Retail Tariff Model

A REPORT PREPARED FOR THE AEMC

August 2012

Retail Tariff Model

Retail Tariff Model

Figures

Tables

Executive summary

The Australian Energy Market Commission (AEMC) is currently undertaking its Power of Choice review. This review involves a wide ranging assessment of ways in which Demand Side Participation (DSP) can be incentivised to reduce the costs of meeting demand for electricity across the NEM and the costs borne by consumers of electricity.

As part of this review, Frontier Economics has constructed a retail tariff model to investigate a range of issues, including:

- The level of incentives needed to encourage customers to switch to more dynamic tariff structures
- Quantifying the extent to which changed patterns of consumption lead to savings on an annual bill
- The tariff structure that provides the highest incentives for DSP

This model is highly customisable and able to consider a wide range of customer load date, tariff structures and varying levels of demand response. This model has been released to the public via the AEMC website.

The tariff model is intended to be a tool that will inform stakeholders and allow high level assessment of issues around incentivising DSP via tariff structures. This is likely to foster further debate amongst stakeholders and consumers around the role of DSP in the NEM.

The analysis presented in this report indicates that achieving significant reductions in system peak demand – and therefore long term benefits – requires highly dynamic tariff structures. Further, such dynamic tariffs need to extend to network pricing. This analysis would benefit from using a wider range of consumer electricity load data, particularly by including load data for customers who differ substantially from average patterns of consumption.

1 Introduction

The Australian Energy Market Commission (AEMC) is currently undertaking its Power of Choice review. Part of this review involves exploring ways in which demand side participation (DSP) can be incentivised to play a larger role in the National Electricity Market (NEM) in order to reduce the overall economic costs of serving load and the costs borne by consumers.

Peak demand imposes significant costs on the power system by requiring additional network and generation infrastructure that is only utilised for a small number of hours every year. These additional costs are ultimately borne by end users of electricity. However, many of these consumers could alter their consumption patterns – via altering overall consumption or by shifting consumption from peak to off-peak times – in a manner that reduces peak demand. In the longer term, there are likely to be significant savings associated with a reduced level of peak demand and a flatter overall system load shape that arise from altered investment patterns in both network and generation assets.

Although these benefits may be significant, the majority of current electricity tariffs do not incentivise consumers to mitigate consumption at peak demand times. Accumulation meters, which are still used by the majority of households and small businesses, do not allow suppliers to measure consumption at different times of the day. This means it is difficult to charge more cost-reflective tariffs that would incentivise consumers to reduce peak demand. To date, despite a number of trials, smart meters that do allow such time-varying tariffs have not been widely adopted. All of these issues are being considered as part of the wider Power of Choice review.

Frontier Economics has built a model that can be used to understand and quantify the incentives for DSP in the NEM. Specifically, this model quantifies the likely impact of alternative tariff structures, some of which are not currently offered in Australia, and consumption patterns on end use electricity costs. This model can be used to investigate a range of issues, including:

- The level of incentives needed to encourage customers to switch to more dynamic tariff structures
- Quantifying the extent to which changed patterns of consumption lead to savings on an annual bill
- The tariff structures that provide the highest incentives for DSP

In addition to issues directly related to DSP, Frontier Economics' model can also be used to investigate issues associated with DSP that are related to changes in consumption patterns and tariff structures:

- Informing on the degree of cross-subsidisation under existing tariff structures between customers with different consumption patterns (such as the cross subsidisation between peak-use customers and off-peak use customers on flat tariffs)

- Estimating the 'transfer costs' associated with different customer types (i.e. the change in the end use bill associated with changes in tariff structure and consumption pattern), which can help to inform on the extent that retailer and network revenues may change upon the take-up of new time-sensitive tariff structures

It should be noted that this model does not quantify the long term benefits of delayed infrastructure investment, only the incentives for DSP in the short term. These long term issues are part of the wider Power of Choice review.

This report seeks to provide a detailed overview of the model to inform users of the model of its key features and to provide them with the tools to use the model for their own analysis. This report also discusses some preliminary analysis of DSP incentives using the model.

1.1 Frontier Economics' engagement

As part of its Power of Choice review, Frontier Economics has been engaged by the AEMC to create a simplified and transparent model that can be used to investigate the likely impact of alternate tariff structures and consumption patterns on end use electricity bills. The ultimate objective of creating such a model is to investigate some of the issues under consideration as part of the Power of Choice review and to foster debate amongst stakeholders with regard to the form of an optimal tariff structure, how to manage transitional impacts on both consumers and how to ensure appropriate protections for vulnerable consumers.

To undertake this task, Frontier Economics have:

- Conducted a review of the literature with regard to load shape data and demand response
- Developed a set of representative customer load profiles
- Developed a consistent cost basis for setting the tariff levels
- Conducted a review of the literature on tariff structures and developed a set of tariff structures and associated levels for the retail tariff model
- Built an Excel model that takes the customer load profiles and tariff levels and calculates an annual bill for each customer load profile, which allows the static assessment of the relative tariff structures
- Developed an approach that quantifies the extent to which customers alter their usage pattern in order to minimise their energy costs, which allows a dynamic assessment of the relative tariff structures

- Extended the model to allow calculation of effects such as cross-subsidisation and transfer costs between different customer classes

1.2 Structure of this report

This report details the framework that underpins Frontier's tariff model along with all underlying assumptions and calculations. Analysis and conclusions drawn from using the tariff model are also presented. The report is structured as follows:

- Section 2 discusses the framework and methodology underpinning the retail tariff model
- Section 3 sets out the model's input assumptions
- Section 4 presents Frontier's analysis and results
- Detailed calculations performed in the model are provided in Appendix A

2 Methodology

At a high level, the objective of the retail tariff model is to allow the user to investigate the impact of tariff *structures*, rather than tariff *levels*, on end use customers' electricity bills.

The effect of alternative tariff structure on customers' bills is influenced by two key variables:

- The shape of the customer's load profile (ie the extent to which they consume electricity at peak times compared to off-peak times) and
- The degree to which customers engage in demand response when faced with different tariff structures

The model quantifies the customer bill impact of changes in one or both of these variables.

To calculate these bill impacts, we begin by adopting a common cost base to derive the rates under each of the tariff structures considered in the model. This means that all tariff structures incorporate tariff *levels* that are revenue neutral with respect to the hypothetical reference customer's load shape. In other words, the tariffs are calibrated so that the reference customer (absent any demand response) would incur the same annual bill under all tariff structures.

This step (described in more detail below) allows us to focus on isolating the impact on customer bills of changing the *structure* of tariffs and/or allowing different degrees of demand response. Annual bills can then be calculated for a range of customer load shapes, under a range of tariff structures both with and without different degrees of demand response. This process is described in more detail in Section 2.1 below.

2.1 Determining annual bills in the model

Step 1 – Load

The first input to the model is a set of end use customer load shapes, with each representing a different consumer type. The load shapes are entered into the model as a full year of half hourly load data in order to ensure that the annual bill captures the variation in consumption during the year. The model is currently configured to accept seven different load shapes.

From this set of load shapes, one is selected as the *reference load shape*. This is then used to set the tariff levels in Step 2.

Step 2 – Tariff structures and levels

The next step is to define tariff *structures* and *levels*. Tariff structure in this context refers to the form of the charges for electricity, such as Inclining Block or Time of Use (ToU) tariff structures. Conversely, tariff level refers to the actual magnitude of charges (such as $/annum charges or c/KWh rates) that are charged as part of a particular tariff structure. For example, a given ToU tariff structure would involve setting particular tariff levels for each element within that structure (such as specific peak, shoulder and off-peak charges) at appropriately varying rates (in c/KWh).

Tariff structures are defined first. The model is currently configured with eight different generic tariff structures including ToU, critical peak pricing (CPP) and Inclining Block tariffs. These structures can be applied to either or both of the energy and network components of a customer's bill.

The next step is to set tariff levels. The overall tariff levels are set so as to maintain *revenue neutrality* with respect to the reference load shape (selected in Step 1). Revenue neutrality requires the end use electricity bill for a customer with the reference load shape to be the same under all tariff structures. That is, levels of all tariff structures are set such that costs are fully recovered for the reference load shape (but not necessarily for other load shapes).

Retail tariff levels in the model incorporate both network and energy components. The energy component has been pegged to wholesale pool prices such that the final tariff levels reflect the underlying wholesale pool costs faced by electricity retailers in serving a customer with the reference load shape.

Similarly, the network tariff levels have been tied to actual network tariff data. The annual average of the network tariff has been based on the actual regulated network tariff for the EnergyAustralia distribution area[1] for financial year 2012-13. Unlike energy, the time varying nature of network costs is not simple to derive from publically available information. Instead, the time-sensitive tariff levels have been set according to the tariff level ratios currently offered by network businesses. For example, the ratio of peak to off-peak charges in the model is assumed to be the same as time of use offers in the market.

Finally, other costs reflecting non-energy, non-network costs of supplying electricity such as NEM fees, green scheme costs, retail operating expenditure and retail margin are included. These costs are fixed and independent of the tariff structure and are included to more accurately estimate final annual electricity bills for the different customer types.

---

1 Whilst data has been used for a particular distribution area in NSW, Frontier is of the view that the results of the model and their implications are applicable across the NEM.

Step 3 – Calculate bill

The model is configured to analyse six tariff cases: one reference case and five user defined tariff cases. Each tariff case consists of an energy tariff structure and a network tariff structure, which can be the same structure or different structures.

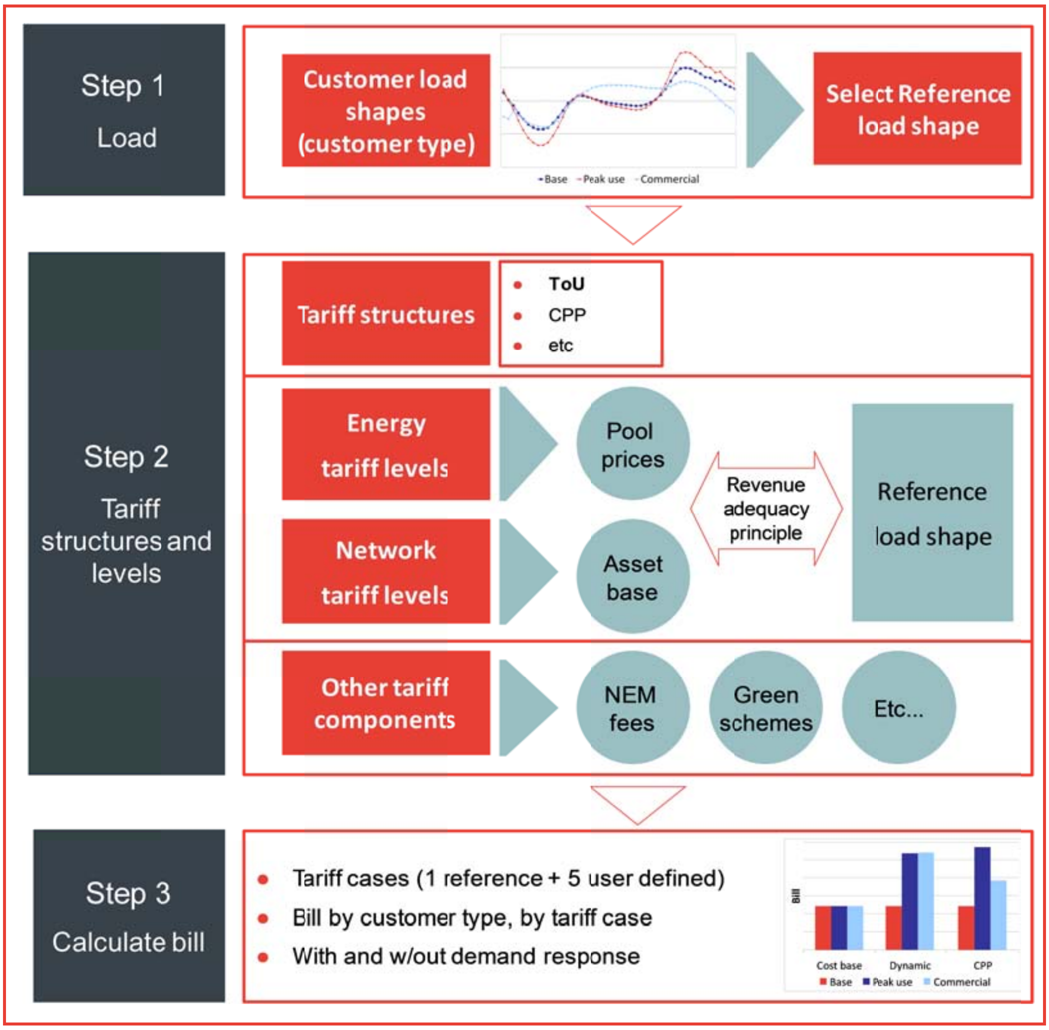
With the load profiles and tariff cases set (in terms of both structure for energy and network components and associated charge levels), it is a simple exercise to calculate the annual bill for each customer type. Each annual bill is the sum of the following components:

- Energy fixed rate component ($/year)
- Energy variable rate component/s (c/kWh) × electricity consumption (kWh/year)
- Network fixed rate component ($/year)
- Network variable rate component/s (c/kWh) × electricity consumption (kWh/year)
- Other variable rate components (c/kWh) × electricity consumption (kWh/year)

Annual consumption (absent any demand response) is an input of the model. For the purpose of this report an annual consumption of 8 MWh, representing average household usage in the NEM, has been assumed. End use annual bills are calculated for this consumption level in financial year 2012/13 and are reported in real 2012/13 dollars.

