Cost benefit analysis of the Warm Up New Zealand: Heat Smart programme

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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 74% of the treatments are additional, within a range of 36% to 113%.[5] The high figure 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 Household Energy Use.
[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, and pharmaceutical costs. Evaluation of the New Zealand Insulation Fund.
[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	16.9	16.9	4.8	14.9
Costs of Insulation + installation	52.5	49.9	64.1	14.7
Costs of Clean heaters + installation	18.9	16.9	42.5	12.1
Total[(1)]	95.7	90.8	117.8	45.2

[(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.

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 for before and after treatment, and health data were obtained relating to hospitalisations (including mortality outcomes) and prescription charges for people 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. 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 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

[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.

costs. Because we have limited the assessment to metered energy use, reductions in other energy (natural gas use) is limited to the North Island.

The present value of estimated savings at a 4% discount rate is shown in Table ES2.

Table ES2 Net Present Value ($ million) of Electricity and Other Energy Savings

	Insulation			Clean heat			
	Energy	CO_2	Total	Energy	CO_2	Total	Total
Electricity	24.4	0.2	24.6	-7.0	-0.1	-7.1	17.5
Other Energy	-1.3	-0.2	-1.5	0.9	0.1	0.9	-0.5
Total	23.1	-0.0	23.1	-6.1	0.0	-6.1	16.9

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 low and middle income earners. 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	802	892
Other insulation	460	550
Total insulation	1,263	1,443
CSC Clean heat	1	1
Other clean heat	2	2
Total clean heat	4	4
Total	1,266	1,446

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 71-424 full time equivalents (FTEs) in the first year and to peak at 94-560 FTEs in 2001/12.

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 = 74%, low = 36%, high = 113%).

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	51	52	49	58	44
Installations - insulation	173	176	165	83	263
Installations - clean heat	85	87	81	41	130
Sub-total	332	339	317	205	460
Benefits					
Energy	17	21	10	8	25
Health	1,266	1,541	816	608	1,926
Sub-total	1,283	1,562	827	616	1,951
Net Benefits	951	1,224	510	411	1,492

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.

The results are dominated by the health benefits, which represent approximately 99% of the total benefits. There are additional benefits that we have not been able to include in our analysis, eg. comfort benefits associated with additional interior warmth, and 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 (positive or negative) 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 energy study found that energy benefits from insulation were greatest for houses in cooler regions. In addition, clean heating resulted in greater total metered energy savings for houses that had reticulated gas than for other houses. The health impacts study shows clear differences between the effects on low to middle income earners and other households, with significantly larger benefits for Community Service Card (CSC) holders.

The overall results suggest that the programme as a whole has had sizeable net benefits, with our central estimate of programme benefits being almost five times resource costs attributable to the programme. The central estimate of gross benefits for the programme is $1.28 billion compared with resource costs of $0.33 billion, a net benefit of $0.95 billion. Nevertheless, even greater benefits may be achievable through consideration of four targeting strategies:

1. Prioritise the insulation component of the programme relative to the clean heating component of the programme.

2. Target clean heating to houses that use reticulated gas rather than electricity for heating prior to treatment.

3. Target insulation to houses in cooler rather than warmer areas.

4. Target insulation to low and middle income earners 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 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 Household Energy Use.
[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, and pharmaceutical costs. Evaluation of the New Zealand Insulation Fund.
[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	18,000	1,000	71,433
Other	22,414	25,912	45,000	13,500	106,826
Total	51,663	49,096	63,000	14,500	178,259
Clean heat					
Low income	7,012	5,692	6,000	1,400	20,104
Other	5,646	5,635	22,500	6,750	40,531
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 more 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 train 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.

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 the separate report on producers and employment, and we extend the findings from

[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

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, 74% 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 74% 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	171.1	8.8	100
Low	61.1	3.2	35.7
Central	127.2	6.6	74.3
High	193.4	10.0	113.0

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

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

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

number of data points, there was a significant uncertainty range: 36% to 113% at the 95% confidence level. 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 (2011) Impacts of the NZ Insulation Fund on Industry and Employment. Report for the Ministry of Economic Development

