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Estimation of Long Run Marginal Cost and Other Concepts Related to the Distribution Pricing Principles

Prepared for Essential Energy

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Report Authors

Oliver Nunn

Adrian Kemp

Simon Arthur

Contact Us

Level 40, 161 Castlereagh Street
Sydney NSW 2000

Phone: +61 2 8880 4800

Disclaimer

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1. Introduction

There have been a number of recent changes to the National Electricity Rules (NER) that relate to the setting of distribution network tariffs. One of these changes obliges each distribution business to provide the Australian Energy Regulator with a Tariff Structure Statement (TSS), which demonstrates compliance with the rule requirements, and explains to customers the basis for their tariff structures.

Essential Energy (hereafter ‘Essential) is currently in the process of developing its inaugural TSS. This requires that Essential:

- estimate the long run marginal cost (LRMC) of its network services;
- estimate the stand-alone and avoidable costs of serving customers assigned to each of its tariff classes; and
- explain the approach that it has adopted to allocate its residual costs in a manner that is consistent with the distribution pricing principles.

HoustonKemp has been engaged to review Essential’s current approach to these tasks, and to recommend changes that may be necessary to ensure compliance with the NER.

1.1 Structure of this report

The remainder of this report is structured as follows:

- Section 2 describes the economic concepts of marginal cost, stand-alone cost, and avoidable cost, and the relevance of these concepts to setting prices for electricity network services;
- Section 3 sets out our advice as to an approach for estimating the LRMC for each of Essential’s services;
- Section 4 sets out our advice as to an approach for estimating stand-alone and avoidable costs for each of Essential’s tariff classes; and
- Section 5 sets out our recommended approach to allocate residual costs in a manner consistent with the distribution pricing principles.

This report is also accompanied by the Excel workbook that we have developed for Essential.

2. Critical Concepts and Background

This chapter sets out relevant background and context for the remainder of the report as follows:

- First, we describe the economic concept of *marginal cost*, and more specifically of *long run marginal cost.*
- Having defined the concept of marginal cost, the next step is to identify the service whose marginal cost we wish to estimate, ie, the *service provided by an electricity network*.
- Finally, we define the concepts of *stand-alone* and *avoidable costs*.

The remainder of this section defines each of these concepts, and their relevance to setting prices for electricity network services.

2.1 The concept of marginal cost

A necessary condition for economic efficiency is that the price of a service equals its *marginal cost*, ie, the change in total costs effected by a small increase in demand for a service.

Marginal cost is therefore a forward-looking concept – by definition it is the cost of the *next* unit, the unit that has *not yet been produced*. This is well described by Kahn, who states that:

> Marginal costs look to the future, not to the past: it is only future costs for which additional production can be causally responsible; it is only future costs that can be saved if that production is not undertaken.[1]

Marginal cost can be estimated either in the *short run or* the *long run.* The fundamental distinction between short run and long run marginal cost is the timeframe over which production processes can be adjusted so as to minimise cost. Specifically:

- short run marginal cost (or 'SRMC') is defined as the cost of an incremental change in demand, holding *at least one* factor of production constant; whereas
- long run marginal cost (or 'LRMC') relaxes the constraints of its short run equivalent, and so is the cost of an incremental change in demand assuming all factors of production can be varied.

The rules require that tariffs be set 'based on LRMC' and so for the purposes of this report, we confine our discussion to the concept of LRMC.

2.2 Marginal cost of an electricity network service

Clause 6.18.5(e) of the NER states that:

> Each tariff must be based on the *long run marginal cost* of providing the service to which it relates to the *retail customers* assigned to that tariff …

The clause suggests that each tariff therefore must relate to a (not necessarily distinct) service provided to a customer. It is therefore essential that we define the service in question. Put simply, to estimate the cost of 'the next unit', we must clearly define what that 'unit' is.

[1] Alfred Kahn, 'The Economics of Regulation – Volume 1', pp 88.

2.2.1 Definition of the service provided by an electricity network

There is no hard-and-fast approach to defining the services provided by a distribution network. For the purpose of estimating LRMC so as to set tariffs, we have defined the fundamental service that a network provides to customers as an energised connection with a set of accompanying rights, which may include:

- the right to withdraw up to a specified amount of power from a defined connection point at any time;
- the right to inject up to a specified amount of power into a defined connection at any time; and
- the right to exercise the rights accompanying the energised connection with some expectation of reliability.

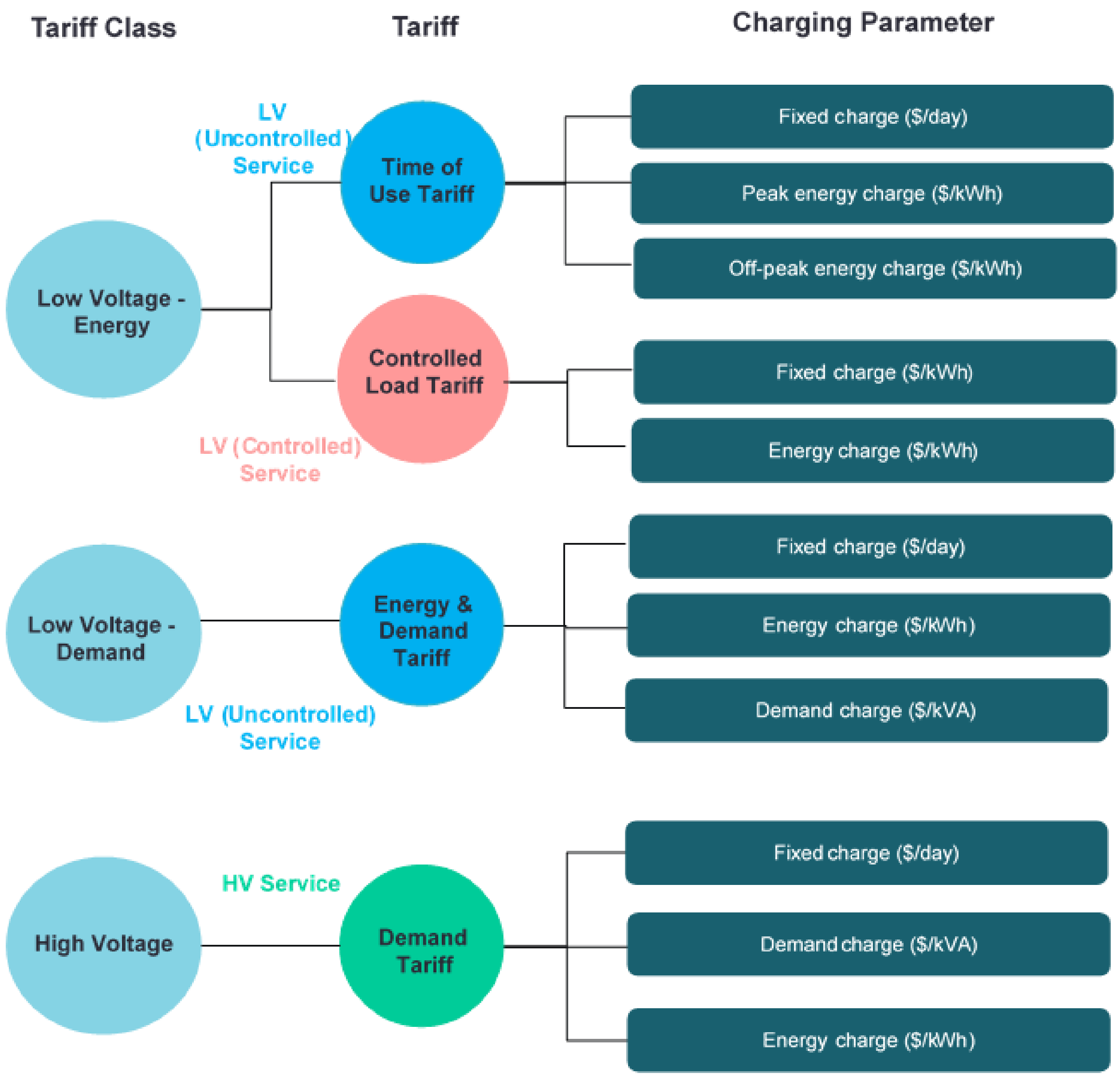
Each right gives rise to an obligation on the network, eg, a right to withdraw creates an obligation on the network to invest in sufficient capacity, so as to provide that service to the customer. Sometimes these obligations are onerous, and so are costly to fulfil; sometimes they are superfluous, and so result in no incremental cost.

Figure 1 overleaf illustrates the relationship between the network service and other critical concepts related to the distribution pricing principles, ie, tariff classes, tariffs, and charging parameters. This example is illustrative – Essential's network has many more tariffs classes, tariffs, and services than this simplified example.

