Smart electricity meters:
How households and the environment can benefit

June 2009

Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata

www.pce.parliament.nz

Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata

PO Box 10 241
Wellington 6143, New Zealand
Tel 64 4 471 1669, Fax 64 4 495 8350, Email pce@pce.parliament.nz

June 2009

Smart electricity meters:

How households and the environment can benefit

June 2009

Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata

Acknowledgements

The Parliamentary Commissioner for the Environment and her investigation team would like to thank all those who assisted with the research and preparation of this report. Particular thanks go to Concept Consulting Group Ltd, Covec, LECG, Strata Energy and John Hancock.

Investigation team

Jo Hendy, Dr Simon Watts, Dr Aaron Lyman

Internal reviewer

Dr Grant Blackwell

External reviewers

Dr Susan Krumdieck, David Prins

Editing

Sharon Cuzens, Sarah Clark, Victoria Parry

Design and layout

The PrintRoom

Photographs

The Office of the Parliamentary Commissioner for the Environment unless specified

Cover Photo

Victoria Parry

This document may be copied provided that the source is acknowledged.

This report and other publications by the Parliamentary Commissioner for the Environment (PCE) are available on the PCE's website: **www.pce.parliament.nz**

Contents

Preface

Electricity is a wonderfully versatile form of energy that has become essential to our way of life. But its generation and transmission have significant effects on the environment, ranging from the global climate change impact of carbon dioxide emissions to a variety of local and regional impacts. All new power plants attract opposition because of these impacts, whether the energy source is 'renewable' or not.

Yet we continue to use more and more electricity. The average amount each of us consumes – the *per capita* consumption – keeps increasing, driving the construction of new power plants and transmission lines (the supply-side). However, the whole answer cannot lie on the supply-side. We must make major gains on the demand-side as well. At the very least, action on the demand-side buys us time while better supply-side technologies are developed. Better demand-side management of electricity can yield environmental benefits by reducing emissions of carbon dioxide and reducing the need for the construction of new power plants.

Smart meters have been on my radar screen for some time, and hold great promise for influencing electricity consumption. They have the potential to create a step change in curbing the growth in the demand for electricity and giving real benefits to consumers, *provided* they are capable of interaction in real time between electricity consumers and retailers.

Shortly after beginning this very rewarding job, I heard mutterings that the smart meters being installed in New Zealand are actually 'dumb meters'. The concern was that the smart meters being installed would deliver benefits to retailers, but would not be able to deliver benefits to the environment or to electricity consumers. This report substantiates that concern.

There are obvious benefits to retailers – remote meter reading, for example. But there are environmental benefits as well. These environmental benefits – reduced emission of carbon dioxide and fewer new power plants – can be delivered if the smart meters are really smart, and have the functionality that will enable peak power to be reduced.

Consumers can also benefit from smart meters through the provision of much better information. A monthly 'post-consumption' power bill is deeply uninformative. If my electricity bill is lower this month, I do not know if this is because I bought a more efficient refrigerator, because the weather was warmer, or because the price had fallen.

Because electricity cannot be stored, the cost of electricity generation, transmission and distribution depends significantly on *when* the electricity is consumed. Smart meters enable sophisticated cost-reflective tariffs, which reflect the variations in the costs of electricity at different times and in different seasons.

Such cost-reflective tariffs would make the Emissions Trading Scheme more effective. Introducing this carbon-pricing scheme into the electricity sector means the cost of generating electricity from fossil fuels will go up relative to the cost of generating electricity from renewable sources. The cost of generating electricity from coal will become relatively higher than the cost of generating electricity from gas because coal power plants emit two to three times as much carbon dioxide as gas power plants per unit of electricity. But consumers on flat rates will have little incentive to change their consumption in ways that would help New Zealand reduce its carbon dioxide emissions.

The Consumers Institute is understandably apprehensive about more cost-reflective tariffs, as many households will have little flexibility in reducing consumption at peak times. In particular, such tariffs might lead to poorer households simply switching off heaters on winter evenings, increasing 'fuel poverty'. For this reason, if more cost-reflective tariffs for households are introduced, it will be *essential* to offer households the choice between the cost-reflective tariffs and a flat rate. Over time, new technology will increasingly allow householders to respond to sharper price signals without hardship.

New Zealand appears to be unusual in the developed world in that the roll-out of smart meters is being undertaken by the market, with no government control. In this report, I recommend that the Government takes a more hands-on approach to the roll-out of smart meters. The competitive challenges of our electricity market go beyond the supply-side oligopoly. One of the requirements for a well functioning market is that consumers are empowered to make fully informed decisions, and smart meters will greatly assist this.

In the longer term, the innovation that could come from really smart meters – in conjunction with a smart grid – is exciting. Imagine using the batteries in a fleet of electric vehicles as storage for our electricity system. An electric car could 'talk' to the retailer via smart communications, automatically ensuring that its battery is charged when electricity is cheapest or the electricity network is least congested.

Further, consider the way in which dry years are managed in this country. Industrial consumers exposed to the very high spot prices occurring during dry years ramp down production to reduce their consumption to 'hedged' levels. But spa pools, for example, continue to be heated at the cost of jobs and productivity because there is no dry year price signal.

Dry year shortages might ultimately be managed more rationally by offering all consumers the option of buying their 'essential' electricity at a fixed price with exposure to the spot market for the remainder. But this would require really smart meters 'talking' to smart appliances. Such smart appliances might include refrigerators that delay defrosting and dishwashers that delay heating until the price begins to fall from a peak.

Finally, I would like to thank my staff who have worked hard on this project, especially Jo Hendy who has cheerfully and competently persisted with unravelling the complexities of this arcane subject.

J. C. Wright

Dr Jan Wright
Parliamentary Commissioner for the Environment

1 Introduction

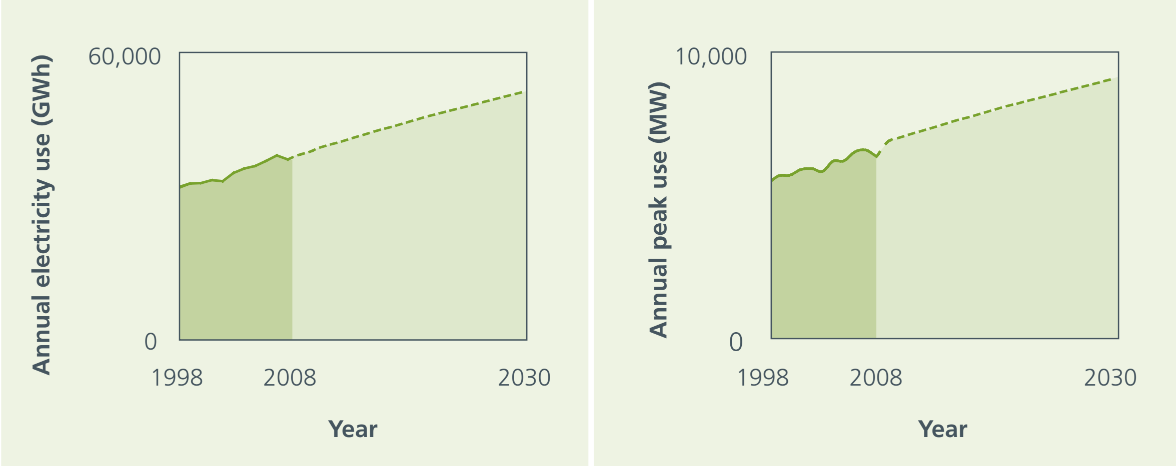
1.1 Smart electricity meters: how households and the environment can benefit

Demand for electricity is growing. Predictions are that our use of electricity will increase at a rate of around one to two percent a year over the next few decades (Figure 1.1), both at peak times and through the year.[1] We know that the generation and transmission of electricity has significant effects on the environment. These range from the impact on the global climate from carbon dioxide emissions to a variety of local and regional impacts associated with the construction of new power plants and transmission lines.

Figure 1.1 Electricity use is increasing

a. Historical and Forecast Total Electricity Use [2]

b. Historical and Forecast Peak Electricity Use [3]



It is hugely important that we plan for and manage these environmental impacts – and for that we need to address both sides of the equation: electricity demand and electricity supply. While there are a number of advances being made that relate to managing electricity supply, these are not discussed in this report. Rather, it is the potential to manage electricity demand that is the focus of attention.

One tool that holds great promise for influencing electricity consumption is the 'smart meter'. Smart meters allow two-way interaction between electricity consumers and retailers, and have the potential to create a step-change in curbing the growth of demand for electricity.

Purpose of this report

This report is the result of an investigation under s16 (c) of the Environment Act 1986. Its purpose is to highlight potential barriers that might make it more difficult to realise the long-term environmental benefits enabled by smart meters.

The report identifies some key functionality that appears to be needed to gain the environmental benefits, and considers if:

- these functions are at risk of being excluded from the initial roll-out of smart meters
- significant additional costs are likely be incurred if these functions must be retrofitted.

The important role of tariff structures in contributing to environmental goals is also discussed.

How the report is structured

Chapter 2 of the report gives an overview of the relationship between electricity generation and the impact on the environment.

Chapter 3 examines household electricity demand.

Chapter 4 analyses the information householders could receive and how they could receive it.

Chapter 5 evaluates the potential for more sophisticated tariffs to incentivise householders to consume electricity more efficiently.

Chapter 6 discusses ways to enable householders to be more flexible in their use of electricity.

Chapter 7 contains nine recommendations to Ministers.

1.2 Why are smart meters important?

Recent research has found that New Zealand households could significantly reduce their peak power demand and overall electricity consumption.[4] To encourage this, however, three aspects of the demand-side of the electricity market need development:

- Information provision
- Price signals
- Demand-side flexibility

Smart electricity meters are a technological solution that could help advances in all these areas, *provided* they have the necessary functionality and appropriate financial incentives are in place.

