A review of literature on electricity network pricing against recent findings in New Zealand.

by
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Overview

New Zealand electricity network companies (ENCs) are under pressure to design and adopt cost reflective prices, in the face of disruptive technology that can enable consumers to use network services at below cost.

The aim of this paper is to assess available literature on electricity network rate design, against the findings from a New Zealand industry working group's discussion paper on rate design, and against the findings of a recent review of a New Zealand ENC by the industry regulator.

This paper concludes that the literature and findings from New Zealand both agree that network costs should be recovered through a charge that reflects the nature of the cost. Where network costs are expected to increase in the future, a charge based on long run marginal costs (LRMC) can be used. It is also generally agreed that existing traditional two part tariffs do not adequately recover costs particularly in the face of new technologies.

Agreement also exists between the literature, and New Zealand examples for the need for stakeholder engagement when designing and implementing new prices. As well as for the need to offer consumers options such as opt-in and opt-out.

Where agreement does not occur in the literature on consumer acceptance of dynamic prices, including demand charges, findings from New Zealand showed consumer preference for time of use (TOU) styled charges, even after nine years of direct billed demand charges in the case of one network company.

Further research on network rate design is suggested including:

- how consumers are impacted by smart technologies, dynamic, unpredictable pricing periods and fixed periods
- the preferred pricing approach when electricity retailers may not pass through pricing signals
- the trade-off between efficiency, simplicity and consumer choice

Other research suggested includes:

- an understanding of consumer behaviour using behavioural economics and Bayesian statistics
- the use of integrated environmental management research to guide network company, electricity retailer relationships and governance.

Introduction

New Zealand ENCs are under pressure to design and adopt cost reflective prices, in the face of disruptive technology that can enable consumers to use network services at below cost.

As a response to both external and internal pressures the Electricity Networks Association (ENA) has tasked a working group to develop guidance for its members to assist them through the process of designing and implementing cost reflective pricing. One of the initial tasks of the working group was to conduct a review of literature on electricity network rate design.

At the same time the industry market regulator the Electricity Authority (EA) has reviewed the pricing methodology of a New Zealand ENC that was facing consumer backlash for direct billing cost reflective network peak demand pricing.

The aim of this paper is to assess the literature reviewed against the findings of the ENA working group, and the EA review, in order to suggest avenues for further research.

Methods

The results and conclusions from 26 papers on ENC rate design have been assessed against the findings of the ENA working group and EA review, to identify areas for further research.

To aid analysis, the common key themes from literature have been categorised into two groups:

1. areas of general agreement amongst authors
2. areas where agreement has not been reached.

This paper has not reviewed literature, on consumer engagement or customer experience unless the authors make reference to how network pricing will be impacted on or how network pricing will impact consumer relations.

Results

Literature review

This paper has reviewed 26 papers on ENC rate design, and cost reflective ENC pricing to use for assessment against recent findings in New Zealand. This literature review is an extension of a review undertaken for the NZ ENA Future Prices Working group (FPWG).

A note about dynamic pricing (DP). Dütschke and Paetz (2013, p. 227) define DP as time varying pricing (measured in kWh) that ranges on a spectrum, that begins with but does not include flat rate TOU styled pricing, and ends with real time pricing (RTP). For the purposes of this paper we will also include as DP, both TOU pricing with peak and off peak periods, and time varying demand pricing, unless otherwise stated.

Summary of reviews

There is general agreement in the literature that network costs should be recovered with a charge that reflects the nature of the cost. It can also be inferred that legacy two part TOU tariffs do not adequately recover network costs.

It was generally accepted, although not unanimously, that a demand or capacity charge more closely matched the nature of network costs than a TOU styled charge. With the exception of the recovery voltage control, and line loss costs. It was also generally accepted that a LRMC charge was appropriate to recover costs where growth in network capacity was foreseen, and a fixed charge or similar (which did not alter consumer consumption) for the recovery of residual costs.

Other agreement centred around the need to work closely with stakeholders, and consumers throughout the process of designing and implementing cost reflective pricing, and in the need to offer consumers choice when implementing prices such as opt-in or opt-out.

Topics where authors did not agree included whether consumers would accept DP (or demand charges), regardless of whether the charge reflected network costs. Or whether efficient pricing was the most important factor of rate design.

A summary of the notable areas of agreement in the literature are as follows.

- Network costs should be recovered with a charge that reflects the nature of the cost.
- Legacy two part tariffs are not adequate to recover network costs.
- LRMC appropriate to recover future capacity costs
- Demand charges best reflect network costs.
- Implementation requires good collaboration and communication with stakeholders.
- Implementation options should include such options as shadow billing, lowest bill, graduated tariffs, opt-in opt-out approaches.

A summary of the notable areas without agreement are.

- The effectiveness of DP to lower peak congestion particularly with enabling technology.
- Consumer acceptance of DP.
- Consumer acceptance of demand charges.
- Efficiency versus other principles of rate design.

To aid analysis with the New Zealand reviews, a summary of the areas of agreement in the literature are presented in Table 1. While those areas of the literature without agreement are summarised and presented in Table 2 below.

Table 1 Areas of agreement

Area where reviewers have general agreement	Notes
Network costs should be recovered with a charge that reflects the nature of the cost	There is general acceptance that network charges should reflect network cost drivers. Those papers that referred to this include; Bonbright (1961, p.61), Faruqui and Palmer (2011), Faruqui (2016) , Hledik and Faruqui (2016), Faruqui et al (2016), Kemp et al (2014), Nelson et al (2014), Lazar and Gonzalez (2015), Wood et al (2014), Sherwood et al (2016). Strengers (2012), takes the focus away from network costs drivers towards investigating social practices and the reframing of the problem of peak electricity demand. Stenner et al (2015) do not disagree with designing charges around cost drivers, but note that consumers find all forms of cost reflective pricing less appealing than existing tariffs. Similarly, Dütschke and Paetz (2013) argue that consumers prefer simple pricing structures.
Legacy two part tariffs are not adequate to recover network costs	There was also general acceptance that legacy tariffs do not recover costs efficiently, particularly with the introduction of new technologies such as distributed generation (DG) Authors who noted this include those listed immediately above on network rate design, and also include Picciariello et al (2015), KPMG (2016), Shepherd (2012), PAWG (2005), Ortega et al (2008), Sherwood et al (2016). As an example, Picciariello et al, reason that although peak time volumetric tariffs signal to consumers to reduce consumption these tariffs may lead to an under recovery of network costs. They cite the Edison Electrical Institute's claim that 'an incorrect pricing of DG power has already caused an increase in costs for the customers with no DG'(p. 372). Picciariello et al conclude that volumetric tariffs are not well suited to network costs which are fixed in the short run.
LRMC appropriate to recover future capacity costs	Professor Bonbright (1961, p.336) wrote in his Principles of public utility rates , that long run marginal costs should be a general basis for setting utility rates. He also notes that these rates provide stability over time. Although he suggests that defining marginal costs is difficult and recommends the use of long run incremental costs in some cases. The Prices Approached Working Group (PAWG, 2005) argue for the use of long run average incremental costs. Kemp et al (2014) consult on approaches to estimating LRMC. Other authors note that LRMC (or LRIC) may not recover all charges or be appropriate for all charges. Picciariello et al advocate for using an optimal combination of short and long run cost drivers when designing rates. While Brown and Faruqui (2014) show that an LRMC rate may not recover residual costs, which should be recovered through a rate that does not change consumer consumption patterns. Others such as Wood et al (2014), Ortega et al (2008) state that rates should also take location into account as well as offer volumetric charges to recover line losses and costs of voltage control.
Demand charges best reflect network costs	Bonbright (p. 310) proposed the use of demand charges for the recovery of network costs. Other authors who agree include Faruqui and Hledik (2016), Faruqui (2016), KPMG, PAWG, Shepherd (2012), Kemp et al, and Sherwood et al. However, Sherwood et al, note that there is a lack of studies on the impact and uptake of peak demand charges. There is little disagreement in the literature reviewed on what rate best reflects network costs, with the exception of Lazar and Gonzalez (2015). They see demand as inappropriate for mass market consumers with the exception of a consumer demand charge for local network assets. Also note the work of Ortega et al, who state that although cost drivers have been studied (leading to a general agreement for recovery of charges from demand) the cost functionality has not 'really' been studied (p. 3). Where dispute around demand charges remains is whether consumers will accept demand charges and react in efficient ways to a demand charge price signal. The reaction of consumers to demand charges is discussed further below.
Implementation requires good collaboration and	It is widely acknowledged that consultation with stakeholders and end consumers is paramount for the successful implementation of DP . A selection of papers which

