EN6590/3

Development of Renewables Framework for Decision Making

Final

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About This Report

Title

Development of Renewables Framework for Decision Making

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Abstract

This report is concerned with an analysis of appropriate local renewable energy solutions for New Zealand houses and neighbourhoods. This helps to support Beacon's energy target "to increase the percentage of energy in homes supplied from local renewable sources". It sets out a framework for decision making to enable the process of technology selection, technology assessment and the evaluation of appropriate renewable options. A series of new and retrofit scenarios are provided to illustrate that a variety of suitable renewable energy options exist to satisfy energy demands at both the home and neighbourhood scales.

Reference

Armstrong, M., Ryan, V. February 2009. **Development of Renewables Framework for Decision Making**. Report EN6590/3 for Beacon Pathway Limited.

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1 Executive Summary

This report is concerned with an analysis of appropriate local renewable energy solutions for New Zealand houses and neighbourhoods, in support of Beacon's energy target "to increase the percentage of energy in homes supplied from local renewable sources".

This is part of a programme of research which extends Beacon's knowledge in renewable energy, by developing a decision making framework to specify optimum renewable energy solutions for new and existing New Zealand homes and neighbourhoods in New Zealand.

It is anticipated that appropriate options will find practical applications as part of Home*Smart* Renovations and Home*Smart* Homes as these parallel programmes develop.

An analysis of previous research assists the definition of a list of suitable renewable technologies for new and retrofit applications. The technologies outlined are capable of delivering low grade heat and high grade electricity from renewable sources and have applications at both a neighbourhood and household level.

Renewable technologies are then assessed against a set of criteria based on fitness for use, ease of uptake, and sustainability. The technology assessment provides a key input to the decision making framework applied to typology and location-based scenarios, to test the ability of the approach to identify scenario-specific energy options.

The technologies produced for the chosen scenarios indicate that the range of options for houses to increase their use of local renewable energy is readily available. There are significant opportunities to be gained by increasing utilisation of low grade heat.

The report identifies that the most readily applicable high grade electricity option is solar photovoltaic technology for the majority of New Zealand's houses – and the most applicable low grade heat is solar thermal and biomass. Passive solar should also be prioritised in both retrofit and new build.

Benefits beyond economics, opportunities and barriers to uptake, future technology development, technology innovation and future research questions are also explored.

2 Introduction

This report introduces a decision making framework that can be utilised to identify suitable renewable technologies for application into new and retrofit situations within New Zealand's residential housing stock. 'Residential' scenarios in this report include community and neighbourhood options as well as those for single residential dwellings.

This report, developed from a series of working papers, serves a number of purposes:

- To act as a repository of information gathered in the development of Beacon's decision making framework for renewable technologies (renewables)
- To summarise previous research applicable to developing the decision making framework
- To assist in the development of the assessment criteria and identification of suitable renewable solutions for the New Zealand residential context
- To provide a means for input from the wider group of experts involved in the development of Beacon's framework
- To test the suitability of the identified technologies alongside the assessment criteria in a series of typology-based residential scenarios

The most desirable application of the report outcomes would be in demonstration houses and retrofit projects with direct monitoring (as per the proven NOW Home model and proposed Home*Smart* Renovation programme). Potential stakeholders in such application could include government agencies, developers and/or individuals interested in implementing renewables

3 Beacon Strategic Context

Beacon's vision is to "create homes and neighbourhoods that work well into the future and don't cost the Earth". To reach this vision we are guided by two goals:

- 90% of New Zealand homes will be sustainable to a high standard by 2012; and,
- Every new subdivision and any redeveloped subdivision or neighbourhood from 2008 onwards to be developed with reference to a nationally recognised sustainability framework.

The research is managed under six streams: Energy, Water, Indoor Environment Quality, Materials, Sustainable Homes and Neighbourhoods.

The Board-approved Energy strategy has three research targets:

1) 90% of New Zealand homes use energy efficient systems for water heating, space heating, lighting and appliances, and have a high standard of insulation (to maintain a minimum temperature of 18^{o}C), by 2012, aiming to reduce the demand on reticulated energy from homes by 40%.
2) All homes will have a minimum net 50% of their energy supplied from local renewable sources and have a minimum temperature 18^{o}C by 2020; AND all energy into all homes/neighbourhoods will be supplied by renewable sources by year 2040.

3) All new homes and consented renovations will be designed to reduce total energy requirements through active management of the passive solar and thermal performance by 2012.

The work outlined in this report responds primarily to Beacon's second energy target above: to increase the percentage of energy in homes supplied from local renewable sources. It is also inextricably linked to targets one and three, in as much as any application of renewable energy to a home or neighbourhood is most effectively installed once the energy demand of that home has been reduced as much as possible.

3.1 Beacon's High Standard of Sustainability for Energy

This research has been undertaken in parallel with the review of the 2008 versions of the HSS High Standard of Sustainability® (HSS®). At the outset of the research Beacon provided the following benchmarks in relation to energy use (kWh/yr)[1]

- Climate zone 1: New 7600; existing 9050
- Climate zone 2: New 8500; existing 11,000
- Climate zone 3: New 9800; existing 12,000

During the course of development of the renewables decision making framework Beacon's HSS benchmarks were under review. An unpublished report (French, 2008) sets forward the following updated energy benchmarks for Beacon. As can be seen from Table 1 and Table 2 below, the benchmarks are considerably lower and more importantly the application of renewable potential has been captured. These figures were still under review at the time of writing but are included here to set the context for the renewables framework and discussion of Beacon's renewable energy targets.