A smart meter is essentially an electronic electricity meter that enables both time-of-use metering (i.e. electricity use is recorded half-hour by half-hour, rather than a total figure being recorded over a long period of time such as a month), and two-way communication between the household electricity meter and the electricity supplier.[5] Evidence suggests that the consumption and price information smart electricity meters can provide, has a real and long-lasting impact on household electricity demand – both at peak times and over time.

Smart meters can also give householders better control of their consumption. More cost-reflective tariffs could reward them financially for reducing peak power use. A key point is that the same smart meter functionality can provide both environmental and consumer benefits.

The rolling out of smart meters

The large-scale installation of smart meters in New Zealand is just underway, with roll-out to 1.3 million households due to be completed within the next four years. Various market participants are deploying meters – mostly electricity retailers, in some cases lines companies, and possibly meter companies. In this report, these groups are referred to generically as 'power companies'.

The New Zealand roll-out is unusual in that it is being driven solely by market participants. In most other jurisdictions where smart meters are being installed, regulatory bodies have been more involved in specifying minimum functionality for these meters. A purely market-led roll-out means there are no requirements to include the functionality that could deliver environmental or consumer benefits.

1.3 MILLION HOUSEHOLDS WILL HAVE SMART METERS WITHIN FOUR YEARS

Benefits for power companies

Power companies will not automatically provide smart meters with this functionality. It seems reasonable to assume that the New Zealand roll-out is motivated by the private benefits power companies stand to gain.[6,7] If this is the case, then suppliers will only choose functionality that will give them the benefits.

Power companies can benefit in obvious ways from smart meters. For example, remote meter reading will reduce the cost of collecting information. Retailers will also gain greater understanding of the patterns of use for their customers; this is likely to be beneficial, for example when developing marketing campaigns. But it is uncertain how much power companies stand to gain from providing functionality that would also deliver environmental benefits.[8] In fact, retailers may earn *less* revenue if consumers reduce their consumption because of smart meters.[9] This suggests regulatory intervention may be needed to ensure the delivery of these wider benefits.

To intervene or not?

There are costs and risks associated with any intervention. These include:

- the cost of delivering the additional functionality
- the risk of stalling the market roll-out
- the risk of locking in the 'wrong' technology
- an opportunity cost if less expensive options could have provided the same benefit.

Striving for the least-cost option to achieve environmental goals is important. It means that power companies are less likely to resist and that environmental benefits are more readily achievable.

The Electricity Commission has released *voluntary* guidelines on minimum smart meter functionality. It is monitoring the roll-out and will make recommendations to the Minister of Energy as issues arise. However, the Commission's approach is 'light-handed', in line with their mandate. Whether this approach will deliver the environmental benefits in this case is of serious concern.

The difficulty in deciding whether or not to intervene relates to uncertainty about the scale of the benefits. But this uncertainty must be weighed against the fact that smart meters are already being rolled out. Waiting for more information before intervening will mean missing this opportunity and incurring additional costs in the future.

2

Electricity generation and the environment

Generating electricity from any source has an impact on the environment. These impacts are related to how much and when electricity is used.

Electricity generation is accompanied by greenhouse gas emissions, mainly CO_2. Much of New Zealand's electricity is produced from hydro (e.g. Figure 2.1), but a large amount is also generated by fossil fuel power plants – proportionally greater during dry years.[10] In fact, around a quarter of New Zealand's greenhouse gas emissions result from electricity generation.[11] The more electricity consumed, the more must be generated. The more fossil fuels are burned, the more CO_2 is emitted.

Electricity cannot be stored, so energy generation must instantaneously match energy use. This means that sufficient generation capacity is needed to meet peak demands. Increasing peak electricity use not only means more electricity must be generated, it also means more generation and network capacity must be built, increasing environmental impacts.

Figure 2.1 A hydro power station (Tekapo A)

It has been estimated that a three percent reduction in total electricity consumption could reduce greenhouse gas emissions by 200,000 to 400,000 tonnes of CO_2 per year.[12] This is equal to around 2–5 percent of New Zealand's greenhouse gas emissions from electricity generation.[13]

Calculating a more detailed yet robust relationship between different electricity consumption patterns and the associated environmental impacts requires a significant modelling effort. That is not undertaken here. Instead, this report is based on the premise that two main demand-side actions will reduce the environmental impacts of electricity generation:

A 3 PERCENT REDUCTION IN ELECTRICITY USE COULD REDUCE GREENHOUSE GAS EMISSIONS BY UP TO 400,000 TONNES OF CO_2 PER YEAR

- reducing total energy consumption relative to business as usual
- shedding some consumption at peak times (*load shedding*).

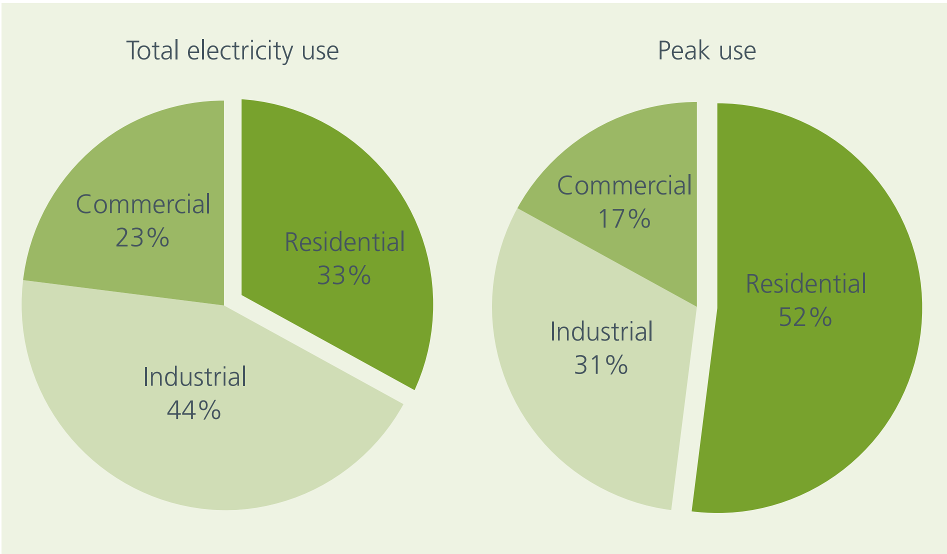
It is also possible that shifting consumption from peak times to off-peak times (*load shifting*) will result in reduced CO_2 emissions. There are two main types of fossil power plants: baseload and peaking. Gas *peaking* plants have higher emissions per kWh than gas *baseload* plants. However, fossil fuel *peaking* plants often emit less CO_2 than *baseload* plants – particularly if the peaking plant is gas-fuelled and the baseload is coal-fuelled.[14] The exact relationship depends on the fuel, the age of the plant and the technology. Without further modelling work, it is not safe to assume that *load shifting* will reduce environmental impacts.

3

Household consumption of electricity

In New Zealand, total electricity consumption is around 40,000 gigawatt-hours (GWh) per year and demand for power peaks at around 6,500 megawatts (MW) (Figure 3.1). Consumers are commonly divided into three groups – residential, industrial and commercial. Figure 3.1 shows the contribution of each sector in 2006 to total energy consumption and peak power demand.

Figure 3.1 Electricity use by sector, 2006[15]



This shows that residential consumers (householders) use around a third of total annual electricity, but contribute to over half of peak demand. Peak demand occurs during winter evenings and is driven mainly by residential space heating, which accounts for around 1,500 MW or almost a quarter of peak power. [16]

Householders could be using their electricity much more efficiently, reducing both total energy consumption and peak power. The Electricity Commission recently commissioned an extensive report to investigate the potential for improving electricity efficiency in New Zealand.[17] The report's authors estimated that a reduction in residential peak power of around 31 percent was economically feasible by 2016.[18]

HOUSEHOLDERS USE AROUND A THIRD OF TOTAL ANNUAL ELECTRICITY, BUT CONTRIBUTE TO OVER HALF OF PEAK DEMAND

3.1 Better results for households and the environment

Increasing the efficiency of electricity use in New Zealand households would benefit both householders and the environment. A material and sustained demand-side action that reduced total consumption and/or shedding of load at peak times would mean:

- Less fuel burnt in fossil fuel plants (e.g. Figure 3.2). This means fewer emissions and lower costs.
- Curbing growth in peak power demand. This would mean less need for new generation or network capacity – saving money and avoiding local environmental impacts.[19]
- Improvements in the electricity market. Enabling consumers to respond to price is one widely acknowledged way of improving the electricity market. [20]

Figure 3.2 Multiple fuel technology power station, Huntly New Zealand

Photo: courtesy of Matthew Gough

Accordingly, this report is based on the premise that reducing consumption and load shedding will reduce environmental impacts, and that sustained long-term reductions will put downward pressure on the price of electricity.[21]

Although the potential benefits are uncertain, some estimates have been produced in a recent report.[22] Based on findings from overseas, the authors of this report suggest that it is reasonable to expect a smart meter-induced reduction in total electricity consumption through energy efficiency improvements of between one and five percent.

In terms of load shifting/shedding at peak, the report suggests reductions ranging between two percent and 10 percent. However, load shifting/shedding also requires price signals being transmitted to consumers by means such as cost-reflective tariffs. The response will depend on the size of the price signals.

Table 3.1 shows estimates of the resulting savings to householders based on these ranges.[23,24] For example, there is the potential for households to save $25 million per year through a one percent reduction in electricity use.

