Smart metering in New Zealand

A report prepared for the Parliamentary Commissioner for the Environment

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Concept Consulting Group Limited
Level 6, Featherstone House
119-121 Featherstone St
PO Box 10-045, Wellington, NZ
www.concept.co.nz

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EXECUTIVE SUMMARY

Introduction

One of the most significant technological changes happening in many electricity sectors around the world is the start of mass-market deployments of so-called ‘smart’ meters. Such meters can not only record time-of-use consumption on a half-hour-by-half-hour basis, but have two-way communication abilities. This enables remote meter reading, and the sending of instructions for the smart meter to ‘do’ something (e.g. control a smart appliance, remotely disconnect or reconnect a property, limit load to the property, etc.)

The range and scale of different benefits such functionality has the *potential* to deliver is considerable including: reduced consumption (leading to avoided generation and network investments, and reduced environmental impacts); reduced retailer and meter owner operating costs; and improved ‘social’ services for vulnerable customers.

However, the *actual* extent to which all these various benefits are realised will depend significantly on:

- how much smart metering is rolled out; and
- how it is implemented, particularly with respect to which technical functional options are included with the smart meters, and how retailers and network companies use such options to offer enhanced products and services to consumers.

This report attempts to answer the following questions:

- What is the potential magnitude of the different types of benefits to New Zealand arising from smart metering?
- What proportion of these benefits is likely to be realised from the current market-led roll-out of smart metering in New Zealand?
- To the extent that potential benefits aren’t likely to be realised, what is the ‘cause’?
- Are there possible regulatory interventions to address such missed benefits, that are likely to be of net benefit to New Zealand?

In doing so this report draws on information and input from key New Zealand stakeholders, as well as overseas studies.

The focus of this analysis is predominantly on the potential environmental benefits from smart metering. Other types of potential benefits (and costs) of smart metering are highlighted but not discussed to the same level of detail.

Potential cost: benefit of smart metering in New Zealand

Benefits

Section 2 indicates that smart metering has the potential to deliver material economic benefits. These are listed in the following table, along with estimates[1] of their potential

[1] It should be noted that such estimates are subject to significant degrees of uncertainty due to poor underlying data, and inherent uncertainties as to the extent of consumers’ behavioural changes to altered information and incentives arising from smart metering. Further, it has not

value to individual residential customers and New Zealand as a whole. The table has been split between those elements that are genuine economic benefits (i.e. resulting in less resources being consumed), and those which are 'just' a wealth transfer in the direction of consumers.

Table 1 - Estimate of scale of benefits of smart metering benefits to individual households, and New Zealand as a whole[2]

Function	Benefit	Low to High range	Annual potential benefit			
			Per customer ($)		NZ ($m)	
			Low	High	Low	High
Economic efficiency improvements						
Time-of-use pricing and information	Peak demand management → avoided peaking generation and network assets	Peak reduction = 2.5% to 10%	16	64	23	94
Improved information to consumers via an in-home display	Energy efficiency response resulting in avoided generation costs[1]	Efficiency response = 1% to 5%	16	79	23	116
Export metering	Enabling microgeneration	?	?	?	?	?
Automated and more accurate meter reading & field services	Lower cost-to-serve through avoided labour, and less errors	Various	20	55	30	77
Richer and more real-time network information	Improved network efficiencies	?	?	?	?	?
Replacing meters that would have had to be checked and/or replaced anyway	Avoided existing meter compliance / replacement costs[2]	Various	8	18	12	26
Total impacts yielding economic efficiency			***60***	***216***	***89***	***313***
Wealth-transfer improvements						
Improved retail competition	Reduced incumbent retailer margins	Reduction in margins = 5% to 10%	4	9	n/a	n/a
Implementation finding missed, tampered with, and inaccurate meters	Reduction in unaccounted for energy	Reduction in UFE = 0.5% to 1.5%	9	25	n/a	n/a
Smart metering can be used for pre-payment purposes	Improved pricing for pre-payment customers	?	?	?	n/a	n/a
Replacing existing meters	Avoided existing 'dumb' meter lease costs to retailers	Average ex-GST lease = $40 to $60	45	68	n/a	n/a
Total wealth-transfer impacts			***58***	***101***	***n/a***	***n/a***

[1] The avoided costs are based on the variable component of current consumers' prices, rather than explicit modelling of avoided long-term variable costs of supply-side assets

[2] Such avoided costs are only assumed to last over a seven year period in the run-up to the 2015 meter compliance deadline.

Section 2.1.1 and Appendix D also outline the potential environmental benefits of smart metering. These are predominantly from the energy efficiency impact of smart metering. The analysis demonstrates that in an environment of growing demand, the predominant generation that is avoided by energy efficiency is the generation that would otherwise have had to be built to meet this growth in demand.

There may be some initial displacement of the plant that is operationally marginal at any one moment in time (typically either a combined-cycle gas turbine or the Huntly coal-fired station). However, the extent of this initial displacement will depend on

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been possible to estimate the scale of some of the benefits. These items have a '?' recorded against the value.

[2] The benefits (per consumer and scaled-up for New Zealand) are only for the estimated 1.65m residential consumers. The benefits for the estimate 0.25m mass-market commercial consumers have not been calculated although, as indicated in the text of the report, these are believed to be greater on a per-customer basis than for residential.
The benefits shown in the table are including GST for individual residential consumers, and excluding GST for New Zealand as a whole.

assumptions around the extent to which the market had anticipated such energy efficiency in its forecasts of demand growth and consequential new investment timings.

The following table shows how much avoided emissions due to a smart-meter induced improvement in energy efficiency are worth for a range of CO2 prices for both electricity and gas residential consumers, with the electricity figure depending on whether a CCGT or Huntly is marginal.

Table 2 - Value of avoided emissions from improved residential energy efficiency

	Electricity				Gas	
	CCGT marginal		Huntly marginal			
CO2 cost ($/tonne)	***20***	***50***	***20***	***50***	***20***	***50***
Household ($/annum incl. GST)	2.34	5.84	5.68	14.20	0.61	1.52
NZ ($m/annum excl. GST)	3.4	8.6	8.3	20.8	0.1	0.3

With regards to what plant will be economically marginal on the longer-term investment time-frame, it will depend on a number of factors. Crudely, the extremes of the future new-investment scenarios can be characterised as either a world dominated by renewables, or a world where fossil-fuelled power stations continue to comprise a significant proportion of new-investment.

Exactly what proportion of new renewable and fossil generation will be developed will depend on a number of factors including:

- The cost of CO2;
- The availability and cost of domestic gas resources, and the likely cost of international liquefied natural gas options;
- The consentability of renewable resources[3]; and
- Government policy such as the currently proposed moratorium on new baseload fossil generation investment.

If the world is one where fossil-fuelled generation continues to play a material role in new generation investment, then energy efficiency will deliver tangible benefits in terms of avoided CO2 emissions.

If, however, the world is one where renewables dominate new generation investments, then the environmental benefit of energy efficiency in terms of reduced CO2 emissions drops closer to zero[4].

Costs

Given the current fluid commercial dynamic, there is little public domain data as to the costs of smart metering in New Zealand. However, it is possible to infer from the fact

[3] Noting that getting consents under the RMA has proven to be a significant hurdle for many hydro, wind and geothermal projects.

[4] There may still be a need to provide back-up thermal plant for the periods of peak demand when wind can't be balanced by existing renewable resources and an open-cycle gas turbine will be required. However, the percentage of time when wind will have to be backed up by such peaking plant will be relatively small (likely to be less than 5%). Accordingly the effective emissions from wind plus thermal back-up will be at least a factor of ten lower than for a CCGT.

that New Zealand retailers are starting to instigate mass-market deployments of smart meters, that the amortised costs they are being charged by the smart meter providers are less than the annual benefits which retailers expect to enjoy with reasonable certainty i.e. principally avoided existing meter lease costs + lower cost-to-serve.

If the other benefits which smart metering can deliver, but which retailers appear not to be including in their smart metering business cases, are taken into account, then smart metering appears to be even more positive for New Zealand.

For comparison, a recent UK government cost: benefit analysis[5] estimated that the one-off per installation costs of the various components of smart metering were as follows:

Table 3 - Breakdown of UK smart metering cost components

• the smart meter (excluding an IHD)	£47	($ 120)
• an in-home-display (IHD)	£15	($ 40)
• installation	£29	($ 75)
• communications[6]	£45	($ 115)
• **total**	**£136**	**($ 350)**

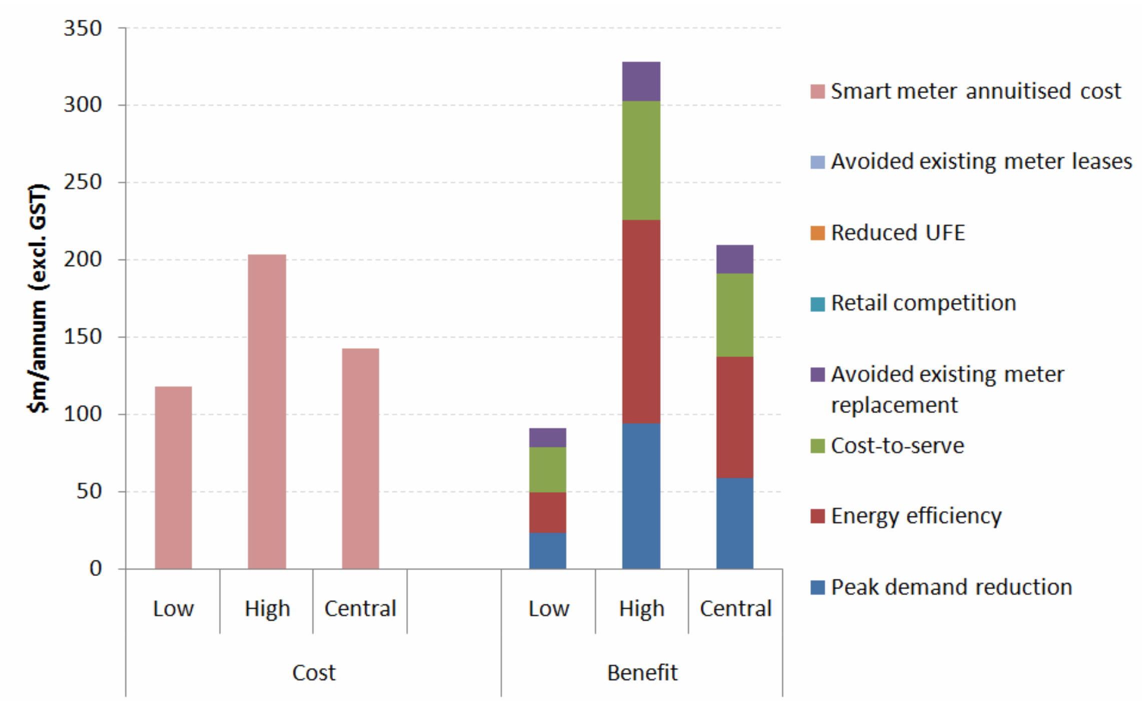
Amortising the total $350 cost over 7 years at a 10% discount rate gives an annual value of $72. It is likely that the UK will be able to enjoy economies of scale from having sixteen times the number of households over which to spread fixed costs, and potentially leverage greater purchasing discounts from vendors. Purely for the purposes of furthering this cost: benefit illustration, Concept has assumed that New Zealand incurs a 20% cost penalty on a per customer basis compared with the UK. This gives an overall amortised cost of $86 per annum.

[5] "*Impact assessment of smart metering roll out for domestic consumers and for small businesses*", BERR, April 2008

[6] This has been back-calculated from the report's estimate that the NPV cost of the most cost-effective communications option (a highbred of piggyback broadband and cellular) would be £1.2 billion. When divided by the 27million electricity meters in Britain, this translates to some £45 per installation.

In aggregate from a New Zealand perspective, the *economic* benefits of smart metering (i.e. as distinct to wealth transfers) are likely to exceed the costs for the majority of residential customers. This is illustrated in the following figure.

Figure 1 - Costs and benefits of residential[7] smart metering to New Zealand

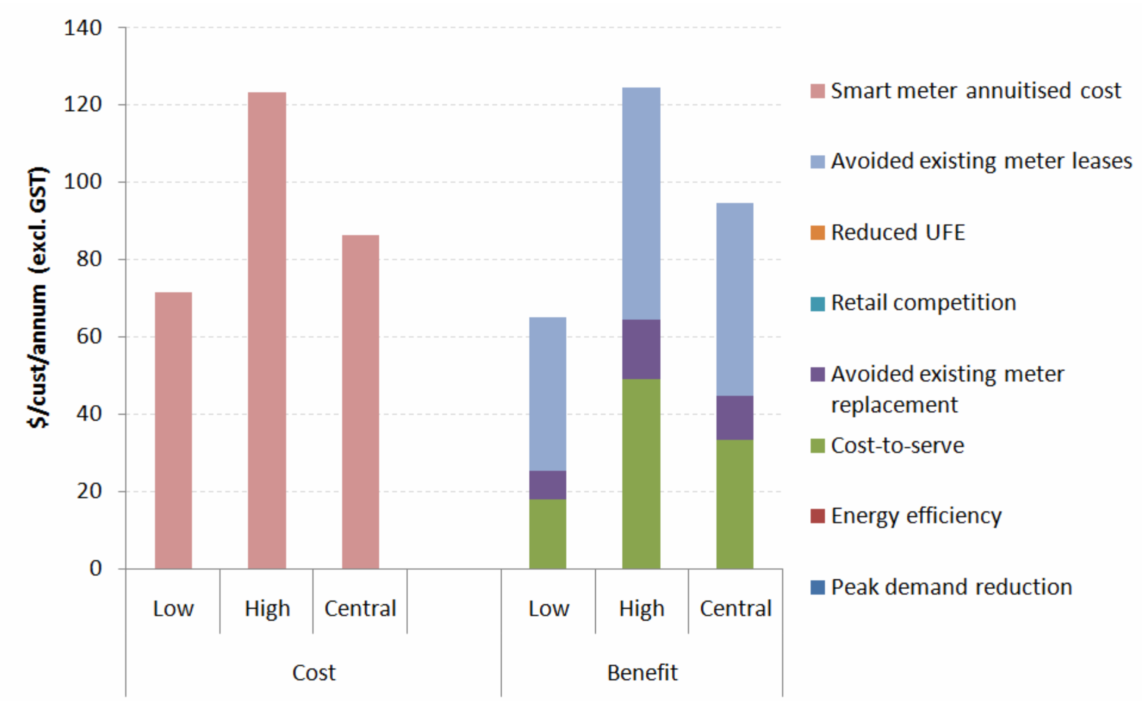


This conclusion is consistent with many overseas jurisdictions that have mandated a mass-market roll-out of smart metering including most of Australia, numerous American and Canadian states, Italy, Ireland, and Sweden. The UK has decided that smart metering is conclusively positive for commercial customers, but is still deciding on whether the benefits for residential customers are sufficient to mandate a compulsory deployment.

However, in the current New Zealand dynamic it is *retailers* that determine whether smart meters should be implemented. It is likely that they will exclude some of the potential benefits outlined above as they will regard them as not sufficiently ‘firm’ to be bankable. However, they will include avoiding paying the existing meter leases as a benefit, despite the fact that, from a New Zealand economic efficiency perspective, this is ‘just’ a wealth transfer. The resulting cost: benefit is shown in the figure below.

[7] Mass-market commercial customers have not been included in this analysis.

Figure 2 - Costs and 'firm' benefits of smart metering to a retailer that doesn't own existing meters

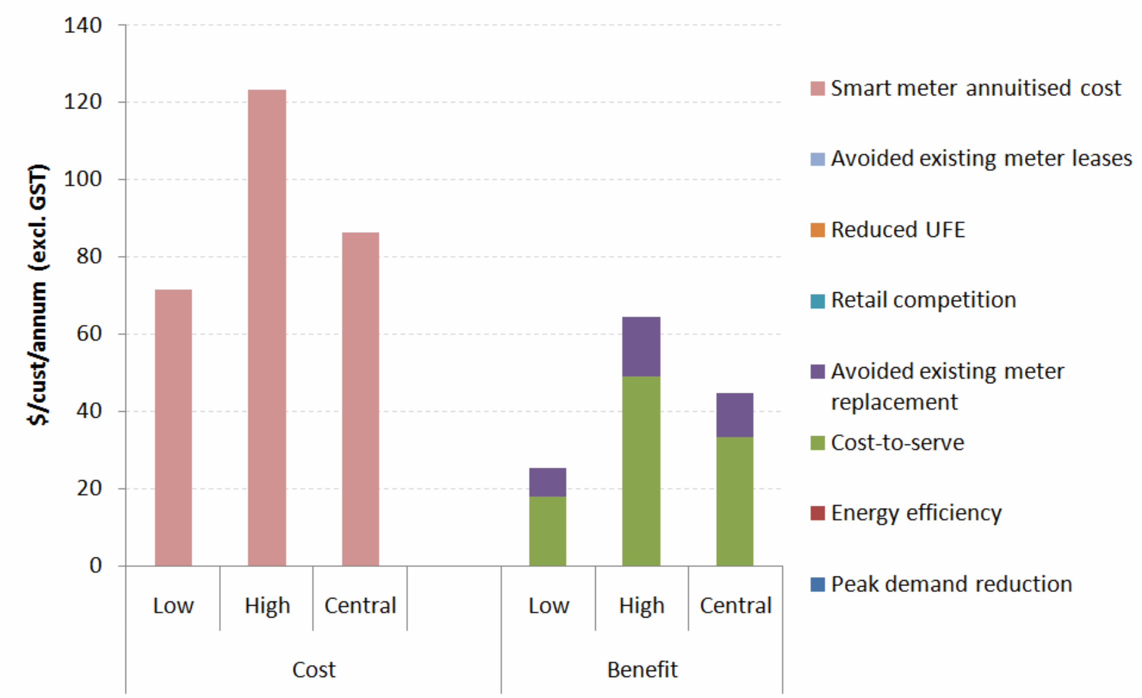


As can be seen, under the central set of estimates, smart metering is just positive for retailers. This conclusion seems plausible as it is only recently that costs have apparently come low enough such that retailers have started to implement smart-metering in their major urban customer bases[8].

[8] In addition to the 'firm' benefits shown above, it is likely that retailers may enjoy some customer acquisition / retention benefits through being able to offer superior offerings around smart peak demand management tariffs and the like. However, based on discussions with some retailers, such additional benefits are being regarded as 'up-side' rather than a core part of the smart metering business case.

If the retailer is also meter owner, then the cost: benefit equation changes significantly as the benefit of avoided existing meter leases can no longer be counted. The changed picture is shown below.

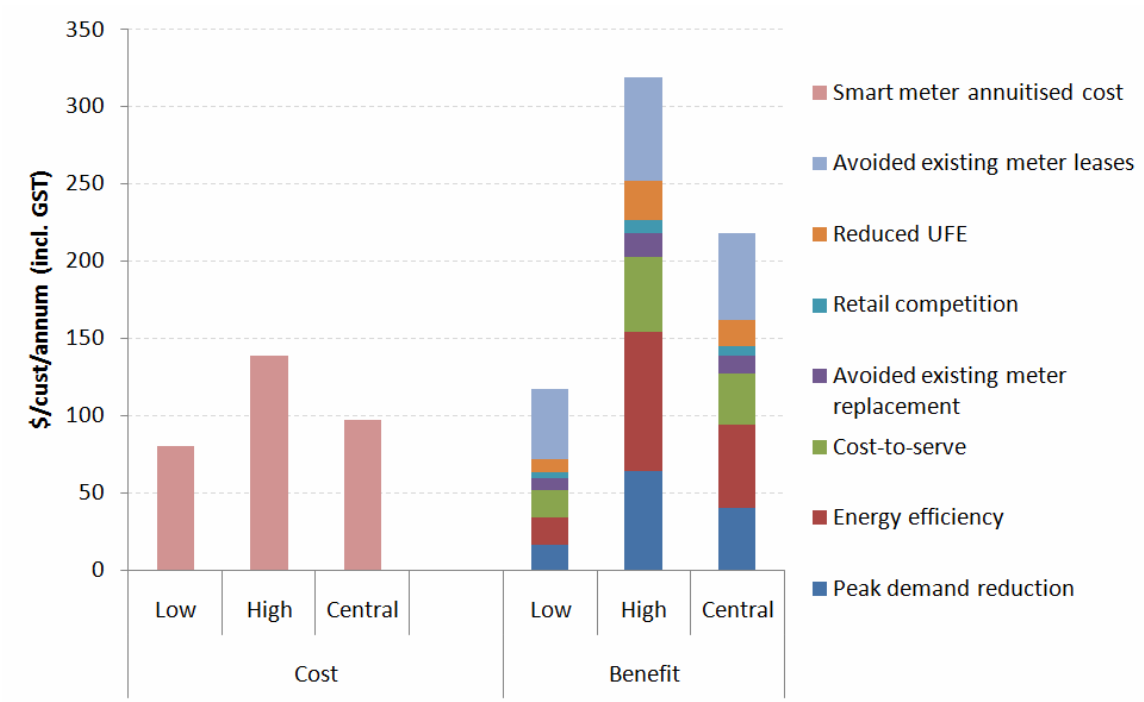
Figure 3 - Costs and 'firm' benefits of smart metering to a retailer that owns existing meters



As can be seen, the benefits no longer exceed the costs. As detailed further in Section 4.1.1, this conclusion is consistent with the behaviour exhibited by TrustPower, the retailer that has the greatest proportion of meters it also owns, who has decided not to implement smart metering at this stage.

From an end-consumer's perspective, the cost: benefit will include all the economic efficiency benefits plus the wealth transfer benefits. This is shown in the figure below.

Figure 4 - Cost: benefit of smart metering from an end residential consumer's perspective



As can be seen, the potential benefits are considerable when compared with the costs. However, as detailed later in this report, the extent to which *actual* benefits are realised will depend on the way in which smart metering is implemented, particularly with respect to whether in-home displays are included, and the nature of any smart peak demand tariffs offered by retailers.