[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, 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 (74%), low (36%) and high (113%) 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)	19.6	22.6	22.6	6.1
PAYE(2)	0.6	0.5	0.5	0.2
GST on overhead expenditure	0.7	0.8	0.7	0.4
Total	20.9	23.8	23.8	6.7
Net Government Expenditure	74.3	84.5	84.3	24.2
Deadweight loss – central additionality	14.9	16.9	16.9	4.8
Deadweight loss – low additionality	16.9	19.3	19.2	5.5
Deadweight loss – high additionality	12.8	14.6	14.5	4.2

(1) GST = 15%; estimated on 74% 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 $2,494.37/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 74% 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	128.9	122.5	157.1	36.2
Clean heat	37.7	33.7	84.8	24.3
Total	166.5	156.2	242.0	60.4

Table 7 Resource costs of installations ($ million)

Product installed	09/10	10/11	11/12	12/13
Insulation	52.5	49.9	64.1	14.7
Clean heat	18.9	16.9	42.5	12.1
Total	71.4	66.8	106.5	26.9

3 Benefits

3.1 Benefits Included

Benefits included in the analysis are those relating to energy savings and improved health outcomes. There will be some additional benefits associated with consumer comfort, but these have not been measured. The analysis here 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.

We leave the comfort benefits as a one-sided uncertainty in the analysis; the total benefits will therefore be higher than those measured.

3.2 Energy Savings

3.2.1 Volume Savings

The impacts on energy use of the additional insulation and clean heating have been estimated from an analysis of the differences between 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 gas) before and after the date of treatment for treated houses and their controls. Regression analysis was used to identify the impact of the separate interventions and the way that this differed by location and by month. 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 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 solid fuel or other non-metered energy heating source prior to intervention. Thus there was no evidence that additional fuel savings were made in houses with other forms of heating. Nevertheless, to the extent that additional non-metered energy savings are made in

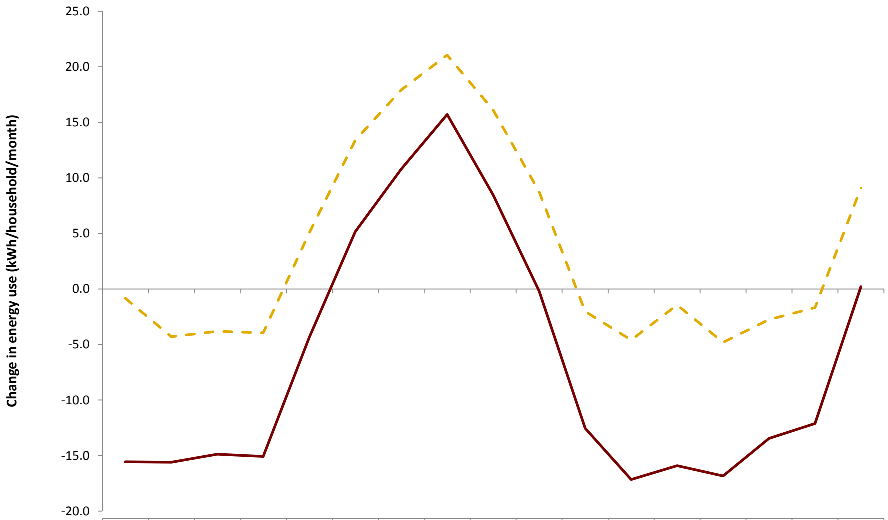
[49] This was location (Census area unit, similar to a suburb), dwelling and house type, number of levels, age (decade of build), floor area and number of bedrooms, whether there is a garage under the main roof and its size (number of vehicles), house construction material (walls and roof), whether or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

[50] Grimes A, 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 Household Energy Use.

treated houses, these savings are left as a one-sided uncertainty in the analysis, akin to the treatment of additional comfort benefits. Both of these one-sided uncertainties mean that actual benefits may be greater than those incorporated explicitly here.

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.