HOUSEHOLDS COULD SAVE $25M EACH YEAR THROUGH A 1% REDUCTION IN ELECTRICITY USE

As a signatory to the Kyoto Protocol, New Zealand is committed to reducing its CO_2 emissions. Improving energy efficiency will reduce the cost of meeting this commitment: a three percent reduction in electricity consumption has been estimated to benefit New Zealand households by $4–$10 million dollars per year (assuming a price of $25 per tonne CO_2).[25]

Table 3.1 Potential savings to New Zealand households[26]

	Potential reduction in electricity use (percentage)	Resulting savings to households ($ per year, excl. GST)
At peak, through load shedding and shifting	2.5%	$23 million
	10%	$94 million
Overall, through energy efficiency improvements	1%	$25 million
	5%	$123 million

4

Providing households with information

A lack of good information has been widely identified as one reason householders do not use electricity as efficiently as they could.[27] This is because they cannot make a direct link between the electricity they use and how much it costs them.

The introduction of smart meters offers one way to provide much better information, although a number of other options are also available. Table 4.1 compares some of these options in terms of timeliness, accuracy, accessibility, type and cost.

Table 4.1 Methods for information provision

Option	Timeliness	Accuracy	Accessibility	Type of information	Estimated additional cost (per customer)
Feasible with current meter stock					
1. Monthly energy bill	Periodic, up to six weeks later	Actual reads & bi-monthly estimates	-	Usage	~$0[28]
2. Media campaigns	Periodic	Household averages	Wide ranging sources	Usage, price, other	Variable
3. Standard in-home display	Real-time	Actual reads	Portable display	Usage	~$265[29]
Feasible with smart meter installed					
4. Smart in-home display	Real-time	Actual reads	Portable display	Usage, price, other	~$70-$150[30,31]
5. Internet portal	Periodic	Actual reads	Requires user logging in	Usage, price, other	~ $0[32]
6. Text messaging/ email	Periodic	Actual reads	Portable	Usage, price, other	~$0[33]

4.1 The monthly energy bill

Householders' main source of information about their electricity use is the *monthly energy bill*, which gives total kilowatt-hours (kWh) consumed over a month.[34] However, these energy bills are neither timely nor always accurate. A householder may have to wait up to six weeks to receive the bill and every second bill is usually based on an estimate rather than an actual reading. With an estimated bill, the kWh charged will not reflect any action householders have taken to reduce their consumption during the month.

LACK OF GOOD INFORMATION IS ONE REASON HOUSEHOLDERS DO NOT USE ELECTRICITY AS EFFICIENTLY AS THEY COULD

4.2 Different ways to inform households

Energy bills provide few details on energy consumption, with not enough information to determine the effect of turning off a heated towel rail or buying a more efficient refrigerator. The energy bill gives no information about a household's contribution to demand peaks. Householders cannot easily learn to reduce their peak consumption when they are given no information on peak usage.

Media campaigns cannot provide real-time information or accurate electricity-use information at the household level. Campaigns are currently used, however, to motivate householders to reduce overall energy consumption – both at times of hydro shortages and to provide information on the electricity usage of different appliances. Campaigns could be used to inform householders when peaks *usually* occur to encourage shifting consumption from peak to off-peak times.[35]

In-home displays have a significant advantage over energy bills and media campaigns: they supply accurate real-time (or near real-time) information on electricity use. Access to this kind of information is powerful because it allows self-teaching.[36]

In-home displays have another advantage over the other options. They can be placed in convenient and readily accessible locations in homes and may help motivate behavioural change by being a constant reminder of electricity use.

In contrast, logging onto an *internet portal* or *checking emails* not only requires a householder to own a computer that can gain adequate internet access but who is also motivated to use the system.

4.3 Using real-time information

Evidence of the effectiveness of real-time information display was found in a review of a number of smart meter studies in the United States, Canada, Scandinavia, the Netherlands and the United Kingdom.[37] The author looked specifically at the effect of information provision on demand reduction. The review found that displaying real-time information about electricity use in a readily accessible place – with no additional price incentives – resulted in lower overall electricity consumption. The response ranged from 5–15 percent. Most significantly, this was a sustained reduction, indicating that behaviour had changed.

A key difference between the smart in-home displays and standard displays is that, as well as consumption information, a smart in-home display can show other real-time information transmitted by the power company, such as price.[38] A standard display cannot do this, as it has no communication link with the power company. The ability to transmit real-time pricing information means retailers could offer more sophisticated tariffs, which incentivise peak shedding at critical times (discussed more in Chapter 5). Sending real-time pricing information could also be done by text messaging or email.

Smart in-home displays appear to offer the greatest promise for inducing overall demand reduction. When applying these results to New Zealand, however, it must be noted that the expected scale of response is uncertain because it is largely due to behavioural change. [39]

4.4 A question of cost

Providing in-home displays will not be free. In contrast, providing an internet portal, text messaging and email notification will be 'costless' because the capability required for these other services is likely to be developed anyway.[40] However, these could only supply information periodically.

Although the Electricity Commission's *voluntary* guidelines state that in-home displays are desirable, it does not appear likely that smart in-home displays will be supplied with smart meters.[41] Most suppliers are not planning to include in-home displays in their initial roll-out.[42] The benefits to power companies from in-home displays are uncertain, making their later inclusion less likely.[43]

Smart in-home displays can be retrofitted, meaning their omission from the initial smart meter roll-out would not necessarily create a long-term barrier, as retrofitting does not incur significant additional costs. As long as the smart meter has home area network communication capability (discussed further in Chapter 6), power companies could just send out a simple display that householders could position themselves.[44]

MOST SUPPLIERS ARE NOT PLANNING TO INCLUDE IN-HOME DISPLAYS IN THEIR ROLL-OUT

5

Using price effectively

Inefficient use of electricity is also related to the price signals householders receive. Price signals send messages: increasing prices encourage householders to reduce consumption. If all the environmental costs were accounted for in the electricity price, then a component of the price signal would relay to householders the environmental impact of their consumption. All other things being equal, they would pay more for electricity when environmental impacts were high and less when impacts were low.[45] This would incentivise a demand response.

PRICE SIGNALS SEND MESSAGES: INCREASING PRICES ENCOURAGE HOUSEHOLDERS TO REDUCE CONSUMPTION

Unfortunately, most New Zealand householders receive inadequate price signals. Many environmental costs have not been included in the price, and the price signal received by householders is dampened because of the tariff structures offered by retailers.

Some tariff structures can better transmit price signals than others. Table 5.1 presents a range of different tariffs and indicates whether they are designed to encourage reducing overall consumption, load shifting or load shedding. The table presents two types of tariff: average-cost tariffs and cost-reflective tariffs.

Table 5.1 Tariff incentives[46]

	Designed to incentivise:		
Tariff Type	Reduction in overall consumption	Load shifting	Load shedding
Average-cost tariffs			
Standard tariff	No	No	No
Low fixed-charge tariff	Partial	No	No
Cost-reflective tariffs			
Time-of-use tariff	No	Yes	No
Critical peak tariff	No	Yes	Yes
Spot market tariff	No	Yes	Yes

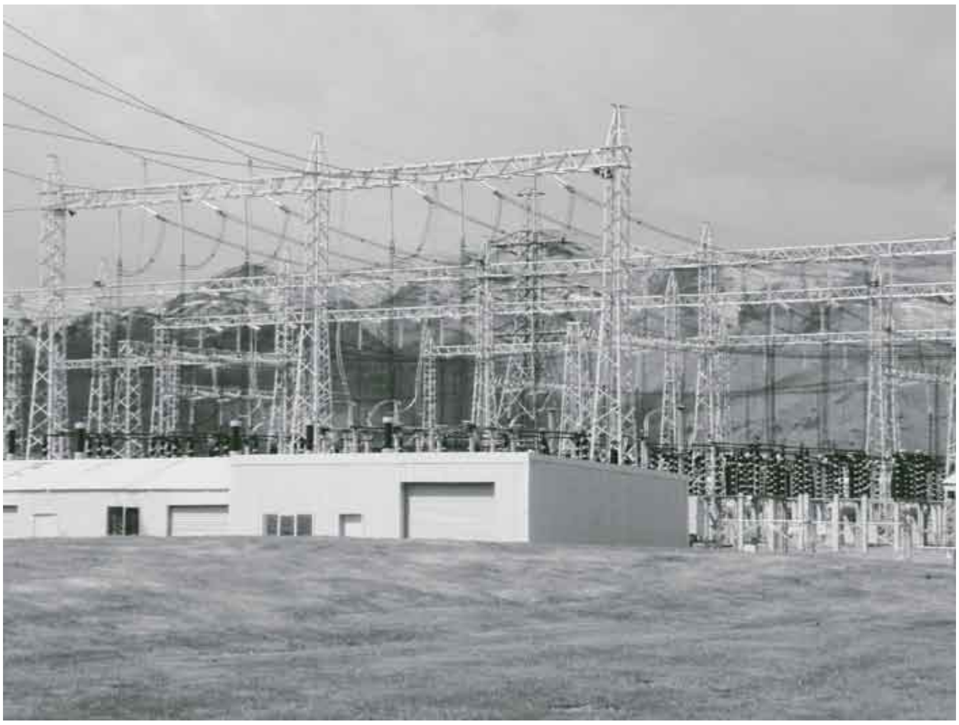
5.1 How households pay for electricity

Average-cost tariffs

Most householders buy their electricity from retailers at a fixed rate.[47] Fixed electricity rates average the costs of supplying electricity to consumers over time (including generation and network costs). Tariff structures based on this approach are commonly called *average-cost tariffs*. The cost averaging protects householders from volatile spot market prices (i.e. the cost of generating electricity), which at times rise sharply. This reduces the risk for householders – which many of them probably want.[48]

As well as averaging generation costs, average-cost tariffs also average the costs associated with transmitting electricity across New Zealand's national grid and distributing electricity via the various local lines companies. Thus, householders receive no price signals reflecting the incremental cost of 'poles and wires' infrastructure (e.g. Figure 5.1).