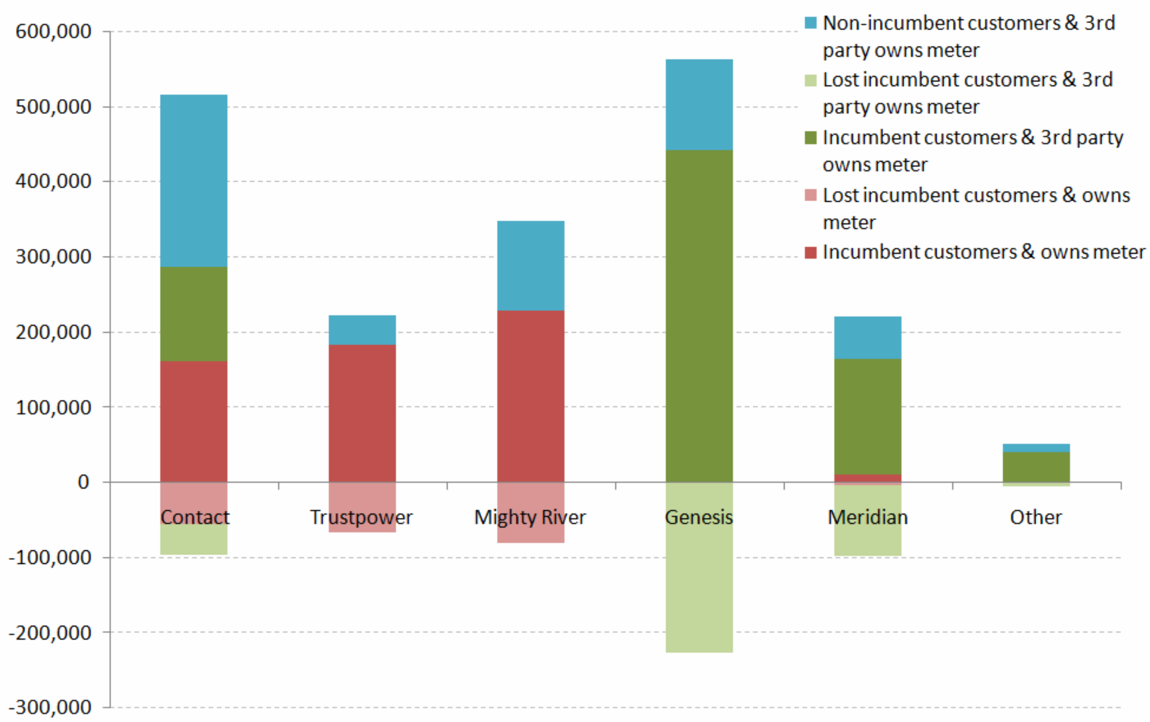
Extent of smart metering roll-out in New Zealand

Section 4.1 details how New Zealand appears to be unique in the world in that a large scale deployment of smart metering appears to be happening driven solely by market forces. In almost all other countries around the world where smart metering is happening on a substantial scale, it has required regulatory intervention of one form or another.

The key dynamic that appears to be delivering a market-lead outcome in New Zealand is that the customer's *retailer* has the right to choose a meter provider, and that in most cases the retailer is not the incumbent meter provider. Thus, in contrast to most overseas jurisdictions, the stranded asset value of the existing meters is not affecting retailers' decisions to switch to smart meters.

Four of the five big retailers in New Zealand have started a mass-market deployment of smart metering across their customer bases. Current indications are that they intend for this to be a complete roll-out across all customers, and that this will happen over a 5-6 year timescale. The largest independent meter provider, Vector, largely in response to this dynamic, is also likely to switch-out its existing meters to smart meters. In total some 85% of customers are covered by these retailers and Vector.

Figure 5 – Electricity retailer customer mix: Incumbency & meter ownership



Source: February 2008 Electricity Commission registry statistics

This smart metering deployment appears to include gas meters, with customers' gas meters being retrofitted such that they can communicate wirelessly with their electricity smart meter. Again, this is being driven by market forces in that retailers won't be able to gain the full cost-to-serve benefits from electricity smart metering if they have to maintain manual processes for gas meters.

TrustPower is the only significant retailer that has indicated that it will not be rolling out smart meters in its incumbencies. Whilst they have not said as much, this is likely to be strongly influenced by the fact they are both retailer *and* meter owner, and thus face the barrier of writing off the value of their existing meter assets – i.e. the same barrier that is affecting smart meter decisions overseas.

However, even for TrustPower, it is likely that market forces may force them into switching out their existing meters and replacing them with smart meters. Two key competition drivers are likely to bring this about:

- Firstly, in some of their incumbencies (e.g. Rotorua, Taupo, and Nelson) they have already lost 40% to 50% of their customers to competing retailers. There is a significant risk that such retailers may decide to switch out TrustPower's existing meters for such customers so as to offer them a superior service, and achieve a lower cost-to-serve. A meter provider such as Vector will be incentivised to offer competitive rates to such retailers so as to grow their meter business.
- Retailers may target TrustPower customers with a superior retail proposition based on smart metering to persuade them to switch.

Accordingly, in order to preserve a viable metering business and to retain its customers, TrustPower may be 'forced' to pre-emptively replace its existing meters with smart meters before another party does it to them. However, due to the lead times in the other retailer's replacement programmes for their own incumbencies, it probably has a couple of year's grace before it will be forced into such a move.

Thus it appears likely that New Zealand will experience a total roll-out of smart metering over the next eight or so years without it being forced by regulatory mandate. In addition to facilitating innovation, such a market-led approach will also mean that customers are not being forced to pay for the stranded asset values of the existing meters as is happening with mandated roll-out in some other countries.

How smart metering is being delivered in New Zealand

Section 4.2 indicates that the meters that are being delivered are functionally rich, and thus have the potential to deliver most of the benefits outlined in Section 2.1.

Again, market forces can arguably be said to have played a part in delivering functionally rich solutions. This is because if a retailer + meter provider combination installs a non-functionally rich meter, they face the risk that an alternative retailer + meter provider combination may be able to offer the customer a superior proposition on the back of a meter with superior functionality. If that were to occur, the original retailer would lose the customer, and the original meter provider would have a stranded asset.

From a regulatory perspective, the Electricity Commission (EC) has focussed on ensuring that there is open and non-discriminatory third party access to metering services such that it does not become a barrier to competition, whilst trying to preserve the conditions for innovation among meter providers and retailers. This policy is summarised in two documents: *"Advanced Metering Policy – May 2008"*, and *"Guidelines for advanced metering infrastructure v1.0 – 22 February 2008".*

As well as making recommendations with regards to the terms for accessing smart metering services, the guidelines also set out recommendations relating to the functionality of smart meters, classing each functionality variously as "Essential", "Desirable", and "Optional". The status of the guidelines are that they are voluntary, but they implicitly come with the threat of future regulations being passed to make them mandatory if smart metering outcomes emerge which are significantly contrary to those identified by the Electricity Commission as being desirable.

This approach of "persuading and promoting"[9], rather than regulating appears to be appropriate given that smart metering is an area of rapid technological development, and highly prescriptive regulations in such markets risk 'locking-in' a sub-optimal technological option and retarding innovation.

The Electricity Commission's regulatory approach also appears to have been successful in that open information protocols do seem to be being developed by the various industry participants, and meters which have the potential for retailers to offer functionally rich services do appear to be being installed.

Despite this general positive outcome for New Zealand to date, there are two question marks as to the extent to which smart meters are going to be implemented in a way which delivers the maximum possible benefit:

- The provision of in-home displays; and
- The type of smart tariffs offered by retailers.

In-home displays (IHDs) and home area networks (HANs)

It appears that all smart meters being rolled-out will have the *capability* to have a HAN chip installed which can communicate with an IHD and other smart appliances. Indeed the Electricity Commission's guidelines state that the *"ability to add and support a suitable HAN interface is required"*.

However, there is uncertainty as to whether a HAN chip or IHD will be included as part of the initial implementation for a number of retailers.

This is important because the IHD is likely to be a critical enabler to deliver the energy efficiency benefits from smart metering (as distinct to peak demand reduction). Appendix A details how this energy efficiency response is not due to any changed price signals from smart metering, but instead is due to the greatly increased information available to customers in the form of direct feedback – i.e. instantaneous information about consumption – and customers' response to such information.

A growing number of overseas studies suggest that such direct feedback engenders behavioural changes in consumers in the form of more efficient energy consumption patterns (switching off unused appliances & lights, turning down thermostats, etc.)[10].

Further, such studies also appear to indicate that this behavioural change can't be as effectively achieved by alternative means of delivering similar information such as via the internet, or richer consumption information on people's bills.

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[9] The phrase used within the guidelines, and which mirrors the desired regulatory approach set out in paragraph 4 of the October 2006 Government Policy Statement on Electricity Governance.

[10] "*The effectiveness of feedback on energy consumption. A review for DEFRA of the literature on metering, billing and direct displays"*¸ Sarah Darby, Environmental Change Institute, April 2006, provides a useful overview of the key studies and issues.

It is not yet certain the extent to which New Zealand retailers will be implementing IHDs at the time of initial installation. For the initial Christchurch roll-out, neither Meridian nor Contact are including IHDs or HAN chips. For other planned deployments there appears to be a mixed approach as to the extent to which they will be including IHDs, with some retailers more likely to implement IHDs than others.

There appear to be a number of factors giving rise to some retailers apparently deciding against installing IHDs:

- Early days in terms of working through retailer < > meter provider < > customer relationships with respect to IHDs

  Unlike the smart meter (and the HAN chip) an IHD will be free standing, and thus faces issues such as customers breaking or removing it. Consequently IHDs may not be leased to the retailer and on-charged to the consumer as with the smart meter, but may need to be purchased up front by the customer. Such a relationship may act against universal roll-out of IHDs, as many customers may not be willing (or able) to incur a one-off fee which may be one to two hundred dollars.

  That is not to say that universal roll-outs won't happen, or that retailers couldn't lease the IHD from the meter provider. Negotiations are currently underway between the various parties discussing such issues so it is hard to draw any firm conclusions about what will and won't happen, particularly as there are a wide range of technological IHD options available (basic through to functionally rich) and a consequential wide range of prices.

- Unproven customer demand for IHD-related services

  Most retailers pointed to the fact that IHDs would likely result in customers paying an extra amount to cover the capital cost, and that it is not clear the extent to which customers would value the extra service that such IHDs provide. This is against the context of retailers planning to introduce smart meters without there being any cost increase to consumers.

- Difficulty for retailers to capture any of the energy efficiency benefit

  Further, to the extent that IHDs deliver an energy efficiency response from customers, this is something that is hard for retailers to capture or use to differentiate themselves from other retailers. The same type of barrier affects other energy efficiency investments such as home insulation.

- Difficulty to 'bank' the benefit of peak demand management

  There are potential opportunities for retailers to offer differentiated products around time-of-use and peak pricing products, and for them to capture some of the benefit. This requires a means of delivering information to customers about when to manage their consumption to maximise this benefit. This information can be delivered by a range of different channels (e.g. txt, email, etc.), many of which are likely to be cheaper than IHDs.

  However, IHDs are potentially one of the most effective channels in terms of maximising consumer response. The retailer that appears most advanced in terms of delivering these smarter products to consumers was considering a number of innovative ways in which IHDs could be the channel to achieve this.

However, the extent of benefit from peak demand management is subject to a much greater degree of uncertainty than, say, cost-to-serve benefits. This is because peak demand management relies on changing customer behaviour in response to altered price signals and information. Because this is inherently subject to great uncertainty, retailers appear to be discounting any such benefit in relation to any smart metering business cases.

- Inadequate electricity market design around capturing peak pricing signals

  Further, to the extent that there are material potential benefits from peak demand management, Appendix C sets out how the price signals required for these benefits to be captured may be being muted by current wholesale and network market design, thereby reducing the incentive on retailers to provide IHDs.

- Immature retailer billing and customer relationship management IT systems

  Lastly, it should be noted that only one of the five major retailers has what could be considered a latest generation billing and customer relationship management system. The other four have billing engines of varying degrees of antiquity, all of which will seriously constrain their ability to offer a full range of smart services to customers. It is therefore perhaps no surprise that the retailer who seemed most advanced in its thinking about how to take advantage of IHDs is the retailer with the most recent billing engine. Given that it may take two to three years for the other retailers to catch-up, their focus and incentives with regards to IHDs may similarly be delayed.

Lastly, it should be noted that if IHDs aren't implemented initially they can be subsequently installed, but will incur some level of implementation cost which could have been avoided. The extent of the subsequent implementation cost will depend on whether the HAN chip was installed at the time of initial implementation. If it was, then the IHD could be mailed out to customers or purchased from an electronic store incurring a very low implementation cost. If it wasn't then a qualified technician will need to visit the customer's property to install the HAN chip, costing around $75[11].

Market forces may incentivise meter providers at the very least to ensure their meters are deployed with a HAN chip already included. This is because they should want to lower the likelihood that a subsequent contractor visit is required to their meter, as such a visit will alter the cost: benefit for a competing retailer switching out the meter for one with superior functionality.

Smart tariffs

It appears that the greatest focus from retailers is in delivering the cost-to-serve benefits of smart metering, and that offering a range of smart products to customers is of secondary importance. However, this is likely to be a result of:

- Immature retailer billing systems

  As detailed above, only one retailer has an IT system that is currently capable of offering a full range of smart products, and the others are likely to be two to three years away. It is therefore probably not surprising that it is only this retailer that seems to be considering more innovative smart tariffs.

[11] It should be noted that this estimate could vary significantly according to customer circumstance, particularly physical location.

- Inadequate electricity market design around capturing peak pricing signals

  As also detailed above, the inadequacies around wholesale and network market design are suppressing scarcity pricing signals, thereby significantly removing the opportunities for retailers to offer innovative smart tariffs.

Possible regulatory responses

In general the current market-lead smart metering dynamic appears to be delivering good outcomes for New Zealand in terms of a complete mass-market deployment of functionally rich smart meters over the next five to eight years.

The most significant potential non-optimal outcome is the lack of a roll-out of in-home displays at the time of initial implementation. To the extent that this results in material energy efficiency savings being foregone or delayed, this is a potentially significant issue.

However, before embarking on a regulatory intervention to mandate the inclusion of in-home displays, there are three issues that need to be considered.

Scale of the problem

There is significant uncertainty about the scale of problem. This uncertainty is in two dimensions:

- Firstly, it is not clear the extent to which IHDs won't be rolled out.

  The retailer that has the most advanced billing engine is clearly thinking of ways in which it can exploit that temporary competitive advantage, some of which include IHDs. This may create a competitive dynamic which results in other retailers being forced to follow suit. Further, even if IHDs aren't included with an initial implementation, meter providers & retailers may be incentivised to include HAN-chips with the initial implementation to lower the switch-out risk from a competing retailer + meter provider subsequently coming along with a superior proposition that includes an IHD and/or other HAN capabilities.

- Secondly, there is a considerable uncertainty as to the amount of energy efficiency response that is delivered by IHDs.

  It is hard to draw firm conclusions on the level of response from overseas studies due to the fact that:

  – often such studies had IHDs as just one element of a number of changes or had a very limited customer samples. It is for this reason that the UK is part way through a two year trial of 40,000 customers in order to draw firmer conclusions; and
  – most overseas jurisdictions have significant differences with respect to the relative uses of electricity in a domestic context (space heating, hot water heating, lighting, cooking etc.), and therefore it is not possible to directly translate a percentage saving in one market to one that might be expected in the New Zealand context.

Thus, just because the UK, say, believes IHDs will deliver a 3% energy efficiency response for domestic electricity consumers, it is not possible to conclude that the same effect will be seen in New Zealand. It may be greater or smaller.

Potential for adverse outcomes

There is a risk that the 'solution' creates more problems than it solves. For example:

- Choosing the 'wrong' technology

  A prescriptive regulatory approach risks stifling innovation and locking-in technological dead-ends. This is a very real concern with technologies such as smart metering and IHDs which are undergoing rapid technological change, and have a range of potential interactions with other data and information services to consumers (telephony, internet, media etc.) which are themselves undergoing significant technological change[12].

- Delay

  Secondly, prescriptive mandatory approaches risk delaying the implementation of smart metering whilst market participants wait to see what the eventual form of the regulations will take.

  In this respect, it is worth noting that in Australia, Government(s), regulatory authorities and the industry have taken years to debate the best course of action, whilst in New Zealand, market participants have already evaluated the options and are currently engaged in a large-scale implementation in Christchurch.

- Stranded asset compensation

  Lastly, it is not clear whether IHDs can be mandated without also mandating smart meters themselves. In such a mandate-driven environment this raises the issue of existing meter owners receiving compensation from consumers for stranded assets costs.

Alternative measures to incentivise the provision of IHDs

There may be alternative measures which result in the provision of IHDs which have reduced adverse outcomes. These include:

- Improving price-signals for peak demand management

  As detailed in Appendix C, the current wholesale and network market design settings may partially reduce prices below cost at times of scarcity. Rectifying such inadequacies will make it more likely that retailers will offer peak-demand products to consumers, with IHDs potentially being part of such a product.

  It should be noted that both the Electricity Commission and Commerce Commission have said they plan to address these inadequacies.

- Using general energy efficiency policy mechanisms

[12] Indeed, the relationship between Vector/Siemens and Vodafone appears to have delivered internationally innovative approaches to smart-metering communications, and may yet deliver further innovative developments relating to in-home communications.

If the desired outcome from IHDs is improved energy efficiency, it may be appropriate to include IHDs within broader energy efficiency policy mechanisms to deliver energy efficiency measures, and the cost: benefit of implementing IHDs be compared against other measures that deliver energy efficiency outcomes (e.g. home insulation).

Conclusion and recommendations

New Zealand is likely to experience a comprehensive mass-market deployment of functionally rich smart meters over a five to eight year timescale. This timescale is comparable with overseas jurisdictions moving to adopt smart meters – but is occurring without a mandatory regulatory requirement. Such a deployment is likely to yield material net benefits to New Zealand.

In general, the regulatory approach from the Electricity Commission appears to have been both appropriate and successful – namely to ensure that there is open and non-discriminatory third party access to metering services such that it does not become a barrier to competition, whilst trying to preserve the conditions for innovation among meter providers and retailers.

The most significant area for doubt is the potential for in-home displays (IHDs) not to be included comprehensively by retailers, and the associated lost energy efficiency response. Given overseas estimates of the scale of energy efficiency response delivered by smart metering are anywhere between 1% to 7.5%, this is a potentially significant lost benefit.

To the extent that the principal *unique* benefit that IHDs deliver is energy efficiency (noting that IHDs aren't necessary for delivery of almost all of the other benefit streams), this is not so much a failure of electricity market design but another example of the inherent barriers facing energy efficiency investments.

Given the significant uncertainty over the scale of this potential issue (both the extent to which IHDs won't be widely implemented, and the extent to which IHDs deliver an energy efficiency response), it would be inappropriate to consider mandating the provision of IHDs at this stage. This is especially as such prescriptive approaches risk adverse outcomes in terms of locking New Zealand down a non-optimal technological path.

Instead, Concept would recommend the following set of actions to ensure that New Zealand enjoys the best potential outcome from smart metering:

- The Electricity Commission should continue its current policy of working to ensure that there is open and non-discriminatory third party access to metering services, whilst trying to preserve the conditions for innovation among meter providers and retailers;
- The Electricity Commission should continue to monitor the development of smart metering, particularly with respect to the comprehensiveness of deployments, the functional richness of solutions, and the degree of open third party access.
- The Government and related agencies (e.g. EECA and the Electricity Commission) should undertake work to better understand the extent to which in-home displays deliver a unique energy efficiency benefit (i.e. not easily substitutable by other

approaches), and the nature and scale of this energy efficiency response in the specific New Zealand context;

- The Electricity Commission and Commerce Commission should work to address the potential wholesale and network market inadequacies they have identified in relation to scarcity pricing signals and peak demand management;
- If IHDs are found to deliver a unique energy efficiency outcome, the Government should explore alternative policy mechanisms to incentivise their delivery, in particular the use of generic energy efficiency mechanisms designed to deliver energy efficiency measures most cost-effectively.

1 Introduction

One of the most significant technological changes happening in many electricity sectors around the world is the start of mass-market deployments of so-called ‘smart’ meters.

Smart meters have a wide range of possible functional features. However, the minimum base level of required functionality before a meter can be considered ‘smart’ is[13]:

- ***Time-of-use recording*** (also known as ‘interval’ or TOU). i.e. the ability to record consumption on a half-hour by half-hour basis[14].
- ***Remote meter reading*** (e.g. via cellular or radio communication); and
- ***<u>Two-way</u> communication*** with the meter. i.e. the ability to not just receive consumption data and other status information, but to *send* instructions to the meter to ‘do’ something.

In addition to this base functionality there are a range of other possible options including:

- Wireless communication with, and control of, ‘smart’ appliances in the customer premises via a home area network (HAN)
- Provision of real time consumption and pricing information to consumers through an in-home display (IHD)
- Remote connection and disconnection of the property (e.g. due to vacancy, or payment default) without the need for a contractor visit
- Load limiting of the property (i.e. limiting the maximum kW amount of power that the property can consume)
- Metering of power export for properties which have microgeneration and which may at times export surplus electricity back to the network
- Tamper detection and outage detection

The range and scale of the different benefits that such functionality has the *potential* to deliver is considerable, including reduced consumption (resulting in avoided investment in generation and network assets, and reduced environmental impacts), reduced retailer and meter owner operating costs, superior customer service, and improved ‘social’ services for vulnerable customers.

However, the *actual* extent to which all these various benefits are realised will depend significantly on:

- ***how much*** smart metering is rolled out; and
- ***how*** it is implemented, particularly with respect to which technical functional options are included with the smart meters, and how retailers and network companies take advantage of such options to offer enhanced products and services to consumers.

This report attempts to answer the following questions:

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[13] It is worth noting the different acronyms used to described smart(ish) metering technologies. Automated Meter Reading (AMR) is merely the ability to remotely read the meter. AMR solutions are not considered ‘smart’ because of the inability to have two-way communication with the meter.
Advanced Metering Management (AMM) or Advanced Metering Infrastructure (AMI) are essentially the same thing and are used to describe truly ‘smart’ meters.

[14] This compares with *aggregate* consumption recording (e.g. total over a month or longer) for the current ‘dumb’ meters.

- What is the potential magnitude of the different types of benefits to New Zealand arising from smart metering?
- What proportion of these benefits is likely to be realised from the current market-led roll-out of smart metering in New Zealand?
- To the extent that benefits aren't likely to be realised, what is the 'cause'?
- What regulatory interventions might address any missed benefits?

In doing so, this report draws on overseas experience, as well as information and information gathered from New Zealand stakeholders.

With respect to overseas experience, there is a large and growing volume of literature on the approaches adopted in different countries. However, whilst some of the experiences highlight issues that are generic to smart metering, a lot of the experiences, and particularly the cost: benefits of smart metering, are very situation specific. Accordingly, this report has only highlighted those overseas situations where lessons can be learned to inform the New Zealand situation.

