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authoritative analysis

Cost-benefit analysis of additional smart meter functionality

Home area networks and in-home devices

Report to the Electricity Commission

2 December 2009

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Executive summary

There are a number of additional functionalities available which retailers are not yet including in the smart meters they are rolling out currently. These additional functionalities would incur additional costs to include, whilst their benefits would accrue to parties other than retailers. The demand for these additional functionalities and whether retailers could recoup the costs of their inclusion are as yet uncertain. This raises two questions – would inclusion of these additional functionalities be of net benefit to New Zealand as a whole and, if so, would the net benefits be greater from inclusion at the time of rolling out smart meters or retrofitting at a later time as consumers demand these additional functionalities?

The Electricity Commission has asked NZIER to provide an initial high-level analysis of the costs and benefits of two additional functionalities – home area network interfaces and in-home displays. Home area network (HAN) interfaces enable smart meters to communicate with consumers' digital devices such as computers, security systems and "smart" appliances (e.g. air conditioners, heat pumps, washing machines) to control these remotely. This communication enables the smart appliances to receive signals of high loading on the electricity system or high prices and to respond by reducing some or all of their electricity consumption in these time periods. In-home displays (IHDs) provide consumers with close to real time information on their electricity consumption and prices to enable more informed consumption decisions. This information can be effective in assisting and encouraging consumers to reduce their electricity consumption or to move some of their electricity consumption to time periods when prices are lower. For the purpose of this cost-benefit analysis (CBA), a HAN modem is deemed to be a prerequisite for operating an IHD.

For this CBA, we are therefore interested in not the total costs and benefits of smart meters, but only the incremental costs and benefits of including the additional functionalities of HAN interfaces and IHDs – how much extra these functionalities would cost to include and would deliver in benefits.

This CBA finds that although deferring installation of HAN interfaces until smart appliances are introduced reduces the present value total costs of including this functionality, the demand response to HAN interfaces alone is still too small to cover these costs. The demand response to IHDs is sufficiently large to cover the ongoing annual costs of including both HAN interfaces and IHDs in smart meters, but not large enough to recoup the very substantial initial installation costs for these functionalities within the next 20 years or even by 2050. Only if the demand response to IHDs can be increased to a 6% reduction in electricity consumption or the cost of the IHDs can be halved would including HAN interfaces and IHDs deliver sufficient net benefits to break even within the next 20 years.

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1. Purpose

New Zealand's major electricity retailers, with the exception of TrustPower, have started installing smart meters at metering installations and announced plans to extend this roll out to most consumers within the next five years. The move to smart meters has been prompted by the operational cost savings that they provide to retailers, such as reducing the collection cost and improving the accuracy of metering information, plus the potential for competitive advantage through offering new products and services to consumers.

There are a number of additional functionalities available which retailers are not yet including in the smart meters they are rolling out currently. These additional functionalities would incur additional costs to include, whilst their benefits would accrue to parties other than retailers. The demand for these additional functionalities and whether retailers could recoup the costs of their inclusion are as yet uncertain. This raises two questions – would inclusion of these additional functionalities be of net benefit to New Zealand as a whole and, if so, would the net benefits be greater from inclusion at the time of rolling out smart meters or retrofitting at a later time as consumers demand these additional functionalities?

The Electricity Commission (the Commission) has asked NZIER to provide an initial high-level analysis of the costs and benefits of two additional functionalities – home area network interfaces[1] and in-home displays. This report outlines the method and results of this cost-benefit analysis (CBA).

2. Options

Home area network (HAN) interfaces enable smart meters to communicate with consumers' digital devices such as computers, security systems and "smart" appliances (e.g. air conditioners, heat pumps, washing machines) to control these remotely. This communication enables the smart appliances to receive signals of high loading on the electricity system or high prices and to respond by reducing some or all of their electricity consumption in these time periods. In-home displays (IHDs) provide consumers with close to real time information on their electricity consumption and prices to enable more informed consumption decisions. This information can be effective in assisting and encouraging consumers to reduce their electricity consumption or to move some of their electricity consumption to time periods when prices are lower. For the purpose of this CBA, we assume that for an IHD to receive information from a smart meter, the smart meter must be fitted with a HAN modem[2].

[1] The HAN interface includes back office functionality (support systems) to operate the HAN.

[2] This is not strictly necessary, as information from the smart meter can be relayed to the IHD via the local telecommunications network.

The Commission has asked us to assess the costs and benefits of three options relative to rolling out smart meters without functionality for HAN interfaces and IHDs:

- option 1 – include HAN interfaces only, at the time of rolling out smart meters
- option 1a – include HAN interfaces only, retrofitted as consumers take up smart appliances
- option 2 – include HAN interfaces and IHDs, at the time of rolling out smart meters.

