PA Consulting Group

Ministry of Economic Development

Evaluation Study of the EECA Water Heating Programme

Stage 1 - Evaluation of the Policy Case for Intervention

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Executive summary

PA has been retained by the Ministry to evaluate both the case for, and the success of, the water heating programme currently delivered by EECA. The study is organised into two stages:

- Stage 1: Evaluation of the policy case for intervention; and
- Stage 2: Evaluation of the design and implementation of the project.

This report presents our findings from Stage 1 of the study. The results of this first stage will determine if a second stage is needed or appropriate.

Overview of this stage of the study

Stage one evaluates the rationale for the programme – are the problems that is it intended to solve well defined, and are they being addressed by the programme in a cost effective manner. As such, this stage addresses the following subjects:

- **Problem definition:** What is the problem that the programme is intended to address, and has it been defined appropriately?
- **Identification of barriers:** To be effective, the programme must overcome barriers that limit the uptake of efficient water heating technologies, and the development of a self-sustaining solar and heat pump water heating industry. This task identifies these barriers, and how they have been addressed.
- **Cost-benefit analysis:** A cost-benefit analysis is to be performed, considering both consumer and national level benefits. This will also consider the additionality of the programme (or, conversely, the extent of the 'free-rider' effect).
- **Commentary on the success of the programme:** A commentary on the success or lack of success of the programme in terms of the following outcomes:
  - Energy security;
  - Creating jobs;
  - Improving consumer choice; and
  - Increasing the availability of energy to assist economic growth in other sectors.

Our conclusions from each of these subjects are described in the following sections.

Problem Definition

A problem definition was drawn from multiple EECA documents. Analysis of this problem definition leads to the following conclusions:

- **The problem definition is not stated consistently within EECA:** Each of the four EECA documents contained a different subset of the bullet points listed above. This is a concern, as the design of the programme should depend on the objectives that the programme is trying to achieve and the barriers it is trying to overcome.
- **The objectives stated by EECA may not be consistent with the Government's:** All of the EECA statements of the potential benefits include energy savings, while none of them include "Signalling the Government's commitment to energy efficiency and renewable energy". In contrast, the Cabinet paper indicates that the Government's main objective is one of leadership rather than

energy savings. Consideration of this this objective may result in the programme placing a greater emphasis on marketing than is currently implemented.

- **The case for Government intervention fails as a prima facie (i.e. self-evident) conclusion:** The following objections could be raised to contradict this conclusion, and have not been addressed. Without addressing issues such as these, the case for government intervention cannot be considered self-evident:
  - The capital cost barrier may be an entirely rational one: The benefits achieved may not justify the capital cost, or there may be other options to achieve the same objectives at lower cost. If this is the case, then financial assistance would be incentivising economically inefficient choices; and
  - It could be argued that the issues of information, consumer choice, product and installation standards and invisibility of benefits should be the responsibility of the industry to resolve, rather than the Government's.

Identification of barriers

We have used a structured approach to identify the barriers to increased uptake of solar and heat pump water heating systems. This has resulted in several barriers being identified that were not identified in the EECA documents reviewed in section 2.

As can be seen from the tables in section 3, several identified barriers remain unaddressed. The programme design should be reviewed to ensure that as many barriers as possible are addressed.

Cost-benefit analysis

The following table summarises the results of the NPVs as calculated by the cost-benefit analysis:

NPV Basis	Solar	Heat Pump
Consumer	$395	$5212
National	-$4766	-$1147

These figures indicate that while the programme has resulted in a positive NPV for most consumers, on a national basis, the NPVs are significantly negative. A first glance, this would appear to indicate that the long-term value of the investment is not economically beneficial to the country as a whole when evaluated on this basis. However, it should be noted that that this analysis does not include the flow on economic benefits of the programme, as well as the intangible benefits such as meeting the Government's objectives as discussed in Section 2.2.3.

Other conclusions that can be drawn from this analysis include:

- A significant proportion of the solar installations have a negative consumer NPV. This suggests that better targeting of the programme towards installations that would produce a positive NPV is warranted.
- The NPV results for heat pump systems are significantly better than for solar systems. This result is because all of the heat pump installations are in 2011 and not earlier, and as a result are exposed to higher electricity prices, rather than heat pump systems being inherently more economic than solar systems.
- There is very limited research available to quantify additionality and related effects in a way that is relevant to the EECA programmes. Adopting an assumption of 25% free riders in the CBA did not alter the conclusions that could be drawn from this analysis.

Commentary

Energy Security

We have estimated total annual energy savings of 19.4 GWh attributable to the programme. In contrast, New Zealand's total annual electricity demand was 38,558 GWh in 2010. Thus, the energy savings from the programme amount to 0.05% of total demand. Saving such a small proportion of the total demand cannot be expected to have a significant impact on national energy security.

Creating Jobs

The number of jobs created by the programme has been estimated as being in the range 18.5 - 38.5 FTEs in 2011 from the installation of systems. Further job gains can be expected from the manufacturing of systems, and testing and training facilities.

Given that job creation was not specified as an objective of the programme, and goals have not been set for this outcome, it is difficult to determine whether these numbers represent success or otherwise. However, under current economic conditions, any job creation as an ancillary benefit of the programme should be seen as a positive outcome.

Improving Consumer Choice

The major benefit from the programme in terms of consumer choice is the creation and application of standards for solar water heaters, creating some certainty for consumers that their system will perform to a minimum standard, and as advertised.

The inclusion of AS/NZS 2712 in the New Zealand building code will ensure that the benefit of this standard will endure beyond the end of the programme.

Increasing the availability of energy to assist economic development

The energy savings achieved by the programme have been estimated at around 0.05% of total electricity demand. Such a small reduction is unlikely to have any significant effect on energy prices and therefore no significant effect on economic growth in other sectors.

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Contents

1 Introduction

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- Stage 1: Evaluation of the policy case for intervention; and
- Stage 2: Evaluation of the design and implementation of the project.

This report presents our findings from Stage 1 of the study. The results of this first stage will determine if a second stage is needed or appropriate.

1.1 Overview of this stage of the study

Stage one evaluates the rationale for the programme – are the problems that is it intended to solve well defined, and are they being addressed by the programme in a cost effective manner. As such, this stage addresses the following subjects:

- **Problem definition:** What is the problem that the programme is intended to address, and has it been defined appropriately?
- **Identification of barriers:** To be effective, the programme must overcome barriers that limit the uptake of efficient water heating technologies, and the development of a self-sustaining solar and heat pump water heating industry. This task identifies these barriers, and how they have been addressed.
- **Cost-benefit analysis:** A cost-benefit analysis is to be performed, considering both consumer and national level benefits. This will also consider the additionality of the programme (or, conversely, the extent of the 'free-rider' effect).
- **Commentary on the success of the programme:** A commentary on the success or lack of success of the programme in terms of the following outcomes:
  - Energy security;
  - Creating jobs;
  - Improving consumer choice; and
  - Increasing the availability of energy to assist economic growth in other sectors.

Each of these subjects is described in the following sections.

2 Problem Definition

In this section, we consider the problem definition: What is the problem that the programme is intended to address, and has it been defined appropriately?

2.1 Approach

The first step to finding any solution is to ensure that the problem is clearly defined and understood. No programme can be meaningfully evaluated unless there is a clearly defined problem that it is designed to address and well stated intentions of what the programme will deliver.