Figure 5.1 Substation near Twizel



Charging an average price dampens price signals, resulting in too little demand response. For example, a householder considering investing in an appliance that would reduce peak power would not receive as much of a financial payback from lower electricity bills as they would if exposed to wholesale electricity costs and the incremental cost of network investment. The householder is reducing electricity demand at costly peak times yet the reduction in the energy bill reflects only the average costs. As a result, householders have little financial incentive to change their behaviour.

HOUSEHOLDERS HAVE LITTLE FINANCIAL INCENTIVE TO CHANGE THEIR BEHAVIOUR

One outcome of average-cost tariffs is that the fixed rate householders pay is probably higher than it might be.[49] Another consequence is that the effectiveness of policies such as an emissions trading system is reduced. An emissions trading system will change the price at which various types of generation are bid into the wholesale market. This changes the mix of generation in New Zealand and thereby reduces emissions. But if householders are charged only an average price for their electricity, they will pay the same amount at times of high CO_2 emissions as they would at times of low CO_2 emissions. The price signal to the demand-side of the market is dampened, with no signal for the fact that electricity generated at 6pm in winter may result in higher CO_2 emissions and cost more to produce than electricity generated at 11pm.

Average-cost tariffs are easy to implement, however. A power company has only to measure the total kWh consumed over a month, which is what is measured by the current stock of electricity meters in New Zealand households.[50] As a result, these are the predominant tariffs in New Zealand.

The low fixed-charge tariff

Retailers are currently required by regulation to offer a low fixed-charge tariff option, as well as standard tariffs.[51] Generally, a householder's monthly energy bill is made up of two components: a fixed charge and a variable charge.[52,53] The low fixed-user tariff has a cheaper fixed charge component and a more expensive variable charge than the standard tariff.

A reduced fixed charge benefits low energy users and provides an additional incentive for householders to reduce overall kWh consumed.[54] But this tariff discourages power companies from promoting energy efficiency to these customers, as recovering fixed costs through variable charges means power companies earn progressively lower profits if customers consume less electricity.[55] It is also not designed to incentivise shifting or shedding of peak demand.[56]

Tariffs that better reflect costs

More *cost-reflective tariffs* encourage greater peak response than average-cost tariffs because they can be designed to more closely signal the network costs and generation cost of the electricity being consumed at a particular time.[57] Householders opting for such tariffs would be rewarded for reducing electricity use when generation, transmission and/or distribution costs are high. At these times, CO_2 emissions also may be high. In this way, cost-reflective pricing encourages shifting or shedding of peak power demand.

Such tariffs, however, would probably signal the combined cost of electricity generation (including emissions cost) and network delivery. This means that, at times, the network costs may cancel out the emissions price signal.

The availability of sophisticated smart meters makes cost-reflective tariffs much more feasible, because such meters allow power companies to measure consumers' actual consumption during each wholesale price interval (currently 30 minutes). Common cost-reflective tariff structures where interval meters are installed include:[58]

SOPHISTICATED SMART METERS MAKES COST-REFLECTIVE TARIFFS MUCH MORE FEASIBLE

- **Time-of-use tariffs:** Different rates are charged at regularly scheduled times. Higher rates are charged during peak times and lower rates during off-peak times – just like traditional telephone toll call charges. Shoulder or mid-peak rates may also be offered. The scheduled rates could be based on time of day, day of week, and season of year. For example, peak prices might be regularly charged between 6 pm and 10 pm every weekday evening in winter. These tariffs are designed to encourage users to *shift* load.[59]

- **Critical peak tariffs:** An even higher rate is charged at short notice (for example, the evening before). These tariffs are designed to encourage users to *shed* load.[60] These are not charged at regularly scheduled times, but are invoked when forecast demand is greater than forecast supply. Householders would be notified a day or so beforehand that a critical peak period is anticipated. Reasons for critical peak periods are likely to be peak electricity (called for by a retailer) and peak network usage (called for by a lines company). These are often used in tandem with time-of-use tariffs.

How effective are cost-reflective tariffs?

The evidence on householder response to more cost-reflective tariffs is encouraging, although results vary. The most compelling evidence comes from a recent report that reviewed 14 pricing experiments in a number of countries including the United States, Australia, France and Canada.[61] The authors found that time-of-use tariff structures created a drop in peak demand of up to five percent. Critical-peak tariffs were found to produce a drop of between 15 and 20 percent.

Another analysis of data from 11 trials of cost-reflective tariffs in the United States, Canada and Australia found evidence of load shedding ranging from 1–12 percent, and load shifting from 2.5–13 percent.[62,63,64]

It still remains to be seen whether cost-reflective tariff structures will be offered in New Zealand. While some lines companies might offer such tariffs to retailers, retailers are not required to pass these on to householders. In theory, power companies could benefit from encouraging peak load shifting or shedding through more innovative tariffs. Yet retailers reveal that such tariffs are receiving little attention and are unlikely to be introduced in the next few years.[65]

Three issues that may be behind this lack of motivation are the[66]:

- degree of uncertainty around the consumer demand response
- impediments to price signals along the supply chain, from generation, lines companies, to retailers
- lack of capability in IT billing systems.

Challenges for the future

The Commerce Commission chair stated in October 2008 that two of the three key issues foreseen for the electricity industry in 2009/10 were the pricing of electricity and the impact of smart metering and load management.[67] The Electricity Commission and the Commerce Commission plan to address inadequacies relating to the impediments to price signals by developing a model distribution pricing methodology.[68] This work does not extend, however, to ensuring that any cost-reflective distribution prices are offered to householders by retailers.

Finally, it is important to remember that, although it may occasionally benefit them to have customers reduce load, in general, retailers are in the business of selling electricity. At times retailers may earn less revenue as householders reduce their consumption because of time-of-use and critical-peak tariffs.[69] Risk management is important to the vertically integrated generator-retailers; they risk over-committing on the retail side and having to buy electricity from wholesale market when prices are high.[70] Because of this, it is risky for them to devolve any choice or responsibility for demand reduction to householders.

An emissions trading system is an economic instrument that introduces a price signal for environmental costs. Electricity generation is scheduled to enter the New Zealand Emissions Trading Scheme on 1 January 2010 (although it is currently under review). Generators will be obliged to pay for their CO_2 emissions, the cost of which will then be passed on to retailers. Retailers might offer cost-reflective tariffs to pass on the cost of CO_2 emissions to their customers.[71] An alternative available to them would be to raise only the price of the average-cost tariff to cover their increased costs. If this occurs, the price signal to consumers will be dampened, and the effectiveness of the Emissions Trading Scheme reduced.

6 Helping households use electricity better

A worldwide weakness in electricity markets relates to the level of flexibility in household energy use. Electricity has become an 'essential good' – our households are filled with appliances that cannot function without it.[72] Because of this, householders have a limited ability to respond to price signals.

The widespread deployment of smart meters opens up potential for advances in increasing householders' flexibility. This chapter discusses three of these:

- Having suitably equipped smart meters to automate some of the choices to reduce or reschedule electricity usage.
- Facilitating feedback to the grid from households engaged in micro generation.
- Using parked hybrid electric vehicles to smooth peaks.

ELECTRICITY HAS BECOME AN 'ESSENTIAL GOOD' – OUR HOUSEHOLDS ARE FILLED WITH APPLIANCES THAT CANNOT FUNCTION WITHOUT IT

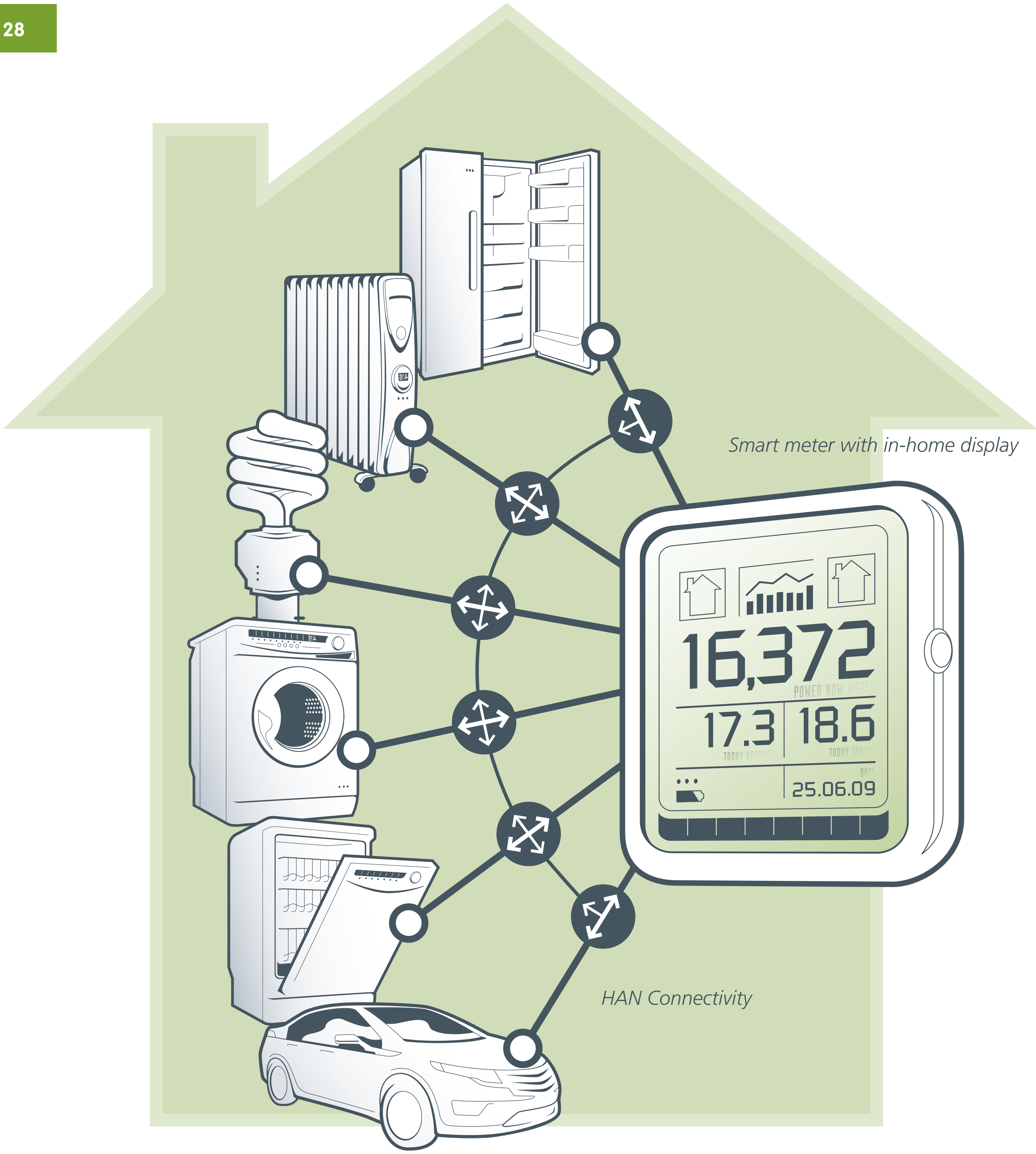
6.1 Making it easy: Automated demand response