[1] ***Adapted from 'Defining the Benchmark's for Beacon's High Standard of Sustainability' PR109, Easton, 2006.***

Potential HSS® benchmarks for new houses kWh/year/house						
	Gas	All electric			Electric and renewable	
HSS™ climate zone	Gas and no solar	No hp or solar	Hp space and no hp water	Hp space and hp water	Hp space and solar water	Renewable space and solar
0	7,300	7,200	6,800	5,300	4,600	4,400
1	9,000	8,600	7,300	5,800	5,100	4,400
2	10,800	10,000	7,800	6,300	5,600	4,400
3	12,400	11,900	8,800	7,300	6,600	4,400

Table 1: Potential HSS® benchmarks for new houses

Potential HSS® benchmarks for existing houses kWh/year/house						
	Gas	All electric			Electric and renewable	
HSS™ climate zone	Gas and no solar	No hp or solar	Hp space and no hp water	Hp space and hp water	Hp space and solar water	Renewable space and solar
0	7,500	7,400	7,100	5,400	4,600	4,400
1	10,700	9,700	7,800	6,200	5,300	4,400
2	12,900	11,800	8,900	7,300	6,400	4,400
3	16,100	14,300	10,000	8,400	7,500	4,400

Table 2: Potential HSS® benchmarks for existing houses

3.2 Research Context

This report forms part of a programme of research which extends Beacon's knowledge in renewable energy (RE) by providing a decision making framework to enable the best renewable options to be considered. Through the development of the assessment criteria, framework and subsequent value case this research provides Beacon with the ability to specify optimum renewable energy solutions for new and existing homes and neighbourhoods in New Zealand; allowing Beacon to inform consumers and communities wishing to install renewable solutions and helping to meet Beacon's targets.

The overall programme of renewable energy has a range of research objectives. Those are:

- To identify the technical criteria that determine which renewable energy options are best suited to different types of New Zealand homes along with available local resources (contributing to the Home*Smart* Renovations program).
- To identify the relative benefits and criteria for dwelling based (domestic) and neighbourhood (local community scale) based interventions.
- To identify and prioritise opportunities for Beacon to provide innovative technical solutions for homes wishing to access renewable energy for space and water heating (low grade energy).
- To identify what conditions have enabled successful use of renewable low grade energy in homes and neighbourhood both here and internationally.
- To identify the constraints to wider uptake of renewable options in New Zealand including analysis of economic constraints (affordability) and technical constraints (information / installation / capacity) and market constraints (uptake, motivations).
- To critically review the mechanisms for facilitating uptake of renewable energy options that have been tried within New Zealand, and internationally, to assist in the development of targeted value propositions.

This project is broken into three main work strands:

- **Work strand 1 Developing a decision making framework** is primarily concerned with an analysis of appropriate local renewable energy solutions for New Zealand houses and neighbourhoods. This will include an indication of opportunities/barriers to uptake.
- **Work strand 2 Defining the 'best technology in the right place at the right scale'** will build on some of this data to outline *where* the identified technologies are best applied in terms of climate, region, access to resources, house and neighbourhood typology.
- **Work strand 3 Demonstrating success - developing the Value Case for enhanced uptake** utilises findings from 1 and 2 to outline *why* the appropriate technologies are critical in the delivery of a sustainable future for New Zealand, making the case to targeted stakeholders.

This research report delivers work strand one above. Further research in Beacon's Renewable Energy Programme builds on the work outlined in this report to deliver Work strands 2 and 3.

4 Methodology

The research presented here develops an analytical framework for decision making that would allow Beacon to determine which renewable energy options would be best suited to different types of New Zealand homes.

As a starting point, analysis of previous research (including Beacon's) was undertaken to help define a list of suitable renewable technologies for new and retrofit applications. In terms of scope, and in line with Beacon's goals and benchmarks, potential technologies were chosen to provide for the delivery of low grade heat and high grade electricity from renewable sources and with applications at both a neighbourhood and household level.

Following the identification of suitable technologies, a set of assessment criteria were developed to establish the prioritisation process capability of the decision making framework. The initial findings from the prioritised list of technologies and the assessment criteria were tested with selected renewable energy experts to ensure robustness of the approach.

This work provided a list of prioritised solutions that small-scale renewable energy can deliver at the household and neighbourhood level. This list was further refined in the context that Beacon Pathway requires 90% of New Zealand houses to meet the HSS High Standard of Sustainability® and to use 50% less reticulated energy while reducing overall energy use.

The framework approach that appears in this report allows Beacon to assess a range of renewable/low energy options in New Zealand homes and neighbourhoods. The analysis presented here provides a wider frame of reference than typical 'pay back' or crude cost benefit analysis found in typical analysis of renewable energy options (cf. EECA Renewable Energy Fact Sheet 4, Photovoltaics, June 2008). It is anticipated that appropriate options will find practical applications as part of Home*Smart* Renovations and Home*Smart* Homes.

An outline of the specific methodology employed is provided below.

4) Literature Search – existing Beacon reports and other research related to renewable technology application in a residential context was sourced from New Zealand and internationally. The emphasis was on technology type and subsequent implementation at a household and/or community scale.
5) Comparison of the technology assessment process – as part of the literature search, examples of the approach used for technology selection in the residential context were identified and compared. The emphasis was on the type and range of criteria used, and how these adapted to the New Zealand residential situation.
6) Renewable Technology – scope for considering technology type, market context, descriptions and technology grouping were detailed according to the base criteria identified for the first assessment step (see 'Base Criteria' page 10)

7) Assessment Criteria set – the full process and rationale for applying a set of relevant technology assessment criteria was described, and applied to the selected technologies (see ‘Assessment Criteria’ page 21).
8) Decision Making Framework for Scenario Assessment – a series of typology based case studies were trialled to demonstrate potential renewables solutions for delivery of low grade and high grade energy (see application of the framework page 28).
9) Implementation Factors - factors impacting on use of renewables in New Zealand beyond the technology were identified, including future research.

5 Existing research

The following section acknowledges the major research of interest from Beacon Pathway and others looking at renewable energy in New Zealand. A full reference list is provided at the end of the report.