We note the following:

- A service can be common to different tariff classes, eg, the LV (Uncontrolled Service) in this example is common to both the 'Low Voltage – Energy' and the 'Low Voltage – Demand' tariff classes.
- A network can supply more than one service to the customers within a tariff class, eg, the LV (Uncontrolled) and LV (Controlled) services are both provided to customers in the 'Low Voltage – Energy' tariff class.
- In some cases the definition of a tariff class will coincide with a definition of service, eg, customers on the HV tariff class only receive the HV service.

Figure 1 – Illustration: Relationship between services, tariff classes, tariffs, and charging parameters



2.2.2 Drivers of forward-looking costs of providing an energised connection

Our definition of the fundamental service provided by an electricity network establishes a clear concept – a network provides an *energised connection service*. To estimate marginal costs, we need to determine the way in which increased provision of this service translates into increases in forward-looking network costs.

The principal determinant of costs for electricity network assets is the expected maximum (or 'system peak') demand. When maximum demand increases, the distributor must augment its network or else risk the prospect of not being able to supply its customers. The network's most important *obligation* therefore arises from customers' right to withdraw power during the system peak.

The marginal cost of an energised connection is therefore typically expressed in terms of the cost per kW (or cost per kVA) of maximum demand. Put another way, the 'cost of the next unit' is assumed to be the cost of supplying one more unit of demand during the system peak.

We emphasise that the marginal cost of a network service depends on the characteristics of that service, ie, on the rights that accompany the energised connection. For example, the marginal cost may be influenced by:

- the ability for the network to interrupt the customer's load (eg, controlled load); or
- the part of the network to which the customer connects (eg, low voltage or high voltage).

It is therefore misleading to refer to *the* marginal cost of network services – the characterisation implies that there is a unique value. In the extreme, we could define a distinct service at every point in time, and for each voltage level, and geographic part of the network. The economic principle of efficient pricing would then suggest that a different price should be charged for each of these services. However, such granular pricing is impractical, and so in practice network businesses use tariff classes or similar concepts to aggregate customers to whom they provide similar services.

2.3 Stand-alone costs and avoidable costs

Electricity network businesses are natural monopolies, and so they exhibit decreasing average total cost curves as demand for network service increases over time. It follows that pricing at LRMC will not allow a network business to recover its total costs. Put another way, there will be 'residual costs' that will not be recovered from setting prices equal to marginal cost.

The manner in which a network recovers its residual costs has implications for efficiency, and so the Rules establish limits on the residual costs that can be recovered from any one group of customers. In particular, clause 6.18.5(e) of the NER states that:

> For each *tariff class*, the revenue expected to be recovered must lie on or between:
>
> (1) an upper bound representing the stand alone cost of serving the *retail customers* who belong to that class; and
>
> (2) a lower bound representing the avoidable cost of not serving those *retail customers*.[2]

The rule introduces two terms that require definition: *stand alone cost* (hereafter written as 'stand-alone cost') and *avoidable cost*.

2.3.1 Stand-alone cost

The *stand-alone cost* of serving a group of customers is the total cost required to serve those customers alone, ie, were we to the build the network anew, removing all other customers from the network.

Clause 6.18.5 (e)(1) states that revenue recovered from a tariff must be less than '…the stand alone cost of not serving retail customers serving those retail customers', ie, the costs that the network would incur, were it *only* to supply those customers.

The upper bound established by the rule ensures customers on any given tariff class do not pay more *as a result of the provision of services to other customers*. In recovering its residual costs, a network business must have regard to this constraint.

[2] AEMC, National Electricity Amendment (Distribution Network Pricing Arrangements) Rule 2014 No. 9, 6.18.5(e).

2.3.2 Avoidable costs

Strictly speaking, the marginal cost refers to the additional cost of supplying a single, infinitesimally small additional unit of output. Marginal cost can equally be interpreted as the cost that would be avoided by producing one less such unit.[3]

The difficulties associated with measuring ‘infinitesimally small’ changes in production have given rise to two related economic concepts that serve as approximations for marginal cost, ie:

- *incremental cost* is the additional cost of supplying any (potentially large) increase in output; and
- *avoidable cost* is the reduction in cost from any (potentially large) decrease in output.

For example, an electricity network might assess the incremental cost of a new industrial customer connecting to the network. Similarly, the network might also assess the avoidable costs resulting from another industrial customer disconnecting from the network. It is worth noting that, like marginal costs, incremental and avoidable costs have both a short run and long run concept.

Clause 6.18.5 (e)(2) states that revenue recovered from a tariff class must exceed ‘…the avoidable cost of not serving’ the retail customers belonging to that tariff class, ie, the costs that could be avoided were the network not to supply these customers.

The economic principle underpinning this lower bound is simple – customers must face a price no lower than the average cost that could be avoided by not supplying them.

[3] This predicates that the cost function is a continuous, and is differentiable at the current level of output.

3. Estimation of Long Run Marginal Cost

This section sets out our advice as to the most appropriate methods for estimating the LRMC for the services that Essential provides. In particular, we describe:

- the principal approaches to estimating LRMC;
- the approach that we recommend Essential adopt to estimate the LRMC of the services it provides; and
- an approach to expressing these 'dollars per kVA per annum' LRMC estimates in terms of the charging parameters that constitute each tariff.

Our recommendations are generally consistent with those that we have provided in a similar report to Endeavour Energy.

3.1 Approaches to estimating LRMC

There are three main approaches to estimating LRMC, ie:

- a perturbation approach;
- an average incremental cost approach; and
- a stand-alone cost, or 'greenfields' approach.

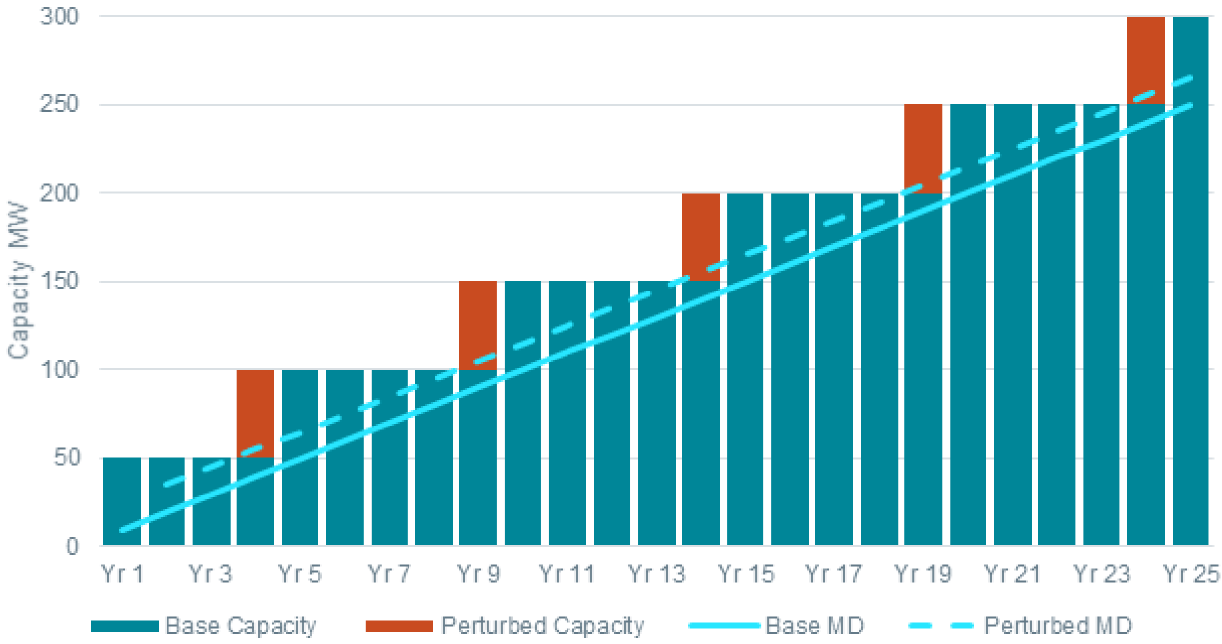
We describe and illustrate the application of each of these approaches in the following sections.

3.1.1 Perturbation approach

The perturbation approach analyses the changes in costs brought about when current forecasts of demand growth are 'perturbed' by a fixed and permanent increment. The perturbation (generally) triggers a change in capacity requirements, and so results in an increase in total supply costs.

Figure 2 sets out an illustrative example of the application of the perturbation approach, indicating projected levels of maximum demand, network capacity, and the change in capacity effected by the perturbation.

Figure 2 – Illustration of the perturbation approach



In this example, a hypothetical network asset experiences periodic upgrades to satisfy a rising maximum demand requirement. The perturbation results in an increase in maximum demand requirement *in every year*, and so capacity upgrades must occur earlier (as indicated in red).

The change in costs arising from the perturbation divided by the change in demand is the basis of the estimate of LRMC, ie:

$$LRMC = \frac{PV(expenditure\ with\ perturbed\ MD - \ expenditure\ with\ base\ MD)}{PV(perturbed\ MD - base\ MD)}$$

In practice, calculation of the perturbation approach requires the following information:

- an existing estimate of total operating expenditure and capital costs for each year over the relevant time horizon;
- an assumed cost and size (in MW) of a network capacity upgrade; and
- forecasts of load growth for the relevant network asset over the relevant time horizon.