We have approached the evaluation as a due diligence exercise to evaluate the problem definition. That is, we have spoken with EECA staff, and reviewed their documentation, focussing on their arguments for intervention and evidence to support those arguments.

A well-defined problem definition for a programme such as this should contain the following aspects:

- A clear articulation of the market failure(s) being addressed; and
- The establishment of a prima facie (or self-evident) case for government intervention.

2.2 Results of Review

2.2.1 Discussions with EECA staff

While the focus of this part of the review is documentation of the problem definition, a noteworthy result was obtained from verbal discussions with the EECA staff members who are operating the programme. While the staff members were able to articulate that the purpose of the programme was to increase the uptake of solar and heat pump water heating technologies, they were not familiar with the justifications for doing so.

This result is reflective of a high staff turnover and strong delivery focus at EECA.

2.2.2 Documents reviewed

An initial request for documentation of the problem definition for the programme did not result in any documents that gave an adequate definition of the problem to be addressed. Consequently, we were given access to EECA's project files for the programme. As a result, the following documents were reviewed for a problem definition for the programme:

EECA Documents

- EECA Portfolio Management System: Programme Plan: Solar & Heat Pump Water Heating (S&HPWH) Programme: 27 October 2010;
- EECA Solar & Heat Pump Water Heating Rebate Scheme: Strategic Policy Document – SWH SP3: Version 2.0 Thursday, 20 May 2010 – 8:27 a.m.;
- The Business Case for a Three Year Fixed Funding ($5.8m pa) Water Heating Programme (Date/Version not specified); and
- EECA Internal Review: Report on the effectiveness to 30 June 2009 of the Solar Water Heating Programme with recommendations: 24 November 2009.

Other Government Documents

- Cabinet Paper: Cabinet Economic Growth and Infrastructure Committee: Solar and Heat Pump Water Heating Programme.

The pertinent excerpts from these documents are reproduced in Appendix A of this report.

2.2.3 Analysis of problem definitions

The problem definition as collectively defined by the EECA documents can be summarised as follows:

1. There is significant potential for energy savings in domestic water heating by applying solar and heat pump technologies. Other potential benefits include (depending on the document):
    - Greenhouse gas emissions savings;
    - Contribution to renewable energy;
    - Promotion of consumer choice;
    - Development of efficient water heating industries;
    - Reduction in consumption of fossil fuels; and
    - Contribute to NZ's security of supply.
2. There are a number of barriers preventing the uptake of solar and heat pump water heating technologies. These include (again, depending on the document):
    - Capital cost;
    - Information;
    - Product performance;
    - Installation quality;
    - Challenging regulatory environment; and
    - The invisible nature of the benefits.
3. The implied conclusion is that the government should intervene (via EECA) with a programme of financial assistance, industry standards, quality assurance and marketing to help overcome these barriers and thus enable the potential benefits to be realised.

Analysis of this problem definition leads to the following conclusions:

- **The problem definition is not stated consistently within EECA:** Each of the four EECA documents contained a different subset of the bullet points listed above. This is a concern, as the design of the programme should depend on the objectives that the programme is trying to achieve and the barriers it is trying to overcome.

  The objectives stated by EECA may not be consistent with the Government's: All of the EECA statements of the potential benefits include energy savings, while none of them include "Signalling the Government's commitment to energy efficiency and renewable energy". In contrast, the Cabinet paper indicates that the Government's main objective is one of leadership rather than energy savings. Consideration of this this objective may result in the programme placing a greater emphasis on marketing than is currently implemented.
- **The case for Government intervention fails as a prima facie (i.e. self-evident) conclusion:** The following objections could be raised to contradict this conclusion, and have not been addressed. Without addressing issues such as these, the case for government intervention cannot be considered self-evident:
  – The capital cost barrier may be an entirely rational one: The benefits achieved may not justify the capital cost, or there may be other options to achieve the same objectives at lower cost. If

this is the case, then financial assistance would be incentivising economically inefficient choices; and

  - It could be argued that the issues of information, consumer choice, product and installation standards and invisibility of benefits should be the responsibility of the industry to resolve, rather than the Government's.

2.3 Conclusions

At the outset of this analysis, we set out to evaluate the problem definition according to the following criteria:

- A clear articulation of the market failure(s) being addressed; and
- The establishment of a prima facie case for government intervention.

The conclusions reached by the above analysis are as follows:

- The market failures being addressed are articulated, but not consistently within EECA. This should be addressed to ensure the programme design addresses all of the market failures that prevent achievement of the programme's objectives; and
- The case for Government intervention fails as a prima facie conclusion. The case for Government intervention should be strengthened to ensure that Government intervention is in fact sound.

3 Identification of Barriers

To be effective, the programme must overcome barriers that limit the uptake of efficient water heating technologies, and the development of a self-sustaining solar and heat pump water heating industry. In this section we identify these barriers, and how they have been addressed.

3.1 Introduction

The uptake of water heating investments is typically hindered by a variety of obstacles. It is only once these barriers have been correctly identified and analysed that one can begin to develop strategies that are capable of overcoming them in a cost-effective manner.

We have identified barriers by considering the following categories:

- **Informational barriers:** These take the form of distorted, biased or confusing signals to the energy user and public misconceptions;
- **Structural barriers:** Structural obstacles refer to those biases against energy efficiency within the economy that are related to existing infrastructure. This includes energy inefficient capital stock such as poorly designed water heating systems and problems with existing plumbing;
- **Attitude/motivation barriers:** This category describes the inefficiencies that arise from a relative lack of interest in alternative energy sources by energy users. These are known in the economics literature as 'bounded rationality'; and
- **Institutional barriers:** Institutional constraints refer to the lack of incentives (or existence of disincentives) for alternative energy solutions inherent in both the public and private sectors.

3.2 Informational barriers

In the following table, we identify informational barriers to the uptake of efficient water heating investments, and how they are addressed by the programme:

Barrier	Measures to address barrier
Weak price signals – Energy price signals that are not related to the full marginal cost of energy supply (including any external costs imposed on the environment) may give rise to poor or irrational energy efficiency decisions	Not addressed by any aspect of the water heating programme. Partially addressed by the Emissions Trading Scheme.
Missing price signals - Lack of metering information specific to water heating energy use can hide the costs to consumers.	This barrier does not exist for consumers with ripple control and associated off-peak prices. Not addressed by any aspect of the water heating programme.
Lack of information – In order for consumers to make rational decisions about energy use, they require information about products on the market so their decisions are informed. This includes the energy performance of conventional water heating equipment as well as the existence and effectiveness of alternative solutions. If this information is not easily available then the consumer is not in a position to trade-off running costs against capital costs, and inefficient choices are likely to result.	Addressed by the information promotion initiative of the programme - marketing and advertising.

Invisibility of benefits - The 'invisible' nature of the benefits, when compared to other potential consumer purchases.	Addressed to some extent by the information promotion initiative of the programme.
Poor public perception - as a result of poorly designed or installed systems in the past.	Addressed by the eligibility criteria for systems. Addressed to some extent by the information promotion initiative of the programme.
Misinformation – Public perceptions of alternative water heating solutions as being ineffective, either in general or for specific climates or situations, can be a barrier to uptake.	Addressed to some extent by the information promotion initiative of the programme.

3.3 Structural barriers

In the following table, we identify structural barriers to the uptake of efficient water heating investments, and how they are addressed by the programme:

Barrier	Measures to address barrier
Energy inefficient capital stock - such as poorly designed or unsuitable existing water heating systems and problems with existing plumbing.	Not addressed by any aspect of the water heating programme.

