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Residential electricity tariff review

Report commissioned by the Energy Supply Association of Australia

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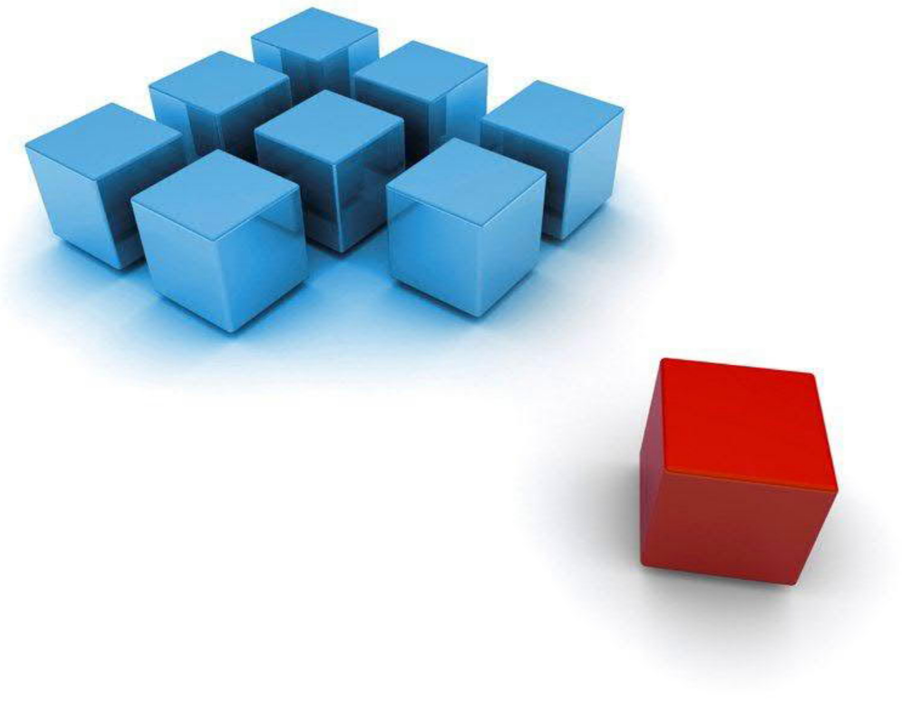
FINAL REPORT



Contents

Executive summary

The need for reform

Australia's electricity system has undergone significant change in recent years, including changes to load profiles, changes to the supply and demand balance and technological changes such as rapid air conditioning and solar PV uptake. One of the most significant changes to Australia's electricity system has been higher levels of peak electricity demand. High peak demand causes electricity systems to be built to a high capacity standard, increasing the cost of the network. While a common proxy for the costs that a customer imposes on the network is a customer's peak electricity demand, a more precise measure of a customer's cost impact is coincident peak demand—a customer's peak demand at the time, for example, when the network component to which the customer is connected (often the substation) is constrained.

These changes to the electricity system, however, may be only a taste of what is to come. For the electricity system to operate in an efficient manner and to promote equitable outcomes between customers, electricity tariffs must be designed so that customers face the right price signals. Further, electricity tariffs need to stand the test of time by continuing to provide the right price signals as technology and usage patterns change.

Scope of work

The Energy Supply Association of Australia (ESAA) has engaged Deloitte to review the merits of different electricity tariff designs by examining the effectiveness, simplicity, stability, equity and likely consumer acceptance of a range of current and potential tariff designs including: Standard Australian household prices (low fixed charge and flat usage charge); Inclining Blocks; Declining Blocks; Time of use pricing (peak, off-peak and shoulder); Critical Peak Pricing/Rebates; Capacity Tariffs; Seasonal Pricing; and Controlled Load tariffs.

Evaluation of tariff designs

In performing the scope of work, we first evaluated alternative tariff designs against four factors that we consider reflect generally positive or desirable attributes of tariffs in the Australian context:

1. Cost reflectivity – Electricity prices should reflect the cost, including the economic cost, of the service provision. Cost reflectivity also promotes equity because it reduces or limits cross subsidies between customers.
2. Simplicity – A tariff's operation should be easy for customers to understand. It should be easy to convey the tariff's operation to a large group of customers. The tariff design should be simple to implement and administer.
3. Stability – In the absence of significant changes in use, customers should not experience unduly large, sudden increases in their electricity bill. Once customers are on a particular tariff design, their charges should be reasonably predictable.
4. Revenue variability – Network electricity businesses should be able to recover their efficient costs and should not experience significant under or over-recovery from one period to the next.

While we have not weighted the factors in undertaking our assessment, considerations of cost-reflectivity are foremost in our analysis on the basis that the lack of cost-reflectivity in current tariff designs is the driving factor behind the need for tariff reform. However, it is also important to note that there are trade-offs between the factors – each tariff design has its own strengths and weaknesses and it is unlikely that any particular tariff design will perform well against every factor or every circumstance. In particular, improvements in cost reflectivity (and equity) may come at the price of increasing complexity and bill stability – which together are key indicators of customer acceptance.

Summary of evaluation

The following table summarises our evaluation of each of the tariff designs against the four factors of effective tariff design outlined above.

Key:

- ● Strong performers
- ○ Poor performers

Table E-1 Evaluation of tariffs against Deloitte's four factors

	Cost reflectivity	Simplicity	Stability	Revenue variability
Two Part Tariff (flat charge)	◔	●	◕	◑
Inclining Block Tariff	◔	◕	◑	◔
Declining Block Tariff	◔	◕	◕	◑
Seasonal Pricing	◔	◕	◕	◑
Time of Use	◑	◑	◑	◑
Capacity Tariff	◕	◔	◑	◕
Peak Time Rebate	◑	○	◕	○
Critical Peak Pricing	◕	◔	◑	○
Controlled Load Tariff*	◑	◕	●	●

Source: Deloitte analysis

Note: * Controlled Load Tariffs shift certain electrical loads to off peak times and charge off peak rates. It is not a stand-alone tariff as it is generally only available for specific, permanently installed appliances such as water and space heating, and must be combined with another tariff design.

Analysis against disruptions and possible future states

Following the generic assessment of the characteristics of each tariff, we developed a set of market scenarios to test how well the various tariff designs available are able to meet the needs of businesses and consumers given the current and potential future state of Australia's electricity system.

The following table provides a summary of the strengths and weaknesses of the various tariff designs in the context of each of the disruptive technology market scenarios.

Table E-2 Summary of scenario-based tariff analysis

Scenario	Impact on system	Tariff analysis
Increasing solar PV uptake	Reduced energy taken from the grid. Limited impact on peak demand and consequent deterioration of load factor.	Best performing tariffs: • Tariffs with a demand-based component: Capacity Tariffs. Poorly performing tariffs: • Tariffs that do not reflect peak costs: Two Part Tariffs (flat charge), Inclining Block, Declining Block • Peak Time Rebates also perform poorly due to challenges in setting baseline usage for rebates under the increasing solar PV uptake scenario.
Penetration of time- controllable distributed generation and storage	Reduced use of system supplied electricity. Increased ability for sophisticated response to price signals.	Best performing tariffs: • Tariffs with the ability to provide sophisticated pricing signals and take advantage of customer response capability: Capacity Tariffs, Critical Peak Pricing and well-designed Time of Use Tariffs Poorly performing tariffs: • Tariffs that do not reflect peak costs: Two Part Tariffs (flat charge), Inclining Block, Declining Block.
Electric vehicle uptake	Increased electricity usage. Uncertain peak impacts – unconstrained charging could lead to deterioration of load factors, while co-ordinated use could improve system stability and security.	Best performing tariffs: • Tariffs that reflect different costs across the day and encourage electric vehicle owners to shift charging to off-peak times: Capacity Tariffs, Time of Use Tariffs • Controlled load tariffs, due to their ability to set a defined charging period (subject to practicalities of varying patterns of vehicle usage). Poorly performing tariffs: • Volume based tariffs: Two Part Tariffs (flat charge), Inclining Blocks, Declining Blocks and Seasonal Pricing.

Overall summary and conclusions

Capacity Tariffs are consistently the strongest performing tariffs in terms of cost reflectivity as well as revenue variability for network businesses in the face of current and expected disruptions to the electricity sector investigated in this report. In particular, Capacity Tariffs based on coincident peak demand are highly cost reflective because coincident peak demand is a key driver of network and wholesale generation costs. On the other hand Capacity Tariffs based on maximum demand provide only a blunt form of cost reflectivity because a customer's peak demand may not coincide with the electricity system's peak demand. Accordingly, there are complexities in designing highly-cost reflective Capacity Tariffs. Concerns about stability in customer bills may also create challenges to widespread implementation.

Controlled Load tariffs perform strongly against the four factors and are also well-suited to the market scenario involving increased uptake of electric vehicles. However, there are few electrical appliances that are conducive to Controlled Load pricing, and thus the overall effect on the electricity system will be relatively minor.

Time of Use Tariffs do not exhibit the same level of precision as Capacity Tariffs in relation to reflecting the underlying costs of Australia's changing electricity sector. In particular, they do not specifically target the high marginal costs or high variable generation costs associated with using electricity at critical peak times. A transition to Time of Use pricing, however, is a smaller deviation from traditional tariff designs than transitioning to Capacity Tariffs.

In addition to deploying tariff designs to manage peak demand, new options for demand management are emerging with the proliferation of smart appliances such as smart air conditioners. With these demand management technologies, network operators will be able to reduce peak demand while minimising the need for customers to actively change their electricity consumption behaviour.

We recognise that electricity is a low-involvement product, with customers not typically highly engaged with the details of cost structures and tariff design. So while we consider that a move towards Time of Use pricing is a step in the right direction towards improving cost reflectivity and equity outcomes, we also note that initiatives to drive substantial changes in the way customers think about and use electricity will require a sustained effort around customer communication and education.

Equity and fairness

For the purpose of this report, we have defined equitable tariffs as those that reduce or limit cross subsidies between customers by charging each customer for the costs they impose on the electricity system. The costs of generating and supplying electricity vary mainly with the time of use and intensity of that use (demand), particularly when usage coincides with when other consumers are using electricity (i.e. peak demand). On this basis, we consider that tariffs that vary with the time electricity is consumed, and the intensity of consumption, particularly at peak times, are most conducive to the promotion of equity. This differs from some notions of fairness, where customers may perceive Two Part Tariffs with a flat charge or Inclining Block Tariffs as being fair due to the relatively simple relationship between usage and charges, despite the inherent cross-subsidies in such tariffs.

Customers may be more accepting of more complex and innovative tariff designs if they understand the benefits. These benefits include reduced cross subsidies, and ultimately, lower overall electricity bills over time. To facilitate a transition towards more complex pricing structures that correspond more closely to underlying cost drivers, electricity businesses will need to engage with customers to design tariff packages that meet customer needs, while educating customers about the trade-offs between alternative pricing approaches. Governments will also need to play a role in educating customers about the problems with existing tariffs and the benefits of more cost reflective designs.

Enabling technologies and transition issues

Advanced metering infrastructure (smart meters) is a pre-requisite for sophisticated time-varying tariffs. Smart meters also provide the advanced communication technology required for real-time feedback to customers about usage information that would enable customers to adjust usage with precision, and respond rapidly to changes in costs driven by peak events. This technology paves the way for a range of enabling devices such as in home displays that show electricity consumption or demand, or communication technologies warning customers about changes in electricity prices as they occur.

How customers are transitioned from their existing tariffs to more sophisticated tariffs not only has implications for customers but also for the electricity system. Approaches that rely on customers voluntarily adopting tariffs may have limited effectiveness on changing overall consumption patterns if only those customers who benefit from the tariff design adopt it. On the other hand, approaches that mandate the adoption of certain tariffs may lead to bill shocks and customer resistance—especially if customers are not fully educated on the tariff's operation.

In addition to driving behavioural change at the customer level, we believe that industry has a crucial role to play in addressing the issues created by rising peak demand. For example, adopting and investing in smart grid technologies, demand management solutions, distributed generation and battery storage all provide avenues to manage peak demand upstream of the customer.

1 Introduction

Australia's electricity system has undergone significant change in recent years. Now is an opportune time to revisit electricity tariff designs so they better meet the needs of our modern electricity system.

The past few years have seen major changes in Australia's electricity system, including changes to load profiles, changes to the supply and demand balance and technological changes such as rapid air conditioning and solar PV uptake.

One of the most significant changes to Australia's electricity system has been higher levels of peak electricity demand which has been largely driven by greater air conditioner penetration. Peak demand has increased to the point where the top 20 per cent of maximum demand occurs for less than 2 per cent of the time. In terms of our electricity networks, this effectively means that 20 per cent of the network is used for only a handful of days per year. This is not only inefficient, it makes the system more costly to run. Additionally, there has been rapid uptake of domestic solar generation, which is placing downward pressure on electricity consumption from the grid.

These changes, however, may be only a taste of what is to come. In the future we may see electric vehicles penetrate the market and more widespread use of smart devices that allow networks and electronic appliances to communicate, and allow customers to remotely activate their appliances.

It is now an opportune time to revisit retail electricity tariff designs so that they better meet the needs of our modern electricity system.

For the electricity system to operate in an efficient manner, electricity tariffs must be designed so that customers face the right price signals. Further, electricity tariffs need to stand the test of time by continuing to providing the right price signals as technology and usage patterns change.

While technology has driven many of the changes to Australia's electricity system, it is also technology that will enable us to design and implement tariffs that will complement the modern electricity system.

It is against this backdrop that we have examined electricity tariff design options in Australia.

1.1 Scope of work

The Energy Supply Association of Australia (ESAA) has engaged Deloitte to review the merits of different tariff designs by examining the effectiveness, simplicity, stability, equity and likely consumer acceptance of tariff designs including:

- Standard Australian household prices: low fixed charge and flat usage charge
- Inclining Blocks
- Declining Blocks
- Time of Use pricing (peak, off-peak and shoulder)
- Critical Peak Pricing/Rebates
- Capacity Tariffs
- Seasonal Pricing
- Controlled Loads.

