Draft Report

Domestic Electricity Tariffs and Demand Side Management

Prepared for

Parliamentary Commissioner for the Environment

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Contents

Executive Summary

The Parliamentary Commissioner for the Environment (PCE) is an officer of Parliament, independent of political parties. The PCE commissioned this work as part of a programme of research on in the electricity industry.

The objective of this report is to review tariff options that could secure greater involvement by the demand side of electricity markets, particularly in the household sector. This is expected to result in less demand overall and/or less demand at times when electricity is especially costly to produce.

There are broadly three ways in which tariff innovations could change the patterns of electricity demand at the household level. They could:

- smooth out demand by shifting it from peak to off-peak periods;
- reduce demand overall; and/or
- shift demand towards distributed generation.

Peak Shaving

Demand can be shifted away from peaks using time-of-use tariffs. We have identified two primary ways of designing these tariffs:

- Posted time-of-use prices; and
- Selective buy-back schemes.

A third option is to adopt "controllable use" tariffs, where parties other than households have the right to curtail supply. These methods are already widely used in New Zealand for hot water systems and night-store space heaters. However they are not "demand response" measures as such because curtailment is not undertaken by the demand side.

While there is international evidence of time-of-use pricing and buy-back schemes, the former is a much more attractive option for ongoing use. There are major design problems with buy-back schemes, principally because of the need to set a reference level of demand against which savings are assessed. Time-of-use pricing however is conceptually straightforward and has good efficiency and equity properties.

Demand Reduction

If the objective is to curtail demand overall, rather than targeting peak periods, then the options include:

- Increasing block tariffs; and
- Recovery of fixed costs through variable charges.

Both of these approaches have the effect of increasing the variable component of tariffs, which increases the incentive to curtail demand. Neither are attractive on efficiency grounds, because they do not align prices with costs. On the contrary, they are specifically designed to avoid doing so.

Increasing block tariffs are widely used internationally, and have been considered in New Zealand but not adopted. They have a superficial equity rationale, which is that all consumers enjoy a quantum of cheaper electricity. However in practice the “needs” of households vary considerably, for example according to the size and composition of the household, so there is no particular equity rationale allocating the same sized block of low cost electricity to all consumers.

Bundling fixed costs into variable electricity tariff components gives end-users an excessive incentive to conserve electricity. Some users who would be willing to pay the full cost of a marginal unit of power do not do so because the price they face is in excess of that cost. This method is already used in New Zealand to some degree.

Distributed Generation

A reasonably strong form of demand response is to invest in self-supply, for example through solar hot water boosters, small wind plants and photovoltaic cells. These options can be made more attractive through tariff reform. Internationally, these efforts are sometimes stimulated in this way, by mandating particular “feed-in” tariffs. These specify the price end-users are paid for surplus electricity injected into the network. One option is known net metering; here the injection and off-take prices are identical. The end-user pays for the difference between the quantum of power drawn out and injected into the network. We also found evidence of much higher prices being paid to particular types of distributed generation, including prices linked to generation costs.

Our view of Desirable Tariff Reform

Based on the review of tariff reform options summarised above, we consider that moving towards greater use of smart metering and associated time-of-use tariffs is the most attractive direction for New Zealand to seek demand response. This strategy has good efficiency properties, unlike increasing block tariffs. It is less challenging than seeking to promote distributed micro generation but does not preclude work in that direction. And provided time-of-use tariffs remain optional rather than compulsory it raises no equity concerns.

How to Achieve This Reform

Our analysis of the practical issues associated with tariff reform began with a review of the incentives facing the relevant layers of the industry, which are lines companies and retailers. We conclude that lines companies have stronger and more reliable incentives to manage peak loads than retailers, for whom such incentives only exist in somewhat unusual circumstances.

We divided the potential reform-promoting actions into three categories: informing, influencing, and intervening. Then, noting the desirability of a dual package comprising smart meters and time-of-use tariff options, we explored the options under each category of potential action.

The resulting recommendations are sequenced, with the idea being that each hurdle needs to be cleared before proceeding to the next action. They are:

1. That the Electricity Commission and/or EECA estimate the costs and benefits of the following two-part strategy:
    a. deploying smart meters to all households in New Zealand; and
    b. requiring all retailers to offer time-of-use tariffs.

    This work should assume that meters conform to common standards, be conducted from the perspective of New Zealand society in general rather than any firms or individuals, value saved electricity at estimates of the system marginal price and include savings in meter reading costs as an additional benefit.

2. That the Electricity Commission require retailers to develop common standards for smart meters. The Commission should facilitate this work including by setting clear timelines. Standards should ensure that any New Zealand retailer can offer time-of-use tariffs through any conforming meter. Once completed, the Commission should ensure that all residential meter installations conform to these standards.

3. That the Electricity Commission mandate the deployment of meters conforming to the common standards, to all residential customers in New Zealand. Following consultation, the Commission should choose between placing this obligation on retailers or lines companies.

4. That the Electricity Commission require all retailers serving residential customers to make a time-of-use tariff available as an option. The off-peak component of this tariff must be lower than any flat tariff offered by the same retailer to residential customers in the same location.

1. Introduction

New Zealand was a relatively early adopter of electricity sector reform, a practice that is now widespread internationally. We also went further than most other countries in some aspects of our wholesale market design, notably by introducing nodal pricing for wholesale electricity in 1996, and by a concerted attempt at industry self-regulation. These innovations originated on the supply side of the industry.

To the extent that the demand side has received attention, it has been primarily initiated by official agencies or as a short-term response to supply shortfalls. The main official agencies involved are the Energy Efficiency and Conservation Authority (EECA) and the Electricity Commission (EC). EECA has undertaken considerable research and led work on appliance labelling. The EC has been effective in stimulating the market for efficient lighting and is currently working on industrial demand through programmes related to electric motors and compressed air systems.

To date, the large electricity companies in New Zealand have not shown much interest in demand side management through tariff innovation. It is common to offer a range of tariff options, some of which have different prices during the day and at night. A small number of households also have access to tariffs that differentiate according to the time of year. These are minimal offerings compared with what might be done, and what is available elsewhere.

This analysis is focussed on electricity tariffs for residential users. It was commissioned by the Parliamentary Commissioner for the Environment (PCE), which has an oversight role across a range of official activities in New Zealand. Our main objective is to review tariff options that could secure greater involvement by the demand side of electricity markets, particularly in the household sector. Greater involvement is likely to mean that households demand less from the supply side of the industry, or shift their time pattern of usage. Alternatively, households could substitute towards energy generated on site (eg solar).

Many forms of tariff innovation require some flexibility in metering technology, such as the ability to record time of use. Metering issues are somewhat complicated in New Zealand, partly because meters are often owned by retailers. Some “smart” meters have been deployed however, and this activity is likely to continue. The PCE has separately commissioned work to analyse smart metering issues. Consequently, in the initial stages of this study, we will largely ignore any constraints that metering technologies might impose on tariff innovation.

The structure of our electricity industry cannot be ignored however, because it is unlikely to change materially in the foreseeable future. In broad terms, the key structural features are as follows.

- Delivery networks (high and low voltage) are mostly structurally separated from entities that generate and sell electricity; their returns are regulated.

- Generation and retailing activities are vertically integrated; there are five relatively large "gentailers" though they do not all compete for retail custom in all areas of the country.
- Wholesale electricity is traded through a single spot market; prices vary by time of day and across more than 200 nodes where the transmission (high voltage) network terminates.

