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Cost Benefit Analysis of the Warm Up New Zealand: Heat Smart Programme

Arthur Grimes[1], Tim Denne[2], Philippa Howden-Chapman[3], Richard Arnold[4], Lucy Telfar-Barnard[3], Nicholas Preval[3] and Chris Young[1]

[1] Motu, Wellington; [2] Covec; [3] He Kainga Oranga/Housing and Health Research Programme, University of Otago, Wellington; [4] Department of Mathematics, Victoria University of Wellington

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Executive Summary

Background

This report summarises the results of an analysis of the costs and benefits of the Warm Up New Zealand: Heat Smart programme. Under the programme, subsidies are provided towards the costs of retrofitting insulation and/or installing clean heating for pre-2000 houses. The benefits that are included in this report are analysed in more detail in three separate papers produced as part of this study that assess the impacts on energy use,[1] health outcomes[2] and producer surpluses, with additional data on employment.[3] The costs of the programme are also assessed in this report and include the costs of the additional insulation and clean heating plus the administrative costs falling on the government. Administrative costs for companies are assessed as part of the report on impacts on industry.[4]

To analyse the effects we include the following key assumptions:

- some houses that receive subsidised treatments (insulation or clean heating) under the programme would have installed insulation or clean heating anyway. We use the results of regression analysis to estimate that 85% of the treatments are additional, within a range of 41% to 129%.[5] A figure of over 100% is explainable by the programme resulting in publicity that encourages others to install insulation or clean heating outside the programme;
- a (real) discount rate of 4%, with sensitivity analysis using 2.5% and 8%. We discount the costs and benefits to the first year of the programme (2009/10); and
- benefits are analysed over 30 years for insulation and ten years for clean heat.

Costs

The costs considered are those of government administration, the deadweight costs of taxation and the resource costs of the insulation and clean heating.

- Administration costs include EECA staff, marketing, audits and other costs, eg. travel and legal advice. Some proportion of the labour costs would have a zero opportunity cost as, in the absence of the programme, they would have been expected to be unemployed;
- The deadweight costs of taxation are included to take account of the distortionary effects of tax that must be raised to pay for the subsidy (net of GST paid on installation and products). We use a value recommended by the

[1] Grimes A, Young C, Arnold R, Denne T, Howden-Chapman P, Preval N and Telfar-Barnard L (2011) Warming Up New Zealand: Impacts of the New Zealand Insulation Fund on Metered Household Energy Use. Report for Ministry of Economic Development.

[2] Telfar-Barnard L, Preval N, Howden-Chapman P, Arnold R, Young C, Grimes A, Denne T (2011) The impact of retrofitted insulation and new heaters on health services utilisation and costs, pharmaceutical costs and mortality. Evaluation of Warm Up New Zealand: Heat Smart. Report for Ministry of Economic Development.

[3] Covec (2011) Impacts of the NZ Insulation Fund on Industry and Employment. Report for Ministry of Economic Development.

[4] Covec (op cit).

[5] This analysis is described in Covec (op cit).

Treasury that public expenditures should be multiplied by a factor of 1.2 to take account of these deadweight costs;[6]

- The cost of the installations is a resource cost and is equal to the opportunity cost of allocating resources to the production and installation of insulation and clean heating. In calculating opportunity costs we deduct producer surplus and costs of labour that would otherwise be unemployed from gross costs.

The costs are summarised in Table ES1.

Table ES1 Annual Costs of the Programme ($ million)

Item	2009-10	2010-11	2011-12	2012-13
Administration	6.8 – 8.0	6.6 - 7.6	6.0 – 7.0	3.2 - 3.7
Deadweight costs of taxation	14.3	16.3	16.2	4.7
Costs of Insulation + installation	59.7	56.8	72.8	16.8
Costs of Clean heaters + installation	21.5	19.2	48.3	13.8
Total[(1)]	102.9	99.4	143.9	38.7

(1) Using the mid-point of the range of administration costs

Benefits

The benefits analysed in this study have been limited to those that can be assessed using measured changes in metered energy consumption and in independently measured health costs (prescriptions, hospitalisations and benefits of reduced mortality). In addition, we have adopted some values of additional health benefits from prior studies. Producer surplus benefits are accounted for as a reduction in net costs, above.

For both energy and health impacts, the effects were analysed by obtaining addresses of houses that have been treated under the programme. We used QVNZ data to identify houses with similar characteristics[7] to these to set up intervention and control datasets. Data were then obtained from energy companies on changes in metered energy use before and after treatment, and health data were obtained relating to hospitalisations (including mortality outcomes) and prescription charges for people before and after treatment at those addresses.

The energy savings were estimated by region and by month. We adopt the energy report's primary estimate of energy savings, which was more conservative than some other estimates of savings in that report (which ranged up to 50% more than the conservative estimate). These estimated savings were subsequently spread over time of day using EECA assumptions on heating energy use profiles. Time of day prices were then used to calculate the benefits. We used a wholesale electricity price to value the savings in kWh. Reductions in winter peak electricity demand were used to identify potential savings in generation and transmission capacity; this was combined with values of new capacity. Gas does not have time of day prices and we have used a

6 New Zealand Treasury (2005) Cost Benefit Analysis Primer. In comparing our results with CBAs of other projects, it is important to ensure that comparators have also included the deadweight costs of taxation into their analysis.

7 This was location (Census area unit, similar to a suburb), dwelling and house type, number of levels, age (decade of build), floor area and number of bedrooms, whether there is a garage under the main roof and its size (number of vehicles), house construction material (walls and roof), whether or not the house was modernised, and quality (building and roof condition) of the dwelling.

simpler approach to measuring the value of savings in gas use, based on a commercial gas price that includes savings in wholesale gas costs and transmission costs. Because we have limited the assessment to metered energy use, savings in reticulated gas use is limited to the North Island. We do not include any allowance for changes in non-metered energy use owing to data limitations. The separate energy report discusses potential impacts of WUNZ: HS on non-metered energy use.

The conservative estimate of the present value of estimated metered energy savings at a 4% discount rate is shown in Table ES2.

Table ES2 Net Present Value ($ million) of Electricity and Reticulated Gas Savings

	Insulation			Clean heat			
	Energy	**CO_2**	**Total**	**Energy**	**CO_2**	**Total**	**Total**
Electricity	27.8	0.2	27.9	-8.0	-0.1	-8.0	19.9
Reticulated Gas	-1.5	-0.2	-1.7	1.0	0.1	1.1	-0.6
Total	26.3	-0.0	26.2	-7.0	0.0	-7.0	19.3

Health benefits differ depending on the income level of houses, measured on the basis of whether they were Community Service Card (CSC) holders or not; CSCs are available to eligible low income earners and high health services users. The present values of health benefits are estimated using both a conservative approach and a more focussed approach, where the latter resulted in a wider estimate of potential benefits. The results at a 4% discount rate are shown in Table ES3.

Table ES3 Present value of health benefits at different discount rates ($ million)

	Conservative	**Focussed**
CSC Insulation	1,330	1,486
Other insulation	228	294
Total insulation	1,558	1,780
CSC Clean heat	3	3
Other clean heat	-	-
Total clean heat	3	3
Total	1,561	1,783

The net employment impacts of the programme, ie. additional jobs that would not exist in the absence of the programme, are estimated to be approximately 64-424 full time equivalents (FTEs) in the first year and to peak at 85-560 FTEs in 2011/12. This compares with an estimated peak gross employment number of 1,140 FTEs in 2011/12 (not all of which can be considered additional jobs).

Net Benefits

The total costs and benefits (using the conservative estimates for both health benefits and energy savings) are summarised in Table ES4 at different discount rates and with different assumed levels of additionality (central = 85%, low = 41%, high = 129%).

The results suggest that there are positive net benefits of the programme at all discount rates examined, including with assumptions of low levels of additionality.

Table ES4 Present Value of Total Costs and Benefits ($ million)

Additionality:		Central		Low	High
Discount rate:	**4%**	**2.5%**	**8%**	**4%**	**4%**
Costs					
Admin costs	23	24	22	23	23
Deadweight costs of tax	49	50	47	57	41
Installations - insulation	197	201	189	95	300
Installations - clean heat	97	99	92	47	147
Sub-total	366	373	350	222	512
Benefits					
Energy	19	24	12	9	29
Health	1,561	1,906	997	750	2,374
Sub-total	1,580	1,931	1,009	759	2,403
Net Benefits	1,214	1,557	660	537	1,891

The results are dominated by the health benefits, which represent approximately 99% of the total benefits. Estimated health benefits show clear differences between low income earners and other households, with significantly larger benefits for Community Service Card (CSC) holders. Energy benefits from insulation were greatest for houses in cooler regions. Clean heating resulted in greater total metered energy savings for houses that had reticulated gas than for other houses. There are additional benefits that we have not been able to include in our analysis, eg. comfort benefits associated with additional interior warmth, and potential savings in other fuels that we have not measured (changes in consumption of coal, wood and LPG).

On the basis of the analysis in this study, we conclude that the dominant benefits (gross and net) of the programme are attributable to the insulation component of the scheme. We are unable to conclude whether there are net benefits or net costs associated with the inclusion of clean heating in the programme, but it is reasonable to conclude that the net benefits of this component are small by comparison to those for insulation.

The largest component of costs is the costs of the installations themselves, ie. the direct costs of insulation materials, clean heaters, and the labour costs for installations.

The overall results suggest that the programme as a whole has had sizeable net benefits, with our central estimate of programme benefits being at least four times resource costs attributable to the programme. The central estimate of gross benefits for the programme is $1.58 billion compared with resource costs of $0.37 billion, a net benefit of $1.21 billion. Greater net benefits may be achievable through consideration of certain targeting strategies, although the administrative, incentive and stigmatisation costs of targeting must be weighed up against any potential savings that targeting may bring. Strategies that may be considered to increase net benefits include: prioritising the insulation component relative to the clean heating component of the programme; targeting clean heating to houses that use reticulated gas rather than electricity for heating prior to treatment; targeting insulation to houses in cooler rather than warmer areas; and targeting insulation to low income households and other at-risk groups in terms of illness.

1 Introduction

1.1 Background

This report summarises the results of an analysis of the costs and benefits of the Warm Up New Zealand: Heat Smart programme. Under the programme, subsidies are provided towards the costs of retrofitting insulation and/or installing clean heating for pre-2000 houses. The benefits of the programme are expected to comprise:

- improvements in comfort of houses because of increased temperatures and reduced damp and draught;
- improved health outcomes as a result of the changes in temperature and damp/draught;
- increased energy efficiency of houses (reduced energy requirement to meet temperature outcomes) that may result in some overall reduction in energy consumption;
- an increase in employment and production, at a time of depressed economic activity, as a result of increased activity in affected sectors.

The benefits are expected to be shared between households and the producers and installers of insulation. The different benefits have been analysed in three separate papers produced as part of this study. These papers analyse the impacts on:

- energy use;[8]
- health outcomes;[9] and
- producer surpluses, with additional data on employment.[10] The producer surplus and additional employment benefits are deducted from gross costs in order to calculate the actual resource costs (ie. opportunity costs) of the programme.

The costs of the programme are assessed in this report and include the resource costs of the additional insulation and clean heating plus the administrative costs falling on the government. Administrative costs for companies are assessed as part of the report on impacts on industry.[11] The costs of the programme are then compared with the benefits to arrive at a calculation of net benefits attributable to the programme.