Area where reviewers have general agreement	Notes
communication with stakeholders	referred to this include Faruqui, Davis, Duh and Warner (2016), Nelson et al (2016), Hall et al (2016), , Stenner et al, Dütschke and Paetz. Groothuis and Mc Daniel Mohr (2014) believe that focussed communication can overcome consumer inertia. Similarly KPMG state that communication is needed to show the costs of cross subsidisation with legacy rates.
Implementation options should include such options as shadow billing, lowest bill, graduated tariffs, opt-in opt-out approaches	Authors reviewed who discussed implementation showed similar sentiments around the need to provide consumers with options for implementation. Sherwood et al, notes that opt-in consumers are more engaged but have lower enrolment than opt-out. Likewise Fenrick eta l (2014) found that opt-in consumers on critical peak pricing reduced their demand the most. Stenner et al, argue that a money back guarantee and free automation device boost the uptake of tariff offers. Others noted for discussion on this topic were Lazar et al (2015), and Sherwood.

Table 2 Areas of without agreement

Areas without agreement	Notes
The effectiveness of DP to lower peak congestion particularly with enabling technology	The most common topic found in the reviews was on the influence of DP to effect a change in consumer behaviour with or without technology. Faruqui and Palmer (2011), Faruqui and Sergici (2013), Fenrick et al (2014), Lessem et al (2017), and Torriti and Grünewald (2014), Fenrick et al (2014), all found peak consumption reduction from dynamic based pricing. Faruqui and Palmer (2011), argue that customers do respond to pricing signals and do so over time. They also argue that the strength of the pricing signal will have a positive impact on response as will enabling technology. Sherwood et al, claims that TOU based charging structures can reduce peak consumption by up to 50% without compromising consumer acceptance. Torriti and Grünewald advocate for real time pricing where peaks are consistent e.g. winter or summer peaks. While Sherwood et al (2016) promote TOU based pricing which they say is easier for consumers to accept. Groothuis and Mc Daniel Mohr (2014) claim that enabling technology alone will cause a reduction in consumption. While Dütschke and Paetz conclude that smart technologies and demand automation are a prerequisite for DP.
Consumer acceptance of DP	Authors who discuss DP where not in agreement that consumer respond positively to DP. Respondents in the Stenner et al, survey found *all* forms of cost reflective pricing less attractive than traditional flat rates, even when DP rates were offered as a free trial. Stenner et al, conclude that income, education, employment, household size and type, influence the uptake of DP . In agreement with Stenner et al, Groothuis and Mohr argue that consumers with lower incomes and less formal education have greater inertia to change to DP. Flaim et al (2013), found a lack of DP being offered by electricity retailers because of a limited understanding of DP by consumers, and retailer competition that focussed on nominal $/kWh. The authors state that the interest of DP in the research has led some to believe that there has been a large uptake in DP, when this has not been the case. In fact 'most of the promising RTP programs have had a participation dwindle to a few customers' (p.10). Flaim et al, could not conclude from the evidence cited that consumers would respond favourably to DP in the long run, although one study noted that consumers continued to respond after three years. However, they did say that consumers have showed a renewed interest in DP with the introduction of smart meters and regular feedback from utilities on usage. Miller et al (2017) reviewed studies on Ontario residential consumers with TOU rates, and concluded that residents found it difficult to react to TOU rates when not home or without enabling technologies. They also conclude that the TOU rates did not yield tangible reductions in peak demand even with a 'modest' differential between peak and off peak periods.
Consumer acceptance of	Overall, the authors who had divergent views on demand pricing were more

Areas without agreement	Notes
demand charges	concerned with consumer acceptance and up-take, than with the appropriateness of the charge to recover network costs. Although Brown and Faruqui (2014) believe that residential consumers with legacy metering should remain on traditional flat rate charges. Sherwood et al (2016) while finding much in the theory advocating demand charges, did not find much empirical data on the use of demand charges for residential consumers. They also note that residential consumers have a greater acceptance of TOU charges than demand charges Stenner et al's results of a survey of Australian residents is an example of the reticence some consumers have to demand charges. They found that respondents were particularly resistant to capacity (demand) pricing over real time pricing. Their results concluded that consumers do not like the idea that electricity should cost more based on demand, and that consumers would not be able to make the lifestyle changes necessary to capitalise on DP pricing in general, even with an education campaign. Similarly, Hall et al's (2016) survey of Australian consumers concluded that residents were more circumspect about demand pricing, and had only a basic understanding of it, which may need to develop before demand prices were accepted.
Efficiency versus other principles of rate design	Bonbright (pp. 121- 134), ranks the importance of fairness and equity alongside economic considerations (efficiency), although efficiency is the most important criteria, He argues that, making rates equal for two parties might lead to the 'victimisation' of another (p.124). Lazar and Gonzalez agree, citing Bonbright's approach to rate design and contend for the 'judicious' application of certain economic guidelines' (p. 5) Namely efficient rate design, which they claim is necessary to address coming challenges. Brown and Faruqui, also cite Bonbright's principles when discussing the recovery of residual costs and also claim that rates should primarily be based on efficiency. However they note that there is a new focus on consumer satisfaction and concede that 'in practice, economic efficiency is only one of five principles and not the only one or even the dominant one' (p. 3). Picciariello et al, debate whether simplicity is a more important cost causality or whether consumers should be charged for the costs caused or the benefits gained. Similarly , Ortega et al note that the focus of tariff design has changed from sustainability of the electrical company to efficiency, transparency and addivity. Sherwood et al, state that the acceptance of having cost recovery as the most important pricing principle is beginning to change. Tension is now found between the need to encourage behaviour change and stability, with cost recovery. Likewise, Nelson et al suggest that factors other than efficiency should be taken into account, including the views of policy makers and civil society.