The implications of these features are embedded in the material below. Our methodology has three main steps. Drawing on the results of an international review of approaches, we describe (in section 2) the main ways that tariffs can be used to manage demand. We then consider the feasibility of such approaches in New Zealand, taking into account the structure of the industry here (section 3). Finally, we develop a set of recommendations for action (section 4).

1.1. Domestic Tariffs and Demand in New Zealand

To place this work in context, we begin with a brief overview of the components of domestic electricity pricing and the patterns of household demand over time.

The charges faced by domestic electricity customers depend on their location, electricity retailer, tariff option, and usage. Electricity tariffs vary widely across the country, and in some cases according to time of use. However in all cases, a significant fraction of a typical household electricity bill is not for the cost of electricity; it is a fixed daily charge which pays (some of) the costs of the transmission and distribution networks.

Fixed charges are unavoidable, except through the extreme step of disconnecting one's household from the network. As a result, they are an efficient way of recovering fixed costs, such as those associated with the delivery networks. Adherence to this basic principle is not universal however. For example, generators also have fixed costs, but electricity is traded in the wholesale market using purely linear tariffs (ie a price per unit of energy).

Figure 1 shows data from the most recent survey of domestic tariffs undertaken by the Ministry of Economic Development (MED) in February 2008. These are the charges that would apply to a typical household, which uses around 8000kWh per annum.

Total charges for 8000kWh of delivered electricity range from $1423 to $2353, and the share going to the delivery networks ranges from 25% to 48%. The customer weighted average network share is 37%. The fact that a sizable fraction of domestic electricity bills is not a payment for electricity *per se* places a cap on the extent to which electricity tariff design can modify demand. That is because the overall payment made by a household falls less than proportionately with reductions in consumption of electricity.

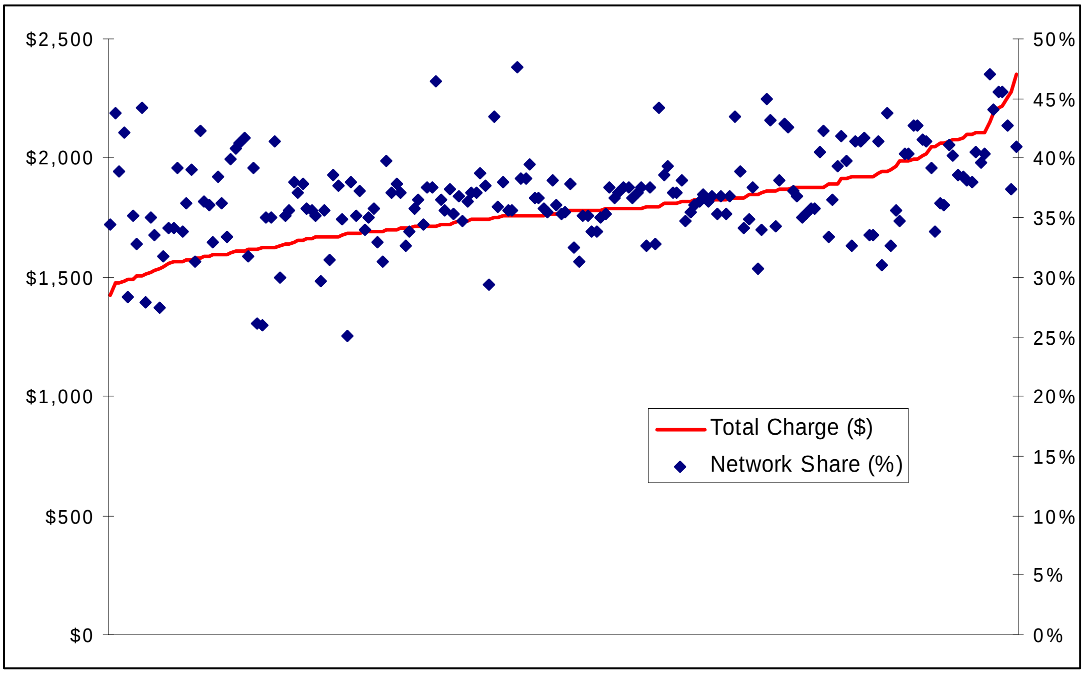

Figure 1 Domestic 8000kWh Charges and Infrastructure Share Feb 2008 (Source: MED)

Overall demand for electricity in New Zealand has increased considerably over recent decades. MED data show that total consumption more than doubled between 1976 and 2006. Most of that increase occurred in the industrial and commercial sectors however. Overall usage in these sectors increased by 257% and 307% respectively, while household sector usage rose a mere 46% over the same period.

More importantly for this project, the number of households has been growing at about the same rate as aggregate household electricity usage, so *average* household electricity consumption has been virtually static for thirty years.

Figure 2 shows the pattern of consumption per household over time, alongside the average price per kWh of delivered electricity.[1] It suggests that, at least in aggregate, households are remarkably insensitive to prices.

There is likely to be considerable variation in price sensitivity within the household sector. Theory suggests, for example, that relatively low income households would be the most price sensitive, in which case tariff innovation might spur greater savings in those sections of the community.

[1] The price data in the graph includes fixed and variable charges: it is the total payment divided by units delivered.

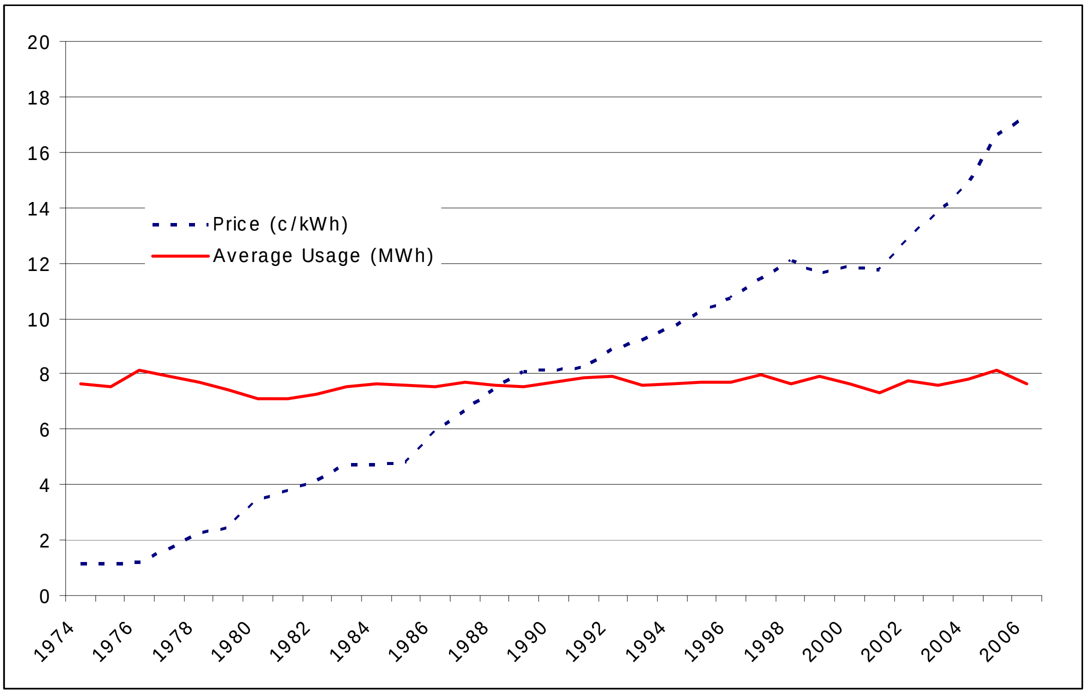

Figure 2 Average Household Electricity Price (incl fixed charges) and Usage 1974-2006 (Source: MED)

It should also be noted that the observed patterns of demand are the outcome of prevailing tariff structures, which are less sophisticated than they could be. Even middle and high income households might therefore respond to different tariff structures.

