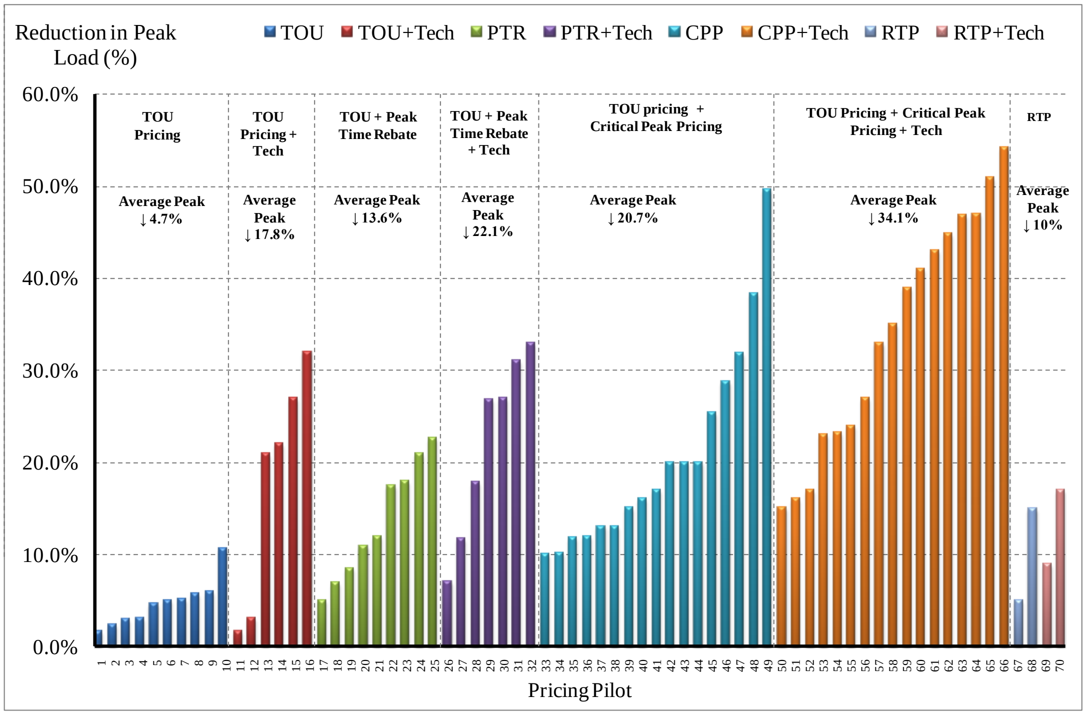
[15] Our thanks to Dr Kay Laochumnanvanit for this analysis of customer demand.

A variation to CPP is Peak-Time Rebate (PTR) pricing, where again up to 20 roaming days are nominated 24 hours in advance, but rather than charge a CPP at a three-times multiple of the peak price, a tariff-rebate of perhaps two-times the regular peak price is used to reward customers with an account credit where they reduce demand below baseline consumption.

The Californian pricing pilot outlined above is one of many examples. The quintessential applied economic analysis of dynamic pricing and its effectiveness is contained in Faruqui (2010b); 70 pricing pilots from North America, Europe and Australia were analysed for their reduction in peak demand. We have reproduced the results from Faruqui (2010b) in Figure 5.[16]

Figure 5: Peak demands reduction arising from various dynamic pricing pilots



Source: Faruqui (2010b).

Pricing pilots reveal that the mere shift from average to TOU tariffs reduces peak demand by 4.7% on average, although to be sure some trials elicited a response as low as 2%. Where technology is added to households to automate Demand Response, reductions were turbo-charged, averaging 17.8% and spanning a range of 2-32%. Technologies include cycling switchers and Programmable Communicating Thermostats which enable appliances such as air-conditioning units to be throttled back, 'kill switches' which turn-off all appliances on stand-by mode, smart whitegoods which schedule their load by time, In-Home Displays (IHD) and so on.