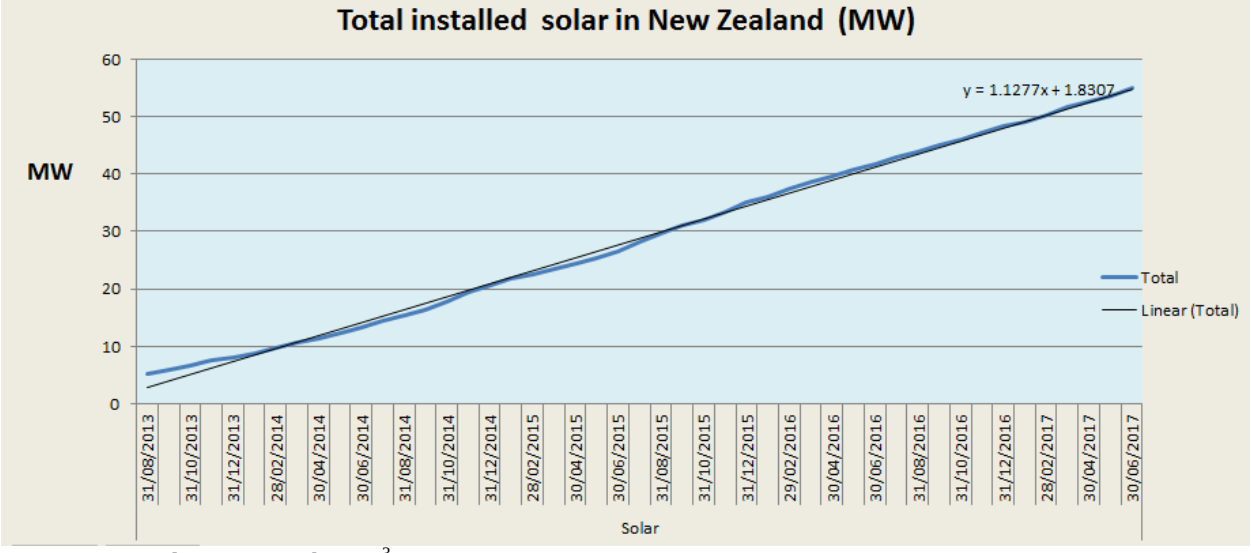
Key findings from New Zealand studies

The following features of the New Zealand electricity network market structure should be taken into account when comparing with results from the literature reviews.

Generation, renewables and DG penetration

86% of New Zealand's electricity generation is from renewable sources, including 57% from hydro generation[1]. Installed DG, generates less than 1% of New Zealand's electricity demand, but has a rate of growth of over 6% per month (see Figure 1). Electric vehicle registrations have increased from 190 in January 2013 to 4200 in July 2017. In the last six months nearly 2000 registrations have been made[2].

Figure 1 Installed distributed generation in New Zealand



Source: Electricity Authority [3]

There are currently 29 distribution companies in New Zealand with a total of 2,093,832 installation control points (ICPs) with an average of 64,000 ICPs per distributor[4]. The 29 ENCs provide network services for 30 electricity retailers.

ENCs service a range of consumer types over a variety of terrain, with some networks servicing mainly urban residential loads, and others serving sparse rural communities and remote areas. Peak times also vary across regions from summer to winter depending on the dominant load. In rural areas with a dry climate irrigation pump load can drive a summer peak demand.

Regulation with respect to network pricing

New Zealand has two regulators with regards to network pricing; the Commerce Commission, and the Electricity Authority (EA). With respect to this paper, regulation under the EA has more bearing.

The EA's statutory objective is to 'promote competition in, reliable supply by, and the efficient operation of, the New Zealand electricity industry for the long-term benefit of consumers' (s15 of the Electricity Industry Act 2010).

Where competition does not exist, the EA will use a variety of tools to promote the long term benefits to consumers. These tools include the electricity participation code (the code) which provide rules to govern electricity participants, voluntary pricing principles, and pressure to develop cost reflective pricing including; published reviews of ENC pricing methodologies, pricing plans, as well as requests for voluntary action.

Of significance to this paper, is the:

- separation of distribution from certain generation and retail activities under Part 3 of the Code
- the allowance of market forces to guide retailer behaviour

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[1] https://www.ea.govt.nz/dmsdocument/20410

[2] http://www.transport.govt.nz/research/newzealandvehiclefleetstatistics/monthly-electric-and-hybrid-light-vehicle-registrations-dec-2016/

[3] https://www.emi.ea.govt.nz/Reports/Retail/Data/GUEHMT?RegionType=ZONE&FuelType=solar

[4] https://www.emi.ea.govt.nz/Reports/Retail/Data/H3WIHL?RegionType=NWKP&MarketSegment=All

- lack of hierarchy in network pricing principles
- pressure on ENCs to adopt cost reflective pricing.

Separation of distribution from retail activities

Under part 3 of the code, ENCs cannot act as retail participants. This means that ENCs in New Zealand do not contract with end users but with electricity retailers. Electricity retailers have certain obligations under the code, but by and large the EA allows the market to determine what product, services and prices retailers can offer. This means there is no guarantee a network price signal will be passed on by retailers to end consumers, unless consumers desire such a charge.

Pricing Principles

The pricing principles assess ENC pricing against the need to:

- signal economic costs
- have regard for consumer demand responsiveness when recovering residual costs
- be responsive to stakeholder requirements and circumstances
- have regard for transparency, price stability and certainty
- have regard to transaction costs and impacts on retailers.

Presently, the EA has not provided industry with a hierarchy for the pricing principles beyond its desire for market led approaches discussed in the decisions and reasons paper (2013). This freedom of movement presently allows NZ ENCs to contrast options for efficient pricing against such outcomes as simplicity and stakeholder/consumer preferences.

Pressure to develop cost reflective prices and increasing competition

The EA is currently reviewing ENC pricing because they are concerned that 'the current pricing arrangements may not be encouraging consumers to use technology in ways that have long-term benefits for all consumers'[5].

The EA (2017b) has stated it will facilitate an industry–led approach for the adoption of efficient network pricing. This approach involves:

- monitoring ENC progress towards adoption of efficient distribution price structures
- review of the pricing principles
- annual assessment of ENC pricing against pricing principles.

Low Fixed Charges regulation

A key regulation that has an impact on an ENCs ability to offer cost reflective pricing are the Electricity (Low Fixed Charge Tariff Option for Domestic Consumers) Regulations 2004. These regulations require an ENC to offer a fixed[6] rate to residential consumers of no more than $0.15 per day, with remaining costs recovered through a variable charge.