2. What Could Tariff Innovation Achieve?

There are broadly three ways in which tariff innovations could change the patterns of electricity demand at the household level. They could:

- smooth out demand by shifting it from peak to off-peak periods;
- reduce demand overall; and/or
- shift demand towards distributed generation.

In what follows, we consider each of these as possible objectives and examine the tariff options that would facilitate them. Before doing so, it may be helpful to characterise the impact of tariff reform generally on pricing and demand in the market for electricity.

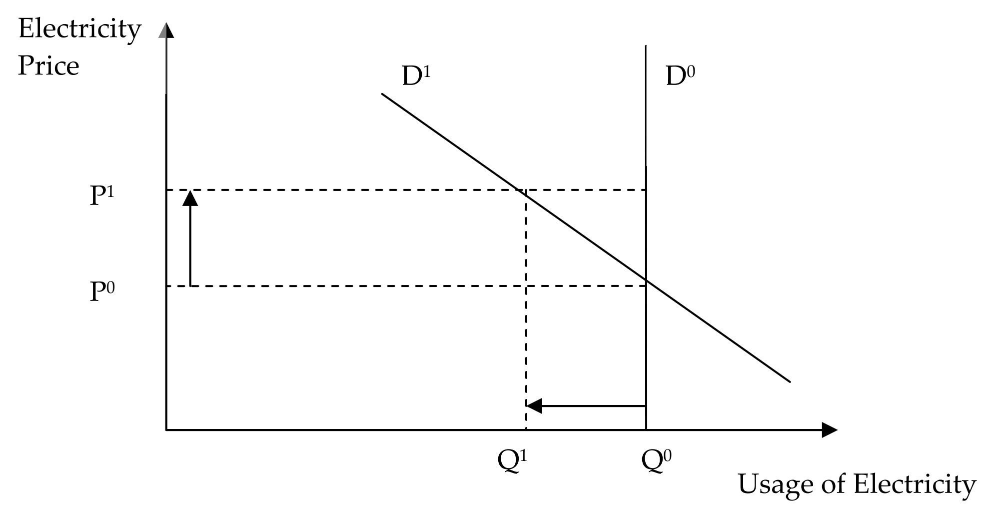

Figure 3 Demand Responses Increases the Elasticity of Demand

The impact of a successful demand response initiative is shown in Figure 3 as a switch from the initial demand curve D^0 to the curve with more responsive demand, D^1. At present, demand is very passive. In the wholesale market, it is still treated as a vertical demand curve that takes whatever price is set in the market. A similar characterisation is reasonable at the household level at least in the short-run, because prices change only rarely.

Demand response, however it occurs, flattens the demand curve as illustrated (D^1). With this curve, price increases (eg from P^0 to P^1) lead to demand curtailment (a shift from Q^0 to Q^1). Again, one can think of this effect as occurring in the wholesale or retail markets.

2.1. Peak Shaving

There are two benefits from shifting demand away from peak periods. One is that it is less costly to produce electricity in off-peak periods. That is because the merit-based dispatch system embedded in our wholesale market ensures that the cheapest sources of electricity are used first. As load reduces, relatively expensive forms of generation are therefore the first to be avoided.

Secondly, if the shift permanently reduces the peak load, it allows the deferral of capital expenditure on new capacity. This effect is potentially relevant to both generation capacity and to the delivery networks. Peak loads will subsequently tend to grow with the level of economic activity, but provided they do so from a lower base, resources will be saved.

Demand can be shifted away from peaks using time-of-use tariffs. We have identified three ways of designing these tariffs:

- Posted time-of-use prices; and
- Selective buy-back schemes.

Before discussing these tariff options further, it is worth briefly mentioning a category of tariffs that do have a peak shaving impact, but are otherwise not relevant to our analysis. These can be described as "controllable use" tariffs. Consumers can often obtain cheaper electricity if they grant their supplier the right to curtail supply. These methods are often used for hot water systems and night-store space heaters. They are invariably peak-shaving devices.

While there is a sense in which these tariffs engage the demand side of the market, that engagement is minimal and qualitatively different to the tariff options we are mainly concerned with. With controllable use tariffs, the only decision required of consumers is to select that tariff option. After that, curtailment decisions are made by the supply side. For this reason, we will disregard this class of tariffs in what follows. However we note in passing that controllable use tariff options are widely available to residential consumers in New Zealand.

2.1.1. Posted Time-of-Use Pricing

The most obvious approach shaving peaks through the use of tariffs is for retailers to post a set of prices that vary by time-of-use. Where such tariffs are used, prices potentially vary at three frequencies:

- Time of day;
- Day of week; and
- Season of year.

An example that includes all three is from Hydro Ottawa. This firm is currently installing smart meters and has not yet announced a start date for its time-of-use pricing. However the proposed pricing structure is available;[2] it is shown graphically in Figure 4. Three rates are used: off-peak; on-peak; and mid-peak. The off peak rate is 3c/kWh and applies on weekends, public holidays, and from 10pm until 7am each night.

[2] https://www.hydroottawa.com/smartmeter/index.cfm?lang=e&template_id=357

An interesting feature of Figure 4 is that peaks are bi-modal during winter (mornings and evenings) but not in the summer. This illustrates a general point which is that tariffs need to be tailored to the specific demand patterns being experienced.

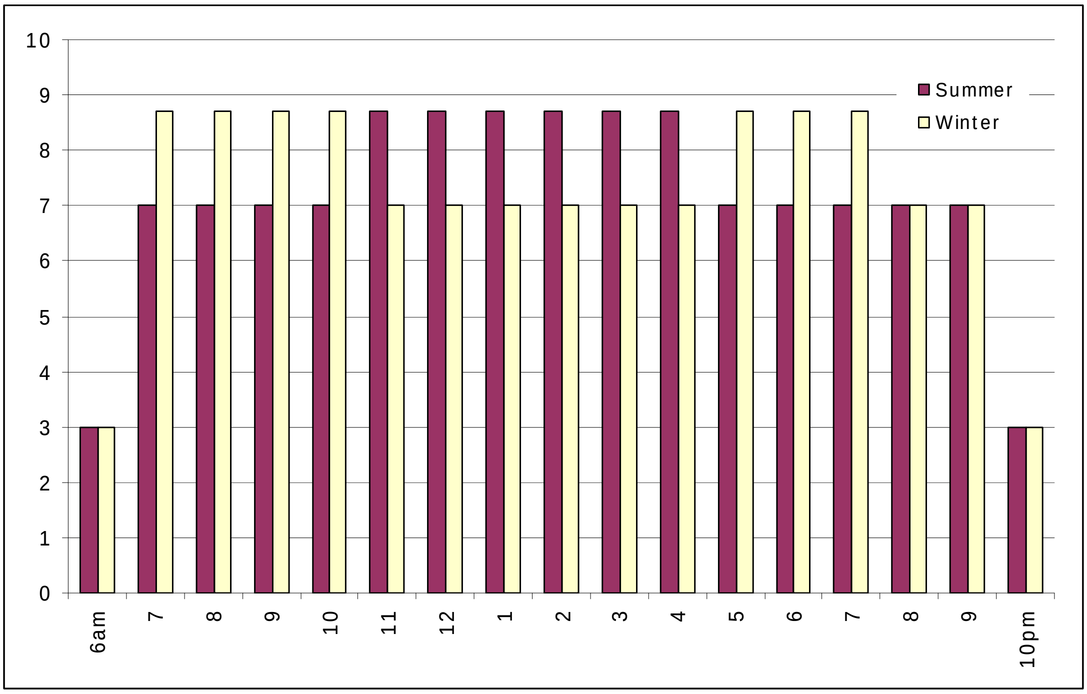

Figure 4 Hydro Ottawa's Proposed Time-of-Use Pricing (c/kWh)

Much of the stress on New Zealand's electricity system occurs at a seasonal frequency, though there are also time-of-day and day-of-week effects. This is relevant because seasonal tariff variation is readily achievable without smart meters, and is already an option for some domestic users in New Zealand. These issues are discussed further in section 3 below.