Additionally, the ESAA has requested that we examine these tariff designs in light of different market circumstances. More specifically, in examining these tariff designs we have been asked to consider the following questions:

1. How do market characteristics such as peakiness of load and deployment of distributed generation influence the merits of the various options?
2. As the penetration of distributed energy, energy storage and electric vehicles increases what are the broad implications of each tariff option for generators, networks, retailers and customers?
3. What combinations of these tariff options, such as a seasonal capacity tariff or inclining blocks only at peak periods, have merit?
4. What are some of the key enablers (for example, in home displays, smart meters) that may determine the appropriate approach in a particular region? What tariff options are available under interval but not smart metering and how does this influence the customer experience?
5. What has been the experience of trials/rollouts of advanced tariffs and enabling technologies overseas and what are the lessons to be learned? This should include identification of key success measures where possible (for example, deferred network expenditure).

1.2 Structure of this report

Chapter 1 – Outlines the introduction, scope of work and structure of this report.

Chapter 2 – Outlines key tariff designs, describes the current state of play in Australia with respect to tariff designs, discusses the enabling devices that are needed to implement different tariff designs and that enhance tariff designs' effectiveness, develops a set of factors which describe attributes of effective tariff designs, and evaluates the key tariff designs against these factors.

Chapter 3 – Tests the tariff designs against market scenarios to determine how well they can cope with the current and likely future state of Australia's electricity system.

Chapter 4 – Outlines our overall summary and conclusions.

2 Evaluating residential tariffs

This chapter outlines tariff designs, describes the current state of play in Australia with respect to tariff designs, develops a set of factors to assess the effectiveness of the tariff designs, and evaluates them against these factors to provide a high-level assessment of the general properties of each tariff. The evaluation in this chapter informs the assessment of each tariff's strengths and weaknesses in the context of alternative market circumstances and disruptions in chapter 3.

2.1 Tariff designs

Residential electricity tariffs can be broadly categorised into three categories:

1. Tariffs that do not vary with a customer's electricity usage characteristics:
   - Two Part Tariff comprising a low fixed charge and flat per kWh usage charge (standard Australian household prices)
2. Tariffs that vary with the amount of a customer's electricity usage, which include:
   - Inclining Block
   - Declining Block
   - Capacity Tariff
3. Tariffs that vary with the time at which customers consume electricity, which include:
   - Seasonal Pricing
   - Time of Use Tariff
   - Peak Time Rebates
   - Critical Peak Pricing
   - Controlled Loads.

An explanation of these designs is provided in section 2.5. Note that this list is not exhaustive, as there are also a number of variations of these key tariff designs. As discussed in more detail in section 2.6, some of these variations come about by combining tariff designs. We also note that electricity network businesses and electricity retail businesses may apply different electricity tariff designs. To assess the characteristics of alternative tariff designs, we have assumed that retail tariffs reflect tariff structures applied at the network level.

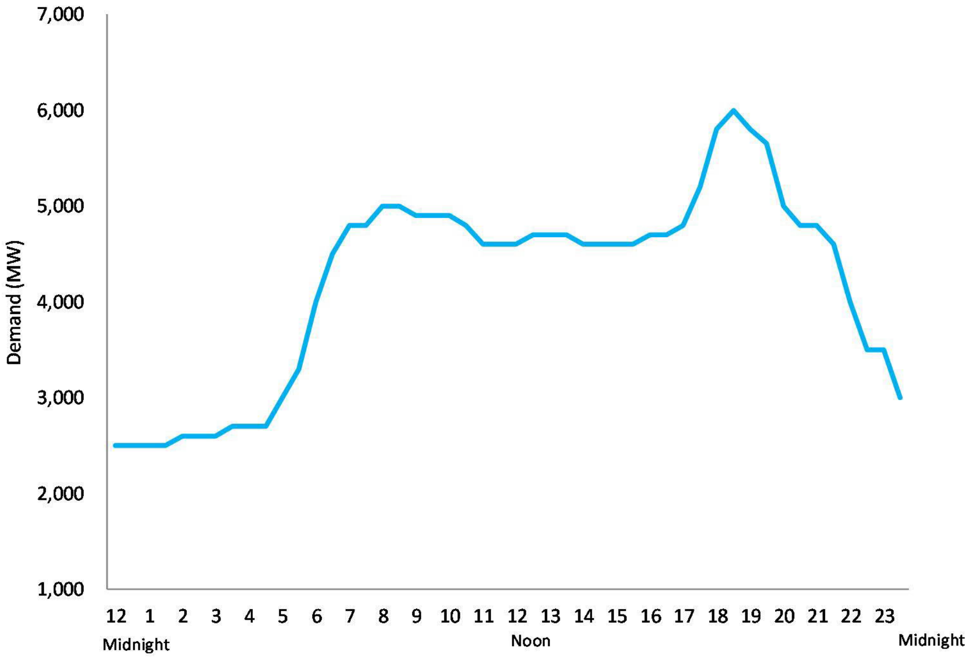
2.2 The current state of play

2.2.1 Typical usage profiles

Daily load profile has a critical impact on the evaluation and selection of tariff design. If electricity use was consistent over the course of the day, then tariff structures with a simple relationship between the amount used and price (e.g. flat usage charges, or inclining/declining blocks) would be sufficient to provide signals to customers about the costs of supply. However, in addition to being highly dependent on weather conditions, energy consumption varies significantly across the day, reflecting a typical pattern of day-to-day activity.

The typical residential daily usage profile is one with a daily morning demand ramp up, peak demand in the morning and/or early evening (usually most pronounced in summer in mainland Australia), falling night demand and a few critical peak events each year. Figure 2-1 illustrates this typical profile.

Figure 2-1 Typical network daily demand profile



Source: Deloitte

Extreme weather events that drive up the use of air-conditioning or heating can put stress on the electricity system, resulting in constraints during peak times. It is these critical peak events that have been a significant driver of capital expenditure and costs in recent years and consequently the need to redesign current tariffs.

Electricity systems that experience high peak demand need to be built to a high capacity standard, yet this capacity is only sometimes used. Peaky electricity systems are therefore less efficient than less peaky systems. The peakiness of a system is measured via the load factor, calculated as the ratio of average load to peak load. Table 2-1 outlines the load factors (where a lower number represents more peaky demand) to demonstrate the relative peakiness of each jurisdiction. In Victoria and South Australia the top 20 per cent of load occurs for less than 2 per cent of the year, or about three days. In NSW and Queensland, the top 10 per cent of peak demand is used over less than three days.[1] A tariff structure that provides incentives for customers to shift their usage from peak times (by providing signals about the costs of usage at peak times and during peak events) can improve the stability of the system and reduce overall costs.

Table 2-1 Electricity consumption, demand and load factor (2012-13)

	Annual energy (GWh)	Maximum demand (MW)	Load Factor
NSW (including the ACT)	68,834	13,946	0.56
Queensland	49,543	8,720	0.65
South Australia	13,144	3,158	0.48
Tasmania	10,247	1,684	0.69
Victoria	47,129	9,793	0.55
Western Australia	17,881	3,735	0.55

Source: AEMO (2013), National Electricity Forecasting Report ; IMO (2013) Electricity Statement of Opportunities 2013; Deloitte analysis

[1] Deloitte (2012), Analysis of initiatives to lower peak demand , Report for the ESAA, April

2.2.2 Current tariff offerings

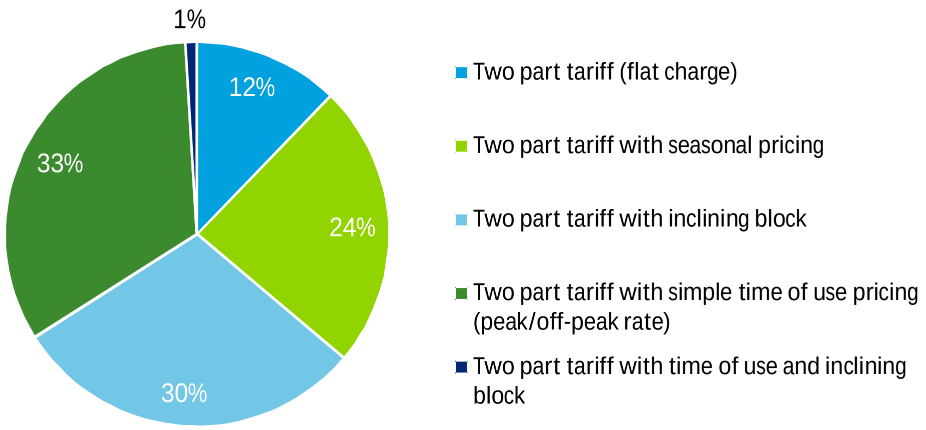
We have examined the tariff designs used by several States in order to provide an overview of the tariffs currently implemented in Australia. While tariff offerings vary between States, for the most part they are relatively simple in design. The problems with these relatively simple tariff designs is that they can result in cross subsidies between customers. This is not equitable because it means some customers pay for the costs that other customers cause. This absence of cost reflective tariffs and the resultant inequities is a significant driver of the need for tariff redesign.

Broadly speaking, the majority of residential customers in these States are on plans that are based either on a Two Part Tariff or Inclining Block tariff. A reasonable proportion of these customers are also on a plan that includes Controlled Load. Although there has been some adoption of time of use pricing in Victoria, the plans adopted are largely based on a simple peak and off-peak time of use structure. A small number of Victorian and Queensland residential customers have adopted a tariff structure based on full Time of Use pricing. Some Victorian retailers have also introduced seasonal pricing.

The majority of residential customers in these States are on plans that involve relatively simple tariff structures that do not utilise all the technologies that are currently available, with the availability and/or uptake of more sophisticated tariff structures such being relatively small.

Almost all Victorian residential customers are on a plan that involves a Two Part Tariff. Of those who are on a two part tariff, the variable component is structured in a number of different ways, namely simple time of use pricing (that is, a standard rate during the day and an off-peak rate during the evenings), Inclining Block pricing, Seasonal Pricing or a simple Flat rate. A very small proportion of customers have adopted a more comprehensive Time of Use Tariff.

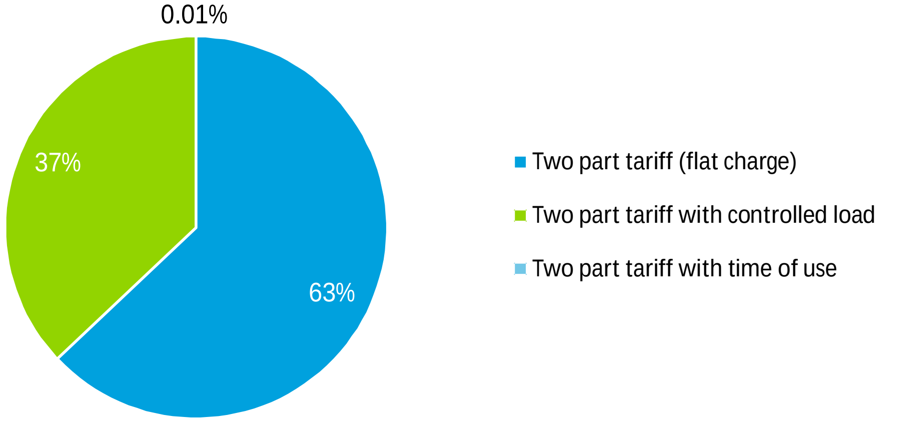
Figure 2-2 Victorian residential tariff offerings



Source: AER, Deloitte analysis
Note: Approximately 16 per cent of Victorian customers' tariffs are combined with Controlled Load

The majority of Queensland residential customers are on a plan that involves a Two Part Tariff with a variable component based on flat rate per kWh. Although some customers are also offered Time of Use pricing, the uptake of these plans has been relatively small. The remainder of customers are on a plan that includes a Controlled Load tariff component.

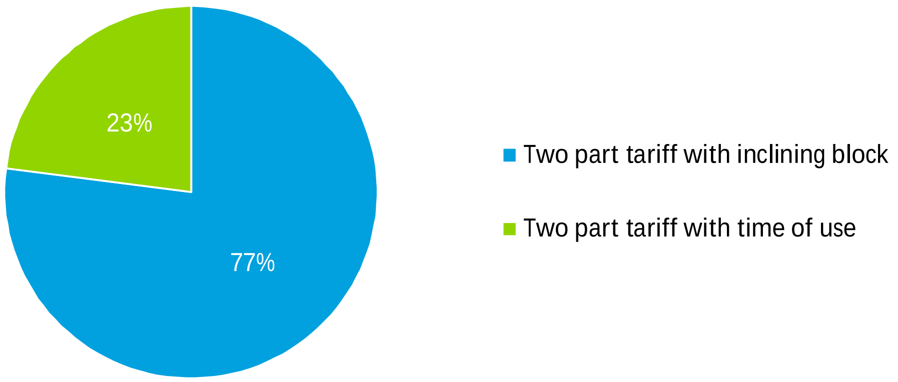
Figure 2-3 Queensland residential tariff offerings



Source: ESAA

Most residential customers in NSW are on a Two Part Tariff with an Inclining Block component. The remainder are on a Two Part Tariff combined with a Time of Use Tariff.