This approach is illustrated in Figure 1 below.

Figure 1: Modelling approach overview



Since the tariff levels are revenue neutral when applied to the reference load shape (absent demand response), the annual bill of the reference load shape customer will be the same under all tariff cases. By 'normalising' the customer bill for the reference load shape customer under all tariff types, the model is able to isolate the financial impact on customers' bills of a change in tariff structure and a change in load shape.

Comparison of the annual bill for a single customer type across the six tariff cases will illustrate the financial impact of the tariff structures for that customer type's load shape. Similarly, a comparison of the annual bill across the customer types within a given tariff case will illustrate the financial impact of the load shape on customer bills.

The model also calculates the impact of demand response on the annual bill of a customer of a given type. For each customer type, the user can select a pattern of demand response, such as peak load reduction or peak load shifting, and the percentage of response relative to the original consumption level. Keeping the tariff cases and levels constant, each annual bill is recalculated with demand response. This allows the savings accruing from demand response to be calculated by the model.

The model is dependent on a number of input assumptions, most importantly with regard to customer load shape data. These are discussed in more detail in the following Section.

3 Input assumptions

The model draws on a number of input assumptions. These will be discussed in detail in this section.

3.1 Load profiles

The most important assumptions in the model are with respect to load data.

Ideally, the model would be populated with actual customer data representing a range of different household types, such as:

- Average household (which would act as the reference load shape)
- Pensioner household
- Low socioeconomic household
- Representative Small to Medium Enterprise (SME) user

Due to the scarcity of publically available load data by customer, actual historical data for these types of customers could not be sourced at a level of detail sufficient for the modelling within the timeframe of the analysis.

As an alternative to actual customer level data, the load profiles adopted for this model are based on the historical, calendar year 2011 net system load profiles (NSLPs) published by AEMO.

Specific distribution areas have been selected as proxies for the load profiles of the different customer types. Selection was based on a visual inspection of the half hourly data, and how well the half hourly profiles matched the typical half hourly profile of each customer type. Selection was also based on a consideration of the consumption pattern of the customers within each distribution area, and how closely they were related to the load profiles we sought to develop.

Ultimately, Frontier hopes that the model can be populated with actual data for the household types of interest. In the interim, proxies have been developed using available data. To the extent that these proxies are significantly different to actual household data, which may be the case for consumers who vary significantly from the 'average' NSLP shape, modelled savings due to demand response under different tariff structures will be less accurate. However, the model is fully capable of quantifying these effects given accurate load data.

Table 1 provides a summary of the load profiles analysed by the model and a brief description of how they were developed from AEMO's NSLPs.

Table 1: Load profile types

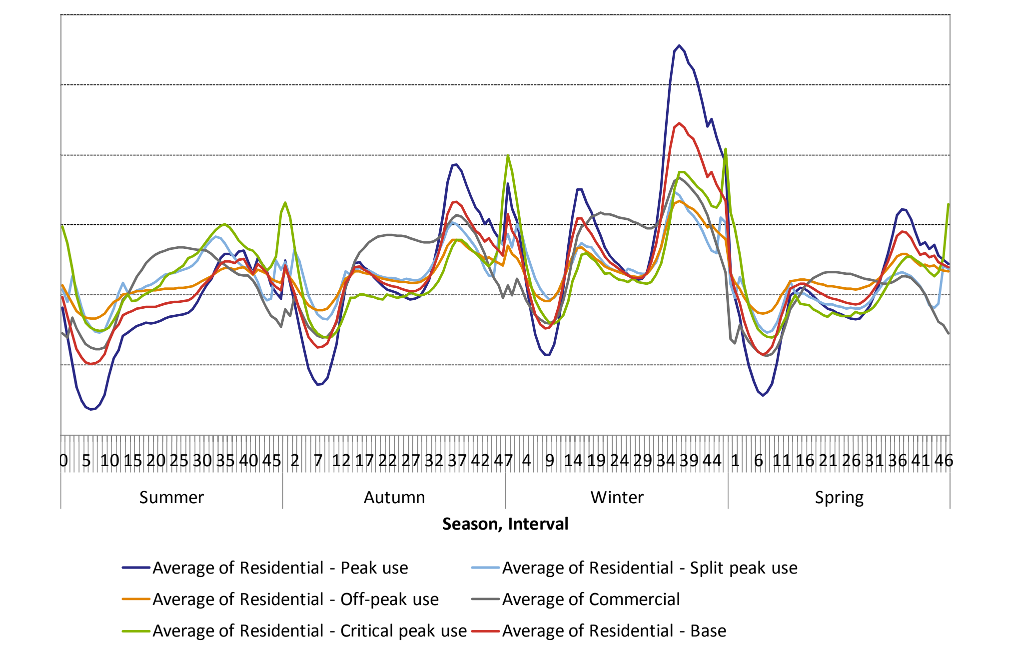
Load profile	Description	Basis
Residential – Base	Average residential customer	EnergyAustralia's (AusGrid) NSLP (with controlled load profile (CLP)[2] added in). The CLP has been added in assuming that CLP is 17% of total energy.
Residential – Peak use	Low load factor customer – represents a customer who consumes relatively more at peak price times	The Base residential profile scaled to a peak demand of 130% of the Base residential peak demand.
Residential – Off-peak use	High load factor customer – represents a residential customer that uses power throughout the day	The Base residential profile scaled to a lower peak demand of 70% of the Base residential peak demand.
Residential - Critical peak use	A consumer with relatively peaky consumption in summer	ETSA Utilities' NSLP with CLP added in to generate a vanilla NSLP without 'peel-off'. The CLP has been added in assuming that CLP is 17% of total energy.
Residential - Split peak use	A split peak residential consumer – with high consumption in both mornings and evenings	Powercor's NSLP

2 The net system load profile of NSW profile areas do not include controlled load. Off-peak hot water makes up the majority of controlled load. Not including controlled load would significantly unstate offpeak usage by these customers.

Load profile	Description	Basis
Commercial	Average small commercial customer	CitiPower's NSLP
Other	Currently a flat profile, provides space for an additional profile to be included.	Flat profile

Figure 2 illustrates the average daily load profiles by season.

Figure 2: Average daily load profile by season



Motivation for using half hourly data

The model uses a full year of half hourly load data for two purposes. First, it allows the model to accurately capture the full variation in consumption over a year in the annual bill. This includes variation due to seasonal and temperature factors, as well as time of day factors (peak/off-peak times) and day type factors (working weekday or weekend). Second, since the reference load shape is selected from this set of load profiles, it ensures that the tariff levels developed in the second stage of the model accurately reflect the annual correlation between the load and the underlying wholesale pool prices (see Section 2.1 for a detailed explanation).

Reference load shape

The Residential – Base load shape has been selected as the reference load shape for calculating the various tariff levels.

3.2 Energy cost base

As described in Section 2, the energy tariff levels have been pegged to a common cost base. This cost base comprises the wholesale pool cost, which includes the carbon price for financial year 2013, and the cost of hedging in the wholesale market.

In the absence of conducting forward-looking market modelling, Frontier Economics has estimated the energy cost using historical pool price data and a number of 'rule of thumb' adjustments for the carbon price and hedging contract costs. These assumptions are summarised in Table 2 (and can be changed by the user in the model).

Table 2: Energy cost base assumptions

Assumption	Value/Description
Wholesale pool price (excluding carbon)	Calendar year 2011 NSW wholesale pool prices (AEMO data)
Carbon price	23 $ / tonne CO_2 nominal in FY 2013 (legislated carbon tax)
Carbon price pass through[3]	100%
Hedging contract premium	5% of the wholesale pool price (including carbon cost) at the Regional Reference Node
Proportion of total end use cost that is fixed	14 per cent of the total end use costs of the Reference load shape

3 Where carbon price pass through is the change in the $/MWh wholesale pool price (i.e. pool price with the carbon price – pool price without the carbon price) divided by the $/tCO2e carbon price

Although the majority of the load shapes and the wholesale pool prices have been taken from NSW, the outputs of the model are primarily focused on changes resulting from altered tariff structures and/or altered consumption. Therefore, the results from this model are also applicable to other jurisdictions in the NEM. Network cost base

As described in Section 2, network tariff levels have been pegged to an actual regulated network tariff. Furthermore, as the exact time varying nature of network costs is not readily available in the public domain, the tariff level ratios (e.g. peak to off-peak ratio) have been based on network tariffs currently offered by network businesses as well as on tariffs from various dynamic network tariff trials. These assumptions and their sources are summarised in Table 3. Descriptions of these tariff structures are provided in Section 3.4.

Table 3: Network cost base assumptions

Assumption	Value/Description (Source)
Regulated asset cost	135 $/MWh, real financial year 2011/12 (IPART, Draft Determination – Changes in regulated electricity retail prices from 1 July 2012, based on the network cost for the EnergyAustralia distribution area)
Proportion of total end use cost that is fixed	17 per cent of the total end use costs of the Reference load shape (Based on various network tariffs currently offered in VIC and NSW)
Network tariff level ratios – ToU tariff (2-part) and CBL & ToU (2-part)	Peak to Off-peak ratio = 6 (Based on various network tariffs currently offered in VIC and NSW)
Network tariff level ratios – ToU tariff (3-part)	Peak to Off-peak ratio = 10 Shoulder to Off-peak ratio = 2 (Based on various 3-part network tariffs currently offered in NSW and VIC)
Network tariff level ratios –CPP*	CPP to Off-peak ratio = 15, CPP days = 12 Peak to Off-peak ratio = 6

Assumption	Value/Description (Source)
	(The CPP ratio is based on various DPP pricing trials conducted in NSW[4])
Network tariff level ratios –CBL** & CPP	CPP to Off-peak ratio = 15, CPP days = 12 CBL charge to Off-peak ratio = 3.07 (The CPP ratio is based on various DPP pricing trials conducted in NSW) (The CBL charge ratio has been selected such that the CPP level is the same in this tariff structure as the CPP tariff structure)

** Critical Peak Pricing (CPP) periods are nominated in advance by suppliers to give consumers an opportunity to alter consumption*

***Customer Baseline Load (CBL) tariffs only charge changes in consumption at the 'new' tariff rates, historical consumption levels continue to be charged at 'old' tariff rates.*

Once again, the fact that the majority of tariff ratios have been taken from NSW and Victoria does not mean that the model is not applicable to other jurisdictions in the NEM. Outputs of the model are primarily focused on changes due to altered tariff structures and/or altered consumption (due to demand response).

3.3 Other cost components

The other costs incurred in supplying electricity include NEM fees, green scheme costs and retail operating expenditure. These costs are independent of the tariff structure but are included in the model's calculation of the annual bill to provide a more accurate estimation of the total annual bill.

These cost components have been adopted from IPART's Draft Report for changes in regulated electricity retail prices. Where the costs differ between distribution areas, EnergyAustralia's costs have been selected. These cost components are summarised in Table 4.

4 Summarised in Futura Consulting, *Investigation of existing and plausible future demand side participation in the electricity market*, pp. 72, December 2011

Table 4: Other costs components

Cost component	Value
Transmission and distribution losses (node to end use losses)	6.5 % of electricity at the regional reference node
Retail operating expenditure and retail margin	5.4 % of all costs faced by the retailer
Green scheme compliance costs (LRET, SRES and other green schemes)	$10.77 per MWh at the RRN, real FY 2012/13
NEM fees and ancillary service charges.	$0.85 per MWh at the node, real FY 2012/13

3.4 Tariff types

The model has been configured to include a number of tariff structures for both the energy and network components of retail tariffs. All tariff structures are summarised in Table 5.

Tariff structures range from the currently available flat and inclining block tariffs to dynamic Time of Use (ToU) and Critical Peak Pricing (CPP) tariff structures. Also included are Flat-ToU, Hybrid and Customer Baseline Load (CBL) tariff structures. The last of these provides cost-reflective, time-sensitive price signals whilst sheltering the consumer from the full impact of a time-sensitive tariff by charging them at the flat rate on some, or all, of their baseline load (see Section 3.4.1 below for more details). In practice, the CBL is based on historical usage; this model adopts the static load profile (no demand response) as the customer baseline load.[5]

Table 5: Tariff structures

Tariff structure	Description	Tariff rate components
Flat	Single rate	Fixed + single flat
Inclining block	Higher rates for higher cumulative consumption	Fixed + increasing flat

5 For further information on the application of CBL products, please refer to the Brattle groups' AEMC Power of Choice report.