3. Method

3.1 Cost-benefit analysis

CBA provides a formal, structured method for systematically assessing proposals in terms of their outcomes relative to their use of resources. In the analysis of government policy, CBA is normally undertaken from a national economy perspective, weighing up the relative costs and benefits to New Zealand as a whole.

The CBA process comprises 10 steps:

1. define the problem
2. select the options for assessment
3. specify the baseline scenario
4. identify the impacts of the options – positive (benefits) and negative (costs)
5. where possible, quantify the impacts
6. where possible, value the impacts
7. adjust for differences in the timing of the impacts
8. calculate decision criteria
9. analyse the sensitivity of the results and
10. document the CBA

3.2 Baseline scenario

A critical step in any CBA is specifying the baseline scenario – the default or prevailing situation or conditions that would occur in the absence of the options under consideration. It is relative to this baseline that the options' costs and benefits are measured.

For the purpose of assessing the costs and benefits of including HAN interfaces and IHDs, we define the baseline scenario as the roll out of smart meters without these functionalities. We do not assess the costs and benefits of this baseline *per se*, but assess the addition to costs and benefits of including these additional functionalities under options 1, 1a and 2.

3.3 Unit costs and benefits

From its review of international experience, Strata Energy (2008) lists a wide range of benefits from smart metering, to consumers, retailers, meter readers, distribution and transmission network operators, the economy and the environment[3]. Smart meters also incur costs to purchase, install and operate.

For this CBA, however, we are interested in not the total costs and benefits of smart meters, but only the incremental costs and benefits of including the additional functionalities of HAN interfaces and IHDs – how much extra these functionalities would cost to include and deliver in benefits.

For the purpose of the CBA, we model the main costs and benefits per meter under options 1, 1a and 2 as shown in Table 1.

Table 1 Unit costs and benefits

Additional to baseline (smart meter without HAN interface and IHD)

	Frequency	Cost or benefit ($)
Option 1 and option 1a – HAN interface only		
Costs		
Purchase and install HAN modem	Initial	71.00 per meter
Additional visit to retrofit HAN modem	Initial	75.00 per meter
Install support systems for HAN interface	Initial	2.00 per meter
HAN interface license fee	Ongoing annual	14.00 per meter
Operate support systems for HAN interface	Ongoing annual	12.00 per meter
Benefits		
Moved peak electricity consumption from HAN interface	Ongoing annual	0.35 per meter
Option 2 – HAN interface and IHD		
Costs		
Purchase and install HAN modem	Initial	71.00 per meter
Install support systems HAN interface	Initial	2.00 per meter
Purchase and install IHD	Initial	142.00 per meter
HAN interface license fee	Ongoing annual	14.00 per meter
Operate support systems for HAN interface	Ongoing annual	12.00 per meter
Replace IHD	Ongoing annual	28.40 per meter
Benefits		
Moved peak electricity consumption from HAN interface	Ongoing annual	0.35 per meter
Reduced electricity consumption from IHD	Ongoing annual	25.71 per meter
Reduced GHG emissions from IHD	Ongoing annual	5.62 per meter
Deferred generation investment from IHD	Ongoing annual	25.71 per meter

Notes: In 2009 dollars

Source: Strata Energy (2008), Concept Consulting (2008), Electricity Commission, industry submissions, NZIER

The values shown reflect the average or "typical" unit costs and benefits across all residential meters. Given the uncertainty of these values, we test the sensitivity of the

[3] Strata Energy (2008) *Review on International Experience with Smart Meters (Energy)*, prepared for the Parliamentary Commissioner for the Environment, pp.18-23.

results across a range of values for each type of cost and benefit in Section 4.3 below[4].

The costs per meter, for both initial installation and ongoing operation, are based on previous studies overseas and in New Zealand[5], information from the Commission and industry submissions[6].

Industry submissions presented differing views on the relative costs of including these additional functionalities at the time of installation of a smart meter versus retrofitting at a later date. Most submitters considered that retrofitting a HAN modem would require an additional site visit to install, but some stated that installation could be combined with a site visit for existing purposes or involve a simple plug in which would take only five minutes and not require a specialist electrician. This has implications also for the costs of installing an IHD, given that an IHD is assumed to require a HAN modem. If a HAN modem has already been installed, an IHD could be simply posted to the consumer.

IHDs are prone to damage or loss by consumers[7]. We assume that they require replacement on average every five years, but test shorter and longer periods in the sensitivity analysis.

Industry submissions noted that there are other mechanisms available to provide consumption and price information to consumers at lower cost (e.g. internet, mobile telephones). Overseas experience suggests, however, that these are much less effective in the magnitude of demand response achieved[8].