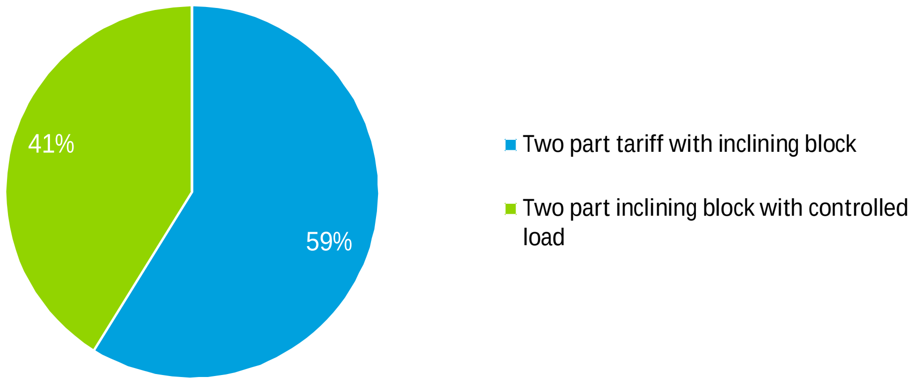
Figure 2-4 NSW residential tariff offerings



Source: ESAA

All residential customers in South Australia are on a plan that is based on an Inclining Block tariff, where around 41 per cent of these customers also have a Controlled Load tariff component.

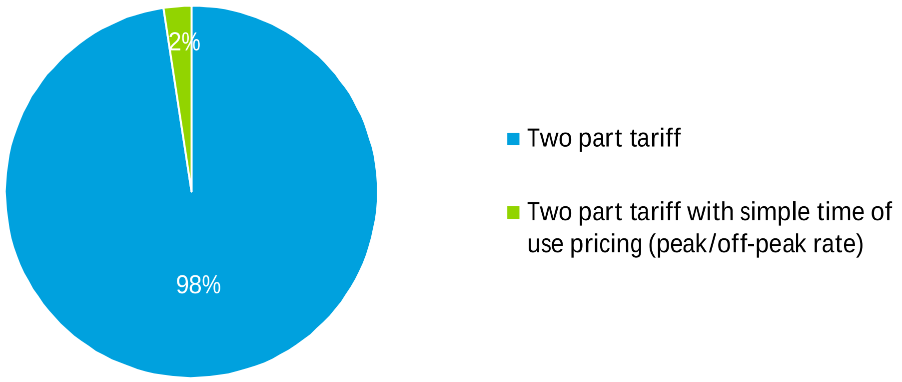
Figure 2-5 South Australian residential tariff offerings



Source: ESAA

In Western Australia the majority of customers are on a Two Part Tariff. For a relatively small number of customers the Two Part Tariff is combined with a simple Time of Use Tariff.

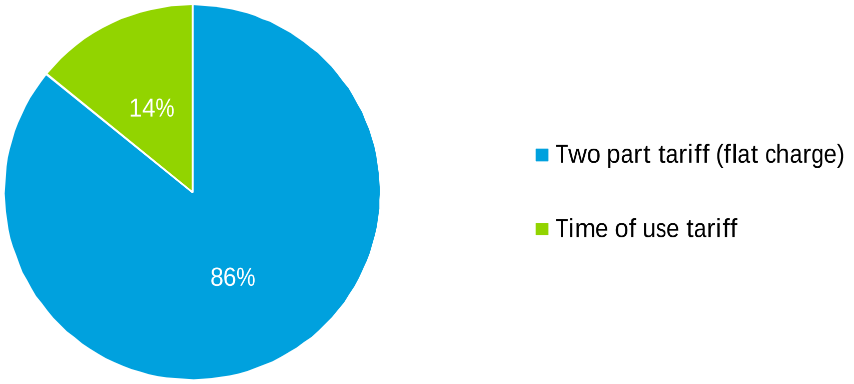
Figure 2-6 Western Australian residential tariff offerings



Source: Western Power 2013/14 Price List Information

In Tasmania the majority of customers are on a flat charge tariff. However, around 14 per cent of customers are on Time of Use Tariffs.

Figure 2-7 Tasmanian residential tariff offerings



Source: Aurora Energy

2.3 Enabling devices

2.3.1 Meters

The three main types of residential electricity meters are accumulation, interval and smart meters.

Accumulation meters (referred to as Type 6 meters in the National Electricity Rules) are the most common type of meter installed Australia. These meters record energy consumption over time. Interval meters (Type 5) record energy use over short intervals, typically every half hour. Smart meters (Type 4) are similar to interval meters although they also allow communication between the electricity supplier and the meter.[2]

Interval meters need to be manually read by inserting a probe into the meter, allowing data to download to a hand held device. Smart meters on the other hand can be read remotely. Smart meters can also communicate electricity usage information to the customer with the aid of other enabling devices.

Some tariffs can only be implemented with certain metering technology. Most simple tariff designs, such as Two Part Tariffs (flat rate) and Inclining/Declining Block tariffs can be implemented with accumulation meters. Accumulation meters can be single or dual element meters. Dual element accumulation meters allow a Controlled Load tariff to be implemented by dedicating a separate circuit to the Controlled Load. The controlled electrical load can be turned on and off by pre-setting the meter or by different electricity frequencies.

Tariffs based on customer (instantaneous) demand (such as Capacity Tariffs) and most tariffs where the charge rate varies with time (Time of Use Tariffs, Critical Peak Pricing and Peak Time Rebates), require interval or smart meters that can record the time when electricity is used. The more simple consumption based tariffs, however, can also be implemented with both of these meter types.

We note that while the Victorian Government has mandated the rollout of smart meters in Victoria, this technology is at present underutilised due to the (recently lifted) moratorium on time of use pricing and delays in the rollout program.

As an illustration of the potential benefits of more advanced meters than the typical accumulation meter, Deloitte has previously estimated that the benefits of the Victorian Advanced Metering Infrastructure (AMI) program will exceed $2 billion. A reasonable portion of this benefit was derived

[2] Deloitte, Advanced metering infrastructure cost benefit analysis , August 2011

from estimates of avoided network and generation augmentation resulting from incentives to reduce critical peaks. [3]

2.3.2 Other enabling devices

Enabling devices provide customers with information that enhances their ability to respond to a tariff's incentives. As demonstrated in section 2.5, international studies have shown that enabling devices have a significant and positive impact on how well customers respond to the incentives of tariff designs. These devices include:

- In the absence of a smart meter, in home displays can display the charge rate of electricity as established by a given tariff. When paired with smart meters (including remotely via wireless technologies) in home displays can convey information about a customer's electricity demand, consumption and predict a customer's upcoming electricity bill. Some in home displays communicate this information to customers' mobile phones, or link with smart appliances such as electric vehicles
- Web portals enable customers to track their energy usage online
- Energy orbs which change colour with the price of electricity, providing customers with signals about changes in the costs at different times
- Switches, controllable thermostats, and other devices that allow appliances and technologies to communicate with the electricity grid. For example, these technologies can enable innovations such as:
    - Automatic remote switching on and off of certain loads in response to electricity prices
    - Establishing price thresholds for technologies such as electric vehicles to discharge their stored power into the grid or recharge at only certain times.

Traditional communication tools such as SMS, telephone and email can also be used to convey information to customers about high price events.

By coupling smart meters and other enabling devices, customers will be provided with all the information they need to respond to the price signals of more complex tariffs. For example, under Critical Peak Pricing, a customer could be notified by SMS, or directly to their in home display, of a critical peak event. Customers could then keep track of their energy demand at this time, from their in home display. The in home display could also convey information about the impact on a customer's bill of not reducing demand during the peak time.

While we have outlined some enabling devices that are already available, the development of these devices is likely to continue in the future. Such devices will continue to enhance the effectiveness of the more complex electricity tariff designs.

In the sections that follow, we have considered how enabling devices could be used when identifying tariff designs that best meet current and future disruption scenarios.

2.4 Evaluating factors

Current tariff designs are not meeting the needs of the modern electricity system. Peak demand has increased to the point that it is a significant driver of costs, yet tariffs are not reflecting this. Smart technologies that can convey information about electricity costs are being underutilised. We believe there is a case for redesigning electricity tariffs. Before policy makers, businesses and customers select the tariff design (or designs) to apply, however, there needs to be an understanding of what can be achieved by redesigning tariffs and an understanding of the positive attributes of an effective

[3] Deloitte, Advanced Metering Infrastructure Cost Benefit Analysis , August 2011

tariff for the electricity system. We have therefore developed four factors that describe the positive attributes of tariff designs:

1. Cost reflectivity
2. Simplicity
3. Stability
4. Revenue adequacy.

In developing these factors, we have had regard to:

- Our scope of work and previous research undertaken by the ESAA
- Network pricing objectives applied by distribution network businesses in their annual tariff reviews
- Factors identified by state regulators during tariff reviews
- Criteria for assessing tariff designs proposed by academics.[4]

2.4.1 Deloitte's four factors

1. Cost reflectivity – Electricity prices should reflect the cost, including the economic cost, of the service provision.

To promote allocative efficiency (that resources are directed towards producing the desired amount of electricity given its cost), customers must be provided with information about the costs of supplying electricity and face incentives to make trade-offs about the amount and time of use. This means that the prices customers face for electricity should reflect the cost of producing and transporting the electricity at that time. Additionally, when prices reflect costs, suppliers are informed about customer preferences and can direct productive resources towards the energy services or time periods that customers value the most (productive efficiency).

Cost reflectivity can have more than one meaning. It can include prices reflecting any combination of the fixed, variable or marginal costs of the generation, network or retail segments of the electricity system. For example, the costs making up the electricity system include:

- The fixed capital costs of generators, and network transmission and distribution businesses. Fixed capital costs can include the cost of existing, and replacing ageing, plant and equipment. These costs make up a significant portion of the existing costs in the Australian electricity system
- The variable costs of generators (such as fuel costs, which differ depending on the generator type), network businesses (such as operating and maintaining the network, or reading meters) and retail businesses (such as billing customers)
- The marginal cost of the network businesses. At times when the network is not constrained the short run marginal cost of using the network is close to zero. It is peak demand or coincident peak demand[5]—a customer's peak demand at the time when the network component to which the customer is connected (often the substation) is constrained—that drives future network augmentation costs. Therefore we consider this to be an important factor to consider when evaluating whether a tariff is cost reflective.

[4] The sources reviewed include: ESAA, Project specification- Electricity tariff review , 8 October 2013; Ausgrid, Network Pricing Proposal For the Financial Year Ending June 2014 May 2013, p. 12; SA Power Networks, Annual Pricing Proposal 2013-2014 , 24 May 2013, p. 29; ActewAGL Distribution, 2013/14 Network Pricing Proposal , May 2013, p. 10; QCA, Review of Electricity Pricing and Tariff Structures – Stage 2 , November 2009; IPART, Inclining Block Tariffs for Electricity Network Services , 2003; The Brattle Group, Managing the Benefits and Costs of Dynamic Pricing in Australia , September 2012.

[5] Although the name suggests the concept of coincident peak demand is relevant only for tariffs that are based on a measure of demand, this is not the case. For example, the charge rates of a Time of Use Tariff could be designed around the time when the network experiences its maximum level of demand.

This means that the costs of the electricity system differ depending on time and location that electricity is used. Therefore to be cost reflective, prices may have to differ significantly by time of use and location.

Some components of the electricity system already charge prices that are based on the cost of producing or supplying electricity. For example, generators charge more when electricity demand is high, which often means expensive fuel types such as gas (rather than coal) can be used. Additionally, the transmission network charges different prices depending on the cost of servicing customers at particular locations.

Cost reflective pricing also promotes equity. For the purpose of this report, we have defined equitable tariffs as those that reduce or limit cross subsidies between customers by charging each customer for the costs they impose on the electricity system. Where cross subsidies exist, the actions of one customer can increase the prices of another customer.

As such, where we have identified tariffs that perform well against cost reflectivity, we also consider that these tariffs will generally result in the most equitable outcomes. Over time, we also consider that cost reflective pricing will tend to reduce the overall costs of the electricity system by providing appropriate signals to consumers and suppliers about the costs of supply and consumer preferences.

2. Simplicity – A tariff's operation should be easy for customers to understand. The tariff design should be simple to implement and administer.

For customers to be able to respond to the incentive properties that a tariff design creates, they need to understand the tariff's operation. Given that any tariff design is likely to apply to a large number of people, it is also important that the tariff's operation can be easily communicated. Accordingly, all else being equal, a simple tariff is generally preferable to a complex tariff.

3. Stability – In the absence of significant changes in use, customers should not experience unduly large, sudden increases in their electricity bill. Once customers are on a particular tariff design, their charges should be reasonably predictable.

This factor captures how much a tariff exposes customers to large and/or unexpected bill shocks. Although tariffs should be reflective of costs (factor 1), this should be balanced with customers' ability to bear the risks of variability in charges. In particular, this factor captures the notion that electricity retailers (and other wholesale purchasers of electricity) will generally be better placed than individual residential customers to bear the risk of extreme price events and fluctuating costs.

Note that in this report we focus on bill shock driven by the inherent characteristics of a particular tariff structure rather than bill shock that is the result of transitioning between one tariff structure and another.

4. Revenue variability – Network electricity businesses should be able to recover their efficient costs, and should not experience significant under or over-recovery from one period to the next.

Network businesses should be able to recover their efficient costs from customers and they should not be exposed to large revenue variations due to tariff design. Revenues and prices for network businesses are generally subject to independent review by regulators and set to recover efficient costs. The extent to which network businesses are likely to recover their efficient costs in any given period depends on several aspects of tariff design.

For example, different tariff designs provide network businesses with differing levels of revenue predictability or revenue variability. The more predicable the revenue from a tariff design the more likely the network business is to be able to set charge rates to recover efficient revenue.

Additionally, in the face of customers changing their electricity consumption patterns due to the incentives placed upon them by different tariff designs, network businesses should not be exposed to undue risks of not recovering their efficient costs. Without consumer responses all tariff designs can easily be implemented to be revenue neutral to the network businesses, but when customers respond to the incentives created by price signals, this is more difficult.

