Innovative Electricity Pricing Models To Support The Energy Transition

Abstract

Australian electricity prices are among the highest in the world, largely due to increased investment in the distribution network to account for rapid growth in peak demand. Australia's national electricity network is shifting from a once highly centralised regulated system to become more renewable, distributed and consumer centric, whilst the retail pricing structure for consumers remains stagnant. Electricity consumers are charged a fixed usage rate with periodic billing cycles thus providing no incentive for electricity consumers to change their usage patterns to better align with the real time-varying cost of generating and supplying their electricity, as represented in the National Electricity Market. Novel approaches to electricity pricing are vital to continue to support Australia's energy transition to integrate a greater proportion of renewable energy sources.

Introduction

Over the past decade, the Australian electricity system has seen unprecedented changes, shifting from a centralised, highly regulated model to a more distributed, consumer-centric model. The significant increase in distributed energy resources (DER), namely rooftop solar PV, solar farms, bioenergy generators and wind turbines, has been largely driven by increased electricity prices, reduction in cost of renewable generation technology and government incentives and policy (CSIRO 2016). In 2018, the Clean Energy Council (2019) reported 21% renewable electricity penetration in the National Electricity Market (NEM). The electricity sector has a central role in the effort to curtail climate change, as 33% of Australia's total greenhouse gas emissions result from electricity production (Department of the Environment and Energy 2019).

Australia's National Energy Market (NEM) is one of the longest interconnected power systems in the world, providing electricity to approximately 9 million properties across Australia's eastern and south eastern coasts (AEMO 2018). The National Energy Market was formed as a result of Australia's microeconomic reform in the 1990's, the State Electricity Commissions had previously been responsible for the operation of Australia's electricity systems in accordance with state jurisdictions (Sharma 2003). The State Electricity Commissions was separated into generation, transmission networks, distribution networks and retail supply functions (Outhred 2004). In most states these new functions were privatised to promote competition in the electricity supply chain and provide consumers with the choice of service. The transmission and distribution network companies formed natural local monopolies as they own the physical electricity supply infrastructure, so in New South Wales and Queensland these organisations remained in full or partial government ownership, whilst in other states regulations were introduced to exploitative behaviour and pricing (Outhred 2004).

Literature Review

Background

Australia's electricity sector continues to evolve with rising fuel prices, increased electricity demands, aging infrastructure and political and social pressure related to environmental burdens. The centralised network has large-scale generators in the high voltage transmission network and low voltage distribution networks connecting the homes and businesses, illustrated in Figure 1. The emergence of distributed energy resources (DER) has put significant pressure on the traditional model designed for power flow in one direction (Langlois-Bertrand & Pineau 2018). Distributed energy resources, like solar PV, have the ability to be produced at small and large scale which has attracted interest and investment from various groups of people. Electricity consumers are empowered with more knowledge to make their own energy choices, and the opportunity to reduce electricity bills. CSIRO (2014) presents four future outlooks for Australia's electricity market to 2050, 'Set and forget', 'Rise of the prosumer', 'Leaving the grid', and 'Renewables thrive', with all four scenarios agreeing the market will shift to become more customer-centric with the removal of regulated monopolies and increased exposure to competition. PricewaterhouseCoopers (2014) predicts that electricity utilities will transform to become versatile 'energy enablers' in the 10 years following 2014, offering several retail electricity product options to suit the diverse customer base, ultimately supporting investment in DER. Figure 1 illustrates the complexity of interactions in the NEM, and the lack of exposure the retail customers currently have to the actual real-time costs of electricity generation and supply (Simshauser 2014).

Current Flat-rate Model

Australian retail electricity bills represent the aggregated costs of generation, making up on average 40%, transmission and distribution, accounting for a further 40%, and metering, retail overheads and environmental schemes (AEMC 2019). Typically these costs are charged with a two-component pricing structure, a fixed charge ($/day) and flat usage rate ($/kWh), Simshauser and Downer (2016) found these to make up for 10% and 90%, respectively, of the total structure for an average residential customer. Simshauser and Downer (2016) reports a two-component electricity charging structure can be traced back as early as 1892, this structure recognises there are two cost drivers; the cost of installing and maintaining generation and distribution infrastructure irrespective of quantity of consumption and the cost of operating generators. The two-component structures proposed were a demand charge ($/kW) and energy charge ($/kWh), however at the time, the necessary metering technology to capture the peak demand was uneconomical, so this was commonly replaced with a fixed daily charge (Simshauser & Downer 2016). Most Australian residential consumers still have mechanical meters which records the accumulated volume of electricity consumption over a period of time, greatly limiting the pricing structure alternatives for these retail customers (Simshauser & Downer 2016). This pricing structure is easily understood by customers, and is processed by retailers existing billing systems (Tayal & Evers 2018). A feed-in tariff is also included on a retail customer's electricity bill if they have embedded generation and export electricity to the grid.

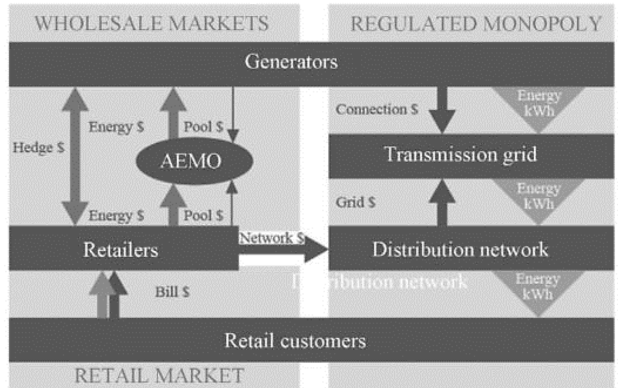

Figure 1: National Electricity Market institutional design (Simshauser 2014)