Tariff structure	Description	Tariff rate components
ToU	Higher rates during peak, lower during off-peak, medium rate during shoulder (3-part)	Fixed + ToU 3-part (peak/off-peak/shoulder)
CPP	Time of use plus pre-nominated critical days that incur a higher rate (3-part)	Fixed + CPP 3-part (peak/off-peak/critical)
Flat – Time of use Hybrid	Consumption up to 70% of the CBL is charged the flat tariff Consumption above 70% of the CBL is charged the ToU (3-part)	Fixed + Flat (70% of CBL) + ToU 3-part (above 70% of CBL, peak/off-peak/shoulder)
Customer baseline load + Time of use (CBL + ToU (2-part))	Consumption of CBL is charged at the flat rate. Deviations from the CBL are charged/credited on a ToU tariff (2-part).[6] (Note: since the CBL is the static load profile (no demand response), deviations from the CBL only occur in the demand response cases.)	Fixed + Flat CBL + ToU 2-part (peak/off-peak) on deviations to CBL
Customer baseline load + Critical peak pricing (CBL + CPP)	Consumption of CBL is charged at the flat rate. Deviations from the CBL are charged/credited on a CPP tariff (2-part).[7] (Note: since the CBL is the static load profile (no demand response), deviations from the CBL only occur in the demand response cases.)	Fixed + Flat CBL + CPP 2-part (off-peak/critical) on deviations to CBL

These tariff structures were selected on the basis that, together, they provide the user with a menu of realistic tariff structures with varying degrees of time-sensitivity. They also include tariff structures based on consumer baselines, which

6 For each half hour, deviations from the CBL are charged according to: (Time-sensitive tariff rate – CBL tariff rate)×(Actual consumption – CBL consumption). This charge can be positive or negative depending on the difference between the time-sensitive and the CBL tariff rates and the difference between actual consumption to the CBL consumption level.

7 For each half hour, deviations from the CBL are charged according to: (Time-sensitive tariff rate – CBL tariff rate)×(Actual consumption – CBL consumption). This charge can be positive or negative depending on the difference between the time-sensitive and the CBL tariff rates and the difference between actual consumption to the CBL consumption level.

provide a degree of protection against higher bills under time-sensitive tariffs (relative to the flat tariff).

3.4.1 Flat-ToU Hybrid and CBL tariff structures

The Flat-ToU Hybrid and CBL tariff structures are designed to provide incentives for customers to reduce or shift consumption from peak to off-peak periods whilst minimising the cost impact of the transition from a flat to a time-varying tariff. Both tariff structures work by basing part of the tariff on the customer's historical consumption pattern, which is referred to as the customer baseline load (CBL).

Figure 3 is a diagrammatic representation of the Flat-ToU tariff structure. Consumption up to 70% of the CBL (dotted line) is charged at a flat time-insensitive tariff (consumption indicated by "A"). Any consumption above 70% of the CBL is charged at a time-varying ToU rate (solid line, consumption indicated by "B"). In this way, the customer is partially sheltered from a large variation in its annual bill when it moves to a time-sensitive tariff as 70% of its "typical" consumption, measured by the CBL, is charged at the flat tariff. However, customers are still provided with incentives to reduce their consumption during peak periods, as any consumption over the 70% CBL is charged at a relatively higher rate during peak periods.

Figure 3: Diagram of Flat-ToU Hybrid Tariff Structure

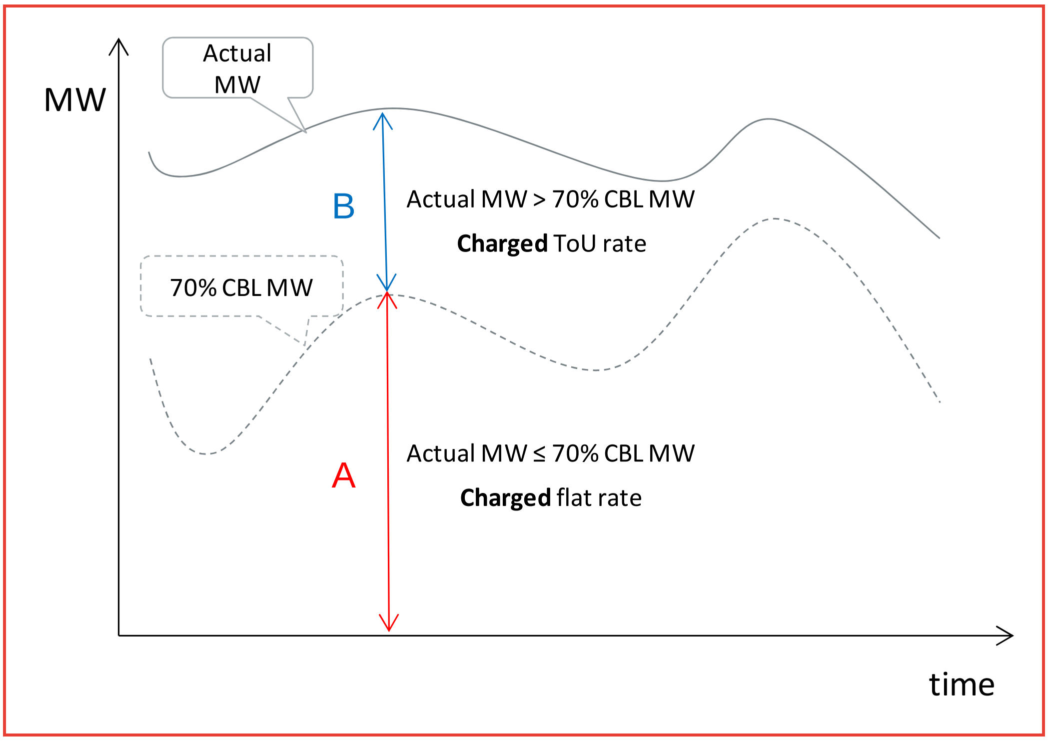
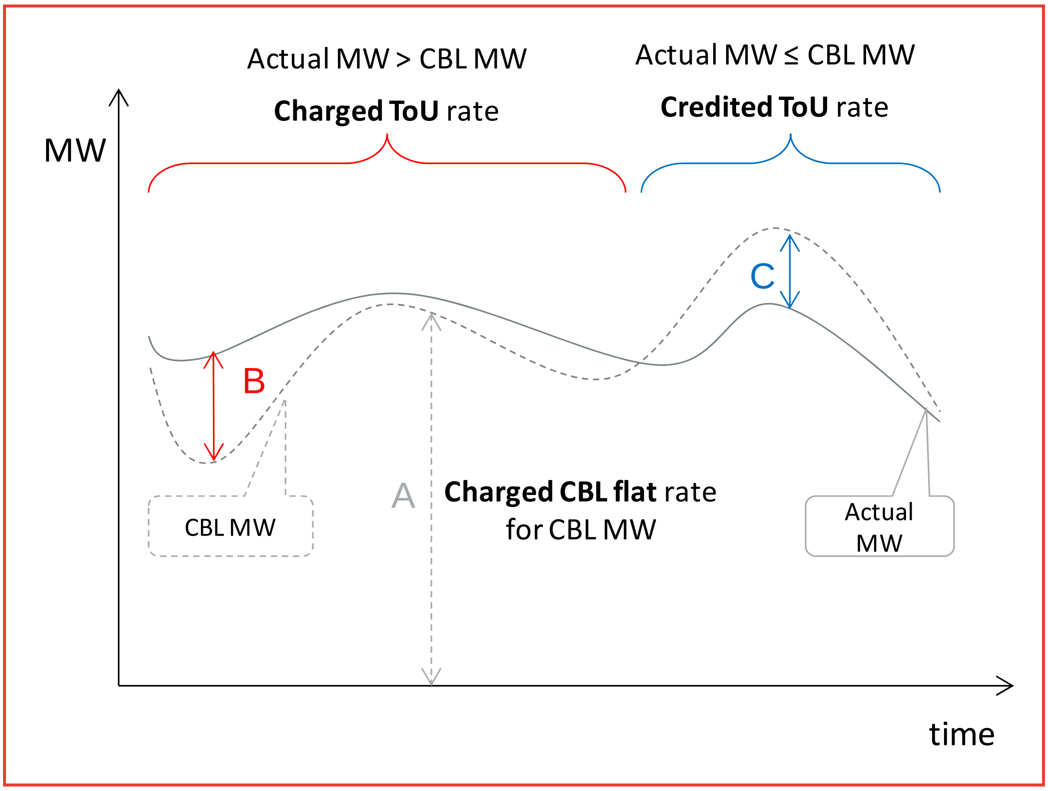


Figure 4 is a diagrammatic representation of the CBL tariff structure. With this tariff structure, the customer is charged the flat rate for its CBL consumption (dotted line, as indicated by "A"). If actual consumption (solid line) is greater than the CBL, the additional consumption is charged at the ToU rate (consumption indicated by "B"). If actual consumption is less than the CBL, the reduction in consumption is credited at the ToU rate (consumption indicated by "C"). In this way, the customer never pays more than the flat tariff as long as it does not change its pattern of consumption significantly from its CBL. Moreover, the customer is provided with incentives to reduce its consumption during peak periods since in doing so it can save the peak ToU rate.

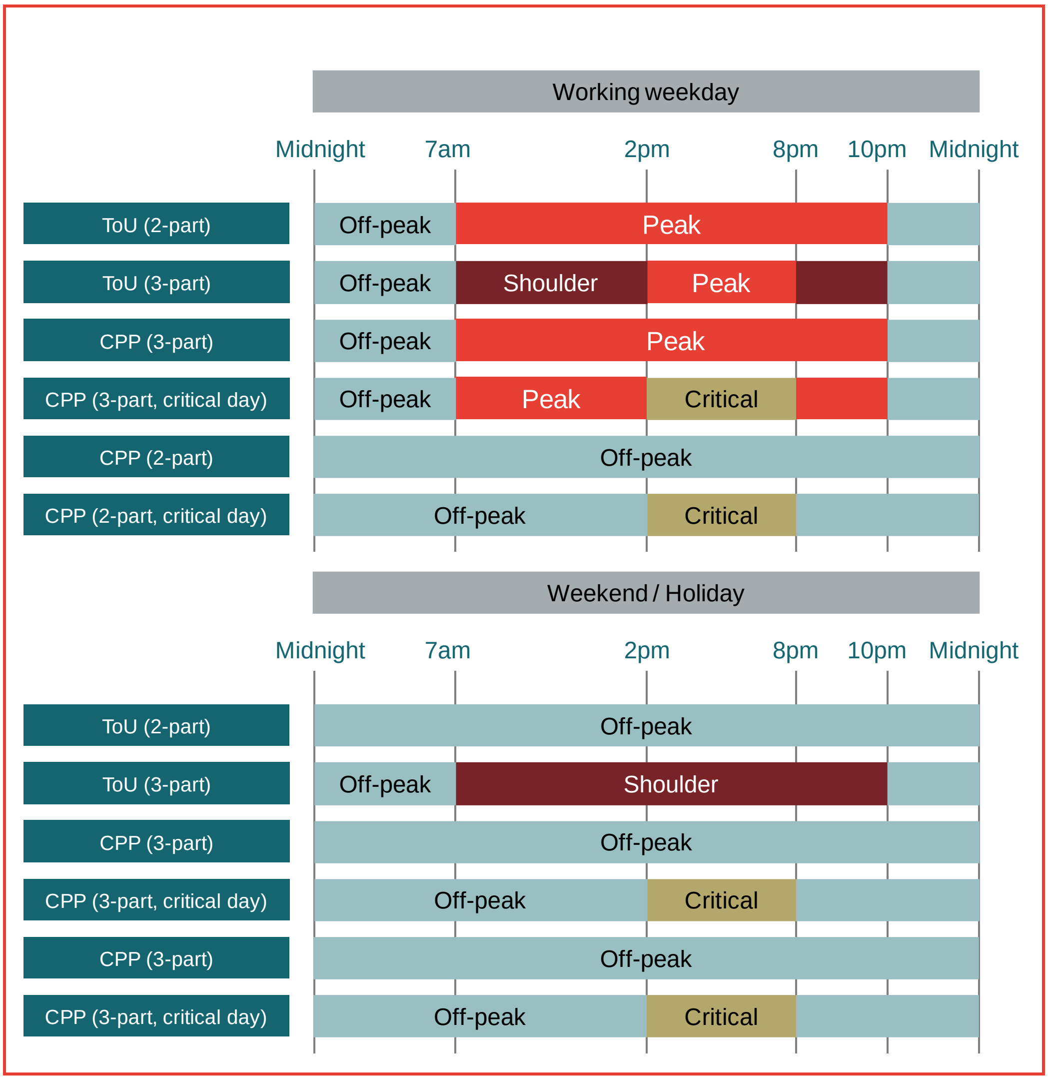
Figure 4: Diagram of CBL Tariff Structure



3.4.2 Summary of time periods

The associated peak/off-peak/shoulder and critical time periods definitions associated with various tariff structures are summarised in Figure 5.