2.4.2 Trade-offs between the factors

While we have not weighted the factors in undertaking our assessment, considerations of cost-reflectivity are foremost in our analysis on the basis that the lack of cost-reflectivity in current tariff designs is the driving factor behind the need for tariff reform. However, it is also important to note that there are trade-offs between the factors – each tariff design has its own strengths and weaknesses and it is unlikely that any particular tariff design will perform well against every factor or every circumstance. In particular, improvements in cost reflectivity (and equity) may come at the price of increasing complexity and bill stability – which together are key indicators of customer acceptance.

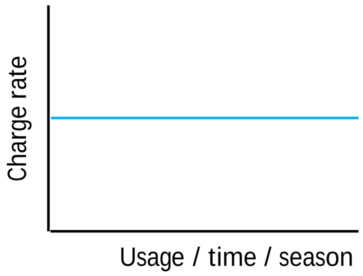
Our four factors do not address the risks to vulnerable customers of a tariff design, which is a criterion adopted by others, and is often a concern of policy-makers when considering reforms. While we recognise that this is an important risk to have regard to, we consider that it should not drive the selection of a particular tariff design to apply to all customers. This risk can be better addressed by separate arrangements such as concessions and customer engagement from retailers and network businesses.

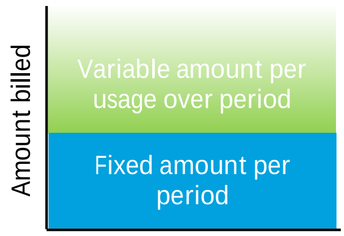
2.5 Evaluating tariffs against Deloitte's four factors

By evaluating the tariff designs against Deloitte's four factors, we can more effectively test the tariff designs against different market scenarios (in chapter 3).

We recognise that combining tariff designs can enhance a tariff's incentive properties or mitigate some of the risks they impose on customers. However, we have not attempted to assess every tariff combination against our four factors. The market scenario analysis in chapter 3 considers how the selected tariffs could better meet the needs of the modern electricity system by combining them.

2.5.1 Two Part Tariff (flat usage charge)





Two Part Tariffs consist of a fixed charge and a per unit charge that is applied to the amount of a customer's electricity consumption (or demand):

- The flat usage charge component remains constant regardless of the amount of electricity consumed and when it is consumed.
- The fixed charge component is designed to be reflective of the fixed costs of supplying electricity. A Two Part Tariff design is commonly offered throughout Australia.

Two Part Tariffs with flat usage charges can be implemented with standard accumulation meters.

Cost reflectivity

Two Part Tariffs are intended to overcome the shortcomings of a stand-alone flat charge, which would tend to overstate the marginal costs of supplying electricity in the presence of large sunk investments in infrastructure.

Economic theory suggests that an efficient usage charge should reflect the marginal costs of supplying an additional unit of electricity. However, flat charges are unlikely to be cost reflective in the case of electricity supply as they are not able to reflect changes in wholesale generation costs as electricity production varies, or variations in network costs related to capacity issues (including network constraints) and the timing of consumption. The electricity system is characterised by large sunk network investments and thus, the average cost to provide electricity generally decreases with the volume of electricity sold. This suggests that a flat charge will tend to overstate the costs of supplying the marginal unit of electricity as total consumption increases, potentially driving electricity use below a welfare maximising level.

The addition of a fixed component provides the following benefits in terms of cost reflectivity:

- It more closely reflects the underlying cost structure of supply, as a significant proportion of costs (in particular, generation and network costs) are fixed, particularly in the short to medium term.
- It allows a lower variable component to be set, which may be closer to the marginal cost of supply than a flat charge.

However in Australia, the fixed component of the charge is usually set below the level that would be reflective of the fixed costs of the electricity system, in part due to customers' desire to have control over their bills.

With a Two Part Tariff, customers with low electricity consumption are paying for the costs they impose from being connected to the network (and having electricity supply available to them) via the fixed component which reflects the fixed costs of generating and supplying electricity. However, where the per unit charge rate of a Two Part Tariff does not vary with time or usage patterns, it results in cross subsidisation of electricity usage at peak times. During times of peak usage, the marginal cost of supplying an additional unit of electricity can be very high (either due to network constraints, or the requirement for high-cost generation, or both), with the result that a flat charge will tend to understate the cost of supply. In this case, flat charges will tend to result in cross subsidies between customers who consume more electricity at peak times and those with a more balanced consumption profile.

Simplicity

Two part tariffs are relatively simple to design, with the variable component set to estimate marginal costs and the fixed component picking up the remainder. This tariff is well established and readily understood by customers.

Stability

Two part tariffs typically result in stable outcomes for customers. Customers have more certainty about their bills given:

- They are they not exposed to extreme price events because the variable tariff component does not vary with usage characteristics
- Variable costs incurred by customers are predictable, and being based on a constant relationship between consumption and price, will be less than under a flat charge alone.

Customers are therefore unlikely to experience short-term bill shocks. However, over the longer term, given the inherent cross subsidies between usage at peak and off-peak times, the overall costs of the system (and therefore prices) will tend to increase, resulting in higher charges for customers.

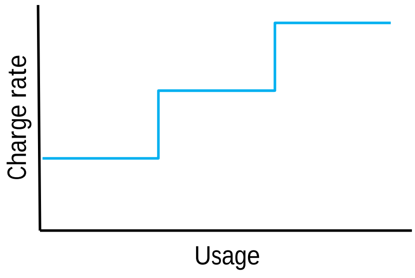
Revenue variability

Under a Two Part Tariff design only a portion of a network business' revenue is fixed, which provides revenue variability – businesses can generally be assured of recovering some proportion of their fixed costs, with revenue from the variable component compensating for variable costs. However, given customer preferences to have greater control over the amount they are charged, the balance between fixed and variable charges will typically mean that businesses must rely on variable charges to recover fixed costs, diminishing revenue adequacy.

On the other hand, because customers do not face strong price signals to change their consumption patterns throughout the billing period, forecast usage may be more easily predicted than for some other tariff types, lessening this risk.

2.5.2 Inclining Block

Under an Inclining Block tariff, consumption over a specified consumption threshold(s) is charged at the rate applicable to that block of consumption. Tariff rates increase as a customer's consumption increases. This electricity tariff design is reasonably common in Australia and is offered in jurisdictions including South Australia, New South Wales and Victoria. An Inclining Block tariff can be implemented with a standard accumulation meter.



Cost reflectivity

Inclining Block tariffs are typically designed with two objectives in mind:

- Relatively low rates are charged for an amount of consumption that is perceived as being required to meet basic needs ensuring that consumers such as low income households are able to access the service
- Higher rates are applied as consumption increases, generally on the basis of considerations about equity, fairness or for resource/environmental reasons.

The cost reflectiveness of this tariff design in the context of the Australian energy system depends on the characteristics of the electricity system. The Australian electricity system typically faces network capacity constraints at certain times. Charging a higher electricity rate when a customer's consumption increases may therefore be appropriate.

By charging a higher rate when consumption increases, this tariff recognises that consumption plays a role in driving requirements for capacity augmentations and in higher wholesale prices. However, in the case of networks and wholesale energy prices, it is peak demand, rather than overall consumption that is the key driver of costs. As peak system demand will not necessarily correlate with times of high consumption for individual customers, the link between higher charges under an Inclining Block and high network costs is not necessarily a strong one. This means the tariff will not necessarily reflect costs when the network is at peak capacity or when the cost of generating electricity is high. Thus, the Inclining Block tariff provides only a very 'blunt' form of cost reflectivity.

This tariff can also result in inequitable outcomes for larger households, who may face significantly higher bills by virtue of the fact that they consume more electricity over a given period, regardless of whether that consumption occurs at peak times and actually results in higher costs to the system.

Simplicity

While slightly more complex than Two Part Tariffs, Inclining Block tariffs are well established and conceptually readily understood by customers. However, Inclining Block tariffs can be difficult to design, with choices about the number and level of the blocks requiring a clear understanding of demand elasticities (as well as balancing other objectives). Further, with accumulation meters customers do not know when they are moving from one block to another.

Stability

As lower consumption blocks are typically set to cover the majority of consumption, Inclining Block tariffs will generally result in relatively stable bills. However, if there are large increases in the charge rates when exceeding a consumption threshold, customers could experience bill shocks.

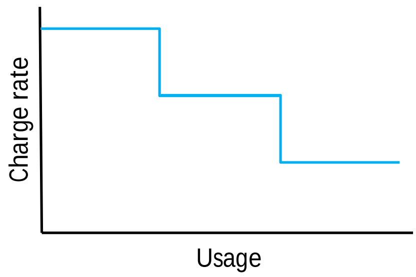
Revenue variability

Revenue variability will depend on the nature of the blocks. If the rates and tariffs are not correctly designed, and in particular where businesses are relying on a significant proportion of revenue from higher blocks, they may face revenue variability issues. For example:

- Payments in higher blocks may need to recover losses from the first block when the lower blocks are designed to provide electricity at low costs for basic needs
- Customers may seek to reduce their overall consumption in the face of higher charge rates when consumption increases over a threshold.

2.5.3 Declining Block

With a Declining Block tariff, consumption over a specified consumption threshold(s) is charged at the rate applicable to that block of consumption. Tariff rates decrease as consumption increases. While this tariff design is available in Tasmania to business customers, it does not appear to be currently offered to residential customers. A Declining Block tariff can be implemented with a standard accumulation meter.



Cost reflectivity

The electricity system is characterised by large sunk network investments and declining average costs with increases in the volume of electricity sold. In the presence of spare capacity, declining block tariffs can be cost reflective to the extent that the blocks accurately reflect reductions in average costs. The first block rate can be set to recover some of the fixed costs of the existing network, adding to cost reflectivity. However, where the initial block is set at an amount equivalent to normal usage, much of the overall electricity charge would be fixed which may lead to questions about the fairness of this tariff.

Additionally, similar to the Two Part Tariff, Declining Blocks do not reflect differences in costs related to the timing of electricity use, and may provide perverse incentives at times of peak demand, as prices fall with rising consumption. Therefore, issues concerning cost reflectivity and cross subsidisation of electricity usage at peak times may be exacerbated under a Declining Block.

Under this tariff, equity between customers may be worse than under a Flat Charge. Customers who consume more electricity (especially those who consume more at peak times) will pay lower rates and hence will not pay their fair share of the costs they impose on the electricity system.

Simplicity

Declining Blocks face similar issues to Inclining Blocks in relation to simplicity, with key challenges being decisions on the number and size of the blocks.

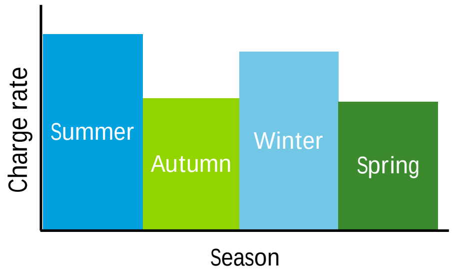
Stability

As charge rates decline as consumption increases, customer bills will typically be relatively stable, being based largely on the early blocks.

Revenue variability

Higher volumes of consumption attract lower prices and therefore the revenue impact of mis-forecasting consumption is less than under an Inclining Block tariff. Also, the first and higher block charge is similar to the fixed component in a Two Part Tariff.

2.5.4 Seasonal Pricing



Seasonal Pricing is a tariff design that varies depending on the season. This tariff design is often combined with other tariff designs. For example, in regions which are summer peaking, it may be desirable to set higher peak prices in summer months. This electricity tariff design is offered in South Australia and by some retailers in Victoria. By aligning billing periods with seasons, seasonal tariffs can be implemented with accumulation meters.

Cost reflectivity

Seasonal Pricing acts in a similar fashion to Time of Use, albeit over longer time periods, and is therefore a blunt form of cost reflectivity. In particular, while generation and network costs are likely to be higher over the course of the season in which peak demand occurs, the actual peak events usually occur over a much shorter timeframe, being just a few days or even hours of maximum demand.

As a result of all customers paying the same charge rate as each other regardless of the costs imposed on the network from peak demand, this tariff results in cross subsidies between customers.

Simplicity

Seasonal Pricing is simple to design, implement and explain to customers, although there may be some difficulties in establishing appropriate differentials between seasons.

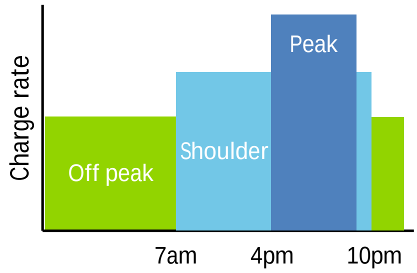
Stability

Although there is the possibility of some bill shock when transitioning between seasons, customers are not exposed to extreme price events because rates do not vary with peak times.

Revenue variability

The revenue variability of seasonal pricing is similar to a Two Part Tariff, with key issues including lack of cost reflectivity for peak events, balanced by reasonably predictable consumption which facilitates revenue forecasting.

2.5.5 Time of Use



Time of Use Tariffs divide the day into time periods and provide a schedule of rates for each period. Prices may also vary by season. These periods often include peak, off-peak and shoulder pricing periods. Time of Use Tariffs are beginning to be taken up in some parts of Australia and have been offered in jurisdictions including Queensland and in Victoria from late 2013. Time of Use Tariffs can be implemented with interval or smart meters.

Cost reflectivity

Time of Use pricing allows electricity businesses to use price signals as a mechanism to encourage consumers to shift consumption away from peak period use. Under a Time of Use Tariff, prices reflect the typical daily network load profile, which encourages customers to use less electricity when the daily generation costs and network (utilisation) costs are higher. Time of Use does not specifically account for network costs at peak times. As noted by the Productivity Commission, "the 'peak' price under a Time of Use Tariff does not, by itself relate well to, or serve to reduce, the more intense peak consumption that is of concern in the NEM from a network investment perspective." [6] However, to the extent that critical peak network events coincide with peak pricing times, there is some level of network peak cost reflectivity embedded in the charge.