2.1.2. Buy-Back Schemes

An alternative way to spread load away from peak periods is through the use of buy-back schemes. These offer cash payments or rebates off future bills to customers who curtail their own demand during particular time periods. One such scheme was used by Mighty River Power during the winter of 2001,[3] which was a time of extreme stress on New Zealand's electricity system. An experimental buy-back programme was also conducted in Anaheim, California in 2005, and subsequently analysed.[4]

These schemes are attractive to electricity retailers when three conditions are met:

1. the retailer is exposed to wholesale spot prices (ie they are not fully hedged);

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[3] http://www.winterreview.govt.nz/submissions/initial/034.pdf

[4] Frank A. Wolak, "Residential Customer Response to Real-time Pricing: The Anaheim Critical Peak Pricing Experiment" (February 14, 2007). Center for the Study of Energy Markets. Paper CSEMWP-151. http://repositories.cdlib.org/ucei/csem/CSEMWP-151

2. the variable retail price is fixed; and
3. spot prices, alone or in combination with transmission and distribution costs, exceed retail prices.

Under these conditions, retailers are losing money. Provided the buy-back price is less than the loss per unit of energy, retailers can mitigate their losses by offering their customers financial incentives to reduce load.

Note however that the above conditions are unusual. Retailers try to avoid being in this position, and have some ability to do that through management of retail tariffs and fixed price supply contracts. This is partly why buy-back schemes of this type are not a regular feature of electricity markets.

There are two aspects of regular buy-back schemes that are worth discussing. One is details of the design of the scheme; the other concerns the impact of the scheme on retailers.

The most difficult design task is to set the reference level of demand, against which 'savings' are measured, and the buy-back price. If people know that their demand over a particular time period will be used to set their reference level, they will tend to over-use electricity during that period. That strategy would magnify their measured 'savings'.[5] There are two possible ways to address.

One option is to surprise the market. This would involve launching the scheme after the end of the period over which reference demands were calculated. That is feasible, but is not a strategy that could be repeated on an annual basis, because people would learn to be profligate in advance of the date at which the scheme was expected to be announced. Moreover, it would likely be necessary to recalibrate reference demands periodically rather than have them fixed for several years, to accommodate changes in household composition for example. For completeness, we note that while only some households would change their composition over a period of a year, a system that allowed those people to request a recalibration would be vulnerable to mis-representation by those seeking a higher reference level.

A second option is to allow customers to select their own reference level, but attach higher off-peak prices to higher reference levels. This strategy embeds an increasing block structure (discussed further in section 2.2.1) into the off-peak rates. It has the advantage of confronting customers very squarely with the trade-off between peak and off-peak demand, and cannot be "gamed" as such. The main disadvantage is that it is somewhat complex.

Turning now to the impact on retailers, we note that successful buy-back schemes create a spill-over benefit for these firms. This arises from the impact a successful buy-back scheme would have on spot prices in the wholesale electricity market. If a large share of demand participates in the scheme, then peak spot prices will be materially reduced.

[5] Wolak (2007) reports that this did occur during the Anaheim experiment.

That provides a double benefit to retailers: demand is reduced at a time when spot prices are very high; and spot prices themselves are reduced by a successful (heavily used) scheme.

2.2. Demand Curtailment

If the objective is to reduce demand overall, rather than in specific time periods, then different tariff options would be used. We have found evidence of two tariff types that achieve this objective:

- Increasing block tariffs; and
- Recovery of fixed costs through variable charges.

2.2.1. Increasing Block Tariffs

An increasing block tariff provides a nominated amount of energy each month at a relatively modest rate, and usage thereafter is charged at a higher price. The impact on a customer's bill is compared with a standard tariff in Figure 5.

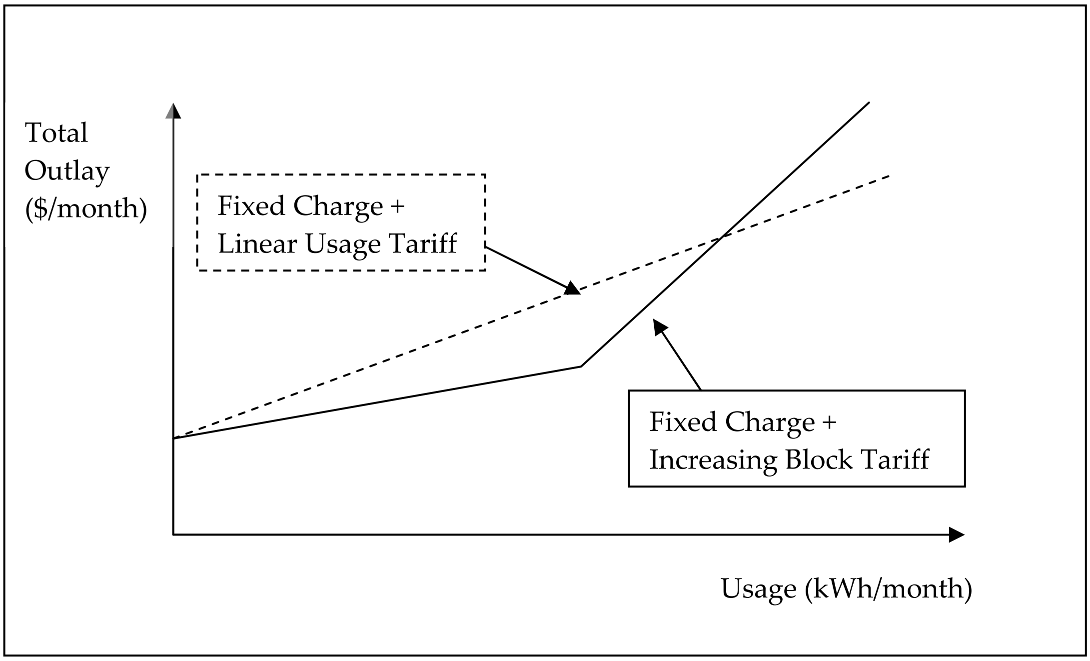

Figure 5 Increasing Block Tariff Illustration

As depicted in Figure 5, the increasing block tariff will provide greater incentives than the linear tariff to reduce demand once the initial (cheap) units have been used. This would be the normal way to construct such a tariff.

We found evidence of increasing block tariffs currently being used in Canada (Hydro Ottawa), Australia (EnergyAustralia), Hong Kong, Thailand, and South America.[6] Some

[6] V Foster and T Yepes, 2006, Is Cost Recovery a Feasible Objective for Water and Electricity? The Latin American Experience, World Bank Policy Research Working Paper No. 3943

European countries (Hungary, Armenia) have recently eliminated them. In other places (eg New South Wales[7]), the merits of introducing them have recently been considered.