The different elements of the analysis are set out below.

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[8] Grimes A, Young C, Arnold R, Denne T, Howden-Chapman P, Preval N and Telfar-Barnard L (2011) Warming Up New Zealand: Impacts of the New Zealand Insulation Fund on Metered Household Energy Use. Report for Ministry of Economic Development.

[9] Telfar-Barnard L, Preval N, Howden-Chapman P, Arnold R, Young C, Grimes A, Denne T (2011) The impact of retrofitted insulation and new heaters on health services utilisation and costs, pharmaceutical costs and mortality. Evaluation of Warm Up New Zealand: Heat Smart. Report for Ministry of Economic Development.

[10] Covec (2011) Impacts of the NZ Insulation Fund on Industry and Employment. Report for Ministry of Economic Development.

[11] Covec (op cit).

1.2 The Programme

The Warm Up New Zealand: Heat Smart programme started in July 2009 and provides co-funding to encourage the retrofitting of insulation and clean heating to houses built prior to 2000. It replaced or enhanced a number of existing government retrofit programmes. The underlying objectives of the programme are: [12]

- Helping New Zealanders to have warm, dry, more comfortable homes;
- Improving the health of New Zealanders;
- Saving energy;
- Improving New Zealand's housing infrastructure through the uptake of cost effective energy efficiency measures; and
- Stimulating employment and developing capability in the insulation and construction industries.

The programme provides partial funding for the purchase and installation of eligible products by approved providers. Depending on their existing insulation and heating, and the characteristics of the house, applications to the Fund may be for funding for insulation and clean heat, insulation only, or clean heat only. The elements of the programme are set out in Table 1.

Table 1 Eligible Recipients of Programme Funding

Recipients[(1)]	Insulation	Clean heating
Homeowners who hold Community Services Cards	60% of the total cost, or more[(2)]	$1200 (incl GST)
Landlords with tenants who hold Community Services Cards	60% of the total cost	$500 (incl GST)
All other houses	33% of the total cost up to $1300 (incl GST)	$500 (incl GST)

[(1)] All houses must be built prior to 2000; [(2)] May be higher, if installation qualifies for a special project where third party funding from charities, lines companies or councils is provided
Source: www.energywise.govt.nz/funding-available/insulation-and-clean-heating

The number of houses treated under the programme to date, and the number that are in current targets for future years, are set out in Table 2.

Table 2 Number of houses treated under the programme

	Actual Installations		Targeted Installations		
Intervention	09/10	10/11	11/12	12/13	Total
Insulation retrofits					
Low income	29,249	23,184	45,000	13,500	110,933
Other	22,414	25,912	18,000	1,000	67,326
Total	51,663	49,096	63,000	14,500	178,259
Clean heat					
Low income	7,012	5,692	22,500	6,750	41,954
Other	5,646	5,635	6,000	1,400	18,681
Total	12,658	11,327	28,500	8,150	60,635

Source: EECA

[12] EECA, personal communication.

1.3 Expected Effects – Lessons from Previous Research

Prior research has shown that the thermal quality of housing affects the health of the population and household energy use. Housing improvements, especially to those exposed to substandard housing, can help improve the health of occupants and potentially prevent ill health. Also, retrofitting houses with insulation and/or clean heating can lead to energy savings through houses becoming more energy efficient, although the savings are limited by the extent that households increase household temperatures (comfort levels) following these retrofits.

1.3.1 Health Effects

Inadequately warmed homes can have health consequences for occupants, particularly during winter periods.[13,14] Colder houses place greater stress on older people, babies and the sick,[15] and are more likely to be damp and provide a favourable growing environment for mould that can cause respiratory symptoms.[16,17] By improving housing quality, especially warmth, these consequences can be minimised and health improvements can be generated.[18, 19]

The potential for health improvements depends on the baseline housing conditions and how well targeted intervention is. There is clear evidence showing that housing interventions can improve house quality, and that these interventions to improve house quality can yield important savings in medical care and improvements in quality of life.[20] Previous research by the University of Otago Housing and Health Research Programme (H&HRP) found a suggestive reduction in respiratory hospitalisations after insulation was retrofitted in dwellings ($p=0.16$ adjusted).[21]

1.3.2 Energy Savings

Retrofitting insulation and installing efficient clean heating improves the energy efficiency of the dwelling, and can lead to energy savings.[22, 23, 24, 25, 26, 27] Research in

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[13] Boardman B (1991) Fuel Poverty: from cold homes to affordable warmth, London: Belhaven Press.
[14] Wilkinson P, Landon M, Armstrong B, Stevenson S, Pattenden S, McKee M and Fletcher T (2001) Cold comfort: The social and environmental determinants of excess winter deaths in England, 1986-96, London: The Policy Press.
[15] Curwen, M (1991) "Excess winter mortality: a British phenomenon?" Health Trends, 4, pp. 169-175.
[16] Tobin R, *et al* 1987. "The significance of fungi in indoor air," Canadian Journal of Public Health. Revue Canadienne de Sante Publique, S1-14.
[17] Institute of Medicine of the National Academies (2004) Damp indoor spaces and health, Washington, D.C.: National Academies Press.
[18] Thompson H et al (2009) The health impacts of housing improvement: a systematic review of intervention studies from 1887 to 2007. American Journal of Public Health, 99 (Supplement 3): S681-S692.
[19] Jacobs et al (2010) A Systematic Review of Housing Interventions and Health: Introduction, methods and Summary Findings. Journal of Public Health Management & Practice, 16(5): S5-S10.
[20] Jacobs et al (op cit).
[21] Howden-Chapman P, Matheson A, Crane J, Viggers H, Cunningham M, Blakely T, Cunningham C, Woodward A, Saville-Smith K, O'Dea D, Kennedy M, Baker M, Waipara N, Chapman R and Davie G (2007) Effect of insulating houses on health inequality: cluster randomised study in the community. British Medical Journal, 334.
[22] Berkhout, PHG, Muskens JC and Velthuijsen JW (2000) "Defining the rebound effect," Energy Policy, 28, pp. 425-432.

Christchurch demonstrated that houses can decrease electricity consumption by around 5% after having insulation retrofitted,[28] and have also been shown to decrease average peak electricity consumption by 18% during winter months.[29] Other New Zealand research has found that houses subject to intervention save on average $25.53 per year on total energy, but spend on average $10.51 more per year on electricity use.[30] Magnitudes of electricity savings are also dependent on the type of heating source being replaced and what it is being replaced with.[31]

Energy efficiency gains can be received by households wholly as energy savings, and therefore reduced household energy costs, or they can substitute part of the cost savings for improvements in comfort and warmth that help to improve health outcomes, a phenomenon commonly known as the 'take-back' or 'rebound' effect.[32,33] Evidence exists that the majority of households 'take-back' energy efficiency improvements as increased comfort levels[34] and that low indoor temperatures induce 'take-back' effects, but the magnitude of 'take-back' reduces as the baseline temperature increases.[35]

1.3.3 Impacts on Producers and Installers

Little research exists specifically looking at the impacts of policies aimed at improving house quality on producers and installers of insulation and clean heating, or the impact on employment levels. Historical data from Statistics New Zealand suggest that imports of glass fibre insulation have noticeably increased in the last three years; however, employment of insulation installers varies depending on the season. Maré discusses impacts of active labour market policies, with respect to wage subsidies, and finds that

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[23] Orion Ltd (2004) "Effects of improved insulation on peak period demand."

[24] Chapman R, Howden-Chapman P, Viggers H, O'Dea D and Kennedy M (2009) Retrofitting houses with insulation: a cost-benefit analysis of a randomised community trial. Journal of Epidemiology & Community Health 63:271-277.

[25] Howden-Chapman P, Viggers H, Chapman R, O'Dea D, Free S and O'Sullivan K (2009) "Warm homes: Drivers of the demand for heating in the residential sector in New Zealand," Energy Policy, 37, pp. 3387-3399.

[26] Phillips Y and Scarpa R (2010) "Waikato Warm Home Study," Paper presented at the 2010 NZARES Conference. Available online at http://purl.umn.edu/96494. Last accessed 11 Jul 2011.

[27] Preval N, Chapman R, Pierse N, Howden-Chapman P, The Housing Heating and Health Group. (2010) "Evaluating energy, health and carbon co-benefits from improved domestic space heating: A randomised community trial," Energy Policy, 38, pp. 3955-3972.

[28] Chapman et al (op cit).

[29] Orion Ltd (op cit).

[30] Preval et al (op cit).

[31] Orion Ltd (2009) "Impact of Environment Canterbury's Clean Heat project on Christchurch electricity usage."

[32] Berkhout et al (op cit).

[33] Howden-Chapman P, Viggers H, Chapman R, O'Dea D, Free S and O'Sullivan K (2009) "Warm homes: Drivers of the demand for heating in the residential sector in New Zealand," Energy Policy, 37, pp. 3387-3399.

[34] Howden-Chapman P, Crane J, Matheson A, Viggers H, Cunningham M, Blakely T, O'Dea D, Cunningham C, Woodward A, Saville-Smith K, Baker M and Waipara N (2005) "Retrofitting houses with insulation to reduce health inequalities: aims and methods of a clustered, randomised trial in community settings," Social Science and Medicine, 61, pp. 2600-2610.

[35] Milne G and Boardman B (2000) "Making cold homes warmer: the effect of energy efficiency improvements in low-income homes," Energy Policy, 28, pp. 411-424.

policies aimed at improving employment levels have a net employment effect (total additional employment over what would have happened otherwise) of around 5-10% of gross employment outcomes (total employment as a result of policy).[36]

1.4 Methodology

Taking account of the results of previous studies, the cost benefit analysis (CBA) incorporates the following costs and benefits:

Costs

- The administrative costs of the programme for the government;
- The costs of raising revenue for the subsidy – the deadweight costs of taxation;
- The costs of the insulation and clean heaters.

Benefits

- The reductions in energy costs;
- The savings in CO_2 emission costs not included in the fuel price;
- Improvements in health outcomes;
- Producer surpluses for suppliers of insulation and clean heaters, ie. the difference between the price and the costs of supply. This benefit is deducted from gross costs to calculate resource costs in the study.

The analysis applies to the insulation and clean heating that is estimated to have been installed as a result of the programme, recognising that some proportion of the total number of households that received a subsidy would have installed these products anyway.

The benefits are estimated over the expected duration of those benefits. For insulation this might be a long period, ie. the duration of the house. The duration of a clean heater is expected to be shorter. However, it is likely that, for some houses at least, some proportion of the benefit will not be additional as it is bringing the timing of the installation forward in time, rather being an absolute saving, ie. some of the houses that received insulation or heating under the programme would have purchased it in the absence of a subsidy at some point in the future; this also means some of the costs are also simply brought forward in time. The starting place is an assumption that insulation benefits will last for 30 years[37] and clean heating for 10 years.

Costs and benefits that fall in different time periods are discounted and we discuss the discount rate used below.

1.4.1 Wider Economic Impacts

The terms of reference for the analysis include consideration of the wider economic impacts of the programme, particularly on employment. These issues were addressed in

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[36] Maré D (2005) "Indirect Effects of Active Labour Market Policies," Motu Working Paper 05-01, Motu Economic and Public Policy Research, Wellington.