Figure 5: Tariff structure time periods



3.4.3 Tariff cases

The tariff model can be used to analyse up to six tariff cases: one reference case and five sensitivity cases. These tariff cases can be set by the user.

Table 6 summarises the tariff cases that have been analysed in this report. The reference case reflects the tariff structures that we have been instructed apply to the majority of NSW customers. The sensitivity cases provide a range of tariff structures, from flat to dynamic, which were used to investigate the impact of dynamic tariff structures on end use annual bills in Section 4.

Table 6: Tariff cases

Tariff case name	Energy tariff structure	Network tariff structure
Reference	Inclining block	ToU (3-part)
Dynamic	ToU (3-part)	ToU (3-part)
CPP	CPP (3-part)	CPP (3-part)
Flat-ToU hybrid	Flat/ToU (3-part) hybrid	ToU (3-part)
CBL & ToU	CBL + ToU (2-part)	CBL + ToU (2-part)
CBL & CPP	CBL + CPP (2-part)	CBL + CPP (2-part)

3.5 Demand response

In practice, it is likely that customers who shift to time-sensitive pricing will alter their behaviour to minimise their electricity charges. This 'demand response' to time-sensitive pricing potentially results in changes in usage patterns for each customer type under different tariff structures. Demand response may involve changing aggregate usage levels and/or shifting usage to different times of the day.

3.5.1 Demand response patterns

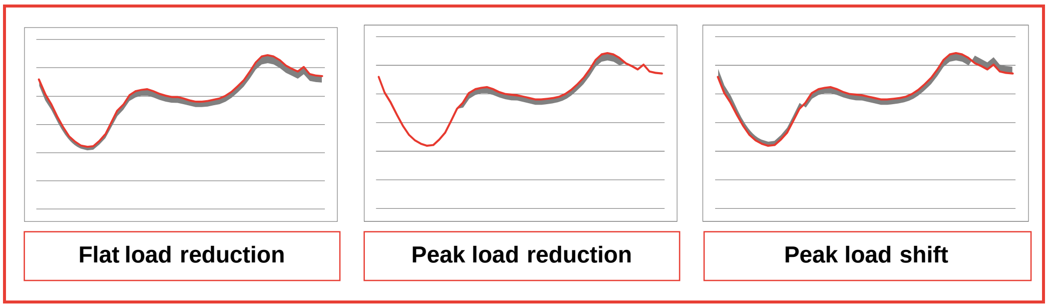
This demand response effect has been incorporated into the model. The model allows the user to select from a different demand response pattern, such as load reduction or load-shifting, for each customer type. The model also allows the user to set the degree of demand response, which is the percentage load reduction or percentage load shift, for each demand response pattern.

The demand response patterns available in the model are summarised in Table 7. There are eight demand response patterns in total. Six patterns are defined by the model, which means that the user sets the percentage of demand response and the model calculates how it is applied across the customer load profile. The model-defined patterns are illustrated in Figure 6. By contrast, the two user-defined demand response patterns allow the user to define the percentage of demand response at each hour of the day.

Table 7: Demand response patterns

Demand response pattern	Description
Flat load reduction	Flat reduction in load by the specified percentage.
Peak load reduction	Reduction in load at peak times by a specified percentage. In this instance, peak is defined as 7am and 10pm on working weekdays.
Seasonal peak load reduction	Reduction in load at peak times by a specified percentage each season. In this instance, peak is defined as 7am and 10pm on working weekdays.
Critical peak load reduction	Reduction in load at critical peak times by a specified percentage. Critical peak is defined as 2pm to 8pm on critical peak days.
Peak load shifting	Reduction in load at peak times by a specified percentage, offset by increased load in off-peak times. In this instance, peak is defined as 7am and 10pm on working weekdays.
Seasonal peak load shifting	Reduction in load at peak times by a specified percentage (by season), offset by increased load in off-peak times. In this instance, peak is defined as 7am and 10pm on working weekdays.
Annual User defined demand response	Demand response at the half hourly level as specified by the user
Seasonal User defined demand response	Demand response at the half hourly level as specified by the user for each season of the year (this allows for responses in summer/winter only).

Figure 6: Illustration of model defined demand response patterns

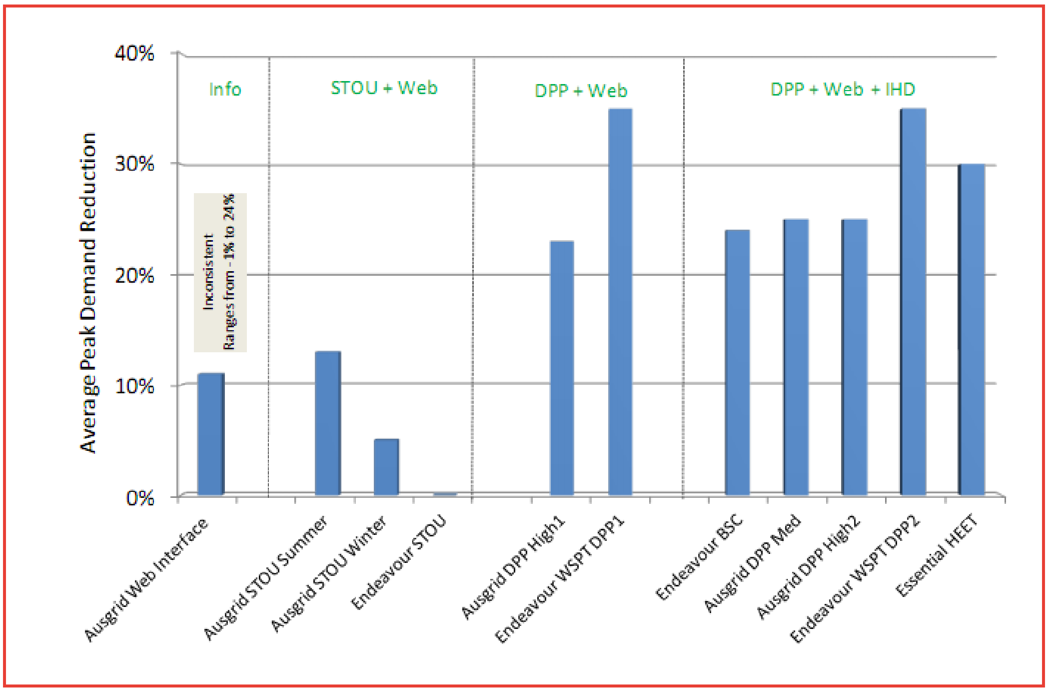


3.5.2 Degree of demand response

The model provides the user with full control over the degree (percentage of reduction or shift) of demand response. However, the model has been set up to include default values that are based on the level of demand response observed in a number of DSP trials conducted by the NSW distribution companies.

Figure 7 shows a summary of peak demand reduction results of seasonal time of use (STOU) and dynamic peak pricing (DPP) arising from trials recently conducted by Ausgrid, Endeavour and Essential Energy. The tariff structures in these studies do not directly match the tariff structures analysed by the tariff model. However, the level of demand response provides a rough guide for the demand response that could be achieved with dynamic pricing. Table 8 summarises the default degree of demand response for each demand response pattern.

Figure 7: Summary of peak demand reduction results from DSP trials



Source: Futura Consulting, Investigation of existing and plausible future demand side participation in the electricity market, pp. 88, December 2011

Table 8: Default degrees of demand response

Demand response	Season	Degree of demand response (%)
Flat load reduction	All	5%
Peak load reduction	All	10%
Seasonal peak load reduction	Summer	12%
	Autumn	0%
	Winter	5%
	Spring	0%
Critical peak load reduction	All	25%
Peak load shifting	All	10%
Seasonal peak load shifting Demand response	Summer	12%
	Autumn	0%
	Winter	5%
	Spring	0%

The default levels of demand response are in most cases conservative and lead to conservative estimates of potential savings due to customer demand response. Individual customers that achieve larger reductions in consumption at times of high prices will be able to capture greater cost savings under dynamic tariff structures. Such outcomes can be easily quantified in the model but are not presented in this report.

4 Results

Frontier has built a model of end use electricity costs that can be used to investigate the likely impact of alternate tariff structures and consumption patterns. This model is highly flexible, customisable and versatile, and can be used to investigate a range of DSP issues. The model was designed this way to best satisfy the two key purposes of this model:

- To investigate some of the issues under consideration as part of the Power of Choice review – to this purpose, this section provides a preliminary analysis of DSP issues using the tariff model configured to the base set of input assumptions (as outlined in Section 3) and
- To foster debate amongst stakeholders with regard to the attributes of an optimal tariff structure – to this purpose, it is intended for the model to be released to Power of Choice stakeholders

The analysis presented in this Section:

- is focused on outcomes for average consumers (load shapes are based on NSLP data that is aggregated over many consumers)
- uses conservative assumptions in some areas (network peak to off-peak tariff ratios are relatively low, demand response levels are relatively conservative, etc)

Changing these assumptions would change the results of the analysis. In some cases, individual consumers may be able to realise a much greater benefit from switching to a dynamic tariff structure and engaging is DSP, such as those who use significantly more energy at peak times than average and who are able to reduce their demand to a greater extent. Given the right inputs, the tariff model can be use to quantify these impacts. However, the analysis presented here is focused on outcomes that would be more likely to reflect average customers.

4.1 Understanding the tariff model's outputs

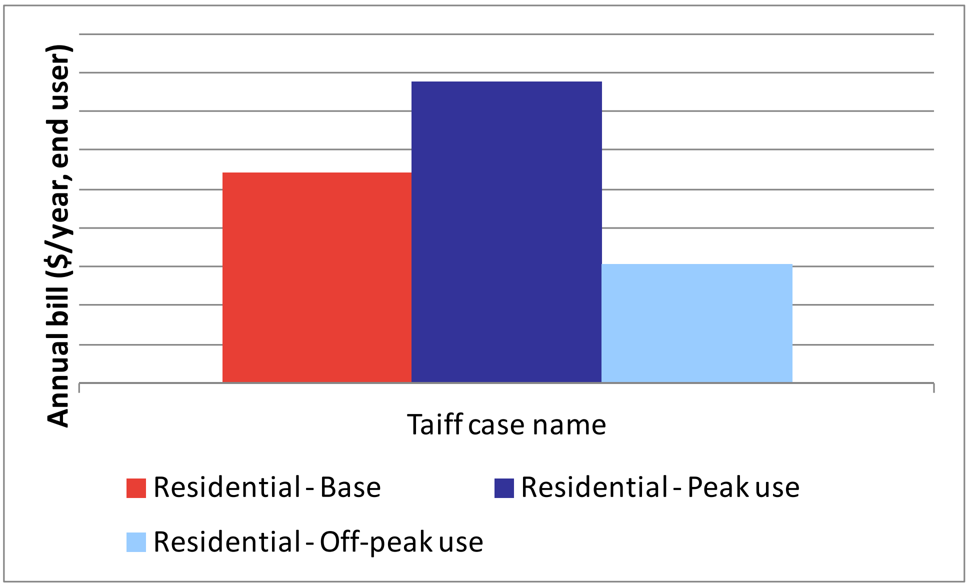
The tariff model reports a number of different results. This section explains the underlying calculations behind each of the model's different outputs.

4.1.1 Annual bill

The annual bill is the absolute value of the end use electricity bill. The end use annual bills are calculated for 8 MWh of consumption (an input to the model) in financial year 2012/13 and are reported in real financial year 2012/13 dollars.

There is an individual annual bill for each customer type for each tariff case. The annual bill of each customer type is presented in the same colour across all tariff cases. In addition, the static and demand response results are presented in separate graphs. Figure 8 shows an example of the annual bill result.