An increasing block tariff can potentially address both equity and efficiency objectives. Since all users can obtain a small amount of electricity at a low price, the impact on household budgets of subsequent higher prices (in the second block) is less problematic for low income households. This is attractive from an equity standpoint. At the same time, the second, higher priced block can serve to promote efficiency and conservation.

While an increasing block tariff goes some way towards meeting both of these objectives, it cannot be fully efficient. If the first (cheap) block reflects the marginal cost of electricity, the second block will lead to excessive savings. That is, people who would have been willing to pay the full cost of supply, will instead be priced out the market.

The converse also applies to some degree: if the second block is aligned with the cost of supply, the first block is arguably subsidised. Notice however that, provided the first block is not too large, there is no over-use resulting from the subsidy, and hence no real efficiency loss. Secondly, one could debate whether the first block is in fact subsidised in this context. It is possible to sell electricity in at "bid" prices rather than the system used in New Zealand (and elsewhere) of selling all electricity at "clearing" prices. Thus, for example, hydro power in New Zealand has very low marginal costs outside of stress periods, such as dry winters. In principle, it could be priced much closer to its marginal cost, and used to supply the first block of (low cost) power to all residential customers.

There are also limits on the equity properties of such tariffs. For practical reasons, they tend to allocate the same sized block of low cost energy to each householder. This means that factors that affect the demand for electricity and willingness/ability to pay are ignored. Results that could conflict with notions of horizontal equity include the following:

- Household income is irrelevant (rich and poor get the same tariff); and
- Household size is irrelevant (a household of six gets the same amount of cheap electricity as a household of two).

Increasing block tariffs, also known as "progressive pricing" have previously been considered for use in New Zealand, but have not been adopted.

2.2.2. Higher Variable Tariff Components

A second option that would moderate overall demand involves loading some fixed costs into the variable component of the tariff as illustrated in Figure 6.

[7] IPART Secretariat, 2003, Increasing Block Tariffs for Electricity Network Services.

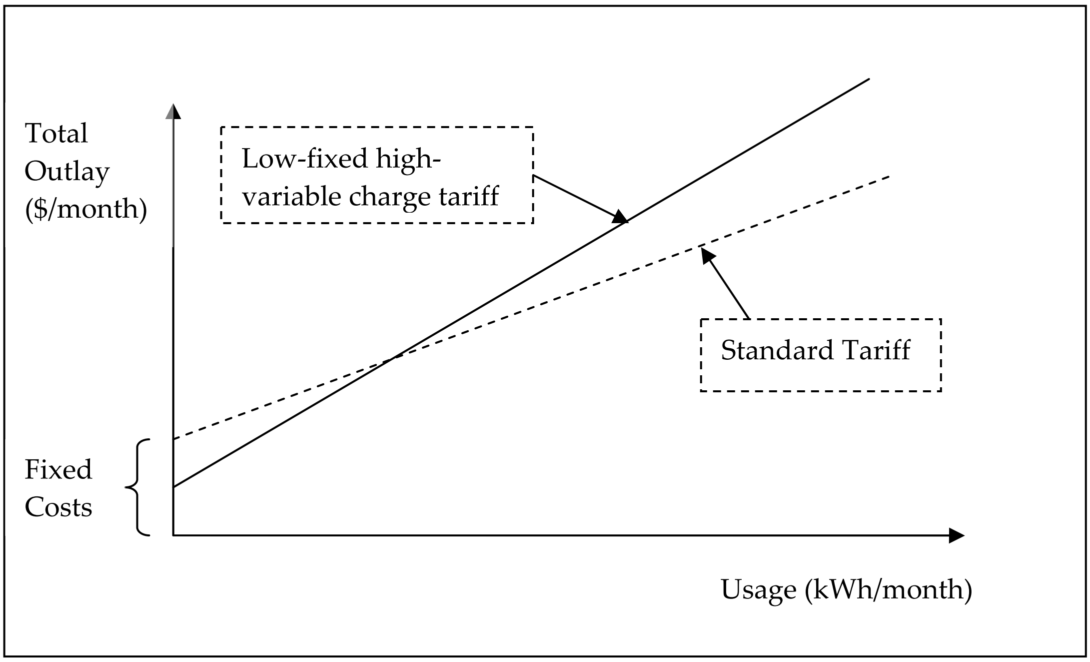

Figure 6 Loading Fixed Costs into Variable Tariff Components

This is done deliberately and explicitly by Hydro Ottawa, which recovers (to some unknown degree) fixed costs for transmission, delivery, regulatory and debt servicing in this way. The components of this firm's variable tariff component are shown in Figure 7. Even in winter, when the variable energy tariff component is higher, the net effect is that over 40% of the variable (per kWh) component of the residential tariff is earmarked for fixed cost recovery.

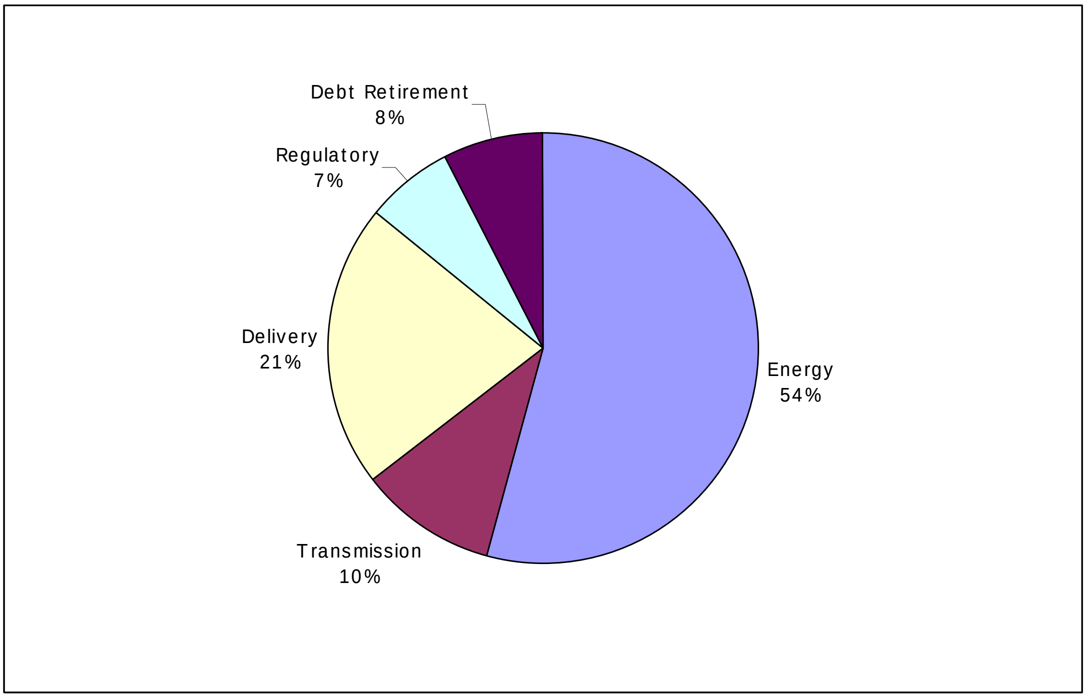

Figure 7 Composition of Hydro Ottawa's (Summer) per kWh Charge for Residential Customers

This approach raises the same efficiency objections as for increasing block tariffs. If a consumer that is considering saving electricity faces a price that is above the marginal cost of electricity, they will tend to save "too much".