In the PTR trials, where consumers were rewarded for reducing demand, peak demand reduced by an average 13.6% and spanned a range of 5-23%. Where technology was added to automate Demand Response, the average reduction was 22.1%.

But CPP trials seem to hold the most promise, and have therefore experienced the greatest number of pilots. As Figure 5 illustrates, CPP pilots have averaged a 20.7% reduction in peak demand at the household level, with results spanning 10-50%. Technology driven Demand Response led to a surprisingly large 34.1% reduction in peak demand.

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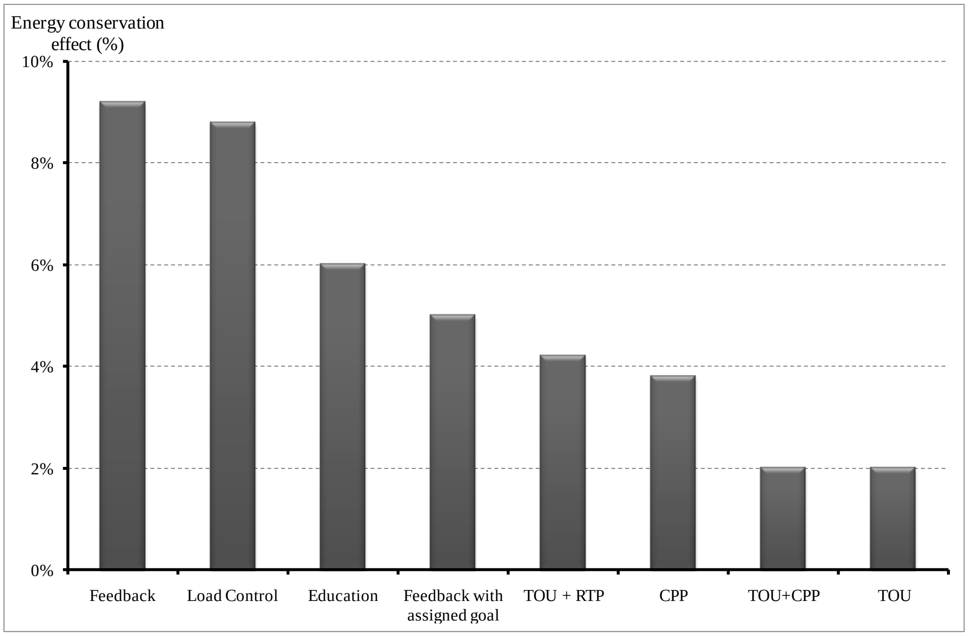
[16] We are grateful to Dr Ahmad Faruqui from the Brattle Group, San Francisco, for supplying us with the underlying data from his 2010 article, "The ethics of dynamic pricing", *The Electricity Journal*, 23(6): 13-27.

RTP trials have been least popular, no doubt due to the material uncertainty such a move would place on household budgets, not least the substantive risk such a move would place on system security, given that a portfolio of customers is required to facilitate the financing of new generating equipment (Simshauser, 2010). Nonetheless, RTP trials have been initiated and generated load reductions of 5-15%.

The analysis above focuses on load shifting effects rather than energy conservation effects. The former relates to shifting peak demand into off-peak periods, whereas the latter refers to an outright reduction in demand. There is evidence of energy conservation effects in pilots. Lewis (2010) provided a summary of average results from pricing pilots, which we have reproduced in Figure 6.[17]

Figure 6: Drivers of energy conservation effects



Source: Lewis (2010)

Figure 6 notes that consumer feedback, education and load control devices result in the highest conservation effect, whereas pricing, while highly effective in reducing peak demand, tends to result in load shifting rather than reduction. What is clear from the empirical evidence is that when smart meters are deployed in pricing pilots, households successfully respond to the signals. Recall from Figure 5 that in CPP trials, the first 20.7% peak demand reduction comes from the price itself. An additional 13.4% reduction (totalling 34.1%) is achieved when technology is involved. One might question whether household technology alone might be deployed without the smart meter and dynamic pricing with an intention of achieving some proportion of the overall total reduction. But without smart meters, there is no CPP for consumers to avoid, nor is there a cheap off-peak price to capitalise upon, just an average tariff, and so a very large part of the signal to install household technology disappears.