Two further types of cost which we do not model explicitly in this CBA are the value of consumers' time spent reading and responding to IHDs and the reduction in consumers' utility in not operating appliances when they otherwise would have.

There are three main types of benefit, which we model as follows.

3.3.1 Avoided generation costs

The demand responses of New Zealand consumers to HAN interfaces and IHDs are uncertain. Overseas experience provides some indication, but varies widely and is influenced by the different climatic, technological and market conditions of different

4 Any more substantial changes in technology or consumer behaviour within the time period covered by the CBA would require remodelling of the CBA.

5 Strata Energy (2008) *Review on International Experience with Smart Meters (Energy)*, prepared for the Parliamentary Commissioner for the Environment, and Concept Consulting (2008) *Smart Metering in New Zealand*, prepared for the Parliamentary Commissioner for the Environment.

6 Submissions on Electricity Commission (2009) *Discussion and Monitoring Paper – Advanced Metering Infrastructure and Interim Metering Compliance*.

7 ARC Innovations has found that the first replacement is required on average three years after initial installation. Incurring this replacement cost could be expected to encourage greater care in future.

8 Concept Consulting (2008) *Smart Metering in New Zealand*, prepared for the Parliamentary Commissioner for the Environment.

countries. Furthermore, it is difficult to isolate the specific responses to each of HAN interfaces and IHDs and separate from other functionalities of smart meters and the tariff structures applied.

Strata Energy (2008) and Concept Consulting (2008) have reviewed demand responses in other countries and how applicable these may be to New Zealand. For New Zealand conditions, Concept Consulting (2008) assumes that smart meters would move between 2.5% and 10% of electricity consumption from peak to off peak times and IHDs would reduce electricity consumption by between 1% and 7.5%, compared with 0% to 20% overseas. We assume that, in combination with smart appliances and critical peak pricing, HAN interfaces would move on average 1% of peak consumption to off peak times, given that the opportunities for peak time load control from appliances other than for water heating are likely to be limited in New Zealand[9], and IHDs would reduce electricity consumption by on average 4% per meter. The magnitudes of demand response are the key uncertainty in this CBA and therefore a particular focus in the sensitivity analysis.

We value these demand responses at the average wholesale price of electricity at the margin of $82/MWh[10] (excluding carbon costs), with typically 30% of electricity consumed during peak times[11] at an average premium of around $15/MWh[12]. Consumers' electricity bills would fall by more than this amount, but would involve the loss of profit margins to retailers, distributors and generators on this reduced consumption. The net benefit from a national perspective is the avoided cost of generating this electricity.

3.3.2 Avoided greenhouse gas emissions

Gas-fired generation typically produces 380 tonnes of carbon dioxide equivalent (CO_2-e) per GWh of electricity generated and coal-fired generation around 900 tonnes[13]. Once constructed, hydro and wind generation plant do not produce any greenhouse gas emissions in generating electricity.

The reduction in electricity consumption due to IHDs is more likely to reduce thermal generation than hydro or wind generation due to the higher marginal costs of thermal generation together with the way the wholesale electricity market is designed to select lower marginal cost generation for dispatch ahead of higher marginal cost generation. We cannot foretell whether it would be gas or coal-fired generation

[9] Consumers are less willing to forgo space heating and other activities such as cooking, which occur around New Zealand's peak time.

[10] Electricity Technical Advisory Group and Ministry of Economic Development (2008) *Improving Electricity Market Performance*, preliminary report to the Ministerial Review of Electricity Market Performance, Figure 32.

[11] Derived from Commission data, defining peak hours as 6am to 9am and 5pm to 8pm.

[12] Based on average price differential between peak and shoulder periods under load control, Electricity Commission (2007) *Load Management Value and Pricing Report*, p.34.

[13] Derived from the Ministry of Economic Development's greenhouse gas emissions data.

reduced, so adopt the mid value of 640 tonnes of CO_2-e avoided for each GWh reduction in consumption resulting from this additional functionality.

The future price of carbon credits is difficult to forecast precisely in the absence of a fully functioning global market. The value of CO_2 used by the Treasury in its June 2009 estimate of New Zealand's Kyoto Protocol liability was $21.61/tonne[14]. Prices on the European Climate Exchange for European Union CO_2 emission allowances (EUAs) used in the European Emissions Trading Scheme, for delivery in December 2012, are currently around $31/tonne, but have been as high as $35/tonne. For the CBA, we adopt the mid value of this range, $28/tonne, to illustrate the value of emissions avoided as a result of the demand responses to HAN interfaces and IHDs.