Time of Use Tariffs reduce cross subsidisation between customers who use electricity at peak times and those that do not, by charging more at peak times. The peak charge, however, is usually lower than the actual cost imposed by customers using electricity at critical peak times, meaning cross subsidies are not eliminated.

Simplicity

Implementing Time of Use Tariffs requires designing the relativities between charges for different periods, which could produce some difficulties. The presence of multiple rates that vary according to time of use may also make communication to customers difficult, but because these prices are set up-front and do not vary each day (although depending on the design, different charge rates may apply on weekends), this communication difficulty is mitigated.

Further, given Time of Use Tariffs have stable price structures, enabling devices that display the price of electricity are not crucial. Once customers learn the peak, off-peak, and shoulder times, they will have a reasonable understanding of the applicable electricity charge rate. Visual aids such as energy orbs, which change colour as the price of electricity changes, could make this tariff more effective by keeping the price signals in customers' minds.

Stability

Once bedded down, Time of Use Tariffs are likely to provide reasonably stable bill outcomes for customers, unless large changes in timing of consumption occur. However, during the implementation phase there may be some variability if customers cannot defer consumption to off-peak times.

Revenue variability

Time of Use Tariffs come with some revenue risk, as customer response may be difficult to accurately predict when the tariffs are first implemented. However, customers' responsiveness to the different prices is likely to be more predictable over time. In implementing Time of Use Tariffs, businesses face a trade-off between providing signals for customers to change behaviour and shift consumption away from peak times, and ensuring revenue adequacy.

Time of Use review

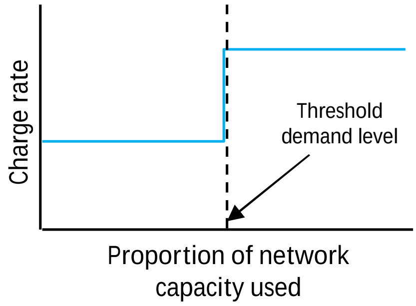
A review of 34 Time of Use Tariff studies undertaken in the US found that customers' demand response increases as the peak to off-peak price ratio increases, but at a diminishing rate. Also, price responsiveness increases when tariffs are coupled with enabling technologies ('price-tech' experiments). The review found that with a peak to non-peak price ratio of 2:1, the expected peak reduction in demand under price only and price-tech experiments was 4.7% and 9.4% respectively. For a price ratio of 5:1, expected peak reductions are 9.9% and 20.7% respectively.

The same review found that for Critical Peak Pricing and Peak Time Rebates tariff designs, with a peak to non-peak price ratio of 5:1, the expected peak reduction in demand under price only and price-tech experiments is 13.8% and 21.7% respectively. For a price ratio of 10:1, expected peak reductions are 15.9% and 27.2% respectively.

Faruqui, A and Sergici, S (no date), Arcturus: international Evidence on Dynamic Pricing

[6] Productivity Commission, Electricity Network Regulatory Frameworks Volume 2 , 9 April 2013, p. 431

2.5.6 Capacity Tariff



A Capacity Tariff is based on electricity demand rather than electricity consumption as per the other tariffs considered here. Demand is distinct from electricity consumption, in that the former measures (in kW) how much electricity is used at a particular point in time whereas consumption measures (in kWh) the amount of electricity used over a period of time.

A Capacity Tariff is based on how much of the network's capacity has been used by a customer during the billing period. Customers are often charged a higher tariff if their demand exceeds specified demand thresholds. Typically the capacity value is based on either the customer's maximum demand or coincident peak demand during the billing period, or season.[7] Coincident peak demand is a customer's demand at the time that coincides when the local electricity supply system experiences its maximum demand.

A Capacity Tariff can be implemented with an interval or smart meter, which record how much electricity is used and the time at which it is used.

Cost reflectivity

A Capacity Tariff's cost reflectivity depends on its design. A Capacity Tariff based on coincident peak demand is highly cost reflective because coincident peak demand is a key driver of network and wholesale generation costs. On the other hand a Capacity Tariff based on maximum demand provides only a blunt form of cost reflectivity because a customer's peak demand may not coincide with the electricity system's peak demand.

The cost reflectivity of a Capacity Tariff also depends on where in the network the coincident peak demand is measured. Coincident peak demand could be a customer's electricity demand when a transmission asset or distribution asset is experiencing peak demand. Coincident peak demand could also be measured at the time when a distribution zone substation is experiencing peak demand, or when a suburban distribution transformer is experiencing peak demand. By measuring peak demand at the network level that first experiences capacity constraints, Capacity Tariffs are most cost reflective. However, measuring coincident peak demand in this manner is also complex.

A coincident peak Capacity Tariff will tend to reduce cross subsidies between customers that may occur due to differences in usage during peak times, as those customers putting more burden on the network during peak times will be required to pay correspondingly. This means that Capacity Tariffs promote equity between customers.

Simplicity

Capacity Tariffs are relatively complex and therefore more difficult to explain to customers. This is because they rely on the concept of electricity demand rather than consumption, a distinction that many people are not familiar with. This also applies to concepts of coincident peak demand. Depending on the approach to setting capacity charge components, there may also be difficulties for customers in understanding what their demand is and when system peaks occur.

While conceptually the design of capacity tariffs should be relatively straight forward, implementation may be difficult because most customers' electricity meters measure consumption rather than demand (although not in Victoria where smart meters are being rolled out).

For customers to be able to better understand and respond to this tariff, it can be paired with devices that display a customer's demand. Educating customers on the concept of electricity demand and how these tariffs work would improve the simplicity of Capacity Tariffs.

[7] AEMC, Power of choice review – giving consumers options in the way they use electricity , 30 November 2012

Stability

Bill stability depends on the approach to setting tariffs, and in particular whether there is a link to peak demand events.

To the extent that customers experience once off high demand events, they may experience large increases in their electricity bill across billing periods. Electricity bills are also likely to vary significantly depending on whether air conditioners or heaters, which require customers to demand a relatively large amount of electricity, are used. Further, under some versions of this tariff, customers are charged penalties for high demand at peak times.

If customers do not know their demand or when coincident peak times occur, they may be unaware of the charge rate that will be applied to them. The stability could be improved, however, with enabling devices that warn customers when they are reaching pre-set levels of demand.

Revenue variability

Capacity Tariffs are similar to fixed tariffs in promoting revenue adequacy, in that even customers who consume relatively small amounts of electricity will be charged for using the network because it is customers' highest demand (or coincident peak demand) that sets the electricity charge. In particular, the ability to closely link capacity charges with underlying network costs provides strong support for revenue adequacy.

Capacity Tariffs in the business sector

Although not offered to residential customers, Capacity Tariffs are offered in Australia to some business customers. Capacity Tariffs for large business customers are usually designed by charging customers for their maximum demand on a rolling 12 month basis. In other words, charge rates will be set with reference to a customer's maximum demand over the past 12 months. This is a blunt form of cost reflectivity because a customer's maximum demand may not coincide with the network peak demand or the times when the generation cost of electricity is high.

A less common Capacity Tariff design for business customers, which is typically applied to smaller business customers, is where the charge rate is set with reference to a customer's monthly maximum demand. This is a lower risk tariff design because a once off high demand event does not affect tariffs for a long (12 month) period.

A third Capacity Tariff design, which is applied to few business customers, is one based on contracted capacity. Under this Capacity Tariff, customers contract for a certain amount of capacity, and demand over that contracted amount is charged at a higher, uncontracted rate.

Possible alternative implementation of Capacity Tariffs

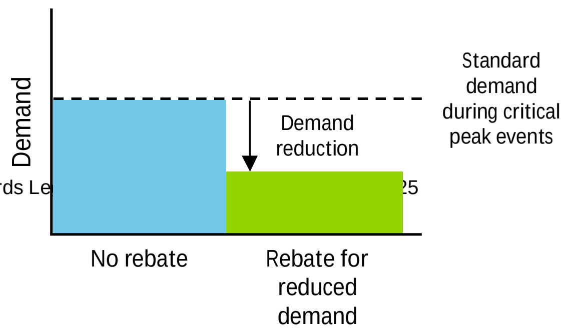
A possible implementation of Capacity Tariffs is one that specifies the maximum demand for use at a premise. If more than the specified demand is used, a customer's electricity supply could trip off (customers could restore their electricity supply once it has tripped off). This would be an alternative to paying higher rates as a result of demanding more electricity.

Implementing Capacity Tariffs in this way would require enabling devices such as fuses, switches, or smart meters that are capable of communicating with the customer or electricity supplier.

The stability of a Capacity Tariff will be improved under this possible implementation because customers would not use, and hence would not be charged for high levels of demand. This implementation, however, would bring significant customer inconvenience with it—having electricity supply momentarily stopped.

2.5.7 Peak Time Rebate

Under Peak Time Rebates customers are paid for load reductions (relative to a customer's baseline



level) during critical peak events. To date, this tariff design has been offered mostly through pilot programs to residential customers in the U.S. including Maryland, Washington DC and California. Peak Time Rebates can be implemented with an interval or smart meter.

Cost reflectivity

By providing rebates to customers for reducing their demand at peak times, Peak Time Rebates recognise that critical peak events are significant drivers of network and wholesale generation costs. Peak Time Rebates, on their own, however, do not account for the fixed costs of the existing network.

However, because rebates apply to changes from an individual customer's own baseline consumption, Peak Time Rebates may not address existing cross subsidies between customers in relation to peak time energy use and hence have equity issues. For example, a customer with an air conditioner will place a relatively high cost on the network at peak times compared to a customer without an air conditioner. However, the customer with the air conditioner will also receive a greater rebate for reducing consumption at peak times because that customer's baseline consumption level would be higher.

Simplicity

Peak Time Rebates are relatively simple for customers to understand in that they receive rebates for reducing their electricity when they are informed about peak times. However, they are very difficult to implement because they require estimation of a baseline level of consumption against which to assess eligibility for rebates. Establishing an appropriate rebate amount may also be challenging, depending on whether the rebate is a fixed amount or varies on the basis of underlying costs/benefits to the business.

Stability

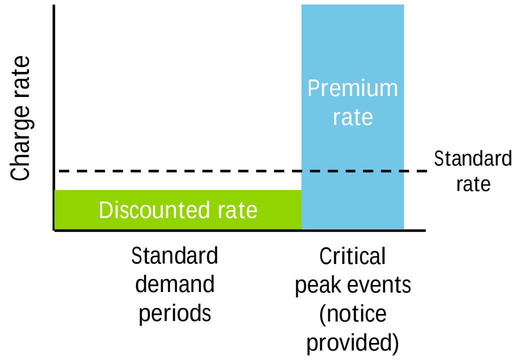
Customers are not exposed to high price events but instead receive a rebate for reducing demand. This means that customers will not be exposed to price shocks, although the general level of prices may increase over time to pay for the rebates.

Customers need to be aware of the timing of critical peak events in order to respond to the price signals of this tariff design. This notification could be done by standard communication devices such as telephone, SMS or email. Alternatively enabling devices such as in home displays could convey this information.

Revenue variability

The key challenge for Peak Time Rebates with respect to revenue variability comes from exposure to the design of the rebate and customer response. If more customers respond to the rebates than anticipated, then revenue recovery can be placed at risk.

2.5.8 Critical Peak Pricing



Customers pay higher rates during critical peak price events and receive a discount on the standard tariff during other hours of the season or year. Customers are typically notified one day in advance of critical peak times. Although this tariff design is offered to business customers in Victoria, it has not been offered to residential customers.[8] Critical Peak Pricing can be implemented with an interval or smart meter.

Cost reflectivity

Critical Peak Pricing addresses the peak usage cross subsidies identified above by recognising that critical peak events are a significant driver of network costs. It does this by charging customers high prices at peak times to encourage them to reduce their demand. Although customers pay more at peak times, they receive a benefit in the form of lower prices at non-critical peak times (unlike under Peak Time Rebates).

Although equitable from a cross subsidisation point of view, critical peak pricing may have a negative effect on those vulnerable customers that are not readily able to adjust their demand at peak times.

Simplicity

The link between peak pricing events and charging adds complexity to this tariff, which is otherwise similar to a time of use tariff. Furthermore, it can be quite difficult to implement as customers need to be made aware of when the critical peak times are going to occur. As these times change each year, mechanisms need to be available to communicate this information and facilitate customer response. This could take the form of standard communication technologies, or in house displays and energy orbs.

Stability

Customers are exposed to bill shocks because charge rates increase (possibly substantially) at critical peak times. While, we note that customers are exposed to high charge rates for only short periods of time, transitioning customers onto this tariff would require education programs.

Revenue variability

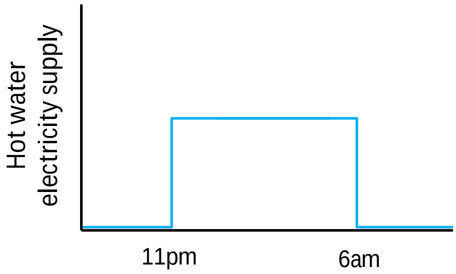
There are revenue risks should tariffs be incorrectly designed and/or customer response underestimated.

If businesses expect to receive a significant amount of their revenue at peak times but customers respond to the price signals by reducing demand, then businesses may not recover all of their required revenue. Additionally, given the number of critical peak events each year is likely to vary each year it may be difficult to design the tariff to recover the required revenue.