7. The impact of Limited-Form Dynamic Pricing on household electricity bills

In preceding sections, we have set out a proximate case for limited-form dynamic pricing on the grounds of reductions in peak demand. In this section, we analyse the distributional effects of such reforms based largely on the framework set out in Faruqui (2010b). In doing so, we have made use of our 52.5 million meter data reads from the 3000 NSW households (as discussed in Section 3). Using a computable model, we tested these households using an average tariff, a

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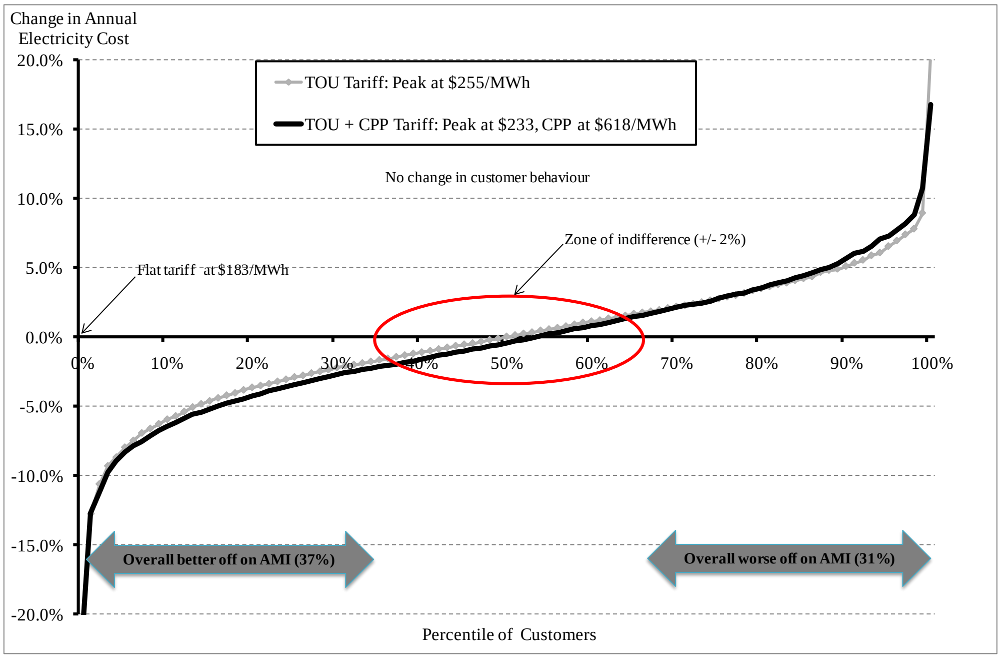
[17] Our thanks to Dr Philip Lewis from VaasaETT for providing us with the data.

TOU tariff, and a TOU+CPP tariff structure, with the results displayed in the Figure 7 “propeller curves”.

Our base case assumes a daily supply charge of 78 cents and an average tariff of $183/MWh. Our TOU structure has a daily supply charge of 88 cents, a peak tariff of $255/MWh (7am-11pm, Mon-Fri) and an off-peak tariff of $78.10/MWh. In the TOU+CPP structure, there is an 88 cent supply charge, a peak tariff of $232/MWh, an off-peak tariff of $78.10/MWh and a CPP of $618/MWh.