While that objection is perfectly valid as an economic proposition, it is also a reality that domestic consumers in New Zealand do currently face retail prices that are well in excess of marginal cost. The simple average of the variable component of domestic electricity tariffs across all locations and suppliers in New Zealand, was 18.68 cents/kWh over the period February 2002 to February 2008 inclusive.[8] This time period matches the longest span of contract prices published on the ComitFree website.[9] The average of all of those prices for the upper North Island (which is the most expensive of the three regions for which data are available) is 7.77 cents/kWh.

There are many caveats applying to the contract prices published on ComitFree. Nevertheless, it is safe to conclude that the variable tariffs faced by domestic consumers in New Zealand are already well above the marginal cost of supply. The difference between variable retail tariffs and (also variable) wholesale prices is attributable to a combination of:

- Fixed cost recovery by generators and retailers
- Contributions to profit; and
- Fixed cost recovery for parts of the transmission system (eg the HVDC link)

2.3. Distributed Generation

The third possible objective of tariff policy is to promote distributed generation. At the household level, this is most likely to take the form of solar hot water, small wind plants, and photovoltaic panels. In a recent discussion paper on the subject the Ministry of Economic Development identified five benefits of distributed generation:[10]

- Meeting demand growth;
- Reduced system losses and deferral of network investment;
- Security of supply benefits;
- Climate change (because renewable generation is likely to be favoured); and
- Market entry and competition.

There are no major physical difficulties with distributed generation. It can be connected to a power network in the same way as other plant, and energy will flow according to the laws of physics. Obviously, this form of energy needs to be taken into account during real time balancing of the power system, but there are mechanisms in place to accommodate it, particularly on the small scales relevant to households.

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[8] Ministry of Economic Development, Quarterly Survey of Domestic Electricity Prices (QSDEP).

[9] http://www.comitfree.co.nz/fta/ftaIndices.display_indices

[10] Facilitating Distributed Generation, September 2006, Resources and Networks Branch, Ministry of Economic Development.

It is the commercial arrangements for distributed generation ('DG') that are potentially difficult, and tariffs are central to these. The main issue is the price DG operators are paid for electricity they supply to the grid, known as a feed-in tariff. Internationally, one can find evidence of two basic forms of tariff, distinguished by the motivation for the tariff as being either:

- Linked to existing retail tariffs; or
- Linked to the cost of distributed generation.

2.3.1. Price-Linked Tariffs

An obvious way to compensate DG operators for electricity fed into the grid is to set a price that is related to the prevailing retail tariff. In an early application of this idea, Germany passed an Electricity Feed Law in 1991. Designed to promote renewable energy, it required any utility supplying power through the grid to pay DG operators for each unit of energy injected in their area. The tariff was a percentage of the utility's average retail revenue per unit of electricity. Wind and solar plants were paid 90% of this measure; small hydro, biogas and small biomass plants were paid 75%.[11]

The International Energy Agency (IEA) maintains a renewable energy database,[12] which shows that feed-in tariffs of this nature have also been used in Austria (from 2001), Denmark (1998) and Italy (2006), and that Bulgaria intends to use them.

When the feed-in tariff is 100% of the retail tariff, it is sometimes referred to as net metering. In essence, the customer's meter runs backwards when power is being injected, and the monthly invoice is for the net quantity withdrawals from and injections to the network. The Danish example cited above mandated net metering for small scale photovoltaic generation.

Price-linked feed-in tariffs offer DG operators a convenient way to dispose of surplus electricity. They do so on terms that are arguably fair. The electricity that arrives at a house is available at a market-determined price. If the householder can generate their own power at or below this price, it is efficient for them to do so. And by injecting surplus back into the network at a similar price, they can supply their neighbours. This trade is mediated by the network owner, but at negligible cost.

2.3.2. Cost-Oriented Tariffs

In some places, a more aggressive approach is used to promote investment in renewables. A good example is Canada, where Ontario recently introduced a standard offer program, containing what is claimed to be the first feed-in tariff to be used in North America in over twenty years.[13]

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[11] http://www.iea.org/textbase/pm/?mode=re&id=1057&action=detail

[12] http://www.iea.org/textbase/pm/?mode=re

[13] http://www.renewableenergyworld.com/rea/news/story?id=48565

In background papers that pre-dated the launching of this programme,[14] the Ontario Power Authority (OPA) discussed whether the feed-in tariff should be "market-based" or "cost-based". While a preference for market-based pricing was expressed, there were several departures from this principle, reflecting:

- The value of distributed generation; and
- Lost economies of scale associated with small scale projects.

The net impact of these allowances was evidently significant, because the feed-in tariff was set at 11 cents/kWh which is well above residential tariffs in the province (which are in the order of 5 – 7 cents/kWh). Additionally, in the case of photovoltaic projects, the tariff was set well above market levels at 42c per kWh to facilitate price discovery for this technology.

[14] http://www.powerauthority.on.ca/Page.asp?PageID=122&ContentID=2009&SiteNodeID=161

3. Constraints and Options for New Zealand

In this section we examine the incentives for promoting demand response from the perspective of parties in the New Zealand electricity industry. We then interpret the responses received from the industry to a set of questions posed by the Parliamentary Commissioner for the Environment in light of those incentives. Finally, we outline what we see as the main constraints and options available for promoting demand response in New Zealand.

3.1. Incentives of Industry Participants

The electricity industry in New Zealand is largely operated by profit seeking firms, though there are some trust-owned lines companies that have broader mandates. A reasonable starting position is that these firms seek to maximise revenues and minimise costs. Since revenues ultimately come from selling electricity-related services to end-users, it is not particularly surprising that demand response has not hitherto been a major area of focus for the industry.

The two main groups of participants we consider in this section are vertically integrated generator/retailers and lines companies. These are the entities that have, or could have, direct relationships with end-users, so their incentives are relevant.

Interposed agreements are the most common contractual structure between lines companies and retailers in New Zealand. Under this structure, lines companies have no direct relationship with end-users. Instead, they invoice retailers who re-package lines charges into their own retail tariffs.

3.1.1. Lines Companies

Lines companies are subject to a "thresholds" regulatory regime administered by the Commerce Commission. Its objectives include ensuring that lines companies are limited in their ability to exploit market power arising from their monopoly position. Service quality is also monitored.[15]

This regime indirectly limits the revenues of lines companies: they are not free to simply increase prices as they might wish. As a result, there is closer attention given to the cost side of the business. Fixed costs, largely driven by the recovery of capital invested in the past, are a very significant share of costs in a lines company. [16] Thus, one of the most attractive ways for a lines company to succeed financially is through economising on capital expenditure.

Capital spending requirements are in turn driven by asset replacement, the timing of which is largely beyond management control, and new investment. When new

[15] An overview of the regime is available from the Commission's website: http://www.comcom.govt.nz/IndustryRegulation/Electricity/ElectricityLinesBusinesses/Overview.aspx

[16] By way of example, depreciation accounted for 29% of the operational expenditure of Transpower in the 2006 year (source: Commerce Commission: http://tinyurl.com/688har).

investment can be deferred for a years (say), a lines company is financially better off. This can potentially be achieved by managing peak loads carefully, since it is increases in peak load that motivate the need for additional capacity. As a result, lines companies have quite strong incentives to initiate and promote peak-shaving behaviour by end-users on their network.

There are also incentive effects that work in the opposite direction, inducing lines companies to promote electricity use. An example is the low fixed charge regime, instituted by the government for the purpose of easing the financial burden of electricity prices on low-income householders.[17] Because this requires some of the fixed costs of lines companies to be recovered through variable tariff elements, lines companies have an interest in ensuring that sufficient electricity is used to cover their own costs.