[8] SP AusNet, < http://www.sp-ausnet.com.au/?id=23013319509D6B39ED5B799B1DCA257990001C586E>

> US Critical Peak Pricing Trial
>
> California's three investor-owned network businesses conducted an experiment in the early 2000s to test the impact of dynamic pricing and Time of Use pricing among residential and small commercial and industrial customers.
>
> Using Critical Peak Pricing and setting the critical peak price roughly five times higher than the standard rate and six times higher than the off-peak price, the estimated average reduction in residential peak-period energy use on critical days was 13.1%. Other findings from the study included:
>
> - the reduction in energy use during high-price periods was almost exactly offset by increases in energy use during off-peak periods.
> - that households with central air conditioning were more price responsive and produced greater absolute and percentage reductions in peak-period energy use than did households without air conditioning
>
> Although using a much smaller sample size, with Time of Use pricing the reduction in peak-period energy use in summer 2003 equalled 5.9% cent, but this impact almost disappeared in 2004.
>
> Charles River Associates (2005), Impact evaluation of the California statewide pricing pilot

2.5.9 Controlled Load Tariffs



Controlled Load tariffs offer lower rates at off-peak times for separately metered and time Controlled Loads. For example, by agreeing to allow appliances such as hot water heaters and pool pumps to run at only pre-specified off-peak times, customers can reduce their overall electricity bill. This electricity tariff design is reasonably common in Australia and is offered in most jurisdictions. However, each customer typically has few electrical appliances that are conducive to being controlled. This means that the overall effect of Controlled Load tariffs on the electricity system is likely to be small. Controlled Loads can be implemented with duel element accumulation meters by separately wiring in the controlled load.

Cost reflectivity

Controlled Load Tariffs move certain loads to pre-defined off-peak times and offers lower charge rates for these loads. By moving some load to off-peak times this tariff reduces general demand at peak times. The ability to directly control the timing of electricity usage, Controlled Load Tariffs have the potential to be highly cost reflective. As noted by the Productivity Commission, in the absence of smart meters, direct load control technologies offer a highly practical option to implement peak demand management.[9]

Simplicity

Controlled Load tariffs are simple for customers to understand given they do not need to actively respond to price signals once the tariff design has been adopted. The tariff is also relatively easy to design and implement.

Stability

Controlled Load tariffs are very stable. By moving consumption to off-peak times customers will be able to reduce their electricity bills and will have a high degree of predictability about charges.

[9] Productivity Commission, Electricity Network Regulatory Frameworks Volume 2 , 9 April 2013, p. 431

Revenue variability

Controlled Load tariffs allow businesses to achieve relatively high levels of certainty about revenue, as the loads that are moved to off-peak times are stable loads such as hot water heaters.

2.5.10 Summary of evaluation

The following table provides a summary of our evaluation of each of the tariff designs against the four factors of effective tariff design outlined above.

Key:

● Strong performers

○ Poor performers

Table 2-2 Evaluation of tariffs against Deloitte's four factors

	Cost reflectivity	Simplicity	Stability	Revenue variability
Two Part Tariff (flat charge)	◔	●	◕	◑
Inclining Block Tariff	◔	◕	◑	◔
Declining Block Tariff	◔	◕	◕	◑
Seasonal Pricing	◔	◕	◕	◑
Time of Use	◑	◑	◑	◑
Capacity Tariff	◕	◔	◑	◕
Peak Time Rebate	◑	○	◕	○
Critical Peak Pricing	◕	◔	◑	○
Controlled Load*	◑	◕	●	●

Source: Deloitte analysis
Note: * Controlled Load Tariffs shift certain electrical loads to off peak times and charge off peak rates. It is not a stand-alone tariff as it is generally only available for specific, permanently installed appliances such as water and space heating, and must be combined with another tariff design.

2.6 Combining tariff designs

As noted above, tariff designs are often combined, with complementary features of tariffs used to design complete tariff structures to assist businesses meet their objectives in terms of signalling costs and influencing customer behaviour.

Network businesses often combine tariff designs. Sometimes tariffs are combined via retailers reflecting the network business' pricing structure, but adding their own pricing structure over the top. Combining tariff designs can enhance a tariff's incentive properties or mitigate risks that customers and businesses may face with a standalone tariff design.

In Australia, almost all tariff designs offered to residential customers include a fixed and variable component (Two Part Tariff design). For example, the Inclining Block tariffs in South Australia, New South Wales and Victoria all include a fixed supply charge component.

Although less common, Seasonal Pricing is regularly combined with other tariffs designs. For example, in South Australia Seasonal Pricing is combined with Inclining Block tariffs, whereby the rates of each inclining block change with the season.

Critical Peak Pricing is commonly combined with Time of Use Tariffs. Under this combination, the Time of Use component reflects the average daily variation in peak and off-peak costs that arise from drivers such as variable generation costs. The Critical Peak Pricing component captures the few hours each year where the electricity system is at capacity. [10]

These are but a few examples of the many possible tariff design combinations. When testing tariffs against market scenarios in chapter 3, we have considered how combining tariffs may help overcome a tariff's weaknesses or enhance its strengths to make it more suitable for use in Australian jurisdictions.

2.6.1 Demand side management

Demand side management is a direct measure taken by a third party (typically a retailer or demand aggregator specialising in demand management) to reduce customer demand for short periods. When combined across a number of customers, it can be effective in shaving peak demand. Energy traders may also seek to establish a demand side management portfolio to hedge against a trading position.

In return for relinquishing control over the time at which electricity for certain devices is available (for example, air conditioners, water heaters, pool filters), customers will typically receive a reduced standard charge, rebates or other reward.

Implementation of demand side management programs typically requires enabling devices such as switches and programmable communicating thermostats for air conditioners that can be remotely activated. For example, communicating thermostats on air conditioners can then be remotely activated to switch off an air-conditioning unit's compressor, but not its fan. [11]

While demand side management programs can be highly complex in their operation, on an individual customer level the approach is relatively simple. Furthermore, once signed up, there is no need for ongoing active participation from customers, which reduces the concerns around simplicity, stability and revenue variability outlined above for tariffs designed to reduce peak demand such as Peak Time Rebates and critical peak pricing.

The main challenges in establishing demand side management measures is in finding customers willing to participate, and setting up and maintaining the systems necessary to directly control customer load. While customers may be reluctant to accept the potential inconvenience associated with losing control of appliance use, results from a trial undertaken by South Australian Power Networks found that customers whose load was cycled felt no perceptible reduction in comfort levels.[12]

While not strictly a tariff, demand side management can be readily combined with a number of the tariff designs discussed above, and forms part of our discussion on combining tariffs to address the market scenarios discussed in the next chapter. The following box provides some examples of the impact of demand side management initiatives undertaken in the US.

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[10] The Brattle Group, *Time-Varying and Dynamics Rate Design*, July 2012, p. 16.
[11] ETSA utilities, *Response to AEMC's issues paper*, 5 September 2011
[12] Ibid.

Con Edison direct load control rollout

Con Edison, an electricity retail, network and generation business in the US implemented a direct load control program for residential customers in New York. The quantifiable objectives were to:

- Measure connected load, including the effects of power factor
- Determine kW load reduction that can be achieved during summer peak load conditions
- Determine the level of customer overrides that can be expected during a curtailment event.

The program controlled air conditioning systems via a two-way thermostat, which communicates with the central air conditioner thermostat via two-way pager, and enables recordable customer overrides, monitoring and thermostat access via internet by both customer and utility, utility control of thermostat, and collection of hourly runtime and temperature data.

The program estimated reduction in demand of approximately 1.1 kW per unit per customer. According to survey results approximately 27% of respondents used their thermostat to override the curtailment event.

Con Edison Company of New York, Lessons Learned and Evaluation of 2-way Central A/C Thermostat Control System Demand Response via Thermostat Control

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Baltimore Gas and Electric Co. direct load control trial

Baltimore Gas and Electric Co. (BGE) conducted a load control trial in 2008 an advanced load-control switch and an advanced programmable communicating thermostat. Using these technologies, BGE could cycle air conditioners by transmitting from a VHF radio frequency. The estimated reduction in peak demand was 1.22 kW per device under a strategy that turned air conditioners off and on at 15 minute intervals. This resulted in an average in home temperature increase of around 1 degree Celsius.

David Greenberg and Mary Straub, Baltimore Gas & Electric Co, Demand Response Delivers Positive Results, 2008.

3 Market scenarios

Technological changes to the electricity system are likely to continue in the foreseeable future. This could further increase the peakiness of network demand. Alternatively, it could fundamentally change the way we consume electricity.

Tariffs should be able to cope with current and foreseeable changes to the electricity system. We have therefore developed a set of market scenarios to test how well the various tariff designs are able to meet the needs of businesses and consumers given the current and potential future state of Australia's electricity system.

3.1 Market scenario designs

3.1.1 Overview

We have designed three market scenarios against which to test the tariffs discussed in chapter 2. Our market scenarios are:

1. Continuing solar PV uptake
2. Time-controllable distributed generation and storage uptake
3. Electric vehicle uptake.

Separate scenarios have been developed for solar PV and other forms of distributed generation on the basis that solar PV customers cannot control when the electricity is produced. This differentiates it from other forms of distributed generation, which allow customers to determine when they use electricity from the electricity network. Storage provides the same flexibility, and has thus been grouped with other forms of distributed generation.

Unlike the disruptions in our first two scenarios, electric vehicles both use electricity, adding to consumption and potentially demand, but can also act like a battery to help meet demand needs. Further, electric vehicles serve a need that is not directly related to the electricity network or reducing a customer's electricity bill—environmentally clean transport. The effect on electricity bills may be a secondary consideration for customers.

Our market scenarios are based on the cost implications and potential changes to usage with respect to a baseline generic load profile that is broadly reflective of the load profile in Australian jurisdictions, as set out in section 2.2.1.

3.2 Continuing Solar PV uptake

This scenario examines the current effects of solar PV, the medium term effects that greater solar PV uptake could have on Australia's electricity system, and the consequent implications for electricity tariff design.

There has been rapid uptake in solar PV in Australia over the past six years or so. The initial uptake in solar PV was largely driven by generous government feed-in tariffs around Australia. For example, in Victoria customers were at one time offered at least 60 cents per kWh for excess electricity fed back into the grid from 2009–11.[13] Similarly in the ACT the feed-in tariff rate was 50.5 cents per kWh (paid

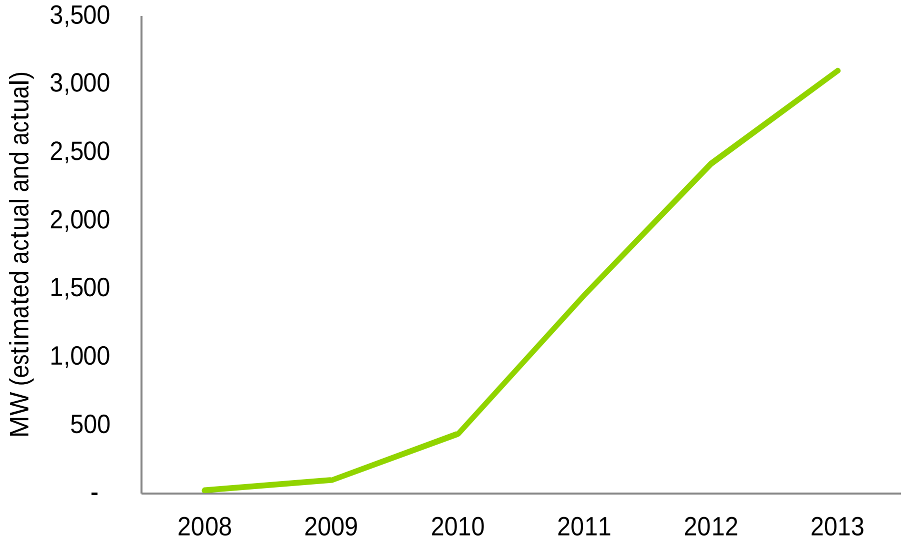
[13] Department of State Development, Business and Innovation Premium Feed-in Tariff , <http://www.energyandresources.vic.gov.au/energy/environment-and-community/victorian-feed-in-tariff-schemes/closed-schemes/premium-feed-in-tariff>

for 20 years) for connections up until June 2010, and prior to July 2013 the rate was approximately 18 cents per kWh.[14]

In recent years these feed-in tariffs have reduced, as take up has exceeded expectations and resulting in challenges for utilities managing changes to load profile. For example Victoria now offers a minimum rate of 8 cents per kWh and the ACT now offers approximately 7.5 cents per kWh.[15]

Figure 3-1 illustrates the rapid ramp up in solar PV capacity since 2008.

Figure 3-1 Installed solar PV capacity in the NEM (to December 2013)



Source: AEMO; Clean Energy Regulator; Deloitte analysis

Notwithstanding the reductions in feed-in tariffs, we expect the uptake of solar PV to continue, driven by improvements in technology and shorter payback periods for solar panels as purchase prices fall. For some Australian households, the price of an average solar PV system has fallen to the point where solar is competitive with day time retail electricity prices.[16]

The amount of energy produced by solar PV in 2011 was estimated to be 1,200 GWh, or around 0.6 per cent of annual energy consumption. It is estimated that the energy produced by solar will be 8,000 GWh by 2020-21 and over 15,400 GWh by 2031.[17] The estimated energy produced by solar PV in each jurisdiction, and the percentages of estimated annual residential and commercial energy consumption in 2012-13 and 2020-21, are outlined in Table 3-1. We note that these percentages would be higher than the figures outlined below if solar PV energy was expressed as percentage of residential customers only.

[14] ICRC, Final Report Electricity Feed-in Renewable Energy Premium: Determination of Premium Rate , March 2010. ActewAGL, Changes to ActewAGL Solar buyback scheme <http://www.actewagl.com.au/Product-and-services/Offers-and-prices/Prices/Residential/ACT/Feed-in-schemes/ActewAGL-Solar-buyback-scheme/Transition-to-net-metering.aspx>

[15] Department of State Development, Business and Innovation, Closed feed-in tariff schemes , <http://www.energyandresources.vic.gov.au/energy/environment-and-community/victorian-feed-in-tariff-schemes/closed-schemes>

[16] Climate Commission, The critical decade: Australia's future – solar energy , 2013.