The focus of this analysis is predominantly on the potential *environmental* benefits from smart metering. Other types of potential benefits (and costs) of smart metering are highlighted but not discussed to the same level of detail.

Acknowledgements

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However, it should be noted that the views expressed in this report are solely those of Concept, and that in no way should it be inferred that the views are representative of those of the above individuals or the companies that they represent.

2 Potential benefits and costs of smart metering

Smart metering can deliver a range of substantial benefits across many different areas of the electricity (and gas) markets, and to many different participants along the supply chain. However, on the flip side the cost of implementing smart metering can be substantial, and it has the potential to cause other impacts on the energy markets.

This section provides a high-level summary of the types of different benefits and costs that can accrue from smart metering, with estimates of their value in the New Zealand context.

2.1 Potential benefits

2.1.1 Reduced consumer demand

Smart metering has the potential to result in a number of different types of demand reduction arising from altered information and incentives to consumers. The potential types of demand reduction include:

- Demand reduction at times of system peak via:
  - Load shedding: infrequent dropping of load at times of system stress
  - Load shifting: permanent changes in when people use electricity from higher to lower cost periods. No kWh are necessarily saved from such behaviour.
- General energy saving *at all times* via improved energy efficiency (e.g. reducing wasteful consumption habits and/or investing in more energy efficient equipment), resulting in savings in kWh consumption.

The distinction between peak demand reduction and general energy saving / efficiency is important to understand.

Peak demand reduction is principally achieved via altered price signals enabled by the time-of-use tariff functionality delivered by smart metering. Such functionality enables retailers to charge consumers more for consumption at times of peak demand (where supply-side costs are greatest), and less at other times. Section 4.2.1 outlines the different types of time-of-use tariffs that can be enabled by smart metering. This is analogous to the peak and off-peak pricing plans that are common in the telecommunications sector (e.g. 'half price' weekends).

Energy saving is *not* in response to changed price signals, but due to increased awareness of energy use, principally through the provision of an in-home display (IHD) delivering information in the form of direct feedback. This is one of the more surprising things to come out of smart metering and is still the subject of a significant amount of contention and uncertainty. However, given the scale of energy efficient response that some overseas studies have apparently witnessed (anything up to 20%!), it is one of the most important issues that policy makers need to understand. Appendix A sets out in more detail the issues around smart metering delivering an energy saving benefit.

Value of peak demand management

Appendix B sets out a simple calculation to provide order-of-magnitude estimates of the value of reducing electricity peak demand, either via load shedding, or via load-shifting. For mass-market customers a central estimate is some $285/kW/yr.

On average, it has been assumed that mass-market residential customers' contribution to system peak demand is roughly 2kW per household[15]. Next, the extent to which smart metering could deliver a load shedding response needs to be estimated.

In an Australian study for the Australian Ministerial Council for Energy[16], NERA assumed that the demand response exhibited by residential customers on a critical peak pricing tariff would be between 10.6% and 21.5%[17].

Given that New Zealand suffers from less extreme peaks than Australia, plus New Zealand already uses a significant degree of load control via hot water management, a reasonable estimate of further reduction that could *potentially* be achieved via smart-metering induced shedding & shifting is between 2.5% and 10%.

This equates to a range of between $16 and $64 per customer per year (including GST), and between $23m and $94m per year (excluding GST) when multiplied across the 1.65 million residential customers[18].

However, as detailed in Appendix C, current pricing arrangements in the wholesale and network markets may reduce the price signals relating to such value from retailers (and hence to consumers). Accordingly, unless these price signals are rectified, it is unlikely that such benefits will be fully realised.

The above estimates are for residential customers. A figure for New Zealand's 0.14m commercial mass-market customers has not been estimated as they are a lot more heterogeneous. However, based on the fact that commercial consumers will face the same fixed $ cost of implementing smart meters, but are likely to have a higher peak kW load than residential customers, it is likely that cost: benefit will be more favourable.

This is consistent with overseas experience, such as the UK government in its recent cost: benefit analysis[19] for smart metering concluding that the benefits for commercial customers (with demand management being a significant proportion of such benefits)

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[15] There is no good data to deliver a firm estimate. Accordingly, the following estimate has been used. Because of their relatively low load factors, it has been assumed that residential mass-market consumers account for 50% of peak demand even though they only account for 35% of total annual consumption. System peak demand (i.e. at the transmission network) is some 6.7GW. Spread over 1.65m residential customers, this gives an average residential customer contribution to system peak of some 2kW.

[16] *"Cost Benefit Analysis of Smart Metering and Direct Load Control. Work stream 4: Consumer Impacts. Phase 1 Report for the Ministerial Council on Energy Smart Meter Working Group"*, NERA, September 2007

[17] It should be further noted that the study assumed that only 7.5% of customers would adopt such a tariff, with 35% choosing a simpler time-of-use tariff, and the remainder (57.5%) staying on a flat tariff.

[18] GST is included when looking at benefits to an individual consumer. However, when looking at economic benefits from a New Zealand perspective, it would be inappropriate to include GST as it is ultimately a transfer among taxpayers.

[19] "*Impact assessment of smart metering roll out for domestic consumers and for small businesses"*¸ BERR, April 2008

unequivocally outweighed the costs of implementation, whereas the case for residential customers was more finely balanced.

Value of energy efficiency

As detailed in Appendix A, overseas jurisdictions are reporting significant changes in consumer behaviour as a result of smart metering that is resulting in material reductions in the amount of energy they consume. The central assumption the UK government is currently using is that it will result in approximately 3% reduction in residential electricity consumption and 2% in residential gas consumption. Whilst, noting that no data exists to determine whether similar effects would be seen in the New Zealand context, for illustrative purposes for New Zealand we will use a range of 1% to 5% that spans these same values[20].

The average *variable* component of a residential consumers' annual bill[21] is approximately $1,590 for electricity and $650 for gas (both figures including GST)[22].

Thus, the potential annual savings to the average consumer are between $16 and $79 for electricity and $6.5 and $33 for gas.

New Zealand has approximately 1.65m residential electricity customers and 0.23m residential gas customers. This gives a total 'gas-weighted' dual fuel benefit of between $17 and $84 per household (including GST), and equates to a total benefit to New Zealand of between $25m and $123m per annum respectively (excluding GST)[23].

In terms of valuing the *environmental* benefit of avoided consumption, principally avoided CO2 emissions, it is necessary to consider the marginal electricity generation plant which such avoided consumption displaces. This is a non-trivial exercise, and set out in detail in Appendix D.

The analysis demonstrates that in an environment of growing demand, the predominant generation that is avoided by energy efficiency is the generation that would otherwise have had to be built to meet this growth in demand.

There may be some initial displacement of the plant that is operationally marginal at any one moment in time (typically either a combined-cycle gas turbine or the Huntly coal-fired station). However, the extent of this initial displacement will depend on assumptions around the extent to which the market had anticipated such energy efficiency in its forecasts of demand growth and consequential new investment timings.

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[20] Given that the nature and scale of residential electricity and gas consumption in the UK is materially different to that in New Zealand (UK households consumer roughly half the amount of electricity as NZ households, but over three times the amount of gas), there are significant degrees of uncertainty as to the applicability of such results to NZ.

[21] It should be noted that these are the variable component of prices, rather than an analysis of the truly variable component of costs.

[22] Source: Concept analysis of a range of retailer tariffs using 9,000kWh per annum for electricity, and 8,000kWh per annum for gas.

[23] It should be noted that this is based on today's energy prices, and that future prices may differ. To the extent that the decline of the Maui gas field and the introduction of a carbon charge increase prices, this will tend to increase the benefits of energy efficiency.

The following table shows how much avoided emissions due to a smart-meter induced improvement in energy efficiency are worth for a range of CO2 prices for both electricity and gas residential consumers, with the electricity figure depending on whether a CCGT or Huntly is marginal.

Table 4 - Value of avoided emissions from improved residential energy efficiency

	Electricity				Gas	
	CCGT marginal		Huntly marginal			
CO2 cost ($/tonne)	*20*	*50*	*20*	*50*	*20*	*50*
Household ($/annum incl. GST)	2.34	5.84	5.68	14.20	0.61	1.52
NZ ($m/annum excl. GST)	3.4	8.6	8.3	20.8	0.1	0.3

With regards to what plant will be economically marginal on the longer-term investment time-frame, it will depend on a number of factors. Crudely, the extremes of the future new-investment scenarios can be characterised as either a world dominated by renewables, or a world where fossil-fuelled power stations continue to comprise a significant proportion of new-investment.

Exactly what proportion of new renewable and fossil generation will be developed will depend on a number of factors including:

- The cost of CO2;
- The availability and cost of domestic gas resources, and the likely cost of international liquefied natural gas options;
- The consentability of renewable resources[24]; and
- Government policy such as the currently proposed moratorium on new baseload fossil generation investment.

If the world is one where fossil-fuelled generation continues to play a material role in new generation investment, then energy efficiency will deliver tangible benefits in terms of avoided CO2 emissions.

If, however, the world is one where renewables dominate new generation investments, then the environmental benefit of energy efficiency in terms of reduced CO2 emissions drops closer to zero[25].

2.1.2 Improved retail competition

Many of the smart metering benefits relating to reduced consumer demand are dependent on retailers offering new and innovative products and services to consumers. The ability of retailers to increase their range of offerings in such a way has the potential to improve retail competition more generally through giving retailers more options to try and win customers.

[24] Noting that getting consents under the RMA has proven to be a significant hurdle for many hydro, wind and geothermal projects.

[25] There may still be a need to provide back-up thermal plant for the periods of peak demand when wind can't be balanced by existing renewable resources and an open-cycle gas turbine will be required. However, the percentage of time when wind will have to be backed up by such peaking plant will be relatively small (likely to be less than 5%). Accordingly the effective emissions from wind plus thermal back-up will be at least a factor of ten lower than for a CCGT.

This has been the case in some overseas jurisdictions such as the Netherlands where new-entrant retailer Oxxio successfully used smart metering as a key proposition to win customers away from the incumbent retailer who was still using dumb metering.

Valuing the benefits of improved retail competition

This is intrinsically a hard question to determine as competition is driven by many complex inter-linked factors. However, recent retail competition analysis Concept has done as part of the Market Design Review for the Electricity Commission indicates that average incumbent retailer margins for a medium-sized domestic customer are higher than might be considered consistent with a vigorously competitive market, but that margins for the cheapest competitor are closer to such ‘competitive’ margins[26].

The typical savings customers could make from switching from their incumbent to the best competitor are of the order of $125 per annum, including GST. Multiplied across New Zealand by the 67% of electricity customers still with their incumbent, this equates to some $75m of margin that is up for grabs (excluding GST).

It is hard to predict how much competition will be shaken up by the introduction of smart metering. If it were to cause a margin squeeze on incumbents of between 5% to 10%, this would equate to average annual savings to customers of between $4.25 to $8.50 including GST.

It would not be appropriate to scale up this value across all consumers to calculate a value to New Zealand as this benefit is a wealth transfer from retailers to consumers, and will not actually result in less resources being consumed.

2.1.3 Facilitating cheaper and/or greener generation development

There are two main types of generation that smart metering may facilitate

- Enabling greater proportions of variable energy sources on the system (e.g. wind solar, hydro, wave etc.) through facilitating more active demand-side response to ‘balance’ the system at times when the output from such sources is low.
- Enabling micro-generation in consumers’ premises (solar pv, micro cogen etc.) through having meters which can measure electricity exported back onto the distribution network when the on-site generation is greater than the consumer’s demand.
- There are two main types of benefit from such increased generation development:
- Economic benefit through facilitating local (or ‘distributed’) generation development that may be cheaper than alternative large scale generation and transmission options
- Environmental benefit through facilitating ‘green’ generation options

[26] A draft of the Market Design review report was released to the Retail Market Advisory Group and has been published along with the minutes of its April meeting. It can be found at http://www.electricitycommission.govt.nz/pdfs/advisorygroups/rmag/8Apr08/Update-market-design-review.pdf

Valuing the benefits of enabling greater proportions of variable generation

Renewable generation technologies such as wind and solar exhibit significant amounts of variability in their output depending on the underlying environmental conditions (i.e. how windy or sunny it is). This variability gives rise to a requirement to have additional resources available to 'balance' and/or supplement such generation at times when it is not windy or sunny.

There are two types of dimension to this balancing requirement:

- Having additional generation resources for times when the renewable plant is not generating, particularly at times of system peak demand; and
- Having sufficiently flexible non-wind generation resources to cope with situations of increased rates of change of output[27].

It is likely that having sufficient capacity at times of system peak will become a constraint sooner than the need to have sufficient flexible non-wind generation on the system[28].

In both situations, the solution is to have flexible yet firm generation resources that will be needed relatively infrequently. Accordingly, solving one constraint automatically solves the other.

The current most cost-effective resource for providing infrequently-used flexibility are open-cycle gas turbines (OCGTs).

The extent to which a MW of OCGT is needed to balance a MW of wind at times of system peak depends on the reliability of the wind resource. This is a non-trivial exercise and the subject of much debate. Essentially the 'answer' depends on your view as to how reliable you believe the system should be in terms of probability of firm output.

Wind plant have annual capacity factors of some 35% to 45%. However, this aggregate figure is made up of many periods of full output and many with zero output. Accordingly, to work out the aggregate reliability at times of system peak requires Monte Carlo analysis of different wind output profiles, taking into account any diversity benefit of having wind plant at different locations.

The current planning figure used by Transpower and the Electricity Commission in terms of their peak adequacy analysis is that 20% of wind's installed capacity can be counted as 'firm' at times of system peak. However, some overseas jurisdictions have used figures substantially lower than this level (4% to 7%) for similar such security analyses.

The annual carrying cost of an OCGT is some 100,000 $/MW/yr. If a 20% peak firmness figure is used for wind, then for each MW of wind, 0.8MW of OCGT is required.

[27] i.e. at the moment, the greatest rate of change of output due to demand increasing is some 1,300MW in a single half-hour. If significant amounts of wind come on the system you could have a situation where a half-hour of greatly increasing demand coincides with a period with wind dropping off significantly. This could give rise to a rate of change of output for non-wind plant that is substantially greater than the current 1,300MW per half hour.

[28] The need to build new generation resources whose predominant raison d'être is meeting peak MW capacity requirements rather than MWh energy, could become reality in the next 5 to 10 years, depending on the extent to which wind rather than firmer generation is built. Conversely, with regards to having sufficiently flexible generation, it is not clear how much extra flexibility the current set of non-wind generation assets is capable of, plus wind generation will need to grow significantly beyond current levels before we reach levels of required system flexibility that the current system will not be able to meet.

The table below shows how this translates to an increase in the effective $/MWh cost of wind for different values of wind peak firmness, and different wind annual capacity factors[29].

Table 5 - Impact of carrying cost of an OCGT on the economics of wind generation

		Peak 'firmness' factor		
		5.0%	**12.5%**	**20.0%**
Annual capacity factor	**35%**	31	29	26
	40%	27	25	23
	45%	24	22	20

As can be seen, having to carry the cost of firming OCGT capacity adds significantly to the cost of wind.

Instead of building an OCGT, it might be more cost-effective for some demand to be voluntarily curtailed at times of system scarcity, thereby potentially reducing the cost penalty faced by wind compared with thermal generators. As discussed above, smart metering has the potential to deliver more cost-effective peak demand management.

However, the avoided cost of an OCGT has already been counted in the valuation of peak demand management set out in Section 2.1.1 above. Accordingly, it would be double counting to count this benefit again.

Valuing the benefits of enabling micro-generation

The benefit of smart meters in this context is for microgeneration options not having to incur the cost of a specific export meter.

Assuming the cost of such a specific export meter is similar to that of a smart meter and thus, including installation would cost approximately $150, and assuming that the capacity factor of the microgenerator is anywhere between 25% and 40%, then for a 1kW unit, the avoided $/MWh cost is between $10/MWh and $16/MWh[30].

Clearly this is a material boost to the economics of microgeneration when compared with typical wholesale market costs of the order of $75/MWh.

Scaling this benefit into a national $m figure requires more data than is readily available on the relative economics of the different microgeneration options compared with grid-based options. Accordingly, no such estimate has been attempted for this study.

2.1.4 Improved network asset management

Often referred to as enabling the 'smart energy grid' this benefit derives from the much more detailed, and potentially closer to real-time, information that smart metering can deliver network owners and operators. Benefits include:

- More targeted asset management through superior information as to the nature of load on the network, the quality of supply (particularly voltage) at individual

[29] The increase in effective cost = Annual carrying cost of OCGT ($/MW/yr) * (1 - wind's peak 'firmness') / (Annual wind capacity factor * Number of hours in year)
[30] The capital cost of the meter has been amortised over 6 years at a rate of 10%.

customers' premises, and better ability to highlight those areas which require investment.

- The ability to work assets harder and/or smarter through the ability to have more dynamic line ratings and the like.

Valuing such benefits is extremely difficult and is the subject of much debate internationally with regards to the improvement in performance that can be achieved. Accordingly, no attempt has been made to value such benefits.

2.1.5 Lower retail cost-to-serve

There are a number of different areas where smart metering automation can replace more costly and error prone manual processes. Some of the main cost-to-serve benefits from such automation include:

- Avoided manual meter reading costs (scheduled and out-of-cycle)
- Avoided manual field service costs (principally visits to premises for connection and disconnection)
- Having monthly meter reads that are accurate. This results in reduced errors arising from poor bill estimation (if meters are currently read less frequently than once a month) and/or human error in reading the meters. The reduction in errors results in a reduced need for call-centre staff (to handle error-related queries), and back-office staff (to correct problems)
- Reduced losses through better control of 'vacant' property consumption (i.e. people consuming power at properties thought to be vacant)
- Reduced bad debt & working capital

Value of avoided manual meter reading and field service costs

Meter reading costs vary significantly depending on whether the customer is urban or rural (with rural on average being some 3 times more costly), and how frequently the meter is read.

Based on how frequently the customer's meter is read (with most retailers reading every month or every other month), typical scheduled read costs are of the order of $5 to $30 per customer per year.

So-called out-of-cycle 'special' reads (e.g. for people switching supplier, or moving property) can add some $2.50 *on average* per customer per year[31].

Disconnections and reconnections (the large majority of which are for vacant premises) plus difficulties accessing many properties can add a further $7.50 or so per *average* customer (much of which is recovered via individual customers rather than being spread across cost-to-serve).

In total, on *average* it is likely to cost between $15 to $40 per customer per year (excluding GST) to read their meters and undertake field service actions[32]. Multiplied

[31] i.e. the actual cost for an out-of-cycle read is substantially greater than for a scheduled read (some 10 times the cost). However, such special reads are required relatively infrequently. Accordingly, when spread across all customers, account for a relatively small cost compared with regular reads.

across the 1.9m mass-market consumers (residential & commercial) this equates to a benefit to New Zealand of between $29m and $76m.

Value of avoided back-office costs

There is little public data available on the break-down of New Zealand retailers' cost-to-serve.

A useful comparator is information on Australian retailers' cost-to-serve. The following table is from a KPMG report to the Ministerial Council of Energy working group on smart metering[33].

Table 6 - Estimated retailer operating cost-to-serve in Victoria (AUS$)

Operating cost		$/cust/yr	%
1. Billing and customer collection			
	Billing	3.4	4.9%
	Data validation	1.1	1.6%
	Customer transfer (switching)	2.8	4.0%
	Payments processing	9.3	13.3%
	Bad debt	2.7	3.9%
	IT costs	14	20.0%
2. Call centre		6.7	9.6%
3. Overheads			
	Office & admin	12.6	18.0%
	Energy trading	1.8	2.6%
	Customer communications	10.3	14.7%
	Pricing & risk management	2	2.9%
	Settlements	1	1.4%
	Regulatory	2.4	3.4%
Total		70.1	100.0%

The report indicated that during a two to three year transitional period, as smart meters are implemented, retailers' recurrent costs are likely to be higher as customers become accustomed to the new technology and tariffs. The scale of increase was estimated at A$5.80/customer/yr or 8.3%.

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[32] This figure is subject to a reasonable margin of error due to poor source data, and differing approaches taken by different retailers. Plus there is likely to be a significant amount of variability among different types of consumers, with those living in rural areas costing significantly more than those in urban areas.

[33] *"Cost benefit analysis of smart metering and direct load control. Workstream 3: Retailer Impacts – Phase 2 Consultation report to Ministerial Council on Energy*". KPMG, March 2008

However, in the longer-term, it was estimated that retailers would benefit from a reduction in recurrent costs of the order of A$3.70 and A$7.40/customer/year, or 5.3% to 10.6%.

Another comparator comes from the recent UK cost: benefit analysis[34], where billing and call centre cost savings from smart metering are estimated to be £2.20 per customer per year (approximately NZ$5.65).

Without access to detailed New Zealand retailer cost-to-serve information, it is hard to say whether such savings could also be expected for New Zealand retailers. However, in discussions with New Zealand retailers, it appears that cost-to-serve savings are being counted as a benefit stream for the business case. Accordingly they can be assumed to be sufficiently robust to motivate investment in smart meters, although some uncertainty remains as to the exact size.

2.1.6 A one-off reduction in 'unaccounted for energy' (UFE)

This is achieved though detecting anomalies during the smart-metering roll-out including:

- Theft (i.e. where customers have deliberately tampered with meters);
- 'Missed' meters (i.e. meters that are currently not being read, or have the wrong tariff loaded against them); and
- Meters who through old age are running slow or have stopped altogether.

Value of recovered UFE

Based on feedback from some initial roll-outs of smart meters in New Zealand, the magnitude of UFE could be of the order of 0.5% to 1.5%.

This benefit will automatically pass through to consumers via the local lines companies adjusting their loss factors which are used to scale-up purchases from the grid. Based on the variable component of consumers' bills being of the order of $1,700 per annum, the value to consumers (except for those whose meter set-ups are contributing to UFE) will be of the order of $8.50 to $25 per annum including GST.

It would not be appropriate to scale up this value across all consumers to calculate a value to New Zealand as this benefit is atransfer from one set of consumers to another. It will not actually result in a saving of resources through consumers consuming less[35], although it should at least provide more appropriate signals (i.e. certain customers will no longer face a 'zero' price)..

2.1.7 Social benefits for 'vulnerable' customers

Such social benefits include:

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[34] *"Impact assessment of smart metering roll out for domestic consumers and for small businesses"*, BERR, April 2008.