3.1.2. Generator-Retailers

The generation and retail sectors of the New Zealand electricity are vertically integrated. All of the significant firms have a portfolio of generation plant and a base of end-users. These two components are approximately "balanced" meaning that each firm's generation assets produce about as much electricity as is required by its end-users.[18] There is a financial incentive for balance: it limits the need to purchase electricity from ones rivals through the spot market, which is particularly costly in times of shortage.

This incentive towards a balanced portfolio places some constraint on integrated generator-retailers' incentives to sell more electricity. Compared to the (balanced) alternative, it is relatively risky to acquire customer load that is well in excess of one's ability to generate electricity. Balance of this type is often referred to as a "natural hedge" against spot market risk.

This is the only consistent incentive we can discern that leads generator-retailers to limit sales of electricity. If one has the ability to make more power available, the primary incentives are to generate and sell it.

The only exceptions to this are

- When the generator-retailer is losing money on each unit sold; or
- When there is a risk of losses on some units of electricity.

We have already referred to the first of these scenarios in section 2.1.2. One (un-integrated and un-hedged) retailer went bankrupt in such an environment during the dry winter of 2001. During the same period an integrated generator-retailer (Mighty River Power) introduced a buy-back programme. As discussed above, such programmes have a strong financial rationale for retailers in times of supply stress, but will otherwise usually reduce profits. They are very unlikely to be observed except when an integrated generator-retailer is short of generation capacity.

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[17] http://www.med.govt.nz/templates/ContentTopicSummary____30249.aspx

[18] Perfect balance is unlikely to be achieved, partly because output from renewable sources (eg hydro, wind) cannot be reliably predicted, and partly because plant needs to compete for dispatch.

The second scenario (potentially higher profit on some units of electricity) could be implemented with a time-of-use meter. These could allow a retailer to link tariffs to the wholesale spot price, guaranteeing a margin. Demand would be curtailed as the price increased, but the retailer would be insured against the risk of losses. While this incentive definitely exists, it is nevertheless quite weak for most generators. That is because even when spot prices do spike, most demand is not exposed to it, because portfolios are approximately balanced. Unless they are actually buying from the spot market, the relevant marginal cost is cost of their own marginal generator.

Overall therefore, there are only weak and sporadic incentives for retailers to stimulate demand response.

3.2. Responses to Questions

As part of this project, a set of questions was posed to lines companies and retailers by the Parliamentary Commissioner for the Environment. Our analysis of the responses suggest that they are closely aligned with the incentives analysis presented above. The following observations seem particularly relevant:

- many of the lines companies indicated they are seeking to mitigate peak loads;
- the low fixed charge regime was cited as a reason to stimulate demand; and
- retailers do not appear highly motivated to help their customers mitigate demand.

In addition, we noted a degree of frustration on the part of some lines companies over the way retailers repackage their tariffs. Orion, which is one of the more aggressive promoters of tariff reform, claimed some success in stimulating demand response from residential consumers, but also observed that not all of its tariff innovations are passed through into retail prices.

We note that some generator-retailers are involved in trials with smart meters. Some of these have been underway for several years. While these may be positive signs, it is also possible that the primary motivations for smart meter programmes are not demand response, but

- continued control of the meter; and
- economising on meter reading costs.

3.3. Constraints

Before developing recommendations, we will review the main constraints to greater residential tariff innovation and consequent demand-side response, and the range of options that might be considered.

It will be useful to divide the constraints into those that are inherent in the system, and those that have some potential to be removed. The main inherent constraint is that some existing load profiles are already quite flat. Figure 8 shows the average time-of-day load profile for the Auckland region, compiled from Electricity Commission data. There are morning and evening peaks, but they are relatively small compared with the afternoon trough. This pattern implies that tariff reforms have a limited ability to spread peaks.

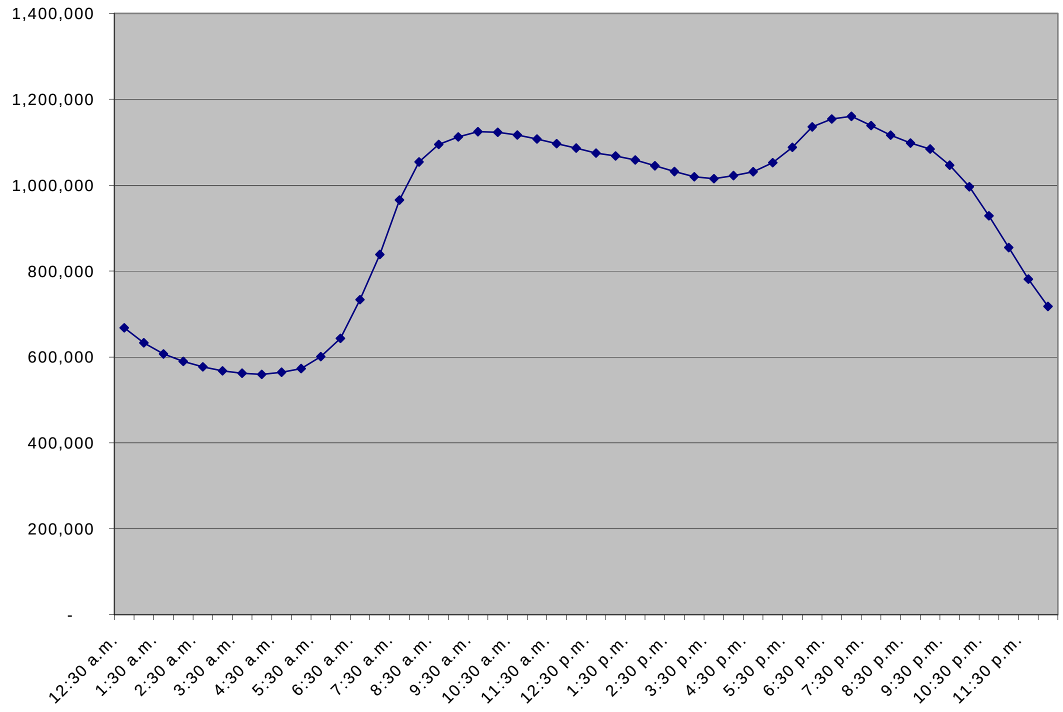

Figure 8 Time of Day Load Profile for Auckland Region (2006) Source: Electricity Commission Centralised Dataset

We expect however that the load profile for any single day might well be more peaked than the averages over a whole year which are shown in Figure 8.

The potentially resolvable constraints can be described at different layers. Most fundamentally, household consumers simply do not have the knowledge or ability to manage their demand sensibly. They do not know the cost of producing their electricity at any point in time, and even if they did know, they are contractually bound by existing tariff structures.

The same constraint can be described at retailer level. Retailers have limited incentives to offer tariffs that promote demand side response, because most of the time those responses would simply lead to lower profits. A desire to avoid complexity inside their business would also be very understandable, and would reinforce the financial incentive.

Another way to frame the problem is that lines companies have insufficient control. At least in principle, lines companies could control metering and use it (in combination with tariffs) to shift load away from peak periods. That would save investment capital for the lines companies, and to the extent that local and national peaks coincide it would also conserve generation-sector resources.[19]

3.4. Options

We are now in a position to develop options for addressing the barriers to greater demand response from the household sector in New Zealand. Based on our review above of what can be achieved through tariff reform we consider that moving towards greater use of smart metering and associated time-of-use tariffs is the most attractive direction for New Zealand to seek demand response. This strategy has good efficiency properties, unlike increasing block tariffs. It is less challenging than seeking to promote distributed micro generation but does not preclude work in that direction. And provided time-of-use tariffs remain optional rather than compulsory it raises no equity concerns.