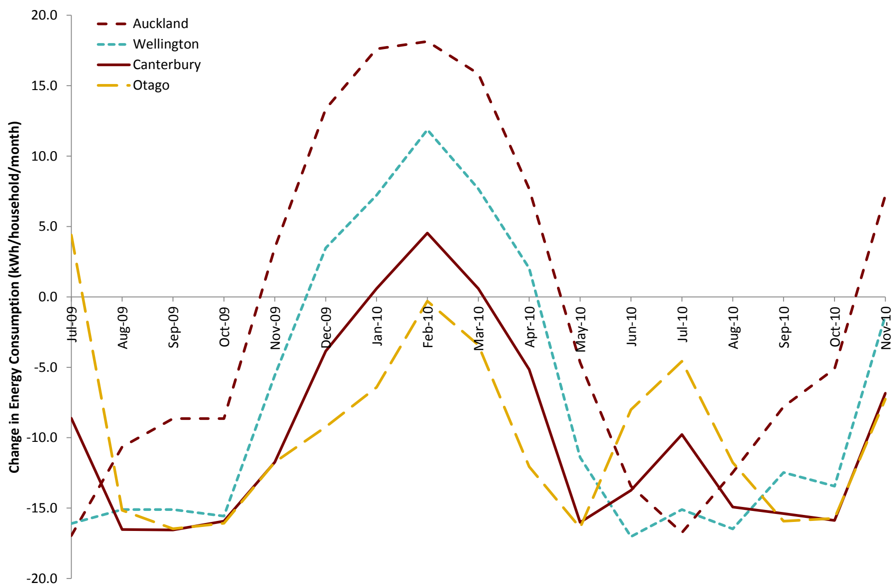
Figure 1 Change in Metered Energy Consumption following Treatment (New Zealand)



	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 these summer months in Otago (although we note 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 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 period from July 2009 to November 2010 – months with 2 records are averaged, eg (July 2009 + July 2010)/2 etc

Source: 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 Household Energy Use

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

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

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.

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 also;

[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

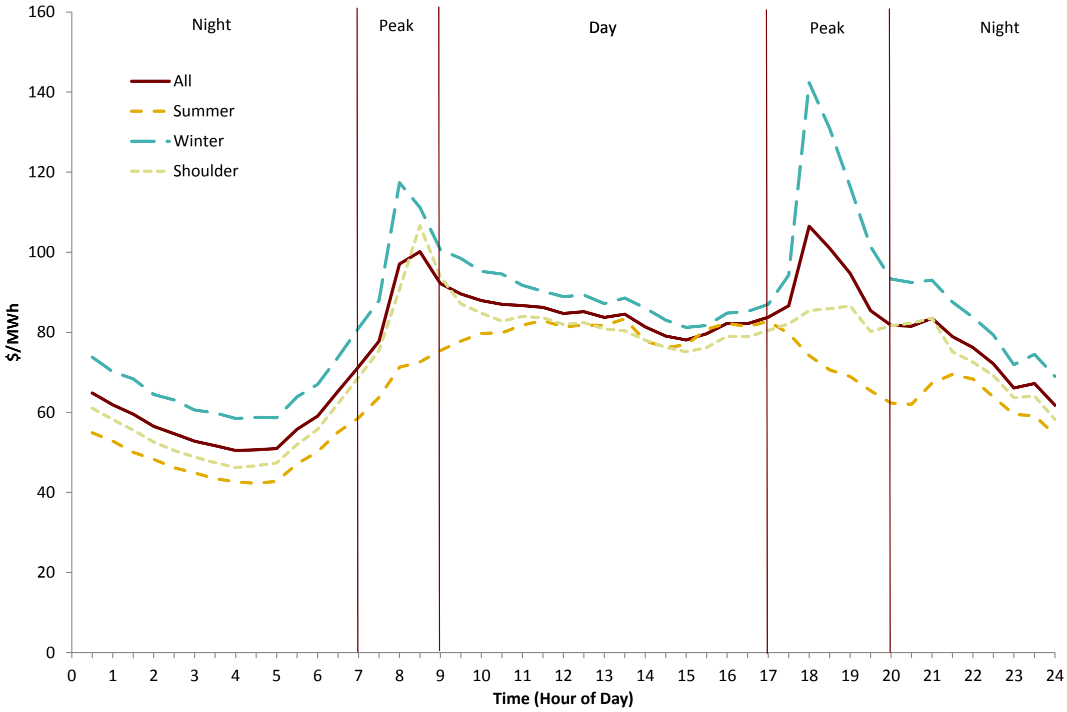
[54] KEMA (2007) New Zealand Electric Energy-Efficiency Potential Study Volume 1. Electricity Commission Wellington, New Zealand

[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 74% 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 74.3% (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 Other Energy Savings