We do not model explicitly any avoidance of greenhouse gas emissions through HAN interfaces moving electricity consumption from peak to off peak times, but this could represent an additional benefit to the extent that load shifting may enable generation by lower emissions plant in place of high emissions peaking plant.

3.3.3 Deferred generation, transmission and distribution investment

Although New Zealand's total electricity demand is forecast to continue growing, the demand response to IHDs would provide a further benefit in deferring the need to build new generation, transmission and distribution assets to meet this demand.

For the CBA, we value this benefit at $82/MWh, the average long-run marginal cost of generation[15], for the reduction in electricity consumption due to IHDs. This assumes that New Zealand wishes to maintain the same margin of generation capacity over peak demand into the future as it has currently. There would be some associated benefits in deferring transmission and distribution investment also, but these would be small in comparison[16].

We do not model explicitly any deferment of investment due to HAN interfaces moving electricity consumption from peak to off peak times. This could represent an additional benefit, although more likely for investment in transmission, which already faces capacity constraints, than generation, for which New Zealand currently has sufficient capacity to meet peak demand except during occasional shortages of fuel, especially water.

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[14] Treasury (2009) *New Zealand's Position Under the Kyoto Protocol.*

[15] Electricity Technical Advisory Group and Ministry of Economic Development (2008) *Improving Electricity Market Performance*, preliminary report to the Ministerial Review of Electricity Market Performance, Figure 32.

[16] Note that if the grid owner or a distributor had constraint issues and sought to defer an investment by providing a cost incentive to consumers, the cost incentive would exist only until this investment took place. What we are referring to in this CBA, however, is the consumer response to IHDs facilitating slower growth in total electricity demand over time and thereby enabling slower expansion in transmission and distribution capacity over time.

3.4 Number of meters

In applying the above costs and benefits per meter to the appropriate number of meters, we need to consider the number of residential meters in New Zealand currently and future growth, whether smart meters would replace all of these, the rate of roll out of smart meters and the rate of uptake of smart appliances.

There are currently around 1.9 million meters in New Zealand, increasing by around 30,000 meters per year[17], a similar rate of increase to forecast total electricity demand. Residential meters number around 1.65 million[18] and we assume they increase at the same rate as residential electricity demand, as shown in Table 2.

For around 5% of meters, however, it would not be technically feasible or financially viable to install a smart meter (e.g. where no signal).

Table 2 Residential electricity demand and meters

Year ending March

	Electricity demand (GWh)	Number of meters
2009	12,936	1,650,000
2010	13,102	1,671,169
2011	13,329	1,700,170
2012	13,532	1,726,065
2013	13,719	1,749,942
2014	13,924	1,776,025
2015	14,141	1,803,782
2016	14,351	1,830,546
2017	14,551	1,855,994
2018	14,754	1,882,000
2019	14,960	1,908,181
2020	15,167	1,934,574
2021	15,367	1,960,114
2022	15,534	1,981,423
2023	15,701	2,002,791
2024	15,869	2,024,188
2025	16,037	2,045,580
2026	16,204	2,066,938
2027	16,368	2,087,756
2028	16,530	2,108,494
2029	16,692	2,129,085

Source: Electricity Commission (2008) *Statement of Opportunities*, Strata Energy (2008), Concept Consulting (2008), NZIER

By the end of October 2009, over 254,500 smart meters had been installed[19]. The major retailers, with the exception of TrustPower, have previously announced plans

[17] Strata Energy (2008) *Review on International Experience with Smart Meters (Energy)*, prepared for the Parliamentary Commissioner for the Environment.

[18] Concept Consulting (2008) *Smart Metering in New Zealand*, prepared for the Parliamentary Commissioner for the Environment.

[19] Electricity Commission (2009) personal communication.

to roll out around 1.55 million smart meters, covering over 80% of New Zealand's existing metering installations, by the end of 2013[20]. We base our assumed roll out to residential meters shown in Table 3 on the rate suggested by these announcements, allowing also for the annual growth in meter numbers.

Table 3 Roll out of smart meters

Percentage of meters, year ending June

	Annual percentage	Cumulative percentage
2009	10%	10%
2010	10%	20%
2011	20%	40%
2012	20%	60%
2013	15%	75%
2014	10%	85%
2015	5%	90%
2016	5%	95%
2017	5%	100%
2018 onwards	Annual growth in meters	100%

Source: Based on Strata Energy (2008), NZIER

Smart appliances, which are necessary to achieve the benefits of HAN interfaces, are not yet commercially available in New Zealand. We assume that they become available and start to be purchased by consumers from mid 2015 and spread over the following 10 years. For the purpose of this CBA, we assume that existing appliances would not be retrofitted to covert them to smart appliances.