Beacon has completed a range of research projects in the area of renewable generation, although not specifically targeted at the neighbourhood scale. Previous work provides a good basic knowledge of energy use in New Zealand, the policy and regulatory environment, renewable energy generation with some gaps in knowledge identified. In particular:

- **Sustainability Options for Retrofitting New Zealand Houses: Energy** (Report TE106/4) - Reviewed existing energy retrofit programmes; most insulation or insulation + heating device; current insulation retrofits not achieving energy savings due to take-back in comfort and insulation alone is not enough – need to install efficient heating device also. Retrofit programmes all aimed at low income (under heated) homes - unknown what impact these might have on "average" homes. Looked at tailored retrofit options and recommended further research.
- **TE101 Evaluation Of Technologies Suitable For Improving The Sustainability Of New Housing In New Zealand (Access restricted) -** Lists and assesses technologies for 'new build'; 175 technologies in database with the majority related to energy directly; top 10 technologies identified.
- **TE102 Retrofit Technologies Database (Access restricted) -** Lists, evaluates and ranks technologies for 'retrofit'; 102 technologies in data base – many energy related; Areas for innovation/adaptation identified, 5 energy related; Summarised some international retrofit programmes – most energy focused.
- **Renewable Energy Opportunities in the NZ Residential Built Environment (Public Report)** (Report TE140/3) - reviewed and assessed five generation methods including solid fuel (biomass) burners, heat pumps, solar water heater, photovoltaic arrays, and wind generation. Discussed the difference between low grade and high grade energy and points out the importance of solid fuel burners in the New Zealand mix. Options for further work highlighted, particularly on: - solid fuel burners, heat pumps, solar water heaters. (Note: This report has extensive coverage of each technology, hence it is not repeated here).

Other reports providing useful support material:

- **Get Smart, Think Small: Local energy systems for New Zealand (2006)-** a comprehensive report on future options by NZ Parliamentary Commission for the Environment.
- **Grid 2.0 The Next Generation (2006) –** a report by the Green Alliance, and Compass UK on an alternative future approach for delivering decentralised power.

- **Grid-connected Domestic and Small-scale Renewables in NZ- BAU uptake projections to 2030 (2007) –** a report by Hydro Tasmania Consulting, for the NZ Energy Efficiency and Conservation Authority (EECA), summarising the current status and projected uptake for domestic renewables. Includes comparisons with international practice, market drivers and technology drivers.
- **A Review of Micro-generation and Renewable Energy Technologies (2008) –** NHBC Foundation (UK) describes technology and features of a number of commercial technologies in the UK.
- **UK Code for Sustainable Homes Technical Guide (2008) –** the Definitions for "Ene 7": Low or Zero Carbon Technologies lists available and acceptable LZC technologies.
- **Warm Homes Technical Report: Detailed Study of Heating Options in NZ, Phase 1 Report, November 2005 –** NZ Ministry for the Environment report exploring options for cleaner heating sources and increased energy efficiency for NZ homes.
- **Renewable Energy in Remote Communities, (May 2007) -** C Underwood et al, J Environmental Planning Management 50 (3) p397. Looks at Low/Zero carbon technology to support a remote community to overcome fuel poverty and reduce dependence on the grid.
- **UK Green Building Council: The definition of zero-carbon, (May 2008) –** Zero Carbon Task Group. Defines allowable renewables to meet local energy generation for Zero Carbon legislation requirements for new buildings.

A pre-research scoping study was performed prior to the renewables workplan being written and the results were provided in the appendix to the Research Identification Brief (and provided again here in the appendix on page 52. In summary the pre-research highlighted that New Zealand has still not got the basics right in terms of house design, performance, insulation etc. As a result, renewable or energy efficient technologies are installed poorly, and misused, contributing to poor performance and low buy-in. The research suggested that the strength of the Beacon model is to create real-life demonstration sites with real people, combined with technology and monitoring to provide evidence for real change. This provides a model for implementing outcomes from this report.

Through the development of the assessment criteria, framework and subsequent value case this research provides Beacon with the ability to specify renewable energy solutions for New Zealand, and to inform consumers and communities wishing to install renewable solutions. Favourable policies and economic incentives will also improve the effectiveness of this research to meet Beacon's targets in the long-term.

6 Renewable Technologies

6.1 Scope

For the purposes of developing the framework the renewable energy technologies have been split into 5 specific groups according to their application as follows:

1) Generation - high grade electricity
2) Generation - low grade heat
3) Generation - combined heat and power (CHP)
4) Energy Management
5) Energy Efficiency

Under Beacon's Renewable Energy programme only technologies involved in generation (groups 1 to 3 above), and energy management (group 4 above) will be assessed. Technologies that are of interest will be those that are applicable at household and/or neighbourhood level and can apply to both retrofit and new build applications in a grid-connected system rather than stand alone off-grid[2] systems.

Some broad base criteria have been applied to narrow the field of possible technologies to be studied. These have been developed in line with Beacon's targets to transform the majority of New Zealand's housing stock by 2012, and to meet challenging targets for renewables by 2020. Further assessment steps are then applied in the section on Assessment Criteria (see page 21), providing a framework for investigating various scenarios based on house typology.

6.1.1 Base criteria (Assessment Step 1):

- Currently available technology (here and proven overseas)
- Capable of application and viable as a tried and tested solution within the next 10 years in New Zealand
- For high grade electricity, to be applicable at the household, neighbourhood or community level as a grid-connected distributed generation solution (i.e. not commercial scale energy generation such as a wind farm)
- At current energy and capital investment prices would provide a pay back in less than 50 years[3]

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[2] ***Beacon's targets are to transform 90% of New Zealand's housing stock - hence the focus on grid connected and 'urban-friendly' technologies***

[3] ***This maximum pay back of 50 years was chosen in order to restrict the research to technologies which have a realistic potential for uptake within the next 10 years without constraining the ability to look at potential solutions with currently uneconomic paybacks by today's standards.***

The assumption is made that the technology will be assessed as if it were being applied to a house or neighbourhood <u>that has already taken measures to reduce energy demand</u> such as upgrading the basic thermal envelope, and installing energy efficient appliances. From Beacon's standpoint, this work is captured in the Home*Smart* Renovations energy retrofit program.

Technologies that form part of a sustainable solution, but are not specifically renewable are acknowledged in this report under energy efficiency. They will not be included in the assessment, and further discussion is required regarding the interface with the HomeSmart Renovations program. The relationship between retrofit to reduce energy demand and assessment of renewable technologies is provided in the diagram below.