Figure 7: Distribution effects of limited-form dynamic pricing without Demand Response

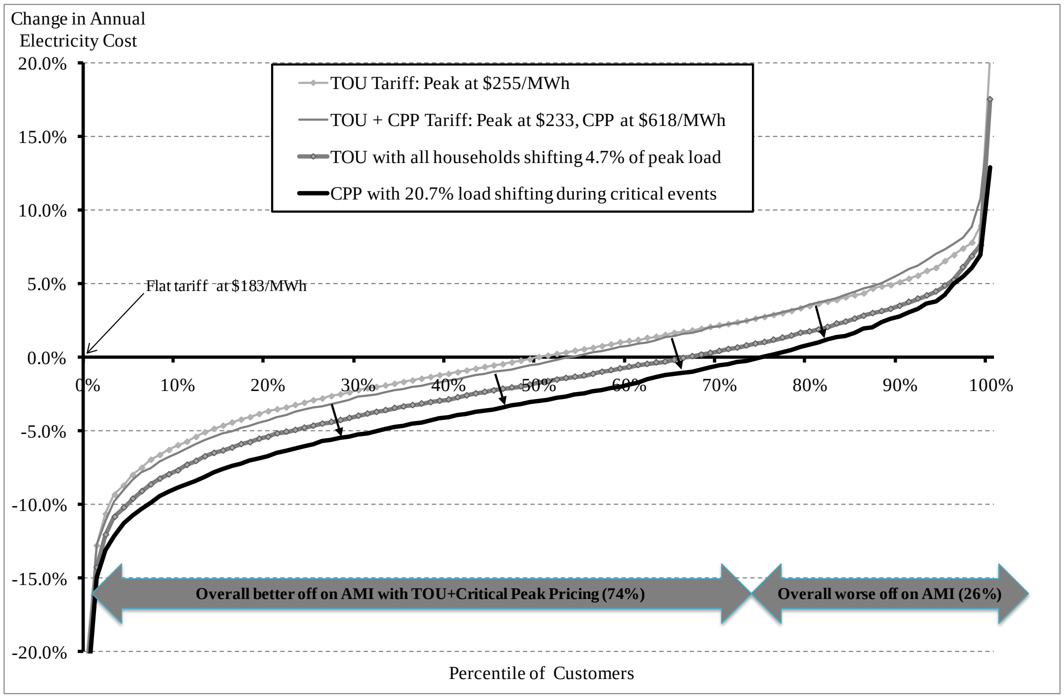


The propeller curves in Figure 7 illustrate distributional impacts on households, that is, those better-off (i.e. bottom of the propeller curves where the change in annual electricity costs is negative, as measured by the y-axis), and those who are worse-off (i.e. the top of the propeller curves). We identify a zone of relative indifference, in which we take to be an impact of +/-2% on annual electricity costs when compared to the flat average tariff of $183, as identified by the origin. Households which are unambiguously better-off account for 37% of the sample, while those clearly worse off account for 31% of the sample. Removing the zone of relative indifference, 50% of households are strictly better off, and 50% worse off, not an entirely surprising result. Crucially, this does not incorporate Demand Response from households, i.e. their consumption patterns have been held constant under conditions of revenue equivalence (i.e. all three cases yield the same total revenue from electricity sales).

To see the potential gains available to households arising from behavioural change, we have undertaken two further scenarios in which average Demand Response from Figure 5 has been universally applied to households; that is, a 4.7% reduction in peak demand in the TOU scenario, and a 20.7% reduction where critical events are called. This is illustrated in Figure 8. These results, whilst theoretically impressive with 66% better-off under TOU and 74% better-off under CPP, should be treated with caution because they assume that all households successfully shift load in a uniform manner. This will not occur in fact. In our sample, 12% of the population were pensioners with average consumption of 4.3MWh pa. As Reiss and White (2008) found in San Diego, households consuming 2.5MWh pa or less were completely price inelastic. Conversely, our results ignore the reductions that might be made by automating Demand Response. Regardless, our simulation illustrates that long run gains are more than a theoretical possibility.

The consolidated household load factor improves by fully 8.2 percentage points under this scenario.