3.5 Time horizon

We model the above costs and benefits over a period of 20 years from 2009/10 to 2028/29 (June years). This time horizon seeks to capture enough of the ongoing costs and benefits after initial installation to provide a robust assessment of the options.

For options 1 and 2, we assume that both additional functionalities would start to be included in smart meters from mid 2010, including retrofitting to smart meters already rolled out by this time. The costs of initial installation and ongoing operation would therefore start flowing from mid 2010 for smart meters already rolled out and increase over subsequent years as the roll out continued. These include costs for HAN interfaces, even though smart appliances would not start being introduced for a further five years, although we do allow for the annual costs of operating HAN interface data, communication and management systems being lower until interacting with smart appliances.

[20] Strata Energy (2008) *Review on International Experience with Smart Meters (Energy)*, prepared for the Parliamentary Commissioner for the Environment, p.66.

Note that there is also a risk under options 1 and 2 of the HAN technology installed initially becoming obsolete before smart appliances are introduced, incurring additional costs to replace with the new technology. We consider these additional costs in the sensitivity analysis.

For option 1a, HAN interfaces would not start to be included in smart meters until mid 2015, by retrofitting, once smart appliances started to become available and would therefore not incur any costs until this time.

The benefits of IHDs under option 2 would start flowing from mid 2010, but those of HAN interfaces would not start flowing until mid 2015, under any options, until smart appliances started to be taken up.

So that we can compare directly costs and benefits occurring at different points in time, we adopt a discount rate of 10% to convert future costs and benefits to their present values in 2009. In the sensitivity analysis, we also model discount rates of 6%, to reflect a public policy perspective, and 12%, to reflect a commercial perspective[21].

4. Results

4.1 Annual costs and benefits

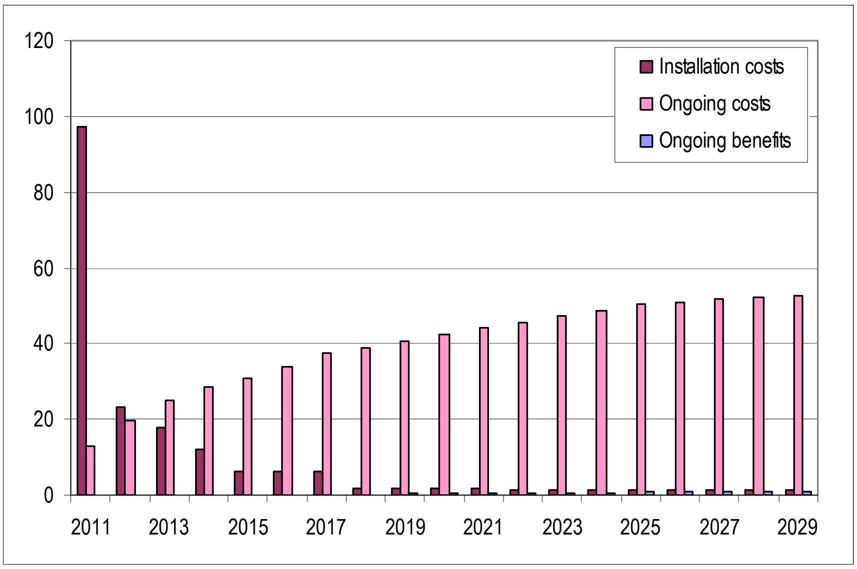
The total annual costs and benefits of the three options, relative to the roll out of smart meters without these additional functionalities, are shown in Figure 1 to Figure 3.

Under all options, the benefits of HAN interfaces do not start until 2015/16 when smart appliances become available, whilst the benefits of IHDs under option 2 start in 2010/11. Costs start in 2010/11 under option 1 and also option 2, given that a HAN modem is assumed to be installed to operate an IHD. Option 1a provides the same benefits as option 1, but does not incur any costs until 2015/16 when smart appliances become available, given that there would be no benefit from installing HAN interfaces before this time. Option 2, with inclusion of HAN interfaces, provides greater annual benefits than HAN interfaces alone, but also costs more both to install initially and to operate ongoing.

[21] Treasury now recommends an 8% real discount rate for energy and water infrastructure projects. This is covered by the range we model in the sensitivity analysis.