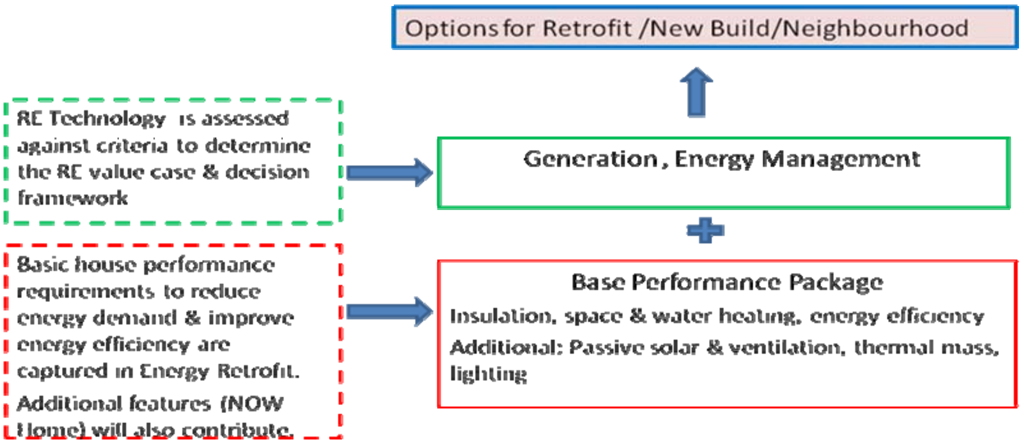

Figure 1: **Relationship of Beacon's Retrofit programme with the Renewable Energy Programme**

Figure 2 below describes the impact of renewable technology options and energy use for a new build or retrofit house where energy efficiency measures have already been implemented (i.e. demand has been reduced as much as possible). The next challenge is to implement appropriate technology (or technologies) to reduce the amount of reticulated energy used by utilising a local renewable energy source. It is then important to maintain, or preferably reduce, overall energy consumption from whatever energy sources are used – rather than increasing energy demand because of the perception of "free" energy[4]. This will enable more local renewables to meet demand, and continue to reduce the drain on reticulated energy from the grid.

4 Further discussion of this can be found in international literature such as Harris et al and E Vine, in Energy Efficiency on-line journal

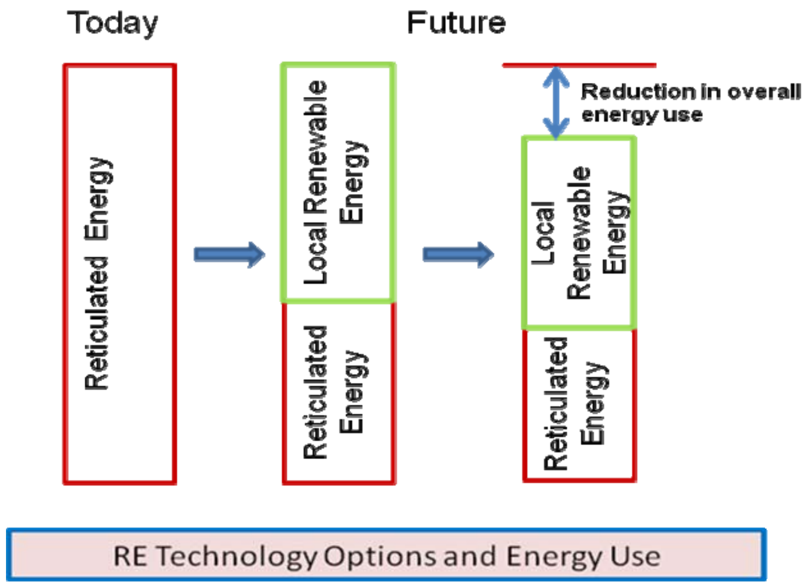

Figure 2: Renewable Energy Programme - Desired Outcome

Note: Figure 2 provides a general reflection of the intent to reduce reticulated energy; it is for illustrative purposes only and it is not intended to suggest that all NZ households have 100% of their energy needs supplied from reticulated energy. Some households already use biomass burners and solar thermal for low grade heat.

There is significant potential for renewable energy systems to increase the understanding of both energy supply and demand, and to assist users with an appreciation for the true ‘value’ of energy within the household. This may lead to a reduction in overall energy use, and potentially a more regular demand profile as users seek to even out their patterns of consumption to maximise use of local renewable energy sources.

6.2 Market Environment

Several aspects of the New Zealand market environment that influence *how* the technology options are employed are briefly considered below and are worthy of further investigation beyond the scope of this report. These aspects are relevant for single household applications but particularly for renewable energy at the neighbourhood scale, for example:

- Pricing and incentives for :
  - Exporting excess energy back into the grid, incentives and structures to manage and reduce demand including at peak[5].
  - Encouraging installation of RE technology at a domestic level for the purposes of offsetting larger-scale generation investment, smoothing demand on the local network,

[5] ***These occur from a commercial scale upwards, but are not in place for residential-type customers; largely because of negative cost-benefit economics for retailers.***

and/or encouraging households to become more engaged with reduction of their carbon footprint.
  - Reducing capital and installation costs for renewable generation
  - Raising education and awareness levels of consumers and developers
- Policy and regulations to:
  - Continue to improve housing standards for thermal performance
  - Trial pricing that reflects national interest rather than supplier benefit.
  - Facilitate an increase in the installation of domestic grid-connected renewables
  - Facilitate implementation of user-friendly smart meters
  - Enable and facilitate community ownership of distributed generation

6.3 Technology Description

6.3.1 Generation - high grade electricity

Technology	Description	Current Status in NZ
Solar PV	Rooftop and ground mounted flat plate arrays	~100 installed, predominantly off-grid
Wind	Micro (up to 20kW): rooftop and tower-mounted to small communal	Numerous off-grid No small communal
Micro Hydro	<100kW ; mostly Pelton wheel	50 (100kW)
Community Biogas from waste	Gas (methane) powered turbine	7 (22.4MW)
Bio-fuel Generators	Diesel gen-sets adapted for bio-fuel, for stand-by and possibly peak load.	Commercially available. Mostly off-grid.

Note: Tower-mounted wind turbines are seen as more efficient for single houses compared to rooftop mounted; but can be subject to urban regulations for installation. Both can be considered as options for urban/suburban sites, but would rarely be recommended for use as wind conditions are often too inconsistent for good performance.