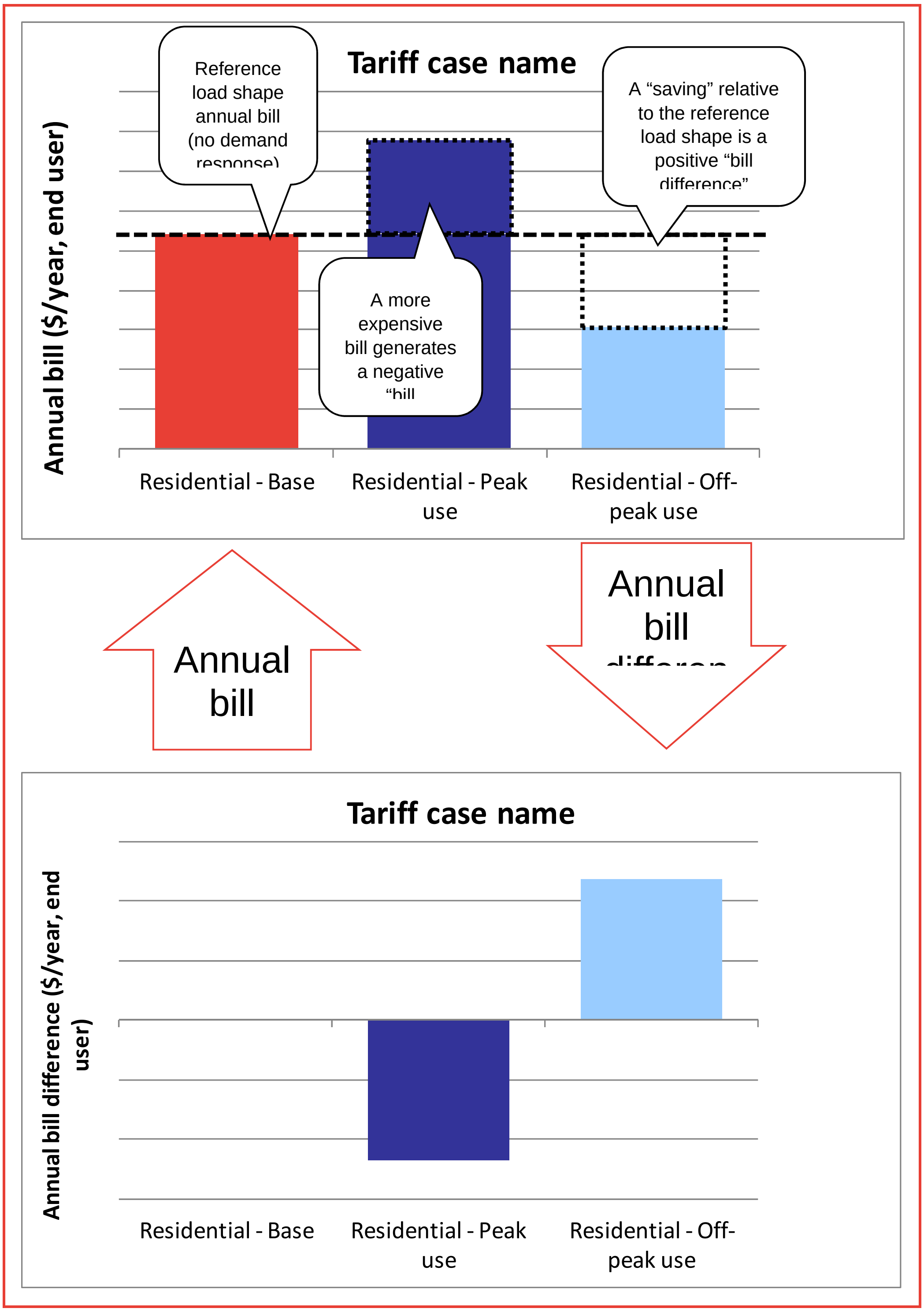
Figure 8: Annual bill example



4.1.2 Annual bill difference

The annual bill difference is the difference in the annual bill relative to the annual bill of the reference load shape consumer for a given tariff case. By convention, a positive bill difference is the 'saving' relative to the reference load shape bill. This is illustrated in Figure 9.

Figure 9: Illustration of the Annual bill difference



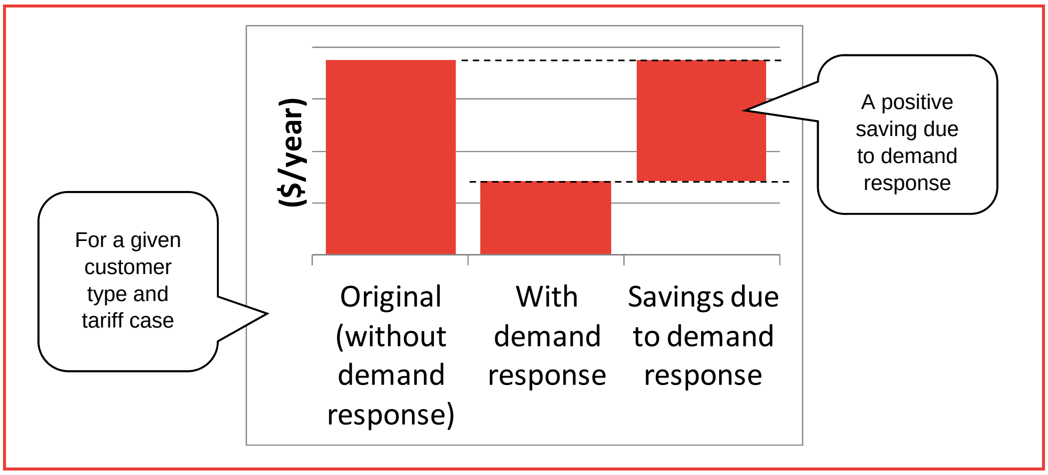
The annual bill difference is reported for all customer types, all tariff cases and also for the demand response cases (noting that the bill difference is always calculated relative to the reference load shape **without demand response**).

4.1.3 Annual bill savings from demand response

The annual bill savings from demand response is the difference between the demand response annual bill and the static (no demand response) annual bill for a given customer type on a given tariff.

It represents the savings for a specific customer (type and tariff case) if the customer implements demand response while tariff levels remained fixed. By convention, the value is positive if the bill with demand response is lower than the bill without demand response. This is illustrated in Figure 10.

Figure 10: Illustration of the annual bill savings from demand response



4.1.4 Percentage reductions from demand response

The model also reports the percentage reduction in the annual bill and in annual electricity consumption from demand response. This is the percentage difference for a given customer on a given tariff case when comparing its static (no demand response) results to its demand response results.

As before, savings are expressed as positive differences. The value is positive if the bill with demand response is lower than the bill without demand response. Similarly, the value is positive if the annual electricity consumption with demand response is lower than the annual electricity consumption without demand response.

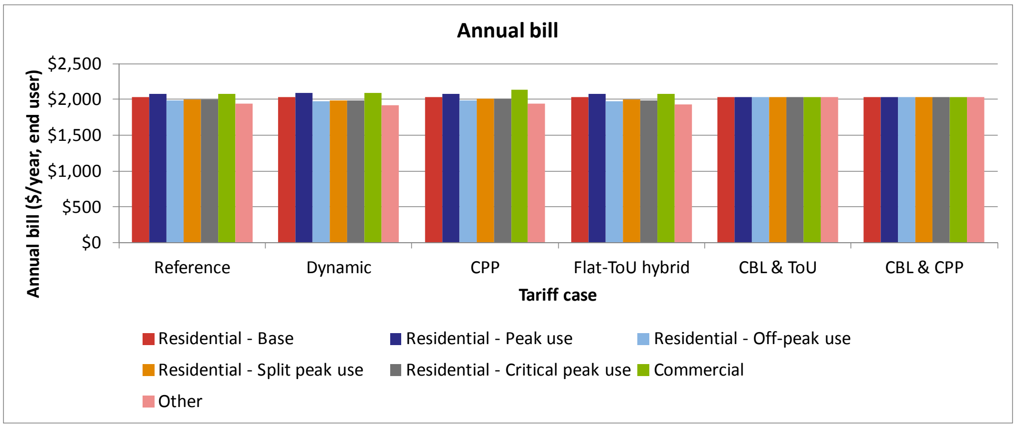
4.2 Static results

This section presents the model's results for the static (no demand response) cases. These results are for the annual bills of the six tariff cases presented in Table 6, and of the load shapes (customer types) discussed in Section 3.1.

Figure 11 illustrates the annual bills for all customer types on all tariff cases. It shows that the annual bills for all consumers on the various tariff cases are about $2000 for financial year 2012/13.[8]

Comparing across tariff cases reveals three features. The first is that the annual bill of the Residential – Base consumer is the same across all tariff cases, in accordance with the design of the model. The cost of meeting the reference load shape (Residential – Base) is used to set the level of all the tariff structures such that the annual bill is the same for the reference load in all cases. Second, for a given tariff case, load shapes that involve greater usage at peak times (Residential – Peak and Commercial) have higher annual bills. Conversely, load shapes with more usage in at off-peak times have lower annual bills. Third, customers moving to time-sensitive tariffs, such as from the Dynamic to the CPP tariff case, face relatively higher bills if they are peak use customers (such as the Residential – Peak use customer) and relatively lower bills if they are off-peak use customers (such as the Residential – Off-peak use customer).

Figure 11: Annual bill (static, no demand response)



Data shown in Table 11, Appendix B

Figure 12 and Figure 13 look at the annual bill differences for the Reference and Dynamic tariff; they provide a detailed view of the effect of the tariff structure on different customer types. Overall, both figures show that for these two time-sensitive tariff cases, the peak use customers (Residential – Peak use and Commercial) have more expensive bills compared to the reference load shape and that other off-peak use consumers have cheaper bills compared to the reference load shape.

8 In the static case, the annual bill for the CBL & ToU and the CBL & CPP tariffs are the same for all customers since their baseline load is their respective static (no demand response) load shape. They are grandfathered this baseline load, which is charged on the flat tariff structure for both energy and network. Deviations to their respective baselines, which is seen in the demand response cases, are charged/credited at the time-sensitive tariff component.

Figure 12: Bill difference for the Reference tariff cases (static, no demand response)

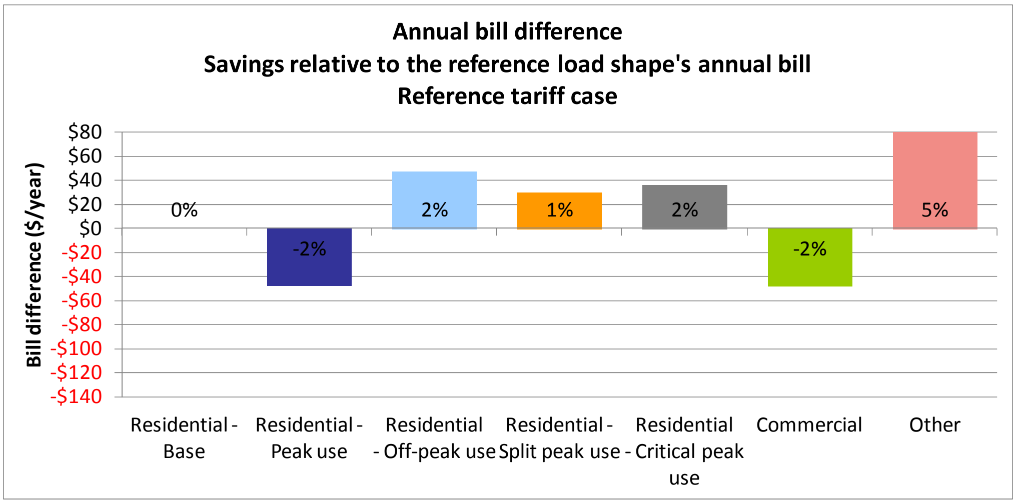
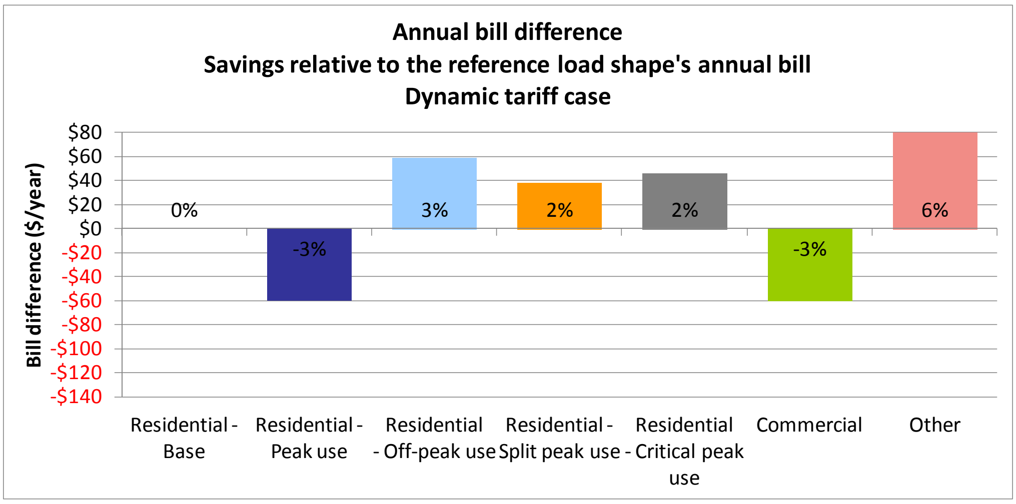


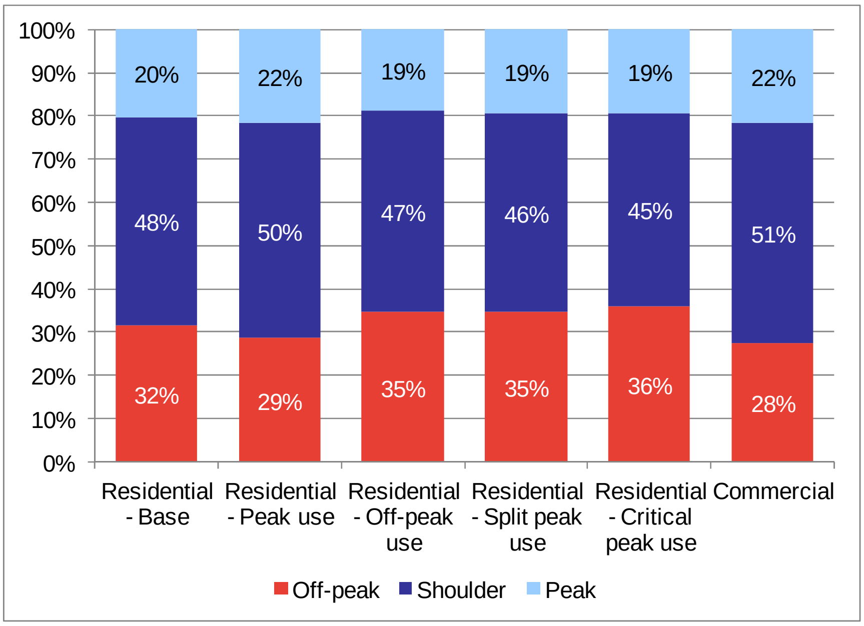
Figure 13: Bill difference for the Dynamic tariff cases (static, no demand response)



Comparing across the tariff cases highlights a result seen previously – that moving to a more dynamic tariff case results in relatively higher bills for peak use customers (such as the Residential – Peak use customer) and relatively cheaper bills for off-peak users (such as the Residential – Off-peak use customer). From another perspective, this result can also be interpreted as a reduction in the degree of cross-subsidisation between customer types. As the tariff changes, the customers move from an inclining block energy tariff structure to a ToU energy tariff structure. With cost-reflective pricing of energy, there is a reduction in the cross-subsidisation between peak use and off-peak use customer types. The magnitude of this change is reflected in the magnitude of the bill differences across tariff cases.