Other considerations; Use of hot water cylinders for transmission and network load control

Load control of the transmission network and local networks is primarily achieved through ripple control on residential consumer hot water cylinders. It is important for NZ ENCs to take into account the impact of both pricing and load control on consumers when evaluating pricing alternatives. For example, a peak price signal may be set at the same time load control occurs, with both used to lower peak usage. After the peak time has ended, the return of the controlled hot water load can create a second peak, unless load is staggered back onto the network, leading to adverse consumer reactions. Alternatively, if load is not controlled during peak times, consumers are charged for the hot water load without the ability to control the load themselves.

Key findings from the Future Prices Working Group

The Future Prices Working Group (FPWG), produced a technical paper (FPWG discussions paper) for ENA members and interested parties on matters relating to cost reflective pricing. The paper was written for three reasons (ENA 2017a).

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[5] https://www.ea.govt.nz/development/work-programme/pricing-cost-allocation/distribution-pricing-review

[6] Recently the EA has published guidelines which include the EAs interpretation of a variable charge. Under the EAs interpretation a variable charge can include demand and capacity charges, provided a consumer can change capacity at a reasonable cost (2016a). At present ENCs are seeking further clarification on the EA interpretation (personal correspondence).

1. Traditional rates do not efficiently recover costs when consumers can avoid consumption, either with new technologies, or through more efficient energy use. The inefficient recovery of costs is exacerbated by the LFC regulations which cap fixed charges to residential consumers at $0.15, and increase the portion of network costs that need to be recovered through a consumption charge.
2. The need for ENCs to signal the future networks costs of upgrading and replacing aging assets, which is not done through traditional pricing structures
3. To hear from consumers on their preferences for network pricing.

Criteria established by the FPWG discussion paper to assess network pricing for residential consumers

The FPWG discussions paper presents research on five types of pricing options including:

1. TOU with a peak off peak rate
2. Network coincident peak demand (CPD)
3. Consumer anytime maximum demand (AMD)
4. Installed capacity
5. Booked capacity.

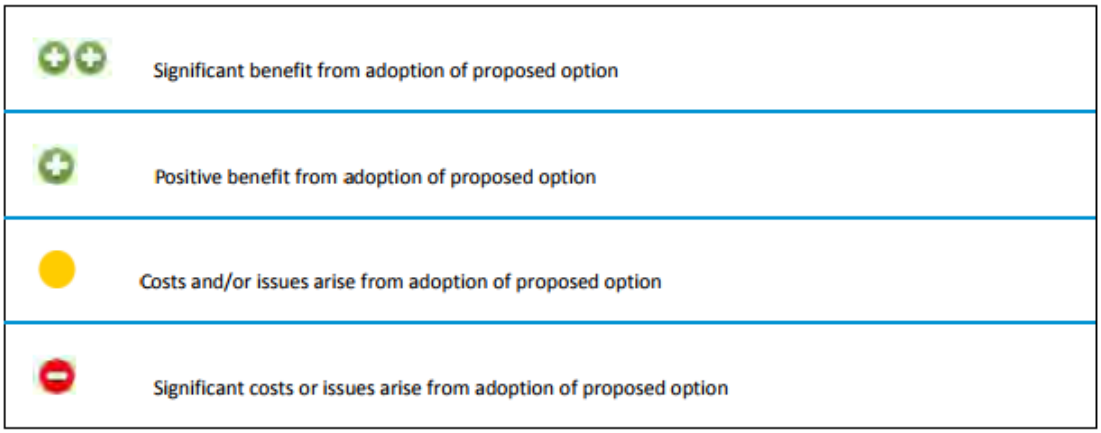
The paper does not offer a recommended pricing option but has developed criteria to assess each pricing option. Altogether 17 criteria were developed to assess the five pricing options, but were summarised into five criteria for presentation at stakeholder forums. The five summarised criteria are shown below in Figure 3.

The summarised criteria include the need for efficiency, simplicity, durability, stability, and the need to be supportive of retail competition. Each option was assessed against the criteria with results shown in Figure 2.

Using the scoring in figure 2, and using a non-weighted score card where a '+' scores one point , a 'o' has zero points, and a '–' has minus one points, the five pricing options are rated in the FPWG discussion paper as follows:

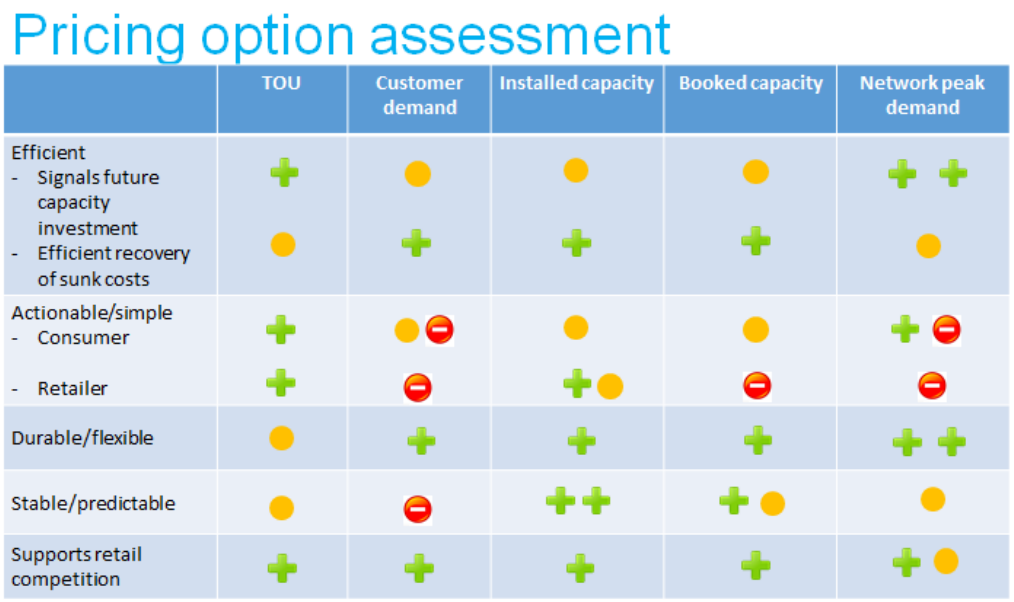
1. installed capacity with six points
2. TOU with four points
3. booked capacity and network peak demand with three points each
4. customer demand with one point.

Figure 2 Rankings used for assessment in the FPWG papers



Source: Electricity Networks Association (2017b)

Figure 3 Criteria and assessment of options in the FPWG paper.



Source Electricity Networks Association (2017a)

If pricing options are assessed against efficiency only, the order becomes:

1. CPD
2. TOU, AMD, installed capacity, booked capacity.

Summary of submissions on the FPWG discussion paper

The FPWG discussion paper was made available to any interested parties, and received 21 submissions, including 12 electricity retailers, the Independent Electricity Generators Association, Major Electricity Users Group, and Consumer New Zealand, a non-profit that independently reviews products and services available in New Zealand.