[37] This is the same assumption used by Chapman R, Howden-Chapman P, Viggers H, O'Dea D and Kennedy M (2009) Retrofitting houses with insulation: a cost-benefit analysis of a randomised community trial. Journal of Epidemiology & Community Health 63:271-277.

the separate report on producers and employment, and we extend the findings from that report to the whole programme in this report. Employment benefits are not part of the cost benefit analysis (the analysis does not attribute additional benefits to employment per se). Rather, labour costs are included on the basis of their opportunity costs (the assumption that the costs of labour in insulation and clean heat provision reflect the value of the labour in some other alternative activity that is displaced). However, labour is measured as having a zero cost if it would otherwise have been unemployed. Thus, in this analysis, some proportion of the private costs of insulation is not counted as an opportunity cost.

1.5 Discount Rate

Discount rates are used in cost benefit analysis to take account of the opportunity costs relating to the timing of costs and benefits. There are two broad approaches:

- Discount rates based on the opportunity cost of consumption assume that policy changes the timing of consumption, eg. spending on insulation/clean heating displaces the consumption of other goods and services, and the benefits of reduced energy and medical costs allows additional consumption. Discount rates based on the opportunity cost of consumption reflect the preference of people to consume sooner rather than later, the expectation of rising incomes (and thus an expectation of a declining marginal utility of income) and some risk of disaster that will not enable future consumption.

- Discount rates based on the opportunity cost of investment assume that policy displaces investment that would have earned a return, eg. spending on insulation/clean heating reduces savings and the availability of capital. Discount rates based on the opportunity cost of investment measure expected market returns on marginal investments.

NZ Treasury recommends an approach that is based largely on an estimate of the opportunity cost of investment (or opportunity cost of capital), estimated as the pre-tax rate of return on investment by the private sector.[38] However, many other countries use rates based on an opportunity cost of consumption (social rate of time preference).[39] The approaches result in a wide range of values, from 2-3% in the US for environmental projects, 3.5% (but falling to 1% for costs and benefits in the distant future) in the UK and 10-15% in a number of developing countries.[40]

The New Zealand Treasury recommends a rate of 8% (real) for energy policy and other policy issues where there is no specific rate. However, other analyses in New Zealand have produced much lower numbers including an estimate by MED of a social rate of time preference of 4.4% (real) undertaken in the context of choosing a discount rate for analysing the government's energy strategy,[41] and a rate of 2.7% to 4.2% (real)

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[38] NZ Treasury (2008) Public Sector Discount Rates for Cost Benefit Analysis.

[39] See range of values in Harrison M (2010) Valuing the Future: the social discount rate in cost-benefit analysis. Australian Government Productivity Commission.

[40] Harrison op cit.

[41] MED (2006) Choice of Discount Rate for the New Zealand Energy Strategy (NZES). POL/1/39/1/1.

recommended by Castalia for use in the Grid Investment Test to analyse the costs and benefits of upgrades to the electricity transmission system.[42]

For analytical robustness and to cover this range, we have used real discount rates of 2.5%, 4% and 8%.

1.6 Additionality

As noted above, some of the activity subsidised under the programme would have occurred without it. Part of the analysis is thus the degree of additionality, ie. the proportion of the total number of installations that are additional to that which would have occurred without the programme.

The costs and benefits of the programme include fixed and variable elements. The fixed elements are the costs of administering the programme, including the costs associated with raising the revenue for the subsidy. These apply regardless of the extent to which the programme encourages additional production and installation of insulation and clean heating.

In contrast, the benefits of the programme and the costs of additional supply of insulation/clean heating are proportional to the estimate of additionality. Where the subsidies have been applied to insulation and clean heating that would have been installed in the absence of the programme there are no benefits and no additional costs of production and installation.

Additionality has been estimated on the basis of econometric analysis of sales of insulation. Regression analysis was used to explain the quantity of insulation installed on the basis of building consent activity and the number of houses subsidised.[43] In the central estimate, 85% of the houses that were insulated under the programme would not have installed insulation in the absence of the subsidy (Table 3). It was not possible to undertake a similar analysis for clean heating as no factors were identified to explain the number installed historically. In estimating the producer surplus associated with clean heating the same assumption was used as for insulation, ie. that 85% were additional.

Table 3 Projected Increases in Insulation Consumption as a Result of the Programme (2009-10)

Estimate	Quantity installed per house (m^2)	Total quantity installed (million m^2)	% of Subsidised
Subsidised Sample	150.5	7.8	100.0%
Low	61.1	3.2	40.6%
Central	127.2	6.6	84.5%
High	193.4	10.0	128.5%

Source: Covec (2011) Impacts of the NZ Insulation Fund on Industry and Employment. Report for the Ministry of Economic Development

The analysis of additionality was based on few data points: data were available for seven years only and three in which a subsidy programme existed. Reflecting the small number of data points, there was a significant uncertainty range: 41% to 129% at the

[42] Castalia (2006) Discount Rate for the Grid Investment Test. Report to Transpower.

[43] Covec (op cit).

95% confidence level (corresponding to the Low and High estimates in Table 3). This wide range of additionality estimates is used in sensitivity analysis.

However, this analysis represents only one aspect of additionality. One possibility is that the benefits that flow from the subsidised installations only bring these expenditures forward in time rather than representing fully additional expenditures. These effects could be picked up if a longer dataset was available. However, we have no data to test this hypothesis and instead we illustrate the effects of assuming a shorter duration of benefits using a sensitivity analysis.

2 Cost Analysis

2.1 Government Administration Costs

To administer the programme, EECA employs 22.5 full time equivalents (FTEs) and 2.1 FTEs of contracted labour.[44] The costs associated with this are estimated at $2.5 million in the first year and to total $7.3 million over the 4 years of the programme. In the analysis of employment effects, it was noted that the introduction of the programme included a period of relatively high unemployment as a result of the global recession. [45] Some proportion of the labour costs would have a zero opportunity cost as, in the absence of the programme, they would have been expected to be unemployed. The number of employees estimated to be additional, and therefore with a zero opportunity cost, ranges from 3 to 15;[46] labour costs are adjusted to take account of the lower average opportunity costs. In addition there are costs associated with marketing, audits, travel, legal advice and so on (Table 4).

Table 4 Costs of government overheads ($ million)

Item	2009-10	2010-11	2011-12	2012-13
Financial Costs				
Marketing	3.5	3.5	3.0	1.7
Audits	1.1	1.4	1.4	0.5
Staff	1.0 - 2.2	0.7 - 1.7	0.7 - 1.7	0.4 - 0.9
Other (travel, legal etc)	1.2	1.0	0.9	0.6
Total	**6.8 – 8.0**	**6.6 - 7.6**	**6.0 – 7.0**	**3.2 - 3.7**

Source: EECA; staff costs – see text

2.2 Deadweight costs of taxation

The deadweight cost of taxation is the result of the distortionary effects of tax.[47] When taxes are raised via increasing the costs of consumption (GST) or reducing the rewards of work (income tax), behaviour is changed. People spend and work less than they would otherwise, and they spend and work differently. This distortion to consumption behaviour involves a cost that is additional to the amount of tax paid. As a result, the Treasury recommends that public expenditures should be multiplied by a factor of 1.2 to take account of these deadweight costs.[48]

Although the government has not raised tax specifically to pay for the subsidy programme, the inter-temporal government budget constraint means that there has to be a long run relationship between government expenditure and the taxation requirement.

[44] EECA, personal communication.

[45] Covec (op cit).

[46] Covec (op cit).

[47] NZ Treasury (2009) Estimating the Distortionary Costs of Income Taxation in New Zealand. Background Paper for Session 5 of the Victoria University of Wellington Tax Working Group; Creedy J (2009) The Distortionary Costs of Taxation. Paper prepared for the New Zealand Treasury.

[48] New Zealand Treasury (2005) Cost Benefit Analysis Primer. In comparing our results with CBAs of other projects, it is important to ensure that comparators have also included the deadweight costs of taxation into their analysis.

However, for analysis care must be taken to apply this multiplier equally to revenue raised and to additional tax paid, eg. the GST paid on goods and services consumed as a result of the subsidy reduces the need for government to raise revenue elsewhere. Thus our concern is just with the distortionary effect of the net tax burden.

The net tax burden can be estimated from the amount paid as grants, plus the costs of overheads, less the tax on additional expenditure. Expenditure is estimated from:

- the grants paid;
- an estimate of the proportion of costs on products and their installation that is covered by grants; and
- the percentage of installations that are additional.

EECA data on the initial set of grants suggests that grants are approximately 50% of total costs, reflecting the mix of general and low income households included in the programme. The estimated deadweight costs are shown in Table 5 for central (85%), low (41%) and high (129%) levels of additionality. The deadweight costs are lower where there is high additionality as it means that a greater portion of GST paid on expenditure is additional and thus the net tax requirement is lower.

Table 5 Estimates of deadweight costs of net taxation ($ million)

	2009-10	2010-11	2011-12	2012-13
Grants	87.8	101.2	101.5	27.5
Overheads	7.4	7.1	6.5	3.4
Total	95.2	108.3	108.0	30.9
GST on expenditure (central additionality)(1)	22.3	25.7	25.7	7.0
PAYE(2)	0.6	0.5	0.5	0.2
GST on overhead expenditure	0.7	0.8	0.7	0.4
Total	23.6	26.9	26.9	7.6
Net Government Expenditure	71.6	81.4	81.2	23.3
Deadweight loss – central additionality	14.3	16.3	16.2	4.7
Deadweight loss – low additionality	16.6	19.0	18.9	5.4
Deadweight loss – high additionality	12.0	13.6	13.6	3.9

(1) GST = 15%; estimated on 85% of expenditure, calculated as grants x 2; (2) Calculated using an average tax rate of 24.1%, based on the average EECA staff cost ($2.5 million/24.6 FTEs)
Source: expenditure data from EECA adjusted to take account of reduced labour costs – midpoint of range in Table 4

2.3 Costs of Installations

The cost of the installations is a resource cost and is equal to the opportunity cost of allocating resources to the production and installation of insulation and clean heating. We calculate this as the costs of the products and their installation to households, less the estimated producer surplus that is discussed below. The producer surplus is the difference between the costs of supply of insulation/clean heating and the retail costs paid by households; it includes an assessment of the extent of the retail cost that represents a pure profit to the producers and installers, and the proportion of labour costs that are estimated to have a zero cost because of the level of unemployment in the economy.

The average costs of insulation across all houses in the initial data provided by EECA is $2,498/house and the average cost of clean heating is $2,977/house. This results in the estimates of total costs shown in Table 6. The resource costs are these costs less the producer surplus estimates that are discussed below (see Table 24) and less the costs of labour that would otherwise have been unemployed. Total resource costs (opportunity costs) once these deductions are made are summarised in Table 7, taking account of the assumption that only 85% of total costs are additional.