[17] AEMO, National Electricity Forecasting Report 2013 , supporting spreadsheets and, AEMO, Rooftop PV Information Paper , 2012. Based on AEMO's moderate growth scenario.

Table 3-1 Estimated residential and commercial rooftop solar PV energy (GWh)

	2012-13			2020-21		
	Total Annual energy	Solar energy produced	Per cent of total	Total Annual energy	Solar energy produced	Per cent of total
NSW (incl ACT)	55,253	659	1.2%	58,097	2,498	4.3%
Queensland	37,434	1,023	2.7%	42,895	2,093	4.9%
South Australia	10,888	497	4.6%	10,399	972	9.4%
Tasmania	4,770	38	0.8%	4,459	152	3.4%
Victoria	37,290	465	1.2%	40,850	1,080	2.6%
Western Australia	18,207*	503*	2.8%	20,855	1,212	5.8%
Total	163,842	3,185	1.9%	177,555	8,007	4.5%

Source: AEMO and IMO Electricity Statement of Opportunities forecasts for residential and commercial customers; Deloitte analysis
Notes: *WA figures are 2013/14 IMO energy estimates for all sectors (including industrial customers)
Estimates using AEMO medium energy forecasts and AEMO moderate uptake scenario of rooftop solar PV. AEMO (2012), Rooftop PV Information Paper; AEMO (2013), National Electricity Forecasting Report for the National Electricity Market .

As at 1 January 2014, installed capacity is 3,096 MW, which is estimated to increase to 5,500 MW by 2020, and 11,300 MW by 2031 under a moderate uptake scenario. [18] In the long term, the uptake of solar PV may reach its saturation point, which is estimated to be an installed capacity of around 22,900 MW (based on the estimated number of suitable dwellings in 2031). [19]

3.2.1 Solar PV impact on the electricity system

Solar generated electricity is not available at all times of the day or year. In mainland Australia, the amount of electricity produced from solar PV starts to rapidly decline from around 1:30pm. AEMO has estimated that in mainland regions of Australia, solar PV produces at around 28-38 per cent of installed capacity in the late afternoon when summer maximum demand typically occurs. In Tasmania where maximum demand typically occurs in winter evenings, solar PV is estimated to be producing at around 2 per cent of installed capacity at this time. [20] This means that while solar PV reduces overall electricity consumption relative to what it would otherwise be, it will have only a limited effect on reducing network demand and the required peak generation.

By reducing the amount of energy taken from the grid during the middle of the day, while having a limited impact on demand during peak times, solar PV generation will actually tend to increase the peakiness of the electricity network. This will result in a deterioration of load factors.

3.2.2 Tariff performance against continuing uptake of solar PV

Poorly performing tariffs

The tariffs that perform relatively poorly in this scenario are Two Part Tariffs (flat charge), Inclining Block, Declining Block and Peak Time Rebates.

Given the continuing uptake of solar PV is likely to cause load factors to deteriorate, solar PV generation will exacerbate the problems of cross subsidies that occur with tariffs that do not charge different rates when the network is congested or high cost generation is in use. This means that

[18] Clean Energy Regulator, <http://ret.cleanenergyregulator.gov.au/REC-Registry/Data-reports>. AEMO, NEFR Supplementary Information 2013, Rooftop PV. <http://www.aemo.com.au/Electricity/Planning/Forecasting/National-Electricity-Forecasting-Report-2013/NEFR-Supplementary-Information-2013>
[19] AEMO, Rooftop PV Information Paper, 2012.
[20] Ibid.

inequity between customers who use electricity at peak times and those that do not will increase for Two Part Tariffs (flat charge), Inclining Block and Declining Block tariffs. Simple Seasonal Tariffs will be similarly affected.

Solar PV also exacerbates the problems that are associated with the simplicity and revenue variability factors for Peak Time Rebates. An effective Peak Time Rebate tariff requires measurement of a baseline level of demand for each customer. The presence of solar PV may distort measurements of customers' baseline electricity demand, resulting in distortions to the intended price signal with flow on effects for revenue collection.

Tariffs that perform well

Capacity Tariffs are the strongest performers in the solar PV scenario.

A Capacity Tariff bases the charge rate on the amount of electricity a customer demands. Although customers with solar PV will generally consume less electricity than those without, their coincident peak electricity demand will be similar – and thus their contribution to the costs of building peak generation and network capacity will likely remain relatively unchanged. Under Capacity Tariffs, and specifically coincident peak Capacity Tariffs, customers with solar PV will still pay their fair share of the costs they impose on the network when they consume electricity at peak times.

Capacity Tariffs must be implemented with interval or smart meters, which are not widely available to residential customers in all States. To enhance the likely customer response to Capacity Tariffs, it can be paired with enabling devices such as in home displays that inform customers about their demand. Enabling devices are even more important under a coincident peak Capacity Tariff because customers need to know when the network is experiencing peak demand. Communication devices and energy orbs can convey this information.

Time of Use Tariffs improve equity between customers by charging customers who use electricity at peak times (when the cost of generating and supplying electricity is higher) a higher charge rate. This is especially important in this scenario, as the increased peakiness of demand can exacerbate cross-subsidies between customer groups (e.g. Two Part Tariffs (flat charge) and Inclining Block Tariffs). Time of Use Tariffs, however, do not address the high marginal cost of using the network at critical peak times.

Combining tariffs

Capacity Tariffs promote equity and perform well with the uptake of solar PV. However, we note that the shortcomings identified in chapter 2, being complexity and possible bill shock for customers, particularly where linked to peak events, remain. We expect that significant customer engagement and education would be required to implement an effective capacity tariff, while concerns about bill shock could be addressed by retaining some level of standard fixed and variable charge similar to existing tariff structures.

Time of Use Tariffs could be combined with Critical Peak Pricing to better reflect the high marginal cost of using the network at critical peak times. Doing so, however, would reduce revenue adequacy and bill stability.

3.3 Time-controllable distributed generation and storage uptake

This scenario examines the effects that time-controllable generation and greater storage could have on Australia's electricity system and how tariff designs can cope with these scenarios.

Distributed Generation refers to relatively small scale generators that are generally connected at a customer's residence or to the grid at the distribution level. Time-controllable distributed generation is distinguished from solar PV as the time at which the generation occurs can be controlled by customers, retailers or distributors. These technologies could include:

- Diesel engines
- Fuel cells – electricity generator that converts gas into electricity and heat through an electrochemical reaction, without combustion or noise[21]
- Gas turbines
- Biomass
- Small hydroelectric generators.

Energy storage refers to systems that convert electricity into a form that can be stored and converted back into electrical energy for later use, providing energy on demand. These devices have the potential to be small or large scale. Storage technologies could include:

- Hydro-electric storage
- Batteries (Lead acid, Liquid metal, Lithium–ion, Lithium sulphur, Sodium-ion, Nano-based super capacitors, Energy cache technology)
- Molten salt
- Flow cells
- Fly wheels.

Storage has not yet been independently taken up by residential customers at scale due to prohibitive costs. Of the small scale storage technologies, batteries are the most proven in the near term. It has been estimated that the cost of batteries for the electricity system could fall from $500 per MWh to between $85-125 per MWh by 2025.[22]

A number of trials are underway to test the potential benefits of this technology:

- The Smart Grid Smart City program involves the installation of energy storage and other similar devices in customers' homes[23]
- On the network side, in 2012 SP AusNet initiated a project to trial the use of a large battery storage system to manage the peak demand and to explore other benefits of storage systems for network management and grid support. [24]

According to Clean Energy Council modelling, the Australian energy storage market has the potential to reach 3,000 MW by 2030, a growth trajectory similar to that of solar PV (in relative terms). [25]

3.3.1 Time-controllable generation and storage impact on the electricity system

Controllable distribution and storage devices have similar effects on the electricity system. Both technologies provide the opportunities for improvements in efficiency of the supply and use of electricity, such as:

[21] Ceramic Fuel Cells, Power of choice – giving consumers options in the way they use electricity; submission to the Australian Energy Market Commission, May 2012.
[22] McKinsey, Disruptive technologies: Advances that will transform life, business, and the global economy , 2013.
[23] Ausgrid, Smartgrid Smart City
[24] SP AusNet, Demand Management Innovation Allowance (DMIA) Annual Report , 2012 March 2013.
[25] Renew economy, October, <http://www.cleanenergycouncil.org.au/dms/cec/reports/2013/Energy-Storage-Study/Energy%20Storage%20Study.pdf//> <<http://reneweconomy.com.au/2013/energy-storage-energy-conference-74569>

- Enabling customers to respond to price signals without changing their consumption patterns—via the use of small scale generation and storage devices installed at customer residences
- Reducing peak network demand by not relying on the network at peak times—via the use of small-scale generation and storage devices installed at customers residences
- Increasing the capacity of the network and deferring capital expenditure—by using larger scale generation and storage devices to supply electricity downstream of network constraints.

3.3.2 Tariff performance against time-controllable distributed generation and storage uptake

Poorly performing tariffs

The following tariffs perform poorly in this scenario: Two Part Tariffs (flat usage charge), Inclining Blocks, Declining Blocks, Seasonal Pricing and Peak Time Rebates.

Where tariffs are characterised by usage rates that do not vary with underlying costs, the potential benefits from time-controllable generation and storage will be unlikely to be achieved. This results in poor performance against the evaluating factors for Two Part Tariffs (flat charge), Inclining Block and Declining Block tariffs. Simple Seasonal Tariffs will be similarly affected. Under such tariffs, customers will face limited incentives (if any) to invest in distributed generation and/or storage technologies that may provide net benefits to the system, and any existing capacity of these technologies may go underutilised.

Peak Time Rebates demonstrate some complementary characteristics with distributed generation and storage, with the critical peak pricing signal under the Peak Time Rebate likely to be effective in eliciting an appropriate response (i.e. going off-grid) from holders of these technologies. However, the problem of measuring a customer's baseline consumption under Peak Time Rebates is exacerbated, which may make implementation impractical, or provide significant risks to businesses in terms of revenue adequacy. For example, customers would have an incentive to understate their ability to respond to critical peak events, and could choose not to use distributed generation or storage technologies during the measurement of their baseline period, thus enabling them to receive higher rebates at critical peak times when they use these technologies.

Tariffs that perform well

Capacity Tariffs and Critical Peak Pricing are the strongest performers in a scenario with increased penetration of distributed generation and storage technologies. A well designed Time of Use Tariff may also be effective. With these tariffs, customers would face incentives to use their distributed generation or storage to reduce their electricity demand when the costs of supplying electricity from the network are high. For example:

- With Capacity Tariffs customers could reduce their demand by using distributed generation or storage when they use high consumption energy devices.
- With Critical Peak Pricing customers could store electricity in response to a notification of a critical peak event or use distributed generation at those times.

Time of Use Tariffs complement customers' ability to shift usage from peak to off-peak times. Time of Use Tariffs provide cost signals to store electricity at off-peak times and generate electricity at peak times. However, in the near term, peak charge rates under a Time of Use Tariff may not be higher than the cost of distributed generation and storage. As such, this tariff design may not provide the price signals needed to elicit the full benefits of distributed generation and storage until the generation and storage costs fall below the cost of peak electricity.

Regardless of the tariff design, larger scale distributed generation and storage that are connected to the network and are operated by electricity distributors would still provide network benefits. At times of peak demand these technologies could defer network expenditure if they can be placed downstream of network constraints. This impact, however, is not unique to the tariff designs that perform well, given the use of larger scale distributed generation and storage technologies will not depend on the retail tariff design, but rather, distributors' business decisions.

3.3.2.1 Combining tariffs

It is also important to note that one of the key risks to businesses under a scenario with extensive penetration of distributed generation and storage will be stranding of assets as more consumption goes off-grid. While the treatment of stranded assets in this case will likely depend on the policy and regulatory response, we consider that it will be important to maintain an appropriate level of fixed charges (whether via a Capacity Charge or standard daily supply charges as under a Two Part Tariff) to ensure that businesses are able to recover efficient costs in the face of declining usage of networks and large scale generation.

3.4 Electric vehicle uptake

This scenario examines the effects of increasing electric vehicle uptake on Australia's electricity system and how tariff designs can cope with this.

There are currently several types of electric vehicles including hybrid electric vehicles, plug in hybrid electric vehicles and battery electric vehicles. With improvements in travel distances and battery costs, it is reasonable to expect an increase in the uptake of electric vehicles in the future.

Ausgrid and SP AusNet are both pursuing investigations into the impacts and benefits of electric vehicles:

- As part of the Smart Grid Smart City program, Ausgrid is trialling the deployment of 20 electric vehicles and associated charging infrastructure. The purpose of this trial is to examine what steps the electricity supply industry must take to support the introduction of electric vehicles if the uptake is found to be significant. Based on the trial's result so far, Ausgrid found that in one scenario analysed, a zone substation cannot support more than about 0.5 electric vehicles per household. [26]
- Another trial is SP AusNet's Residential Battery Storage Trial which will use stationary batteries connected to consumer homes to simulate the potential characteristics of a demand management enabled electric vehicle. The trial will explore how battery storage at the residential level can be used for peak demand management and develop insights into how electric vehicles may interact with the network in the future. [27]

Research suggests that electric vehicles could become cost competitive by 2025 and that between 20-40 per cent of new cars bought globally in 2025 could be hybrid electric vehicles. [28]

Overseas, companies such as Tesla are experiencing significant growth, by applying a strategy of entering the market as a luxury brand (recognising the high unit costs of new technologies), before increasing volumes and lowering prices to go down market. [29]

3.4.1 Electric vehicle impact on the electricity system

Electric vehicles have the potential to increase both electricity consumption and peak demand.