With this general direction set, we now divide our analysis of options into three categories:

- Information;
- Influence; and
- Intervention.

3.4.1. Information

The most basic requirement is to get better information into the hands of end-users. That could occur through greater deployment of smart meters, but there are also other options.

Starting at the technologically and financially simple end of the spectrum, we note that there are some reliable patterns in the New Zealand electricity system. Demand peaks arising during morning and evening hours coinciding broadly with residential load around meal times. We also know that periods of supply side stress generally occur during winter. Some residential customers are likely to be willing to curtail load during these periods if they were informed about the benefits of doing so, even if those benefits were widely dispersed (ie even without reaping any direct financial reward themselves). That conjecture is supported by the fact that demand responds to periodic dry-winter conservation campaigns. If regular messages were tailored to appeal to the environmental conscience of end-users, responses could be available from people that might otherwise resent the perception that dry-winter campaigns are simply a bail-out of an industry that cannot organise itself properly despite ongoing price increases. Very simple messages, such as starting kitchen and laundry washing appliances towards the end of the evening, could potentially shift load away from peak periods.

[19] Some lines companies may have peaks that differ from those in the spot market, because of unusually combinations of load type. In that case the preferred structure of tariffs for the lines company tariffs would not be fully efficient, because it would tend to shift some load towards times of system-wide peaks rather than away from those times.

While more could be done to harness voluntary actions of this type, there are limits to the effectiveness of such policies, and to the political will that may be required to mandate them. We note a very understandable reluctance on the part of politicians to publicity that could be interpreted as suggesting our electricity industry is struggling to maintain supply.

Greater transparency in retail invoices is another way of improving the flow of information to end-users. The Electricity Commission has recently received submissions on new versions of model contracts for the customers of retailers with interposed agreements.[20] While the Government Policy Statement (GPS) sets an expectation of "transparency of charge components", and the existing model contract requires this to be delivered through invoices, some retailers have not complied because they claim that:

- the cost of changes to their billing systems to provide this information on each invoice would be excessive;
- that where the distributor charges in bulk at the grid exit point the retailer can only arbitrarily establish a way to allocate these charges to individual consumers;
- that there are no benefits to consumers; and
- it would cause confusion for the majority of consumers.

The Electricity Commission accepted these arguments and is proposing that decomposed information will be provided on retailer websites, and directly to consumers at the time of any tariff changes. We note that if the cost of changes to billing systems prevent a simple decomposition of tariff components, the cost of introducing time-of-use tariffs may be even less acceptable to retailers.

The next step up in information provision would be through the introduction of smart meters. The benefits of this step alone (ie without being backed by time-of-use tariffs) are likely to be minimal and not materially greater than what could be achieved with the regular information campaigns outlined above.

3.4.2. Influence

We view this category as being just one step short of intervention. If a party with the ability to intervene, such as the Electricity Commission, was to actively push for particular outcomes, the impact could be similar to what is achievable through threat-based regulation.[21] As a consequence, the outcomes that could be sought via influence are similar to those that could be sought via intervention (section 3.4.3). However it is also possible to influence without any implied threat, so there are different "strengths" of influence available.

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[20] http://www.electricitycommission.govt.nz/consultation/modelcontracts08

[21] Credibility is pivotal to success of threat-based regulation. The Electricity Commission could credibly threaten to regulate some activities, so any (explicit or implied) threats it made would potentially be very effective.

Retaining the existing industry structure, appropriate outcomes to promote demand response could include:

- Agreement over common standards for smart meters
  - It is essential for retail competition that customers can switch suppliers. Since many meters are owned by retailers, differential metering standards will retard switching between retailers, at least by those households using smart meters to their full potential (who have as much right to competitive supply as any other customer).
- Targets for deployment to household customers of meters complying with those common standards
- An agreed date by which retailers will make time-of-use tariffs available as an option for those customers with smart meters

Prior to setting these outcomes up as expectations, it would be desirable to investigate their costs and benefits more fully. This is an important step but beyond our scope.

We note that not all retailers are trialling smart meters at present. This raises some difficulties over "implied threat" influence, which we discuss under the "intervene" category below. Retailers not currently working with smart meters are unlikely to do so in response to less intense types of influence.

If householders were eager to adopt smart meters and the associated tariffs, a relatively light-handed approach may be sufficient on the supply side of the market. Customers would switch towards retailers that offer demand response functionality and those that do not would then have an incentive to follow suit. There may consequently be value in targeting customers directly in an influencing strategy.

3.4.3. Intervention

Potential outcome targets for intervention include the ones cited above under "influence". However because interventions are more intrusive, a wider range of options can also be considered, including structural adjustments. A correspondingly higher standard of analysis would also be appropriate before intervention options are adopted.

Meter ownership is a potentially interesting structural issue. It seems more natural and more pro-competitive for meters to be owned by householders or lines companies than by retailers. If that was so, and these meters looked likely to become widely adopted, retailers would have a stronger incentive to seek common technical standards than is currently the case. Households may come to view a smart meter as an investment, the benefits of which would be capitalised into property values.

If there was a case for mandating widespread smart meter installation, that policy could be implemented via household or lines company ownership. Financial assistance could be provided, funded through an industry levy. This approach need not be any more costly than expanding the roll-outs currently underway by retailers.

Once smart meters are widely available, it is feasible to place some pressure on retailers to offer time-of-use tariff options. That pressure should probably come from the Electricity Commission, and might usefully start with an "influence" strategy, moving towards intervention later if necessary.

4. Recommendations

Our analysis suggests that there are several methods that could be considered to promote demand response by residential consumers. They range from relatively passive options in which information is provided and moral suasion is relied upon, through to much more active initiatives aimed squarely at the deployment and use of smart meter functionality. For the reasons described above, we do not advocate moving in other directions such as increasing block tariffs, or the recovery of more fixed costs through variable tariff components.

We question the effectiveness of options at the most passive end of the spectrum. Voluntary responses to previously observed patterns of peak demand will only be adopted in an ongoing manner by a small section of the community, compared with the response available when financial incentives are offered.

Our recommendations are therefore focused more squarely on smart meter deployment and optional time-of-use tariffs. They are also sequenced, with each stage requiring satisfactory outcomes in the previous stage.

5. That the Electricity Commission and/or EECA estimate the costs and benefits of the following two-part strategy:
    a. deploying smart meters to all households in New Zealand; and
    b. requiring all retailers to offer time-of-use tariffs.

    This work should assume that meters conform to common standards, be conducted from the perspective of New Zealand society in general rather than any firms or individuals, value saved electricity at estimates of the system marginal price and include savings in meter reading costs as an additional benefit.

6. That the Electricity Commission require retailers to develop common standards for smart meters. The Commission should facilitate this work including by setting clear timelines. Standards should ensure that any New Zealand retailer can offer time-of-use tariffs through any conforming meter. Once completed, the Commission should ensure that all residential meter installations conform to these standards.

7. That the Electricity Commission mandate the deployment of meters conforming to the common standards, to all residential customers in New Zealand. Following consultation, the Commission should choose between placing this obligation on retailers or lines companies.

8. That the Electricity Commission require all retailers serving residential customers to make a time-of-use tariff available as an option. The off-peak component of this tariff must be lower than any flat tariff offered by the same retailer to residential customers in the same location.