Table 6 Total costs of installations ($ million) including GST

Product Installed	09/10	10/11	11/12	12/13
Insulation	129.1	122.6	157.4	36.2
Clean heat	37.7	33.7	84.8	24.3
Total	166.7	156.4	242.2	60.5

Table 7 Resource costs of installations ($ million)

Product installed	09/10	10/11	11/12	12/13
Insulation	59.9	56.9	73.0	16.8
Clean heat	21.5	19.2	48.3	13.8
Total	81.4	76.1	121.3	30.6

3 Benefits

3.1 Benefits Included

Benefits included in the analysis are those relating to metered energy savings (electricity and reticulated gas) and improved health outcomes. There will be some additional benefits associated with consumer comfort and potentially to savings on non-metered energy (wood, LPG, etc), but these have not been measured. The analysis measures the benefits that accrue to households that would not install insulation or clean heating in the absence of the programme but that do so as a result of the programme. The difference may be attributed to the net benefits to the household that arise from the subsidy (ie. the household was not initially willing to install if they had to pay the full price, but are willing to do so at the subsidised price.) It may also, in part, be attributed to the educational/information benefits that arise as a result of the programme that makes people understand better the benefits of insulation and/or clean heating.

Our analysis uses the results from the prior three papers in the study (footnotes 8-10). The health and industry benefits are quantified in monetary terms in those papers, while the energy effects are quantified in terms of energy savings. We convert the energy savings estimates into monetary terms in this paper. We leave the comfort benefits and non-metered energy savings as one-sided uncertainties in the analysis below; total benefits will therefore be higher than those measured.

3.2 Metered Energy Savings

3.2.1 Volume Savings

Impacts on metered energy use of the additional insulation and clean heating have been estimated from an analysis of the differences between metered energy use in treated versus untreated houses. The addresses of the houses where the interventions occurred were obtained and, using QVNZ data, these were matched with houses with similar characteristics[49] to identify a set of controls. Data were then obtained from energy companies on metered energy consumption (electricity and reticulated gas) before and after the date of treatment for treated houses and their controls. A regression model was developed that estimated the difference in monthly electricity and total metered energy consumption between houses with and without interventions as a function of monthly regional temperatures and the intervention type (insulation and/or clean heating). The approach and results are described in detail in the separate energy study.[50]

The approach has limitations. Because we have used metered data only to estimate changes in energy use, we have no data on the impacts on other fuels, eg. coal, wood or LPG. Sensitivity analysis reported in the energy study found no significant difference in metered energy savings according to whether a treated house already had a non-

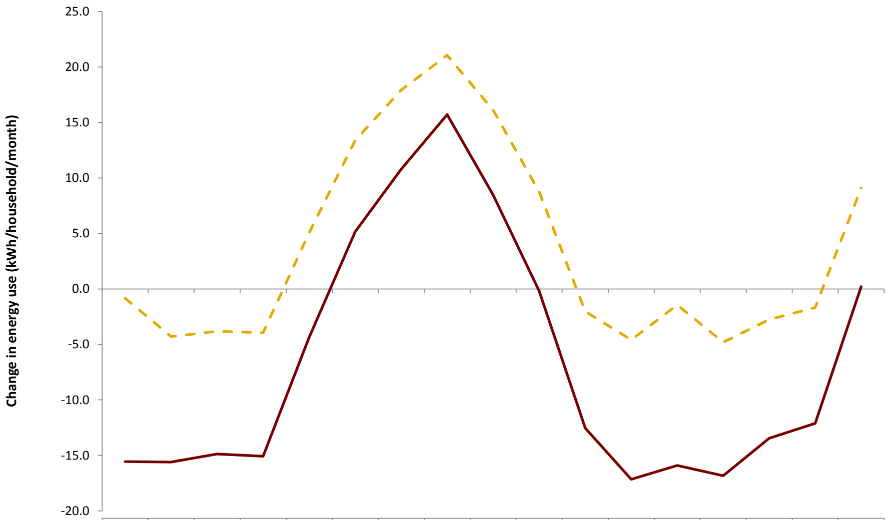
[49] This was location (Census area unit, similar to a suburb), dwelling and house type, number of levels, age (decade of build), floor area and number of bedrooms, whether there is a garage under the main roof and its size (number of vehicles), house construction material (walls and roof), whether or not the house was modernised, and quality (building and roof condition) of the dwelling.

[50] Grimes A, et al (op cit).

metered energy heating source prior to intervention, but the available sample for this analysis was limited. To the extent that additional non-metered energy savings are made in treated houses, these savings are left as a one-sided uncertainty in the analysis.

Estimates of the average change in energy use per house across New Zealand are shown in Figure 1. The analysis suggests that there is a reduction in energy consumption in winter but an increase in summer.

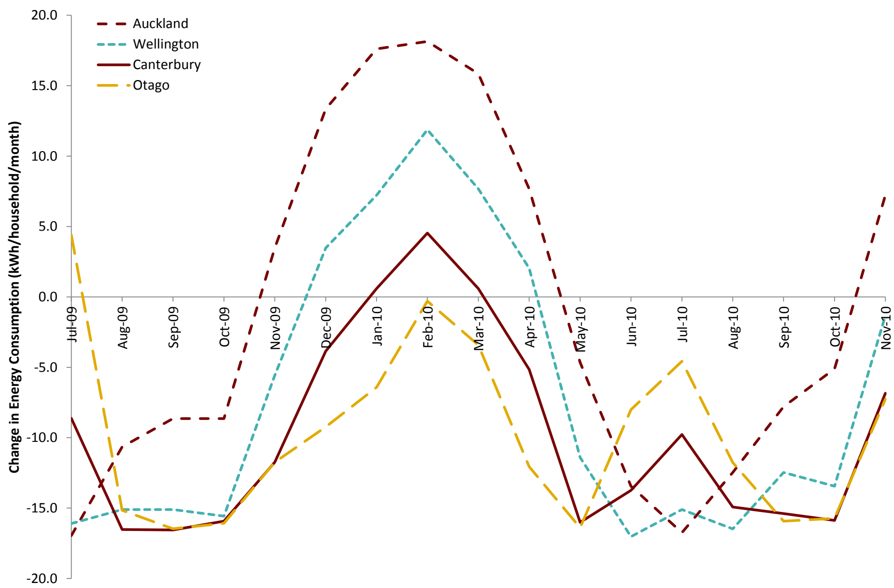
Figure 1 Change in Metered Energy Consumption following Treatment (New Zealand)



	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10	Jul-10	Aug-10	Sep-10	Oct-10	Nov-10
Insulation	-15.6	-15.6	-14.9	-15.1	-4.3	5.2	10.8	15.7	8.5	-0.2	-12.5	-17.2	-15.9	-16.8	-13.5	-12.1	0.2
Clean heat	-0.8	-4.3	-3.8	-3.9	5.1	13.4	17.9	21.0	16.1	8.8	-2.0	-4.6	-1.4	-4.8	-2.8	-1.7	9.1

The effects vary significantly by region also. Figure 2 shows the effects of insulation on total metered energy use in four regions of New Zealand: Auckland, Wellington, Canterbury and Otago. The impact varies significantly. The period in which energy use increases extends from November to April in Auckland, but not at all in Otago (apart from a trivial increase in July 2009).

Figure 2 Change in Metered Energy Consumption following Insulation Treatment by Region



The aggregate impact across a year is shown for each region in Table 8; this includes the impacts on electricity and all metered energy consumption as a result of treatment with insulation and clean heating. The South Island data are the results calculated from the regression analysis using data for houses with no reticulated gas. In practice there may be savings of other fuels (coal, wood, LPG), but we have no data on these changes, as noted above.

Table 8 Impact on Annual Metered Energy Consumption of Treatment by Region (kWh/house)[(1)]

	Insulation			Clean heating		
	Electricity	**Other**	**All metered**	**Electricity**	**Other**	**All metered**
NZ	-70.2	18.7	-51.5	144.6	-78.8	65.9
Northland	-2.3	30.5	28.2	119.0	3.7	122.6
Auckland	-12.0	28.4	16.4	135.4	-25.5	109.9
Waikato	-66.0	18.8	-47.3	152.1	-83.2	68.9
Bay of Plenty	-85.7	14.3	-71.4	166.2	-108.6	57.6
Gisborne	-42.7	23.2	-19.5	139.8	-52.4	87.5
Hawke's Bay	-83.9	16.1	-67.8	151.1	-96.3	54.9
Taranaki	-108.7	11.8	-96.8	161.7	-128.1	33.5
Manawatu-Wanganui	-87.0	15.4	-71.6	155.5	-103.8	51.7
Wellington	-77.2	17.9	-59.3	141.1	-80.9	60.2
Marlborough	-64.9		-64.9	143.3		143.3
Nelson	-58.1		-58.1	135.4		135.4
Tasman	-81.1		-81.1	136.8		136.8
West Coast	-120.4		-120.4	150.7		150.7
Canterbury	-99.1		-99.1	140.9		140.9
Otago	-111.0		-111.0	159.9		159.9
Southland	-92.8		-92.8	188.0		188.0

[(1)] Measured over July 2009 -Nov 2010; months with 2 records are averaged, eg (July 2009 + July 2010)/2.
Source: Grimes A, et al (op cit).

The results suggest that:

- following insulation there is a net reduction in electricity consumption in all regions and a net increase in other metered energy use in areas with reticulated gas (North Island);
- following installation of clean heating, there is a net increase in electricity use in all regions and a reduction in other energy use in all regions (apart from a trivial increase in Auckland).

To estimate the value of these savings, the electricity savings need to be estimated by time of day because: (1) generation costs vary with total instantaneous consumption, and (2) capacity costs vary with peak demand.

Orion Energy analysed the difference in peak demand for electricity of 116 Christchurch households before and after the installation of insulation, compared with changes in electricity demand in a control group of houses.[51] They estimated the average net effect of installing insulation was an 18% (0.39kW) reduction in peak winter demand; they also noted a 1-2°C increase in internal temperature. However, the Orion data do not include estimates of the change in energy use outside of the winter peak; nor do they include estimates of the time of day of reductions.

[51] Orion (2004) Effect of improved insulation on peak period demand.

EECA estimates the heating profiles for different locations and time periods using the results of modelling by BRANZ. Different profiles are produced for different regions of New Zealand; an example is given in Table 9, with the full set included in Annex 1. The definitions used are listed in Table 10.

Table 9 Heating Profiles for Auckland (% of heating energy used in different periods)

Time period	Profile 1: 24hr (living), evening only (bedrooms+kitchen)	Profile 2: Evening only (living)	Profile 3: Evening only (living+ bedrooms+kitchen)
Summer day	1%	0%	0%
Summer night	4%	0%	0%
Summer peak	0%	0%	0%
Winter day	22%	77%	56%
Winter night	33%	0%	0%
Winter peak	18%	17%	33%
Shoulder day	5%	5%	8%
Shoulder night	14%	0%	0%
Shoulder peak	3%	0%	2%
Total	100%	100%	100%

Source: EECA

Table 10 Definitions used in heating profiles

Season	Definition	Time of day	Definition
Winter	May to September	Day	09:00 to 17:00 & 20:00 to 23:00
Summer	December to February	Night	23:00 to 07:00
Shoulder	March-April & October-November	Peak	07:00 to 09:00 & 17:00 to 20:00

Source: EECA

To make use of these profiles we need an estimate of the proportion of households that are characterised by the different profiles. The only data we have identified are the modelling assumptions used by BRANZ in its Household Energy End-use Project (HEEP), and as recommended by EECA (Table 11). It shows the percentage of houses that heat specified rooms at a specified time, eg. 1.5% of houses only heat their living room on a weekday in the morning, but 45.5% heat the living room on a weekday in the evening only.

We use these to estimate the proportion of households under each profile from Table 9. The three profiles do not match the wide range of heating options, but we use the data to make the assumed spread shown in Table 12.