Submissions were made on 36 questions that ranged from opinions on the direction of future prices, and questions on stakeholder engagement, to questions on peak pricing times for TOU (ENA 2017c). A summary of responses relevant to this paper are as follows. (*ibid*).

- Most submitters are supportive of cost reflective pricing.
- Submitters prefer cost reflective pricing to be actionable before it is efficient.
- There is broad support for TOU pricing but no clear preference for when peak pricing periods should occur.
- Submitters had a clear preference for TOU style charges over demand charges, and network peak demand over customer demand, with a slight preference for fixed peak periods, and annual resets.
    - Four submitters had a preference for fixed peak periods when recovering CPD costs.
    - One submitted had a preference for dynamic peak periods for collecting CPD costs.
    - There was a slight preference for annual demand resets when recovering demand charges.
- There was little support for capacity charges.
- There was general support for the criteria chosen by the FPWG and published in the discussion paper, but mixed support for the assessment of each pricing option made in the discussion paper.
- Other issues identified where customer privacy around data, as well as the deployment of AMI.
- There was no consensus on whether uptake should be voluntary or mandated.
- Distributors and retailers need to work closely together when communicating with consumers, although submitters generally agreed that competition can be relied upon to pass through network pricing signals.

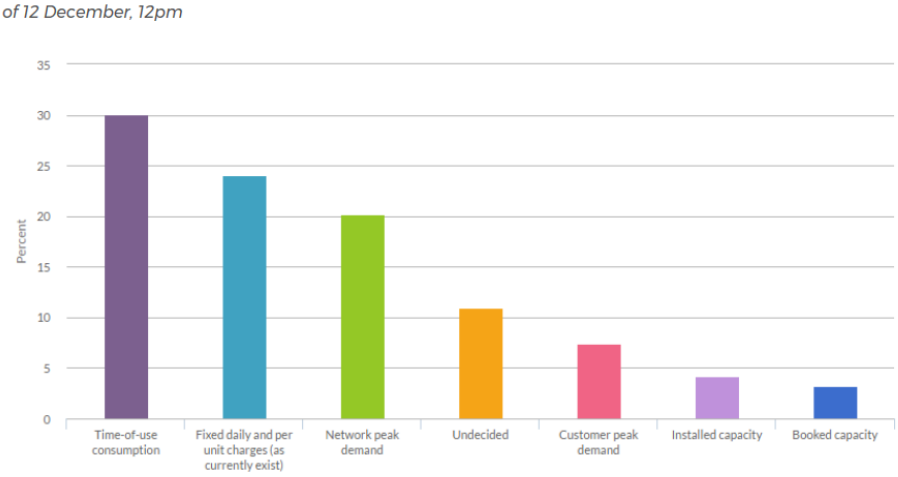
Consumer New Zealand survey

One submitter, Consumer New Zealand conducted its own phone survey on preferred pricing options, canvassing 362 of its members (Consumer NZ, 2017). The survey included both qualitative and quantitative analysis. A summary of the Consumer survey is shown in Figure 4 and as follows.

'Of the 344 respondents: 66% preferred one of the five pricing options outlined in the discussion paper, with 23% opting for the status quo (fixed daily and per-unit charges) and 11% undecided. About a third (32%) favoured time-of-use consumption, with network peak demand the next most popular at 20%. Customer peak demand drew 7% support, while the least popular options were installed capacity at 4%, and booked capacity 3%'. (*ibid*, p 2).

It is important to note that the existing rate structure for residential consumers in New Zealand does include a TOU component through a 'day/night' price. If the number of respondents who preferred the existing day night pricing are combined with those that preferred TOU the number is over 50% of respondents. According to Consumer, those who preferred TOU cited 'simplicity' as one of the main reasons for their choice. One consumer commented 'it is essential that consumers understand the way they are charged…a simple model is important. However, the charging scheme must also provide incentives for usage [to reduce] the "peak demand problem". Time of use consumption is a reasonable compromise' (*ibid*, p.2).

Figure 4 Results of Consumer NZ survey



Source: https://www.consumer.org.nz/articles/new-line-charges-proposed

A summary of the key concerns Consumer NZ found with the FPWG discussion paper are as follows .

- Cost reflective pricing if implemented properly can empower consumers to reduce their electricity costs as well as use new technologies in a way the 'benefits all New Zealander's.
- Changes in prices could unfairly impact consumers unable to shift demand, especially low income consumers.
- Even if average power bills are lower for the year, power bills may be higher during winter adversely effecting consumers with low incomes.
- The issues of The Lines Company (see below) shows that more than one type of pricing option should be offered.
- Consumers need to receive tariff information quickly.
- Preference for a suite of pricing options, including a legacy option.
- Change to tariffs needs to occur gradually, accompanied by safeguards to bills especially for vulnerable consumers.
- Before prices are instituted consumers need a detailed overview of findings from ENCs and retailers.

Consumer NZ has also recently submitted to the EA on the 'implications of evolving technologies for pricing of distribution services consultation paper'(Consumer NZ, 2016). Two key points made by the Consumer NZ submission relevant to this discussion are:

- the cost of maintaining the existing tariff structure in terms of inefficient investment in new technologies has been overstated
- there is a need to weigh fairness against efficiency, while the greatest pricing principle is stability and certainty.

Key findings from the review of The Lines Company pricing methodology

The Lines Company (TLC), is the only ENC in New Zealand to directly bill their consumers rather than electricity retailers. TLC is also unique in that it has been charging residential consumers a network peak demand charge since 2007. The combination of direct billing and a customer peak charge has had a strong impact on consumer power usage as well as consumer attitudes towards TLC.

TLCs pricing methodology has received criticism from its consumers for some time leading to an internal review by TLC Board of Directors, and an external review by the EA.

Overview of TLC's network

TLC owns and operates a distribution network 4,500 kms long that services 24,000 IPCs. 72% of the total circuit length services rural communities, with 12% servicing main townships with a combined urban population of

around 10,000 . 14% of the total circuit length services remote and rugged connections, including New Zealand highest connection on Mount Ruapehu home to the country's largest ski fields.

There are a large proportion of holiday homes at the ski fields. Holiday homes are required to pay TLC charges regardless of whether the homes are occupied, a fact that has influenced consumer perceptions of TLC pricing.

Overall TLC has a ratio of 5 installation control points (ICPs)/km of circuit length, the fourth lowest ratio of its type in New Zealand. This means a greater proportion of TLC costs are spread over fewer ICPs than other networks. Increasing the risk that cross subsidisation occurs, due to inefficient recovery of network charges.

The network is not considered constrained with the exception of potential transmission constraints.

Overview of TLC's pricing methodology

As noted above, TLC direct billed its consumers (thereby avoiding the dilution of price signals that can occur if retailers do not pass through distribution charges intact) and charged residential consumers a dynamic peak CPD charge ($/kVA). The CPD charge was recovered using the six highest network peaks from the prior year, which . set an 'fixed annual fee' for the following year. The CPD charge recovered 25% of TLCs annual required revenue. To avoid a single period of consumption being used to set all six peaks, a minimum five hour gap was placed between pricing.