In response to cost-reflective tariffs, some householders might invest in technology allowing them to reduce their peak electricity use. Examples include insulation, log burners and night-store heaters. Householders could also change habits – delaying using the clothes drier or dishwasher until after peak times, for example. But such actions may be inconvenient and, to have a noticeable effect in terms of CO_2 emissions, would require many people to change long-established habits. For significant sustained savings, it must be easy to respond to price signals.

Smart meters could be used to address this by automating the demand response. Using a range of different in-home communications technologies (e.g. protocols such as Zigbee or Bluetooth), a smart meter could interact with smart appliances around the home, signalling to them to reduce their electricity usage when required (Figure 6.1).[73]

Figure 6.1 Smart meter interacting with appliances through a home area network (HAN)

Stylised illustrations of how smart electrical appliances could communicate with a smart electricity meter through a home area network.



Appliance manufacturer GE has recently introduced a line of smart appliances to the United States market.[74] Examples include refrigerators that turn off their auto-defrost cycles at peak times, and dishwashers and washing machines that slow down their cycles. Fisher & Paykel is currently working with Arc Innovations to develop smart appliances for the New Zealand market.[75]

Managing peak load reduction

Overseas evidence has shown that by far the greatest peak load reduction is delivered by the combination of critical-peak pricing and automated control of smart appliances.[76] At critical peak times, the result of this combination was a reduction in load by between 25 and 45 percent (Table 6.1).

Table 6.1 Peak power usage reduction[77]

Price structures	Automated response	Resulting peak power reduction
Time of Use Prices only	No	<5%
Time of Use & Critical Peak prices	No	10-15%
Time of Use & Critical Peak prices	Yes	25-45%

The New Zealand context

Two caveats must be considered before extrapolating these results to New Zealand. First, the load available for shedding or shifting at peak times in New Zealand will not be the same as other countries. California peaks, for example, are driven by air conditioning on summer afternoons whereas the New Zealand peaks are driven by heating on winter evenings. The different make-up of electricity use at the peak will mean a need for different demand-side solutions to reduce that peak, and resulting peak demand reductions will also differ.

Reports suggest, however, that New Zealand's summertime afternoon peaks are rising, which would align more closely with the Californian situation. Transpower has reported that unexpected power demand spikes are occurring during summer. Auckland, particularly, has shown an increase in power demand during hot weather due to heat pumps being used to cool homes.[78]

NEW ZEALAND'S SUMMERTIME AFTERNOON PEAKS ARE RISING, PARTLY DUE TO HEAT PUMPS BEING USED FOR AIR-CONDITIONING HOMES

Second, New Zealand already has an extensive 'ripple control' infrastructure where residential water heating is controlled remotely by retailers or lines companies, who turn the heaters off at critical times. The scale of load control from non-hot water appliances may not be large,[79] although if summer peaks increase there may be a substantial benefit from controlling air conditioning via smart meters.

The ripple control infrastructure in many regions is ageing and reportedly falling into disuse.[80,81] If nothing takes its place, this would be a backwards step for load management. Instead of upgrading this infrastructure, a smart meter infrastructure could take over this role.

Smart meters can control load more precisely.[82] Ripple control cannot target specific households, whereas smart meter infrastructure could. Also, instead of turning off water heaters completely, a smart meter might just reduce the temperature to which the water is heated for the critical peak period. This would be more convenient for householders, although it may require upgrading many water heating systems.

This also raises a question, not addressed further in this report, about who should control the load – householders, retailers or lines companies. The Electricity Commission is currently investigating issues surrounding the property rights associated with load management.[83]

Other options exist that might carry out a similar function without householders needing to invest in new appliances. This is not an exhaustive review, but some options might be:

- Timer plugs used to turn appliances on and off at regularly scheduled times. These could help with regular peak periods but could not respond at critical peak times.
- Dynamic demand controllers, which respond to frequency changes in the grid by switching appliances on or off. They can be retrofitted cheaply to appliances and require no centralised control.[84]
- A device retrofitted to appliances allowing a smart meter to control its power supply.

Retrofitting these options to existing appliances, however, means the control would be generally limited to switching appliances on and off.

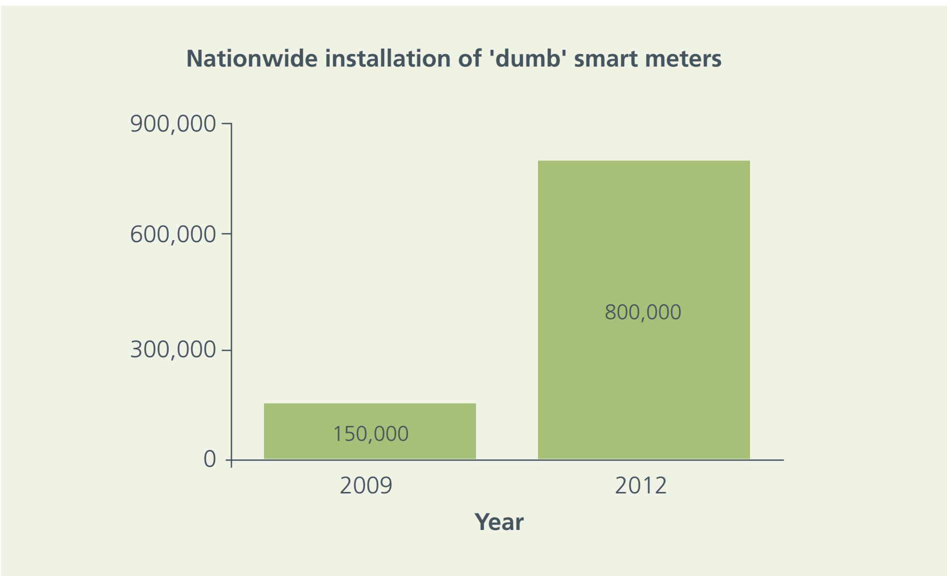
Smart meters that 'talk' in the home

For automated demand response, smart meters would need to have home area network (HAN) communication capability. The Electricity Commission's *voluntary* guidelines have classified this capability as "essential".[85]

800,000 METERS *WITHOUT* HAN CAPABILITY WILL BE INSTALLED BY 2012

As at April 2009, 150,000 'smart' meters *without* HAN capability, and a much smaller number *with* it, have been installed into homes. Retailers are planning to have installed a total of 800,000 meters *without* HAN capability by 2012 (Figure 6.2).[86]

Figure 6.2 Smart meters rolled out without Home Area Network (HAN) capability



The initial cost of supplying a smart meter is estimated to be around $300.[87] This includes the cost of the meter (without an in-home display), installation costs and a proportion of the cost of the infrastructure needed to enable communication between the meter and the retailer.

If the deployed meter is incapable of networked communication, retrofitting the functionality would require an additional visit by a technician, perhaps costing around an extra $75.[88] If HAN functionality has to be retrofitted to 800,000 smart meters, this could result in an additional cost of around $60 million.

Omission of HAN communication capability has implications for in-home displays. A smart meter would need a communications capability to run it because the in-home display would need to be located somewhere easily accessible to householders – and this is unlikely to be where the meter is currently located.

6.2 Proprietary protocols: barriers to competition

Automated control of smart appliances requires some form of communication network between the appliances and the smart meter within the home. For the communication to work well, however, any brand of smart meter must be able to communicate with any smart appliance. This is to avoid issues when switching retailers or moving house.

Networked communication requires the use of protocols – "the format and procedure that governs the transmitting and receiving of data".[89] Protocols can be thought of as the way in which devices communicate with each other. Smart meters and appliances may use proprietary protocols to communicate, which may not be made publicly available by manufacturers. Indeed if proprietary protocols are used in smart meters, consumers could face significant barriers switching between electricity retailers.

CONSUMERS COULD FACE SIGNIFICANT BARRIERS SWITCHING BETWEEN ELECTRICITY RETAILERS IF PROPRIETARY PROTOCOLS ARE USED

Ensuring that protocols are 'open access' is one way to avoid this. With open access protocols each manufacturer would have to make their protocols available to other manufacturers, allowing any manufacturer to make an appliance or device that could communicate with another's appliance.[90]

For communication protocols within home area networks (HANs), the Electricity Commission's guidelines (where AMI – Advance Metering Infrastructure – refers to the smart meters and the associated back-office computer systems) state:

"Provision for HAN interface:

> *44. AMI systems are expected to make provision for a suitable HAN interface of their choosing, to allow NZ to take advantage of the emergence of worldwide standards in this area.*
>
> *45. It is anticipated that the rate of change in this area will see such standards evolve naturally over the next few years. This is an area where an industry working group may add value by centralising information on worldwide trends for emerging candidate standards and protocols."*

The Electricity Commission's guidelines do not specify open access protocols. The Commission, however, plans to review the minimum guidelines when international standards emerge, although by this time a large number of meters may already be installed. [91]

6.3 The potential for micro generation

Micro (or distributed) generation involves electricity generation close to the end-user, but still connected to the grid, using small generation sources such as roof-top solar panels or single wind turbines.[92] Micro generation from renewable sources can benefit the environment if it results in reduced CO_2 emissions from the electricity sector.[93]

To enable appropriate tariffs, micro generation requires export metering. In the past, a specific export meter was needed as well as an import meter. If all smart meters deployed are capable of import *and* export metering, the cost of installing a specific export meter could be avoided.[94] It may be unnecessarily expensive, however, to install this functionality in all 1.6 million households, as only a proportion of them might engage in micro generation and this functionality can be retrofitted.