Table 11 Percentage of houses on different heating schedules

Room:	Living		Bedroom		Utility	
Time period:	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend
Morning	1.5%	1.8%	3.2%	2.6%	3.0%	2.5%
All day	0.7%	1.6%	0.3%	0.7%	0.7%	1.0%
Evening	45.5%	37.2%	21.8%	19.7%	11.4%	9.0%
Night	1.7%	1.8%	6.7%	6.5%	1.2%	1.3%
Morning/day	0.0%	0.0%	0.2%	0.0%	0.2%	0.3%
Morning/evening	13.9%	11.3%	6.0%	4.7%	4.0%	3.0%
Morning/night	1.0%	1.0%	0.2%	0.3%	0.0%	0.0%
Morning/day/evening	9.3%	12.3%	1.4%	2.3%	3.0%	4.2%
Morning/evening/night	0.3%	0.3%	0.0%	0.3%	0.7%	0.5%
Daytime/evening	5.0%	10.3%	1.0%	2.0%	2.5%	3.0%
Evening/night	3.2%	2.8%	4.0%	4.0%	1.0%	0.7%
Daytime/evening/night	0.5%	0.8%	0.0%	0.0%	0.3%	0.5%
24 hours	10.9%	10.8%	5.0%	4.7%	4.7%	4.8%
No heating	6.5%	8.0%	50.2%	52.2%	67.3%	69.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Burgess J (2007) Accurate modification for New Zealand. BRANZ EC1353

Table 12 Proportion of houses in different heating profiles

Profile	Data used(1)	% of total	Adjusted %
1- 24hr (living), evening only (bedrooms + kitchen)	All day (living) + morning/evening/night (living) + daytime/evening/night (living) + 24 hours (living)	19%	36%
2 - Evening only (living)	Evening (living) + evening/night (living) – Evening (bedroom) - evening/night (bedroom)	22%	42%
3 - Evening only (living + bedrooms + kitchen)	Evening (utility) + evening/night (utility)	12%	22%
Total		52%	100%

(1) Weighted average of weekday and weekend used

These data enable us to combine the monthly changes in energy use in different regions to times of day. The household level energy savings are spread across the different regions on the basis of the initial data on the location of installations (Table 13). We assume that this distribution continues.

Table 13 Proportion of Installations in Each Region (July 2009 – May 2010)

Region	Insulation	Clean Heating
Northland	5%	3%
Auckland	21%	14%
Bay of Plenty	7%	6%
Waikato	10%	5%
East Coast	8%	7%
Manawatu-Wanganui	4%	3%
Taranaki	3%	1%
Wellington	12%	12%
North Island	70%	50%
Nelson Marlborough Tasman	4%	6%
Canterbury	18%	37%
West Coast	0%	0%
Otago	5%	6%
Southland	3%	1%
South Island	30%	50%

Combining the household level energy savings (Table 8) with the heating profiles (Table 9 and Annex 1), the proportion of houses in each profile (Table 12) and the distribution of interventions (Table 13), the weighted average energy savings from the insulation and clean heat programmes are summarised in Table 14.

Table 14 Savings in Energy Use from Interventions (kWh/household per year) (1)

	Summer Day	Summer Night	Summer Peak	Winter Day	Winter Night	Winter Peak	Shoulder Day	Shoulder Night	Shoulder Peak
Electricity from Insulation									
NZ	-3.23	-16.41	-1.26	43.59	9.77	24.38	9.99	5.39	4.19
NI	-4.13	-22.22	-1.64	44.76	9.99	21.76	5.51	3.50	2.17
SI	-1.17	-3.03	-0.40	40.90	9.29	30.40	20.32	9.76	8.83
Other Energy from Insulation									
NZ	-1.42	-6.79	-0.56	-0.52	-0.12	-0.19	-3.32	-2.51	-1.14
NI	-2.03	-9.74	-0.80	-0.75	-0.17	-0.28	-4.76	-3.60	-1.64
SI	-	-	-	-	-	-	-	-	-
Electricity from Clean Heat Installations									
NZ	-6.67	-20.03	-2.63	-52.73	-11.88	-32.63	-22.15	-13.06	-8.88
NI	-5.07	-25.12	-1.99	-51.69	-11.53	-25.14	-19.60	-14.34	-6.94
SI	-8.53	-16.15	-3.36	-55.58	-12.65	-41.24	-25.25	-12.15	-11.02
Other Energy from Clean Heat Installations									
NZ	-2.44	-10.90	-0.95	29.22	6.52	14.61	0.98	0.44	0.46
NI	-4.58	-21.38	-1.79	57.28	12.78	28.09	1.51	0.46	0.81
SI	-	-	-	-	-	-	-	-	-

(1) Negative numbers are increases in energy use

We also consider changes in peak use separately so that we can estimate the impacts on the long run requirement for electricity capacity (generation and transmission). We estimate the peak use by taking the total savings for the winter peak periods and assuming it is uniform over winter peak hours (Table 15).

Table 15 Savings in Peak Electricity Use (kW/household)(1)

	Insulation	Heat Pump
New Zealand	0.020	-0.027
North Island	0.018	-0.021
South Island	0.025	-0.034

(1) Negative numbers are increases in energy use

To take account of transmission losses, we use the following factors to scale up the savings:

- to value the savings in electricity we increase metered electricity savings by 6.39%. This represents the average (2006-2010) difference between the total electricity entering the system and the total (observed) electricity demand.[52] Total electricity entering the system is used because this is the point at which prices are measured;

[52] MED (2011) Energy Data File. Table G.1.

- to value savings in CO_2 emissions, we increase electricity savings by 12.01%. This represents the average (2006-2010) difference between the total (gross) electricity generation and the total (observed) electricity demand.[53]

These adjustments are made below when we calculate savings in costs.

3.2.2 Valuing Energy Savings

Changes in energy use have different benefits in the long and short run. In the short run there is a saving from reduced fuel consumption either used directly (eg. as gas for heating) or indirectly in electricity generation. In the long run there are savings from the reduced capacity requirement for energy supply. To estimate the benefits we use different approaches for electricity and gas.

For electricity we use the same broad approach as adopted by KEMA in estimating avoided costs of electricity efficiency measures;[54] this is to estimate the fuel savings separately from the capacity savings. The fuel savings are based on estimates of reduction in kWh of electricity consumption; we spread estimates of monthly savings over different hours of the day to estimate the savings in generation costs using time-of-day wholesale prices. The capacity savings, for generation and transmission, are based on reductions in peak demand, using the change in winter peak and a capacity cost based on the costs of new generation and transmission.

For gas we take a simpler approach, using a delivered price of gas as the basis for our estimate of the savings in costs of supply. This is because gas supply does not have the same variability in supply costs over time as does electricity.

Electricity

To estimate the impacts on electricity costs we use the following assumptions:

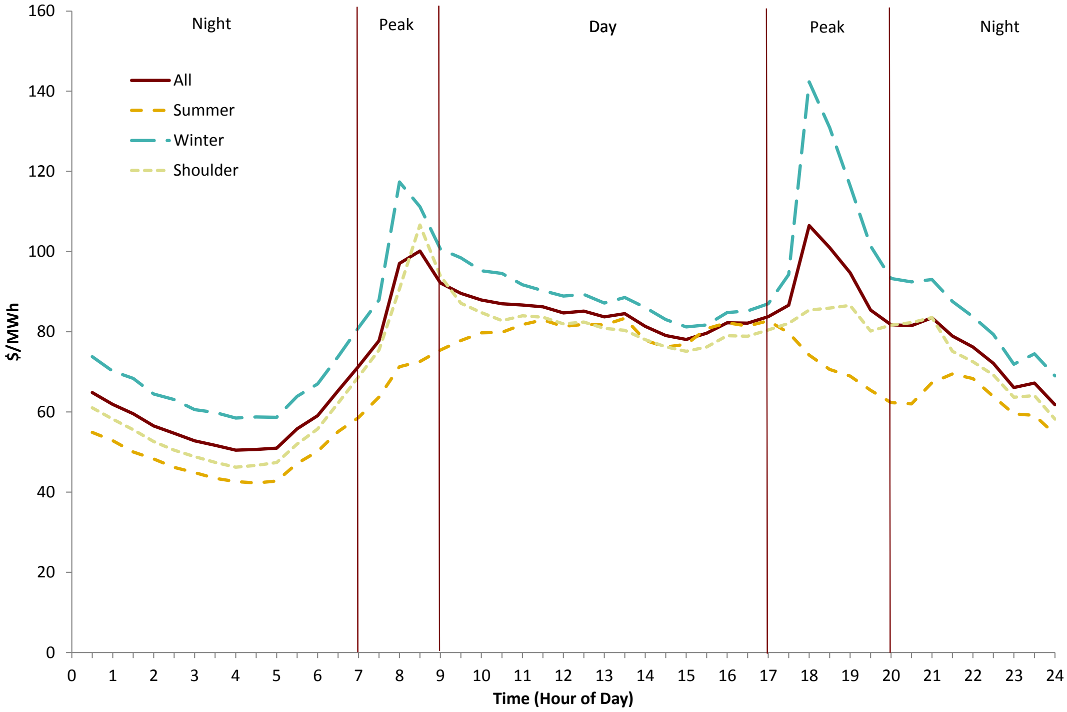
- Marginal generation costs are estimated using time of day pricing at the Haywards node, calculated as a percentage of the annual average price. This is then combined with MED's projections of future (annual average) electricity prices to estimate future time of day prices;[55]
- Generation capacity costs are based on the capital costs of a gas peaker, the same assumption as used by KEMA. We use a value of $1,000/kW derived from estimates by PB Consulting;[56]
- Transmission capacity costs use the same assumption as used by KEMA, ie. $300/kW.

There are differences in the costs of electricity supply over time that reflect the source of generation. These result in differences in price by time of day. Average time of day prices (for 2006-10) for electricity in different seasons are given in Figure 3. These half

[53] MED (2011) Energy Data File. Table G.1.
[54] KEMA (2007) New Zealand Electric Energy-Efficiency Potential Study Volume 1. Electricity Commission Wellington, New Zealand.
[55] MED Energy Outlook – wholesale electricity price projections with no carbon cost.
[56] PB (2009) Thermal Power Station Advice. Report for the Electricity Commission.

hourly prices are used to estimate relative prices in Table 16, ie. a summer night price is 61% of the annual average, but a winter peak price is 143% of the annual average.

Figure 3 Time of day electricity prices at Haywards node (average 2006-10)



Source: Half-hour Data from Electricity Authority Centralised Dataset

Table 16 Relative prices (% of annual average) in different time periods

	Summer	Winter	Shoulder
Day	92%	111%	106%
Night	61%	84%	74%
Peak	85%	143%	115%

Electricity prices are estimated using MED projections of prices[57] with no carbon cost; carbon costs are estimated using a constant value of \$25/t of CO_2 and a marginal emissions factor based on an estimate of the proportion of time that different plants are on the margin for electricity generation for a heating demand profile (Table 17).

Table 17 Derivation of electricity emission factor

	Fuel emissions factor (kg/GJ)	Heat rate (GJ/GWh)	Emissions (t CO_2/MWh)	% of time on margin
Geothermal	0	0	0.1	3%
Wind + Hydro	0	0	0	3%
Huntly coal	91.2	10,500	0.96	70%
Gas - CCGT	57.8	7,050	0.41	7%
Gas peaker	57.8	10,000	0.58	18%
Weighted average			0.81	

Source: Concept Consulting Group (2010) Cost: benefit analysis for increasing the direct use of gas in New Zealand. A report prepared for Gas Industry Co.