In general, the magnitudes of these bill differences are driven by the differences in the consumption patterns of each customer type with respect to the ToU 3-part pricing categories. Figure 14 shows the percentage break-down of annual electricity consumption into the peak/shoulder and off-peak categories for all customer types. It shows that there is a relatively small difference in the consumption patterns across the customer types. For example, there is only a 2% difference between the Residential – Base and Residential – Peak use customers' peak period consumption. This relatively small difference is consistent with the relatively small 2% bill difference in the Reference tariff case (in Figure 12).

Figure 14: Break-down of annual consumption into ToU 3-part categories – All customer types

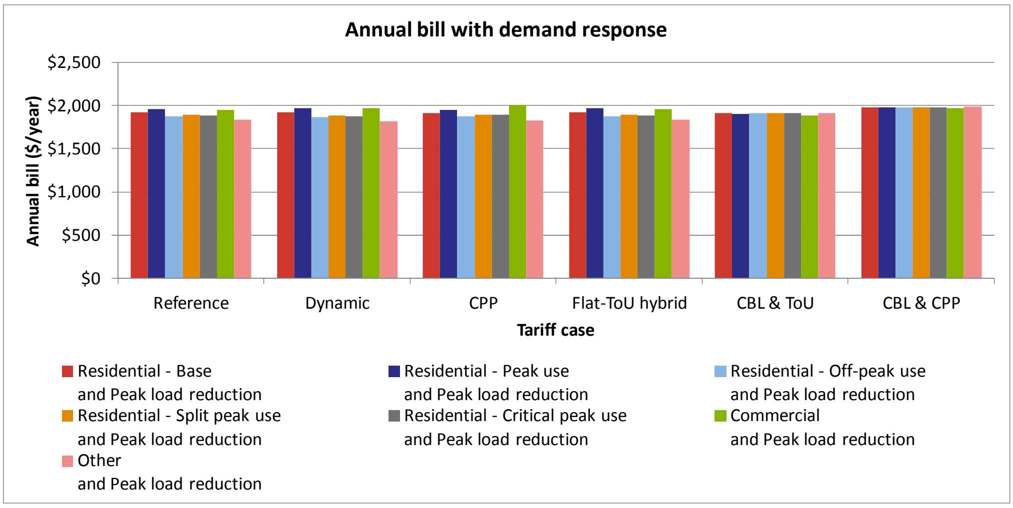


4.3 Demand response results

This sub-section presents the results for peak load reduction of 10% for all customer types. As discussed earlier, the user of the model can input a wide range of different types of demand response and control the magnitude of the response. Figure 15 shows the total annual bill with demand response and Figure 16 shows the annual bill savings due to demand response relative to the original load shape.

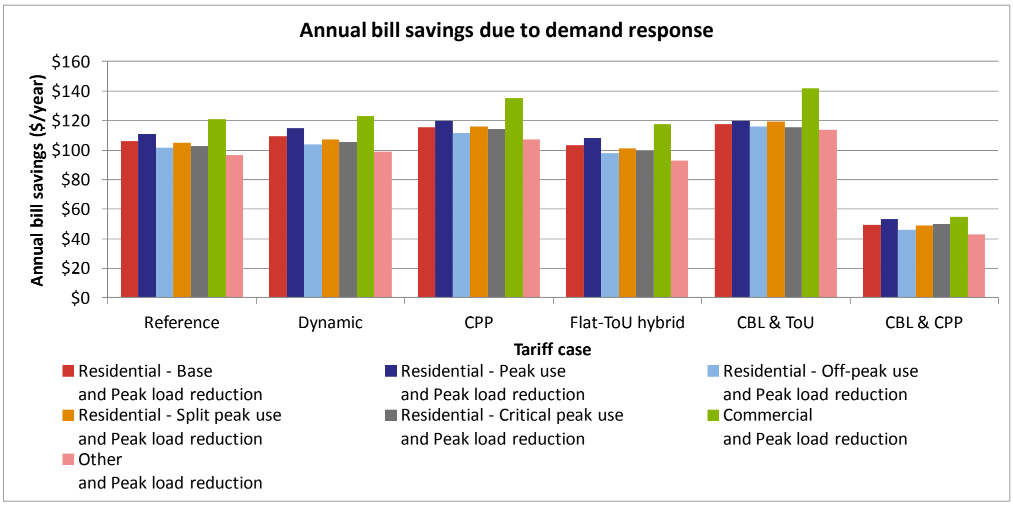
Consistent with intuition, these figures illustrate that savings are higher under the more dynamic tariff structures. For example, in general, customers save the most on the CPP and CBL & ToU tariffs. In particular, customers benefit most when their peak load reduction is well aligned with relatively highly-priced periods.

Figure 15: Annual bill with demand response - peak load reduction of 10%



Data shown in Table 12, Appendix B

Figure 16: Annual bill savings with demand response - peak load reduction of 10%



Data shown in Table 13, Appendix B

In terms of DSP incentives, this result has interesting implications. By showing that customers can make greater savings when they align their load reduction with relatively high-priced periods, the model suggests that tariff structures that include relatively high-priced periods may be more effective at incentivising DSP. For example, Data shown in Table 12, Appendix B

Figure 16 shows that all customer types make greater saving with the CPP tariff than the Dynamic tariff for the same demand response. This demonstrates that the higher the marginal cost of consuming, the greater the benefit of reducing consumption.

Figure 17 shows the percentage reductions in annual consumption and the annual bill resulting from demand response (each value refers to the percentage reduction achieved by a given customer type on a given tariff case) by reference to the Dynamic tariff case. It shows that all customers can achieve a relatively larger percentage reduction in their annual bill compared to the percentage reduction in their annual consumption. This result is due to customers reducing their consumption at relatively high-priced times.

Figure 17: Percentage reductions with demand response – peak load reduction of 10%

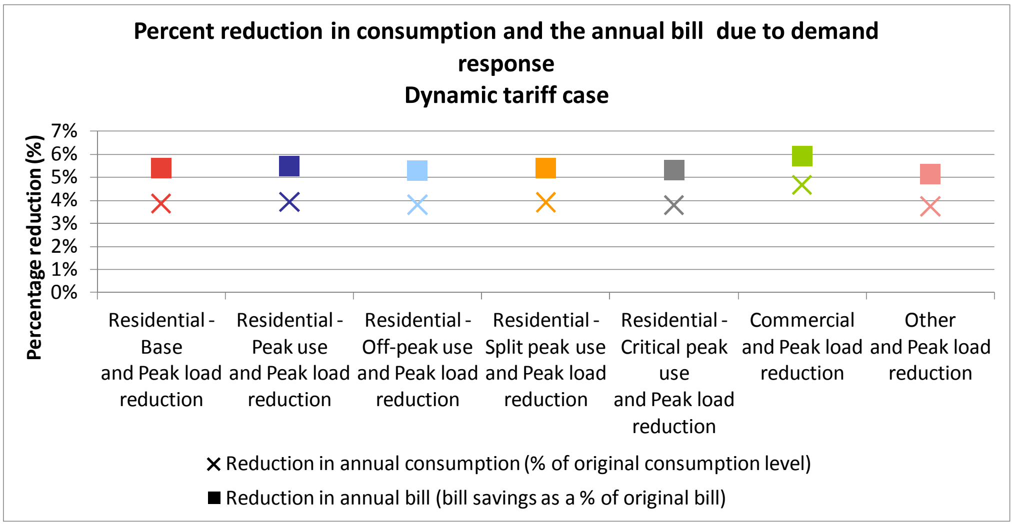


Figure 18 and Figure 19 show the annual bill difference for the Dynamic and CPP tariff cases (with demand response), respectively. They show that all customer types that engage in a peak load reduction of 10% make savings relative to the reference load shape consumer type.

For the sake of clarity, it is worth exploring one result set out in these figures in more detail. The figures show that the demand response bill savings available to the off-peak customer types, such as the Residential – Off peak use consumer, are larger than for other customer types. This may seem counter-intuitive, because these customers already consume less of their energy at peak times than other customers. Hence, they would seem to have less to gain from *further* reductions in peak demand. The result can be explained by separating the two factors driving the aggregate savings result:

- First, the savings accruing to the off-peak customer relative to the reference load shape customer *in the absence of any demand response*, and
- Second, the effect of demand response on the relevant customers' bills.

Due to the first factor, off-peak use consumers face relatively lower annual bills compared to the reference load shape because they use relatively less electricity at peak periods. This factor drives the larger savings available to off-peak use customers against the reference load shape customer than other customer types. The second factor allows off-peak consumers to make further savings by reducing their peak use consumption, even though these savings are less than those available to peakier customers. Individually, the two factors result in relative savings for the off-peak use customers, and the combined effect is a relatively large net saving.

For precisely the opposite reasons, the savings relative to the reference load shape customer are relatively smaller for peak use consumers, such as the Residential – Peak use customer. This is because in the absence of demand response, peak use customers face higher annual bills under the Dynamic and CPP tariffs compared to customers with the reference load shape. Demand response enables these customers to make larger savings than other customer types by reducing their peak use consumption. However, the strength of the former effect means that in net terms, peak-use customers make smaller savings relative to the reference load shape bill as compared with other customer types.

Figure 18: Annual bill difference for the Dynamic tariff with demand response – 10% peak load reduction

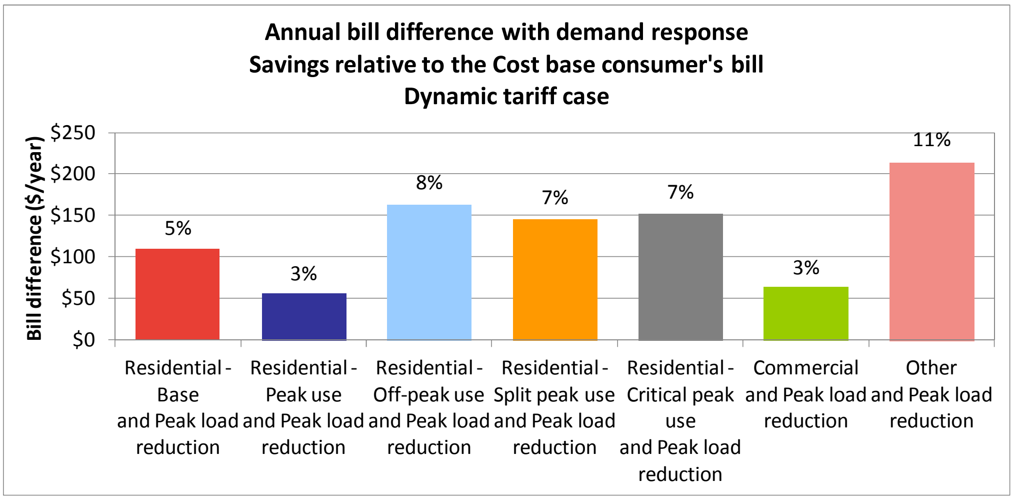
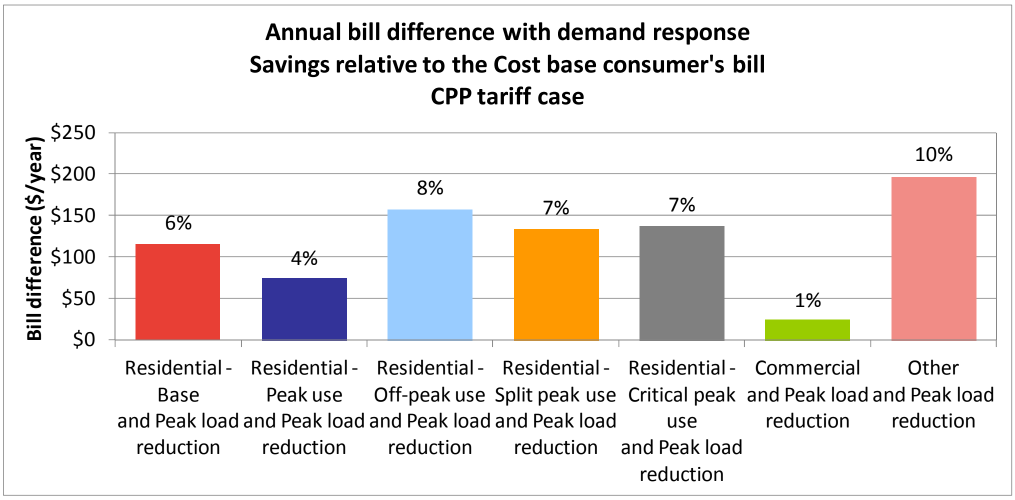


Figure 19: Annual bill difference for the CPP tariff with demand response – 10% peak load reduction



An important implication of these annual bill results is that changes in tariffs and demand response are likely to diminish the revenues earned by retailers and network businesses. For example, as well as representing the savings available to a Residential - Peak use customer who moves from the Reference tariff to a Dynamic tariff and reduces its peak load by 10%, the dark blue bar in Figure 18 also shows the revenue lost to retailers and network businesses. As all savings are positive, it indicates that in the short term where these tariff levels are fixed there will be "lost revenue" from all customer types who move to time-sensitive tariffs and reduce their peak load.