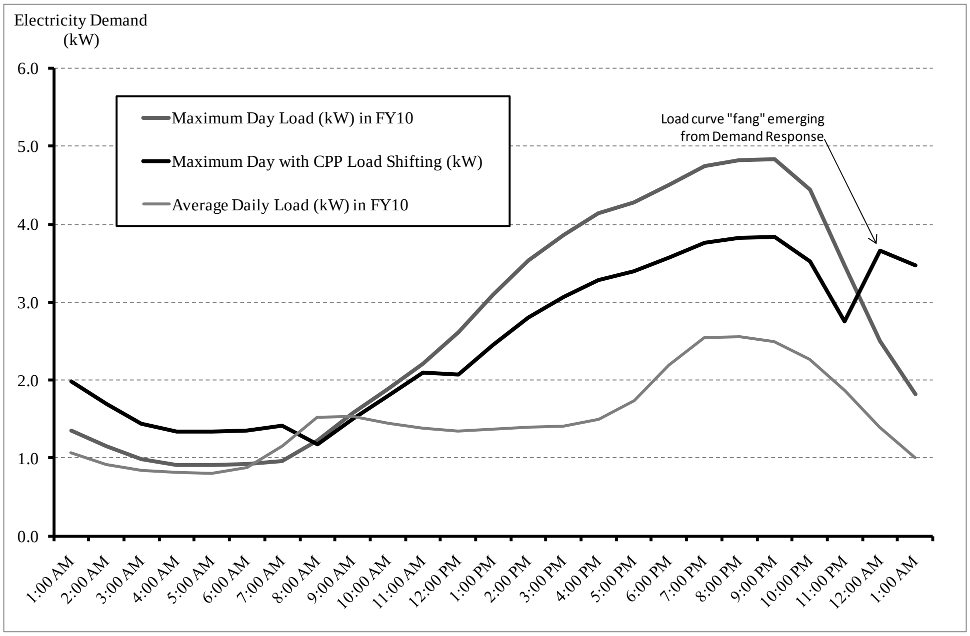
Figure 8: Distribution effects of limited-form dynamic pricing with Demand Response



We noted earlier in Section 3 that Demand Response induced via limited-form dynamic pricing will not translate into immediate reductions in capital investment, and therefore immediate reductions in retail prices. Demand Response must first be demonstrable. Additionally, Demand Response needs to be very carefully modelled because the benefits to the power system are highly unlikely to be linear, as Earle, Kahn and Macan (2009) demonstrated. In fact, Demand Response at the household level is likely to be subject to decreasing returns to scale.

In the Earle et al. (2009) study, electricity load from California was modelled with Demand Response triggered under CPP. Using the same system planning principles and techniques that guide reserve plant margin determinations (i.e. Loss of Load Probability developed by Calabresse, 1947), they demonstrated that in the 40,000MW Californian system, once Demand Response exceeds 2000MW of participation, the reliability of that response decreases sharply. Starting at 90% effectiveness, Demand Response reduces at the rate of approximately 10 percentage points for each additional 1000MW of participation. The logic of this modelled result is intuitive; when a 100MW generating unit is added to the NEM, it is subject to forced (i.e. essentially random) outages. A 500MW unit with exactly the same level of availability decreases relative grid reliability because the larger unit outage presents a much greater risk to system security than say five smaller units. And so too, therefore, is a larger Demand Response. Additionally, given limited energy conservation effects, they argued that shifting consumption results in load curves acquiring a “fang” - thereby creating new shoulder peaks. We found similar results with our modelling of Demand Response, per Figure 9. Analysis of gains from Demand Response therefore needs to be tempered, as opposed to extrapolated, in power system analysis.

Figure 9: Demand Response impact on the load curve



8. On the equity and ethics of limited-form dynamic pricing

While the potential gains to power system utilization arising from limited-form dynamic pricing seem clear enough, the welfare implications are of such a shift are non-trivial. The reason for this is, as Figure 8 illustrated, there will be losers. This raises issues of equity and ethics in shifting.