In general, the perturbation approach requires more information than its alternative. Where this information is not readily available, it may not be feasible to estimate LRMC via a perturbation approach.

Inputs to the calculation of LRMC

It is helpful to provide some additional description of the inputs to the formula set out above. In particular, we note the following:

- **Forecasts of costs** – the forecasts of cost with and without the perturbation are generally calculated using costs *as incurred*. For example, at the moment of an upgrade, the entire cost of that upgrade is incurred. This can give rise to 'end effects' (ie, where a finite time horizon essentially distorts the modelling results).
- **Definition of maximum demand –** the maximum demand parameter in the equation above is ultimately a measure of the driver of capacity upgrades, and so network costs. The relevant maximum demand parameter is therefore that which is most closely aligned with network costs. In the case of distribution

networks, this will often be the sum of coincident or non-coincident demand across relevant network assets, say bulk supply points.

- **Length of time horizon –** as a general rule, the time horizon should be as long as possible. In practice, limitations on data and the uncertainty of demand forecasts mean the time horizon is typically over a period of 5 to 10 years.

These principles also apply to the average incremental cost approach.

3.1.2 Average incremental cost approach

The average incremental cost approach estimates the LRMC of network services as the average change in projected operating and capital expenditure attributable to future increases in demand. In practice it is estimated by:

1. projecting future operating and capital costs attributable to expected increases in demand;
2. forecasting future load growth for the relevant network asset (or assets); and then
3. dividing the present value of projected costs by the present value of expected increases in demand.

In simple terms, the average incremental cost approach averages the total cost of supplying new growth in demand over that growth in demand.

Figure 3 – Illustration of the average incremental cost approach

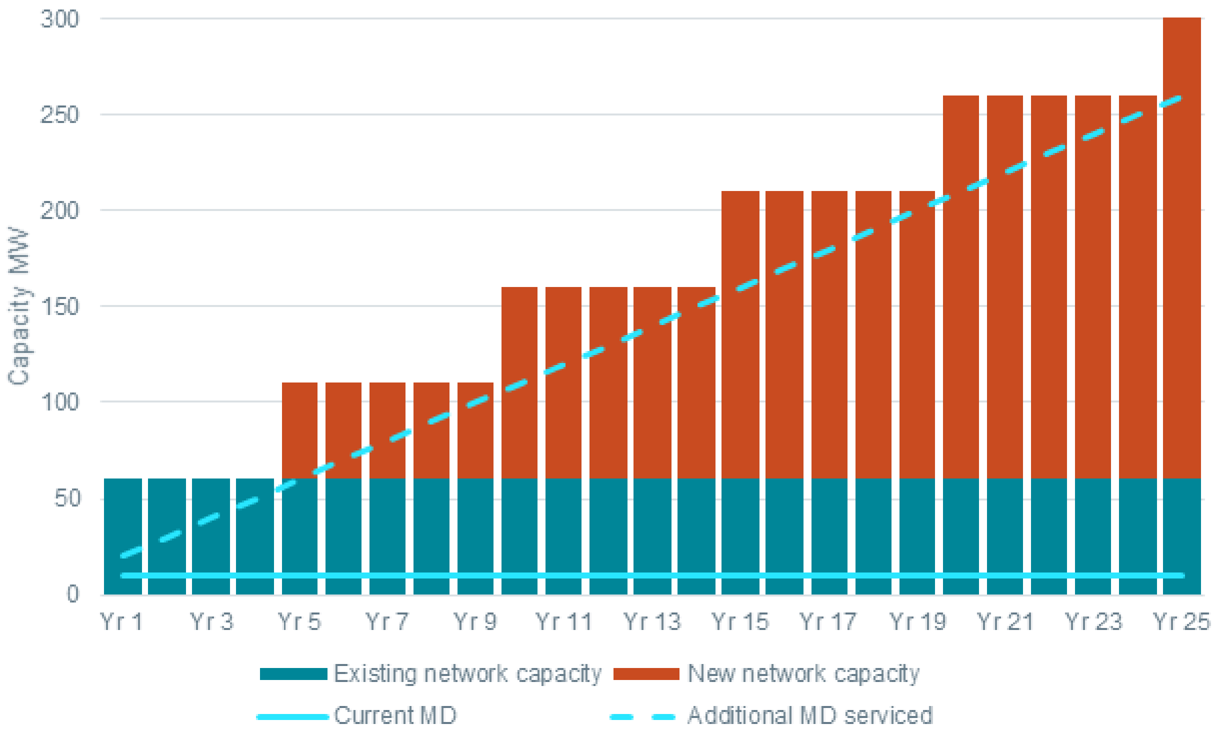


Figure 3 sets out an illustrative example of the application of the average incremental cost approach. By way of explanation:

- the blue line represents the current level of maximum demand;
- the green bars represent the current network capacity;
- the dashed blue line represents projected increases in maximum demand above its current level; and

- the red bars represent projected increases in network capacity required to meet the projected increases in demand.

Using the projected cost attributable to the increases in capacity, the formula for estimating the average incremental cost is:

$$LRMC = \frac{PV(expenditure\ relating\ to\ new\ network\ capacity)}{PV(additional\ demand\ serviced)}$$

We note that the average incremental cost approach requires that there be a positive increment in demand. Put another way, the average incremental cost approach is undefined when demand is flat or falling.

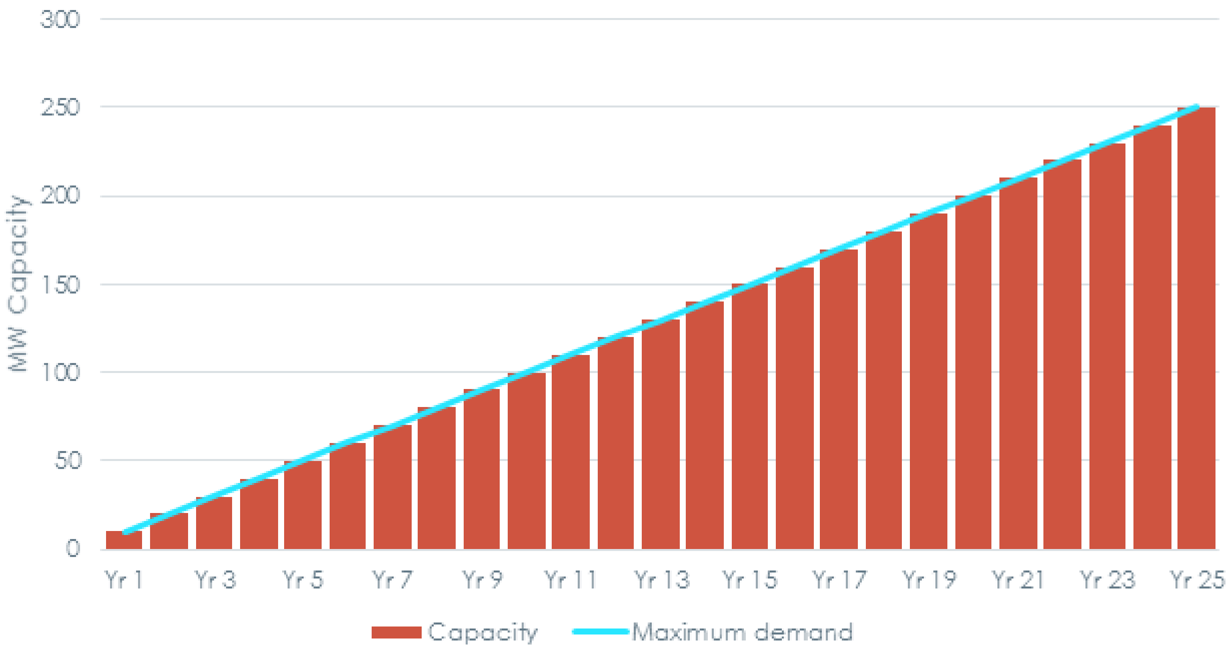
3.1.3 Stand-alone approach

The stand-alone approach estimates LRMC based on the cost to build the network anew, ie, assuming that there is no pre-existing network to serve prevailing electricity demand. The stand alone cost is therefore unaffected by the current level of capacity, and so is effectively a measure of constructing new network infrastructure.

The stand-alone approach is a relatively crude method for estimating LRMC, and tends to be most appropriate in markets where demand is increasing and where supply can be increased in relatively small increments.

Figure 4 illustrates the build profile that is implicit in the stand-alone cost approach. Unlike the lumpy build profiles exhibited by the perturbation and average incremental cost approaches, the stand-alone cost method assumes that a network service provider can build the exact amount of capacity required to meet its annual demand.

Figure 4 – Illustration of the stand-alone approach



The lumpy nature of electricity network investment therefore means that the stand-alone approach tends to produce estimates of LRMC that are a poor proxy for actual changes in network costs arising from changes in demand.