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[26] Ausgrid, Smart Grid, Smart City Program, Customer Applications: Electric Vehicles 1 July 2012 – 31 December 2012 .
[27] SP AusNet, Demand Management Innovation Allowance (DMIA) Annual Report , 2012 March 2013.
[28] McKinsey, Disruptive technologies: Advances that will transform life, business, and the global economy , 2013.
[29] Tesla, The Secret Tesla Motors Master Plan (just between you and me) , <http://www.teslamotors.com/blog/secret-tesla-motors-master-plan-just-between-you-and-me>

Significant uncontrolled charging of electric vehicles would have large adverse consequences for the electricity system in terms of increasing peak demand and creating system instability, as unconstrained use would likely see many drivers charging their vehicles after getting home from work, when electricity demand is at its highest.

However, properly managed, electric vehicles could also help manage peak demand by taking advantage of the storage properties of electric vehicle batteries to provide grid support or electricity directly to households during peak times. To take advantage of this would require not just the appropriate enabling technologies (both at the individual car/household level and the network level), but also appropriate tariff designs to ensure customers are provided with incentives.

Studies in the US have also suggested that electric vehicles could be used to provide frequency control ancillary services.[30]

3.4.2 Tariff performance against electric vehicle uptake

Poorly performing tariffs

The following tariffs perform poorly in this scenario: Flat Charges, Two Part Tariffs, Inclining Blocks, Declining Blocks and Seasonal Pricing.

Where charges are based entirely (or largely) on the volume of energy consumed, electric vehicle owners will not be provided with appropriate signals to avoid putting more pressure on demand at peak times and critical peak times, resulting in increased pressure on the system and costs. Under these tariffs, penetration of electric vehicles would be likely to exacerbate the peakiness of the system, driving down load factors and increasing system-wide costs as more generating and network capacity would be required to manage the increased load.

Tariffs that perform well

The following tariffs perform well in this scenario: Time of Use Tariffs, Critical Peak Pricing, Capacity Charging and Controlled Load.

Tariffs that increase charge rates at peak times perform well in this scenario by encouraging customers to shift their electric vehicle charging to off-peak times. In the case of Capacity Charges, customers will be encouraged to reduce their demand by charging their electric vehicles when they are not using other appliances, which is likely to coincide with off-peak times, improving load factors.

Critical Peak Pricing specifically addresses network peak events by discouraging electric vehicle charging at those times. Importantly, if feed-in tariffs reflect the Critical Peak Pricing pattern, then customers will have incentives to have their vehicles discharge into the network during daily peak times (vehicle-to-grid electricity).

Controlled Load Tariffs, if properly designed could also be highly effective in managing increased electricity usage from electric vehicles. The advantage of these tariffs is that they rely less on customer response, but provide less flexibility for customers whose needs for charging vehicles may vary significantly depending on usage (unlike typical appliances subject to controlled load, where usage is generally very stable).

The implementation of interval or smart meters will be critical to implementing suitably sophisticated time varying charges to achieve the appropriate customer response. Additional in-home and in-vehicle technologies may also be required to provide the capability for electric vehicles to achieve their peak and system management potential. For example, the Tesla Model S electric vehicle already includes a touchscreen that can be used to create a customised charging schedule enabling customers to charge during off-peak times when electricity rates are lower. [31]

[30] Lipman, Fuel cells system economics: comparing the costs of generating power with stationary and motor vehicle PEM fuel cell systems, 2004. Willett Kempton, Jasna Tomic, Vehicle-to-grid power fundamentals: Calculating capacity and net revenue

[31] Tesla, <http://www.teslamotors.com/en_AU/models/features#/performance>

3.4.2.1 Combining tariffs

Time of Use Tariffs can be combined with Critical Peak Pricing to reflect both daily and critical peak changes in network costs. This combination will provide a greater incentive for customers to avoid charging electric vehicles at peak and critical peak times. Similar benefits could be achieved by combining Capacity Tariffs with a Time of Use component.

3.5 Longer term changes to energy use

Electricity consumption has historically followed reasonably predictable patterns, however, this is changing with changes in technology and lifestyles. Devices that enable customers to remotely switch on or off appliances are already available.[32] With greater proliferation of such devices there may be a shift in electricity consumption patterns in the future. For example, customers may switch on air conditioners or heaters before they arrive home from work so that their house is at the desired temperature. Customers may switch on cookers or computers throughout the day so that dinner or movies are ready when they arrive home. Technological enhancements may allow more people to work from home putting greater demands on the network during the day.

Demand may also become peakier with the development and proliferation of new appliances and technologies. This has been discussed in the context of uptake solar PV uptake, however, current trends such as greater uptake of induction rather than gas cooktops may also exacerbate the peakiness of demand – some residential induction cooktops are rated up to 10 kW.

These changes could result in a fundamental shift in how energy is consumed, and may make consumption and demand unpredictable both throughout the day, and in response to what are currently considered to be typical peak events. While new technologies can assist the community to meet the needs of the modern electricity system, new technologies can also exacerbate existing problems and create new ones.

In the longer term, therefore, more sophisticated and dynamic tariffs such as Capacity Tariffs, Critical Peak Pricing, or demand side management practices may be required. These tariffs would need to be paired with sophisticated metering and enabling devices to instantaneously alert customers about changes in charge rates. Any tariff designs adopted today should prepare the community, in terms of technological capability and customer education, to cope with the future.

[32] See for example,<http://www.originecostore.com.au/WeMo-Switch-iPhone-iPad-Remote-Controlled-Power-Socket-Belkin/F7C027AUAPL.htm>

3.6 Summary of performance against market scenarios

The following table provides a summary of the strengths and weaknesses of the various tariff designs in the context of each of the disruptive technology market scenarios.

Table 3.2 Summary of scenario-based tariff analysis

Scenario	Impact on system	Tariff analysis
Increasing solar PV uptake	Reduced energy taken from the grid. Limited impact on peak demand and consequent deterioration of load factor.	Best performing tariffs: • Tariffs with a demand-based component: Capacity Tariffs. Poorly performing tariffs: • Tariffs that do not reflect peak costs: Two Part Tariffs (flat charge), Inclining Block, Declining Block • Peak Time Rebates also perform poorly due to challenges in setting baseline usage for rebates under the increasing solar PV uptake scenario.
Penetration of time- controllable distributed generation and storage	Reduced use of system supplied electricity. Increased ability for sophisticated response to price signals.	Best performing tariffs: • Tariffs with the ability to provide sophisticated pricing signals and take advantage of customer response capability: Capacity Tariffs, Critical Peak Pricing and well-designed Time of Use Tariffs Poorly performing tariffs: • Tariffs that do not reflect peak costs: Two Part Tariffs (flat charge), Inclining Block, Declining Block.
Electric vehicle uptake	Increased electricity usage. Uncertain peak impacts – unconstrained charging could lead to deterioration of load factors, while co-ordinated use could improve system stability and security.	Best performing tariffs: • Tariffs that reflect different costs across the day and encourage electric vehicle owners to shift charging to off-peak times: Capacity Tariffs, Time of Use Tariffs • Controlled load tariffs, due to their ability to set a defined charging period (subject to practicalities of varying patterns of vehicle usage). Poorly performing tariffs: • Volume based tariffs: Two Part Tariffs (flat charge), Inclining Blocks, Declining Blocks and Seasonal Pricing.

4 Summary and conclusions

4.1 Best performing tariffs

Capacity Tariffs are consistently the strongest performing tariffs in terms of cost reflectivity as well as revenue stability for network businesses in the face of current and expected disruptions to the electricity sector investigated in this report. In particular, Capacity Tariffs based on coincident peak demand are highly cost reflective because coincident peak demand is a key driver of network and wholesale generation costs. On the other hand Capacity Tariffs based on maximum demand provide only a blunt form of cost reflectivity because a customer's peak demand may not coincide with the electricity system's peak demand. Accordingly, there are complexities in designing highly-cost reflective Capacity Tariffs. Concerns about stability in customer bills may also create challenges to widespread implementation. Transitioning residential customers from traditional tariff designs based largely on usage over time (with small fixed charges) to a tariff based on instantaneous demand at a single point represents a significant shift in the way customers have historically paid for electricity. In addition, the potential for customer's bills to be set by single high-demand events, albeit this depends on the exact design of the tariff, may raise concerns among customers about the tariff's fairness.

Controlled Load tariffs perform strongly against the four factors and are also well-suited to the market scenario involving increased uptake of electric vehicles. Controlled Load tariffs generally aid cost reflectivity by restricting the use of certain appliances and charging customers less at off peak times when the cost of supplying electricity is lower. Controlled Load tariffs are also simple to understand, provide stable bill outcomes for customers and promote revenue adequacy for network electricity businesses. However, there are few electrical appliances that are conducive to Controlled Load pricing, and thus the overall effect on the electricity system will be relatively minor.

Time of Use Tariffs do not exhibit the same level of precision as Capacity Tariffs in relation to reflecting the underlying costs of Australia's changing electricity sector. In particular, they do not specifically target the high marginal costs or high variable generation costs associated with using electricity at critical peak times. However, we consider that Time of Use Tariffs are generally an improvement from traditional Two Part (flat charge) and Inclining Block tariffs on the basis of cost reflectivity. Higher levels of cost reflectivity are also generally expected to improve equity outcomes by reducing cross subsidies between customers. Additionally, a transition to Time of Use pricing is a smaller deviation from traditional tariff designs, making barriers to take-up around complexity and customer acceptance lower than those faced by Capacity Tariffs. In some situations, Time of Use Tariffs may therefore represent a first step towards greater cost reflectivity and pave the way for more cost reflective forms of pricing such as Capacity Tariffs.

Nevertheless, we also recognise that electricity is a low-involvement product, with customers not typically highly engaged with the details of cost structures and tariff design. So while we consider that a move towards Time of Use pricing is a step in the right direction towards improving cost reflectivity and equity outcomes, we also note that initiatives to drive substantial changes in the way customers think about and use electricity will require a sustained effort around customer communication and education. Supported by this type of engagement strategy, a move towards Time of Use pricing could be a practical step towards opening the way for more sophisticated and cost reflective capacity-based charging mechanisms in the future.

4.2 Equity and fairness

For the purpose of this report, we have defined equitable tariffs as those that reduce or limit cross subsidies between customers by charging each customer for the costs they impose on the electricity system. The costs of generating and supplying electricity vary mainly with the time of use and intensity of that use (demand), particularly when usage coincides with when other consumers are using electricity (i.e. peak demand). On this basis, we consider that tariffs that vary with the time electricity is consumed, and the intensity of consumption, particularly at peak times, are most conducive to the promotion of equity.

We note that this definition may differ from traditional notions of fairness. For example, Inclining Blocks are often perceived to promote fairness, in that customers pay increasing rates for higher usage, and the ability to reduce bills by reducing the volume of consumption over a given period is well understood. However, Inclining Block tariffs may not be cost reflective if higher priced blocks of usage are not aligned to peak consumption or demand and hence have a limited relationship with underlying costs. Similarly, flat variable charges can also be perceived as being fair, in that all consumption is charged at the same rate. However, not only do such charging structures result in cross subsidies between consumers using electricity at peak versus off peak times, over time, they will also tend to drive up costs for all customers by sending weak signals about usage and costs.

On the other hand, Capacity Tariffs improve cost reflectivity and equity by charging customers for the burden they place on the system. This aligns with our definition of equity, but we note that Capacity Tariffs may not be perceived to be fair by some where charges rely substantially on isolated high demand events.

Customers may be more accepting of more complex and innovative tariff designs if they understand the benefits. These benefits include reduced cross subsidies, and ultimately, lower overall electricity bills over time. To facilitate a transition towards more complex pricing structures that correspond more closely to underlying cost drivers, electricity businesses will need to engage with customers to design tariff packages that meet customer needs, while educating customers about the trade-offs between alternative pricing approaches. Governments will also need to play a role in educating customers about the problems with existing tariffs and the benefits of more sophisticated designs.

4.3 Enabling technologies and transition issues

It is important to note that advanced metering infrastructure (interval meters or smart meters, as compared to the accumulation meters in place for the majority of Australian households) are a pre-requisite for sophisticated time-varying tariffs. Both interval and smart meters are also able to measure electricity usage at a particular time (i.e. electricity demand), which is necessary for capacity-based charging. However, only smart meters provide the advanced communication technology required for real-time feedback to customers about usage information that would enable customers to adjust usage with precision, and respond rapidly to changes in costs driven by peak events. This technology paves the way for a range of enabling devices such as in home displays that show electricity consumption or demand, or energy orbs and communication technologies warning customers about changes in electricity prices as they occur.

The way in which customers are transitioned from their existing tariffs to more sophisticated tariffs not only has implications for customers but also for the electricity system. The Australian Energy Market Commission recently recommended that residential customers with smart meters have the option to opt-in to time based flexible pricing, larger customers have the option to opt-out, and for the largest customers to have mandatory time based pricing, to effect an orderly transition and encourage consumer engagement and confidence in flexible pricing. [33]

Approaches that rely on customers voluntarily adopting tariffs may have limited effectiveness on changing overall consumption patterns if only those customers who benefit from the tariff design adopt it. On the other hand, approaches that mandate the adoption of certain tariffs may lead to bill shocks and customer resistance—especially if customers are not fully educated on the tariff's operation. A third alternative, which lies between these two approaches, is an opt-out approach where all customers are transitioned to a tariff unless they choose otherwise. Such approaches

[33] AEMC, Power of choice review – giving consumers options in the way they use electricity , 30 November 2012.

typically result in a higher uptake of the new tariff than an opt-in approach, which may result in improved cost reflectivity and still provide customers with a choice of tariff.

In addition to driving behavioural change at the customer level, we believe that industry has a crucial role to play in addressing the issues created by rising peak demand. For example, adopting and investing in smart grid technologies, demand management solutions, distributed generation and battery storage all provide other avenues to manage peak demand upstream of the customer.

5 Limitation of our work

General use restriction

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