Bio-fuel Generators are included for completeness, particularly if bio-fuel sources are available from local sources (e.g. ethanol, willow, wood chip, waste vegetable oil, algae etc). Appropriateness of such generators requires further discussion at a national level, but if the ratio of local renewables was to be as high as possible, gensets may become relevant especially to provide base load. Their use is flexible (i.e. base load, or for peak lopping) depending on the site and the load profile.

6.3.2 Generation - low grade heat

Technology	Description	Current Status in NZ
Biomass Burners	Wood, pellet, chip burners for space and water heating (wetback)	Widespread across NZ
Solar Thermal	Flat-plate and evacuated tubes; for hot water.	15,000 to 20,000 (estimate)
Boilers	Fed by biomass or bio-fuel; for whole-house space (radiators) and water heating	Commercially available, used mainly in the South Island.
Community Heating Schemes	Heat re-used from local industrial waste heat (or potentially from biogas, geothermal, or biomass), distributed to nearby houses.	1 scheme in Christchurch. Considered to be very underutilised in NZ[6].
Passive Solar Design	Combining orientation for solar gain with thermal mass, insulation and glazing to store and distribute space heat	Limited range of deliberately designed NZ examples aiming to use it as a major energy source (e.g. Waitakere NOW Home).

Note: A potential barrier to the use of biomass for low grade heat is the particulate emissions standards being promoted by Ministry for the Environment, which place restrictions on make and function of some burners and boilers. The fuel type and the efficiency of various systems in terms of heating performance and particulate emissions need to be considered. Restrictions vary by region and apply mainly to urban environments.

Boiler-fed central heating systems are growing in use for space and water heating, especially in colder climates. Retrofitting such a system is possible for wall-mounted radiators to distribute heat, but not for under floor piping. In some areas, these systems are well-complemented by solar thermal for provision of summer hot water.

Passive solar design is not a new approach for building design, but needs much greater emphasis in New Zealand as an option for improving home comfort and energy efficiency. It is the cheapest form of low-grade heat available, especially if insulation levels are provided that meet or exceed the current standard.

[6] *Pers. Com, Bob Lloyd, 2008*

6.3.3 Generation - combined heat and power

Technology	Description	Current Status in NZ
Micro CHP	5.5kW heat: 1 kW power from a Stirling engine fuelled by gas or LPG, currently trialling on biodiesel	Whispergen models commercially available; 2 DC domestic systems installed in NZ

Note: CHP technology based on a steam or gas-driven turbine is used commercially, but is aimed at power outputs >30kW. More investigation is needed for New Zealand suitability and possible application for these systems in larger scale settings such as apartments.

Small or micro-scale CHP technology has been utilised in the UK and Europe for some years to meet the thermal loads of their colder climate. CHP systems work on the basis of cogeneration to ensure maximum energy efficiency – the cooling required for generation of power can be utilised as heat. At a domestic scale, CHP units are run primarily to meet thermal load requirements (mainly space and water heating), with electricity produced as a by-product. However, where thermal loads are intermittent (such as in temperate climates) then power generation becomes more important.

6.3.4 Energy Management

Technology	Description	Current Status in NZ
Electricity Meters	Smart meters - for making data available to users as well as retailers. Domestic time-of-use (TOU) meters - especially for communities, or where linked to an appropriate tariff.	Meridian is installing 100,000 smart meters over next 2 years; other retailers working on their own version. Time of use meters are used at an industrial level currently.
Load Monitoring	Devices connected to switchboard, or individual appliances to monitor instant load for household use.	Small product range commercially available. (e.g. Centameter)
Demand Management Systems	For managing multiple inputs, ripple relays and alarms for managing internal ripple control and peak demand levels. Usually require wireless capability.	Available for customer networks (rest homes, apartments, malls), and commercial customers

Note: The term 'smart meter' is widely used to describe a variety of systems. However, smart meters are not created equal. They are a recent feature for New Zealand households, but have been used internationally for some time. In order for consumers to be fully informed and make consequential changes in the way they manage demand, the meter information needs to be accessible and linked to tariff incentives to change behaviour. Smart meter introduction has been driven by the retailer need to cut costs for meter reading and ripple control – data will only be available monthly. There is an opportunity to influence and drive developments in this area by demonstrating the economic benefits (to consumers and network managers) from having the data accessible and linked to tariffs.

There is also considerable scope for more intelligent smart meters to provide feedback to homeowners in relation to the energy systems used to power the house and also the energy consumed within the house. If this can be developed to provide a 'dashboard for the house' there is scope for the homeowner to become more engaged in household performance which could have additional energy saving benefits[7].

Demand management systems also provide the opportunity to optimise the use of RE systems for communities. Implemented correctly they provide an opportunity for a community to optimise both their energy production and energy utilisation.

6.3.5 Energy Efficiency

Technology	Description	Current Status in NZ
Heat Delivery	Efficient conversion technology via heat pumps, e.g. Air-air/air-water (COP up to 4, dropping to 2 in colder temperatures) Ground-source Heat Pump (COP 5 constant) Waste heat recovery from ceiling air, and shower/laundry water.	All available commercially, with significant air-air installations. ~10 GSHP installed higher capital cost and harder to retrofit. Suitable for geothermal areas? Air distribution systems well established. Heat recovery systems for waste water are available but not widely used.
Appliances and Lighting	Use appliance with appropriate minimum energy performance standards (MEPS) and star ratings	Availability good (e.g. washing machines and refrigerators) and labelling is evolving for a range of appliances.

[7] ***This is supported by Fischer (April 2008) in a study on 'Feedback on Household Electricity consumption'. Fischer indicates 'that the most successful feedback combines the following features: it is given frequently and over a long time, provides an appliance-specific breakdown, is presented in a clear and appealing way, and uses computerized and interactive tools.'***

Design and Construction	To reduce energy use and improve house performance, e.g.: super- insulation double-glazing natural lighting, passive ventilation passive solar/thermal mass	Building Code has upgraded recently, but NZ is still lagging internationally. HERS introduction could drive change (if house-value is affected), but may need to be mandatory.

Note: Energy efficiency is not a panacea to reducing consumption – it can have the effect of maintaining or increasing consumption levels if other activities and demands occur to take advantage of any gains. Positive change will be brought about by improving house design and construction; and through a programme of ongoing education to achieve the benefits of energy efficiency and conservation.