3.2 Recommended approach to estimating LRMC in Essential's network

We recommend that Essential adopts an average incremental cost approach to estimate the LRMC of each of its services. Our recommendation is based on the following two considerations, or reasons.

First, although the perturbation method provides the most precise estimate of marginal cost – ie, the change in future costs attributable to a permanent increase in demand – Essential does not have information as to current, projected, and hypothetical capacity upgrade costs throughout its network. In contrast, Essential does possess sufficient information to apply an average incremental cost approach.

Second, recall that the purpose of the estimate of LRMC is to inform the levels at which Essential sets its charging parameters for each of its tariffs. In the main, Essential's tariffs apply to customers spread out across many different locations, and supplied by many distinct network assets.

The tariffs are therefore providing a uniform price signal that will likely not align with the specific costs of additional consumption at individual points in the network. In some locations, additional demand for network services will result in costs that exceed the level implied by the tariff; in others locations, additional costs will be less than the level implied by the tariff. This is not an outcome of Essential's selection of tariff classes, but rather a consequence of the necessity of grouping customers for the purpose of setting tariffs.

One shortcoming of the average incremental cost approach is that it does not provide the highly granular signal of the perturbation approach, which connects highly specific consumption decisions with the costs that they impose. However, because the LRMC estimate's purpose is to set tariff levels for tariff classes that span the entirety of Essential's network, more granular estimates of the LRMC are unlikely to give rise to more efficient price signals.

An additional shortcoming of the average incremental cost approach is it will likely underestimate the LRMC when a significant capacity augmentation is imminent, and overestimate the LRMC when a significant capacity augmentation is not required in the foreseeable future. That said, it is a reasonable approximation of the LRMC when greater precision about the efficient price signal is not likely to effect changes in customer behaviour so as to avoid those future costs.

3.2.1 Our implementation of the average incremental cost approach

Our implementation of the average incremental cost approach is based on the following inputs, or assumptions:

- **time horizon** –we have used a five year time horizon in order to estimate LRMC;
- **demand forecasts** – we have used forecasts of system-wide coincident maximum demand, with a 50 per cent probability of exceedance; and
- **growth-related capex and opex forecasts** – we have used Essential's estimated growth-related capex, and have made an assumption that growth opex is 2 per cent of growth related capex over the time horizon.

Table 1 sets out Essential's projections of demand and growth related capex over the five year time horizon.

Table 1 – Demand and capex projections

Forecast	2015-16	2016-17	2017-18	2018-19
Increase in Demand (MVA)				
LV	24	38	56	71
HV	27	43	63	80

ST	32	51	74	94
Growth Capex ($'000)				
LV	34,679	39,419	39,623	39,252
HV	34,679	39,419	39,623	39,252
ST	16,542	9,421	3,908	4,508

Table 2 sets out the estimates of LRMC that result from application of the average incremental approach for each of Essential's services.

Table 2 – Estimates of the LRMC of the services provided by Essential

Service	LRMC Estimate ($ per kVA·year)
Low Voltage	
Non-controlled	316
Controlled 1	0
Controlled 2	16
High Voltage	165
Sub-transmission	32

3.2.2 Importance of annualising projections

In principle, all costs – even those that occur far into the future – are relevant to an estimate of LRMC. However, in practice it is not feasible to model a series of payments that stretches infinitely far into the future, because of the increasing uncertainty associated with the lengthening of the time horizon.

The problem of results being heavily influenced by the seemingly arbitrary selection of time horizon is sometimes referred as the 'end-effects problem'. Two possible approaches to addressing the end-effects problem are to:

- identify whether there is a point in time beyond which outcomes are unaffected by the perturbation – if this is the case, select that point as the end of the time horizon; or
- select a suitably distant end point for the time horizon, at which point the residual value of all assets will be tallied, and subtracted from total costs.

Given the short time horizon of the model we have implemented, we have addressed 'end effects' by using forecast capital expenditure on an annualised basis, ie, growth capex enters the LRMC estimate as the annual payment for an annuity at the current discount rate assuming repayment over the operating life of the asset. This approach effectively is subtracting the residual book value of all assets from total costs at the end of the modelling horizon, and so is consistent with the second of the two approaches set out above.

3.3 Translation of LRMC estimates into charging parameters

The average incremental cost approach yields an LRMC estimate for each network service expressed in dollars per kVA per annum. However, many customers are not, and indeed cannot, be charged on the basis of their contribution to the network's maximum demand. It is therefore necessary to express these 'dollars per kVA per annum' LRMC estimates (hereafter termed 'base LRMC estimates') in terms of the charging parameters that constitute each tariff.

Translation of LRMC into charging parameters for non-ToU tariffs

Translation of LRMC into charging parameters for non-ToU tariffs involves two steps, ie:

1. Converting the base LRMC estimate using the *power factor* for a given customer class.
2. Converting the resultant estimate to dollars per kWh by dividing by the number of hours in a year:

$$LRMC\ estimate\ (\$\ per\ kWh) = \frac{LRMC\ (\$\ per\ kW \cdot year)}{8760\ hours}$$

Translation of LRMC into charging parameters for ToU energy tariffs

Expressing the base LRMC estimate in terms of time-of-use tariffs requires an additional term to capture the probability that maximum demand (or 'MD') for the network occurs during a given time period (ie, peak, shoulder or off-peak). After adjusting for the power factor, the LRMC estimate for each time period can be calculated as follows:

$$LRMC\ \ estimate\ (\$\ per\ kWh\ ) = \frac{LRMC\ \ \times Prob.of\ MD\ occurring\ during\ time\ period}{Total\ number\ of\ hours\ in\ time\ period\ in\ the\ year}$$

Table 3 illustrates this calculation for Essential's BLNT2AU tariff.

Table 3 – Efficient charging parameters for Essential's BLNT2AU ToU energy tariff

Time Period	LRMC of the service ($ per kVA·year)	Power Factor	LRMC of the service ($ per kW·year)	Probability of MD	Number of Hours per annum	LRMC Estimate (c/kWh)
Peak	316	0.85	371	50%	1,260	14.74
Shoulder	316	0.85	371	50%	2,520	7.37
Off-Peak	316	0.85	371	0%	4,980	0.00

Translation of LRMC into charging parameters for time of use demand tariffs

Essential's demand tariffs have charging parameters that are more closely aligned with the base LRMC estimate, because they are already expressed in terms of dollars per kVA per annum. The efficient charging parameters can be estimated as follows:

$$LRMC\ \ estimate\ (\$\ per\ kVA\ per\ month\ ) = \frac{LRMC\ \ \times Prob.of\ MD\ occurring\ during\ time\ period}{Number\ of\ months\ for\ which\ time\ period\ applies\ in\ the\ year}$$

Table 4 illustrates this calculation for Essential's BLNT2AU tariff.

Table 4 – Efficient charging parameters for Essential's BLNT2AU ToU demand tariff

Time Period	Tariff Class LRMC ($/kVA)	Probability of MD	Number of Months	Efficient Charge ($/kVA/month)

Peak	316	50%	12	13.16
Shoulder	316	50%	12	13.16
Off-Peak	316	0%	12	0.00

3.3.1 Treatment of controlled load

Many of Essential's low voltage customers purchase a controlled load service in addition to their standard low voltage service. Essential has the capability of interrupting a controlled load during system peak events, and so limiting their contribution to the key driver of LRMC. For this reason, the controlled load service will have a much lower LRMC than its non-controlled equivalent.

Essential has two different controlled load services, namely:

- the controlled load 1 service, supplied under the BLNC1AU tariff; and
- the controlled load 2 service, supplied under the BLNC2AU tariff.

To account for the differing obligations on the network arising from these services, we note that:[4]

- the controlled load 1 service only allows a customer to withdraw at times that do not coincide with system peak events; and
- the controlled load 2 service is largely interruptible, but can nevertheless contribute to a maximum demand event.

Consistent with these observations, we recommend that Essential assumes that the controlled load 1 service has an LRMC of zero, and that the controlled load 2 service has an LRMC greater than zero, and less than the LRMC of the non-controlled low voltage service. The exact value should be assessed based on an assessment of the probability of controlled load 2 servicing contributing to Essential's system peak.

[4] BLNC1AU Controlled Load 1 - Supply will be made available for 5 to 9 hours overnight on weekdays and extra hours on weekends except where the load is controlled by a time clock

BLNC2AU Controlled Load 2 - Supply will be made available for 10 to 18 hours per day on weekdays and all hours on weekends except where the load is controlled by a time clock.

Source: Essential Energy Network Price List V4, p.3.

4. Estimation of Stand-alone and Avoidable Costs

This section sets out our recommendation as to the most appropriate methods for estimating stand-alone and avoidable costs for each of Essential's tariff classes.

Essential has an existing model, and approach for estimating stand-alone and avoidable cost, which it has applied for the last several years. Our advice therefore comprises:

- a review of Essential's existing approach; and
- an assessment of whether that approach is consistent with the economic concepts of stand-alone and avoidable costs.