3.4 Attitude/motivation barriers

In the following table, we identify attitude and motivation barriers to the uptake of efficient water heating investments, and how they are addressed by the programme:

Barrier	Measures to address barrier
Water heating costs comprising too small a proportion of total household costs to warrant consideration of possible alternative methods.	Addressed to some extent by the information promotion initiative of the programme.
Environmental concerns not ranking sufficiently highly on the range of attributes sought by consumers in products purchased.	Addressed to some extent by the information promotion initiative of the programme.
Short-term mentality – where consumers motivated more by short-term installation costs than by long-term energy savings.	Addressed to some extent by the information promotion initiative of the programme.

3.5 Institutional barriers

In the following table, we identify institutional barriers to the uptake of efficient water heating investments, and how they are addressed by the programme:

Barrier	Measures to address barrier
The ‘landlord/tenant impasse - This describes the situation whereby the costs and benefits of energy efficiency are such that neither the tenant nor the landlord has the incentive to undertake the investment.	Not addressed by any aspect of the water heating programme.
Regulatory environment - Expensive, time-consuming and/or difficult building consent processes.	EECA has done some work on reducing regulatory costs.

3.6 Conclusions

In this section, we have used a structured approach to identify the barriers to increased uptake of solar and heat pump water heating systems. This has resulted in several barriers being identified that were not identified in the EECA documents reviewed in Section 2.

As can be seen from the tables in this section, several identified barriers remain unaddressed. The programme design should be reviewed to ensure that as many barriers as possible are addressed.

4 Cost-Benefit Analysis

A Cost-Benefit Analysis (CBA) was conducted from two viewpoints:

- Consumer - is each water heating installation financially beneficial to the purchaser?
- National - are installations resulting from the programme cost-effective from a purely national economic standpoint?

This section discusses the analysis and its limitations.

4.1 Approach

This is a high-level retrospective study that compares the economic benefits of actual water heating installations during the period of the programme to the costs incurred. The objective is to determine the economic viability over the lifetime of the investment. To assess the economic viability the CBA uses a Net Present Value (NPV) analysis which considers costs and benefits over the lifetime of the investment and accounts for the time-value of money.

Solar and Heat Pump water heating installations are evaluated separately.

4.1.1 Consumer CBA

The Consumer CBA calculates an NPV for each installation from the point of view of the person(s) purchasing and using the system over its lifetime. The factors considered are limited to the following:

Benefits

- Reduction in electricity costs to the consumer over the lifetime of the system.

Costs

- Installation cost net of any subsidy and of the cost of a standard water heating system if applicable.
- Maintenance over the lifetime of the system.
- Note that only monetary costs and benefits are considered.

4.1.2 National CBA

The National CBA considers each installation from a national perspective in terms of the stated goals of the programme. The factors considered are limited to the following:

Benefits

- The value of reductions in electricity use, valued at wholesale electricity prices.
- The value of reductions in GHG emissions, valued at New Zealand carbon prices.

Note that other stated goals such as improving the security of supply and the promotion of energy efficiency and renewable energy are not readily quantifiable and are excluded from this analysis. Other ancillary benefits that are created by the programme such as jobs created and revenue generated for manufacturers, retailers and installers are also not considered.

Costs

- Installation cost net of the cost of a standard water heating system if applicable.
- Maintenance over the lifetime of the system.

Note that any subsidy is included in the cost (i.e. it is ignored) for the National CBA, while installations that did not receive a subsidy are removed from this analysis.

4.2 Input Data and Assumptions

This analysis relies heavily on data provided by EECA. Where EECA does not, or is not able to, collect relevant data we are forced to make estimations, sometimes with very limited information.

4.2.1 EECA programme data

For Solar systems we received data from EECA for 8694 installations. The data received includes

- Purchase price
- Date of installation
- Region
- Value of subsidy given
- Size of solar collector
- Size of water cylinder (for some installations only)
- Estimate of energy performance (for some installations only)
- Configuration (for some installations only)

Some data was missing or corrupted for some installations, for example a number of installations had an installation cost of $10 with a subsidy of $1000. Energy performance data was not provided for 2343 of the 8694 installations so we estimated this based on the collector size. Overall, 362 installations were removed from the analysis due to errant or insufficient data.

For Heat Pump systems we received valid and complete data from EECA for 129 of the 153 installations that had been performed. The data received includes

- System ID, specifying the make and model of the system installed
- Purchase price
- Date of installation
- Region and zone
- Value of subsidy given
- Size of water cylinder
- Estimate of energy performance

The energy performance data supplied was found to be inaccurate and so was replaced with the energy performance estimate associated with each system ID. This data was more complete than the solar data and no installations were removed from the analysis.

A number of additional data inputs are required and needed to be estimated from other sources. These are discussed in the following sections.

4.2.2 Installation circumstances

No data was provided by EECA regarding the following important inputs:

- The size of the household/business or amount of energy used for water heating;
- Whether installations were for new or existing buildings; and
- Whether an existing water heating cylinder was replaced.

4.2.3 Maintenance cost

We assumed $150 (in 2005 dollars) every five years.

4.2.4 Energy required for water heating

All installations were assumed to be households. We used the available data to estimate the number of people in the household and then used the averages in the following table to assign water heating energy use to the household.

Number of occupants	1	2	3	4	5	>=6
Average annual use (kWh)	1,819	2,493	3,332	3,906	5,053	5,044

Source: BRANZ - "EC1248/01. Hot water and total energy: market segmentation"

4.2.5 Electricity prices

Retail electricity prices are required for the Consumer CBA; nominal historical averages are given in the table below.

	Units	2005	2006	2007	2008	2009	2010
Retail electricity price	c/kWh	19.19	20.56	22.10	23.28	24.13	25.50

Source: MED Website

These historical prices were extrapolated to estimate future prices by increasing them at the assumed CPI inflation rate (3%). The resulting prices were then multiplied by 84.5% to reflect cheaper retail prices available through the time-of-use rates available to customers with ripple control. The 84.5% factor was a result of previous work performed by PA for EECA.

Wholesale electricity prices are required for the National CBA; nominal historical averages are given in the table below.

	Units	2005	2006	2007	2008	2009	2010
Wholesale electricity price	c/kWh	3.40	7.24	7.59	5.08	12.19	3.86

Source: Electricity Authority Centralised Dataset

These prices are generation-weighted annual average prices at each generator injection point. These historical prices were extrapolated to estimate future prices by increasing them at the assumed CPI inflation rate (3%). We did not attempt to adjust for timing of water heating electricity use to account for ripple control and seasonal use which could lower the average effective price.

4.2.6 Carbon emission rates and prices

A CO_2 emission rate for electricity production of 520 kg/MWh was assumed, being the most recent electricity emission factor used by the Ministry for the Environment. Again, no attempt was made to adjust for the timing of water heating electricity use. Carbon prices are given in the following table.

	Units	2005	2006	2007	2008	2009	2010
Carbon price	$/tonne	$8.63	$12.51	$15.77	$24.59	$22.22	$19.72

Source: Ministry for the Environment

These historical prices were extrapolated to estimate future prices by increasing them at the assumed CPI inflation rate (3%).

4.2.7 Cost of a standard hot water cylinder

The cost of purchasing and installing a standard hot water system was estimated based on the size of the cylinder installed in the Solar or Heat Pump system using the following costs.