CUAC (2010) observed that senior and concession consumers, who are mainly at home during the day, would struggle to pay peak rates for electricity. McGann and Moss (2010) identified two key segments of low-income consumers who will be worse-off with dynamic pricing. The first group is peaky households who are high users of energy because of unemployment, disability, or caring for young children or elderly relatives. The other group is households with inelastic electricity use, those unable to shift their usage due to the inability of appliances to be programmed to run in off-peaks.

There is also the usual short term cost, long term gain 'lag'. As Hanser (2010) noted, although it is nearly certain in the long run that the increased cost of providing smart meters and usage information to consumers will be beneficial, that long run could be *quite long*. Consumers view the deprivation of electricity, whether by economics or reliability, as a major violation of their rights and expect a level of protection regarding the level of service from extreme short-term price variability. On the other hand, as Hanser (2010) observed, doing nothing would deprive consumers of potentially large savings that dynamic pricing would permit.

The notion of moving residential customers en masse to dynamic pricing is fraught with adverse consequences and could contribute to a customer revolt against the Smart Grid agenda (Alexander, 2010). This is more than a theoretical possibility. A pilot in Seattle resulted in exactly that, largely as a consequence of the political economy of electricity prices. *The Economist* (2009) noted:

> *...Where variable rates have been introduced, they have not always been a success. When they were tried in Seattle a few years ago, most suburbanites liked the idea at first. They duly resisted turning on their dishwashers and so on until 9pm, the magic moment at which the local utility, Puget Sound Energy (PSE), started to charge less. But the mood quickly soured when it turned out that many households on the "time-of-use" rate plan*

> *actually paid more than ordinary ones. Consumers quit the programme in droves. In November 2002, only 18 months after it was introduced, PSE cancelled it with the backing of regulators... To avoid a backlash, utilities and their regulators will need to move slowly...*

Alexander (2010) reasoned that consumers pay utilities a flat average price to dampen the volatility of tariffs, since customers don't have the tools or sophistication to manage short-term events, whereas merchant utilities clearly do, via physical plant and futures contracts. Limited-form dynamic pricing also sends 'punitive signals' to pensioners, which has welfare ramifications in extreme weather events. She noted that during the Chicago heat wave of 1995, more than 730 'excess deaths' were documented amongst elderly citizens who refused to use cooling appliances on the grounds that their electricity bills would be unaffordable.

One of the most important of Alexander's (2010) arguments is that pilot programs, such as those in Figure 5, are based on relatively small groups of volunteers who receive extensive education and *'hand holding'* during a relatively short pilot. And low-income households invariably have a significantly lower level of price elasticity than high-income customers. This was evident in Reiss and White (2008), and Felder's (2010) US data confirms the strong positive correlation between income and energy consumption.

The most obvious problem associated with an initial implementation of limited-form dynamic pricing is 'bill shock'. Brand (2010) noted that over the long run, the ability of customers to respond will be a function of the differential between peak and off-peak rates. But in the short run, steep increases in peak prices may cause bills to rise dramatically unless the reasonable means to respond to scarcity pricing exists. And since the economic cost of automation technology may not yet be feasible for the average consumer (let alone vulnerable households), dynamic pricing would be perceived as unfair by many.

Bunzl (2010, p.8-9) argued that policy settings should be designed in light of Rawls' famous phrase, *"from behind the veil of ignorance"*. That is, in selecting policy, I will not know whether I am rich or poor, renter or owner, and so on. And in doing so, *"I would do well to decide with an eye on making the worst-case alternative the best of all possible worst-case scenarios; I ought to focus on being both poor and having a peakier load than average."* With this in mind, he suggested inverted-block tariffs, which do not require metering changes, and appear to be an attractive alternative to dynamic pricing on the grounds of fairness. However, as we noted earlier, inverted-block structures come with distinct problems; over-consumption is highly likely to occur during critical events because no direct nexus exists between TOU and price, thus it will fail to meet the prime objective function of reducing peak demand. US energy economist William Hogan (2010) noted that setting tariffs to discriminate by consumption levels is a blunt instrument, a point acknowledged by Bunzl (2010) in that it raises problems of identifying special classes of adversely affected customers. And conversely, lightly occupied holiday homes or vacant rental properties of wealthy consumers would be subsidised.