An issue to consider regarding heat pumps is the *fuelling* of the heat pump technology and the relative efficiencies of the systems when heat is needed most. In the UK, heat pumps are not promoted as carbon-neutral unless they are powered by renewable electricity. Points to consider:

- Better placement and use of air-air and air-water systems to maintain COP, or to allow smaller systems to be used (by better utilising warm air streams around the house).
- Not using air source systems in very cold parts of New Zealand where efficiencies can drop significantly. Instead boilers or ground-source systems may be better suited for harsh climates with high demand for heating in winter.
- Promoting alternatives to using heat pumps as cooling options in summer and considering adoption of a standard requiring heat pumps to not cool below certain temperatures
- Educating consumers to understand that heat pumps use energy and do not create it, regardless of efficiency.
- Understand better how heat pumps can be used to **reduce** the overall energy requirements for heating air or water. i.e. how many standard resistive heaters are they replacing? How much less is spent powering a heat pump than on other forms of heating? How big an impact user behaviour and adequate training has on heat pump energy use; The temperatures that heat pumps are likely to be set at; How much more of the house is heated as a result; and what is the comparable cost of whole-house heating using other systems? (BRANZ is undertaking research to address some of these issues)
- Convenience rapidly supersedes efficiency, especially if the user perceives they are getting something for nothing (or more for the same price).
- Keeping pressure on retailers and installers to provide correct operational information rather than marketing hype, and ensure installation standards are maintained[8].
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[8] ***As an example the following claims are made on a prominent manufacturer's website (unnamed for legal reasons) "Electric Heatpumps... They're the world's most efficient heaters and they make great air conditioners. A heat pump represents excellent value because it heats in the winter and cools in summer, unlike natural gas which only does half***

6.4 Technology Grouping

Variability of resource and season severity across New Zealand means a number of technologies are required to be grouped together in order to provide for house or community needs year-round. The technologies (individual and groups) must also be used in combination with the energy efficiency features of the house (including insulation, thermal mass, orientation etc), and behaviour change. It is important to note that no single technology can deliver all the desired benefits.

Generation technologies are needed to deliver high grade electricity for running a variety of appliances such as lighting, home entertainment and security systems.

Low grade heat technologies complement generation by reducing the need for direct use of electricity for space and/or water heating. The challenge here is the provision of renewable heat when alternative resources are unavailable or unsuitable (e.g. low levels of sun; urban wood supply is unavailable or too expensive). In this case generation options will need to supply electricity for heating if other options are not available; or non-renewable sources will need to be considered.

Figure 3 below indicates the seasonal impact on the usefulness of the various generation options, and highlights why more than one generation option may be needed if the grid is to be supplemented. In order to provide "*a minimum net 50% of their energy supplied from local renewable sources*"[9], a degree of base load needs to be available to ensure basic energy needs can be met all year round.

In determining the final generation mix for a particular location the following criteria need to be considered:

- Proportion of the base load provided by the grid
- Availability and consistency of renewable resources
- Site suitability for different renewable solutions
- Specific energy needs, and pattern of energy demand
- Seasonal variation

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the job. High energy efficiency is a huge plus to help you save on heating bills. Absolutely nothing else compares."

[9] ***Beacon's interim renewables target as set out in the Beacon Energy Strategy***

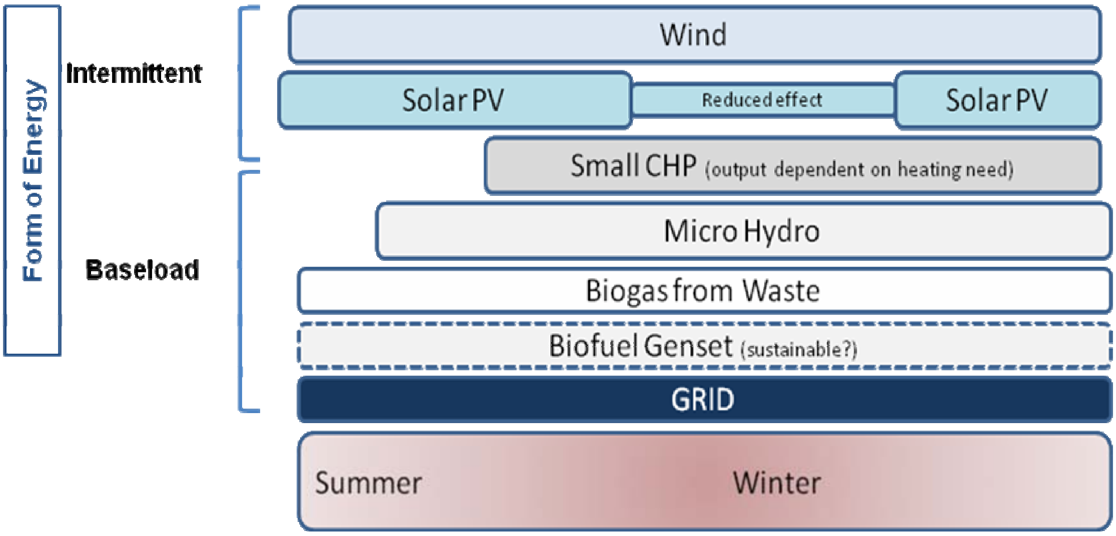

Figure 3: Generation Technologies – Seasonal Application

Heating technology is considered according to whether space and/or water heating is provided, and the relative convenience of heat provision. Convenience isn't necessarily the only dimension to consider, but may represent a significant use barrier for those who don't want to have to load fuel, or who want easy on-demand water and space heating (e.g. those with young children; the elderly; or those with a disability). Pellet burners are evolving to improve storage and dispensing of the pellet fuel. Figure 4 outlines the technology options in terms of heat provision and relative convenience.