Australians saw their electricity bills increase by an average of 50% from 2009 to 2014 after two decades of stable rates. This occurred despite the average household usage over the same period decreasing by 21% (Nelson 2017). Graham, Brinsmead and Hatfield-Dodds (2015) attribute approximately 60% of the price increase to increases in distribution costs resulting from increased capital expenditure on replacement of aging infrastructure and upgrades to system capacity necessary largely due to increased ownership of air conditioners causing a growth in peak demand. Both Nelson (2017) and Simshauser and Whish-Wilson (2017) indicate the importance of policy and regulatory environment developing at a rate which aligns with technological changes and market developments. An example being regulated distribution costs, which are most commonly charged to retail customers at an average cost flat-rate per unit energy, Simshauser and Downer (2016) describes this structure as inefficient and inequitable and Nelson (2017) as inflexible and non-reflective, as this model provides no opportunities for customers engaging with the time-varying electricity market and reduce their peak demand through energy efficiency, load shifting and embedded generation. However, in some jurisdictions, consumers can opt to select a time-of-use tariff or capacity based tariffs, provided they meet the requirements.

Demand management aims to reduce consumer's electricity consumption in periods of high grid demand, or shift their consumption to low demand periods, increasing the efficiency of their electricity use. Demand response programs are commonly categorised into incentive-based programs and price-based programs (Nilsson, Stoll & Brandt 2017). The current flat-rate usage charge has no demand response incentive, while time-of-use (TOU) and critical peak pricing tariffs are incentive-based programs and a real-time pricing (RTP) model is a price-based program.

The Time-of-use Model

The TOU model uses two electricity charges set for different times of the day, namely peak and off-peak (in some cases a shoulder rate is also included), thus providing an incentive to shift consumption to off-peak periods helping reduce network costs (Yang et al. 2018). TOU was the first model to address the inconsistencies between the wholesale market and the traditional flat-rate tariff. Ultimately, the TOU pricing does not reflect the real-time costs because charges would need to be reassessed regularly as the proportion of intermittent renewable generation in the network increases. Some areas already offer a TOU option to customer as an alternative to the flat-rate, this is dependent on the jurisdiction and local distribution company. In Western Australia, only 2% of residential customers with the required advanced meter have opted onto the TOU tariff, indicating there is an educational or behavioural barrier which will need to be addressed (Tayal & Evers 2018). TOU tariffs are more commonly selected by retail customers overseas, and also made compulsory for all homes with compatible meters in some areas, like Italy (Lampard & Aspinall 2014).

The Real-time Pricing Model

Alternatively the RTP model charges consumers at the half-hourly cost of supply which is dependent on the wholesale market prices, with this model the consumer is exposed to price fluctuations risks, where the NEM wholesale price can fluctuate from $-1000/MWh to $14,200/MWh (AEMO 2018). The advantages of this model is RTP enables significant reductions in network demand peaks and therefore more accurate modelling of capacity requirements and potential avoidance of infrastructure upgrades, as well as the ability for retail customers with embedded generation and battery to arbitrage the difference between high and low prices (Tayal & Evers 2018). Liyan and Lang (2016) proposed a day-ahead hourly pricing model, where hourly rates are set by retailers each day corresponding to the next day. The price change allows retailers to adjust pricing to align with the wholesale energy market and provide some price certainty to consumer whilst still providing the opportunity for demand response.

Retail Customer Perception

The successful implementation of demand response programs is largely based on the consumers education, attitude and willingness to participate. Tayal and Evers (2018) studied retail customer's perceptions of the electricity sector, renewable technology and pricing structure in Western Australia. From their study of 100 participants, they found 79% believe they spend too much on electricity and 77% said they would 'definitely yes' or 'probably yes' change their electricity usage habits if it saved them money. While this survey indicates a promising proportion of retail customers would be incentivised by new pricing models, this study is based on participants stated responses rather than revealed preferences, so in practice their behaviours may or may not represent their statements. Quantitative studies have been completed overseas, Jessoe, Rapson and Smith (2014) found overall consumption decreased by 9-10% when consumers changed to a TOU pricing structure offering lower rates in the north-eastern United States, this study concluded that non-financial incentives can dominate consumers behaviours. Nilsson, Stoll and Brandt (2017) studied a small test group in Sweden on an RTP pricing structure, on average 5% of the consumer's total daily electricity usage was shifted from peak periods to off-peak periods as an effect of real-time price visualisation.

Knowledge Gaps & Research Questions

The two major retail pricing structures which incorporate incentive-based or price-based demand response are the time-of-use model and real-time pricing. Whilst both of these models encourage consumer behaviour changes and reward customers with embedded generation, the literature does not explore the overall impact on Australia's clean energy transition, and how pricing models may change should renewable energy penetration increase significantly. The literature clearly shows the slow evolution of retail electricity pricing structures limited by metering technology and the regulatory framework, and aside from the two time-varying models aforementioned there is minimal mention of other pricing structures recently proposed by Australian industry. The literature review stressed the importance of understanding consumer behaviours when setting pricing structures, overseas case studies were identified and results reported, however there is a gap in understanding how Australian consumers may respond to time-varying pricing structures. On the other hand, the literature does not examine the effect of time-varying pricing structures on vulnerable electricity consumers with little or no ability to load shift. Four major research questions have been identified from the literature review:

- How will future electricity pricing structures enhance electricity consumers participation in the clean energy transition in Australia?
- What pricing structures have recently been proposed to the Australian Energy Regulators by the utilities, and what was the rationale for the resistance to change of regulation?
- How do Australian residential electricity consumer's behaviours change when shifted from a flat-rate to a time-varying pricing structure?
- How can time-varying electricity pricing structures be designed and implemented to benefit all electricity consumers regardless of their demand management capability?

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