We have also developed a new Excel model for Essential that implements this approach to estimate stand-alone and avoidable cost for each tariff class.

4.1 Methods for estimating stand-alone and avoidable costs

Estimating stand-alone and avoidable costs for the customers on a tariff class essentially involves asking two questions, ie:

1. **To assess stand-alone costs:**

   'What costs would the network incur, were the network ***only*** to supply those customers?

2. **To assess avoidable costs:**

   What costs would the network avoid, were it not to supply those customers?

Answering these questions is an inherently hypothetical exercise. Networks neither routinely assess the cost reductions that might result from disconnecting large groups of customers, nor estimate the cost to supply those customers under the assumption that the remainder of their customer base no longer exists. In the absence of these type of detailed studies, it is necessary to make assumptions. An approach to estimating stand-alone and avoidable cost comprises these assumptions, and the rationale for their adoption.

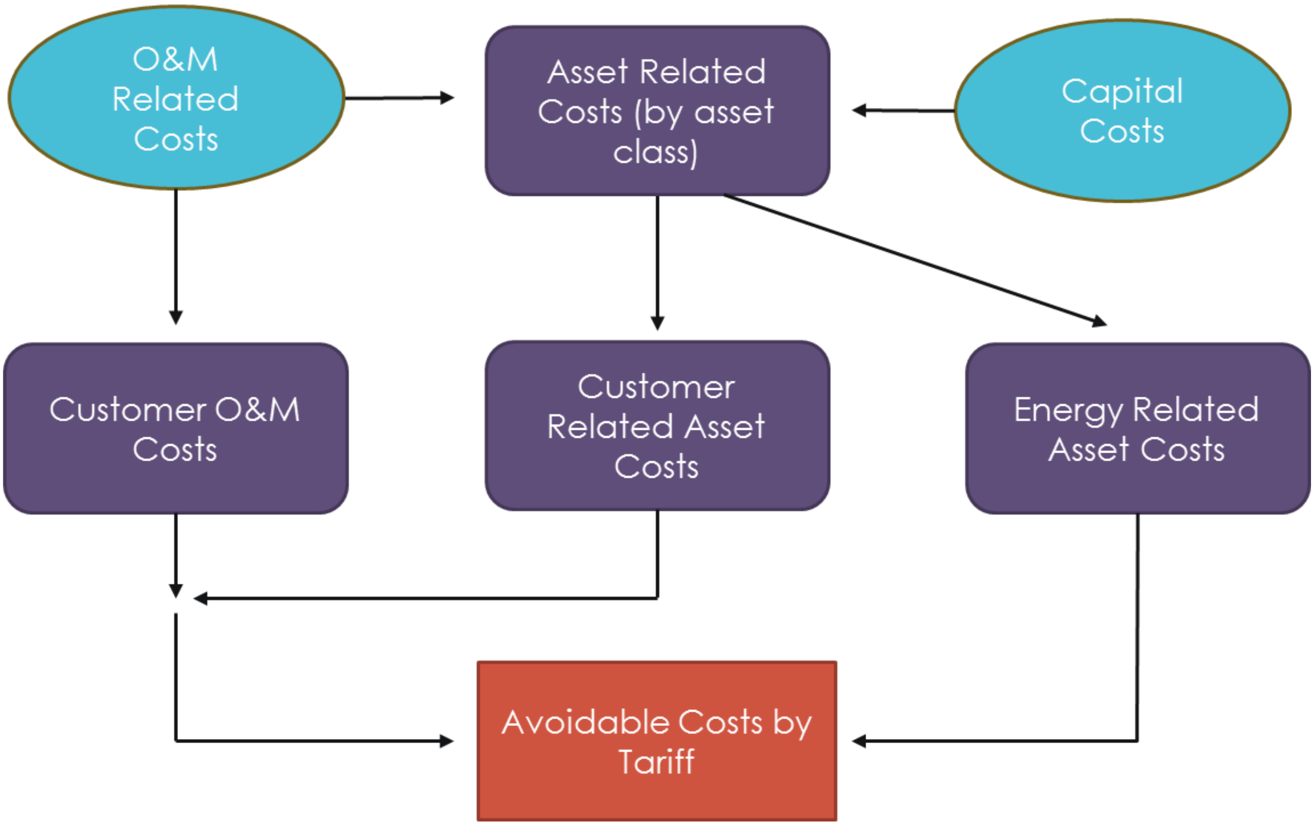
4.2 Essential's approach to estimating avoidable cost

Essential has calculated avoidable cost for each of its tariffs in the following steps:

1. Categorise opex as being either customer related or asset related.
2. Classify total asset related costs, which includes asset related opex and capital costs, as either:
   - customer related asset costs; or
   - energy related asset costs.
3. Customer opex costs, customer related asset costs and energy related asset costs are each allocated to individual tariffs using weights derived from customer numbers, and energy consumption.

This approach is summarized schematically in Figure 5 below, where each arrow represents a separate allocation process.

Figure 5 – Essential's approach to estimating avoidable cost



In general terms, the approach that Essential has adopted to estimate avoidable cost is sound. Nevertheless, there may be benefit in clarifying, or providing more information, around the allocation process. We have not been able to identify any publicly available documents that explain this allocation process, and so there may be benefit for Essential in considering the rationale for its current allocation processes to support its tariff structure statement.

More importantly, we note that under the Rules avoidable costs create a constraint on the revenue that can be recovered from *tariff classes* rather than tariffs. We are unclear whether Essential has been applying this constraint at the tariff level, and so made its pricing task unnecessarily restrictive. We therefore recommended that the current approach be reconfigured to focus on avoidable costs per tariff class.

4.3 Essential's approach to estimating stand alone cost

In order to estimate stand alone cost, Essential calculates the cost of self-supply under four different scenarios. That is, Essential estimates the maximum demand for the average customer on each tariff and estimates how much this customer would have to spend to meet this maximum demand using either:

- a micro-generator;
- natural gas;
- solar; or
- some combination of the above.

Essential's approach is likely a useful assessment to inform its internal business decisions. However, it does not, of itself, directly address the requirement to estimate stand alone cost under the Rules.

4.4 Our recommended approach to estimating standalone cost

In the context of the Rules, the concept of stand alone cost is more readily applicable as an estimate of the costs of serving a tariff class alone. Therefore a more relevant approach to estimating standalone costs could involve classifying costs in a similar manner to Essential's approach to estimating avoidable cost. Each cost could be attributed to tariff classes using a weighting mechanism, where the weighting mechanism could be the number of customers on each tariff class, energy usage or some other measure. The two questions that must be asked when performing this analysis are:

> 'Which of these assets are needed to supply high voltage customers only?'; and
>
> 'What adjustments would be made to sub-transmission assets if there were only high voltage customers?'

One way to do this is assess costs one by one and categorise them on the basis of two dimensions as follows:

- **Whether costs are direct or indirect** – the framework assumes that a cost is either:
  - 'direct' or 'avoidable', ie, the cost can be attributed to a specific group of users and would not be incurred but for those users; or
  - 'indirect' or 'shared', ie, the cost is common to multiple groups of users.

  For example, customer metering is directly attributable to individual customers. In contrast, operational expenditure costs are generally indirect, eg, the cost of equity raising cannot be attributed to specific customers or customer groups.

- **Whether costs are fixed or variable** – the framework assumes that a cost is either:
  - ''variable', ie, the cost tends to increase in proportion to the scale at which the service is provided; or
  - 'fixed', ie, the cost is independent of the scale at which the service is provided.

  For example, maintenance and repair costs are considered variable as they are likely to be highly dependent on the physical size of the network. In contrast, equity raising costs are likely to be relatively independent of network characteristics such as the number of customers or maximum demand.