AMI metering has been used to record use, with 10 minute intervals. By 2016, 69% of ICPs had AMI metering installed. ICPs without an AMI meter were allocated one of three profiles; residential, dairy or temporary accommodation.

With charges set on a profile prior to the introduction of AMI meters, consumers could not give effect to peak pricing signals, although their efforts to reduce demand would be reflected in lower network investment in the longer term.

Other charges to consumers included a capacity charge (network charge), based on the physical capacity at the ICP, and a dedicated asset charge. The minimum capacity for residential consumers was recorded at 5 kVA. Consumers eligible for the LFC regulated charge paid a fix rate of $0.15 per day rather than the capacity charge, as well as paying a higher customer peak charge.

Use of load control and technology to signal peak events

At the time of the EA review, TLC controlled load when regional transmission load reached a threshold, and for local network events. To enable consumers to know when TLC was load controlling TLC provided:

- an interactive map on the company website
- a mobile app
- a 'switch-it-device' available for hire, which when plugged into a wall socket would light up during load control times
- AMI metering.

Load control times often coincided with peak network times which were used to set consumer charges for the following year. Consumers would often change behaviour during notified load control times in an effort to reduce their charges. But because load control occurred whenever a regional load threshold was reached, TLC would signal load controlling events more times than the number of pricing periods used to calculate charges. This resulted in consumers altering behaviour or investing in equipment to reduce their charges, but often without effect.

Findings from the EA review of The Lines Company pricing methodology

A summary of the EA review is as follows (Electricity Authority, 2017c).

- Linking pricing and load control together can create confusion for consumers.
- Pricing that creates long delays between consumer actions and pricing impacts, generates considerable consumer stress.
- Uncertainty of when peak pricing events are occurring also generates considerable consumer stress.
- Implementing a new pricing methodology is complex and needs suitable resources.
- Pricing must be understood by consumers and consumers must be able to evaluate how their investments will influence on future distribution charges.
- Distributors should recognise consumers are used to making choices. Implementation strategies that don't offer opt-in or opt-out choices, need to be carefully thought through, and phased in.
- Distributors need a review process that monitors that pricing signals are working as intended, and to allow early intervention if changes are required.
- Distributors should remain responsive to feedback from consumers and retailers with regard to implementation.
- TLC must balance the need for cost reflective pricing with simplicity so that consumers can understand and react to pricing.

Note, the EA review did not criticise the use of network peak demand charges.

Summary of survey results for EA review

The EA contracted UMR Research who surveyed 500 TLC consumers. Results are as follows (UMR Research 2016).

- 39% of respondents stated that they did not understand TLCs pricing methodology, while 36% stated they did understand.
- Of those that did not understand the charges or were neutral:
    - 36% wanted to know why the charges were so high
    - 17% wanted further information on how the charges were calculated
    - 19% did not want to know how the charges were calculated.
- 45% of respondents felt they were adversely affected by the TLC pricing structure and load control.
- 35% of respondents want to change the billing or pricing structure.
- 18% want a reduction in prices.
- 9% want better quality of information.
- Customers from Taupo and Ruapehu (where the highest concentration of holiday homes within the network reside):
    - were more engaged and knowledgeable about what makes up their line charges
    - were more concerned about peak pricing and were more likely to believe they had been adversely affected by TLC pricing
    - had taken permanent action to reduce charges, and invested in alternative energy sources.
- Close to 63% of respondents stated they were concerned about peak pricing, while 31% were neutral or were not concerned. Those that were concerned with peak pricing cited the following reasons:
    - 46% mentioned cost as the main concern.
    - 31% stated unfairness.
- During load control times, 14% of respondents monitored their respective technologies to determine when TLC was conducting load control. Of the 14% that monitored load control devices, the most common methods/devices were:
    - the switch-it-device (light that glowed during periods of control), 25%
    - checking the meter, 24%
    - mobile app, 23%
    - via the internet, 16%.
- Over a quarter of respondents (29%) indicated they have taken *permanent* steps to minimise their line these steps included:
    - efficient lights, 33%
    - using a wood burner, 30%
    - gas, 26%
    - purchase of efficient appliances, 21%.
- 46% of respondents have taken *ongoing* actions to minimise charges including:
    - turning off lights, and heating, 29%
    - avoiding peak times, 18%
    - turning off appliances at the wall, 12%.
- 15% had invested in new technologies to reduce charges including:
    - wood burner, 50%
    - LPG, 22%
    - natural gas 14%
    - solar panels, 13%.

Internal review of TLC

TLC contracted PricewaterhouseCoopers (PWC) and Roger Sutton[7] to conduct a review of its pricing methodology. A summary of the TLC internal review (the internal review) is as follows (The Lines Company, 2017).

- A recommendation is made to move from a demand charge to a variable TOU charge
- The review found that the existing methodology:
    - has too much emphasis placed on the recovery of revenue from a demand charge
    - is too complex for consumers to make sensible decisions to consume or conserve electricity
    - actions in one year do not affect consumers until the following year
    - has complex rules for consumers who move properties.

[7] Roger Sutton is a former CEO of Orion New Zealand, a South Island ENC.

- The existing methodology is a more efficient way to recover costs but is considered by the reviewers to be less equitable than TOU. TOU is also considered simpler to understand.
- The suggested change from demand pricing to TOU will not impact TLCs required revenue, but will change how costs are allocated to customers.
- The reviewers consider the advantages of TOU pricing over demand to be as follows.
    - Pricing will be known in advance.
    - Quantities will be known in advance and can be responded to.
    - Invoices can be issued a month after consumption.
    - Providers of crucial load control can be rewarded.

Comparison of New Zealand results with the literature reviewed

The results from the FPWG discussion paper and TLC reviews compare and contrast with results from the literature review in the following ways.