[35] Those meters which are now being properly recorded may result in the consumption associated with such meters reducing. However, this is likely to be very much a second order effect.

- *Improved treatment of pre-pay customers*. Whereas at the moment pre-pay customers need special meters, with smart metering they can have exactly the same meters as everyone else, thereby:
  - Reducing the cost penalty they currently face through being charged extra for these special meters;
  - Removing the issue of pre-pay customers being effectively ‘locked-in’ to their retailer due to inter-retailer hardware incompatibilities; and
  - Making it easier for customers having budgeting difficulties to switch to a pre-payment option if that is the most appropriate approach for helping them.
- *Reduced ‘hard’ disconnections.* The load limiting feature of smart meters means that retailers will be able to postpone undertaking ‘hard’ disconnections (i.e. complete shut-off of power supply) of customers that are having difficulty paying but instead have progressive ‘choking’ of supply. This will mean that customers will still be able to use lights and other low power-using appliances reducing the risk of house fires from the use of candles and the like, whilst still providing a strong incentive to pay outstanding debt.

It is hard to place a value on such benefits. However, there are likely to be tangible human welfare benefits, particularly where households included dependents (such as children or the elderly) who are not responsible for the financial situation of the household yet suffer the consequences.

Accordingly, no attempt at placing an economic value on this smart metering benefit, but it is noted that various government agencies such as EECA are placing increased effort on incorporating human welfare impacts on energy-related investments.

2.1.8 Avoided meter asset management costs

The main benefits in this category include

- Avoided costs of replacing meters that would have had to be replaced anyway; and
- Easier / cheaper meter asset management

Value of avoided meter lease / replacement costs

The typical meter lease charged by meter owners to retailers for use of a ‘dumb’ meter is some $50 per year. This dumb meter lease would be avoided by retailers if they switch to a smart meter (for which they would be charged a different lease cost).

From a New Zealand perspective, unless such dumb meters would need to have been replaced anyway, this is not a genuine economic cost saving but rather a wealth transfer from the old meter provider to the new meter provider.

However, the Electricity Commission has recently passed a rule that by 2015 all meters must have been inspected and tested to ensure compliance with a technical standard relating to accuracy. Accordingly, there will be a need for meter owners to send a qualified contractor to visit every one of their meters before then to check whether they comply.

If a smart meter is installed before then, this will avoid the need for such contractor visits, plus will avoid the need to replace those dumb meters that fail to meet the standard. If the cost per contractor visit is between $50 and $100, and the cost of a replacement dumb meter is between $30 and $60 then, assuming between 5% and 15% of existing meters fail to meet the standard, then the genuine economic benefit to New Zealand of *one-off* avoided meter asset costs is between $12m and $26m per year if spread evenly over 7 years, which equates to some $8 and $18 per meter per year (including GST). While plausible values have been chosen for the assumptions, this figure is subject to a significant amount of uncertainty.

2.1.9 Summary benefits

The table below summarises the scale of the different benefits estimated in the above section, split between those that are genuine economic benefits (i.e. resulting in less resources being consumed), and those which are 'just' a wealth transfer in the direction of consumers.

Table 7 - Estimate of scale of benefits of smart metering benefits to individual households, and New Zealand as a whole[36]

Function	Benefit	Low to High range	Annual potential benefit			
			Per customer ($)		NZ ($m)	
			Low	High	Low	High
Economic efficiency improvements						
Time-of-use pricing and information	Peak demand management → avoided peaking generation and network assets	Peak reduction = 2.5% to 10%	16	64	23	94
Improved information to consumers via an in-home display	Energy efficiency response resulting in avoided generation costs[1]	Efficiency response = 1% to 5%	16	79	23	116
Export metering	Enabling microgeneration	?	?	?	?	?
Automated and more accurate meter reading & field services	Lower cost-to-serve through avoided labour, and less errors	Various	20	55	30	77
Richer and more real-time network information	Improved network efficiencies	?	?	?	?	?
Replacing meters that would have had to be checked and/or replaced anyway	Avoided existing meter compliance / replacement costs[2]	Various	8	18	12	26
Total impacts yielding economic efficiency			***60***	***216***	***89***	***313***
Wealth-transfer improvements						
Improved retail competition	Reduced incumbent retailer margins	Reduction in margins = 5% to 10%	4	9	n/a	n/a
Implementation finding missed, tampered with, and inaccurate meters	Reduction in unaccounted for energy	Reduction in UFE = 0.5% to 1.5%	9	25	n/a	n/a
Smart metering can be used for pre-payment purposes	Improved pricing for pre-payment customers	?	?	?	n/a	n/a
Replacing existing meters	Avoided existing 'dumb' meter lease costs to retailers	Average ex-GST lease = $40 to $60	45	68	n/a	n/a
Total wealth-transfer impacts			***58***	***101***	***n/a***	***n/a***

[1] The avoided costs are based on the variable component of current consumers' prices, rather than explicit modelling of avoided long-term variable costs of supply-side assets

[2] Such avoided costs are only assumed to last over a seven year period in the run-up to the 2015 meter compliance deadline.

[36] The benefits (per consumer and scaled-up for New Zealand) are only for the estimated 1.65m residential consumers. The benefits for the estimate 0.25m mass-market commercial consumers have not been calculated although, as indicated in the text of the report, these are believed to be greater on a per-customer basis than for residential.
The benefits shown in the table are including GST for individual residential consumers, and excluding GST for New Zealand as a whole.

2.2 Costs

2.2.1 Capital costs

The most significant cost associated with smart metering is the initial capital cost of the meters, their installation, and the development of the associated communications and IT infrastructure.

The exact magnitude of costs is dependent on a number of different factors including

- the density of premises over which smart metering is being rolled out (urban being significantly cheaper than rural);
- the type of communication technology chosen (e.g. radio mesh, power line carrier, GPRS etc.); and
- the type of smart meter and associated consumer-related technology ‘optional extras’ (e.g. in-home display, home area network).

Many of the elements in the smart metering ‘technology stack’ are continuing to enjoy ongoing cost-reductions as they move along the new technology maturity curve, and it is likely that in 5 years time, say, costs will be significantly less than they are now.

There is little public domain data as to the cost of smart metering in New Zealand. However, as set out in Section 4.1.1, the majority of New Zealand retailers are planning a mass-market deployment of smart meters, with the business case being predominantly around avoiding meter lease costs + meter reading costs + field service costs + retail cost-to-serve. i.e. the cost savings that *retailers* can capture and ‘bank’ with relative certainty. It is not clear the extent to which retailers are firmly valuing the potential benefits of smart metering giving them a superior customer proposition, and thus enabling them to be more successful at winning and retaining customers.

Based on such savings, it appears that smart meter providers are charging an amortised service fee which must be equivalent or less than these current costs retailers face (i.e. the sum of the current meter cost and other operating costs such as bad debt etc). This amortised fee will need to cover the capital and installation cost of the meters, the national communications infrastructure, and IT systems[37].

For comparison, a recent UK government cost: benefit analysis[38] estimated that the one-off per installation costs of the various components of smart metering were as follows:

[37] It should be noted that the initial smart-meter deployments in Christchurch are without a home area network (HAN) chip included, or an in-home display.

[38] "*Impact assessment of smart metering roll out for domestic consumers and for small businesses"*, BERR, April 2008

Table 8 - Breakdown of UK smart metering cost components

• the smart meter (excluding an IHD)	£47	($ 120)
• an in-home-display (IHD)	£15	($ 40)
• installation	£29	($ 75)
• communications[39]	£45	($ 115)
• **total**	**£136**	**($ 350)**

Amortising the total $350 cost over 7 years at a 10% discount rate gives an annual value of $72. It is likely that the UK will be able to enjoy economies of scale from having sixteen times the number of households over which to spread fixed costs, and potentially leverage greater purchasing discounts from vendors. Purely for the purposes of furthering this cost: benefit illustration, Concept has assumed that New Zealand incurs a 20% cost penalty on a per customer basis compared with the UK. This gives an overall amortised cost of $86 per annum.

This is the figure that much be compared with the potential economic benefits of smart metering to determine whether it is in New Zealand's interests.

2.2.2 Other potential costs

Smart metering also has the potential to have other impacts on the electricity market including:

Creating barriers to switching in the retail market.

Such a situation could arise if retailers tied the provision of smart meters to consumers with long-term contracts for supply of electricity. In New Zealand, this does not appear to be the case, particularly as those retailers who are implementing smart metering appear to be doing so because of cost-to-serve drivers, and accordingly are giving smart meters to customers 'free of charge'.

Creating barriers to new-entry by retailers

Such a situation could arise if a group of major retailers developed the IT infrastructure with access conditions which were more favourable to them than other retailers. Whilst, such 'club' arrangements could potentially fall foul of general competition law, another negative outcome could occur if the major retailers / meter owners developed highly proprietary IT protocols thereby requiring new-entrant retailers to develop a significant amount of additional IT functionality in order to operate in the market, and increasing the cost of entry into the market.

Neither situation appears to be emerging in New Zealand. Indeed, much of the Electricity Commission's focus has been on ensuring that open protocols are developed to prevent such situations emerging, and with apparent success based on developments to-date (noting that it is still relatively early days in developing a lot of the systems).

[39] This has been back-calculated from the report's estimate that the NPV cost of the most cost-effective communications option (a highbred of piggyback broadband and cellular) would be £1.2 billion. When divided by the 27million electricity meters in Britain, this translates to some £45 per installation.

Reducing cross-subsidisation between customers

At the moment there is a degree of cross-subsidisation between consumers arising from the fact that the amount of electricity people with dumb meters are assumed to have consumed at the different times of day is based on generic 'average' profiles. Thus people who consume proportionately more at lower-cost periods (e.g. night and weekends) are effectively cross-subsidising those who consume more at higher-cost periods (weekday morning and evening peaks). The time-of-use element of smart metering will start to remove such cross-subsidies.

Whilst this is economically efficient, it will result in cost-increases for some customers, some of whom may be in the low-income category with associated social consequences. Conversely, other customers will enjoy lower bills. Again, it is possible that some of these may be in the low-income category.

Calculating the nature and scale of cross-subsidy, and which classes of customers are likely to be 'winners' and 'losers' through more cost-reflective pricing, is a non-trivial exercise and thus has not been attempted for this study.

Such an exercise was undertaken by Trowbridge Deloitte for the Essential Services Commission in Victoria, as part of an analysis of the impacts of smart metering[40]. It came to the conclusion that the range of cross-subsidisation arising from profiling was between -5% to 15% (at delivered cost). i.e. some consumers were paying 5% too much under profiling, whereas others were paying 15% too little.

It would not be possible to translate the results of this study to the New Zealand situation given the very different nature of the wholesale market price drivers in particular, and the different drivers of peak demand in the two countries (air conditioning in Australia, and heating in NZ). Given the less peaky nature of New Zealand demand, it would be expected that the level of cross-subsidisation is less than in Australia.

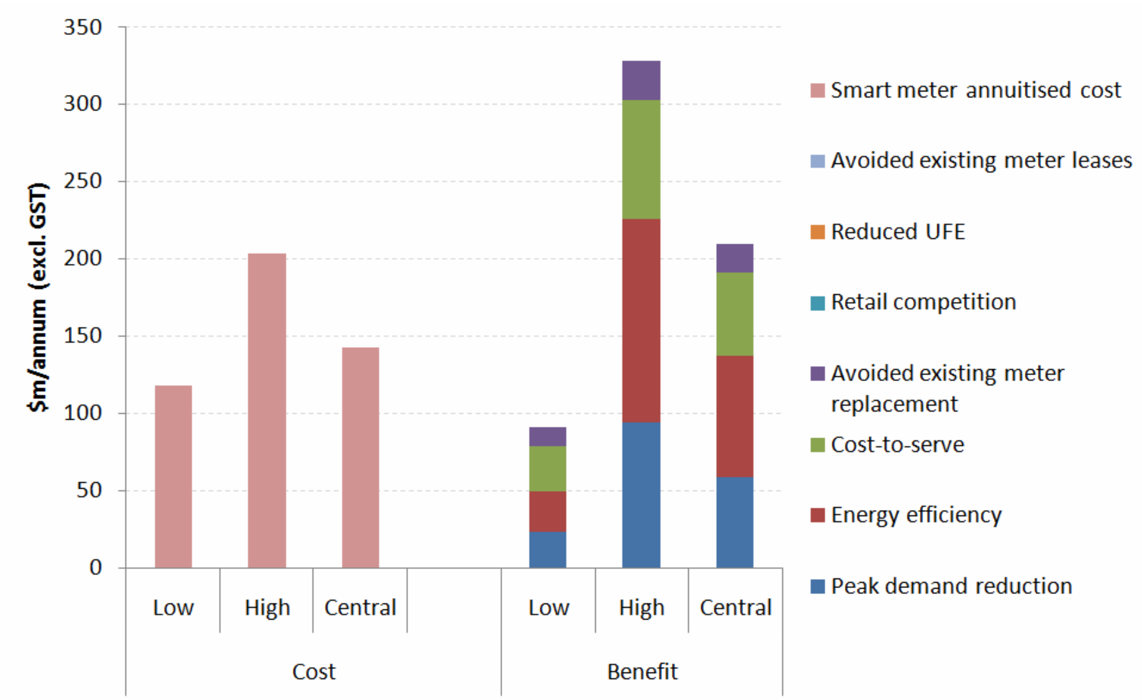
2.3 Summary cost: benefit analysis

As was indicated earlier, different parties will experience different costs and benefits from smart metering.

From a New Zealand perspective, it is only those benefits that result in improved economic efficiency that should be counted in a cost: benefit analysis. Using the numbers estimated in Sections 2.1 and 2.2 above, the following chart illustrates this cost: benefit equation.

[40] *"Customer Energy Cross Subsidies in the Victorian Electricity Market"*, Trowbridge Deloitte, September 2003.

Figure 6 - Costs and benefits of residential[41] smart metering to New Zealand

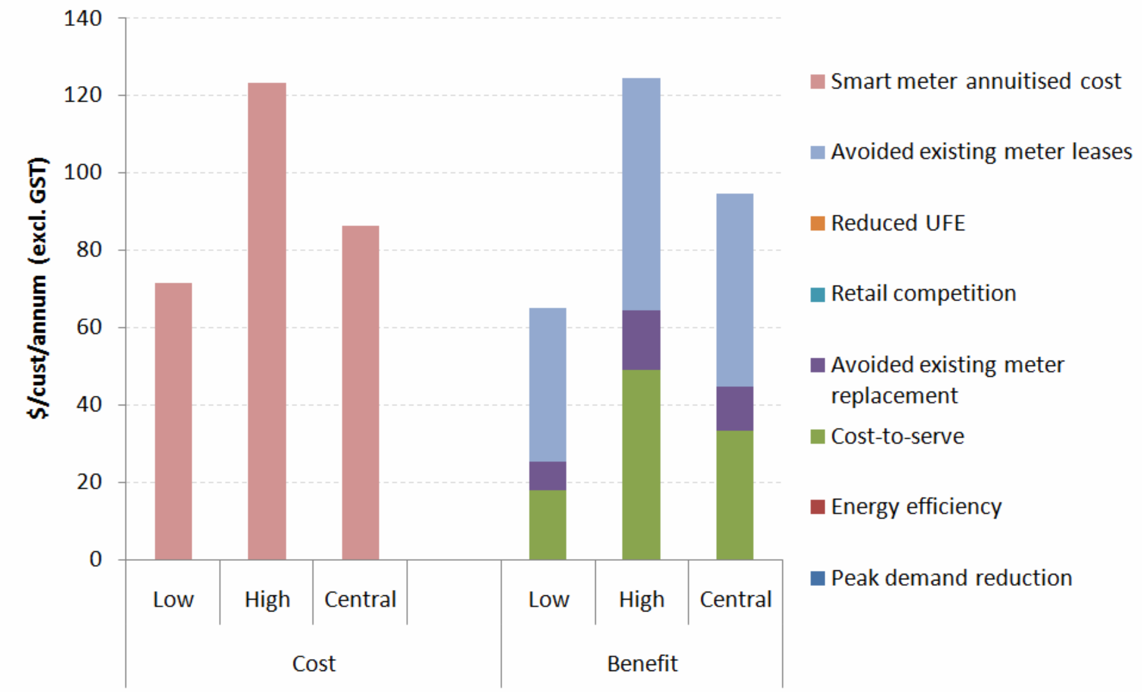


As can be seen, using the central estimates, the potential benefits appear to outweigh the costs.

However, in the current New Zealand dynamic it is retailers that determine whether smart meters should be implemented. It is likely that they will exclude some of the potential benefits outlined above as they will regard them as not sufficiently 'firm' to be bankable (detailed further in Section 4). However, they will include avoiding paying the existing meter leases as a benefit, despite the fact that, from a New Zealand economic efficiency perspective, this is 'just' a wealth transfer. The resulting cost: benefit is shown in the figure below.

[41] Mass-market commercial customers have not been included in this analysis.

Figure 7 - Costs and 'firm' benefits of smart metering to a retailer that doesn't own existing meters

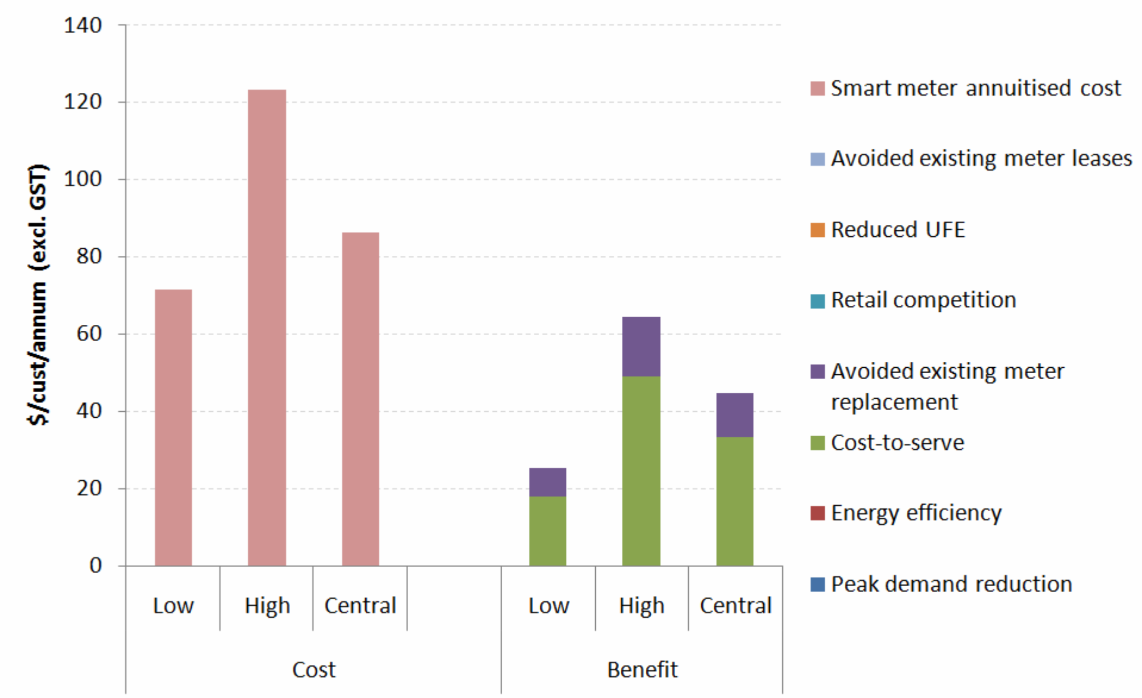


As can be seen, under the central set of estimates, smart metering is just positive for retailers. This conclusion seems plausible as it is only recently that costs have apparently come low enough such that retailers have started to implement smart-metering in their major urban customer bases.

In addition to the 'firm' benefits shown above, it is likely that retailers may enjoy some customer acquisition / retention benefits through being able to offer superior offerings around smart peak demand management tariffs and the like. However, based on discussions with some retailers, such additional benefits are being regarded as 'up-side' rather than a core part of the smart metering business case.

If the retailer is also meter owner, then the cost: benefit equation changes significantly as the benefit of avoided existing meter leases can no longer be counted. The changed picture is shown below.

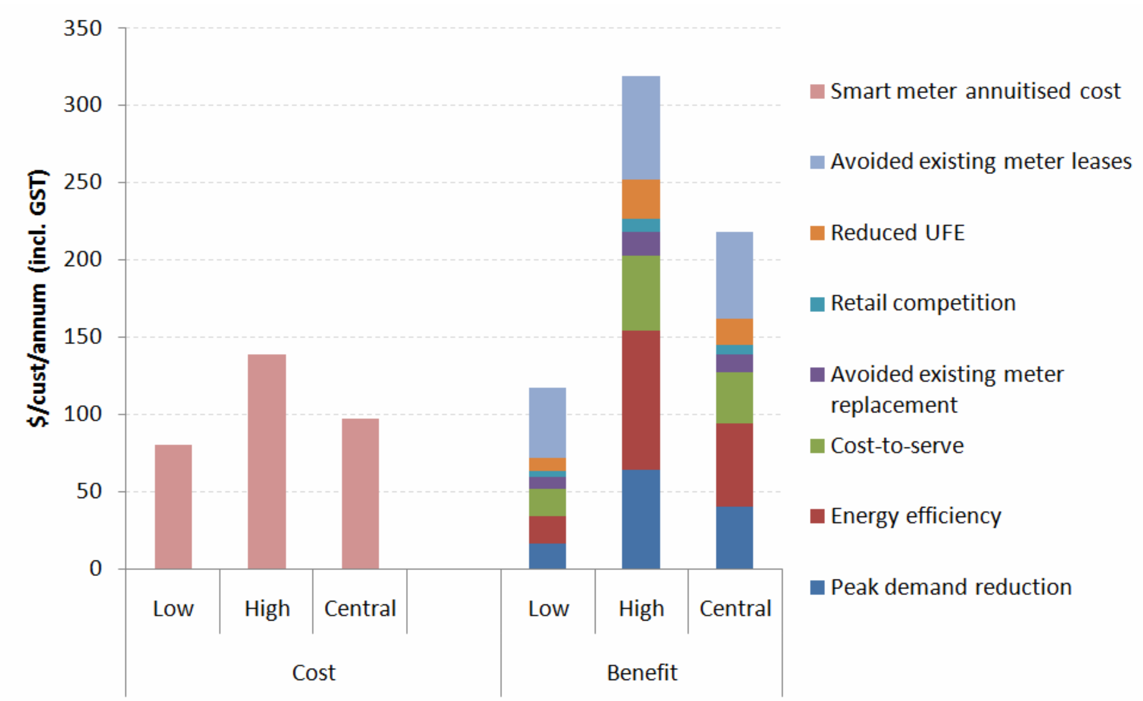
Figure 8 - Costs and 'firm' benefits of smart metering to a retailer that owns existing meters



As can be seen, the benefits no longer exceed the costs. As detailed further in Section 4.1.1, this conclusion is consistent with the behaviour exhibited by TrustPower, the retailer that has the greatest proportion of meters it also owns, who has decided not to implement smart metering at this stage.