Figure 1 Annual costs and benefits of option 1 – include HAN interfaces in rolling out smart meters

$ million, year ending June

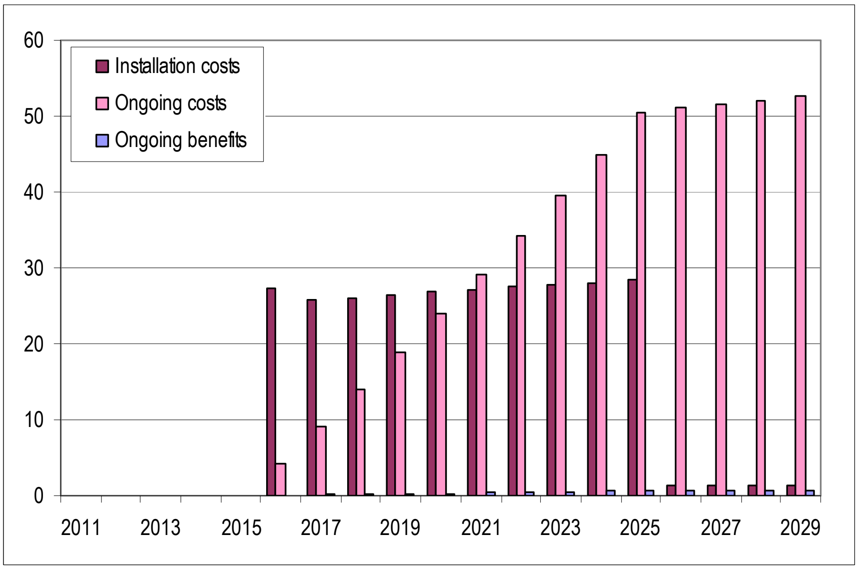


Notes: In 2009 dollars

Source: NZIER

Figure 2 Annual costs and benefits of option 1a – retrofit HAN interfaces as consumers take up smart appliances

$ million, year ending June

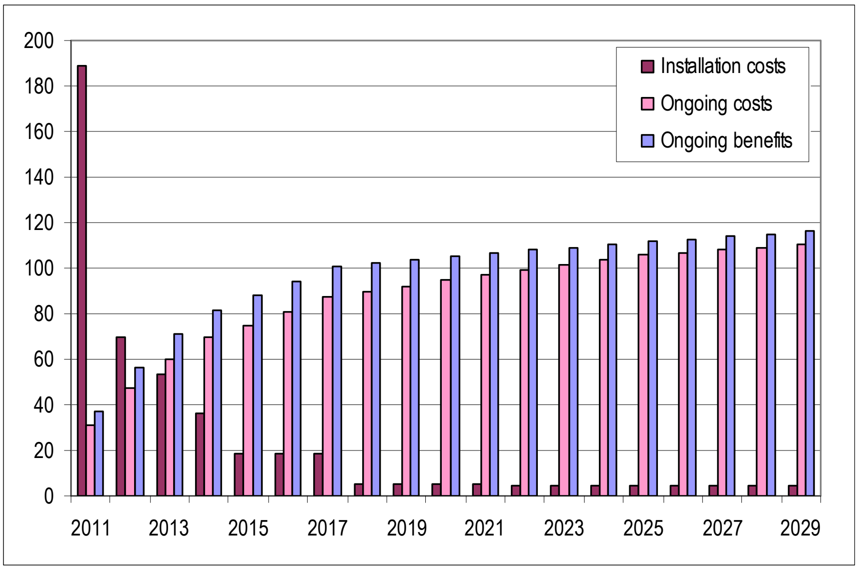


Notes: In 2009 dollars

Source: NZIER

Figure 3 Annual costs and benefits of option 2 – include HAN interfaces and IHDs in rolling out smart meters