	Insulation			Clean heat			
	Energy	CO_2	Total	Energy	CO_2	Total	Total
@ 4%							
Electricity	24.4	0.2	24.6	-7.0	-0.1	-7.1	17.5
Other Energy	-1.3	-0.2	-1.5	0.9	0.1	0.9	-0.5
Total	23.1	-0.0	23.1	-6.1	0.0	-6.1	16.9
@ 2.5%							
Electricity	29.7	0.2	29.9	-7.6	-0.1	-7.7	22.2
Other Energy	-1.6	-0.2	-1.9	0.9	0.1	0.9	-0.9
Total	28.0	-0.0	28.0	-6.8	0.0	-6.8	21.2
@ 8%							
Electricity	15.9	0.1	16.0	-5.7	-0.0	-5.8	10.3
Other Energy	-0.8	-0.1	-0.9	0.9	0.0	0.9	0.1
Total	15.2	-0.0	15.2	-4.8	0.0	-4.8	10.3

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 Energy Savings (Limited Duration)(1)

	Insulation			Clean heat			
	Energy	CO_2	Total	Energy	CO_2	Total	Total
@ 4%							
Electricity	11.6	0.1	11.7	-4.2	-0.0	-4.2	7.5
Other Energy	-0.6	-0.1	-0.7	0.5	0.0	0.5	-0.1
Total	11.0	-0.0	11.0	-3.7	0.0	-3.7	7.4
@ 2.5%							
Electricity	12.5	0.1	12.6	-4.4	-0.0	-4.4	8.2
Other Energy	-0.6	-0.1	-0.7	0.5	0.0	0.5	-0.2
Total	11.9	-0.0	11.9	-3.9	0.0	-3.9	8.0
@ 8%							
Electricity	9.7	0.1	9.8	-3.7	-0.0	-3.7	6.1
Other Energy	-0.5	-0.1	-0.5	0.5	0.0	0.5	0.0
Total	9.3	-0.0	9.3	-3.2	0.0	-3.2	6.1

(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, and the approach and detailed results are set out in the separate paper.[62] Addresses of houses that had received treatment were matched with similar houses to provide a control group of addresses. Data were then obtained on hospitalisation and pharmaceutical costs of the treatment and control groups; benefits were estimated using the difference between treated and untreated houses. Additional benefits were estimated from previous studies under the Heating, Housing and Health Study; these included reduced medical visits, reduced days off school or work and associated reductions in caregiver

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[62] 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, and pharmaceutical costs. Evaluation of the New Zealand Insulation Fund.

costs. The total benefits per household are summarised in Table 20. The authors note that they prefer the conservative estimates of benefits that include the total benefits calculated in the study plus the benefits imputed from previous studies; they include a more focussed assessment of benefits that includes only respiratory and circulatory benefits which produces a higher monthly saving.

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	95.49	95.49	95.49	9.27	9.27	9.27
Value of reduced mortality	465.36	649.11	229.11	0	0	0
Total health benefits	**636.33**	**854.4**	**335.64**	**9.27**	**9.27**	**9.27**
Focussed Assessment						
Hospitalisation and pharmaceutical use related benefits	168.24	206.04	76.56	0	0	0
Benefits imputed from previous Studies	95.49	95.49	95.49	9.27	9.27	9.27
Value of reduced mortality	465.36	649.11	229.11	0	0	0
Total health benefits	**729.09**	**950.64**	**401.16**	**9.27**	**9.27**	**9.27**

[1] CSC = Community Service Card, available to those on a low to middle income

Source: 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, and pharmaceutical costs. Evaluation of the New Zealand Insulation Fund

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 74% of total installations (Table 3). The health benefits are dominated by the insulation benefits ($1,263 million of a total of $1,266 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	802	974	521	892	1,083	580
Other insulation	460	564	293	550	674	350
Total insulation	1,263	1,537	813	1,443	1,757	929
CSC Clean heat	1	1	1	1	1	1
Other clean heat	2	3	2	2	3	2
Total clean heat	4	4	3	4	4	3
Total	1,266	1,541	816	1,446	1,761	932

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 (and 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	399	433	328	444	482	365
Other insulation	229	251	184	274	300	220
Total insulation	629	684	512	719	781	584
CSC Clean heat	1	1	1	1	1	1
Other clean heat	1	2	1	1	2	1
Total clean heat	2	2	2	2	2	2
Total	631	686	514	721	784	586

(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 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	0.54 - 1.19	92 - 203	538	538
Installation	4.74 - 6.70	811 – 1,146	433	433
Total	5.27 - 7.89	902 – 1,349	970	970

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 74% 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.