From an end-consumer's perspective, the cost: benefit will include all the economic efficiency benefits plus the wealth transfer benefits. This is shown in the figure below.

Figure 9 - Cost: benefit of smart metering from an end residential consumer's perspective



As can be seen, the *potential* benefits are considerable when compared with the costs. However, as detailed elsewhere in this report, the extent to which *actual* benefits are realised will depend on the way in which smart metering is implemented, particularly with respect to whether in-home displays are included, and the nature of any smart peak demand tariffs offered by retailers.

3 Overseas experiences with smart metering

3.1 Who is doing what where?

Smart metering has developed significantly over the couple of decades since it was first seriously considered.

Early implementations were largely around advanced meter reading (AMR) – i.e. the ability to remotely read a meter using a variety of different technologies, but without the meter necessarily being smart in any other way. Several initiatives in the US progressed such an approach.

However, it is only in the last five or so years that truly ‘smart’ mass-market metering initiatives have progressed. Key early initiatives have been seen in Italy, the Australian state of Victoria, California, the Canadian province of Ontario, Sweden and the Netherlands. Peak demand management has been a key focus of many of these early initiatives (particularly Victoria and California). In others, (e.g. Italy) greater focus has been placed on cost-to-serve savings.

In the last year or so, almost all electricity jurisdictions in OECD countries have undertaken, or are in the process of undertaking, a review of whether they should follow such early adopters and mandate the implementation of smart metering. Australia (via the Ministerial Council of Energy), Ireland, Alberta, British Columbia, have recently concluded that they should adopt such an approach. The British government has concluded that the case is conclusively positive for commercial customers, but is yet to come to a firm decision for residential customers for which the case is more finely balanced.

3.2 Implications for New Zealand

All these overseas reviews have included cost: benefit studies as to whether / how smart metering should be rolled out in their particular jurisdictions.

What is telling is that there does not appear to be a strong consensus as to the magnitude of either the costs or benefits of smart metering, and thus whether a roll-out should be mandated.

Looking closer at the detail of such studies reveals that this is not necessarily due to differences in approach to such economic appraisals, but more due to inherent differences in the nature of the electricity and gas systems across the jurisdictions in question.

Key differences include:

- The fuel mix at a domestic level which will determine:
  - How much electricity and gas is used for different purposes, and thus the magnitude (in both % and absolute kWh terms) of potential savings from increased energy efficiency
  - Whether smart metering only applies to electricity, or whether gas meters also need to be included

- The nature of the supply-side of the industry, in particular:
  - whether the electricity system suffers from acute demand peaks (e.g. in Australia), and thus the magnitude of peak demand savings (generation and network related);
  - the type of marginal existing and new entrant generation plant, which will determine the per kWh magnitude of any CO2 and other environmental savings;
  - whether the system already has a lot of flexible generation, in which case the benefits of peak demand management to accommodate more variable generation will be reduced; and
  - whether the economics of large scale generation in the country are significantly more favourable compared to small-scale generation, in which case the benefits of facilitating microgeneration will be reduced.
- Whether customers are predominantly in urban environments (relatively cheap to install meters and associated communications infrastructure), or in rural locations (relatively expensive);
- The frequency of existing manual meter reading, and thus the scale of costs that can be avoided. For example, In the UK meters are only read approximately once every six months, compared with once every one to two months in NZ;
- The extent to which pre-payment metering exists within the jurisdiction;
- The nature of retail competition, and thus the extent to which smart metering will deliver competition benefits

Thus the costs and benefits calculated for one market may be very different for another.

Further, it is apparent that the degree to which benefits are realised is in part determined by who is driving the implementation (e.g. government, network companies, meter owners etc.), and the market structure with respect to vertical integration between the respective functions of network company, retailer and meter owner. Thus, for example, network company driven implementations tend to have a stronger focus on peak demand management than retail company driven implementations which focus more on lowering cost-to-serve.

In these respects as well, New Zealand is unique compared to the rest of the world. This is principally due to its vertically disaggregated market structure, coupled with the contestability for meter services (detailed further in Section 4.1.2).

Thus, whilst overseas studies will inform considerations of smart metering in New Zealand to a certain extent, the differences in the specific situations of the different countries are significant enough that such studies cannot be used to draw direct conclusions about whether / how smart metering should be rolled-out in New Zealand.

Moreover, as detailed in Section 4, the market driven dynamic in New Zealand appears to be delivering a functionally rich mass-market roll-out of smart metering so that such considerations may be less relevant.

Indeed, one of the key learnings from overseas experiences is how centrally mandated approaches need not deliver optimal outcomes, and how it can be harder to reverse poor centrally mandated decisions. Examples include:

- Jurisdictions where the communications technology chosen may not offer much opportunity for richer future services. For example power line carrier (plc) communications technologies (sending the signal over electricity company wires) offers reduced data transfer capability than other options. However plc is often strongly driven as a solution by the electricity lines companies (as is the case in the current Australian debate);

- The provision of in-home displays (a key potential factor to deliver the energy efficiency benefits described in Section 2.1.1), has not been mandated in a number of jurisdictions;
- The IT aspects and decisions around handling the vast quantities of data can still be problematic (as appears to be the case in Ontario);
- The fact that consumers can be required to pay stranded asset compensation to owners of existing meters;
- Centrally mandated decisions to select an AMR option, and thus foreclosing potential benefits from truly smart meters; and
- The amount of time and money it can take to achieve a regulated decision compared with the decision timeframes of market participants.

Given the above, the remainder of this report focuses on the specifics of the New Zealand situation, and only draws on overseas experience with respect to those New Zealand issues where non-optimal outcomes may emerge – principally whether an in-home display is included with a smart metering roll-out.

4 Smart metering in New Zealand

4.1 How much smart metering is likely to be implemented in New Zealand?

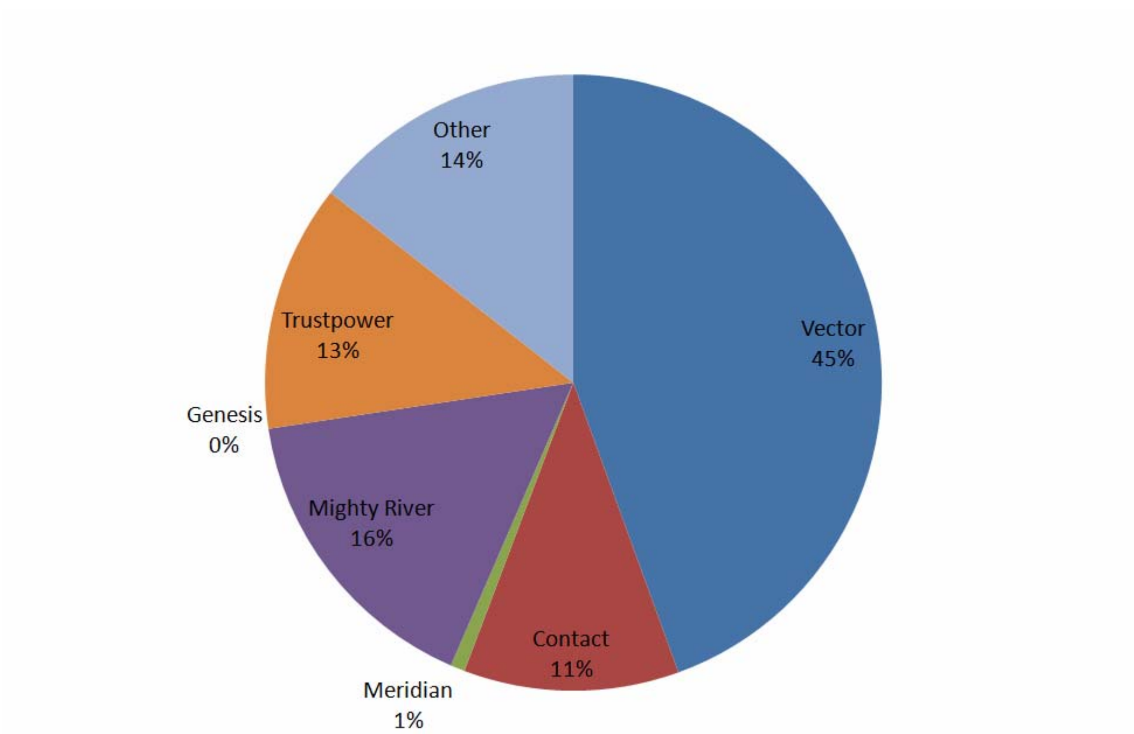
4.1.1 Current scale of implementation

New Zealand appears unique in the world in that a mass-market deployment of smart metering is likely to occur driven purely by market forces.

Based on information supplied to the PCE and subsequent discussions, the current situation appears to be that four of the five big retailers (Meridian, Contact, Genesis, and Mercury (i.e. Mighty River Power)) plan to roll-out smart meters to all their customers over the next five or so years. In addition, three of the big meter owners (Vector, Contact and Metrix (i.e. Mighty River Power) plan to roll-out smart metering to replace their existing meters in a similar timescale.

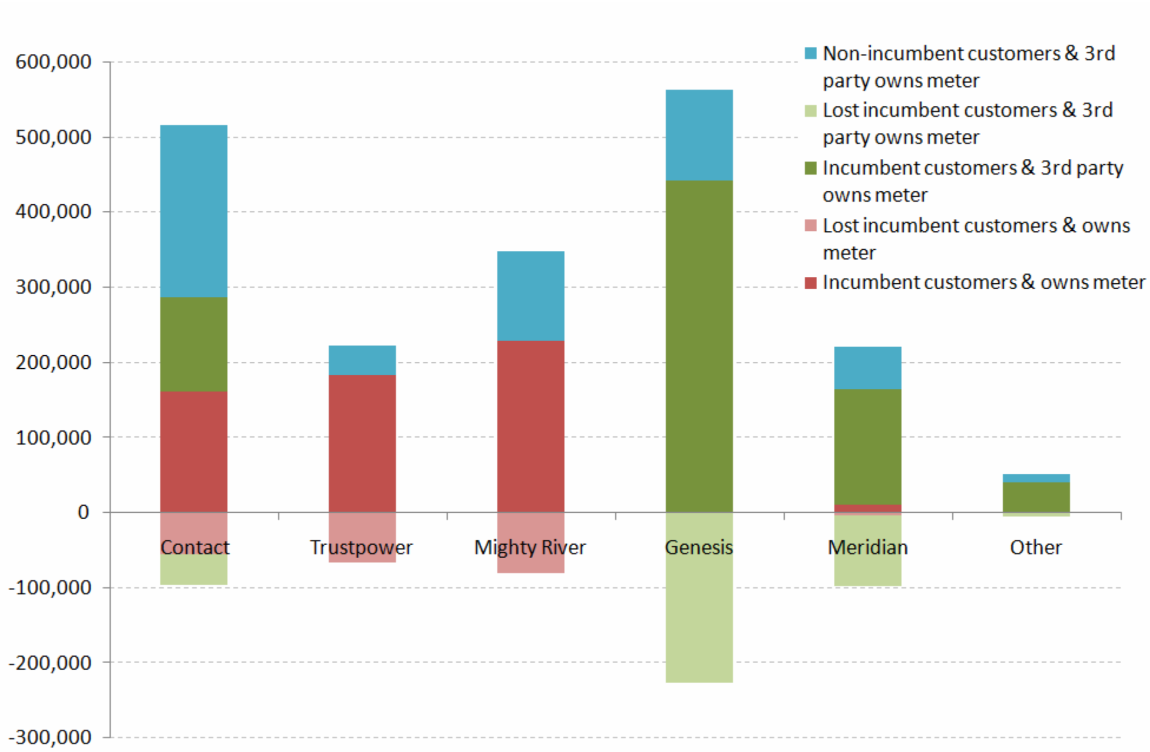
In total, the above companies represent over 80% of electricity meters in New Zealand and over 90% of gas meters.

Figure 10 - Ownership breakdown of New Zealand's electricity meters



Source: Concept estimate based on February 2008 Electricity Commission registry statistics of ICP numbers

Figure 11 – Electricity retailer customer mix: Incumbency & meter ownership



Source: Concept estimate based on February 2008 Electricity Commission registry statistics of ICP numbers

4.1.2 Drivers behind the current implementations in New Zealand

As can be seen, Contact and Mighty River are both retailer and meter owner, yet they appear to have reached the conclusion that they should incur the financial cost of writing off the value of their existing 'dumb' meters, by replacing them with smart meters.

TrustPower is the only other big retailer and meter owner, yet has decided not to replace its existing meters, stating that they cannot make the cost: benefit work for them.

The different positions of Contact & Mighty River versus TrustPower gives an insight into why market forces are delivering large scale smart metering to most of New Zealand, yet have not been able to in other parts of the world.

The crucial dynamic in New Zealand appears to be that:

- retailers have the right to choose their meter provider;
- there is mixed ownership of electricity meters, with roughly 45% owned by Vector as an independent meter owner[42], 40% owned by retailers[43], and 15% owned by a variety of smaller network companies;

[42] Only in one network area, the North Shore, is Vector both the meter owner and network company. This only accounts for some 24% of its electricity meter base.
[43] Roughly split between Contact, Metrix (Mighty River), and TrustPower. Genesis don't own any meters (having sold them to Vector), and Meridian own a very small meter base.

- retailers who don't own the meter therefore do not incur an asset write-off cost through installing a smart meter, yet can reap some benefits through enjoying a lower cost-to-serve and superior customer offerings.

Two competitive factors appear to have kick-started the process in New Zealand.

One is the emergence of a home-grown smart metering company, Arc Innovations, developed as a start-up by one of the major retailers, Meridian. As soon as Arc had developed a mature technology solution, Meridian started the process of switching meters by starting to change the meters for its entire Christchurch customer base of some 120,000 customers (whose meters are currently owned by Vector).

Apparently in response to this initiative, the other main retailer in Christchurch, Contact, decided to replace its own customers' meters, and struck a deal with Vector (via a joint venture with Siemens called Advanced Metering Solutions (AMS)) for replacement of all its Christchurch customer meters.

It is likely that even without the emergence of Arc, the smart-metering process would have happened anyway in New Zealand, but it is probably the case that it wouldn't have happened so quickly. It is almost certainly the case that it placed real pressure on Contact to consider smart metering for its Christchurch customers sooner than it would otherwise have done or risk losing them to Meridian. Plus it is probably the case that it forced Vector to deliver a competitive price for delivery of its own smart metering solution in response to an initiative by Contact and Genesis to tender for replacement of meters for their entire retail customer bases across New Zealand.

The other factor is a significant drop in the cost of the communications element of smart metering, particularly the price mobile phone operators are charging for use of their services. As well as continuing technology and cost improvements in the telecommunications sector, there are a variety of other potential factors driving the specific significant cost reduction for smart metering communications:

- According to some within the industry this is in response to the emergence of RF being a viable technology alternative, and the consequent threat to mobile phone companies of the development of a national RF network.
- It may also be due to the realisation by cellular companies that there are potential opportunities that could be exploited through having a SIM card in everyone's home and the opportunity to offer services that can piggy-back off this.
- Lastly, it is clear that Vodafone has developed some fairly innovative approaches to licensing and technology (e.g. the ability for such cards to be 'asleep' for most of the time) such that they have been able to offer a lower price for use of their cellular network.

Whatever the reason, coupled with ongoing cost reductions in the cost of the meters themselves, this has meant that for the first time it appears that the benefits to retailers in terms of reduced cost-to-serve and avoided meter lease costs has about reached parity with the costs of services provided by a smart meter.

The most interesting dynamic appears to be the differing positions that Mighty River and TrustPower are taking on this issue. Both of them own the meters in their retail incumbencies (Mighty River in its sole incumbency of central Auckland, and TrustPower across its 12 much smaller-scale regional incumbencies). Both of them have a 74%

retail market share in these incumbencies[44]. Yet Mighty River has decided to replace all its existing meters with smart meters, whereas TrustPower says it cannot make the cost: benefit equation work for it (presumably in terms of the benefit of smart meters not outweighing the write-off costs for its existing meter fleet).

It may be that they have different views on the threat of competition. Certainly, Mighty River has a mass-market smart meter roll-out due to happen on its doorstep (the North Shore) where Vector will be replacing its meter fleet in response to the Contact / Genesis initiative. Accordingly, the opportunities for Contact and/or Genesis to switch-out Mighty River meters in the Auckland area at relatively low incremental cost are probably much greater than to conduct a similar exercise in TrustPower's scattered and more rural incumbencies.

Mighty River may also have a different view as to the extent to which the provision of smart metering services will be a competitive differentiator in the retail market, and thus risk a further erosion of its incumbent customer base through competitors offering 'smart' retail services.

Only time will tell which of them has adopted the 'right' strategy. It may be that they are *both* right, and that the competitive dynamic is much stronger in cities (where the cost of meter installation and of acquiring retail customers is much lower) than in rural areas. This certainly appears to be the case through analysis Concept has undertaken which indicates that the proportion of customers that have switched retailer is significantly higher in cities (33% on average) than in small town / rural areas (21% on average).

It is likely that the initial roll-out of smart metering will focus on the major metropolitan areas which, given the scale of the undertaking, could take several years[45]. However, as attention starts to turn in a couple of years' time to medium New Zealand towns, the competitive risk from smart metering is likely to increase for TrustPower to a level similar to that Mighty River currently faces. Accordingly, it too may start to roll-out smart metering as an attempt to pre-empt competitors switching out its meters for customers they already service, and/or winning new customers from TrustPower on the back of smart services.

Smart metering for gas

Whilst the majority of focus is on electricity metering, it is important to also consider the position of gas meters.

Some of the elements in the benefit stack outlined in Section 2.1 for mass-market smart metering for electricity are likely to be considerably less for mass-market gas smart metering, including

- The benefits from being able to measure consumption on a time-of-use basis and signalling more dynamic load management;
- Dynamic network management; and
- Facilitating green generation.

[44] Based on February 2008 registry data published by the Electricity Commission.
[45] Installation rates for smart meters are likely to be of the order of XXX per electrician per day. In order to replace the meters in some 1,800,000 properties this equates to a lot of electricians and/or a lot of days! Getting extra qualified electricians to install such meters is likely to be a major limiting factor on the speed with which smart meter deployments can be undertaken.

In large part this is because, whilst residential gas customers account for 96% of total NZ gas customer numbers, they only account for some 4% of total gas consumption. But it is also due to the greater ability of the gas network to 'flex' within-day using quasi-storage capabilities such as linepack within the gas pipeline.

However, there are likely to be similar order-of-magnitude gains for other elements of the smart-metering benefit stack including:

- Cost-to-serve benefits;
- Delivering an energy efficiency response from customers;
- Social benefits relating to pre-pay;
- One-off reduction in 'unaccounted for energy' losses;
- Social benefits for 'vulnerable' customers; and
- Avoided meter asset management costs.

In particular, with respect to the cost-to-serve element, many of the electricity cost-to-serve savings would be negated if manual processes had to remain for reading gas meters. Accordingly, given that retailers are driving the smart metering dynamic, at this stage it appears that the main dual fuel retailers *will* implement a smart metering solution for gas at the same time as they implement one for electricity[46].

4.1.3 Likelihood a total deployment of smart metering in New Zealand

As indicated above, TrustPower and other retailers and meter owners are not currently planning to roll-out smart meters. Whilst this is 'only' likely to be of the order of 15% of meters, this nonetheless represents a material lost potential benefit to New Zealand and the specific customers in question.

However, as also discussed above, the competition dynamic that appears to be forcing Vector and Mighty River to replace their existing meters in their city incumbencies is likely to progressively extend to the rest of New Zealand. The speed with which this occurs will be influenced by:

- How much smart metering costs continue to reduce, given that these non-metropolitan areas suffer higher implementation and communications costs; and
- How much smart metering acts as a spur to retail competition through retailers being able to offer customers superior products and services. In turn, this is likely to be a function of:
  - The opportunities for retailers to offer innovative peak management products with real value to customers given the underlying price drivers.

    This is an area where the value available to retailers (and consequentially customers) is currently not as great as it probably should be. This is detailed further in Appendix C, as is a discussion of the regulatory initiatives to address these issues. It appears reasonable to expect that the ability of smart meters to deliver valuable peak management products to consumers is likely to increase over time.

[46] Because the gas and electricity meters in people's properties can often be separated by a fair distance (e.g. one in the house, one at the property boundary), and the physical characteristics of the meters are very different, the smart metering solution for gas will likely consist of a clip-on for the existing gas meter. This will then be able to communicate wirelessly with the electricity smart meter which can then send both electricity and gas meter readings to the meter service provider.

– The capability of retailers to offer innovative products given the limitations of their current IT systems for billing and customer relationship management.

  This is an area where most retailers are likely to be hamstrung by their existing legacy systems, which may variously be one to three years away from being replaced.

  Conversely, Genesis has recently completed a major project to update its retail IT systems to the latest version from its software provider, and is therefore likely to be in a much better position to offer innovative products. If Genesis is able to exploit this advantage, it may act as a spur to smart metering becoming a real competitive differentiator and a spur to competition.

– Customers' desire for such new services.

  This is a big unknown, and to a large part driven by the nature of the different products and services retailers offer customers off the back of smart metering. At least one overseas retailer (Oxxio in the Netherlands) has managed to be highly successful at winning customers on the back of a smart metering proposition.

Based on the above, there is a reasonable prospect of competition pressures continuing the dynamic which results in a continuing roll-out of smart metering to the rest of New Zealand.

Further, it should be noted that the full cost-to-serve benefits of a smart-metering roll-out will only be realised once smart metering is universal. i.e. there are costs associated with maintaining systems and process to deal with dumb meters. Thus as the proportion of dumb meters declines, the value per remaining dumb meter of replacement with a smart meter grows disproportionately.

Also, whilst rural / remote customers have significantly higher smart meter implementation costs, they also currently suffer significantly higher manual meter reading and field service costs (roughly 3 to 5 times higher than urban customers) making the cost-to-serve benefits of smart metering much greater.