Litres	Cylinder Cost	Installation Cost	Total Cost	Total Cost incl. GST
90	900	1000	1900	2185
135	935	1000	1935	2225
180	1000	1000	2000	2300
250	1300	1000	2300	2645
300	1400	1000	2400	2760

Source: cost of Rheem mains pressure electric cylinders from http://www.hotwatercylinder.co.nz

The cylinder size was estimated by multiplying the size of the cylinder in the EECA data by 0.7 to represent that standard electric cylinders are smaller than those used with Solar or Heat Pump systems.

The cost of a standard system is only applicable in some cases, as outlined in the table below.

Situation	Tank Purchased?	Net out Tank Cost?
New building	Yes	Yes
System Replacement when worn out	Yes	Yes
System Replacement without need	Yes	No
Retrofit to existing tank	No	No

Due to the lack of data available on this, an approximating assumption was used that where a cylinder size was given the tank cost was netted out.

4.2.8 Financial assumptions

Assumption	Value	Units
System lifetime	20	Years
Future CPI	3%	Per annum
Discount rate	7%	Per annum

The CPI used was chosen as a typical inflation rate for New Zealand, in light of CPI values from recent years (as shown below). The discount rate was chose as a typical home mortgage rate, on the basis that home owners would typically fund the heaters from their home mortgage.

CPI for historical years is shown in the table below.

	2005	2006	2007	2008	2009	2010	2011
CPI	3.2%	2.6%	3.2%	3.4%	2.0%	4.0%	4.6%

Source: Treasury Website

4.3 Results

The results of the CBA analyses are presented in this section. It should be noted that due to the data limitations as discussed in the preceding sections, and the inherent uncertainty in forecasting future prices, these results should be taken as an estimates rather than definitive values.

4.3.1 Consumer CBA

The Consumer CBA calculates an NPV for each installation from the point of view of the person(s) purchasing and using the system over its lifetime, as detailed in section 4.1.1.

Solar systems

The average Consumer NPV across all of the installations was $395 (in 2011 NZD). This may indicate that the long-term value of the investment is economically marginal and therefore the subsidy received can make a difference to whether the investment is economically beneficial. In fact, the average subsidy received was $756, so for most cases, the investment would not have been economically beneficial without the subsidy.

It should also be noted that a significant proportion of the installations have a negative NPV. This suggests that better targeting of the programme towards installations that would produce a positive NPV is warranted.

The distribution of NPVs is shown in Figure 1 below.

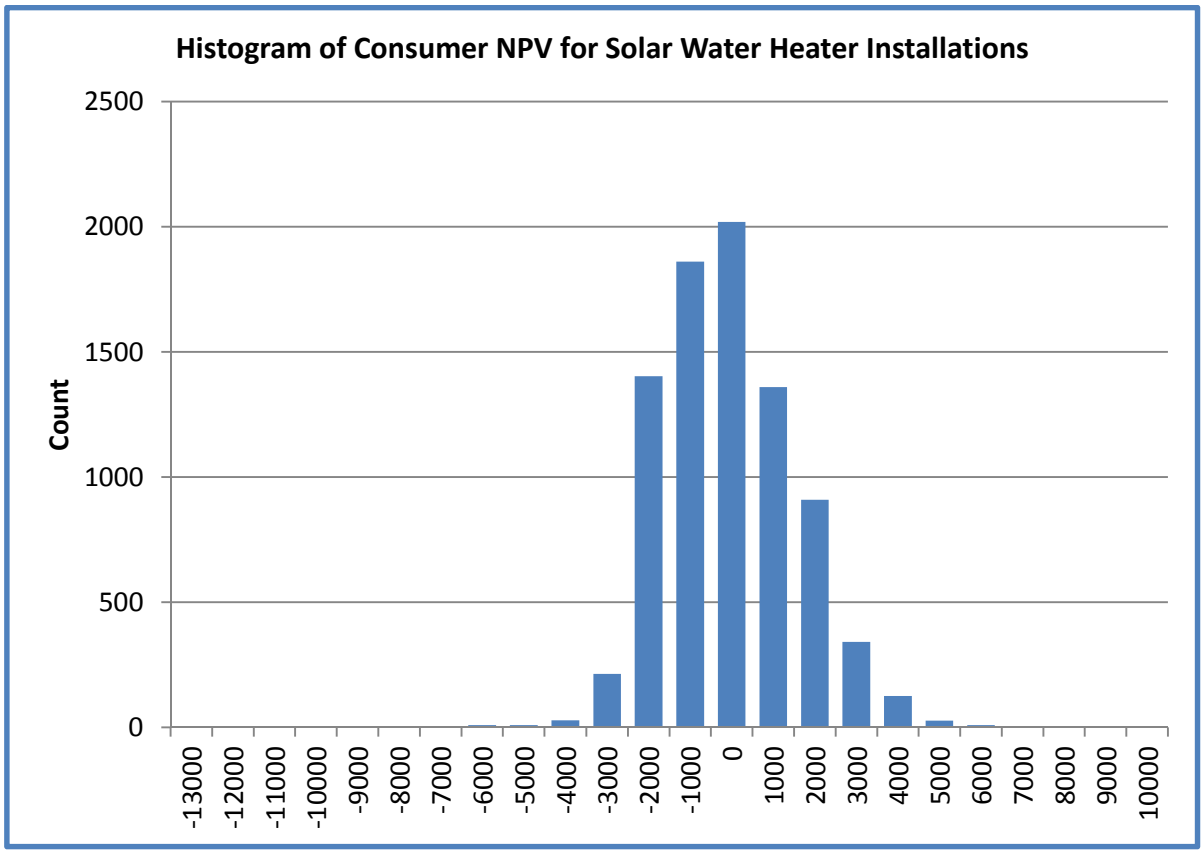

Figure 1. Consumer NPV for solar water heater installations

Heat Pump systems

The average Consumer NPV across all of the installations was $5212 (in 2011 NZD). This may indicate that investment in a Heat Pump water heating system is economically viable for the consumer in most cases even without the subsidy. However, the subsidy programme is likely to provide both awareness and incentive which results in installation decisions that would not otherwise be made. The distribution of NPVs is shown in Figure 2 below.