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

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

Treatment	09/10	10/11	11/12	12/13
Surplus to Producers				
Insulation	34.8	33.0	42.4	9.8
Clean heating	8.0	7.2	18.0	5.2
Sub-Total	42.8	40.2	60.4	14.9
Zero Labour Costs				
Insulation	8.4	8.0	10.3	2.4
Clean heating	1.1	1.0	2.5	0.7
Sub-Total	9.6	9.0	12.8	3.1
Total	**52.3**	**49.2**	**73.3**	**18.0**

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

	4%	2.5%	8%
Insulation	142.2	144.7	136.0
Clean heating	41.2	42.1	39.0
Total	183.4	186.8	175.0

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.

However, this does 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 reflects the uncertainty over the extent to which the jobs created are additional, as opposed to the additionality of the insulation/clean heating that is reflected in the low, central and high

[64] Covec (op cit)

columns– see Table 3 for definitions. Using these figures, the estimates of total additional employment over the four years of the programme are given in Table 29.

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

Table 28 Additional employment per 10,000 houses

Additionality:		Low	Central	High
EECA(1)	Direct	3 - 15	3 - 15	3 - 15
	Indirect	3 - 18	3 - 18	3 - 18
	Total	6 - 33	6 - 33	6 - 33
Insulation	Direct	3 - 20	7 - 42	11 - 64
	Indirect	2 - 12	4 - 25	6 - 37
	Total	5 - 32	11 - 66	17 - 101
Clean heat	Direct	0.3 - 2	3 - 20	5 - 30
	Indirect	0.3 - 2	3 - 19	5 - 28
	Total	0.6 - 4	6 - 38	10 - 58
Total	Direct	6 - 37	13 - 77	18 - 109
	Indirect	5 - 32	10 - 61	14 - 84
	Total	12 - 69	23 - 138	32 - 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	6 - 33	6 - 33	6 - 33	6 - 33
Insulation	Low	28 - 165	26 - 157	34 - 201	8 - 46
	Central	58 - 343	55 - 326	70 - 418	16 - 96
	High	88 - 522	83 - 496	107 - 636	25 - 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	34 - 203	33 - 194	41 - 245	14 - 82
	Central	71 - 424	68 - 402	94 - 560	27 - 160
	High	106 - 628	100 - 595	140 - 835	38 - 227

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.

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 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	51	52	49	58	44
Installations - insulation	173	176	165	83	263
Installations - clean heat	85	87	81	41	130
Sub-total	332	339	317	205	460
Benefits					
Energy	17	21	10	8	26
Health	1,266	1,541	816	608	1,926
Sub-total	1,283	1,562	827	616	1,951
Net Benefits	951	1,224	510	411	1,492

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 2.6 and 4.6, with a central (4% discount rate) benefit-cost ratio of 3.9. 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 74% of the total health benefits ($1,130 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 measured results suggest approximately zero (or even slight net costs) associated with clean heat. This may be because, unlike retrofitted insulation which does not involve on-going household expenditure, installation of clean heat heaters will only affect health outcomes if the household is able and willing to afford the metered energy costs.[65] However, there are significant missing benefits that we are unable to quantify, including those of household comfort and possible reductions in non-metered energy use.

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

	Insulation	Clean heat	Total
Energy	23	-6	17
Health	1,263	4	1,266
Total	1,286	-3	1,283

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.

4.2 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.

Table 8 shows the differences between regions in the impacts of insulation and clean heating on metered energy use. The results for Northland and Auckland suggest small reductions in electricity consumption but an overall increase in total metered energy use; elsewhere there are overall reductions in total metered energy use.

Clean heating results in increases in energy use in all regions. The energy study showed, however, that there were positive energy savings for treated houses that already had reticulated gas, in contrast to the result for other houses. Thus energy savings from installation of clean heating may be increased if clean heating is targeted at houses that initially use reticulated gas rather than electricity for heating.

The health impacts study shows clear differences between the effects on low to middle income earners and 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 4.8 times resource costs

[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, Fuel Poverty comes of age: 21 years of research into fuel poverty

attributable to the programme. Nevertheless, even greater benefits may be achievable through consideration of four targeting strategies:

1. Prioritise the insulation component of the programme relative to the clean heating component of the programme.

2. Target clean heating to houses that use reticulated gas rather than electricity for heating prior to treatment.

3. Target insulation to houses in cooler rather than warmer areas.

4. Target insulation to low and middle income earners 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