Reductions in revenue are not necessarily a problem as long as they accompany reductions in cost such that profit margins are maintained for both network and retail businesses.

For retailers of electricity, who pass-through network costs and can control energy costs via prudent financial derivative contracting and wholesale energy purchases, it will be relatively easy to adjust to altered levels of consumption by customers in short term. As such, retailers should be able to match reductions in revenue due to reduced consumption with reductions in costs in the short term. Most retailers contract on a rolling basis and would be able to readjust their position effectively in real time. This is how uncertainty around load is managed and is one of the primary functions of a retail electricity business.

For network businesses, most costs represent capital investment decisions that are already sunk and which cannot be reversed or altered. Network businesses would find it difficult if not impossible to reduce costs in line with reductions in revenue due to lower consumption in the short term. Absent any other measures, this would be likely to lead to reduced profit for the network businesses in the short term and may lead to under-recovery of costs for the businesses. In practice, the regulatory arrangements would ensure cost recovery by allowing increases in revenue from other areas (for example via higher fixed charges on customers who remain on time-invariant tariffs). In the longer term, new capital investments would be made with regard to reduced peak demand levels leading to lower overall costs to meet demand.

4.4 Case study

The retail tariff model is flexible enough to analyse a number of issues. This section presents an analysis using the model to determine the degree of demand response required to achieve a certain reduction in the end use annual electricity bill.

In particular, it was recently reported that Endeavour Energy's Western Sydney Price Trial participants saved about $200 compared to their normal time-invariant tariff.[9] Correspondingly, the retail tariff model has been used to analyse what degree of demand response is required to achieve a saving of $200 with peak load reduction.

How to save $200 with peak load reduction

The model shows that a peak load reduction of about 18% is required to achieve a saving of $200 on the end use electricity bill, where a peak load reduction of

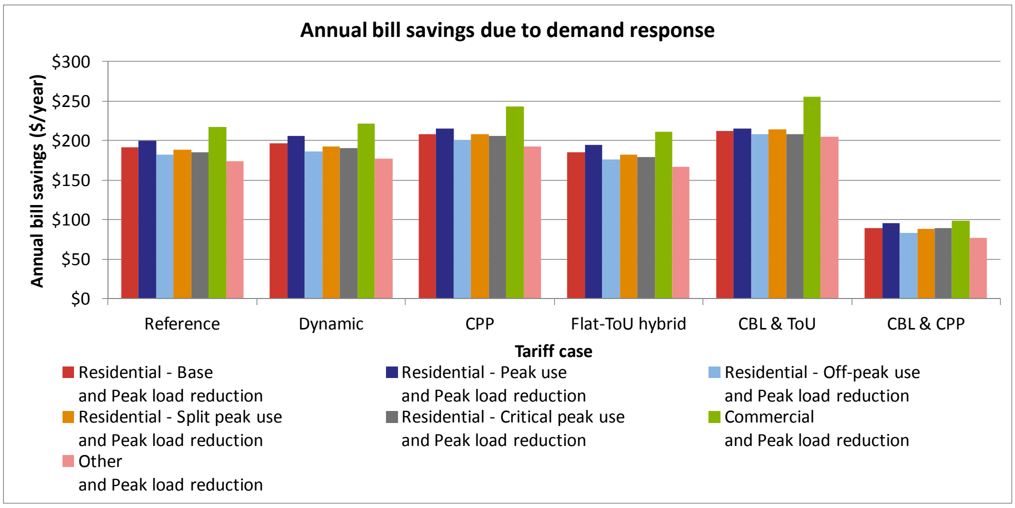
---

9 Futura Consulting, *Investigation of existing and plausible future demand side participation in the electricity market*, pp. 72, December 2011

18% corresponds to an annual average demand reduction of around 7% for all customer types.

This result is illustrated in Figure 20, which shows the annual bill savings for an 18% peak load reduction for all customer types for all tariff cases. The savings achieved are about $200 for all cases except for the CBL & CPP case. In general, savings are relatively higher for peak use customers and savings are also relatively higher for the more dynamic tariff structures (the CPP and CBL & ToU cases).

Figure 20: Annual bill savings from demand response – peak load reduction of 18%



Data shown in Table 14, Appendix B

Case study conclusion

This case study shows that a $200 saving is achievable for all customer types with a percentage load reduction of roughly 18%. Frontier is of the view that the reported $200 savings "as a result of moving off a time-invariant tariff" most likely includes reductions in aggregate consumption rather than just time-shifting demand. The model indicates that significant reductions in peak demand would be needed to achieve such a saving.

5 Conclusion

Frontier Economics has created a simplified and transparent model that can be used to investigate the likely impact of alternate tariff structures and consumption patterns on the end use electricity bills. This model satisfies the objectives of allowing investigation of some of the issues under consideration as part of the Power of Choice review and of fostering debate amongst stakeholders with regard to the attributes of an optimal tariff structure.

The model confirms some intuitive expectations and provides useful insights in a number of areas.

- Annual bills calculated in the model are in line with 'real world' bills for residential customers.
- The impact of different tariff structures in dependent of the usage pattern (or load shape) of a particular customer.
- Demand response provides customers with the ability to reduce annual bills via reduced and/or altered patterns of consumption. However, the magnitude of the reduction is relatively small compared to total annual bills unless significant reductions in consumption occur (greater than 10% usage reductions).
- For an annual consumption level of 8 MWh, significant reductions in peak consumption (of around 18% of original usage) are required to achieve savings in the order of $200 on an annual bill.
- More dynamic tariff structures provide more opportunity for customers to avoid high marginal electricity prices. Critical Peak Pricing structures provided the greatest incentives for customers to alter patterns of consumption.
- The combination of highly dynamic tariff structures (such as CPP) combined with Consumption Baseline Load (CBL) mechanisms could strongly incentivise consumers to reduce peak demand whilst protecting consumers, particularly vulnerable consumers, against excessive increases in their cost of living.
- Savings realised by customers represent reductions in revenue for retail and network businesses. In the case of retailers, this is unlikely to present any issue. However, for network businesses this may lead to under recovery of costs, at least in the short term. This could be remedied by increasing cost to customers that remain on tradition accumulation meters, which would represent an explicit cross-subsidy.

This report details the framework, calculations and input assumptions unpinning the model and presents the results of analysis performed by Frontier Economics to quantify issues around incentivising DSP. Many of the assumptions regarding load data and cost information have been based on the more populous jurisdictions of NSW and Victoria. However Frontier Economics is of the opinion that this does not significantly reduce the model's ability to assess the impacts of alternate tariff structures and DSP in other jurisdictions. Furthermore, the majority of these inputs can be altered by the user of the model if required.

In performing this analysis, Frontier has in general focused on typical or average customer load shapes, moderate peak pricing levels for network charges and relatively conservative levels of demand response. Individual consumers that achieve larger demand reductions at times of high prices will be able to capture even greater cost savings under dynamic tariff structures. Such outcomes can be easily quantified in the model but are not presented in this report.

Frontier believes that the model, while useful with the load profiles that have been used, could provide further opportunity for analysis if more accurate load data became available.

Appendix A – Detailed model calculations

This Appendix discusses the calculations performed by the model in Step 2 of Figure 1. In particular, this Appendix explains the calculations behind the tariff levels of each network and energy tariff structure.

These tariff levels are calculated to ensure that the revenue adequacy principle holds with respect to the reference load profile. This tariff model has been configured so that the Residential – Base load shape is the reference load shape (the Residential – Base load shape is based on the EnergyAustralia NSLP, see Section 3.1 for details).

The tariff levels are also pegged to the actual underlying costs to serve. These include wholesale pool prices for the energy tariff levels and the regulated asset base cost for the network tariff levels. See Section 3 for a detailed discussion of these input assumptions.

Since the energy and network tariffs have different cost bases, the calculations for the tariff levels are different. This Appendix discusses the calculations for the energy tariff levels first and the network tariff levels second.

Energy tariff levels

The energy tariff levels are set such that:

- They revenue neutrality principle holds with respect to the reference load profile;
- They reflect the underlying common cost base, which comprises the wholesale energy cost (including the cost of carbon) and the hedging contract premium; and
- They reflect the energy fixed and variable component proportions as defined by the user (as the user can define the proportion of the energy component of the end use customer’s bill that is fixed/variable for the reference load shape).

These three requirements are met by simply setting the tariff levels such that the revenue from the reference load profile is equal to the underlying cost which is derived from the common cost base. Following this formula, the tariff levels are set according to the equations detailed in

Tariff structure	Tariff rate / notation	Calculation
All	Fixed / t_{fixed}	t_{fixed} = Annual wholesale pool cost of the reference load shape including carbon × (1 + hedging contract margin) × fixed proportion of end use bill
Flat	Single flat / t_f	Reference load shape annual consumption × t_f = Annual wholesale pool cost of the reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
ToU (2-part)	Peak / t_p	Reference load shape annual ToU (2-part) peak consumption × t_p = Annual ToU (2-part) peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
	Off-peak / t_o	Reference load shape annual ToU (2-part) off-peak consumption × t_o = Annual ToU (2-part) off-peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
ToU (3-part)	Peak / t_p	Reference load shape annual ToU (3-part) peak consumption × t_p = Annual ToU (3-part) peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
	Off-peak / t_o	Reference load shape annual ToU (3-part) off-peak consumption × t_o = Annual ToU (3-part) off-peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract

Tariff structure	Tariff rate / notation	Calculation
		margin) × variable proportion of end use bill
	Shoulder / t_s	Reference load shape annual ToU (3-part) shoulder consumption × t_s = Annual ToU (3-part) shoulder wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
CPP (2-part)	Off-peak / t_o	Reference load shape annual CPP (2-part) off-peak consumption × t_o = Annual CPP (2-part) off-peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
	Critical / t_c	Reference load shape annual CPP (2-part) critical peak consumption × t_c = Annual CPP (2-part) critical peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
CPP (3-part)	Peak / t_p	Reference load shape annual CPP (3-part) peak consumption × t_p = Annual CPP (3-part) peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
	Off-peak / t_o	Reference load shape annual CPP (3-part) off-peak consumption × t_o = Annual CPP (3-part) off-peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
	Critical / t_c	Reference load shape annual CPP (3-part) critical peak consumption × t_c

Tariff structure	Tariff rate / notation	Calculation
		= Annual CPP (3-part) critical peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
Inclining block	Block 1 / t_1 Block 2 / t_2	Block 1 consumption × t_1 + Block 2 consumption × t_2 = Annual wholesale pool cost of the reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill Where • the price scale is: $t_1 = 0.95\ t_2$ • Block 1 consumption = 0.8 × Reference load shape annual consumption • Block 2 consumption = 0.2 × Reference load shape annual consumption

.