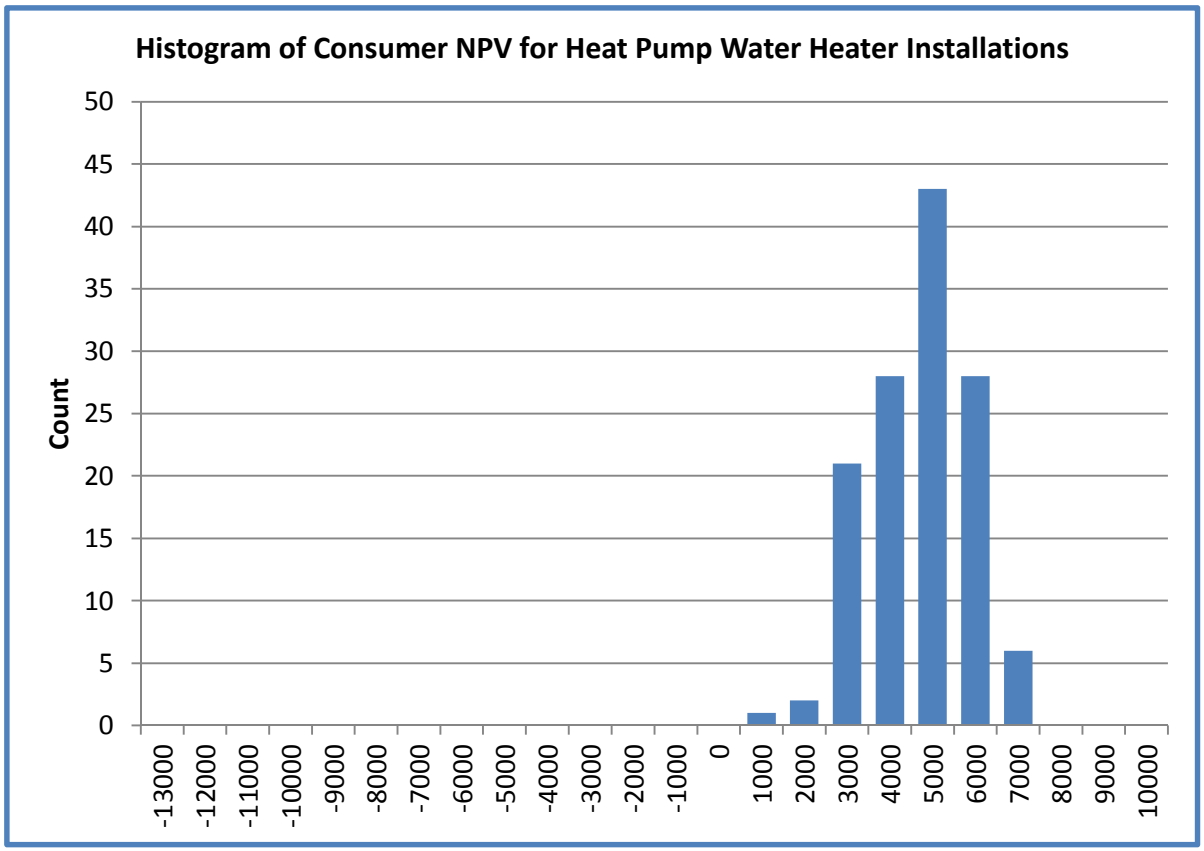

Figure 2. Consumer NPV for heat pump water heater installations

4.3.2 National CBA

The National CBA considers each installation from a national perspective in terms of the stated goals of the programme, as explained in section 4.1.2.

Solar systems

The average National NPV across all of the installations was -$4766 (in 2011 NZD). This may indicate that the long-term value of the investment is not economically beneficial to the country as a whole when evaluated on this basis. However, it should be noted that that this analysis does not include the flow on economic benefits of the programme, as well as the intangible benefits such as meeting the Government's objectives as discussed in Section 2.2.3. The distribution of National NPVs for Solar installations is shown in Figure 3 below.

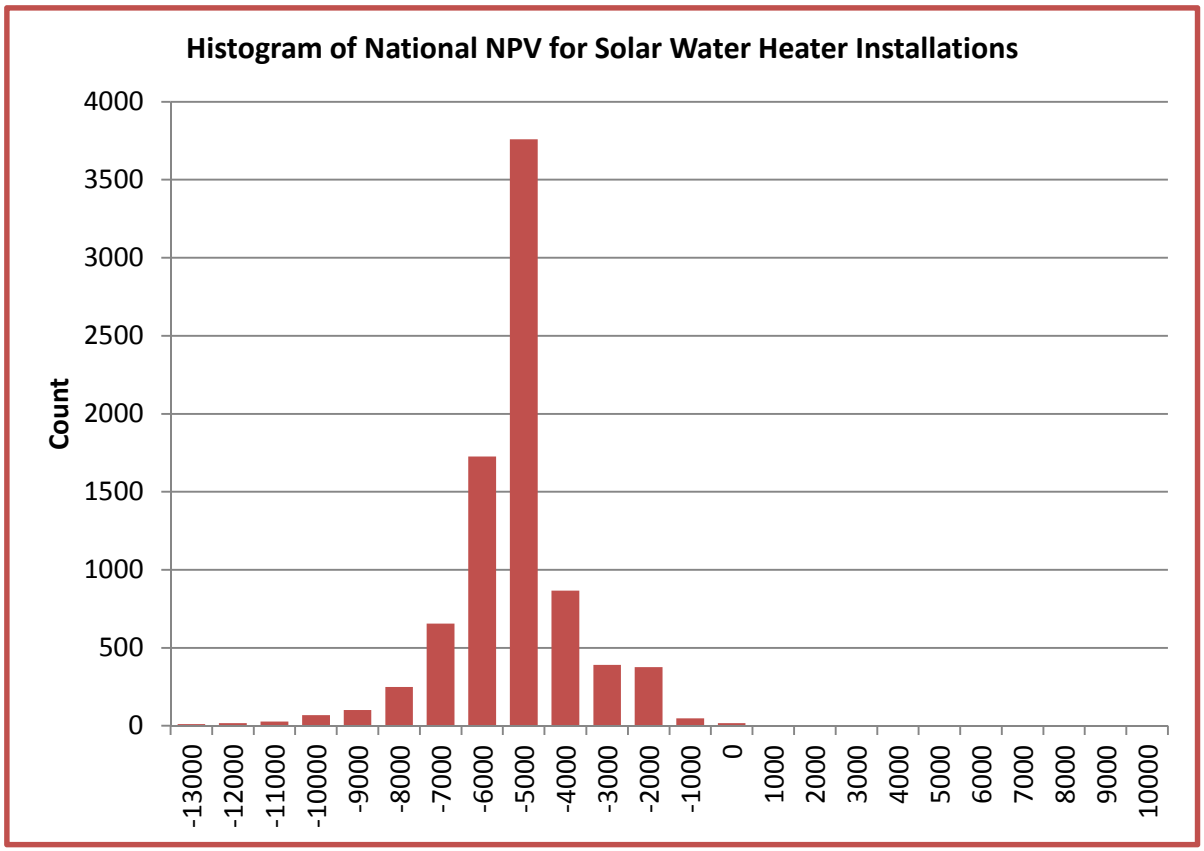

Figure 3. National NPV for solar water heater installations

Heat Pump systems

The average National NPV across all of the installations was -$1147 (in 2011 NZD). As above, this may indicate that the investment is not economically beneficial to the country as a whole when evaluated on this basis. The distribution of National NPVs for Heat Pump water heating systems is shown in Figure 4 below.