$ million, year ending June



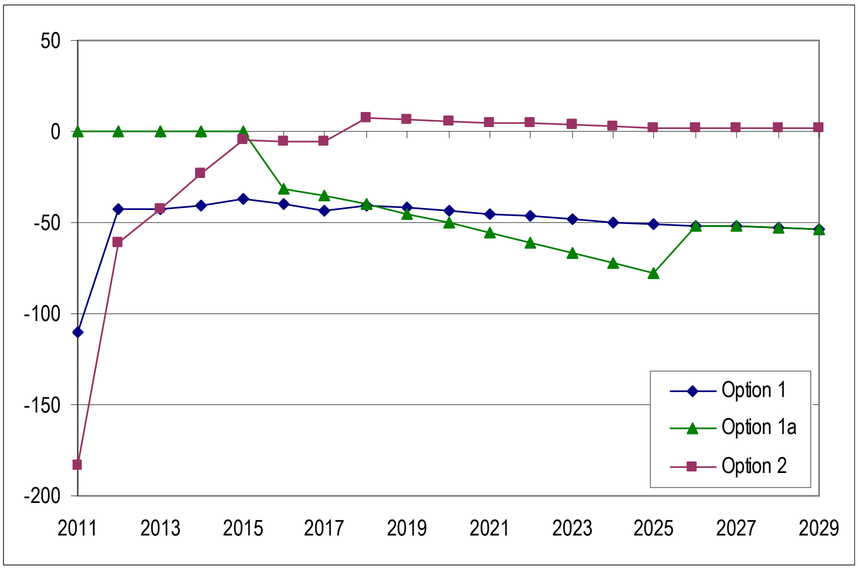
Notes: In 2009 dollars

Source: NZIER

The reduction in electricity consumption in response to IHDs under option 2 is sufficient for annual benefits to outweigh annual costs from 2017/18, after all smart meters, with HAN interfaces and IHDs, have been installed. As shown in Figure 4, under options 1 and 1a, there are no years in which annual benefits outweigh annual costs, due to the modest demand response to HAN interfaces, even if the costs of HAN interfaces are not incurred until smart appliances are introduced.

Figure 4 Annual net benefits

$ million, year ending June



Notes: In 2009 dollars

Source: NZIER

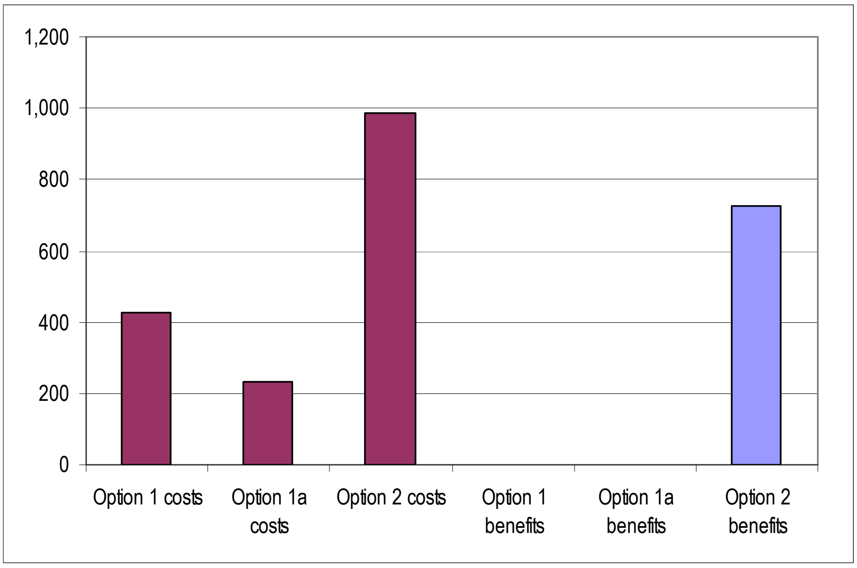
4.2 Total costs and benefits

With discounting to reflect their relative timing, the above annual costs and benefits imply present value total costs over 2009/10 to 2028/29 of $429 million under option 1, $231 million under option 1a and $987 million under option 2. Although option 1a incurs an additional cost for site visits to retrofit HAN modems, it avoids incurring any costs until HAN interfaces are required by smart appliances.

Inclusion of the additional functionalities delivers present value total benefits over the next 20 years of just $1.718 million under each of option 1 and option 1a and $727 million under option 2, given the larger demand response to IHDs than HAN interfaces alone.

The net benefits are therefore -$427 million under option 1, -$229 million under option 1a and -$260 million under option 2. Although option 2 achieves greater benefits, it also incurs larger costs. For each dollar of cost, option 1 and option 1a return less than $0.01 in benefits, whilst option 2 returns $0.74. None of the options break even within the next 20 years. Although, as shown in Figure 4 above, option 2 does reach a point (from 2017/18) where its annual benefits outweigh its annual costs, these annual net benefits are not large enough to cover the initial installation costs within the next 20 years or even by 2050.

Figure 5 Present value total costs and benefits over 2009/10 to 2028/29
$ million