The grounds for shifting to limited-form dynamic pricing to meet environmental objectives is contentious because of the dominance of load shifting, as opposed to energy conservation effects (Alexander, 2010; Brand, 2010). As we highlighted in Figure 6, unless technology and education features in the reform, the primary effect is load shifting. Brand (2010) noted in the case of the US, off-peak power is the primary domain of coal plant, whereas peaking plant tends to be lower emission technologies such as gas. This is equally applicable to the NEM.

At face value, a policy stalemate might appear inevitable. Like all modern economic reforms worthy of pursuit, a Pareto solution, where at least one consumer is better off and no consumer is worse off, will surely remain elusive for dynamic pricing. However, limited-form dynamic pricing will meet the more pragmatic Hicks-Kaldor approach; a policy is worth pursuing if the gains exceed the losses (Faruqui, 2010b). As Cornell University economist Robert Frank (2009, p.127-128) noted:

> *"If the benefits of congestion pricing are so compelling, why is it so rarely adopted? Although studies have shown, for example, that daily and seasonal variations in electric rates would substantially reduce the average consumer's utility bills, proposals to adopt such rate plans are typically rejected because of concerns about low-income users who may lack the flexibility to alter their consumption patterns. That such concerns often block economically efficient programs is one of the enduring mysteries of modern political economy. An economically efficient program is, by definition, one whose benefits exceed its cost. That means there must be ways of redistributing the gains so that every citizen, rich and poor, comes out ahead. Failure to adopt an efficient program thus raises the question of why we couldn't figure out how to accomplish the necessary transfers. Why are we leaving cash on the table?"*

Hogan's (2010) contribution to the debate on the ethics of dynamic pricing provides useful guidance. The following criteria should be present in any such program (1) the provision of accurate information on rate design and usage, (2) customer education (as critical), (3) an ability to change behaviour (i.e. elastic demand), and (4) benefits exceeding the expected costs.[18] One critical observation that Hogan (2010) makes is that the choice of the default tariff *is important*, and we know this from research on related problems. Additionally, he observes that smart meters are not free and their cost structure differs importantly from the cost of providing energy. While the deployment of smart meters may be more efficient if it is universal (such as VIC's mandated roll-out), the allocation of the substantive joint costs should not be in excess of the net benefits to a given customer.

9. Policy recommendations: the importance of pacing and sequencing reforms

The ethics and fairness of shifting to limited-form dynamic pricing is complex, as is the incidence of the cost of smart meter roll-outs. But the counterfactual is also important. Currently, it is well understood by consumer advocates in Australia that average tariffs lead to over-consumption in peak periods, with that demand dominated by non-vulnerable households. However, all consumers, and proportionately, especially vulnerable households, are bearing the cost of power system augmentation. Since dynamic pricing deals to these issues, it can meet the fairness criteria 'in aggregate' if the pacing and sequencing of reform is constructed carefully. Importantly however, as Stiglitz (2002) noted in the case of macro and microeconomic reforms enforced on countries by the International Monetary Fund, incorrect pacing and sequencing can often do *much more* damage than it ever does good.