Risks of mandating a roll-out for the percentage of customers still without smart meters

The above analysis appears to suggest that a comprehensive deployment of smart-metering is likely to occur driven purely by market forces, and within a timeframe that is comparable to mandated overseas deployments (i.e. of the order of five to eight years).

Even if total coverage wasn't likely within such a timeframe, there may be negative consequences of mandating a complete roll-out.

In particular, such a mandated approach may raise the prospect of the owners of the existing dumb meters receiving compensation for the stranded asset as has occurred in overseas jurisdictions. Currently in New Zealand consumers are not having to pay for such stranded assets, with the costs instead being borne by the meter owners themselves. (Although it should be noted that from an economic perspective this is 'just' a wealth transfer from meter owners to consumers).

Another risk would be increased regulatory uncertainty whilst such regulations were developed and implemented, potentially leading to a delay in the implementation of those smart meters that would have been implemented anyway.

4.2 Potential non-optimal outcomes of the New Zealand situation

4.2.1 Potentially reduced focus on innovative tariffs

As indicated in Section 2.1.1, one of the material potential benefit streams from smart metering is the opportunity to get more dynamic demand-side management from mass-market customers, leading to reductions in peak demand from what it would otherwise have been. The indicative calculation in this Section indicated that the scale of such benefits is of a similar order of magnitude to cost-to-serve savings.

However, for such benefits to be realised requires retailers to offer new types of tariffs to consumers which deliver benefits from peak demand management. Appendix E briefly outlines the types of different tariffs that smart metering can facilitate.

Yet at this stage it appears that the opportunity to deliver such new tariffs is not receiving anywhere near as much focus from retailers as the opportunities to deliver cost-to-serve savings.

There are three likely factors driving this position by retailers:

- Cost-to-serve benefits are much more firm and tangible benefits that can be 'banked', whereas peak demand benefits are dependent on the degree of consumer behavioural response which is subject to a much greater degree of uncertainty;
- As discussed in Appendix C, the price signals that retailers receive from the wholesale market and network use-of-system charges suppress prices at times of scarcity below levels which more accurately reflect the scarcity value of supply. This reduces the opportunities for retailers to develop peak demand products which will be beneficial for consumers and give the retailer a point of differentiation over its competitors.
- As detailed in Section 4.1.3 above, most retailers don't have the IT billing systems that are capable of delivering such innovative new tariffs. This likely explains why
  - Genesis (the only retailer who does have a modern billing system) appears to be the most advanced in its thinking with respect to delivering innovative tariffs; and
  - to-date, in a number of areas retailers have 'squashed' some of the peak management signals that are coming from some network companies' charges because the extra complexity involved would create extra cost to implement.

As and when the price signals at times of peak scarcity become more acute, and once most retailers have up to date billing systems, we should expect to see greater focus on the delivery of smart tariffs by retailers.

4.2.2 Patchwork technology solutions

The different initiatives by different parties is likely to result in a range of different meter technologies being implemented, in some places with different technologies being implemented within different houses on the same street.

This situation has the potential to be deliver non-beneficial outcomes if the technologies, in particular the communications protocols, were not open access such that retailers were tied to particular meter technologies.

However, it appears that all the main players are working on developing a service-driven approach to meter provision with third party access. For example, a 'service' could be *"get a meter reading"*. Retailers should be able to send the signal from their own IT platforms to a hub which passes it on to the individual meter providers who can then use their own proprietary communications protocols to send a signal to their meter.

The Electricity Commission's approach and proposed guidelines is supportive of this approach, such that an open access framework appears to be being developed without the Electricity Commission having to resort to heavy-handed prescriptive regulation.

Thus, this approach appears to be delivering smart-metering with common provision of the core meter functionalities by all the different providers, but without adversely impacting on the ability of meter providers to develop new and innovative products and services.

4.2.3 Limited adoption of some technology options

The extent to which some potential benefits are realised is dependent on *how* smart metering is implemented, in particular various technical options.

Given that retailers are driving the deployment of smart metering, it is likely that only those options which the retailers perceive as being of benefit to them will be implemented.

That said, it appears that functionally rich smart metering solutions appear to be being implemented which have the potential to deliver all of the benefits outlined in Section 2.1.

The one significant caveat to this statement appears to be the extent to which in-home displays (IHDs) and home area network (HAN) capabilities are included.

The inclusion of HAN and IHD capabilities has also been a key point of debate for many overseas jurisdictions. This is because the scale of potential benefits is driven to a huge extent by consumers' behavioural changes in response to the new information and incentives that come with smart metering. Forecasting such behavioural changes is inherently very uncertain.

Given that this issue is likely to be the most significant in terms of potential environmental benefits, it is explored in detail in the following section.

5 Provision of home area networks (HANs) and in-home displays (IHDs) in NZ

5.1 Assessment of current situation

5.1.1 Cost: benefit of IHDs

As indicated earlier in Section 2.1, the smart metering technical option which is likely to yield the greatest environmental benefit is the inclusion of an in-home display, and the consequent *energy efficiency* response (as distinct to any peak demand response) it engenders in consumers.

As is further outlined in Appendix A, this energy efficiency response is largely driven by the direct feedback that an IHD provides, and that such feedback and response is not readily provided by alternative approaches (e.g. sending information via the web, email, txt, bills etc.). This compares with information provision for the purposes of encouraging peak demand response by consumers, where alternative approaches may yield similar (although possibly inferior) outcomes to the use of an IHD.

The following cost: benefit calculation attempts an indicative estimation of the scale of potential benefit that IHDs might deliver through improved energy efficiency compared with the cost of the IHDs. It shows the national NPV benefit measured over ten years (assuming an initial 5 year roll-out) for a range of different IHD costs and consequential efficiency responses. A 5% discount rate is used consistent with the pre-tax real discount rate specified for evaluation of energy efficiency investments in the 2008 Government Policy Statement on Electricity.

Table 9 - Estimate of the scale of monetary and energy benefit from a smart-metering induced energy efficiency response from consumers

		NPV ($m)		TWh saved over 10 years
		IHD cost / customer		
		$70	*$150*	
Efficiency response	*1.0%*	90	-40	1.5
	2.5%	400	270	3.6
	5.0%	910	780	7.3
	7.5%	1,430	1,300	10.9

Source: Concept calculations

As can be seen, the potential benefit from IHDs is significant, even at the upper end of cost. The range of 1% to 7.5% is large, but compares with a range from overseas studies of 0% to 20%.

The lower-end $70 cost of an IHD came from an estimate provided by a meter provider who stated that a mid-range IHD itself would cost approximately $50, and the Zigbee chip required for the meter to communicate with the IHD would cost a further $20. This matches a figure used by the UK government in its recent cost: benefit analysis where it stated the cost of a real-time display was some £15 (approximately NZ$39)[47].

However, it should be noted that in current negotiations, a number of retailers are stating that meter providers are quoting an annual service fee figure for provision of a Zigbee chip and IHD which is equivalent to a one-off cost figure that is many times this level.

When considering a New Zealand net benefit analysis of IHDs, the appropriate counter-factual should be to consider the best *alternative* means of achieving a similar outcome.

In other words, the cost should be the extra cost of the IHD compared with alternative measures, and the efficiency response is the response that IHDs will deliver *over and above* these alternative measures. Using such a framework, if an alternative measure could deliver similar savings more cheaply, the net benefit of IHDs would be negative.

In this respect the most likely alternative means of providing similar information to consumers will come from the internet, email, bill or txt services. A conservative assumption could be that such measures are 'costless' to retailers in that they are likely to have to develop such capability anyway. This would mean the full costs of IHDs shown in the above table remain the appropriate comparator.

With respect to the efficiency response, Appendix A details some overseas research which states that the *direct* feedback delivered by IHDs results in an efficiency response which is different (i.e. <u>not</u> substitutable) to that of these other methods, but they may be complementary. Again, this would support use of the figures in the above table.

5.1.2 Likelihood of retailer-led implementation of IHDs

Current indications from retailers are that the majority of them will probably <u>not</u> be installing IHDs with their initial deployment of smart meters, with the general exception of pre-payment customers where the IHD will be an integral part of their vending solution. Furthermore, the current Christchurch implementation by Meridian (using Arc meters), and Contact (using Vector/ Siemens meters) does not include IHDs.

The rationale behind this approach appears to be:

- It is still early days in terms of working through retailer < > meter provider < > customer relationships with respect to IHDs. Unlike the smart meter (and the HAN chip) an IHD will be free standing, and thus faces issues such as customers breaking or removing it. Consequently IHDs may not be leased to the retailer and on-charged to the consumer as with the smart meter, but may need to be purchased up front by the customer.
- Retailers did not believe customers would value the extra information from IHDs sufficiently highly to be prepared to pay for the $70 - $150 extra capital cost (roughly between $20 and $40 per year extra on a bill if recovered over a 5 year period);
- They believed there were potentially more cost-effective mechanisms to deliver signals for consumers to take action for peak demand management and/or to present them with useful summary information about their consumption (e.g. txt, email, bills etc.).

[47] "*Impact assessment of smart metering roll out for domestic consumers and for small business*", BERR, April 2008

Interestingly, most of the retailers spoken to appeared unaware of the potential for smart metering (and specifically the IHD element of smart metering) to deliver an energy efficiency response among consumers as distinct to peak demand response.

Even if they had been aware of the energy efficiency benefits of smart metering, it is not clear that this would alter their decision as it is much harder for retailers to share any of the benefits of energy efficiency gains and/or differentiate themselves from competitors on the back of such gains. This is one of the main barriers to retailers (or indeed any other company) voluntarily implementing energy efficiency measures on consumers' behalf.

That is not to say that all retailers will not be implementing IHDs. One retailer in particular appears to view IHDs as a potentially important means of delivering a competitive advantage, and was considering a number of innovative options to deliver value-enhancing services (including new tariff options) as a way of differentiating their offering from other retailers.

If this retailer implements IHDs and they were found to drive success in acquiring and retaining retail customers, it would be highly likely that other retailers would be forced to follow suit or lose market share.

However, what is not clear at this stage is whether this retailer will be rolling out IHDs to all consumers, or just those customers who are prepared to pay the extra cost in order to receive the superior services.

5.1.3 Later installation of IHDs

Not installing an IHD initially does not preclude it being installed subsequently. However, such subsequent installation will incur an extra implementation cost which would have been avoided if it had been installed at the same time as the smart meter.

The scale of the subsequent IHD implementation cost will depend on whether or not the initial smart meter roll-out included the home area network (HAN) communications chip.

If it *did not*, then the subsequent installation of the IHD will require the visit of a technician to install the HAN chip within the smart meter. The cost of such a technician visit could be of the order of $75[48], effectively doubling its cost to consumers.

If the initial smart meter instillation *did* include a HAN chip then potentially the IHD could simply be posted to customers or purchased from a retail outlet, with customers then 'installing' it themselves (i.e. take it out of the box and plug the power cable into the appropriate wall socket). The installation cost of this option would thus be relatively small (up to $5, say, to cover postage).

[48] The precise cost of a technician visit will be determined by the same factors as the initial smart-meter roll-out costs, i.e. it will depend on:

- Whether IHD roll-outs are on an every-house-in-the-street basis (cheaper), or on an ad hoc customer-by-customer basis (more expensive); and
- Whether IHDs are being rolled out to urban (cheaper), or rural (more expensive) customers.

5.2 Possible policy response

This situation whereby IHDs may deliver significant net benefits to consumers, but may not be implemented by retailers, creates an public policy problem from a couple of perspectives:

- Firstly, there is considerable uncertainty as to the scale of the potential problem – i.e. whether it requires fixing; and
- Secondly, the 'solutions' carry a risk that they cause damage that outweighs the benefits of the intervention.

These issues are discussed further below.

5.2.1 Uncertainty regarding the scale of 'problem' requiring fixing

Extent to which retailers will not implement IHDs

Whilst initial indications are that IHDs will not generally be rolled out by retailers as part of the initial implementation, it is not clear that this is indeed what will happen. It might transpire that IHDs are a big hit with customers, and that the retailer mentioned earlier who is considering innovative ways of delivering services via IHDs will achieve considerable success. If this is the case then IHDs will probably be delivered by the market in a relatively timely way.

Further, it is also not clear as to whether smart meters will be rolled out with a HAN chip already installed even if an IHD isn't part of the initial implementation. One retailer appears to be considering including the HAN chip with its initial implementation in order to future proof itself so as to be able to subsequently offer an IHD at relatively low cost.

From a meter provider's perspective, they may be even more incentivised to roll-out their meter with a HAN chip already included as it lowers the risk of their meter being switched out by a subsequent retailer who wins the customer and wants to offer services requiring a HAN chip. This is because if that retailer has to bear the cost anyway of sending a technician to install a HAN chip, the cost threshold will be lowered for them deciding to switch out the meter completely and replace it with a smart meter from a meter provider with whom they had a closer relationship.

It should also be noted that those properties that have gas metering will probably have their electricity smart metering solution rolled-out with a HAN chip in order to communicate with the gas meter.

Extent of lost energy efficiency benefit

As detailed in Appendix A, whilst there is a reasonable body of literature indicating that direct feedback via IHDs can deliver a material energy efficiency response, it is acknowledged that the scale of response is very situation specific due to the fact that such a response is largely due to *behavioural* change.

Thus the likely size of response for New Zealand electricity and gas customers, and the degree to which such response could not be replicated by other more cost-effective measures, is subject to a significant degree of uncertainty.

Unless a sufficiently comprehensive study was undertaken to establish this with a greater degree of confidence, it would be hard to justify mandating spending $100 - $150m.

5.2.2 Potential for adverse regulatory outcomes

If the Government and/or Electricity Commission were to come to the view that IHDs would deliver tangible benefits yet were not likely to be implemented if left to the market alone, one option would be for the government to regulate to *mandate* the provision of IHDs.

In deciding whether to adopt such a course of action, consideration would need to be given to potential adverse outcomes.

Delay

One such outcome could be that market participants delay their roll-out of smart meters in response to the increased regulatory uncertainty whilst government goes through the process of determining and then implementing the required legislation and/or regulations. Such a delay would represent a lost benefit in terms of the benefits that could have otherwise been delivered by smart meters during this period.

In this respect, it is worth noting that in Australia, Government(s), regulatory authorities and the industry have taken years to debate the best course of action, whilst in New Zealand, market participants have already evaluated the options and are currently engaged in a large-scale implementation in Christchurch.

Locking-in the 'wrong' technology

A potentially more significant adverse outcome could arise if the mandated approach caused the industry to lock-in a particular type of technology solution that turned out to be sub-optimal. The danger with such an approach is that the particular locked-in technology may prove to be the 'wrong' choice, and that New Zealand ends up in a technological dead-end whilst the rest of the world moves down a different technology path.

For smart metering this is a very pertinent consideration as the technology is evolving rapidly. Plus there are dynamics emerging from the internet and telephony sectors around the changing provision of data and voice services to homes, and the rapid growth of various different devices that can communicate wirelessly with each other (e.g. phones, computers and mp3 players).

Accordingly, if Government was highly prescriptive in the nature of its mandate, there is a risk that it may take New Zealand down a path which precludes adopting other, cheaper opportunities that may emerge.

This may be even more of an issue for New Zealand compared with other countries given New Zealand's small size. Thus, whilst a market the size of California or the UK may be big enough to persuade manufacturers to produce appliances that meet a specific technological standard mandated in such countries, New Zealand's relatively small size means that it will not have such a luxury. Accordingly, New Zealand needs to be ‘nimble’ enough to adopt whichever technological solution appears to be the best at any given moment in time.

5.2.3 Alternative policy mechanisms to deliver desired outcomes

Measures to improve the price signals for peak demand management

A potentially better solution to the problem of under-provision of IHDs would be to correct any aspects of current policy which dilute the incentive on retailers to provide IHDs.

Appendix C identifies that the wholesale and network market settings are not currently sending the correct price signals for management of demand at times of peak. If such arrangements were addressed, then retailers would have greater incentives to offer sophisticated peak demand management products and services to consumers.

If IHDs are the most effective means of engendering a response (in terms of quantity of kW shifted and shed) compared with alternative means (e.g. delivering signals by internet, txt etc.), then sharpening these peak pricing signals will make it more likely that retailers provide IHDs to consumers.

In addition, if there are strong price signals for peak demand management there is greater incentive to install HANs which can enable retailers to automatically control smart appliances on consumers’ behalf.

Alternative approaches to incentivise the provision of IHDs

If the desired unique outcome from IHDs is improved energy efficiency, it may be appropriate to include IHDs within broader energy efficiency policy mechanisms to deliver energy efficiency measures. Through such mechanisms, the cost: benefit of implementing IHDs would be compared against other measures that deliver energy efficiency outcomes (e.g. home insulation), and should only receive support if IHDs are more cost effective than alternative measures.

6 Conclusions & recommendations

A comprehensive mass-market deployment of functionally rich smart meters looks likely in New Zealand over a five to eight year timescale – comparable with overseas – but without the need for regulatory mandate. Such a deployment is likely to yield material net benefits to New Zealand as detailed below:

Table 10 - Estimate of scale of benefits of smart metering benefits to individual households, and New Zealand as a whole[49]

Function	Benefit	Low to High range	Annual potential benefit: Per customer ($) Low	Per customer ($) High	NZ ($m) Low	NZ ($m) High
Economic efficiency improvements						
Time-of-use pricing and information	Peak demand management → avoided peaking generation and network assets	Peak reduction = 2.5% to 10%	16	64	23	94
Improved information to consumers via an in-home display	Energy efficiency response resulting in avoided generation costs[1]	Efficiency response = 1% to 5%	16	79	23	116
Export metering	Enabling microgeneration	?	?	?	?	?
Automated and more accurate meter reading & field services	Lower cost-to-serve through avoided labour, and less errors	Various	20	55	30	77
Richer and more real-time network information	Improved network efficiencies	?	?	?	?	?
Replacing meters that would have had to be checked and/or replaced anyway	Avoided existing meter compliance / replacement costs[2]	Various	8	18	12	26
Total impacts yielding economic efficiency			***60***	***216***	***89***	***313***
Wealth-transfer improvements						
Improved retail competition	Reduced incumbent retailer margins	Reduction in margins = 5% to 10%	4	9	n/a	n/a
Implementation finding missed, tampered with, and inaccurate meters	Reduction in unaccounted for energy	Reduction in UFE = 0.5% to 1.5%	9	25	n/a	n/a
Smart metering can be used for pre-payment purposes	Improved pricing for pre-payment customers	?	?	?	n/a	n/a
Replacing existing meters	Avoided existing 'dumb' meter lease costs to retailers	Average ex-GST lease = $40 to $60	45	68	n/a	n/a
Total wealth-transfer impacts			***58***	***101***	***n/a***	***n/a***

[1] The avoided costs are based on the variable component of current consumers' prices, rather than explicit modelling of avoided long-term variable costs of supply-side assets

[2] Such avoided costs are only assumed to last over a seven year period in the run-up to the 2015 meter compliance deadline.

The regulatory approach from the Electricity Commission appears to have been both appropriate and successful to date – namely to ensure that there is open and non-discriminatory third party access to metering services such that it does not become a barrier to competition, whilst trying to preserve the conditions for innovation among meter providers and retailers.

[49] The benefits (per consumer and scaled-up for New Zealand) are only for the estimated 1.65m residential consumers. The benefits for the estimate 0.25m mass-market commercial consumers have not been calculated although, as indicated in the text of the report, these are believed to be greater on a per-customer basis than for residential.
The benefits shown in the table are including GST for individual residential consumers, and excluding GST for New Zealand as a whole.

The most significant potential non-optimal outcome is the potential for in-home displays (IHDs) not to be included comprehensively by retailers, and the associated lost energy efficiency response. Given overseas estimates of the scale of energy efficiency response delivered by smart metering are anywhere between 1% to 7.5%, this is a *potentially* significant lost benefit.

To the extent that the principal *unique* benefit that IHDs deliver is energy efficiency (noting that IHDs aren't necessary for delivery of almost all of the other benefit streams), the under-provision of IHDs by retailers will not so much be a failure of electricity market design but an example of the inherent barriers facing retailers voluntarily undertaking energy efficiency investments on consumers' behalf – namely it is much harder for retailers to share any of the benefits of energy efficiency gains and/or differentiate themselves from competitors on the back of such gains.

Given the significant uncertainty over the scale of the potential problem (both the extent to which IHDs won't be widely implemented, and the extent to which IHDs deliver an energy efficiency response), it would be inappropriate to immediately move to mandating the provision of IHDs. This is especially as such prescriptive approaches risk adverse outcomes in terms of locking New Zealand down a non-optimal technological path.

Instead, Concept would recommend the following set of actions to ensure that New Zealand enjoys the best potential outcome from smart metering:

- The Electricity Commission should continue its current policy of working to ensure that there is open and non-discriminatory third party access to metering services, whilst trying to preserve the conditions for innovation among meter providers and retailers;
- The Electricity Commission should continue to monitor the development of smart metering, particularly with respect to the comprehensiveness of deployments, the functional richness of solutions, and the degree of open third party access.
- The Government and related agencies (e.g. EECA and the Electricity Commission) should undertake work to better understand the extent to which in-home displays deliver a unique energy efficiency benefit (i.e. not easily substitutable by other approaches), and the nature and scale of this energy efficiency response in the specific New Zealand context;
- The Electricity Commission and Commerce Commission should work to address the potential wholesale and network market inadequacies they have identified in relation to scarcity pricing signals and peak demand management;
- If IHDs are found to deliver a unique energy efficiency outcome, the Government should explore alternative policy mechanisms to incentivise their delivery, in particular the use of generic energy efficiency mechanisms designed to deliver energy efficiency measures most cost-effectively.

APPENDICES

Appendix A. Energy saving response from smart metering

The types of decisions consumers make depends on the information and incentives they face. Smart metering has the potential to alter both such factors, and consequentially alter their energy consumption decisions.

The change in *incentives* stems from the ability to offer time differentiated tariffs (e.g. charging relatively more at times of peak demand). In response to such altered incentives, consumers have typically moved some of their time-discretionary consumption activities (e.g. when to switch on a dishwasher) away from higher priced periods to lower priced periods.

The change in *information* comes in a number of potential different forms:

- ***accurate, regular meter readings*** presented in monthly bills provides superior information to customers compared with situations where bills have estimated meter reads and are subject to a significant margin of error.
- ***richer historic consumption reporting***, whereby customers' consumption at different times of the day and year (associated with different costs for such times) can be presented to customers on their bills or other media such as the internet.
- ***real-time information*** about the level of consumption, the price of electricity (including whether the time of day is a peak price period), and the total cost of consumption at that moment in time. Such readily accessible real-time information can only be provided if an in-home display (IHD) is included with the smart meter[50].