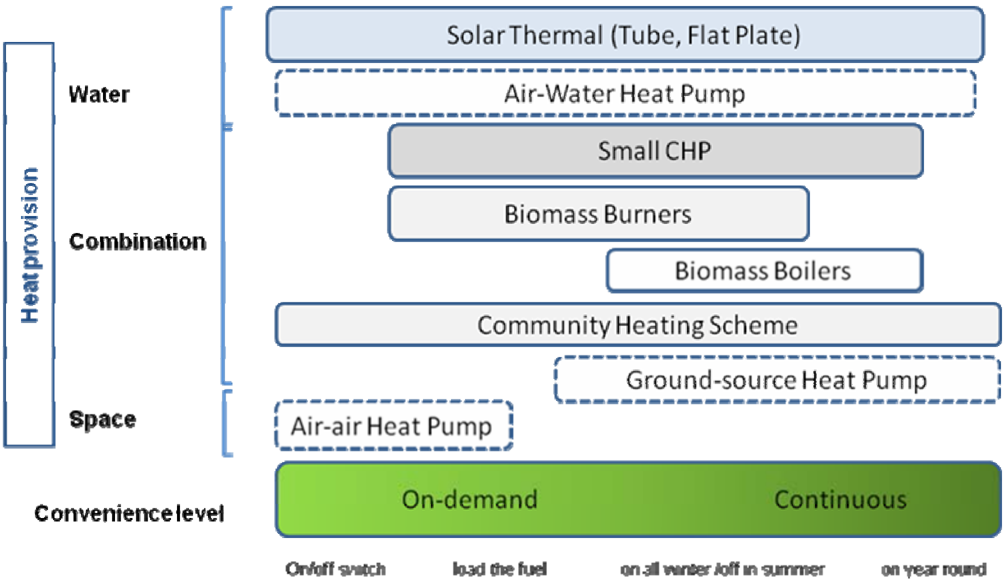

Figure 4: Heating Technology Options

Various heat pumps are shown on the diagram as a comparison. The air-air heat pump represents an on-demand heating option that is showing a dramatic rise in uptake within New Zealand. Air-water heat pumps may be options for boosting solar thermal systems, or even as alternatives in some areas if cost and performance are attractive. Part of the appeal of heat pumps is the 'energy efficiency' feature, as well as the convenience of use. However, it still requires high-grade electricity to operate.

The choice of space and water heating technology options will depend on:

- Availability of renewable fuel source
- Seasonal severity and climate zone
- Existing features from house design – insulation, passive solar, etc
- Convenience of use for technology for individuals
- Suitability of dwelling typology to accommodate the technology option
- Regional regulations such as emissions standards and consenting processes.

7 Assessment Criteria

A series of criteria to assess renewable technologies has been produced as part of the decision making framework. These are utilised to identify the various technology groupings for different scenarios, and to act as a repository for collating comments and issues.

The assessment process follows a series of steps, with the first step using some base criteria to generate the initial list of technologies. Steps 2A and B provide more detailed criteria concerned with fitness for use, along with broader market-focussed criteria around uptake and sustainability. The technologies from Step 1 are assessed against the criteria from Step 2. The decision making framework approach is then applied in Step 3 against selected scenarios. The process is shown below in Figure 5:

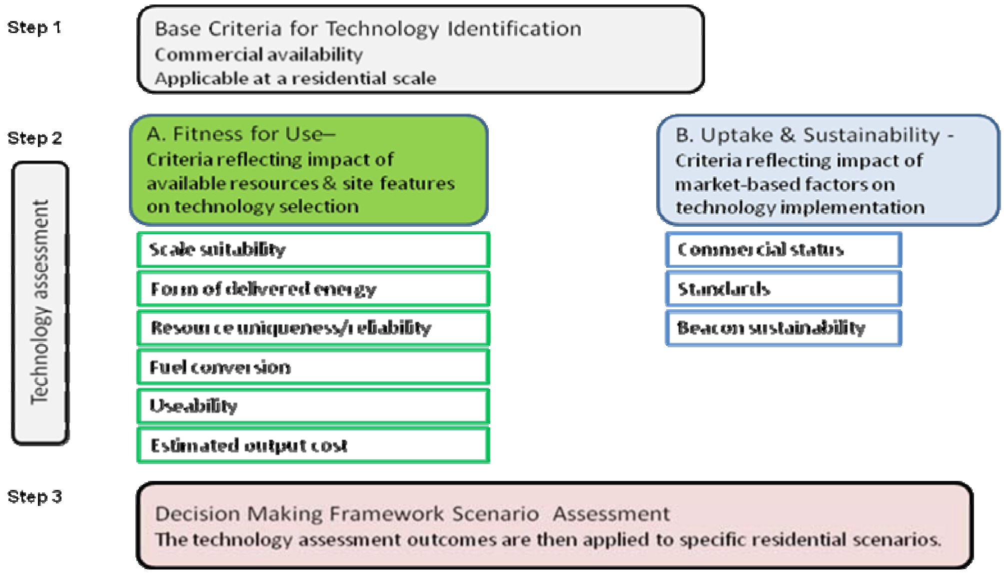

Figure 5: Applying the Assessment Criteria

7.1.1 Step 1: Base Criteria

The following criteria (introduced on page 10) were applied to generate the base list of technologies:

- Currently available technology (available here and proven overseas)
- Capable of application for both retrofit and new and viable as a tried and tested solution within the next 10 years in New Zealand
- Applicable at the household, neighbourhood or community level as a grid-connected distributed generation solution (i.e. not commercial scale energy generation such as a wind farm).
- At current energy and capital investment prices would provide a pay back in less than 50 years

7.1.2 Step 2: Technology Assessment Criteria

The criteria definitions for Steps 2A & 2B are numbered and described below. This enables cross reference to in the Technology Assessment Matrix tables (outlined in this report on page 26) which combine the technologies identified in Step 1, with the assessment criteria.