Having categorised individual costs, the next step would be to use a weighting mechanism such as customer numbers to attribute cost categories to each tariff class. In equation form, this process can be expressed as follows:

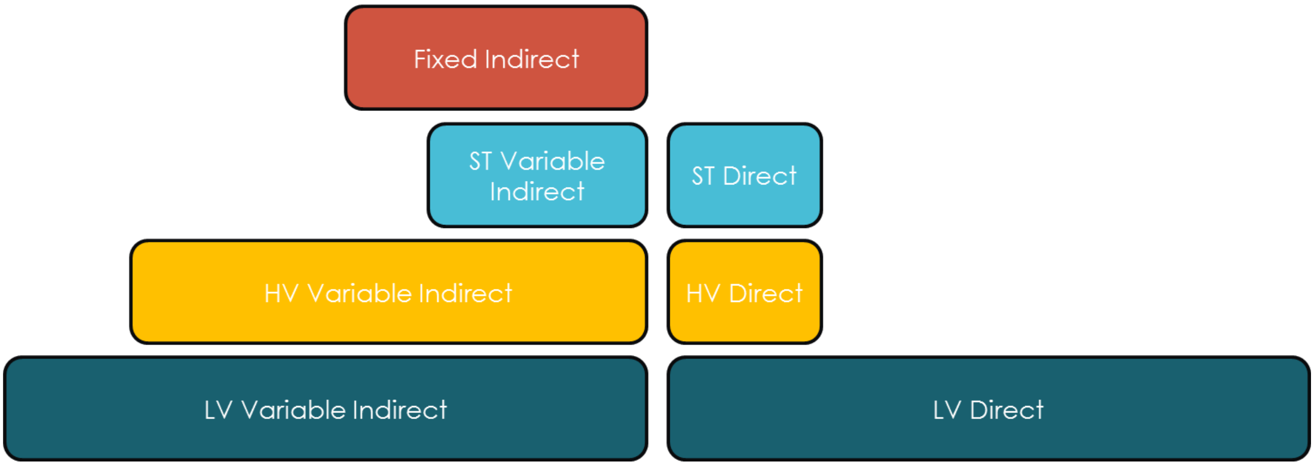
$$Stand\text{-}alone\ Cost_i = \ Avoidable\ Cost_i + \ Fixed\ Indirect\ Costs + \sum_{j=1}^{n} \beta_{i,j} Variable\ Indirect\ Costs_j,$$

Where:

- i represents each of Essential's tariff classes;
- $Stand\ alone\ Cost_i$ is the stand-alone cost to serve customers on tariff class i;
- $Avoidable\ Costs_i$ is the avoidable cost to serve customers on tariff class i;
- j represents each of Essential's variable indirect cost categories; and
- $\beta_{i,j}$ is the scaling factor (some value between zero and one) applied to cost category j.

Figure 6 illustrates this process applied to each of the three voltage levels in Essential's network, ie, sub-transmission, high voltage, and low voltage.[5] The figure illustrates the relationship between the different cost components and their relative size.

Figure 6 – Components of standalone costs of for Essentials three voltage levels

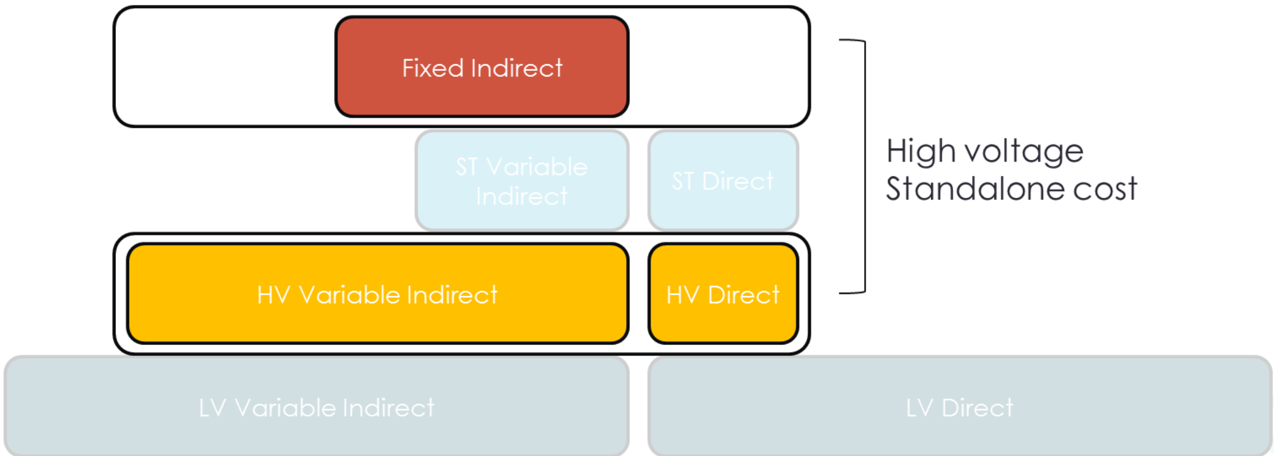


Variable indirect costs of higher voltage services necessarily feed into the variable indirect costs of lower voltage services. Put another way, part of the low voltage variable indirect costs are associated with providing sub-transmission and high voltage services, which are necessary precursors to low voltage supply.

Figure 7 shows that stand alone costs of a particular customer group are calculated to be the sum of:

- fixed indirect costs;
- direct costs incurred by that group; and
- variable indirect costs attributable to that group.

Figure 7 – Framework for calculating stand-alone cost of high voltage customers



[5] [5]For the purposes of illustration, this picture simplifies Essential's tariff classes by the LV Energy and LV Demand tariff classes, and omitting the Inter-Distributor Transfer and Unmetered tariff classes.

We have implemented our recommended approach in the Excel model that accompanies this report. This approach yields the estimations of stand-alone cost set out in Table 5.

Table 5 – Components of standalone cost for each tariff class ($2015-16m)

Tariff Class	Avoidable costs	Fixed indirect	Variable indirect	Stand-alone
LV Energy	104	0	767	872
LV Demand	13	0	767	780
HV Demand	4	0	499	503
ST Demand	11	0	77	88
Unmetered	0	0	384	384

Low voltage classes have been attributed the highest variable indirect costs, because the majority of Essential's customers, energy and demand are associated with low voltage customers.

4.5 Rationale for recommended approach

The approach we are recommending predicates that current network expenditure is a valid reference point for answering the two questions set out in section 4.1 above. There is no guarantee that this assumption will always hold.

For example, consider a tariff class consisting only of large industrial customers located at one remote, isolated part of the network. Expenditure to supply these customers via the existing network could potentially well exceed the cost of a new network constructed solely to service these customers alone, say in the form of a small network with energy supplied via a local generator.

In contrast, it seems reasonable to assume that the optimal network to supply *all* of the customers in the low voltage network – and only those customers – would have similar characteristics to the current network, albeit with a reduction in the scale of investment in the high voltage and sub-transmission systems. Given that Essential's tariff classes are principally defined with respect to voltage level, in our opinion the approach that we have recommended is reasonable.

In the case of Essential's network, there is the question as to whether there are some customers that might reasonably be supplied without a network solution, such as those located at the end of very long radial lines. In such a case, the argument might be made that the relevant standalone cost of serving these customers might be based on a non-network solution, eg, via an embedded generator.

However, any such customers are likely to sit within a much larger tariff class, and so Essential's current tariff classes are better suited to the approach we have recommended above. Were Essential to have a tariff class for customers located in isolated parts of the network – something which is consistent with the rules surrounding the constitution of tariff classes – it might be reasonable to adopt the off-grid supply approach that Essential is currently using to estimate stand-alone cost for those customers where a non-network solution would be technically feasible.

4.6 Summary of Results

Table 6 sets out our indicative estimates of Essential's avoidable cost and standalone cost by tariff class. In the time available to us, preparing these estimates has required that we make many assumptions about the characteristics of Essential's costs, and the connection between those costs and specific groups of customers. We recommend that in the future Essential should conduct a more detailed review of these input assumptions, which might yield different results.

Table 6 – Estimates of avoidable cost, implied and expected revenue, and stand-alone cost ($m)

Tariff Class	Avoidable Cost	Standalone Cost
LV – Energy	104	872
LV – Demand	13	780
HV – Demand	4	503
ST – Demand	11	88
Unmetered	0	384

5. Allocation of Residual Costs

This section sets out our recommended approach to allocate residual costs in a manner consistent with the distribution pricing principles. In particular, we describe:

- the critical requirements emerging from the rules; and
- our recommendation as to an approach to allocate residual costs in a manner consistent with the rules.

5.1 Requirements emerging from the Rules

We have described the requirements to set prices based on LRMC, and to ensure that the recovery of residual costs does not violate the upper and lower bounds established by the stand-alone and avoidable costs of each tariff class. Paragraphs (g) and (h) of Clause 6.18.5 of the NER establish the additional constraints on the recovery of residual costs.

5.1.1 Requirements on the recovery of revenue from a tariff

Rule 6.18.5(g) of the NER states that:

> The revenue expected to be recovered from each tariff must:
>
> (1) reflect the *Distribution Network Service Provider's* total efficient costs of serving the *retail customers* that are assigned to that tariff;
>
> (2) when summed with the revenue expected to be received from all other tariffs, permit the *Distribution Network Service Provider* to recover the expected revenue for the relevant services in accordance with the applicable distribution determination for the *Distribution Network Service Provider*; and
>
> (3) comply with sub-paragraphs (1) and (2) in a way that minimises distortions to the price signals for efficient usage of the network that comply with the pricing principles set out in paragraph (f).

From an economic perspective, we have interpreted the three sub-paragraphs as follows.

Subparagraph (1) – Revenue recovered must 'reflect … total efficient costs'

Subparagraph (1) states that:

> '… revenue expected to be recovered from each tariff must reflect … total efficient costs of serving the retail customers that are assigned to that tariff'.

The term 'cost reflective' is often used to mean 'efficient'. However, 'cost reflective' and its derivatives are neither economic terms of art, nor are they typically applied in manner that is consistent with economic theory. Subparagraph (1) therefore does not have a clear, unambiguous economic meaning.