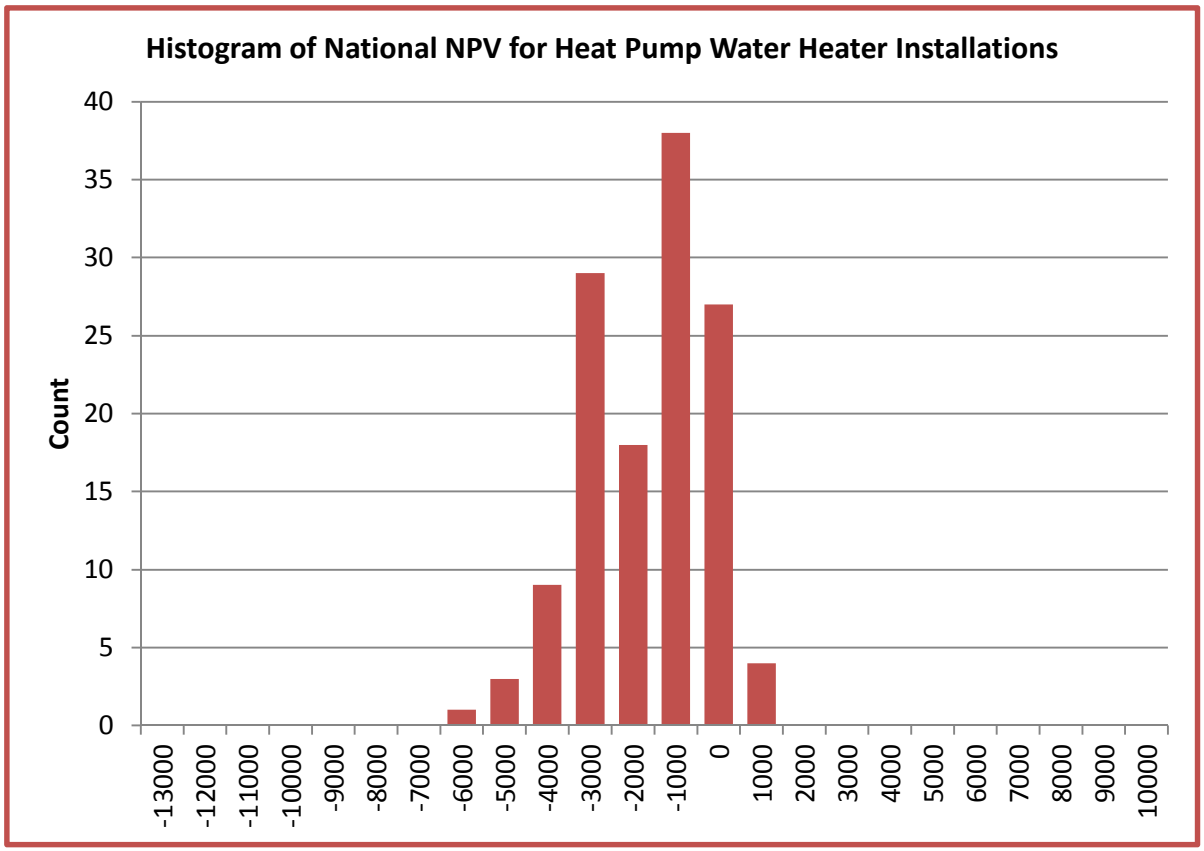

Figure 4. National NPV for heat pump water heater installations

4.4 Consideration of Additionality and Related Effects

When reviewing the results of a subsidy programme such as this, the following effects should be borne in mind:

- **Additionality:** This is the extent to which the water heating systems would have been installed without the programme funding – also known as the 'free rider effect';
- **Spillover:** Spillover occurs when there are reductions in energy consumption or demand caused by the presence of the programme, but which the programme does not directly influence; and
- **Rebound effect:** Rebound is a change in energy-using behaviour that increases the level of service and results from a new water heater installation under the programme. The most common form is 'take back', which can occur if consumers increase energy use as a result of a new installation (for example, taking longer showers due to reduced concern about water heating costs.

No data has been collected by EECA to support the quantification of these effects.

There is very limited research available to quantify these effects in a way that is relevant to the EECA programmes. A study by the Australian Gas Association (AGA) concluded that 25% of participants in the equivalent Australian solar water heater finding schemes would have purchased their systems without the government funding[1]. This provides some quantification of the possible extent of the additionality/free rider effect, subject to the following caveats:

[1] "Reducing greenhouse emissions from water heating: natural gas as a cost-effective option", Research Report 16, Australian Gas Association, November 2002.

- The study is from different programmes in a different jurisdiction, so many factors will be different, which may affect this result; and
- The purpose of the publication was to lobby for an alternative technology (natural gas water heating).

For these reasons, this 25% result should only be taken as an indication of the possible extent of the free rider effect, rather than a reliable estimate.

4.4.1 Effect of the free rider effect on CBA results

The CBA analysis as described in this section was modified as follows to allow for the free rider effect:

- For the consumer-level CBA, only the value of the grant is considered for the affected installations - all the other costs and benefits would have been realised without the programmes. The value of the grant is treated as a benefit for the consumer; and
- For the national-level CBA, again only the value of the grant is considered for the affected installations - all the other costs and benefits would have been realised without the programmes. The value of the grant is treated as a cost for the nation.

The affected installations were chosen as the 25% of the installations for which the grant represented the lowest fraction of the overall cost of the installation, on the assumption that the grant would be less of a deciding factor for these installations.

Making these modifications have the following effect on the average NPVs in the CBA results:

NPV Basis	Solar - No Free Riders	Solar - 25% Free Riders	Heat Pump - No Free Riders	Heat Pump - 25% Free Riders
Consumer	$395	$470	$5212	$4309
National	-$4766	-$3774	-$1147	-$522

With the exception of the heat pump consumer NPV, these results show that considering the free rider effect produces a more positive average NPV. This is due to the finding that, after the grant is received, the average installation is losing money. The more positive average NPV is effectively saying that less of these losses can be blamed on the programmes, as the losses would have occurred without the programme due to the free rider effect.

The exception is the consumer NPV for heat pump systems, which were economically beneficial on average. This decreases when the free riders are considered, as some of these benefits would have been realised without the programme due to the free rider effect.

In each case, consideration of the free rider effect does not change whether the average NPVs are positive or negative, so does not change the high-level conclusions regarding whether the programmes are economically beneficial or not.

4.5 Conclusions

Table 1 summarises the results of the average NPVs as calculated by the cost-benefit analysis:

Table 1. Summary of cost-benefit analysis results (2011 NZ$)

NPV Basis	Solar	Heat Pump
Consumer	$395	$5212
National	-$4766	-$1147

These figures indicate that while the programme has resulted in a positive NPV for most consumers, on a national basis, the NPVs are significantly negative. At first glance, this would appear to indicate that the long-term value of the investment is not economically beneficial to the country as a whole, however it should be noted that that this analysis does not include the flow on economic benefits of the programme, as well as the intangible benefits such as meeting the Government's objectives as discussed in Section 2.2.3.

Other conclusions that can be drawn from this analysis include:

- A significant proportion of the solar installations have a negative consumer NPV. This suggests that better targeting of the programme towards installations that would produce a positive NPV is warranted.
- The NPV results for heat pump systems are significantly better than for solar systems. This result is because all of the heat pump installations are in 2011 and not earlier, and as a result are exposed to higher electricity prices, rather than heat pump systems being inherently more economic than solar systems.
- There is very limited research available to quantify additionality and related effects in a way that is relevant to the EECA programmes. Adopting an assumption of 25% free riders in the CBA did not alter the conclusions that could be drawn from this analysis.

5 Commentary

In this section, we provide a commentary on certain subjects as requested by the Ministry, namely, the success or lack of success of the programme in terms of the following outcomes:

- Energy security;
- Creating jobs;
- Improving consumer choice; and
- Increasing the availability of energy to assist economic growth in other sectors.

Each of these topics is discussed in the following sections.

5.1 Energy security

In providing this commentary, we will define 'energy security' as the nation's ability to supply its energy needs without interruption.

In general, New Zealand is blessed with multiple energy resources, many of which are renewable. A key energy resource is hydroelectric power, which provides the majority of New Zealand's electricity needs. This leads to the issue that has been the only significant threat to energy security in recent years: The potential for electricity shortages in 'dry' years. As water heating is a major use of electricity (around 30% of household use[2]), a large-scale uptake of efficient water heating technologies could conceivably improve New Zealand's energy security in this respect.