Table 3 Summary of New Zealand results against areas of agreement in literature

Area where reviewers have general agreement	**Findings from the FPWG review**	**Findings from the TLC reviews**
Network costs should be recovered with a charge that reflects the nature of the cost	There is general agreement in the FPWG discussions paper (ENA 2017b), and from submissions for the need for cost reflective pricing (ENA 2017c). However submitters to the FPWG paper were divided as to whether new cost reflective pricing structures should be employed now or later. Consumer NZ (2016) felt that case for cost reflective pricing has been overstated.	The EA (2017c) states that efficient pricing should reflects the cost of services provided. 'If distribution prices are a good reflection of the cost of providing distribution services then that should result in an outcome that is optimal to society as a whole'(p. 27) The EA also acknowledges that TLC must balance cost reflective pricing with simplicity (*ibid*, p.29). The internal review acknowledges pricing should match cost drivers.
Legacy two part tariffs are not adequate to recover network costs	The FPWG discussion paper states that existing residential pricing is not service based and not cost reflective (p.5). A general agreement was found in submissions to the FPWG paper to move towards cost reflective pricing (and therefore) acknowledge limitations with existing rates. Consumer NZ (2017), notes that there are advantages with more cost reflective pricing but there are risks as well.	The EA in its consultation paper on evolving technologies stated (cited in EA 2016a, p, 2) 'distributor's price structures don't align with their costs and do not signal the cost of new capacity.' The internal review stated that 'globally there is emerging focus on more service based electricity network pricing structures' (p. 29 of the PWC report attached to the TLC internal review).
LRMC appropriate to recover future capacity costs	The FPWG discussion paper notes that LRMC based pricing helps to signal long costs of capacity upgrades (p. 20). LRMC was not generally referred to in submissions, however one submitter Alan Carvel (2016) believes that long run costs should be recovered through the capital contributions policy.	The internal review calculates an LRMC charge to compare whether TLCs existing charges accurately signal capacity constraints (p. 21 of the PWC report). The EA in its review of TLC (EA, 2017c) refers to LRMC in reference to transmission pricing deferring transmission investment. It also states 'economic theory suggests that an efficient price for providing network services is the long run cost of the new network assets that would be required if demand increases from existing levels' (p. 30).
Demand charges best reflect network costs	The FPWG discussions paper rates CPD as the most efficient pricing structure to recover future investment costs in capacity. Submissions on the FPWG paper rated CPD over AMD, and fixed network	The EA review notes the use of 'peak pricing' (CPD) to recover costs where network capacity is constrained. EA also notes that residual costs recovery should have regard to consumer responsiveness (*ibid*, p. 8).

Area where reviewers have general agreement	Findings from the FPWG review	Findings from the TLC reviews
	peak pricing over dynamic periods, when asked what pricing is preferred *if* demand pricing was used. There was no clear discussion by submitters as to why demand charges were preferred or not i.e. whether demand charges were acceptable because they were a good representation of network costs or whether demand charges were not acceptable because they would not be well received by consumers. Although the Sustainable Electricity Association of New Zealand (SEANZ) believes that a ENC should charge for the conveyance of energy and not capacity. While Transpower (2017) (owner of the national grid) accepted that recovery of costs depended on available capacity. Transpower also noted that it agreed pricing should reflect critical peaks.	The TLC internal review stated that too much emphasis was placed on recovering revenue from a single demand charge. Particularly as the network was not constrained (p. 2 of the PWC report). The PWC review found that customers were over penalised for consumption at peak times.
Implementation requires good collaboration and communication with stakeholders	The need for effective stakeholder engagement is acknowledged in the FPWG discussion paper and in submissions. There was a general agreement distributors and retailers should work closely together. Some submitters stated that retailers should be involved throughout the process, and not just on an ad hoc basis, since retailers hold the contractual relationship with end consumers. Six submitters believed that retailers should be contacted before ENCs consulted with consumers, to ensure that misleading messages regarding pricing and consumer impacts were avoided. Two retailers felt that ENCs should not contact end consumers at all. Other suggestions included a pan industry steering group, coordination at industry level, sharing pricing trial data, consistent approaches amongst ENCs and prioritising stakeholder engagement.	The need for effective stakeholder engagement is acknowledged in the EA review and in the TLC internal review. The EA review notes that the complexity of the TLC pricing methodology, particularly the linking of load control with pricing, leads to consumer confusion. In the Executive summary the EA states 'Implementing a new network pricing approach is a complex process and should be given an appropriate level of resource by distributors.'. The TLC internal review notes that feedback from community leaders and customers is an important factor if any changes to pricing are made. PWC include an implementation criteria when assessing TLCs pricing methodology. This criteria includes the need for; clarity, stability, practicality, durability, transition and implementation
Implementation options should include such options as shadow billing, lowest bill, graduated tariffs, opt-in opt-out approaches	Submitters to the FPWG discussion paper had a mixed response to the question of whether rates should be made mandatory or not. Three submitters suggested a mandatory approach, four, a voluntary approach, and three for a voluntary approach initially followed by a mandatory approach. The advantage of a mandatory approach was that it led to consistency across the industry. Some submitters suggested a reward to encourage uptake. Consumer NZ (2017) believes consumers should be given pricing options, and bill protection, with change	The EA in its review states that if opt-in or opt-out are not used, price changes need to be carefully introduced (*ibid*, p. iii). The TLC review recommends a new pricing approach using TOU. It is interpreted that there will be a compulsory transition to TOU. .

Area where reviewers have general agreement	Findings from the FPWG review	Findings from the TLC reviews
	needing to occur slowly. In general there was a mixed response from submitters as to whether implementation should be made voluntary.	

Table 4 Summary of New Zealand results against areas of without agreement in the literature reviews

Areas without agreement	Findings from the FPWG review	Findings from the TLC reviews
The effectiveness of DP to lower peak congestion particularly with enabling technology	The FPWG discussion paper notes that there is more incentive for consumers to adopt AMD pricing if they have in house technology . Use of technology also helps consumers respond to a CPD charge . As noted above, submitters generally agreed for the need to review existing pricing structures. Although real time and peak event pricing were not considered in the FPWG paper, it can be concluded that submitters had a basic acceptance of DP. Those submitters in favour of a review of pricing, also considered that technology was a key to promote stability. Submitters showed broad support for TOU pricing although there was no consensus on what peak periods to use. Consumer NZ concluded from survey results that cost reflective pricing can reduce electricity costs to consumers if implemented properly.	The EA review indicates that consumers will respond to DP but a number of factors can inhibit uptake. These are discussed in the section below. From the UMR survey, consumers did respond to demand charges for the nine years that TLC had DP in place, with 46% recorded to have taken ongoing actions to reduce charges, and 15% had invested in technologies to reduce charges. Only 14% of respondents to the EAs TLC survey used technology to help them monitor and manage their electricity consumption during load control times. The most popular technology device used was the 'switch it' light control, which glowed during load control times. The TLC internal review believes that TOU pricing with peak off peak periods, can achieve desired results.
Consumer acceptance of DP	As noted above, submissions on the FPWG discussion paper were generally supportive of cost reflective pricing, but there was not unanimous support. Contact Energy, New Zealand's second largest retailer by ICP numbers, submitted that critical peak and real-time pricing are not appropriate and too complex for residential consumers. Consumer NZ was reticent in its acceptance of cost reflective pricing, concerned it would adversely affect vulnerable consumers. Of those surveyed by Consumer NZ 34% either opted for the status quo or were undecided, while the remainder opted for some form of DP (including TOU) or capacity charges. Of greatest importance was the need for simplicity. One issue identified in the FPWG paper was the potential for pricing signals not to be passed through by retailers, and hence inhibit the ability of consumers to respond to DP. Submitters to the FPWG paper when	The EA review shows that consumers do respond to DP but there are factors which inhibit successful uptake. These factors include the length of time from consumer actions to pricing impacts, the uncertainty of when peak pricing events will occur, complexity of the pricing methodology, and a lack of consumer engagement to see that pricing signals are working. The TLC internal review backed up the EA review with similar findings on the delay between actions and results, and complexity. The review does recommend however that TOU style charges will achieve a better result particularly with the following changes; notifying consumers in advance when pricing peaks will occur, better use of technologies so that consumers know what their peak charges are in real time, and invoices issued a month after consumption.