MICRO GENERATION FROM RENEWABLE SOURCES CAN BENEFIT THE ENVIRONMENT IF IT RESULTS IN REDUCED CO_2 EMISSIONS

The Electricity Commission's *voluntary* guidelines state that, as a minimum requirement, Advanced Meter Infrastructure (AMI) systems should (among other things):

> *"provide ability to meter both import and export power on sites where this is formally contracted between the energy retailer and their customer."*[95]

Most of the meters being rolled-out by the generator-retailers are capable of export metering as well as import.[96] However, one generator-retailer is rolling-out meters that would require some retrofitting to add this functionality, stating that there has been "no demand for this"; they plan to deploy on an "as needed" basis.[97]

A number of policy issues surround the kinds of tariffs needed to reward micro generation:

- What should the export tariff be? (Overseas approaches include linking to the existing retail tariffs or to the cost of the micro generation.[98])
- If the export tariff is not the same as the retail import tariff, should the net export or the gross export be rewarded at the higher rate?
- Should a householder be paid the same for exported generation at all times of day? Should this depend on the householder's imports or should they be separated?
- Who should pay for lines losses and at what rate?

6.4 Hybrid and electric vehicles

A future development in demand management is the charging of electric vehicles at off-peak times, which could smooth electricity demand as well as reduce transport emissions. This already happens in California. If the practice remains small-scale, it could be treated in the same way as other automated demand management options, as highlighted in section 6.1. If it rapidly becomes large-scale, however, it could create new peak periods and become a major problem for the networks.

Longer term, if battery technology improves significantly, it may be feasible to use batteries in vehicles to supplement our relatively small hydro storage. Plug-in hybrids could act as a kind of 'distributed battery' for the national grid, with the grid drawing electricity from the vehicles during peak times, reducing the need for more supply from peak power plants. In this way, plug-in hybrid vehicles could help us optimise our use of both electricity and transport fuels.

7 Conclusions and recommendations

Smart meters are a technological solution that could lead to more efficient use of electricity in New Zealand households. By using electricity more efficiently, reducing both consumption and peak demand, carbon dioxide emissions and other environmental impacts will be reduced.

Smart meters can be used to:

- provide better information to householders
- add financial incentives to encourage householders to respond to that information
- make it easy and convenient for householders to strengthen that response.

The delivery of these benefits, however, depends on the necessary functionality being included in the meters and on more cost-reflective tariffs being offered.

In New Zealand at present, electricity generator-retailers are deploying the majority of smart meters and so decide on their functionality. Most generator-retailers are planning to omit the functionality that is key to delivering the environmental and consumer benefits. This is not surprising given that encouraging more efficient electricity use appears to offer little financial benefit to retailers. This suggests regulatory intervention is needed to ensure environmental and consumer benefits can be delivered.

There is, of course, a cost to any intervention: the cost of delivering the additional functionality, a risk of stalling the market deployment, and a risk of locking in the ‘wrong’ technology. Other, cheaper options may also be available to induce demand response.

The difficulty in making a decision on intervention ultimately comes down to uncertainty. The size of the environmental benefits depends on the amount of demand-side reduction that can be achieved. And considerable uncertainty surrounds the resulting level of reduction.

In deciding when to intervene, however, the uncertainty must be weighed against the fact that smart meters are already being rolled out by power companies. Waiting for more information before intervening would mean missing this opportunity as retrofitting the key functionality costs considerably more.

7.1 Ensuring smart meters really are 'smart'

To take advantage of this opportunity, there is a need to urgently identify functions that will:

- benefit the environment
- be unlikely to be delivered by the power companies of their own accord
- cost more to retrofit than if they were included in the initial roll-out.

Based on the above criteria, this report highlights two key smart meter functions: home area network (HAN) communication capability and real-time in-home displays.

Smart meters with HAN communication capability will enable a number of functions that show promise in delivering sustained demand reduction and – with appropriate tariffs – load shedding and shifting.

Network communication capability is necessary to enable in-home displays to be installed in places where they are easily visible. Evidence shows that displays that are located in convenient places can deliver sustained demand reduction.

If demand-side management is easy and convenient, it is more likely to be sustained. HAN communication capability will enable easy management. Through network communication, smart meters could interact with smart appliances and smart electric vehicles. This means householders could programme their smart meters to manage their household electricity consumption automatically, mainly delivering load shedding and load shifting. Shedding load at peak times and shifting some load to outside peak times would reduce the need for new power plants.

800,000 meters *without* HAN capability are planned for roll-out by 2012. Without HAN capability, the benefits from smart meters almost entirely accrue to the retailer. Consumers will end up paying for meters that provide them with minimal benefits.

If this functionality must be added later it will cost an estimated $60 million more – creating an unnecessary barrier. So regulators must ensure that smart meters are rolled out with this capability. This requires *urgent* intervention.

I recommend that:

1. **The Minister of Infrastructure, the Minister of Energy and Resources, and the Minister of Consumer Affairs urgently require power companies to only install *smart meters* that will not need the capability for home area network communication retrofitted, by making the relevant Electricity Commission guidelines mandatory.**

7.2 Enabling switching between retailers

Network communication between devices is governed by protocols. If manufacturers all use different protocols and are not required to share them, it could add unnecessary costs when switching retailers or moving house. This is inefficient, but more importantly, creates a barrier to switching retailers.

This situation can be avoided by requiring:

- the same protocol to be used by all manufacturers. This protocol might be chosen to match one used in a larger jurisdiction.
- 'open access' protocols to be used, meaning that manufacturers must share them.

After the provision of telecommunications in New Zealand changed from a monopoly to competition, it took years before people were able to take their phone numbers with them when they switched providers. Number portability was a barrier to consumers. In a similar vein, if proprietary protocols are used in smart meters, consumers could face significant barriers switching between electricity retailers.

I recommend that:

2. **The Minister of Infrastructure, the Minister of Energy and Resources, and the Minister of Consumer Affairs require the protocols used in all smart meters and smart appliances to be either the same or 'open access' in order to avoid a potential barrier to consumers switching between retailers.**

7.3 Informing consumers

Many households already have smart meters that do not have home area network (HAN) communication and so lack the potential to deliver consumer and environmental benefits.

A public information campaign informing householders about smart metering is needed. Power companies that are deploying smart meters *with* home area network communication capability have an incentive to provide this information, but others do not, and a government-led campaign may be required.

I recommend that:

3. **The Minister of Energy and Resources and the Minister of Consumer Affairs consider running a public information campaign to inform consumers about smart metering and the opportunities it will bring, provided the meters have Home Area Network communication capability.**

7.4 In-home displays

Smart meters with in-home displays can provide real-time information about electricity consumption. Good information empowers householders to better manage their electricity consumption, benefitting both consumers and the environment. Indications are, however, that the majority of smart meters rolled out by 2012 will not include in-home displays.

Provided a smart meter has home area network communication capability, adding an in-home display is relatively cheap. In-home displays are likely to deliver environmental and consumer benefits mainly by motivating demand reduction, but the size of these benefits is uncertain. Putting in-home displays in every home would probably cost about $100-200 million, so a good estimate of the potential benefit is required before advocating for their inclusion.

To achieve this, a pilot study could be carried out by the government in partnership with a power company, where in-home displays are rolled out to a sample of households and the effects monitored. Careful project design would ensure that the results were statistically significant and regionally representative.

A cost/benefit analysis should then be conducted using the results from the pilot. If justified by this analysis, in-home displays should then be made available to customers. This could be done in a number of ways, such as:

- regulation requiring companies to make them available
- residential end-use electricity efficiency projects
- public/private partnerships to supply them to households.

I recommend that:

4. **The Minister of Energy and Resources and the Minister of Consumer Affairs work in partnership with industry to undertake a pilot study to quantify the benefits of in-home displays and, if justified by the results, promote in-home displays to consumers.**

7.5 One meter for import and export

To enable appropriate tariffs, micro generation requires export metering. The majority of major generator-retailers are rolling-out meters that can do this, but one is not. The Electricity Commission's *voluntary* guidelines state that, as a minimum requirement, smart meters should have export as well as import functionality if micro generation is contracted between a retailer and its customer.

I recommend that:

5. **The Minister of Energy and Resources requires retailers to provide export and import functionality in smart meters if micro generation is contracted between a retailer and its customer, by making the relevant Electricity Commission guidelines mandatory.**

7.6 Cost-reflective tariffs

To gain the greatest load shedding and shifting, it is logical to expect that cost-reflective tariffs must be offered alongside smart meters, and overseas evidence supports this. Both load shedding and load shifting reduce the need for new capacity and so reduce local environmental impacts.

I recommend that:

6. **The Minister of Infrastructure, the Minister of Energy and Resources and the Minister for the Environment investigate the merits of intervening to ensure that retailers offer householders tariffs that will better reflect the costs of generation and transmission at different times.**

7.7 Climate change

The effectiveness of an emissions trading scheme in the electricity sector may well be enhanced by more cost-reflective tariffs, which would strengthen the carbon dioxide price signal. Before robust conclusions can be drawn, however, the potential effect of load shifting on carbon dioxide emissions from electricity generation needs further analysis.