Similarly, the compound expression 'total efficient costs' is also unclear when referring to serving a specific group of customers. For the purposes of determining the costs to be recovered from each tariff, we have defined 'total efficient costs' as the costs necessary to provide the service to customers including allocated operating costs and a return on and of the regulated asset base as allocated to the provision of the service to those customers. The 'total efficient costs' are therefore determined at the discretion of the distributor so as to promote the pricing objective (ie, rule 6.18.5(a)) in a manner consistent with the National Electricity Objective.

Subparagraph (2) – Distributor must be permitted to recover its expected revenue

Subparagraph (2) states that the revenue that a distributor recovers across all of its tariffs should align with its revenue allowance. Put another way, this paragraph states that a distributor must be able to recover all of its residual costs from all of its tariffs.

Subparagraph (3) – Recovery of revenue must minimise distortions to price signals for efficient usage

From an economic perspective, paragraph (3) implies that a distributor must allocate its residual costs across tariffs so as to promote efficient usage of the service, ie, in a manner which 'minimises distortions to price signals for efficient usage' that would result from tariffs based on the LRMC of the service.

5.1.2 Requirements to consider customer impact

Clause 6.18.5 (h) of the Rules states that:

> A *Distribution Network Service Provider* must consider the impact on *retail* customers of changes in tariffs from the previous *regulatory year* and may vary tariffs from those that comply with paragraphs (e) to (g) to the extent that the *Distribution Network Service Provider* considers reasonably necessary having regard to:
>
> (1) the desirability for tariffs to comply with the pricing principles referred to in paragraphs (f) and (g) albeit after a reasonable period of transition (which may extend over more than one *regulatory control period*);
>
> (2) the extent to which *retail customers* can choose the tariff to which they are assigned; and
>
> (3) the extent to which retail customers are able to mitigate the impact of changes in tariffs through their usage decisions.

From an economic perspective, paragraph (h) creates a requirement on distributors to consider and limit customer impact, and allows them to deviate from efficient pricing to meet that requirement. The principle establishes:

- an objective of transitioning to more efficient tariff structures over time – sub-paragraph (1);
- the relevance of whether customers can change their tariff, and so lessen the impact of a transition to more efficient prices – sub-paragraph (2); and
- the relevance of whether customers are able to alter their consumption, and so lessen the impact of a transition to more efficient prices – sub-paragraph (3).

5.2 An approach to the allocation of residual costs

We have explained the requirements on the allocation of residual costs that arise from the pricing principles. This section describes our recommended approach, or framework, to the allocation of residual costs.

The critical requirement is established by clause 6.18.5(g)(3), ie, that residual costs must be recovered from each tariff in a manner that minimise distortions to price signals for efficient usage. This requirement has implications for:

- the manner in which residual costs are recovered from each tariff, ie, from the different charging parameters that make up each tariff; and
- the manner in which residual costs are recovered from, or allocated to, different tariffs.

We address these two implications separately.

5.2.1 Recovery of residual costs from different charging parameters

The need to recover a network businesses residual costs has critical implications for the charging parameters that it sets. Once a network business has set its charges equal to LRMC, any additional charges levied on the customer have the potential to distort the price signals for efficient usage.

However, the absence of substitutes for the network service means that a customers' decision to purchase an energised connection is highly price inelastic. Put simply, in general it is not feasible for customers to sever their connection to the network in favour of some alternative supply option, even if prices for the service increase.

Given that customers will tend to remain connected, it follows that residual costs can generally be recovered via fixed charges, also called 'network access' charges. Because these charges are independent of customer's usage decisions, they have no effect on the price signals for efficient usage of the network service. When the customer's usage charges (either in the form of charges for energy or demand) are set equal to LRMC, the marginal cost to the customer is equal to the marginal cost to the network, which promotes efficiency.

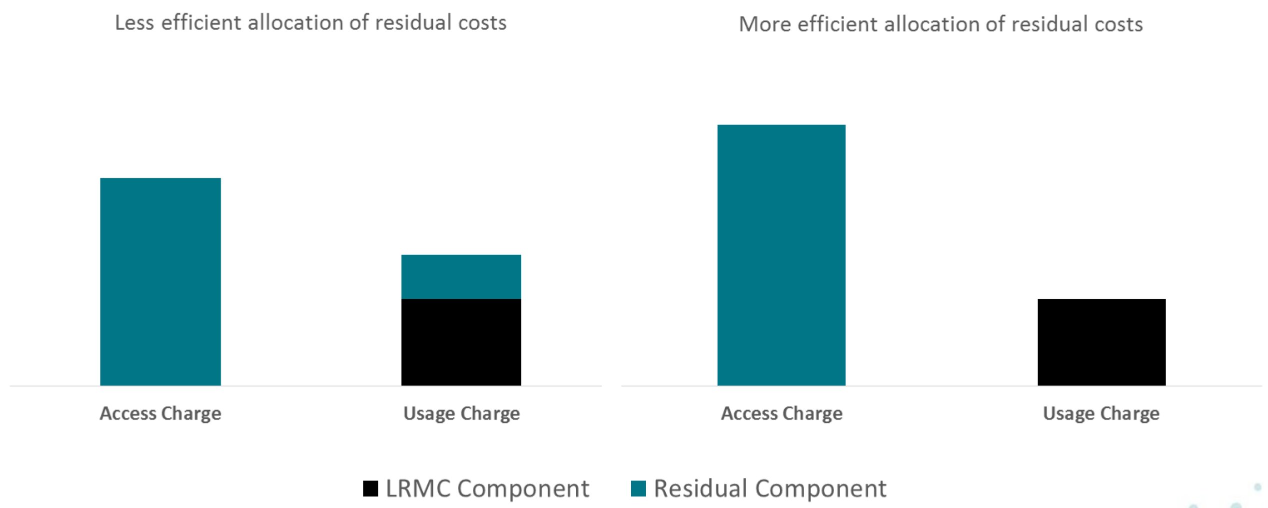
Example – recovery of residual costs from a two-part tariff

Consider the example of a two-part tariff. Assuming that customers do not have an alternative to the service, a two-part tariff that minimises distortions to price signals comprises:

- an energy charge set at a level equal to LRMC; and
- a fixed charge that recovers any residual costs allocated to the tariff.

A mark-up to usage charges over and above the level of LRMC (see Figure 8) has the potential to result in inefficient outcomes. However, this assumes that customers' usage of energy is elastic, ie, that they respond to the signals that they receive for usage of energy.

Figure 8 – Illustrations of the efficiency of different allocations of residual costs for a two-part tariff



In summary, the approach to the allocation of residual costs to charging parameters that will minimise distortions to price signals sees the residual costs recovered exclusively from the network access charge.

Exceptions to the allocation

An exception to the rule set out above occurs where a substitute exists for the service. For example, consider the case of controlled load for water heating, where a customer has the scope to switch to other sources of energy and so disconnect from the controlled load service.

The existence of a substitute for the service has two implications.

- First, we would expect a smaller quantum of residual costs to be recovered from this tariff than if there were no substitute.
- Second, for any residual costs that are ultimately allocated to the tariff, there is no 'hard-and-fast rule' as to the manner in which these costs should be allocated across the two charging parameters.

In particular, it is incorrect to assume that residual costs should be simply recovered via the fixed charge. It will often be sensible to mark-up usage charges rather than fixed charges, so as to ensure that customers with low levels of usage do not cease to purchase the service.

5.2.2 Recovery of residual costs from different tariffs

A second consideration is whether the manner in which residual costs are recovered from distinct tariffs distorts prices signals for efficient usage of the network. For example, consider the case where a customer has an option of choosing a declining block, or a time-of-use tariff.

Assuming that both tariffs have been set based on LRMC, the time-of-use tariff provides a more efficient price signal than the declining block tariff. Similarly, a demand tariff might provide a more efficient structure than the time-of-use tariff. Provided that the benefits of transitions outweigh the costs, over time a network business should encourage customers moving towards the most efficient tariff structures, as is illustrated in Figure 9.

Figure 9 – Networks should encourage customers to shift towards more efficient tariffs structures

Consistent with the Rules, the allocation of residual costs *across* these three tariffs should harness, or alternatively minimises distortions to, the price signals for efficient usage that these tariffs provide.

Our recommended approach to allocating residual costs across tariffs involves three considerations, or principles:

- **For tariffs where customers have no alternative tariff**, or where the structure of alternative tariffs provides the same strength signals for efficient usage, residual costs can be allocated to the tariff as decided by the distributor, provided that that allocation does not violate the customer impact principle.
- **For tariffs where a customer can switch to a tariff with a different strength price signal**, residual costs should be assigned so as to encourage customers to shift to tariffs that have the most efficient

price signal. Put another way, residual costs should be allocated to tariffs so that customers on more efficient tariffs pay a smaller quantum of residual costs.

- **Over time charging parameters will need to be rebalanced** to ensure that the shifting of customers between tariffs:
  - does not lead to under- or over-recovery of revenue; and
  - does not violate the customer impact principle.