57 MED Energy Outlook 2010.

Gas

To value savings in gas use we use an estimate of the retail charge for gas to commercial customers, currently estimated as 5.7c/kWh.[58] We use the commercial charge rather than the residential charge recognising that the gas supply network has more surplus capacity than does electricity, as noted by Concept Consulting, suggesting that small marginal changes in demand may not result in measurable changes in distribution costs. We note that in the short run benefits may be closer to the wholesale price of gas of (2.7c/kWh). However, reductions may have long run benefits in terms of reduced transmission costs and we use a commercial price to take account of some of these benefits.

As for electricity, future price estimates are based on MED's price projections. We use a historical average ratio between commercial and wholesale prices (2.67:1) to scale up MED wholesale price projections.[59]

For CO_2 emissions from gas use we use a weighted average of New Zealand gas production in 2010 at 53.16kg CO_2/GJ.[60]

3.2.3 Present Value of Energy Savings

We assume that the benefits from insulation are achieved over 30 years and the benefits of a heat pump are achieved over 10 years. We discount the energy and carbon savings to present value terms using a discount rate of 4%; we also show the results at alternative discount rates.

Taking account of the additionality of interventions, we use a central estimate of 85% of the changes in energy use being a result of the programme. The results are presented in Table 18. To calculate these benefits, the savings in electricity related costs per household from Table 14 are combined with:

- Estimates of number of houses treated in each year (Table 2);
- The transmission losses to scale up the savings;[61]
- The relative electricity prices in the different time periods in Table 16;
- Projections of future electricity prices from MED's Energy Outlook;
- The assumed additionality of 84.5% (Table 3);
- The assumed marginal electricity emission factor of 0.81t CO_2/MWh (Table 17) and a constant real price of $25/tonne.

Consistent with the energy study, other energy is restricted to reticulated gas. We use an emission factor of 53.16kgCO_2/GJ.

[58] MED (2010) Energy Data File. $33.46/GJ including GST.

[59] MED Energy Outlook 2010.

[60] MED (2010) New Zealand Energy Greenhouse Gas Emissions (2009 Calendar year Edition).

[61] 6.39% for losses between electricity entering the system and final consumption, and 12.01% for losses between generation and consumption.

Table 18 Net Present Value ($ million) of Electricity and Reticulated Gas Savings

	Insulation			Clean heat			
	Energy	CO_2	Total	Energy	CO_2	Total	Total
@ 4%							
Electricity	27.8	0.2	27.9	-8.0	-0.1	-8.0	19.9
Reticulated Gas	-1.5	-0.2	-1.7	1.0	0.1	1.1	-0.6
Total	26.3	-0.0	26.2	-7.0	0.0	-7.0	19.3
@ 2.5%							
Electricity	33.7	0.2	34.0	-8.7	-0.1	-8.8	25.2
Reticulated Gas	-1.9	-0.2	-2.1	1.0	0.1	1.1	-1.1
Total	31.9	-0.0	31.8	-7.7	0.0	-7.7	24.1
@ 8%							
Electricity	18.1	0.1	18.2	-6.5	-0.1	-6.6	11.7
Reticulated Gas	-0.9	-0.1	-1.0	1.0	0.1	1.1	0.1
Total	17.3	-0.0	17.2	-5.5	0.0	-5.5	11.8

We test the impacts of the duration of benefits in sensitivity analysis in Table 19. This is to examine the implications if the programme merely brought installations forward in time; we assume a duration of benefits of 10 years for insulation and 5 years for clean heating. At a 4% discount rate this reduces the benefit by 57%.

Table 19 Sensitivity Analysis: NPV ($ million) of Metered Energy Savings (Limited Duration)(1)

	Insulation			Clean heat			
	Energy	CO_2	Total	Energy	CO_2	Total	Total
@ 4%							
Electricity	13.2	0.1	13.3	-4.7	-0.0	-4.8	8.5
Reticulated Gas	-0.7	-0.1	-0.8	0.6	0.0	0.6	-0.2
Total	12.6	-0.0	12.6	-4.2	0.0	-4.2	8.4
@ 2.5%							
Electricity	14.2	0.1	14.3	-5.0	-0.0	-5.0	9.3
Reticulated Gas	-0.7	-0.1	-0.8	0.5	0.0	0.6	-0.2
Total	13.5	-0.0	13.5	-4.4	0.0	-4.4	9.1
@ 8%							
Electricity	11.1	0.1	11.2	-4.2	-0.0	-4.2	6.9
Reticulated Gas	-0.5	-0.1	-0.6	0.6	0.0	0.6	0.0
Total	10.6	-0.0	10.6	-3.6	0.0	-3.6	7.0

(1) Insulation benefits assumed to last 10 years; clean heating for 5 years

3.3 Health Savings

The health savings are estimated in a similar way to the energy savings. The approach and detailed results (plus sensitivity analyses) are set out in the separate paper, and so the calculations are not reproduced in detail here.[62] The authors conducted a retrospective cohort study. Changes in the numbers of hospitalisation events were analysed using a negative binomial model using individual level exposure time measured in "person-days" controlling for age and season. This analysis did not reveal any statistically significant changes in the rate of hospitalisation following the installation of either insulation or improved heating under the programme.

62 Telfar-Barnard L, et al (op cit).

However, when hospitalisation costs, which included transfers and readmissions, were analysed using a fixed effects model at the household level, small but statistically significant reductions in hospitalisation costs were calculated of approximately $64.44 in total hospitalisation costs per year for a household that received some combination of ceiling or floor insulation under the WUNZ:HS programme. When circulatory illness related hospitalisation costs were analysed separately, a $67.44 yearly saving was found. When respiratory illness related hospitalisation costs were analysed separately a $98.88 reduction was found and for asthma-related hospitalisation costs (a subset of respiratory illness) a higher saving was found at $107.52. Differences between the total hospitalisation figure and the sum of the circulatory and respiratory figures are likely to be the result of statistical noise from hospitalisation types unaffected by changes in insulation.

Limiting analysis to those households that received ceiling or floor insulation and who received WUNZ:HS funding as CSC holders showed that there was a higher average cost saving per year for all four hospitalisation cost categories, compared to those on higher incomes; an overall $109.80 yearly saving in total hospitalisations, $85.56 yearly saving in circulatory illness related hospitalisation costs, $117.84 saving in respiratory illness related hospitalisation costs and a $129.12 yearly saving in asthma-related hospitalisation costs. There was only one statistically significant change for non-CSC holders: a reduction in respiratory hospitalisation costs of $76.56 per year.

Analysis of changes in hospitalisation costs at the household level following improved heating (using the fixed effects model) did not find any statistically significant changes for any group.

Analysis of pharmaceutical costs at the household level found a very small but highly statistically significant reduction in annual pharmaceutical costs as a result of receiving ceiling or floor insulation, except for respiratory pharmaceuticals where costs fractionally increased. There was no change in pharmaceutical costs estimated as a result of receiving a heating retrofit.

Because the study did not have access to records of GP visits, sick days or days off school these potential benefits were imputed for improved insulation and heating based on previous analyses. It was predicted that the average household in the study would gain an additional combined $47.75 from improved insulation and $4.64 from improved heating. CSC households were predicted to gain $95.49 and $9.27 respectively while non-CSC households were not predicted to gain any additional benefit.

Finally, potential reductions in mortality were analysed. The mortality analysis used a sub-cohort of the study group, comprised of those aged 65 and over who were hospitalised, but not deceased, prior to treatment date. The analysis compared mortality rates after treatment between the treatment and control groups, and costed any change. Among those in the mortality sub-cohort who had been hospitalised with circulatory conditions (ICD-10 chapter IX), those in the treatment group had a significantly lower mortality rate than those in the control group. These results suggest that treatment prevented about 18 deaths among those aged 65 and over who had previously been hospitalised with circulatory illness, with a 95% confidence interval of 0 to 45 deaths prevented.

This statistically significant drop in mortality was then modelled based on the demographic structure of the treatment group as at July 2009: it was estimated that there would be an annual reduction of 0.852 deaths per 1000 households (with an average of 3.61 individuals per household). In order to model the value of the life years gained as a result of treatment in a given year a number of decisions had to be made about the value of a life year (the primary analysis used a figure of $150,000 which was based on the lower end of assessments used in a range of cited prior studies), predictions about the additional life years beyond the first gained by a person who avoided mortality due to treatment (four years in the primary analysis) and how to discount these benefits (a range of discount rates was used), with adjustments to avoid "double counting" (annual benefit reduced by 15% in the primary analysis).

The primary model estimated on-going annual benefits from reduced mortality of $439.95 per year per treated household (95% CI [confidence interval] $0.00 - $765.84). The benefit per year was $613.05 (95% CI $0.00 - $1,067.16) for CSC households and $216.38 (95% CI $0.00 - $376.66) for those who did not, reflecting different proportions of vulnerable occupants. Different modelling assumptions lead to a range of outcomes ranging from an annual benefit per household of $23.59 (95% CI $0.00 - $41.06) to $1925.66 (95% CI $0.00 - $3,352.07). It is assumed that these benefits are all the result of improved insulation in the analysis.

Finally, the health report combined the hospitalisation, pharmaceutical and mortality results to estimate total health benefits per household. These total benefits per household are summarised in Table 20.

Table 20 Summary of annual health related benefits (savings) per household treated ($/house)

	Insulation			Clean heating		
	All	CSC[1] Holders	Other	All	CSC Holders	Other
Conservative Assessment						
Hospitalisation and pharmaceutical use related benefits	75.48	109.8	11.04	0	0	0
Benefits imputed from previous studies	47.75	95.49	0	4.64	9.27	0
Value of reduced mortality	439.95	613.05	216.38	0	0	0
Total health benefits	563.18	818.34	227.42	9.27	9.27	0
Focussed Assessment						
Hospitalisation and pharmaceutical use related benefits	168.24	206.04	76.56	0	0	0
Benefits imputed from previous Studies	47.75	95.49	0	4.64	9.27	0
Value of reduced mortality	439.95	613.05	216.38	0	0	0
Total health benefits	655.94	914.58	292.94	4.64	9.27	0

(1) CSC = Community Service Card, available to eligible individuals on a low income.
Source: Telfar-Barnard L, et al (op cit).

Results are presented based on total hospitalisation and pharmaceutical cost savings (conservative assessment) and on circulatory and respiratory hospitalisations cost savings only (focussed assessment). Both the health study and this cost benefit analysis adopt the conservative estimates of benefits as outlined above together with upper and lower confidence intervals for total benefits based on the confidence intervals estimated for the value of reduced mortality (since the benefits of reduced mortality dominate the overall health benefit and the uncertainty from these benefits dominates other sources of uncertainty).

Table 21 shows the present value of the health benefits spread over the duration of those benefits (30 years for insulation and 10 years for clean heat). These are spread over the assumed number of houses treated under the programme (Table 2), adjusted to take account of the assumed additionality of 85% of total installations (Table 3). The health benefits are dominated by the insulation benefits ($1,558 million of a total of $1,561 million).