I recommend that:

7. **The Minister for Climate Change Issues initiates a study to clarify the relationship between carbon dioxide emissions and electricity demand and supply patterns.**

7.8 Fuel poverty

'Fuel poverty' is exacerbated by the reliance of many poorer households on inefficient electric heating. More cost-reflective tariffs may disadvantage households that cannot be flexible in their electricity use. Poorer households, particularly, may respond to these tariffs by simply switching off heaters on winter evenings to save money.

A number of different measures could help mitigate fuel poverty. Until this issue is fully addressed, however, if cost-reflective tariffs for households are introduced, it will be *essential* to offer households the choice between these tariffs and an average-cost tariff.

I recommend that:

8. **The Minister of Energy and Resources requires retailers to continue to offer an average-cost tariff to households if, and when, cost-reflective tariffs are made generally available.**

7.9 Low-user tariff

Retailers are currently required to offer a low fixed-charge tariff. This encourages householders to keep their consumption low so that they can be eligible for the low fixed-charge tariff. This tariff option should remain in place, at least until in-home displays and cost-reflective tariffs are widely available.

I recommend that:

9. **The Minister of Energy and Resources maintains the requirement for retailers to offer a low fixed charge tariff to householders.**

Endnotes

1. Electricity Commission. 2008. Statement of Opportunity.
2. Historical data from: Ministry for Economic Development. 2009. "Table 11: Electricity Consumption by All Sectors". Energy Data (Last Updated 14 September 2007). Available online at www.med.govt.nz/templates/MultipageDocumentTOC____21430.aspx [accessed May 2009]. Forecast data from: Electricity Commission Statement of Opportunity 2008.
3. Historical data from: Ministry for Economic Development. 2009. "Table 11: Electricity Consumption by All Sectors". Energy Data (Last Updated 14 September 2007). Available online at www.med.govt.nz/templates/MultipageDocumentTOC____21430.aspx [accessed May 2009]. Forecast data shows "expected" peak demand, from: Electricity Commission Statement of Opportunity 2008.
4. Kema. 2007. *New Zealand Electric-Efficiency Potential Study*. September 2007. Electricity Commission, Wellington, New Zealand.
5. Strata Energy Consulting (Strata). 2008. *Report on international experience with smart meters (energy).* A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Strata. Available online at www.pce.parliament.nz.
6. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand*. A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.
7. Strata Energy Consulting (Strata). 2008. *Report on international experience with smart meters (energy)*. A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Strata. Available online at www.pce.parliament.nz.
8. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand.* A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.
9. Strata Energy Consulting (Strata). 2008. *Report on international experience with smart meters (energy)*. A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Strata. Available online at www.pce.parliament.nz.
10. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand.* A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.
11. Calculated from Ministry of Economic Development. 2007. *New Zealand Energy Greenhouse Gas Emissions 1990-2006.* June 2007. Available online at http://www.med.govt.nz/upload/49905/1_GHG_report.pdf [last accessed January 2009].
12. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand.* A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.
13. Based on emissions calculated: Ministry of Economic Development. 2007. *New Zealand Energy Greenhouse Gas Emissions 1990-2006.* June 2007. Available online at http://www.med.govt.nz/upload/49905/1_GHG_report.pdf [last accessed August 2008].
14. Climate Change Office (CCO). 2003. *Electricity Emission Factor.* Wellington: CCO. www.mfe.govt.nz/publications/climate/electricity-emissions-factor-reports/2004/html/page2.html [last accessed 26 May 2009].
15. Kema. 2007. *New Zealand Electric-Efficiency Potential Study*. September 2007. Wellington: Electricity Commission.
16. Kema. 2007. *New Zealand Electric-Efficiency Potential Study.* September 2007. Wellington: Electricity Commission.
17. Kema. 2007. *New Zealand Electric-Efficiency Potential Study.* September 2007. Wellington: Electricity Commission.
18. This estimate is based on widely available technology.
19. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand.* A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.
20. For example see Evans, L. and Meade, R. 2005. *Alternating Currents or Counter-Revolution contemporary Electricity Reform in New Zealand.* Victoria University Press, Wellington, New Zealand.
21. In the short-term, reduced consumption might actually increase the unit price of electricity, as the fixed costs of the infrastructure are divided over less units of electricity.
22. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand*. A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.
23. This accounts for reduced (or delayed) investment costs for transmission, distribution and new generation.
24. This is based on estimates calculated by Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand*. A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

25. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand.* A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

26. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand*. A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

27. See: New Zealand Treasury. 2005. *Demand-side management.* Paper prepared by the New Zealand Treasury and LECG. 2008. *International and domestic electricity tariffs and tariff structures.* Report prepared for the Parliamentary Commissioner for the Environment. Wellington: LECG. Available online at www.pce.parliament.nz.

28. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand*. A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

29. Based on the cost of a "cent-a-meter" as quoted on www.centameter.co.nz/order.php [last accessed March 2009] being $190 and installation by a licensed electrical tradesperson as recommended by Centameter, estimated to cost around $75.

30. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand*. A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

31. This assumes the smart meter is capable of home area network communication. If the meter is not, the cost of retrofitting this capability would need to be factored in.

32. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand.* A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

33. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand.* A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

34. LECG. 2008. *International and domestic electricity tariffs and tariff structures.* Report prepared for the Parliamentary Commissioner for the Environment. Wellington: LECG. Available online at www.pce.parliament.nz.

35. For more discussion on this see LECG. 2008. *International and domestic electricity tariffs and tariff structures.* Report prepared for the Parliamentary Commissioner for the Environment. Wellington: LECG. Available online at www.pce.parliament.nz.

36. Darby, Sarah. 2006. *The effectiveness of feedback on energy consumption.* Review for DEFRA of the literature on metering, billing and direct displays. Environmental Change Institute. University of Oxford.

37. Darby, Sarah. 2006. *The effectiveness of feedback on energy consumption.* Review for DEFRA of the literature on metering, billing and direct displays. Environmental Change Institute. University of Oxford.

38. This should not be confused with the fact that they can display an expected price programmed in by the householder.

39. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand*. A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

40. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand.* A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

41. Electricity Commission, 2009. *Guidelines on Advanced Metering Infrastructure Version 2.0*. Available online at http://www.electricitycommission.govt.nz/opdev/retail/ami [last accessed February 2009]

42. Based on information provided to the Parliamentary Commissioner for the Environment by major electricity retailers in 2009.

43. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand.* A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

44. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand*. A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

45. But all other things are not equal, and there could be times when due to other factors prices are higher when environmental impacts are low and lower when environmental factors are high.

46. For more discussion on this see Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand.* A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz. and LECG. 2008. *International and domestic electricity tariffs and tariff structures*. Report prepared for the Parliamentary Commissioner for the Environment. Wellington: LECG. Available online at www.pce.parliament.nz.

47. Although not widely available, some customers have meters that are capable of facilitating very simple time of use tariffs (day and night tariffs) and have opted for these tariffs. (LECG. 2008. *International and domestic electricity tariffs and tariff structures.* Report prepared for the Parliamentary Commissioner for the Environment. Wellington: LECG. Available online at www.pce.parliament.nz.).

48. Evans, Lewis and Meade, Richard. 2005. *Alternating Currents or Counter-Revolution contemporary Electricity Reform in New Zealand.* Victoria University Press, Wellington, New Zealand.

49. Tietenberg. 2006. *Environmental and Natural Resource Economics.* Seventh Edition. Pearson Education, Inc.

50. Strata Energy Consulting (Strata). 2008. *Report on international experience with smart meters (energy).* A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Strata. Available online at www.pce.parliament.nz.

51. Electricity (Low Fixed Charge Tariff option for Domestic Consumers) Regulations 2004.

52. The fixed charge pays for fixed costs, such as retailer overheads. The variable charge is proportional to how much electricity is used in the household over the month. The householder is charged a set rate for every kilowatt-hour of electricity they use.

53. LECG. 2008. *International and domestic electricity tariffs and tariff structures.* Report prepared for the Parliamentary Commissioner for the Environment. Wellington: LECG. Available online at www.pce.parliament.nz.

54. LECG. 2008. *International and domestic electricity tariffs and tariff structures.* Report prepared for the Parliamentary Commissioner for the Environment. Wellington: LECG. Available online at www.pce.parliament.nz.

55. LECG. 2008. *International and domestic electricity tariffs and tariff structures.* Report prepared for the Parliamentary Commissioner for the Environment. Wellington: LECG. Available online at www.pce.parliament.nz.

56. Covec Consulting, 2008. *Domestic Electricity Tariffs and Demand Side Management*. Report prepared for The Parliamentary Commissioner for the Environment. Auckland: Covec. Available online at www.pce.parliament.nz.

57. Covec Consulting, 2008. *Domestic Electricity Tariffs and Demand Side Management.* Report prepared for The Parliamentary Commissioner for the Environment. Auckland: Covec. Available online at www.pce.parliament.nz.

58. Faruqui, Ahmad and Sergici, Sanem. 2008. *The power of experimentation. New evidence on residential demand response.* Discussion Paper. The Brattle Group (2008). www.brattle.com.

59. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand.* A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

60. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand.* A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

61. Faruqui, Ahmad and Sergici, Sanem. 2008. *The power of experimentation. New evidence on residential demand response.* Discussion Paper. The Brattle Group (2008). www.brattle.com.

62. Six of which were the same as the Faruqui and Sanem (2008) study.

63. LECG. 2008. *International and domestic electricity tariffs and tariff structures*. Report prepared for the Parliamentary Commissioner for the Environment. Wellington: LECG. Available online at www.pce.parliament.nz.