The programme has resulted in 8694 solar water heater installations to date (ignoring free rider and related effects). According to our model used for the CBA analysis, the 8332 installations for which adequate data existed will result in a combined annual energy saving of 18.2 GWh. Assuming the installations for which adequate data exists are representative of all installations, we estimate total annual energy savings from solar water heater installations under the programme to be 19.0 GWh.

Similarly, the programme has resulted in approximately 153 heat pump water heater installations to date (again, ignoring free rider and related effects). According to our model used for the CBA analysis, the 129 installations for which adequate data existed will result in a combined annual energy saving of 378 MWh. Assuming the installations for which adequate data exists are representative of all installations, we estimate total annual energy savings from solar water heater installations under the programme to be 448 MWh.

This results in total annual energy savings of 19.4 GWh attributable to the programme. In contrast, New Zealand's total annual electricity demand was 38,558 GWh in 2010[3]. Thus, the energy savings from the programme amount to 0.05% of total demand. Saving such a small proportion of total demand cannot be expected to have a significant impact on national energy security.

5.2 Creating jobs

Job creation is not stated as one of the objectives of the programme in the EECA documents that were reviewed, but is an ancillary benefit of the programme.

[2] HEEP Year 6 Analysis

[3] Electricity Authority Centralised Dataset

Job creation outcomes of the programme are not recorded by EECA; however EECA's 2009 internal review of the solar water heating programme provides a basis for estimating the number of jobs created. This specifies a range of 12-25 full time equivalents (FTEs) directly employed in solar water heater installation. Assuming a similar range for heat pump water heaters, this range results in the following estimate of jobs created for the installations under the programme:

Table 2. Estimate of job creation in installation

Year	Number of installations	Employment - lower limit	Employment - upper limit
2005	464	5.6	11.6
2006	961	11.5	24.0
2007	568	6.8	14.2
2008	680	8.2	17.0
2009	2184	26.2	54.6
2010	2427	29.1	60.7
2011	1539	18.5	38.5

Other categories of job creation include:

- **Manufacturing:** This was estimated by the 2009 study to be 10-15 FTEs in 2008. Given the increase in volume of installations, this can be expected to have increased, but it is not clear to what extent this figure is proportional to manufacturing volume.
- **Testing and Training Facilities:** This was estimated by the 2009 study to be 6-8 FTEs. These numbers are not expected to be proportional to the number of installations, and so are expected to remain around this level for the lifetime of the programme.

Given that job creation was not specified as an objective of the programme, and goals have not been set for this outcome, it is difficult to determine whether these numbers represent success or otherwise. However, under current economic conditions, any job creation as an ancillary benefit of the programme should be seen as a positive outcome.

5.3 Improving consumer choice

Again, this was not highlighted as an objective of the programme by any of the EECA documents, was mentioned by the Cabinet paper as a reason to develop a mix of renewable energy sources (see Appendix 2.1).

A range of solar water heaters were available prior to the introduction of the programme, and heat pump water heaters were available prior to their inclusion in the programme. The major benefit from the programme in terms of consumer choice is the creation and application of standards for solar water heaters, creating some certainty for consumers that their system will perform to a minimum standard, and as advertised.

The applicable standards are:

- AS/NZS 2712 - SWH Design and construction
- AS.NZS 4234 - SWH Energy performance modelling

The fact that AS/NZS 2712 has been included in the New Zealand building code will ensure that the benefit of this standard will endure beyond the end of the programme.

5.4 Increasing the availability of energy to assist economic growth in other sectors

This outcome is related to the one of energy security discussed in section 5.1. If energy demand used for water heating is reduced, this could be seen as 'freeing up' energy to assist in growth in other sectors. Given New Zealand's open and market-based access to energy, the means by which this would happen would be via energy prices. A significant reduction in energy demand would result in lower energy prices, increasing the profitability and competitiveness of those sectors.

However, as discussed in section 5.1, the energy saving achieved by the programme have been estimated at around 0.05% of total electricity demand. Such a small reduction is unlikely to have any significant effect on energy prices and therefore no significant effect on economic growth in other sectors.

6 Conclusions

In this section, we summarise our conclusions from this review.

6.1 Problem Definition

A problem definition was drawn from multiple EECA documents. Analysis of this problem definition leads to the following conclusions:

- **The problem definition is not stated consistently within EECA:** Each of the four EECA documents contained a different subset of the bullet points listed above. This is a concern, as the design of the programme should depend on the objectives that the programme is trying to achieve and the barriers it is trying to overcome.

  The objectives stated by EECA may not be consistent with the Government's: All of the EECA statements of the potential benefits include energy savings, while none of them include "Signalling the Government's commitment to energy efficiency and renewable energy". In contrast, the Cabinet paper indicates that the Government's main objective is one of leadership rather than energy savings. Consideration of this this objective may result in the programme placing a greater emphasis on marketing than is currently implemented.
- **The case for Government intervention fails as a prima facie (i.e. self-evident) conclusion:** The following objections could be raised to contradict this conclusion, and have not been addressed. Without addressing issues such as these, the case for government intervention cannot be considered self-evident:
  - The capital cost barrier may be an entirely rational one: The benefits achieved may not justify the capital cost, or there may be other options to achieve the same objectives at lower cost. If this is the case, then financial assistance would be incentivising economically inefficient choices, and
  - It could be argued that the issues of information, consumer choice, product and installation standards and invisibility of benefits should be the responsibility of the industry to resolve, rather than the Government's

6.2 Identification of barriers

We have used a structured approach to identify the barriers to increased uptake of solar and heat pump water heating systems. This has resulted in several barriers being identified that were not identified in the EECA documents reviewed in section 2.

As can be seen from the tables in section 3, several identified barriers remain unaddressed. The programme design should be reviewed to ensure that as many barriers as possible are addressed.

6.3 Cost-benefit analysis

Table 3 summarises the results of the NPVs as calculated by the cost-benefit analysis:

Table 3. Summary of cost-benefit analysis results (2011 NZ$)

NPV Basis	Solar	Heat Pump
Consumer	$395	$5212

National	-$4766	-$1147

These figures indicate that while the programme has resulted in a positive NPV for most consumers, on a national basis, the NPVs are significantly negative. A first glance, this would appear to indicate that the long-term value of the investment is not economically beneficial to the country as a whole when evaluated on this basis. However, it should be noted that that this analysis does not include the flow on economic benefits of the programme, as well as the intangible benefits such as meeting the Government's objectives as discussed in Section2.2.3.

Other conclusions that can be drawn from this analysis include:

- A significant proportion of the solar installations have a negative consumer NPV. This suggests that better targeting of the programme towards installations that would produce a positive NPV is warranted.
- The NPV results for heat pump systems are significantly better than for solar systems. This result is because all of the heat pump installations are in 2011 and not earlier, and as a result are exposed to higher electricity prices, rather than heat pump systems being inherently more economic than solar systems.
- There is very limited research available to quantify additionality and related effects in a way that is relevant to the EECA programmes. Adopting an assumption of 25% free riders in the CBA did not alter the conclusions that could be drawn from this analysis.