The provision of such information is often referred to as 'feedback' in that consumers have the ability to see the results of any consumption decisions they take (e.g. changing patterns of use, or investing in more efficient appliances) on their subsequent total consumption and associated cost.

The provision of real-time information is referred to as 'direct' feedback, whereas historic information that has been processed in some way before being presented on a bill or the internet is referred to as 'indirect' feedback.

There have been numerous studies over the years looking at the impact of improved information on consumers' consumption decisions. Few, however, have looked solely at the impact of improved feedback from innovative meters. One of the most significant pieces of research on this topic was by Sara Darby from Oxford University's Environmental Change Institute. In a report she did for DEFRA[51], she reviewed numerous overseas studies to determine what could be learned about the impact of smart metering on consumption decisions. Some of the key conclusions were:

"Clear feedback is a necessary element in learning how to control energy use more effectively over a long period of time and that instantaneous direct feedback in

[50] Some clip-on electricity display devices can be used in properties without smart meters to give some real-time information about kWh being used. However, the type of information provided is a lot less than can be delivered from an IHD connected to a smart meter. Similarly, the internet could be used as a delivery mechanism for such information. However, studies have indicated that it is not regarded as readily accessible by consumers, with the consequence that after initial interest, consumers rarely access the relevant page.

[51] Darby, S. (April 2006). The Effectiveness of Feedback on Energy Consumption. A review for DEFRA of the literature on metering, billing and direct displays.

combination with frequent, accurate billing (a form of indirect feedback) is needed as a basis for sustained demand reduction. Thus feedback is useful on its own, as a self-teaching tool. It is also clear that it improves the effectiveness of other information and advice in achieving better understanding and control of energy use.

Savings from direct feedback (from the meter or a display monitor) range from 5-15%.

Indirect feedback (feedback that has been processed in some way before reaching the energy user, normally via billing) is usually more suitable than direct feedback for demonstrating any effect on consumption of changes in space heating, household composition and the impact of investments in efficiency measures or high-consuming appliances. Savings have ranged from 0-10%, but they vary according to context and the quality of information given."

As well as stating that feedback can deliver significant, sustained consumer demand reduction, one of the most important conclusions was that in-home displays were by far the most effective means of delivering the direct feedback necessary to deliver sustained energy savings.

This is important because retailers are considering alternative means of delivering information to consumers (such as txt, email, the internet) to alter their *peak demand* consumption behaviour. Whilst such media have been shown to be effective to deliver a response at times of peak demand, it appears that they may not be effective to deliver a sustained energy saving response.

This has been borne out in a number of other studies for example in the Netherlands and Sweden, where consumers were found not to have been interested enough in feedback to go to the effort to access the appropriate page on the internet.

However, there is a great deal of uncertainty as to how 'real' the savings from feedback (direct and indirect) are. Issues include:

- the fact that many of the consumers involved in such trials also received energy efficiency advice. Therefore splitting out the savings achieved due to the feedback compared with that due to the advice is highly speculative;
- the very fact of being in a trial may have sensitised consumers to their energy consumption patterns eliciting a demand response that would not be seen outside a trial environment;
- the scale and nature of residential electricity and gas consumption in one country may be materially different to another viz. the extent to which electricity and gas is used for space heating or cooling, water heating, lighting, cooking, and other appliances. Accordingly, it is hard to draw firm conclusions about the % or absolute savings witnessed in one country being likely to be observed in another.

In the UK, this issue is the topic of much current debate, and is illustrative of the range of different positions and uncertainty that is being seen in other countries around the world that are considering such matters.

Defra, the UK government department responsible for smart metering policy, appears to have come to the view that a substantial proportion of savings are solely due to the provision of an in-home display (IHD):

- In the cost benefit study which it commissioned, almost 90% of the benefit in terms of savings from peak-load management and increased energy efficiency was attributable to an in-home display, with only 10% attributable to time-of-use billing functionality
- In concluding its recent consultation on energy billing and metering the UK government stated:

"the provision of better information about consumption should help consumers engage with their energy use. For this reason the Government's view is that a standalone real-time display should be provided with a smart meter if the full environmental and energy efficiency benefits are to be generated from a roll out of smart metering.[52]"

- In its cost: benefit analysis of smart metering it "*assumed the following gross annual reductions in demand will take place as a result of improved feedback on the use and cost of energy: 2.8% for electricity, and 2% for gas*"

The energy regulator, Ofgem, is a lot more conservative and uses a 1% figure based on the view that it is hard to draw firm conclusions from the studies to-date. Other stakeholders in the UK appear to believe that higher savings will be achieved. For example EnergyWatch (the independent gas and electricity watchdog) gives a range of 3.5 – 7% , and the Energy Saving Trust states that 5% is more realistic.

To help inform this debate, the UK has embarked on a two year trial of 40,000 households (some of whom will have IHDs, and some of whom won't) to determine the impact of smart metering on consumer behaviour. The trial is due to conclude in November of this year.

Similar such debates are occurring around the world. For example, the topic of the provision of in-home displays was probably the subject of greatest debate in the Australian Ministerial Council of Energy's work to determine whether smart metering should be mandated across Australia. Although no final decision has been arrived at, the current recommendations from the workstream are that a HAN chip be included in any roll-out, but no mandate for inclusion of an IHD is currently recommended[53].

The only firm conclusions that can probably be drawn are:

- Improved information in the form of feedback will almost certainly impact on consumers' consumption decisions;
- The impact of direct feedback is likely to be different (i.e. not substitutable) to that of indirect feedback, but they may be complementary;
- The nature and scale of consumer response is likely to be quite situation specific according to the different types of use of electricity and gas.

However, the magnitude of consumer reduction is subject to a significant degree of uncertainty (although even at the 'low' end, 1% is still very significant).

Given the country-specific nature of energy consumption, such uncertainty is only likely to be resolved through field trials of a statistically significant number of customers.

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[52] Section 3.7 of *"Energy Billing and Metering: Changing customer behaviour. Government response to a consultation"* BERR, April 2008

[53] "*Cost-benefit analysis of options for a national smart meter roll-out (Phase two – Regional and detailed analyses) Consultation regulatory impact statement."* Standing Committee of Officials of the Ministerial Council on Energy. April 2008

Appendix B. Value of peak load management

Load shedding and load shifting at times of peak demand will reduce the amount of supply-side resources required at system peak. The value of this is likely to be different at different locations and at different points in time.

For example, in an area where demand growth is likely to require transmission investment within the next 5 years, using load management to delay by 1 to 2 years what is inherently a very large and chunky investment could be extremely valuable. Alternatively, if such an investment had already occurred relatively recently, the value of load management would be less.

The same holds true with respect to generation investment in markets which have a current capacity surplus to ones which have a shortfall.

Therefore, for the purposes of this exercise, the most appropriate way to value load management is to look at the long-run $/MW/yr cost of generation, transmission and distribution assets. This follows the logic that if in the long-run (e.g. 8 to 10 years hence) peak demand is 100MW less, then the need for peak supply assets will also be 100MW less.

For network assets in particular, this valuation is not a straightforward exercise, and thus a simplified approximation has been adopted as follows:

Transmission

Transpower's total future revenue requirements are assumed to be approximately $600m/yr[54].

Assuming that the vast majority of costs are driven by the need to meet system peak demand, a $/MW/yr cost of transmission figure can be derived through dividing some proportion of annual revenue requirements by system peak demand.

In the UK, the Transmission owner, National Grid Transco, has in the past estimated that around 90% of their costs are driven by system peak. This seems high and may reflect a different context of NGT's number. Accordingly, a slightly lower value of 70% has been used for New Zealand in this analysis.

The $/MW/yr value is therefore derived by multiplying the annual $m/yr cost by the proportion of costs driven by system peak, and dividing the result by the total MW system peak.

It should be noted that this approach implicitly assumes that the relative disposition of generation and demand around the country (and thus the extent to which bulk transmission will be required) stays roughly the same into the future.

Distribution

The data to derive an equivalent figure for the cost of distribution assets is even more disparate and a different approach is required based on the observed ratio between transmission and distribution costs. Different ratios are used for the different types of customers (v. large industrial, commercial, and mass-market).

[54] 2007 total revenue of $540m, multiplied by 110% reflecting the allowed price increase by the Commerce Commission to fund Transpower's forthcoming grid upgrades.

In addition, a different value is used for the proportion of distribution company costs that are driven by system peak. A central figure of 45% is used, based on the Christchurch distribution company, Orion's, 2003 pricing methodology which said that 46% of costs were driven by meeting load growth.

Having a different value for distribution and transmission assets appears appropriate given the different nature of their businesses, in particular the far greater distribution focus on providing assets to individual customers' premises.

Generation

Given that demand-side response will be used infrequently at times of system scarcity, the generation assets that it would be displacing are infrequently-used peaking gensets. The most appropriate type of generation in this respect would be an open-cycle gas turbine (OCGT) as it is currently the most economic type of generation for low capacity factor operation.

Although in the past New Zealand has not been capacity constrained, the steady reduction of the proportion of hydro on the system means that New Zealand is now reaching a situation of capacity constraint. Accordingly, a number of generators have started to build OCGTs in response.

Current annual fixed costs for such plant are approximately $100,000/MW.

Results

The resultant evaluation of the value of demand-side response in terms of avoided supply side assets is shown in the table below:

Table 11 - Estimated break-down of the value of demand-side response

Transmission

Annual cost	600	$m/yr		Note: Based on Transpower annual revenue
System peak	6,700	MW		
	High	Central	Low	V. Low
Proportion of Tx cost driven by peak	90%	70%	45%	30%
Resultant $/MW/yr Tx cost of peak demand	80,597	62,687	40,299	26,866

Distribution

Multiple of Dx to Tx costs on consumers' bills		V. High	High	Central	Low
Mass-market	3	241,791	188,060	120,896	80,597
Commercial	1.5	120,896	94,030	60,448	40,299
Large Industrial	0	-	-	-	-

Generation

Fixed cost of OCGT	100,000	$/MW/yr	Note: the most cost-effective peaking plant

Total <u>$/MW/yr</u> value of DSM

	High	Central	Low
Mass-market	368,657	283,582	220,896
Commercial	274,627	223,134	180,597
Industrial	180,597	162,687	140,299

Effective <u>$/MWh</u> central value of DSM

	Hours / year DSM needs to be called to be 'firm'		
	5	15	30
Mass-market	56,716	18,905	9,453
Commercial	44,627	14,876	7,438
Industrial	32,537	10,846	5,423

The last array of numbers uses the central $/MW/yr cost of supply side assets to meet 1 MW of peak demand, and factors them by various estimates of the amount of time demand-side response would be required to operate in order for it to be 'firm' in terms of avoiding the system peak.

As can be seen, the value of avoiding supply-side investments to meet peak MW demand is extremely large.

If you assume that demand-side response would need to be called 15 times a year in order to be considered firm, say, then it would be economic for consumers to reduce load at times of system peak if their value of electricity was less than the figures shown in the central column of the bottom array of numbers.

Appendix C. Current market settings for delivery of peak demand management

As indicated in Appendix B above, a high proportion of a consumer's costs are determined by their level of peak demand – even if this level only occurs for a few hours per year.

Such a high proportion of carrying costs for infrequently-used assets is because of the unusual characteristic of electricity in that it cannot be economically stored on a large scale, coupled with the fact that demand for electricity varies significantly within the day and year. This gives rise to a requirement for some generation and network assets to be built that will be infrequently used.

Clearly, having to carry such low utilisation assets is expensive, and thus being able to reduce load at times of stress to avoid the need for such supply-side assets can be extremely valuable.

There are two main means of achieving such peak load reduction:

- ***Shedding***: infrequent dropping of load at times of system stress
- ***Shifting***: changes in users' consumption patterns from high cost to low cost time periods, without necessarily resulting in any reduction in kWh consumed.

Appendix B estimates that the central value (in terms of avoided supply-side costs) of infrequent load shedding at times of system stress can be of the order of some $19,000/MWh. This is many orders of magnitude greater than the average cost that consumers pay for their power, and likely to be greater than the value which most consumers obtain from using electricity for these periods.

However, it should be noted that this avoided supply-side value has a big range depending on the number of hours per year load shedding needs to occur in order to deliver a 'firm' drop in consumption ranging from $56,000/MWh if only 5 hours are required, down to $9,500/MWh if 30 hours are required.

For most consumers the current biggest barrier to active demand management is the fact that their 'dumb' meters simply record aggregate consumption over a long period of time (e.g. a month or greater), rather than on a half-hourly basis. This means that the individual action of a consumer with such a meter dropping load at a critical time cannot be identified, resulting in any benefit in terms of avoided system costs being shared amongst <u>all</u> consumers. This effectively eliminates the incentive on the individual customer to take such action.

The time-of-use (TOU) recording functionality associated with smart meters will largely eliminate this barrier.

However relatively simple (i.e. non-'smart') time-of-use meters have been available for some time at a cost that would be justified for many commercial consumers if they delivered savings of the magnitude outlined in Appendix B.

The fact that such meters have not generally been installed to-date is therefore indicative of a number of *other* barriers to active demand-side management which may similarly impact smart meters.

Fixed price variable volume contracts

One insight into such barriers can be gleaned from the fact that even among those industrial customers who do have TOU meters, the vast majority have so-called 'fixed price variable volume' contracts with their retailer.

Under such contracts, consumers pay a pre-agreed price for their power (sometimes the same rate throughout the year, sometimes differentiated by different times of the day and year) without any upper or lower limits on how much they consume. This is the standard tariff-type contract used for most customers including domestic users.

With respect to active demand-side management, the critical issue is that whilst such contracts provide consumers an incentive to *shift* load from high to low price periods, they remove any incentive to *shed* load at times of system stress.

To illustrate this point consider a consumer that has a fixed price with a retailer at 20c/kWh, say. There is little incentive on the consumer to shed load at times when the market price reaches 500c/kWh because the only cost they would be avoiding is 20c/kWh, and it would be the *retailer* who would be benefiting from not having to purchase power at 500c/kWh in order to sell it on to the consumer at 20c/kWh.

In order to take on the risk of managing such volatile price exposure, retailers will charge a premium to consumers to cover this risk – effectively analogous to an insurance premium.

If a consumer chose a contract structure which directly exposed them to spot price they could shed load at times of extreme price in order to enjoy a lower overall cost of electricity over the year as a whole, and avoid the risk premium charged by retailers associated with fixed price variable volume contracts.

However, there are two main reasons why most industrials to-date have elected not to go onto such spot contracts:

- Transactions costs
- Nature of price signals

Transactions costs

There is a considerable amount of effort required for consumers to actively monitor the electricity markets on a half-hour by half-hour basis in order to be able to respond to the handful of periods of system stress if and when they occur.

Such active participation is clearly impractical for all but a few super-large industrial consumers for whom electricity bills can run into millions of dollars. Faced with these and other 'hassle factor' costs[55] (known as 'transactions costs' in economics parlance) it is more cost effective for such consumers to pay an insurance premium to retailers to manage their wholesale risk, and use the time freed-up in pursuits (business or leisure) which have higher value to the consumer.

Whilst transactions costs are genuine economic costs, the size of the potential prize from active demand-side management across all consumers is such that electricity

[55] Other transactions costs include having the capability to actively trade electricity on a half-hourly basis in the wholesale market, and negotiating and paying network use-of-system charges with lines companies for delivery of electricity to premises. For many customers, it is clearly more cost-effective for retailers to undertake such activities on their behalf in return for a service fee.

market participants around the world have sought to develop alternative approaches to help minimise the costs associated with consumers having to actively monitor the market in order to respond to critical periods. The three main approaches have been:

- Time-differentiated tariffs;
- Direct load control; and
- Improved information provision to consumers

Time differentiated tariffs

Time differentiated tariffs are where prices are fixed ahead of time, but split into different blocks for the different times of day and year. For example, within-week prices could be split into day / night / weekend / 'peak' (weekday morning and early evening), and within-year prices into summer / winter. Thus peak periods will have a higher price than off-peak periods.

The intention of such time differentiated tariffs is to encourage sustained *shifting* of load from higher priced periods to lower-priced.

A variant which is also designed to encourage *shedding* of load at times of system stress is to have time differentiated tariffs where peak prices are set in advance (typically at very high levels) but the periods at which such prices will come into effect will only be signalled a short period ahead of, and/or during, real-time. Such an approach is generally known as critical peak pricing.

Thus, although the $/kWh charge is set in advance, the time at which it will be implemented is not known. Typically such tariff options limit the number of periods during a year where such peak periods will be called[56].

Direct load control

One of the most effective ways to overcome market participation transactions costs is for consumers to hand over control over some of their consumption to a retailer or some other party to manage on their behalf, and allow them to directly reduce their consumption at times of system stress. For example, a retailer or network company could send a signal to the consumer's premises at times of system peak which would cause appliances to automatically reduce consumption.

Around the world the most common domestic-scale appliances where such automatic control has been introduced include hot water cylinders, thermostats on air conditioning units and/or space heating, fridges, and heaters and pumps for swimming pools and spa pools.

In return for handing over control to this third party, the consumer is generally rewarded with a lower tariff.

Until recently, the delivery of such control has generally been via specific control equipment consisting of pulses (or 'ripples') being sent over the wires of the distribution

[56] A variant on this is where utilities signal that a period is *likely* to be one of the peak periods for the year, but the determination of which periods were *actually* used for peak charging is not determined until the end of the period where peak charging is implemented (typically the winter period where peak demand is driven by heating, although in some countries the peak period is in the summer driven by air conditioning load).

network which are received by relays on the circuit board of the customers' premises that are hard wired to the specific equipment to be controlled. Indeed, at the domestic scale, New Zealand already has one of the world's leading frameworks for delivery of such control via its hot water ripple control infrastructure.

Smart metering has the potential to deliver the same type of direct load control (DLC) benefit through the ability of such meters to communicate with appliances within the home via home area network (HAN) functionality. However, HAN-type load control requires that the smart meter is installed with such functional capability in the form of a Zigbee chip or other such enabling device. The cost of such chips, if they were solely to be installed to deliver load-control ability with smart appliances, needs to be weighed against the benefit.

In this context it is worth noting that in New Zealand the size of the 'prize' available from introducing such smart metering capability is likely to be significantly reduced compared with overseas jurisdictions due to the fact that we already have a comprehensive load control infrastructure in the form of domestic hot water ripple control. In comparison the scale of load control available from other appliances in the home is relatively small.

Further, in relation to the cost: benefit of including HAN-type capability as part of a smart metering installation, it also requires there to be smart appliances with which the meter can communicate.

At the moment there are effectively no smart appliances being installed in New Zealand so there would arguably be little point in introducing HAN-capable meters. This is a classic 'Catch 22' situation: Why buy a smart appliance if you don't have a HAN-capable smart meter, and why install a HAN-capable smart meter if there are no smart appliances to talk to?

Overseas jurisdictions which have mandated the introduction of HAN-type functionality in their smart meters have linked it to mandating functionality around certain appliances, effectively breaking this Catch 22 situation. However, because the scale of load control from other (non-hot water) appliances is unlikely to be large in New Zealand, it would be hard to see the benefits from such an approach outweighing the costs to consumers from more expensive appliances.

Further, the relatively small size of the New Zealand market (compared with, say the UK or California), means that appliance manufacturers could incur significant costs (on a per appliance basis) specifically tailoring appliances just for the New Zealand market, or they may not bother to supply New Zealand at all.

One smart metering option which may have promise is the load limiting functionality of such meters. Such functionality enables supply to premises to be 'choked' below the maximum capacity feeding the property. For example, residential customers may have a 20kVA connection, but the load limiting feature could limit the amount of power that could be drawn to significantly below that (e.g. 5kVA).

Such load limiting could be triggered centrally in response to a scarcity situation, and last for the duration of the situation (which may only be half-an-hour). During this period, consumers would be able to use appliances whose collective consumption was below the kVA limit. If a consumer turns on appliances which collectively exceed this level, a switch would trip dropping power completely to the property. The consumer would be able to reset the switch and turn the power back on once they had turned off sufficient appliances to be below the kVA limit.

It is conceivable that retailers could offer different products to consumers with regards to the maximum number of times load limiting was called, and/or the degree to which load is limited, and/or the market price threshold used to trigger load limiting. Consumers who were prepared to sign-up for greater numbers of periods of load limiting would receive a lower cost of electricity for the rest of the year than those who wanted a less interrupted supply.

Improved information provision to consumers

Another approach to overcoming the transaction costs associated with consumers monitoring the market is to 'push' the information to consumers, alerting them to a critical period so they can take action.

Smart metering has significant potential in this respect, in particular through the ability to display information to consumers via in-home displays (IHDs). However, as with direct load control, IHDs are optional extras with associated extra costs.

Further, when considering the cost-benefit of IHDs, they should be with reference to alternative approaches to achieve similar outcomes. For example, some overseas jurisdictions which operate critical peak pricing have found that a considerable amount of response can be achieved through adverts in the newspaper indicating that due to a forecast cold-snap, say, a critical peak pricing period will be in force.

In France, EDF advises consumers each day of the pricing classification for the following day – red for peak rate (typically five times the standard rate), white for standard rate, and blue for low rate (typically half the standard rate). This information is communicated either through a box with 3 coloured lights (red, white & blue), SMS to the customers' mobile phone, and via the newspaper and EDF's own website.

Accordingly, the cost: benefit with in-home displays needs to take into account the cost of these alternatives, and their relative effectiveness in terms of delivering a 'firm' customer response.

Price signals

The second reason those industrial customers who currently have TOU meters have largely elected not to go on tariff options which reward active demand management is because historically the price signals have not been that compelling. These price signal issues will be just as much of an issue (if not more so) for smaller customers with smart meters.

The analysis in this sub-section sets out the extent to which such price signals are inherent features of the underlying physics of New Zealand's situation, or whether they are an artifice of the current design of the New Zealand market and regulatory framework.