64. A New Zealand Treasury study comprising four case studies suggested limited potential for load shifting. To apply this result to New Zealand more generally, however, requires a broader analysis. (New Zealand Treasury. 2005. *Electricity Demand-side Management.* Report prepared by the New Zealand Treasury).

65. LECG. 2008. *International and domestic electricity tariffs and tariff structures.* Report prepared for the Parliamentary Commissioner for the Environment. Wellington: LECG. Available online at www.pce.parliament.nz.

66. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand*. A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

67. Commerce Commission. 2008. Submission on *Big Picture – October 2008*. Available online at http://www.electricitycommission.govt.nz/submissions/subscorporate/big-picture08 [last accessed February 2009].

68. Electricity Commission. 2009. *Principles or model approaches to distribution pricing.* Wellington: Electricity Commission. Available online at www.electricitycommission.govt.nz/opdev/transmis/distrib-pricing [Last accessed May 2009].

69. Strata Energy Consulting (Strata). 2008. *Report on international experience with smart meters (energy).* A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Strata. Available online at www.pce.parliament.nz.

70. LECG. 2008. *International and domestic electricity tariffs and tariff structures.* Report prepared for the Parliamentary Commissioner for the Environment. Wellington: LECG. Available online at www.pce.parliament.nz.

71. Although, retailers would be likely to include all time-differentiated costs, not just those relating to carbon dioxide emissions.

72. LECG. 2008. *International and domestic electricity tariffs and tariff structures.* Report prepared for the Parliamentary Commissioner for the Environment. Wellington: LECG. Available online at www.pce.parliament.nz.

73. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand*. A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

74. SmartMeters.com, 2008. *GE developing smart meters for Kentucky utility.* Thursday, 25 September 2008. Available online at www.smartmeters.com/the-news/162-ge-developing-smart-meters-for-kentucky-utility.html [last accessed March 2009].

75. Meridian Energy. 23 January 2009. Personal communication. Email.

76. Faruqui, Ahmad and Sergici, Sanem. 2008. *The power of experimentation. New evidence on residential demand response.* Discussion Paper. The Brattle Group (2008). www.brattle.com.

77. Faruqui, Ahmad and Sergici, Sanem. 2008. *The power of experimentation. New evidence on residential demand response.* Discussion Paper. The Brattle Group (2008). www.brattle.com.

78. NZPA 2009. Heat pumps pose new challenge for Transpower NZ2/4/2009.

79. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand.* A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

80. Strata Energy Consulting (Strata). 2008. *Report on international experience with smart meters (energy)*. A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Strata. Available online at www.pce.parliament.nz.

81. Note that the distribution company Orion is an exception to this.

82. Strata Energy Consulting (Strata). 2008. *Report on international experience with smart meters (energy)*. A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Strata. Available online at www.pce.parliament.nz.

83. Electricity Commission. 2009. *Load management infrastructure.* Wellington: Electricity Commission. www.electricitycommission.govt.nz/opdev/retail/loadmgt [last accessed May 2009].

84. Department for Business Enterprise and Regulatory Reform. August 2007. *Dynamic demand: government response to clause 18 of the climate change and sustainable energy act.* Available online at www.berr.gov.uk [last accessed March 2009].

85. Electricity Commission, 2009. *Guidelines on Advanced Metering Infrastructure Version 2.0.* Available online at www.electricitycommission.govt.nz/opdev/retail/ami [last accessed February 2009].

86. Aggregate number based on information provided to the Parliamentary Commissioner for the Environment by major electricity retailers in 2009. It will be possible to retrofit these meters with HAN capability, though it will be more expensive.

87. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand*. A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

88. Concept Consulting Group Limited (Concept). June 2008. *Smart Metering in New Zealand.* A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Concept. Available online at www.pce.parliament.nz.

89. PCMAg.com. 2009. http://www.pcmag.com/encyclopedia_term/0,2542,t=protocol&i=49877,00.asp [last accessed February 2009].

90. Strata Energy Consulting (Strata). 2008. *Report on international experience with smart meters (energy)*. A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Strata. Available online at www.pce.parliament.nz.

91. Electricity Commission. 21 January 2009. Personal communication. Email.

92. Parliamentary Commissioner for the Environment. 2006. *Get smart, think small: Local energy systems for New Zealand.* Report. Wellington: Parliamentary Commissioner for the Environment.

93. Ministry of Economic Development (MED). 2006. *Facilitating Distributed Generation: Second Discussion Paper.*, September 2006. Wellington: MED.

94. Strata Energy Consulting (Strata). 2008. *Report on international experience with smart meters (energy)*. A report prepared for the Parliamentary Commissioner for the Environment. Wellington: Strata. Available online at www.pce.parliament.nz.

95. Electricity Commission, 2009. *Guidelines on Advanced Metering Infrastructure Version 2.0*. www.electricitycommission.govt.nz/opdev/retail/ami [last accessed February 2009]. Paragraph 11h.

96. Based on information provided to the Parliamentary Commissioner for the Environment by major electricity retailers in 2009.

97. Based on information provided to the Parliamentary Commissioner for the Environment by major electricity retailers in 2009.

98. Covec Consulting. 2008. *Domestic Electricity Tariffs and Demand Side Management.* Report prepared for The Parliamentary Commissioner for the Environment. Auckland: Covec. Available online at www.pce.parliament.nz.

Glossary

Average-cost tariff	A tariff where the customer pays the same fixed rate for every unit of electricity consumed. The fixed rate reflects the average costs of generating and supplying electricity to end consumers.
Base load plant	Base load plants are used to meet some or all of a given region's continuous energy demand, and produce energy at a constant rate, usually at a low cost relative to other production facilities available to the system.
Cost-reflective tariff	A tariff where the customer pays a different rate depending on when the unit of electricity is consumed (for example, night and day rates). These types of tariff can be designed to more closely signal the network costs and generation cost of the electricity being consumed at a particular time.
Demand-side management	Management that influences the amount or timing of users’ energy demand in order to use scarce energy resources most efficiently. This includes reducing the peak demand by spreading the customer load more evenly over the entire daily or weekly period.
Micro generation (or distributed generation)	Micro generation is also called distributed generation, on-site generation, dispersed generation, embedded generation, decentralized generation, decentralized energy or distributed energy. It involves generating electricity from many small energy sources such as roof-top solar or single wind turbines.
Emissions Trading Scheme (ETS)	The Climate Change Response (Emissions Trading) Amendment Act 2008 established the New Zealand Emissions Trading Scheme (ETS). The ETS puts a price on greenhouse gases to provide an incentive for reducing emissions.
Fuel poverty	Households that cannot afford to keep adequately warm.
Generator	An entity that produces electrical energy.
Generator-retailer	An entity that is both a generator and a retailer.
Gigawatt hour (GWh)	1,000,0000,0000 watt hours. See Watt hour.
Home area network (HAN)	A home area network is a collection of appliances and/or devices that can communicate with each other.
Householders	Residential consumers.
Hybrid electric vehicles (HEVs)	Vehicles that combine an internal combustion engine and one or more electric motors.
In-home display (IHD)	A visual interface between the smart meter and the end consumer. It could be used to show electricity use through a series of coloured lights (red, orange, green) based on level of consumption or display actual electricity usage or usage over different periods of time.
Kilowatt (kW)	1,000 watts. See Watt.
Kilowatt hour (kWh)	1,000 watt hours. See Watt hour.

Lines companies	Entities that are responsible for transmitting electricity from the national grid to consumers. They also step down voltages to levels usable by households.
Load reduction	Reducing electricity consumption.
Load shedding	Reducing electricity consumption at peak demand times, which also results in reduced overall consumption.
Load shifting	Reducing electricity consumption at peak demand times by shifting consumption to off-peak. Load shifting does not result in reduced overall consumption.
Low fixed-charge tariff	An average-price tariff offered to people who use a low amount of electricity (<8000kwh in New Zealand).
Megawatt (MW)	1,000,000 watts. See Watt.
Megawatt hour (MWh)	1,000,000 watt hours. See Watt hour.
Meter company	Third party metering providers.
National grid	The high voltage power cables that transmit electricity from where it is generated to local lines networks or directly to industrial users; operated by Transpower.
Peak load/Peak demand	The times when demand for electricity is at its maximum, requiring generation to operate at or near its full capacity.
Peaking-plant	A plant used occasionally to generate electricity when demand is at its highest.
Power company	Either a generator, retailer, lines company or meter company.
Power line carrier	Using the power line to transmit management information.
Protocol	A set of rules governing the format and procedures of messages that are exchanged between electronic devices. Protocols that are made available to other manufacturers are 'open access' protocols.
Retailer	A company that sells electricity to consumers.
Ripple control	Remote control of certain loads (mostly residential water heaters) that can be shut off if electricity demand exceeds supply.
Shedding	See load shedding.
Smart appliance	An appliance that is capable of communicating with a smart meter or home area network.
Smart meter	A smart meter is essentially an electronic electricity meter that enables both time-of-use metering (i.e. electricity use is recorded half-hour by half-hour, rather than a total figure being recorded over a long period of time such as a month), and two-way communication between the household electricity meter and the electricity supplier.
Standard in-home display	Measures and displays electricity being consumed without communicating with a smart meter.
Watt (W)	Measure of power equal to one joule per second. See Kilowatt and Megawatt.

Watt hour (Wh)	A measure of energy equivalent to one watt of power used for one hour, or 3,600 joules. See Kilowatt hour, Megawatt hour, and Gigawatt hour.
Wireless communication	Communication without wires for example Zigbee, Bluetooth or some other format.

Parliamentary Commissioner for the Environment
Te Kaitiaki Taiao a Te Whare Pāremata

PO Box 10 241
Wellington 6143
New Zealand
Tel 64 4 471 1669
Fax 64 4 495 8350
Email pce@pce.parliament.nz
www.pce.parliament.nz

June 2009

ISBN 978-1-877274-27-5 (print)
978 -1-877274-02-2 (electronic)