Table 21 Present value of health benefits at different discount rates ($ million)

	Conservative			Focussed		
Discount rate:	**4.0%**	**2.5%**	**8.0%**	**4.0%**	**2.5%**	**8.0%**
CSC Insulation	1,330	1,626	848	1,486	1,817	947
Other insulation	228	277	148	294	357	190
Total insulation	1,558	1,903	995	1,780	2,174	1,137
CSC Clean heat	3	3	2	3	3	2
Other clean heat	-	-	-	-	-	-
Total clean heat	3	3	2	3	3	2
Total	1,561	1,906	997	1,783	2,177	1,140

As with the energy benefits, we examine the implications of reducing the duration of benefits in Table 22. The shorter duration of benefits (10 years for insulation, rather than 30 and 5 years for clean heating, rather than 10) reduces the total benefits under the conservative scenario (with a 4% discount rate) by approximately 50%.

Table 22 Sensitivity analysis: present value of health benefits at different discount rates ($ million) (Limited Duration)[(1)]

	Conservative			Focussed		
Discount rate:	**4.0%**	**2.5%**	**8.0%**	**4.0%**	**2.5%**	**8.0%**
CSC Insulation	662	723	533	740	808	596
Other insulation	114	123	93	146	159	120
Total insulation	776	846	626	887	967	715
CSC Clean heat	2	2	1	2	2	1
Other clean heat	-	-	-	-	-	-
Total clean heat	2	2	1	2	2	1
Total	778	848	627	888	969	717

(1) Insulation benefits assumed to last 10 years; clean heating for 5 years

3.4 Producer Surplus

Producer surplus is defined as the total sales revenue attributable to the programme, minus all opportunity costs of production.

Producer surplus benefits were calculated from an estimate of the difference between costs of supply of insulation and clean heating and the costs to households; the methodology and results are reported separately.[63] This calculation includes the surplus to producers, any tax paid that is included in the costs to households plus a proportion

[63] Covec (op cit).

of the labour costs that we estimate would otherwise be unemployed (in the short run) and therefore has a zero opportunity cost. We deduct producer surplus from gross costs of the programme to arrive at opportunity costs, being the appropriate definition of resource costs attributable to the programme. (To avoid double counting, producer surplus is therefore not included as a separate benefit.)

The main inputs to the analysis are summarised in Table 23; this takes the results from the separate paper and reports them as a surplus per house treated (insulated or clean heating installed).

Table 23 Elements of Producer Surplus

Element of Surplus	Insulation ($/m^2)	$/house	Clean heating ($/unit)	$/house
Production	0.52 - 1.19	78 - 179	538	538
Installation	4.71 - 6.70	709 – 1,008	431	431
Total	5.23 - 7.89	787 – 1,187	968	968

Source: Covec (op cit); insulation surplus per house estimated from 171.1m^2 insulation/house

The resulting total producer surplus, taking account of the additionality factor of 85% and the number of houses treated (Table 2), is shown in Table 24. It uses average values for insulation and splits the surplus into those that are from benefits accruing to producers and those relating to zero labour costs (these are 20% of the total surplus for insulation and 12% for clean heating). The present value over the four years over the programme is given at different discount rates in Table 25.

Table 24 Elements of Producer Surplus by Year ($ million)

Treatment	09/10	10/11	11/12	12/13
Surplus to Producers				
Insulation	39.6	37.6	48.2	11.1
Clean heating	9.1	8.1	20.5	5.9
Sub-Total	48.7	45.7	68.7	17.0
Zero Labour Costs				
Insulation	9.6	9.1	11.7	2.7
Clean heating	1.3	1.1	2.8	0.8
Sub-Total	10.9	10.2	14.5	3.5
Total	59.5	56.0	83.3	20.5

Table 25 Present value of total producer surplus at different discount rates ($ million)

	4%	2.5%	8%
Insulation	141.8	144.3	135.6
Clean heating	41.2	46.7	47.8
Total	188.6	192.1	179.9

3.5 Scale of Activity and Employment Effects

The total level of activity under the programme is summarised in Table 2 in terms of the number of houses treated; in Table 26 we summarise the level of total expenditure under the programme. A total of $318 million in grants is expected to result in $625 million of expenditure on insulation and clean heating over the four years of the programme.

Table 26 Estimated level of grants and total expenditure ($ million)

	Actual Installations		Targeted Installations		
Intervention	**09/10**	**10/11**	**11/12**	**12/13**	**Total**
Grants	88	101	102	27	318
Insulation expenditure	129	122	157	36	445
Clean heat expenditure	38	34	85	24	180
Total	167	156	242	60	625

The employment effects were calculated in the study of impacts on producers.[64] In Table 27 we estimate the gross employment effects associated with the programme; this is the total number of people required to produce and install the insulation and clean heating subsidised under the programme. It includes the direct employment plus indirect employment that results from the requirement for additional workers by firms supplying the producers, importers, retailers and installers of clean heating, plus the induced employment effects associated with the increased expenditure of these workers.

Table 27 Estimated Gross Employment Effects of the Programme

	09/10	**10/11**	**11/12**	**12/13**
Insulation - direct	484	460	590	136
Insulation - indirect	286	271	348	80
Insulation - total	769	731	938	216
Clean heat - direct	34	30	76	22
Clean heat - indirect	32	28	71	20
Clean heat - total	65	58	147	42
Government - direct	25	25	25	25
Government - indirect	30	30	30	30
Government - total	55	55	55	55
Total - direct	542	515	691	182
Total - indirect	347	329	449	130
Total	889	844	1,140	313

However, these figures do not take account of the additionality of employment. In Table 28 we set out the estimated additional employment as a result of the programme, per 10,000 houses under the three additionality scenarios. The range of values given in each cell reflects the uncertainty over the extent to which the jobs created are additional (as opposed to displaced from other employment). Separately, the additionality of the insulation/clean heating is reflected in the low, central and high columns– see Table 3 for definitions.

Using these figures, the estimates of total additional employment due to the WUNZ: HS scheme over the four years of the programme are given in Table 29. The figures in Table 29 are the appropriate figures to use to consider employment effects of the scheme (rather than the gross figures in Table 27).

[64] Covec (op cit)

The monetary value of the additional direct employment is estimated by multiplying the direct additional employment by estimated wage rates, as discussed in the separate report. The resulting values are an estimate of the financial costs of labour for which there is a zero social opportunity cost. These values are included in the Producer Surplus calculation above, and summarised in Table 24.

Table 28 Additional employment per 10,000 houses

Additionality:		Low	Central	High
EECA[(1)]	Direct	2 - 15	2 - 15	2 - 15
	Indirect	3 - 18	3 - 18	3 - 18
	Total	5 - 33	5 - 33	5 - 33
Insulation	Direct	3 - 20	6 - 42	9 - 64
	Indirect	2 - 12	4 - 25	6 - 37
	Total	5 - 32	10 - 66	15 - 101
Clean heat	Direct	0 - 2	3 - 20	5 - 30
	Indirect	0 - 2	3 - 19	5 - 28
	Total	1 - 4	6 - 38	10 - 58
Total	Direct	6 - 37	12 - 77	17 - 109
	Indirect	5 - 32	9 - 61	13 - 84
	Total	10 - 69	21 - 138	30 - 192

(1) EECA employment numbers assumed to be independent of number of houses

Table 29 Additional employment under the programme with low, central and high additionality

Source	Additionality	09/10	10/11	11/12	12/13
EECA	All	5 - 33	5 - 33	5 - 33	5 - 33
Insulation	Low	24 - 165	23 - 157	30 - 201	7 - 46
	Central	51 - 343	48 - 326	62 - 418	14 - 96
	High	77 - 522	73 - 496	94 - 636	22 - 146
Clean heat	Low	1 - 5	1 - 4	2 - 11	1 - 3
	Central	8 - 48	7 - 43	18 - 109	5 - 31
	High	12 - 74	11 - 66	28 - 166	8 - 47
Total	Low	30 - 203	29 - 194	36 - 245	12 - 82
	Central	64 - 424	60 - 402	85 - 560	24 - 160
	High	94 - 628	89 - 595	127 - 835	34 - 227

4 Net Benefits and Conclusions

4.1 Net Benefits

4.1.1 Total Net Benefits

The total resource costs and benefits are summarised in Table 30. The benefits for health and metered energy are, in each case, conservative estimates obtained from the two related studies.

Table 30 Present Value of Total Costs and Benefits ($ million)

Additionality:		Central		Low	High
Discount rate:	4%	2.5%	8%	4%	4%
Costs					
Admin costs	23	24	22	23	23
Deadweight costs of tax	49	50	47	57	41
Installations – insulation	197	201	189	95	300
Installations - clean heat	97	99	92	47	147
Sub-total	366	373	350	222	512
Benefits					
Metered Energy	19	24	12	9	29
Health	1,561	1,906	997	750	2,374
Sub-total	1,580	1,931	1,009	759	2,403
Net Benefits	1,214	1,557	660	537	1,891

Given our baseline assumptions for the horizon of benefits from each of insulation and clean heating, the results suggest that there are positive net benefits of the programme at all discount rates examined, even with assumptions of low levels of additionality, or with a high discount rate.

Thus even our conservative estimates of benefits indicate that the programme, overall, has had considerable net benefits. While care must be exercised in formulating benefit-cost ratios (owing to alternative ways of attributing certain categories either as benefits or as offsets to costs), the ratio of benefits to costs in Table 30 ranges between 2.9 and 5.2, with a central (4% discount rate) benefit-cost ratio of 4.3. These results indicate that, overall, the Warm Up New Zealand: HeatSmart programme has been well justified in terms of positive net benefits.

4.1.2 Distribution of Benefits

The results are dominated by the health benefits; they represent approximately 99% of the total benefits. The benefits from reduced mortality are the most significant health benefits, comprising approximately 78% of the total health benefits ($1,213 million for the central, 4% scenario). However, the programme would still have positive net benefits even in the absence of mortality benefits.

The benefits are also dominated by insulation (Table 31); the estimates suggest approximately zero benefits associated with the clean heat portion of the programme. This may be because, unlike retrofitted insulation which does not involve on-going household expenditure, installation of clean heat appliances will only affect health outcomes if the household is able and willing to afford the metered energy costs. For some households, issues of 'fuel poverty' may affect the household's ability to use installed clean heaters.[65] In interpreting the benefits summarised in Table 31, we reiterate that there are significant missing benefits that we are unable to quantify. These include increased household comfort and possible reductions in non-metered energy use. These unquantified benefits are likely to be relevant to both the insulation and the clean heat aspects of the programme.

Table 31 Benefits by Category ($ million) (Central additionality; 4% discount rate)

	Insulation	Clean heat	Total
Metered Energy	26	-7	19
Health	1,558	3	1,561
Total	1,584	-4	1,580

4.1.3 Cost Components

The largest component of costs is the costs of the installations themselves, ie. the insulation, clean heaters and the labour costs for installations. The deadweight cost of taxation is a significant component, and one that is frequently ignored in cost benefit analyses. Here it is estimated at approximately 15% of the total costs.

4.1.4 Key Uncertainties

A number of key uncertainties and sensitivities exist for the analysis that mean that our central estimate of net benefits could be either over-stated or under-stated. Table 30 highlights two such sources, being the discount rate and the estimate of additionality for the programme (i.e. the degree to which houses treated under the programme were houses that would not otherwise have adopted insulation and/or clean heat treatment in the absence of the programme).