In our view, in aggregate the roll-out of smart meters and a shift to TOU+CPP structures is both a necessary and worthwhile reform. The analysis we have presented in this article provides key pointers to *the size of the prize* as it relates to peak demand-induced costs. A gradually flattening load curve will, over the long run, substantially delay the rate at which new capacity investment is required, and will utilise existing plant more effectively. Both elements will have the effect of reducing the cost of supply. Our modelling, in which we flattened the household load curve from 38.5% to 50%, indicated a reduction in unit costs of about $32/MWh, and if applied unilaterally across the four primary NEM states, a reduction in costs of some $1.6 billion pa in the household sector alone. We noted, however, that an 11.5 percentage point improvement in the load curve is not insignificant. Our segment modelling of 3000 customers demonstrated an 8.2 percentage point improvement if all customers responded uniformly, albeit without the aid of automated Demand Response. Clearly, such outcomes will take time.

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[18] This was in fact contained in a letter by the New Jersey Department of Public Advocate. See Hogan (2010, p.29) for details.

From a pacing perspective, the roll-out of smart meters must form the starting blocks, and as VIC has done, place a moratorium on dynamic pricing in the first instance. The cost of recovering this infrastructure might be best dealt with by adding a variable rate to tariffs, ideally added to peak tariffs (once limited-form dynamic pricing commences) to ensure the incidence of the cost of smart meters falls on those who are likely to gain from reform in the future.

The transformation from flat to limited-form dynamic structures needs to be strategically orchestrated. An intensive consumer education program with substantial government focus and resources is a prerequisite. Substantial commitment from politicians will be required, as the QLD government did with its highly successful water campaign in 2007. The energy industry must also take responsibility to ensure that consumers begin to understand the component costs of electricity and drivers of consumption in the household. As Honebein (2010, p.77-79) noted:

> *Smart meters can help customers save money. They can reduce your carbon footprint... However, the road to achieving these benefits is a curvy one with numerous potholes along the way… Customer education is a process, not an event. Customers need some basic educational materials before the rate starts to point them in the right direction. Then as the program evolves, they need educational boosters along the way…*

With smart meters and a mobilised education campaign, limited-form dynamic pricing could then commence, although crucially, outside the summer period to minimise the incidence of initial bill shock. TOU+CPP structures should be the default tariff, subject to a number of carve-outs (with an ‘opt-in’ option), acknowledging that Alexander’s (2010) arguments on ‘punitive signals’ to vulnerable, low consuming households, the elderly and medically bound consumers is clearly more than a theoretical one. Carve-outs might include consumers using less than 2.5MWh pa in combination with some form of welfare flagging mechanism to avoid carving-out the holiday homes or vacant rental properties of non-vulnerable households. Healthcare cardholders and appropriately means-tested elderly citizens are also obvious candidates for carve-outs.

Carve-outs will dilute participation rates, and therefore *some* of the potential gains. But the alternative is an attempt to be all-encompassing, which would result in a head-on collision between voters, politicians, welfare groups and the energy industry. The outcome would be predictable.

Over time, the ideal solution would be to utilise transfer systems available to governments so as to facilitate appropriate compensation to vulnerable households, thus allowing widespread use of limited-form dynamic pricing, in the interests of an efficient allocation of resources nationally. In doing so, vulnerable households could face dynamic prices and choose to either hold their demand constant and fund this by compensation received, or modify consumption and use compensation in other ways to lift their standard of living. Given this would relate to vulnerable households, surely no Australian would begrudge either outcome. This was of course the primary strategy of the federal government’s original plan on emissions trading. Through the transfer systems, households would be compensated at the rate of 110% of the expected incidence of the carbon price. At face value, households could hold their consumption constant and be left better off from the reform (with the burden of carbon compliance being directed to the supply-side). But households would have an incentive to reduce demand due to rising prices, and if they did so, their compensation could be redirected.

That $900m of capital has been invested in the southeast Queensland grid, for use 3½ days per year, would incense any macroeconomist from a national resource allocation perspective. Capital allocated to the grid, and to generating equipment across the entire NEM for “momentary use” must surely be a vast multiple of this. One can only speculate upon the benefits of alternate use of such scarce capital in our economy. But to try and correct such adverse distortions into the future, all roads lead back to the critical importance of equipping all households with a smart meter.

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