There are three different price components which need to be considered:

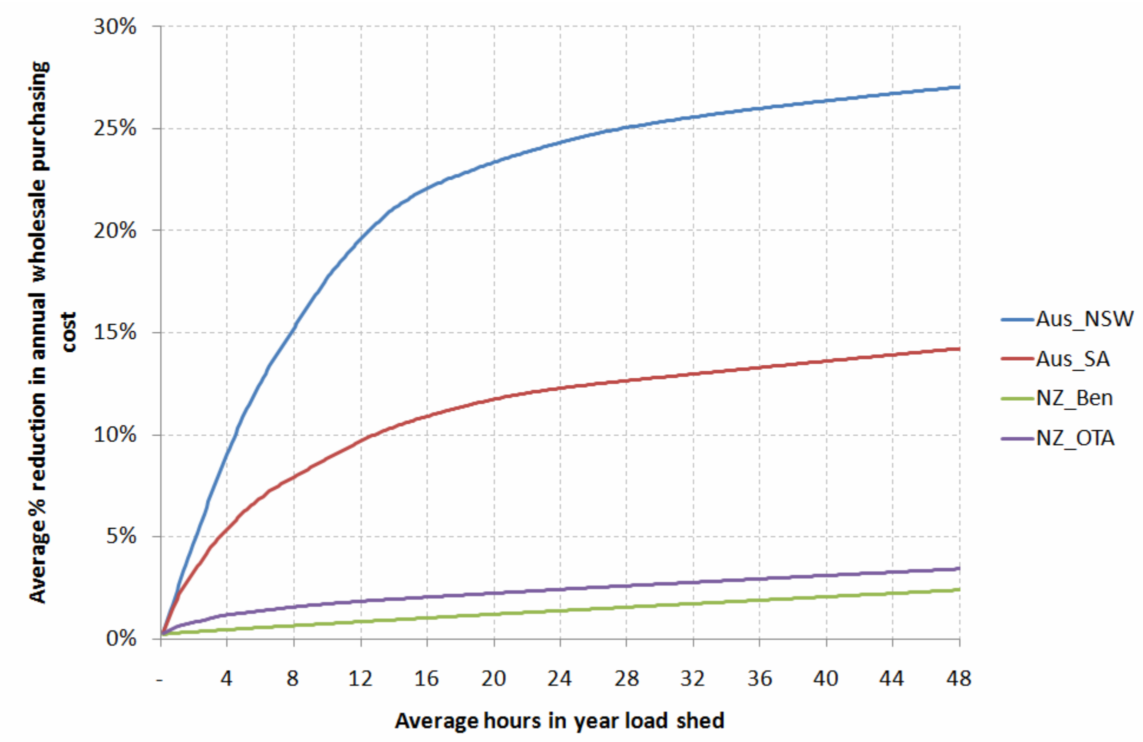
- Wholesale market prices (i.e. reflecting the cost of generation)
- Transmission charges (i.e. reflecting the cost of bulk national transmission across Transpower's network); and
- Distribution charges (i.e. reflecting the cost of distributing electricity from the transmission grid exit point across the local lines company's wires to the consumer's premises)

Each of these can be a significant element of consumers' final costs, although to varying degrees.

Historically, New Zealand's investment in large quantities of hydro generation to meet its GWh energy requirements has meant that it has had more than enough firm MW capacity to meet periods of peak demand[57].

Accordingly New Zealand's wholesale market prices haven't had the price spikes at times of high demand that are associated with 'capacity constrained' markets. Instead it has had year-on-year variation in average prices due to swings in hydrology reflecting its 'energy constrained' nature. This is illustrated in the following figure which compares New Zealand prices with those in Australia.

Figure 12 - Impact of avoiding the top n hours of the year on average electricity prices. Australia and New Zealand, Jan 2004 to Aug 2007

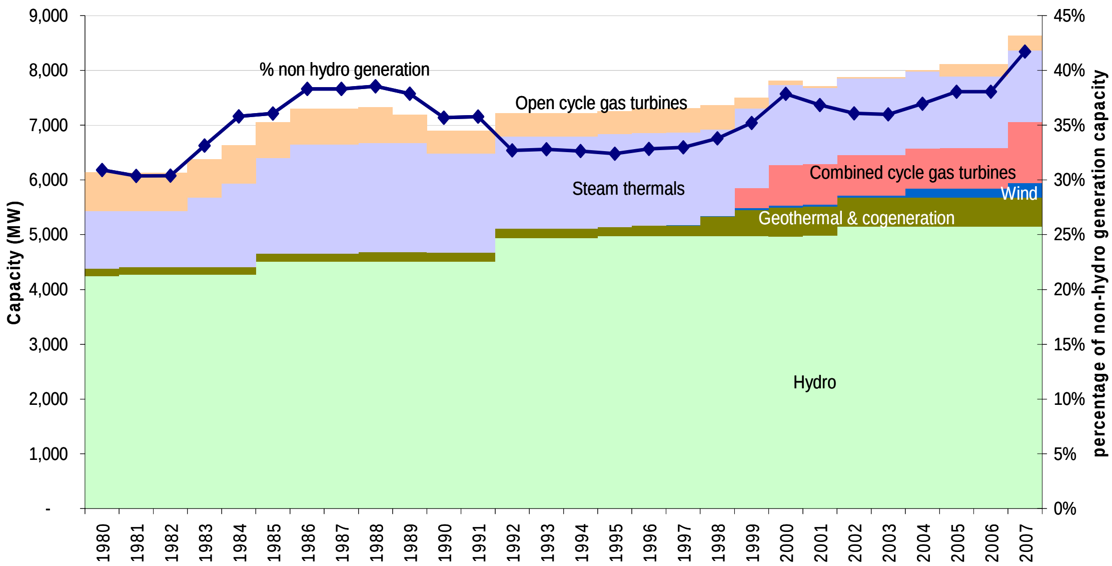


As can be seen, the historic price benefit of shedding load in New Zealand has been substantially less than in a capacity constrained market.

However, as the graph below indicates, over the past couple of decades investment in generation capacity to meet our GWh energy needs has been from predominantly non-hydro sources of generation. This is projected to continue over the next few decades with our GWh energy needs predominantly being met by new geothermal, wind and some thermal generation (subject to the thermal moratorium on new baseload thermal generation).

[57] This is because for every GWh of hydro investment you get just over twice as much peak MW capacity as for thermal plant. This is because hydro plant is 'fuel' limited to give average capacity factors of 40%, compared with thermal plant who can achieve capacity factors of some 90%.

Figure 13 - Historical composition of new-build generation in New Zealand



Source: Various historical data

This is starting to result in New Zealand becoming capacity constrained, particularly in areas behind transmission constraints. For example the whole of the North Island is projected to be tight this winter due to the unexpected retirement of the New Plymouth power station and part of the HVDC link between the South and North islands.

As New Zealand becomes more capacity constrained, then the economic benefit of avoided generation investment from load shedding will become increasingly like that outlined in Appendix B. However, the extent to which this will be realised will depend on the nature of the price signals that emerge from the market.

A number of issues with the design of the current wholesale, network, and retail market arrangements have been raised by stakeholders as potentially suppressing prices below cost at times of system peak.

The nature of the issues is often esoteric and subject to debate, and is also outside the scope of this report. However, the main issues can be summarised as follows:

- The wholesale market design may not be sending appropriate price signals at times of scarcity, in particular through not fully reflecting the value of voluntary or forcible demand curtailment at such times of scarcity
- Transmission charging may not be sending consumers as acute a price signal at times of peak demand as it should;
- Most distributors pricing structures are not sending material price signals to control load at times of system peak, potentially as a consequence of the structure and operation of the so-called 'Thresholds' price-control regime operated by the Commerce Commission. As well as not sending economically efficient signals relating to the cost of distribution assets, such charging also 'squashes' any peak pricing signals coming from transmission charging; and
- Retailers may further 're-package' what pricing signals there are from distributors, further suppressing price signals to consumers.

Action to address these issues

It appears that the relevant regulatory authorities plan to address almost all of these issues.

Thus in relation to the wholesale market, the Electricity Commission has indicated it will be exploring any perceived inadequacies with the wholesale market design to determine the extent to which they yield sub-optimal outcomes and, to the extent that such design inadequacies are material, considering design improvements to rectify the situation.

Similarly, in relation to distribution charging, the Electricity Commission is starting to look at the structure of network charges, both in terms of standardising their diversity, and in terms of ensuring they send appropriate price signals.

The Electricity Commission is also looking at ways in which retailer charges can be better structured to pass through network price signals to consumers.

Lastly, with regards to the impact on distribution companies of the thresholds regime the Commerce Commission is reviewing the current approach with a view to rectifying any identified inadequacies.

Appendix D. Environmental value of avoided generation

In terms of valuing the environmental benefit of avoided consumption, principally avoided CO2 emissions, it is necessary to consider the marginal electricity generation plant which such avoided consumption displaces.

Short-term operational marginality

Initially let us consider the situation from a relatively simplistic *operational* evaluation of marginality.

The majority of New Zealand's generation comes from renewable resources, principally hydro, geothermal, and (to a much lesser extent) wind. The fuel for such plant is essentially 'free', so the short-run marginal costs of operation are close to zero. Fossil-fuelled thermal plant, however, generally face a significant cost of fuel which results in a short-run marginal cost that is substantially greater than renewable plant[58].

Accordingly, at any moment in time, such fossil-fuelled plant are operationally marginal on the system. Thus, for every kWh saved by energy efficiency, the amount of CO2 avoided will be dependent on what type of fossil-fuelled plant is at the margin.

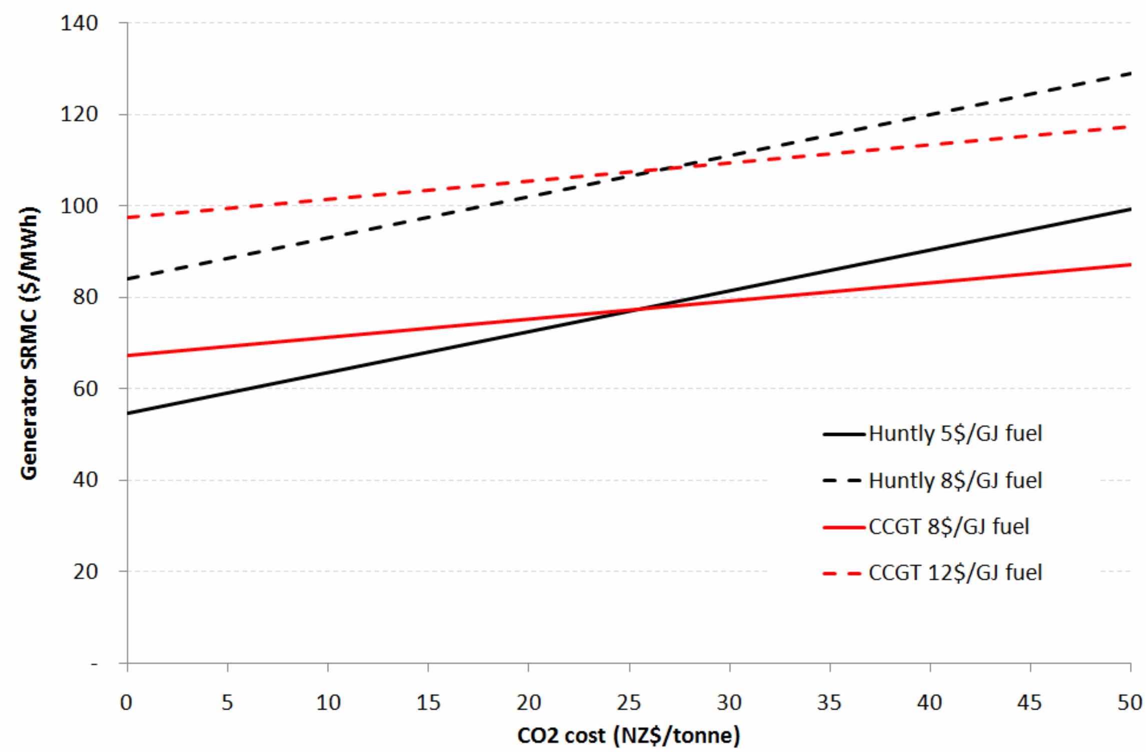
In New Zealand, there are fundamentally two types of fossil-fuelled power station that should be considered in this respect. Relatively high-efficiency combined cycle gas turbines (CCGTs) owned by Contact and Genesis, or the lower efficiency Huntly coal-fired power station owned by Genesis. Despite CCGTs being considerably more efficient than Huntly (some 51% efficient compared with 34%), $/GJ gas prices are currently about twice as expensive as coal prices. Accordingly, it would appear that CCGTs are currently more operationally marginal than Huntly (noting that the *actual* opportunity cost that Contact and Genesis face for their fuel may be subject to confidential commercial terms in their fuel supply contracts that may alter this dynamic).

In the future, the relative economics of the CCGTs and Huntly will depend on the extent to which coal and gas prices move (with both having the potential to move significantly), and the nature and scale of any cost of CO2 emissions. On this last point, coal is more carbon intensive than gas (some 91,200 tCO2/PJ compared to 52,800 tCO2/PJ). Coupled with Huntly's lower fuel efficiency, this gives much higher CO2 emissions per MWh of electricity generated compared with CCGTs (some 958 kg/MWh compared with 372 kg/MWh).

One way of looking at this is to see how the costs of Huntly and a CCGT change with changing CO2 prices as illustrated in the following chart:

[58] Hydro plant face an opportunity cost issue with regards to whether to release water now or release later. However, over the timeframe of a year, hydro generators must use it or lose it, and accordingly over such periods, and thus effectively they face a lower SRMC than thermal generators.

Figure 14 - Comparison of Huntly and CCGT SRMCs under different fuel and CO2 prices

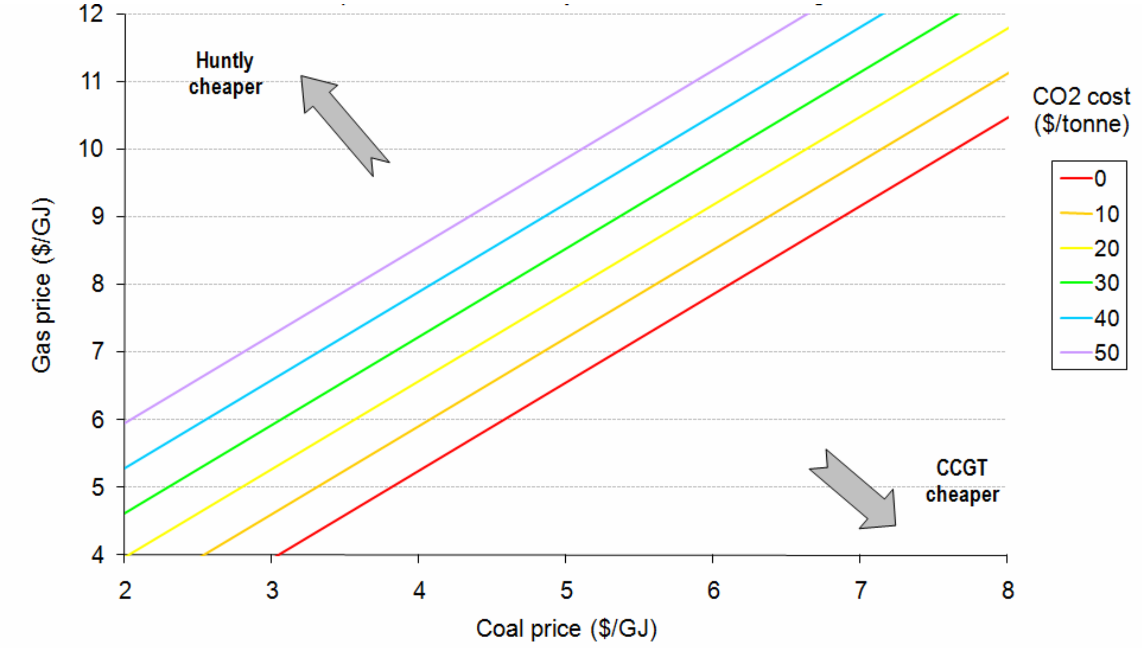


As can be seen, not only does the CO2 price have a significant impact (with the rate of increase of Huntly's SRMC being much greater than for a CCGT), but the fuel price has a significant impact (as illustrated by having two lines for each plant, each representing a different fuel price).

An alternative way at looking at this relative sensitivity between fuel and CO2 costs, and the relative economics of Huntly and CCGTs is illustrated in the following chart showing the fuel 'iso-SRMC' lines between Huntly and a CCGT for different CO2 costs[59].

[59] Thus, for a given CO2 cost, the diagonal line represents the coal / gas price combination where the SRMCs of Huntly and a CCGT are equivalent. The area to the upper left of a line represents coal / gas price combinations where Huntly is cheaper, and vice versa for the lower right of the line.

Figure 15 - Huntly and CCGT SRMC break-even curves for differing fuel and CO2 costs



As can be seen, as CO2 prices rise, the break-even coal price for a given gas price has to get lower and lower.

In summary, at the moment the relative gas: coal prices are such that CCGTs would appear to be marginal. Assuming that this is the case, the emissions intensity of avoided generation is 'only' some 372 kg/MWh. However, if coal prices increase relative to gas prices, or electricity generation is subject to material CO2 costs, Huntly's SRMC will rise above that of CCGTs, and the emissions intensity of avoided generation will rise to some 958 kg/MWh.

In terms of valuing these avoided emissions, even though electricity generators may not be subject to a cost of CO2 now, every tonne of CO2 emitted today increases New Zealand's liability under the Kyoto protocol. Accordingly, emissions avoided today represent real value to New Zealand.

The following table shows how much avoided emissions due to a smart-meter induced improvement in residential energy efficiency are worth for a range of CO2 prices for both electricity and gas residential consumers, with the electricity figure depending on whether a CCGT or Huntly is marginal. The % improvements in energy efficiency are assumed to be 3% for electricity consumption and 2% for gas consumption (i.e. the same values used in Section 2.1.1, based on the central assumptions used by the UK government for smart-metering induced improvements in energy efficiency).

Table 12 - Value of avoided emissions from improved residential energy efficiency

	Electricity				Gas	
	CCGT marginal		Huntly marginal			
CO2 cost ($/tonne)	***20***	***50***	***20***	***50***	***20***	***50***
Household ($/annum incl. GST)	2.34	5.84	5.68	14.20	0.61	1.52
NZ ($m/annum excl. GST)	3.4	8.6	8.3	20.8	0.1	0.3

Long-term <u>economic</u> marginality

The above analysis has been based on what is *operationally* marginal at any one moment in time.

However, the demand for electricity in New Zealand is growing steadily (roughly 2% per annum) in response to economic and population growth. This is giving rise to a need for a steady investment in new generation to meet this growing demand.

In such an environment of growing demand, the predominant generation that is avoided by energy efficiency is the generation that would otherwise have had to be built to meet this growth in demand. In other words, instead of building a power station to meet a 100 GWh increase in demand, it is possible to save 100GWh of existing demand through increased energy efficiency.

There may be some initial displacement of the plant that is operationally marginal at any one moment in time (typically either a combined-cycle gas turbine or the Huntly coal-fired station). However, the extent of this initial displacement will depend on assumptions around the extent to which the market had anticipated such energy efficiency in its forecasts of demand growth and consequential new investment timings.

With regards to what plant will be economically marginal on the longer-term investment time-frame, it will depend on a number of factors. Crudely, the extremes of the future new-investment scenarios can be characterised as either a world dominated by renewables, or a world where fossil-fuelled power stations continue to comprise a significant proportion of new-investment.

Exactly what proportion of new renewable and fossil generation will be developed will depend on a number of factors including:

- The cost of CO2;
- The availability and cost of domestic gas resources, and the likely cost of international liquefied natural gas options;
- The consentability of renewable resources[60]; and
- Government policy such as the currently proposed moratorium on new baseload fossil generation investment.

If the world is one where fossil-fuelled generation continues to play a material role in new generation investment, then energy efficiency will deliver tangible benefits in terms of avoided CO2 emissions.

[60] Noting that getting consents under the RMA has proven to be a significant hurdle for many hydro, wind and geothermal projects.

If, however, the world is one where renewables dominate new generation investments, then the environmental benefit of energy efficiency in terms of reduced CO_2 emissions drops closer to zero[61].

[61] There may still be a need to provide back-up thermal plant for the periods of peak demand when wind can't be balanced by existing renewable resources and an open-cycle gas turbine will be required. However, the percentage of time when wind will have to be backed up by such peaking plant will be relatively small (likely to be less than 5%). Accordingly the effective emissions from wind plus thermal back-up will be at least a factor of ten lower than for a CCGT.

Appendix E. Possible innovative tariffs that could be enabled by smart metering

The types of different innovative tariffs that could be enabled by smart metering include:

- Time-of-use (TOU) tariffs, whereby prices to consumers are split into different blocks. For example, within-week prices could be split into day / night / weekend / 'peak' (weekday morning and early evening), and within-year prices into summer / winter. Such tariffs are designed to encourage load shifting from higher to lower cost periods.
- Critical peak pricing tariffs where peak prices are extreme but the periods at which such prices will come into effect are relatively few, and will only be signalled a short period ahead of, and/or during, real-time. Thus, although the c/kWh charge is set in advance, the time at which it will be implemented is not known. Typically overseas such tariff options limit the number of periods during a year where such peak periods will be called[62].
- Greater discount to consumers from having appliances on an interruptible basis, plus greater ability to offer a range of different maximum interruption regimes for different prices. This could extend from hot water cylinders to other potential smart appliances such as air conditioners, fridges and the like.
- Load limiting tariffs whereby consumers agree to have the whole of their load limited at times of system stress (i.e. not just specific appliances), in return for paying a discount to the normal price over the course of the year[63]. Again, different discounts to the normal price could be linked to different system stress thresholds for load limiting. E.g. Customers who agree to have their load limited when wholesale prices go above $1,000/MWh, say would receive a greater discount than those who signed up to a plan where the wholesale price threshold was set at $5,000/MWh.

It is unlikely that mass-market consumers will sign-up to spot related tariffs given the asymmetric price risk associated with electricity prices at times of peak, and thus the sophistication required to evaluate the cost: benefit of such tariffs and the measures necessary to optimise peak demand management. As set out in Appendix C, this is one of the main reasons why most industrial customers who currently have time-of-use meters have elected not to go onto spot-related tariffs.

Given that smart meter tariffs are the focus of another PCE work stream, they are not considered in any more detail within this report.

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[62] A variant on this is where utilities signal that a period is *likely* to be one of the peak periods for the year, but the determination of which periods were *actually* used for peak charging is not determined until the end of the period where peak charging is implemented (typically the winter period where peak demand is driven by heating, although in some hot countries the peak period is in the summer driven by air conditioning load). Such coincident peak pricing approaches are generally only really used for large industrial customers.

[63] It should be noted that in such situations the whole of the consumers' load would not need to be dropped, but that the ability of the consumer to draw power above a certain level would be limited e.g. limiting capacity to 6 kVA, say.