Estimates of employment additionality for a given level of installations (see Table 29) provide another source of uncertainty. The higher the proportion of gross jobs filled by otherwise unemployed workers, the lower are the true resource costs of the scheme. We use estimates from other studies to estimate employment additionality, and we have been conservative in our estimates in this regard. If a greater (lesser) proportion of gross employment attributed to the scheme has been sourced from unemployed workers, the resource costs of the scheme will be lower (higher) than estimated and the net benefits correspondingly higher (lower).

As highlighted already in the report, the estimated metered energy savings do not include any savings made with respect to non-metered energy sources. While the energy report found no clear evidence that non-metered energy savings are made following either insulation of clean heat treatment, we cannot rule out such savings. The potential for non-metered energy savings represents a one-sided uncertainty to our estimates, and net benefits may therefore be higher than we estimate.

[65] Howden-Chapman P, Viggers H, Chapman H, O'Sullivan K, Telfar-Barnard K, Lloyd B (in press) Tackling cold housing and fuel poverty in New Zealand: a review of policies, research and health impacts. Energy Policy.

Another uncertainty related to the metered energy benefits is the range of estimates provided in the energy report for national energy savings due to WUNZ: HS based on the use of differing samples in the regression analysis. The estimates used in this report are based on a narrowly defined 'cleaned' sample referred to as 'Preferred Specification' in Table 32. Estimated savings using broader samples of treated houses are shown below those for the Preferred Specification in the table (where the sample extensions relate to the section numbers in the energy report).

Most, but not all, of the broader samples indicate moderately higher metered energy savings due to retrofitted insulation. The highest estimates are for an annual household electricity saving of 1.41% and a total household metered energy saving of 1.03% following insulation treatment (compared with the Preferred Specification savings of 0.96% and 0.66% respectively). The impacts of heat pump installation show that the estimates of extra metered energy use from the broader samples are balanced around the estimates from the cleaned sample.

Overall, therefore, the Preferred Specification provides moderately conservative estimates of metered energy impacts of the WUNZ:HS scheme. However, none of the alternative estimates is notably greater and, given that the energy benefits are small relative to the health benefits, even use of the highest savings estimates for metered energy would have only small effects on our estimates of overall net benefit of the programme. Similarly, it may be inferred that any non-metered energy benefits will be minor relative to the estimated health benefits.

Table 32 Predicted Annual Percentage Metered Energy Savings from Treatment (Alternative Samples)

	Insulation		**Heat Pump**	
	Electricity (%)	**Total Metered Energy (%)**	**Electricity (%)**	**Total Metered Energy (%)**
Preferred Specification	0.96	0.66	-1.92	-0.75
Heater Extension (6.3)	0.81	0.57	-1.90	-0.99
Sample Extension (6.5.1)	1.03	0.75	-1.93	-0.65
Sample Extension (6.5.2)	0.83	0.46	-1.53	-0.53
Sample Extension (6.5.3)	1.24	0.91	-1.54	-0.70
Sample Extension (6.5.4)	1.41	1.03	-2.08	-1.13
Sample Extension (6.5.5)	1.35	0.97	-2.11	-1.19

The greatest uncertainties for the study relate to the estimated health benefits, although these uncertainties are distributed in both upward and downward directions around the values used in this study. Estimates of savings in hospitalisation costs and pharmaceutical costs are quite tightly defined, but the use of the more focussed benefits (eg. just savings in circulatory and respiratory related costs) would lift the estimated benefits relative to the more conservative approach adopted in this study (see Table 21).

The greatest uncertainty for the estimates of health benefits relates to the value of mortality cost savings. Table 12 and Appendix 3 of the health report show that the estimated mortality cost savings can vary considerably depending on which estimated value of preventable fatality (VPF) is used, in turn based on prior New Zealand studies.

These values range from $2.2 million to $5.7 million per preventable fatality; we adopt a moderately conservative estimate of $3.4 million, corresponding to a figure used in transport analyses. We then adopt conservative assumptions to convert this figure into an annual benefit per life year. As discussed in section 3.3 above, our preferred central estimate of health benefits relating to mortality cost savings translates into an annual benefit of $439.95 per treated household. Differing methodologies yield central estimates that range from $23.59 to $1,925.66 per year per household, and the confidence interval of the latter ranges from $0.00 to $3,352.07. Our preferred estimate is towards the lower portion of this range.

Finally, the omission of comfort benefits may result in a material benefit omission. Our energy analysis indicates that total metered household energy use falls by around 0.7% following insulation treatment (and space heating metered energy use falls by approximately 4%). This modest reduction in metered energy use suggests that houses become warmer as a result of insulation treatment. In turn, this added warmth results in explicit health benefits. However the estimated health benefits only relate to those people who have reduced hospitalisation or pharmaceutical costs or are saved from preventable fatality. Most households will not be reflected in these benefit categories, but are likely to have warmer, more comfortable, houses following treatment under WUNZ: HS that they value, but which we are unable to put an explicit value on.

On balance, it appears that our assumptions and unavoidable omissions mean that our central estimate of the net benefit of WUNZ: HS is conservative. Furthermore, the timing of this evaluation is such that only (approximately) the first year's benefits have been evaluated. Health benefits, in particular, may be dependent on length of exposure to a treated house (i.e. there may be a cumulative element to health benefits). A longer study of the health benefits (e.g. over two to three years), using the same cohort of treated houses, is likely to provide a stronger basis for inference and for future policy decisions than is possible given the limited evaluation period available for this study.

4.2 Potential Programme Refinements

The energy study found that energy benefits from insulation were greatest for houses in cooler regions. This result most likely reflects the fact that energy use for heating purposes prior to treatment is greater for houses in cooler areas than for those in warmer regions. There is therefore greater scope for energy savings following treatment for houses in cooler areas.

The health impacts study shows clear differences between the effects on low income earners and high health services users relative to other households, with significantly larger benefits for Community Service Card (CSC) holders (Table 20). This result is consistent with prior research (see section 1.3.1) that the sick and other at-risk groups are most adversely affected by cold house temperatures. These groups therefore have the most to gain from installation of retrofitted insulation.

The overall results suggest that the programme as a whole has had sizeable net benefits, with our central estimate of programme benefits being at least four times resource costs attributable to the programme. The central estimate of gross benefits for the programme is $1.58 billion compared with resource costs of $0.37 billion, a net benefit of $1.21 billion. Greater net benefits may be achievable through consideration of certain targeting strategies, although the administrative, incentive and stigmatisation costs of targeting must be weighed up against any potential savings that targeting may bring. Strategies that may be considered to increase net benefits include: prioritising the insulation component relative to the clean heating component of the programme; targeting clean heating to houses that use reticulated gas rather than electricity for heating prior to treatment; targeting insulation to houses in cooler rather than warmer areas; and targeting insulation to low income households and other at-risk groups in terms of illness.

Annex 1 Heating Profiles

Profiles: % of heating energy consumed in different time periods.

Region	Profile[1]	Summer day	Summer night	Summer peak	Winter day	Winter night	Winter peak	Shoulder day	Shoulder night	Shoulder peak
Northland	1	1%	4%	0%	22%	33%	18%	5%	14%	3%
	2	0%	0%	0%	77%	0%	17%	5%	0%	0%
	3	0%	0%	0%	56%	0%	33%	8%	0%	2%
Auckland	1	1%	4%	0%	22%	33%	18%	5%	14%	3%
	2	0%	0%	0%	77%	0%	17%	5%	0%	0%
	3	0%	0%	0%	56%	0%	33%	8%	0%	2%
Hamilton	1	1%	4%	0%	22%	33%	18%	5%	14%	3%
	2	0%	0%	0%	77%	0%	17%	5%	0%	0%
	3	0%	0%	0%	56%	0%	33%	8%	0%	2%
Bay of Plenty	1	0%	0%	0%	77%	0%	17%	5%	0%	0%
	2	0%	0%	0%	77%	0%	17%	5%	0%	0%
	3	0%	0%	0%	56%	0%	33%	8%	0%	2%
Rotorua	1	1%	4%	0%	22%	33%	18%	5%	14%	3%
	2	0%	0%	0%	77%	0%	17%	5%	0%	0%
	3	0%	0%	0%	56%	0%	33%	8%	0%	2%
Taupo	1	2%	6%	1%	23%	25%	17%	7%	13%	5%
	2	0%	0%	0%	53%	0%	35%	10%	0%	2%
	3	2%	0%	0%	41%	0%	37%	13%	0%	6%
East Cape	1	1%	4%	0%	22%	33%	18%	5%	14%	3%
	2	0%	0%	0%	77%	0%	17%	5%	0%	0%
	3	0%	0%	0%	56%	0%	33%	8%	0%	2%
New Plymouth	1	2%	5%	1%	23%	24%	18%	8%	13%	6%
	2	0%	0%	0%	52%	0%	36%	9%	0%	3%
	3	1%	0%	0%	40%	0%	38%	14%	0%	6%
Manawatu	1	2%	5%	1%	23%	24%	18%	8%	13%	6%
	2	0%	0%	0%	52%	0%	36%	9%	0%	3%
	3	1%	0%	0%	40%	0%	38%	14%	0%	6%
Wairarapa	1	2%	5%	1%	23%	24%	18%	8%	13%	6%
	2	0%	0%	0%	52%	0%	36%	9%	0%	3%
	3	1%	0%	0%	40%	0%	38%	14%	0%	6%
Wellington	1	2%	5%	1%	23%	24%	18%	8%	13%	6%
	2	0%	0%	0%	52%	0%	36%	9%	0%	3%
	3	1%	0%	0%	40%	0%	38%	14%	0%	6%
Nelson/ Marlborough	1	1%	4%	0%	22%	33%	18%	5%	14%	3%
	2	0%	0%	0%	77%	0%	17%	5%	0%	0%
	3	0%	0%	0%	56%	0%	33%	8%	0%	2%
West Coast	1	2%	6%	1%	23%	25%	17%	7%	13%	5%
	2	0%	0%	0%	53%	0%	35%	10%	0%	2%
	3	2%	0%	0%	41%	0%	37%	13%	0%	6%
Christchurch	1	2%	6%	1%	23%	25%	17%	7%	13%	5%
	2	0%	0%	0%	53%	0%	35%	10%	0%	2%
	3	2%	0%	0%	41%	0%	37%	13%	0%	6%
Queenstown Lakes	1	2%	6%	1%	23%	25%	17%	7%	13%	5%
	2	0%	0%	0%	53%	0%	35%	10%	0%	2%
	3	2%	0%	0%	41%	0%	37%	13%	0%	6%
Otago Central	1	2%	6%	1%	23%	25%	17%	7%	13%	5%
	2	0%	0%	0%	53%	0%	35%	10%	0%	2%
	3	2%	0%	0%	41%	0%	37%	13%	0%	6%

Dunedin	1	2%	6%	1%	23%	25%	17%	7%	13%	5%
	2	0%	0%	0%	53%	0%	35%	10%	0%	2%
	3	2%	0%	0%	41%	0%	37%	13%	0%	6%
Invercargill	1	2%	6%	1%	23%	25%	17%	7%	13%	5%
	2	0%	0%	0%	53%	0%	35%	10%	0%	2%
	3	2%	0%	0%	41%	0%	37%	13%	0%	6%

(1) See Table 9 for definitions

Source: EECA