Implementation of our recommended approach

The first of these three considerations is straightforward to implement – Essential can allocate residual costs to these customers in line with its current approach, provided that the allocations satisfy other requirements that we have already identified in the price principles.

The more challenging consideration is where customers have a choice between different tariffs. We have developed a simple model and framework to inform decisions about the allocation of residual costs such tariffs.

It is helpful to explain the implementation of our approach by way of a worked example. This example is not intended to represent any of Essential's current tariffs – it is merely an illustration. Our example assumes a distributor has group of customers that can choose between three tariffs, namely:

- a two-part tariff;
- a time-of-use tariff; and
- a demand tariff.

The starting point for our example is that two thirds of customers are currently on the two-part tariff, one third of customers are on the time-of-use tariff, with no customers on the demand tariff (which for argument's sake we assume has only recently been introduced).

Recall that all residual costs are being recovered via the fixed charge parameter. It follows that to provide a price signal to move from one tariff to another, the distributor need only allocate more residual costs to the less efficient tariff *on a per customer basis*.

The critical decision for the distributor is to set the strength of the price signal for shifting between tariffs, while ensuring that this does not violate the customer impact principle. For our example we have assumed that the distributor allocates residual costs according to the following rules:

- residual costs (and so fixed charges) are **10 per cent higher** for each non-ToU customer than for each ToU customer; and
- residual costs (and so fixed charges) are **10 per cent higher** for each ToU customer than for each demand tariff customer.

It is straightforward to allocate residual costs via these rules, as set out in the accompanying model. We are not prescribing the values of 10 per cent, or suggesting that they are reasonable. Essential might consider greater or smaller values more appropriate.

An important consideration is whether the movement between tariffs over time might lead to volatility in the prices received by customers, and so limit the distributor's ability to implement such an approach. Figure 10 shows the number of customers on each of the three tariffs over time for our illustrative example, assuming that every year:

- 20 per cent of customers on the non-ToU tariff switch to the ToU tariff; and
- 10 per cent of customers on the ToU tariff switch to the demand tariff.

These assumptions would be consistent with a relatively rapid shift towards more efficient tariffs.

Figure 10 – Illustration of movement of customers towards more efficient tariffs over time

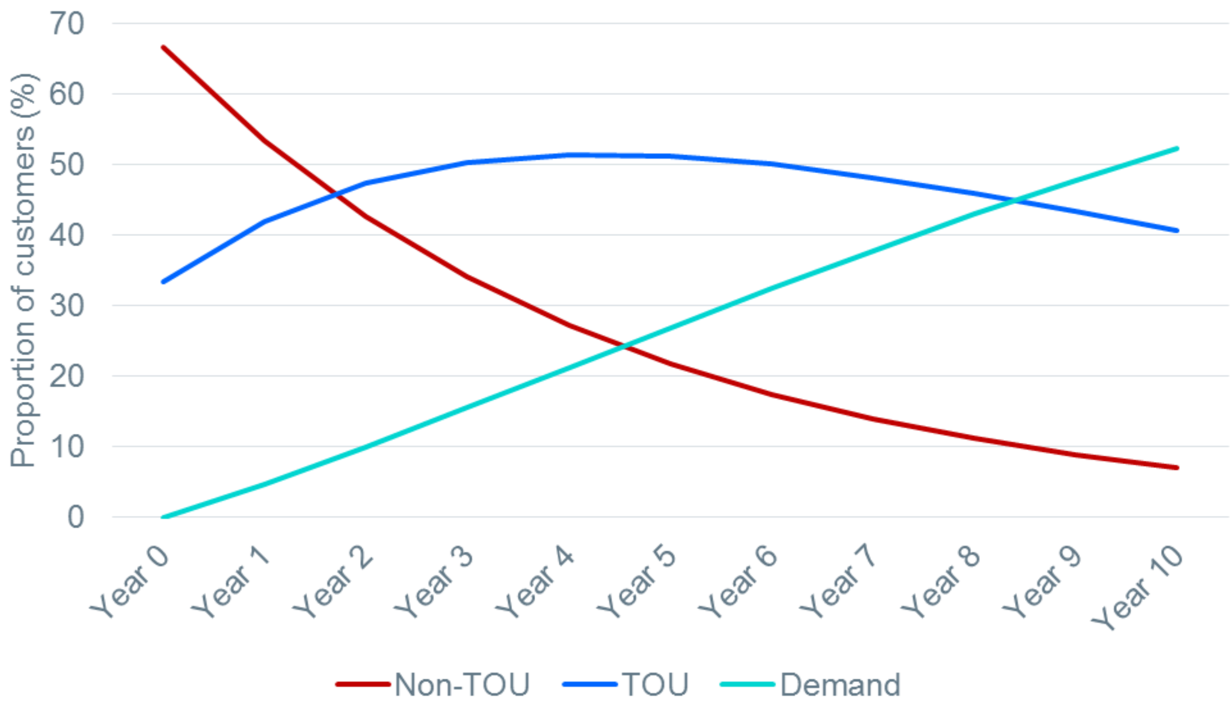
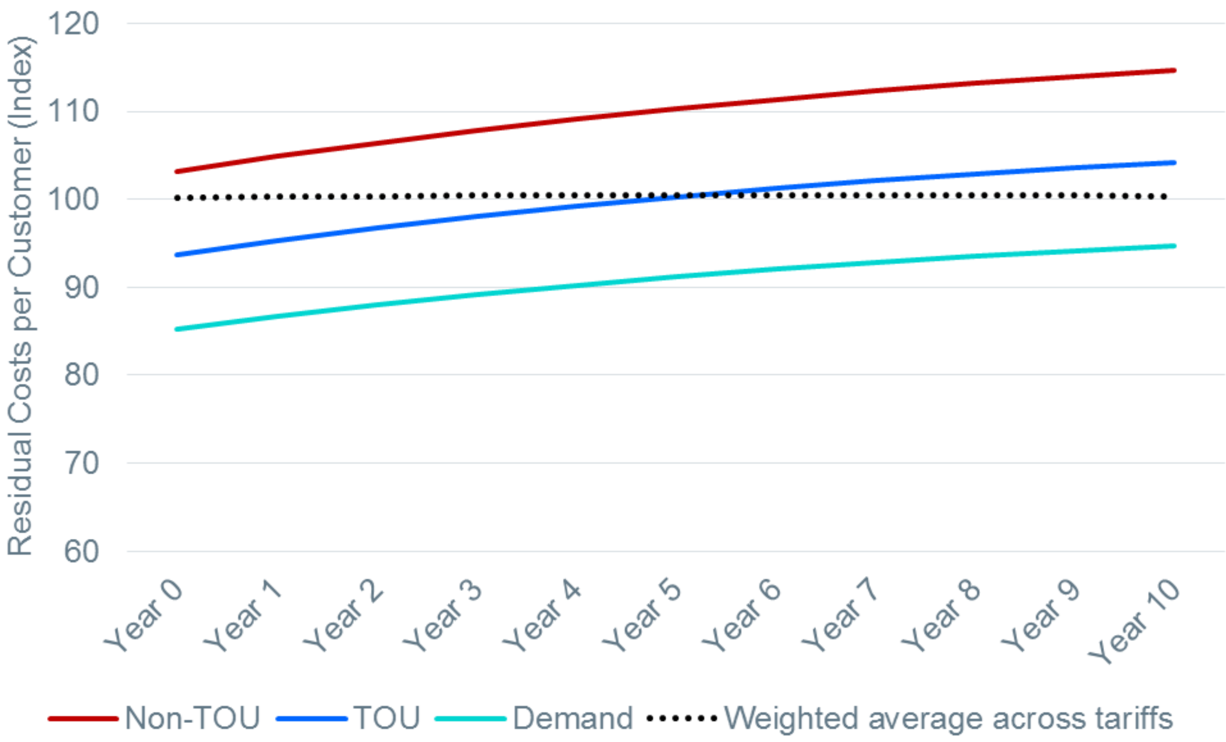


Figure 11 shows that over time residual costs per customer increase at between 0 and 2 per cent per annum. Perhaps counterintuitively, the shifting of customers between tariffs does not give rise to substantial volatility in prices. Importantly, the weighted average residual cost per customer across all three tariff class remains unchanged over the course of the 10 year period. However, there is a constant incentive for customers to switch to more efficient tariff structures.

Figure 11 – Illustrative example: residual costs per customer by tariffs class



The intention of this example is to illustrate the allocation of residual costs according to our recommended approach:

- minimises distortions to price signals for efficient usage of the network resulting from tariff based on LRMC;
- considers customer impact, by ensuring that customers do not experience large changes in the residual costs, and so their bills, from one year to the next; and
- has regard to 'the desirability for tariffs to comply with the pricing principles in [6.18.5](f) and (g), albeit after a reasonable period of time'.

HOUSTONKEMP
Economists

Level 40, 161 Castlereagh Street
Sydney NSW 2000 Phone: +61 2 8880 4800