Areas without agreement	Findings from the FPWG review	Findings from the TLC reviews
	asked about whether competition can be relied upon to ensure consumers face DP signals, stated that retail competition can be relied upon. Some submitters argue that simplistic and consistent prices (between ENCs) were more likely to get passed through. SEANZ and three other submitters felt that network charges should be passed through and repackaged by retailers, with the suggestion retailers would focus on selling energy and not network capacity.	
Consumer acceptance of demand charges	In submissions to the FPWG discussion paper there was a preference for TOU charges over demand. The Consumer NZ survey (2017) showed a preference for TOU charges and the status quo (day night kWh charges) although a minority preferred demand based charges, and of those, 20% preferred CPD and 7% AMD. Consumer NZ notes that those who preferred demand charges were also likely to prefer user-pays pricing, and included a large proportion of engineers and or people who had worked in the electricity industry. Of the 7% of respondents who preferred AMD, some noted they appreciate the ability to decide when peak demand occurred. One respondent noted 'if anyone wants to know how the alternatives work, they need only look to The Lines Company in the King Country where a peak demand pricing model has been in place for 10 years. It has depressed the area, economically and socially, creating a Them & Us environment with people dependent on electricity only, paying transmission charges in excess of any electricity charges they pay, and often 2x as much' (p. 6).	The TLC example has shown that demand charges did have an impact on consumer behaviour and were in place from 2007. But ultimately demand charges were not acceptable to at least some of TLCs consumers. The UMR Research survey showed that 45% of respondents felt adversely effected by demand charges, while 63% were concerned about peak pricing. Of those concerned 46% mentioned cost as the main concern while another 31% considered unfairness as the main concern. Consumers from areas with a high holiday home concentration were more likely to be engaged and knowledgeable about pricing, more likely to be adversely affected, and more concerned about peak pricing than other respondents. As noted the TLC internal review recommends a move from demand to TOU charges. However, both the EA review and the TLC internal review note that if confusion around when peak pricing events occurred could be reduced, along with the complexity of the pricing arrangement better outcomes could eventuate. It can also be inferred that TLCs pricing signal based on six pricing periods, may have been too sharp, particularly when the network was not constrained. PWC noted that TLCs demand charge was 2 to 6 times higher than LRMC. The combination of confusing price signals and strong peak pricing led the EA to conclude that consumers could not make efficient investments in new technologies.
Efficiency versus other principles of rate design	The FPWG discussion paper develops criteria for network pricing, and notes the trade-offs between the need for cost reflection and simplicity, but the paper does not recommend a preferred approach leaving the decision to individual ENCs. Submitters to the paper overall state	When reviewing TLCs pricing the EA noted that there are no mandatory rules specifying how rate design should look, other than the voluntary pricing principles which are not ordered into a hierarchy. However the EA has indicated in other communications that they regard efficiency as the more important criteria.

Areas without agreement	Findings from the FPWG review	Findings from the TLC reviews
	that prices should be actionable before being cost reflective. The Consumer NZ survey shows that consumers desire simplicity the most, while Consumer NZ concludes that the most important rate designs are stability and certainty. Consumer NZ indicate that the most important factors to rate design are around consumer impacts especially to vulnerable consumers.	The TLC board differ in their opinion of most important criteria to the EA. The Board states that the overarching objective of the review, is to achieve a pricing methodology that is equitable, simple and transparent for customers (PWC report, p.2).

Conclusions

There is general agreement in the literature and from New Zealand examples that network costs should be recovered through a charge that reflects the nature of the cost. Where network costs are expected to increase in the future, a charge based on LRMC can be used. It is also generally agreed that existing traditional two part tariffs do not adequately recover costs particularly in the face of new technologies.

Agreement also exists between the literature and New Zealand examples for the need for stakeholder engagement when designing and implementing new prices. As well as for the need to offer consumers options such as opt-in and opt-out.

The literature suggests that demand charges best reflect network cost drivers, with the exception of voltage control costs, line losses and residual costs. The literature also suggests that DP (both with and without technology) is effective to lower consumption, although consensus on this issue was lacking from some authors.

The New Zealand situation *does* show that consumers respond to demand charges when directly billed, and have done so, despite technology, for nine years. However TLC consumers ultimately rejected demand pricing because of:

- its complexity
- the long delays between consumer actions and effect on prices
- a lack of perceived equity
- uncertainty of when peak pricing times occurred
- the linking of load control times and signalling with peak pricing times

Results from New Zealand also show a strong consumer preference for TOU charges. A TOU charge:

- is more likely to be passed through to consumers by retailers
- is more likely to be accepted and understood
- may have less issues with data and privacy
- is less complex than demand charges
- is more equitable than demand.

New Zealand results also showed that consumers and stakeholder believe equity is of equal or of more importance than efficiency when pricing options were considered. Other criteria considered equally important by respondents are simplicity, and being actionable. Concern also exists that efficient price signals will not be passed through by retailers leading to discussions on what other pricing options should be considered that may achieve positive long term outcomes for ENCs. TOU with peak off peak periods, is one option that was favoured above others.

Areas for further research

If a TOU charge (with a strong peak to off peak ratio) was to be considered for recovering future network costs can it effectively signal LRMC, and enable consumers to make efficient investments in new technology? Will it help ENCs to avoid a death spiral if battery storage capabilities improve?

What is the cost of trading a demand charge for a TOU styled charge which is more likely to be passed through and accepted by consumers? Is a demand charge considered effective if it cannot be passed through and implemented?

In making decisions about changing to a cost reflective tariff, it could also be useful to determine the:

- likely penetration of new technologies on the network such as DG and electric vehicles
- cost of not adopting cost reflective prices
- trade-off between fixed and dynamic tariffs and consumer acceptance of unpredictable pricing periods
- impact of unpredictable pricing periods on consumer well being
- strength of the pricing signal and its impact on efficient investment in new technologies

- the impact of new technologies (to inform consumers of peak periods) on consumer behaviour
- type of pricing appropriate when the price signal may not be passed through by retailers
- trade-off between efficiency, simplicity and consumer choice.

Other areas for further research could also include a better understanding of consumer behaviour. Can we predict a negative response to demand pricing in most cases?. Do consumers prefer costly outcomes for perceived low risk scenarios? Understanding the political and social environment will help researchers understand potential consumer behaviours, including likely responses from consumers with different educational backgrounds and incomes, and likelihood of political and social action. What light would further study in behavioural economics, utilising Bayesian statistics produce in this regard? How can transactional analysis help ENCs communicate with consumers when implementing new forms of pricing where trust may be an issue?

For ENCs that are not integrated with retailers, further investigation into collaborative management such as described in integrated environmental management literature used to solve 'wicked problems' could be useful.

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