In

Tariff structure	Tariff rate / notation	Calculation
All	Fixed / t_{fixed}	t_{fixed} = Annual wholesale pool cost of the reference load shape including carbon × (1 + hedging contract margin) × fixed proportion of end use bill
Flat	Single flat / t_f	Reference load shape annual consumption × t_f = Annual wholesale pool cost of the reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
ToU (2-part)	Peak / t_p	Reference load shape annual ToU (2-part) peak consumption × t_p = Annual ToU (2-part) peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
	Off-peak / t_o	Reference load shape annual ToU (2-part) off-peak consumption × t_o = Annual ToU (2-part) off-peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
ToU (3-part)	Peak / t_p	Reference load shape annual ToU (3-part) peak consumption × t_p = Annual ToU (3-part) peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
	Off-peak / t_o	Reference load shape annual ToU (3-part) off-peak consumption × t_o = Annual ToU (3-part) off-peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract

Tariff structure	Tariff rate / notation	Calculation
		margin) × variable proportion of end use bill
	Shoulder / t_s	Reference load shape annual ToU (3-part) shoulder consumption × t_s = Annual ToU (3-part) shoulder wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
CPP (2-part)	Off-peak / t_o	Reference load shape annual CPP (2-part) off-peak consumption × t_o = Annual CPP (2-part) off-peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
	Critical / t_c	Reference load shape annual CPP (2-part) critical peak consumption × t_c = Annual CPP (2-part) critical peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
CPP (3-part)	Peak / t_p	Reference load shape annual CPP (3-part) peak consumption × t_p = Annual CPP (3-part) peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
	Off-peak / t_o	Reference load shape annual CPP (3-part) off-peak consumption × t_o = Annual CPP (3-part) off-peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
	Critical / t_c	Reference load shape annual CPP (3-part) critical peak consumption × t_c

Tariff structure	Tariff rate / notation	Calculation
		= Annual CPP (3-part) critical peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
Inclining block	Block 1 / t_1 Block 2 / t_2	Block 1 consumption × t_1 + Block 2 consumption × t_2 = Annual wholesale pool cost of the reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill Where • the price scale is: $t_1 = 0.95\, t_2$ • Block 1 consumption = 0.8 × Reference load shape annual consumption • Block 2 consumption = 0.2 × Reference load shape annual consumption

, the left hand side of each equation represents the revenue from the reference load profile. The right hand side of each equation represents the cost, based on the common cost base, of the reference load profile. Explicitly, the annual wholesale pool cost of the reference load shape including carbon is calculated using the following equation:

$$\sum_{\text{for all i (half hours in the year)}} (\text{wholesale pool price}_i + \text{carbon price pass through} \times \text{carbon price}) \times \text{reference load}_i$$

The right had side is also scaled to the energy fixed and variable bill component proportions, depending on whether the equation is used to set a fixed or variable rate. Also, each equation references a time period associated with the tariff structure, such as ToU (2-part) peak and CPP (2-part) critical peak, which refer to the time periods definitions illustrated in Figure 5.

With the complete set input assumptions, the only unknown values are the tariff levels. Therefore, the tariff levels can be calculated by simply inputting the assumption values and rearranging the equations. The inclining block tariff is a slight exception to this general rule as it requires additional assumptions on the ratio between the first and second block consumption sizes and tariff rates.

Appendix A – Detailed model calculations

Table 9: Energy tariff level calculations

Tariff structure	Tariff rate / notation	Calculation
All	Fixed / t_{fixed}	t_{fixed} = Annual wholesale pool cost of the reference load shape including carbon × (1 + hedging contract margin) × fixed proportion of end use bill
Flat	Single flat / t_f	Reference load shape annual consumption × t_f = Annual wholesale pool cost of the reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
ToU (2-part)	Peak / t_p	Reference load shape annual ToU (2-part) peak consumption × t_p = Annual ToU (2-part) peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
	Off-peak / t_o	Reference load shape annual ToU (2-part) off-peak consumption × t_o = Annual ToU (2-part) off-peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
ToU (3-part)	Peak / t_p	Reference load shape annual ToU (3-part) peak consumption × t_p = Annual ToU (3-part) peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
	Off-peak / t_o	Reference load shape annual ToU (3-part) off-peak consumption × t_o = Annual ToU (3-part) off-peak wholesale

Tariff structure	Tariff rate / notation	Calculation
		pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
	Shoulder / t_s	Reference load shape annual ToU (3-part) shoulder consumption × t_s = Annual ToU (3-part) shoulder wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
CPP (2-part)	Off-peak / t_o	Reference load shape annual CPP (2-part) off-peak consumption × t_o = Annual CPP (2-part) off-peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
	Critical / t_c	Reference load shape annual CPP (2-part) critical peak consumption × t_c = Annual CPP (2-part) critical peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
CPP (3-part)	Peak / t_p	Reference load shape annual CPP (3-part) peak consumption × t_p = Annual CPP (3-part) peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
	Off-peak / t_o	Reference load shape annual CPP (3-part) off-peak consumption × t_o = Annual CPP (3-part) off-peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill

Tariff structure	Tariff rate / notation	Calculation
	Critical / t_c	Reference load shape annual CPP (3-part) critical peak consumption $\times\, t_c$ = Annual CPP (3-part) critical peak wholesale pool cost of reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill
Inclining block	Block 1 / t_1 Block 2 / t_2	Block 1 consumption $\times\, t_1$ + Block 2 consumption $\times\, t_2$ = Annual wholesale pool cost of the reference load shape including carbon × (1 + hedging contract margin) × variable proportion of end use bill Where • the price scale is: $t_1 = 0.95\, t_2$ • Block 1 consumption = 0.8 × Reference load shape annual consumption • Block 2 consumption = 0.2 × Reference load shape annual consumption

Network tariff levels

The network tariff levels are set such that:

- They revenue neutrality principle holds with respect to the reference load profile; and
- They reflect the underlying common cost base, which is based on recovering actual regulated network tariffs for the reference load profile;
- The dynamic tariff levels reflect the tariff level ratios that are currently offered by network companies; and
- They reflect the network fixed and variable component proportions as defined by the user (as the user can define the proportion of the network component of the end use bill that is fixed/variable for the reference load shape).

These four requirements are met by simply setting the tariff levels such that the revenue from the reference load profile is equal to the underlying cost derived from the common cost base, subject to the tariff level ratio assumptions and the network fixed and variable bill component proportions. The common cost base and tariff level ratios assumptions are set out in Table 3.

Following this formula, the tariff levels are set according to the equations detailed in Table 10.

Table 10: Network tariff level calculations

Tariff structure	Tariff rate / notation	Calculation
All	Fixed / t_{fixed}	t_{fixed} = Annual regulated asset cost to the reference load shape × fixed proportion of end use bill
Flat	Single flat / t_f	Reference load shape annual consumption × t_f = Annual regulated asset cost to the reference load shape × variable proportion of end use bill

Tariff structure	Tariff rate / notation	Calculation
ToU (2-part)	Peak / t_p Off-peak / t_o	Reference load shape annual ToU (2-part) peak consumption × t_p + Reference load shape annual ToU (2-part) off-peak consumption × t_o = Annual regulated asset cost to the reference load shape × variable proportion of end use bill Subject to: • t_p / t_o = Peak to Off-peak ratio
ToU (3-part)	Peak / t_p Shoulder / t_s Off-peak / t_o	Reference load shape annual ToU (3-part) peak consumption × t_p + Reference load shape annual ToU (3-part) shoulder consumption × t_s + Reference load shape annual ToU (3-part) off-peak consumption × t_o = Annual regulated asset cost to the reference load shape × variable proportion of end use bill Subject to: • t_p / t_o = Peak to Off-peak ratio • t_s / t_o = Peak to Off-peak ratio
CPP (2-part)	Critical / t_c Off-peak / t_o	Reference load shape annual CPP (2-part) off-peak consumption × t_o + Reference load shape annual CPP (2-part) critical peak consumption × t_c = Annual regulated asset cost to the reference load shape × variable proportion of end use bill Subject to: • t_c / t_o = Critical peak to Off-peak ratio
CPP (3-part)	Peak / t_p Off-peak / t_o Critical / t_c	Reference load shape annual CPP (3-part) peak consumption × t_p + Reference load shape annual CPP (3-part) off-peak consumption × t_o + Reference load shape annual CPP (3-part) critical peak consumption × t_c

Tariff structure	Tariff rate / notation	Calculation
		$=$ Annual regulated asset cost to the reference load shape $\times$ variable proportion of end use bill Subject to: • t_p / t_o = Peak to Off-peak ratio • t_c / t_o = Critical peak to Off-peak ratio
Inclining block	Block 1 / t_1 Block 2 / t_2	Block 1 consumption $\times t_1$ + Block 2 consumption $\times t_2$ $=$ Annual regulated asset cost to the reference load shape $\times$ variable proportion of end use bill Where: • the price scale is: $t_1 = 0.95\ t_2$ • Block 1 consumption = 0.8 $\times$ Reference load shape annual consumption • Block 2 consumption = 0.2 $\times$ Reference load shape annual consumption

Appendix B – Data tables

This Appendix presents the data underlying Figure 11, Figure 15, Figure 16 and Figure 20.

Table 11: Data for Figure 11 Annual bill (static, no demand response)

Tariff case	Residential - Base	Residential - Peak use	Residential - Off-peak use	Residential - Split peak use	Residential - Critical peak use	Commercial	Other
Cost base	$2,028.34	$2,075.48	$1,981.26	$1,998.43	$1,992.33	$2,075.90	$1,936.72
Dynamic	$2,028.34	$2,085.76	$1,971.00	$1,991.47	$1,983.72	$2,086.64	$1,916.75
CPP	$2,028.34	$2,070.48	$1,986.25	$2,013.16	$2,007.00	$2,140.78	$1,946.43
Flat-ToU hybrid	$2,028.34	$2,078.56	$1,978.18	$1,996.34	$1,989.75	$2,079.12	$1,930.73
CBL & ToU	$2,028.34	$2,028.34	$2,028.34	$2,028.34	$2,028.34	$2,028.34	$2,028.34
CBL & CPP	$2,028.34	$2,028.34	$2,028.34	$2,028.34	$2,028.34	$2,028.34	$2,028.34

Appendix B – Data tables

Table 12: Data for Figure 15: Annual bill with demand response - peak load reduction of 10%

Tariff case	Residential - Base	Residential - Peak use	Residential - Off-peak use	Residential - Split peak use	Residential - Critical peak use	Commercial	Other
Cost base	$1,922.23	$1,964.61	$1,879.90	$1,893.78	$1,889.46	$1,955.02	$1,839.85
Dynamic	$1,919.56	$1,971.61	$1,867.57	$1,884.61	$1,878.48	$1,963.85	$1,818.38
CPP	$1,913.19	$1,951.30	$1,875.13	$1,897.80	$1,893.12	$2,005.90	$1,839.12
Flat-ToU hybrid	$1,924.81	$1,969.88	$1,879.79	$1,894.63	$1,889.72	$1,961.38	$1,837.18
CBL & ToU	$1,911.27	$1,909.20	$1,913.34	$1,910.10	$1,913.42	$1,887.51	$1,915.30
CBL & CPP	$1,978.80	$1,975.63	$1,981.98	$1,979.38	$1,978.74	$1,972.94	$1,984.98

Table 13: Data for Figure 16: Annual bill savings with demand response - peak load reduction of 10%

Tariff case	Residential - Base	Residential - Peak use	Residential - Off-peak use	Residential - Split peak use	Residential - Critical peak use	Commercial	Other
Cost base	$106.11	$110.87	$101.36	$104.65	$102.87	$120.89	$96.87
Dynamic	$108.78	$114.15	$103.43	$106.86	$105.24	$122.79	$98.36
CPP	$115.15	$119.18	$111.12	$115.37	$113.88	$134.88	$107.31
Flat-ToU hybrid	$103.53	$108.68	$98.39	$101.71	$100.03	$117.75	$93.54
CBL & ToU	$117.07	$119.15	$115.00	$118.24	$114.93	$140.84	$113.04
CBL & CPP	$49.54	$52.72	$46.37	$48.96	$49.60	$55.40	$43.36

Table 14: Data for Figure 20: Annual bill savings from demand response – peak load reduction of 18%

Tariff case	Residential - Base	Residential - Peak use	Residential - Off-peak use	Residential - Split peak use	Residential - Critical peak use	Commercial	Other
Cost base	$191.00	$199.56	$182.45	$188.37	$185.17	$217.60	$174.36
Dynamic	$195.81	$205.47	$186.17	$192.35	$189.44	$221.02	$177.05
CPP	$207.27	$214.53	$200.02	$207.66	$204.99	$242.79	$193.15
Flat-ToU hybrid	$186.04	$195.30	$176.81	$182.76	$179.75	$211.58	$168.10
CBL & ToU	$210.73	$214.46	$207.00	$212.83	$206.87	$253.50	$203.48
CBL & CPP	$89.17	$94.89	$83.46	$88.13	$89.29	$99.71	$78.05

FRONTIER ECONOMICS NETWORK
BRISBANE | MELBOURNE | SYDNEY | BRUSSELS | COLOGNE | LONDON | MADRID
Frontier Economics Pty Ltd 395 Collins Street Melbourne Victoria 3000
Tel: +61 (0)3 9620 4488 Fax: +61 (0)3 9620 4499 www.frontier-economics.com
ACN: 087 553 124 ABN: 13 087 553 124