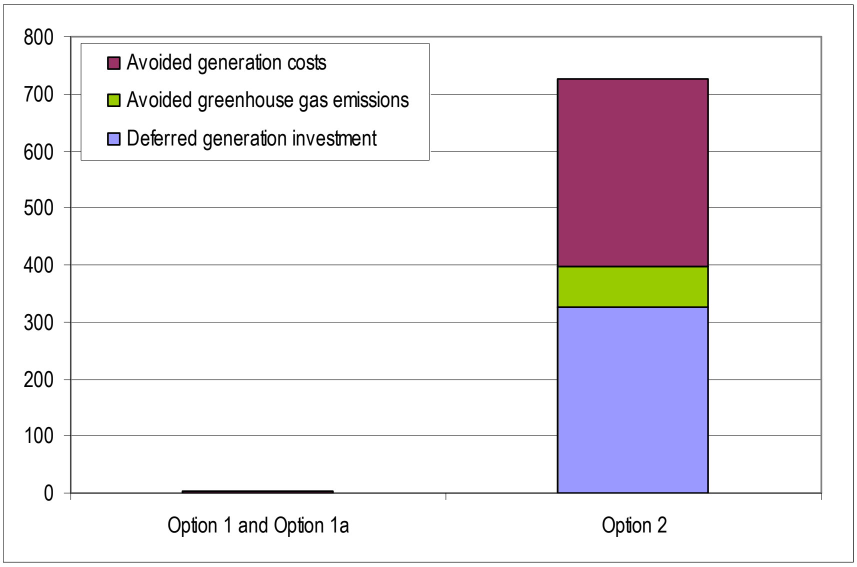
Notes: In 2009 dollars
Source: NZIER

These results indicate that, although deferring installation of HAN interfaces until smart appliances become available reduces the costs of including this functionality, the demand response to HAN interfaces alone is still far too small to cover these costs. The demand response to IHDs is sufficiently large to cover the ongoing annual costs of including both HAN interfaces and IHDs in smart meters, but not large enough to recoup the very substantial initial installation costs.

The largest cost component is the licence fee for HAN interfaces under option 1 (42%), the purchase and installation by retrofitting of HAN modems under option 1a (44%) and the replacement of damaged or lost IHDs under option 2 (37%). The benefits are solely avoided generation costs under options 1 and 1a and split equally between avoided generation costs (45%) and deferred generation investment (45%) under option 2, as shown in Figure 6. Of the total benefits of option 2, reduced electricity consumption (load shedding) accounts for almost 100% and electricity consumption moved from peak to off peak times (load shifting) accounts for just 0.2%.

Figure 6 Present value total benefits over 2009/10 to 2028/29

$ million



Notes: In 2009 dollars

Source: NZIER

4.3 Sensitivity analysis

As noted above, the unit costs and benefits used in the CBA reflect the average or "typical" values indicated by the existing literature and industry submissions. Given the uncertainty of these unit values, we test the sensitivity of the above main results in terms of how adopting alternative values would alter the estimated present value total net benefits of each option over the next 20 years. The alternative values used reflect the range of opinion expressed in the literature and industry submissions. The results of this sensitivity analysis are shown in Table 4.

Only if the demand response to IHDs can be increased to a reduction in electricity consumption of 6% or more, or the cost of IHDs can be halved, would option 2 break even within the next 20 years. Throughout the remainder of the sensitivity analysis, all three options remain of negative net benefit.

Table 4 Sensitivity analysis

Present value net benefits over 2009/10 to 2028/29

		Net benefits ($ million)		
		Option 1	Option 1a	Option 2
Main results		**-427**	**-229**	**-260**
Moved peak consumption from HAN interface	0%	-429	-231	-261
	2%	-425	-227	-258
	3%	-424	-225	-256
Reduced consumption from IHD	2%	-427	-229	-622
	3%	-427	-229	-441
	5%	-427	-229	-79
	6%	-427	-229	**103**
Purchase and install HAN modem (per meter)	$40	-384	-207	-217
	$60	-412	-221	-245
	$80	-439	-235	-272
	$120	-495	-264	-328
Additional cost to retrofit HAN modem (per meter)	$0	-383	-177	-216
	$40	-406	-205	-239
Purchase and install IHD (per meter)	$70	-427	-229	**23**
	$200	-427	-229	-488
Frequency of replacing IHD	3 years	-427	-229	-500
	7 years	-427	-229	-157
Set up support systems for HAN interface (total cost)	$2,000,000	-426	-228	-259
	$4,000,000	-428	-229	-261
HAN interface license fee (per meter)	$10	-376	-209	-209
	$20	-503	-258	-336
Operate support systems for HAN interface (per meter)	$2.50	-344	-183	-176
	$4	-357	-190	-189
LRMC of generation/MWh	$75	-427	-229	-316
	$90	-427	-229	-196
Value of emissions/tonne	$21	-427	-229	-278
	$35	-427	-229	-242
Discount rate	6%	-559	-357	-271
	12%	-380	-186	-254

Notes: In 2009 dollars

Source: NZIER

There is also a risk under options 1 and 2 of the HAN technology installed initially becoming obsolete before smart appliances are introduced, incurring additional costs to replace with the new technology, possibly including new IHDs to operate with the new HAN technology. Under inclusion of HAN interfaces alone, this is in effect equivalent to starting with option 1 and then switching to option 1a in 2015/16 when smart appliances start to be introduced. This combination has a present value total net benefit over the next 20 years of -$447 million. The eventuation of this risk under inclusion of both HAN interfaces and IHDs would cause an even greater loss.