6.4 Commentary

6.4.1 Energy Security

We have estimated total annual energy savings of 19.4 GWh attributable to the programme. In contrast, New Zealand's total annual electricity demand was 38,558 GWh in 2010. Thus, the energy savings from the programme amount to 0.05% of total demand. Saving such a small proportion of total demand cannot be expected to have a significant impact on national energy security.

6.4.2 Creating Jobs

The number of jobs created by the programme has been estimated as being in the range 18.5 - 38.5 FTEs in 2011 from the installation of systems. Further job gains can be expected from the manufacturing of systems, and testing and training facilities.

Given that job creation was not specified as an objective of the programme, and goals have not been set for this outcome, it is difficult to determine whether these numbers represent success or otherwise. However, under current economic conditions, any job creation as an ancillary benefit of the programme should be seen as a positive outcome.

6.4.3 Improving Consumer Choice

The major benefit from the programme in terms of consumer choice is the creation and application of standards for solar water heaters, creating some certainty for consumers that their system will perform to a minimum standard, and as advertised.

The inclusion of AS/NZS 2712 in the New Zealand building code will ensure that the benefit of this standard will endure beyond the end of the programme.

6.4.4 Increasing the availability of energy to assist economic development

The energy savings achieved by the programme have been estimated at around 0.05% of total electricity demand. Such a small reduction is unlikely to have any significant effect on energy prices and therefore no significant effect on economic growth in other sectors.

Appendix A: Problem definition statements from reviewed documents

In this section, we reproduce pertinent excerpts from the documents that were reviewed for statements of the problem definition.

A.1 EECA Documents

A.1.1 EECA Portfolio Management System: Programme Plan: Solar & Heat Pump Water Heating (S&HPWH) Programme: 27 October 2010

1.2 Programme Objectives

The Solar and Heat Pump Water Heating (S&HPWH) programme aims to enhance the energy efficiency of New Zealand houses by reducing the amount of purchased energy used for residential water heating through providing support for efficient and/or renewable water heating technologies.

The EECA Statement of Intent 2010-2013 outlines that this programme will achieve energy and greenhouse gas emissions savings. The programme output for 2010/11 is:

- Grants for at least 2,300 water heaters.

The wider objectives of the 2010/13 Solar and Heat Pump Water Heating (S&HPWH) programme are:

- In the short term:
  - Increase the uptake of S&HPWH systems, and
  - Encourage the industries to improve the quality and energy performance of their products
- In the medium term:
  - Develop consumer demand and industry capacity so that the S&HPWH industries will maintain a high uptake of installations and the grants can be removed.

1.3 Key Barriers

Capital Cost - S&HPWH technologies are expensive to purchase but cheap to run. Capital cost is viewed as the principle barrier to the S&HPWH industries delivering a sustained high level of installations.

Information - Many householders remain unaware of S&HPWH technologies and the costs and benefits associated with them. Similarly, most residents are unaware that government support in the form of grants may be available.

Product performance and installation quality - Historically there have been issues with SWH product quality and performance, while many of these issues have been resolved, the risk is that the reputation of the technology could be adversely affected by individual brands or industry players (e.g. retailers or installers). For HPWH, the technology is very new in NZ and so there are risks relating to product and installation quality - both of which have the potential to undermine the long-term reputation of HPWHs.

A.1.2 EECA Solar & Heat Pump Water Heating Rebate Scheme: Strategic Policy Document – SWH SP3: Version 2.0 Thursday, 20 May 2010 – 8:27 a.m.

Strategic Solar Water Heating Policy

Vision

The EECA Strategic Plans sets out EECA's vision for water heating in New Zealand. This includes achieving energy savings for residential properties of 10 PJ per annum and an overall renewable energy contribution for New Zealand of 45% (including a 90% renewable electricity target).

Strategic Objectives

Objectives specific to residential water heating set out in the EECA Strategic Plan include:

- Within 5 years (by end 2014) – efficient water heating systems in all new houses and upgraded systems in 5% of existing
- 2025 target – household electricity and gas for water heating is reduced by 30% from 2007 levels

Through the achievement of these objectives, EECA is able to contribute to the Government's priority areas, including "Energy efficiency, energy conservation and the use of renewable energy resources to improve security of supply, productivity and health outcomes".

A.1.3 The Business Case for a Three Year Fixed Funding ($5.8m pa) Water Heating Programme

EECA Objectives

EECA is established under section 20 of the Energy Efficiency and Conservation Act 2000. The Act states 'the function of the Authority is to encourage, promote, and support energy efficiency, energy conservation, and the use of renewable sources of energy'.

EECA Objectives include:

- To contribute towards the objectives of the New Zealand Energy Efficiency and Conservation Strategy in the following areas:
  - ENERGYWISE^{TM} Homes – Reduced energy costs through better products, better information for householders and by increasing the uptake of household renewable energy.
  - ENERGYWISE^{TM} Business – Taking action through improving hot water requirements in industrial and commercial settings, provision of training, advice services, and energy efficient accommodation in tourism sector.
- To contribute towards the objectives of the EECA Strategic Plan in the following areas:
- Within 5 years (by end 2014) – efficient water heating systems in all new houses and upgraded systems in 5% of existing
- 2025 target – household electricity and gas for water heating is reduced by 30% from 2007 levels

Programme Objectives

The objectives of the proposed Water heating programme are to:

- Maximise household energy savings for hot water services without compromising those services;
- Promote choice for customers in relation to energy efficient and renewable hot water services; and
- Incentivise efficient and renewable water heating technologies in order to assist developing those industries.

…

The Barriers

- **Information** - Householders will benefit from impartial information on a broad range of technological and behaviour solutions than they might be offered by businesses with specific technologies
- **Technical performance** - Ensuring that stated performances of technological solutions are real and that the implications of the performance criteria are understood.
- **Installation quality** - Ensuring that the quality of installation allows the stated technical performance to be maximised, that customers of the technology understand what good installation practice entails, and that suitable support is provided to industry associations to train and assure installation quality.
- **Up-front costs** - Some technologies are expensive and require financial assistance to generate sufficient momentum for consumer demand to become self-sustaining. Other technologies pay for themselves within two years but they are not implemented because homeowners do not know about the option or realise its value.

A.1.4 EECA Internal Review: Report on the effectiveness to 30 June 2009 of the Solar Water Heating Programme with recommendations: 24 November 2009

1.4.1 Policy Rationale

The policy rationale that underpins the development of the SWH Programme is to encourage the development of and increase the uptake of renewable energy in NZ. Solar energy can contribute to, and therefore save 50 to 75% of domestic water heating bills. SWH can reduce the consumption of fossil fuels and could contribute to NZ's security of supply both in terms of adding to the renewable energy availability and reducing the dependence on other forms of energy.

…

1.4.2 Energy potential and Market Barriers

…

The market barriers identified for SWH in September 2006 included:

- High upfront cost, contributing to low cost-effectiveness, particularly compared to other options for reducing energy bills and other options for water heating;
- A lack of credible, authoritative and simple information on SWH performance and specifications;
- A challenging regulatory environment; especially poorly understood building consent requirements;
- Limited industry capability or capacity, for example, lack of or inadequate product, performance and installation standards; and
- The 'invisible' nature of the benefits compared to other high cost consumer durables and other uses of disposable income.

A.2 Other Government Documents

A.2.1 Cabinet Paper: Cabinet Economic Growth and Infrastructure Committee: Solar and Heat Pump Water Heating Programme: 4 June 2010

(Text not included in this report as paper is not in the public domain).

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