7.1.3 Step 2A: Fitness for Use

Fitness for Use criteria are based on energy source and application. They are applied to each technology as shown in the Technology Assessment Matrix (refer page **Error! Bookmark not defined.**):

a) **2Aa**: Scale suitability – applicable at a house (**H**) and/or community (**C**) scale?

b) **2Ab**: Form of delivered energy – is delivered energy in the form of heat (seasonal variation); supplementary power (e.g. wind); or guaranteed "base load" power (e.g. CHP or generator). Is there a seasonal effect impacting energy delivery? (Refer Figure 3 on page 19)

c) **2Ac**: Resource Reliability- is the required resource site or region dependent; or available NZ-wide? Specific resource criteria descriptions:

- **i)** Solar reliability – based on hours of direct sunlight in winter; assumes panels can be frame-mounted to best orientation if roof is not ideal. Generally >4 hours direct sun in winter is required.
- **ii)** Wind reliability – based on proximity to obstacles (more open areas provide more consistent wind). Annual wind speeds > 5 m/sec are considered minimum.
- **iii)** Biomass – availability of pellets, wood or waste for fuel.
- **iv)** Bio fuel – based on commercially available fuels (e.g. biodiesel, ethanol)
- **v)** Micro-hydro – dependent on proximity to waterways with minimum flow (~15 l/min) and head (>2m) for a small turbine with minimal environmental impact.

d) **2Ad**: Fuel Conversion – is fuel-driven technology able to convert from fossil to future renewable fuels (e.g. diesel to bio-fuels from waste; LPG to hydrogen or bio-gas)

e) **2Ae**: Usability – is technology reliable, durable, and convenient to operate (i.e. to deliver energy, is a minimal or active input required by owner? (Refer Figure 4 on page 19)

f) **2Af**: Estimated output cost (c/kWh) – cost range that delivered energy could fall into by 2020 (<20c/kWh; 20-50c/kWh; >50c/kWh). These cost options are chosen as a comparative reference against current retail electricity prices (i.e. less than, similar, greater than).

7.1.4 Step 2B: Uptake and Sustainability Criteria

Uptake and Sustainability criteria are based on capability of technology to deliver in terms of quality and inputs required to increase market uptake (as shown in Technology Assessment Matrix on page **Error! Bookmark not defined.**):

g) **2Ba**: Commercial Status in NZ
Uptake rate - Is this high, low or developing in the NZ residential market?
Development Required to Build Uptake - are further developments required to increase uptake such as technology, capital cost, education, regulation (state which)?
Economy of scale - are there opportunities to improve cost to consumers?

h) **2Bb**: Standards - do these exist for quality of construction, installation and performance?

i) **2Bc**: Beacon sustainability criteria (low/medium/high) compiled from previous reports (e.g.TE140: Kane, 2006).

Identify which criteria if any, will be negatively impacted by implementing the technology:

Sustainability Criteria	Description
Technical	Can the technology provide a technical solution to some of the barriers in the New Zealand context?
Economic	Issues from economic aspects of the technology (including pay back and contribution to the asset value of households).
Environmental	Issues from environmental impact of the technology, and any existing LCA information.
Social	Issues concerned with social aspects of the technology.
Cultural	Cultural impact of the technology in the NZ context.
General/Regulatory	Issues of location dependency, territorial authority and regulatory impact (support from NZES and NZEECS). Fit with Beacon’s Renewable energy and High Standard of Sustainability (HSS) targets.

7.1.5 Step 3: The Decision Making Framework for Scenario Assessment

The scenarios used to assess and select appropriate technology are predominantly based on location and house typology information derived from previous Beacon research (Ryan, 2008).

The approach of the decision making framework was evaluated using the following process:

j) Select those technologies relevant to the scale of the scenario (household or community)
k) Group technologies by form of delivered energy, to identify the possible 'technology grouping' to ensure energy needs can be met year round. The recommended requirements are:
   i) At least 1 intermittent high-grade energy option
   ii) At least 1 supplementary low-grade heat option for water and space heating
   iii) At least 1 base load power option
   iv) No local regulatory issues
   v) Ensuring Beacon's goals are not compromised
l) Assess impact of :
   i) Resource reliability (including fuel conversion considerations)
   ii) Relevant standards and regulations for particular locations and typologies
   iii) Usability and convenience
m) For multiple options, attractiveness is then based on remaining features of output cost, uptake and sustainability

Note: Passive solar is rated as year round heat, as good solar design aims to capture maximum winter sun - when other solar technology is less effective.

The fundamental requirement for each scenario is the ability of the technology to perform with available resource. In other words, if a renewable resource is less available, or less reliable, the technology cannot be expected to deliver benefits of electricity or heat to the desired levels.

The 'user input' required to achieve maximum benefit, and standards that vary by region need to be recognised as a criteria that can be household, or community specific – particularly for low grade heating options.

Complementarity of technology and a whole system approach needs to be considered for each scenario. This supports the development of a technology package when equipping a home or neighbourhood where the technologies:

- are appropriately sized and will deliver in terms of available resources;
- are useable at a level that fits with a household/community capabilities
- meet required standards for performance, for that location
- are the most viable economically, with the option of improving economic and sustainable performance through policy, education, cost reductions etc.

In the scenarios developed in Step 3 it is assumed that the baseload electricity will be provided by the grid. This is the most realistic option in the short term while renewable technologies are trialled, and may even be the preferred scenario for the majority of New Zealand's housing stock.

7.1.6 Assumptions for scenarios

- Single storey apartments, blocks of flats and houses with their own share of roof area can be regarded as a 'stand-alone' dwelling.
- Multi-storey apartments without own roof area are treated as a 'community'.
- Community scenarios will include multi-level apartments, or a cluster of independent households. For sub-divisions, hapu communities or even blocks of single-storey flats the smaller-scale technologies will be relevant as well as the larger community scale options.
- High-grade energy generation options would be grid-tied.
- Residential electricity meters provide feedback and data on usage profile as required by the user. Current energy use if not provided by a meter can be obtained from a commercial load monitoring device.
- System sizing: because the technology will be supplementing grid energy in the short term (as opposed to delivering peak loads), a stand-alone dwelling may only require a high grade electricity system with a capacity of 1-2 kW; and/or a low-grade heating system capable of supplying 3-5kW. A community system will need to be sized according to the number of users.
- Heat pumps have not been included in this discussion as a retrofit option (although they are considered as part of the energy retrofit options within Beacon's retrofit work and through the Home*Smart* Renovations programme. However, it is highly likely that in order to achieve heating needs in a retrofit scenario that involves replacing existing resistive or gas heaters, a heat pump may be a viable option if (a) a burner is not permitted; or (b) the same/less electricity is used to run the heat pump to deliver more/the same amount of heat.

7.2 Technology Assessment Matrix

Step 2A: Fitness for Use (refer to definitions on page 22)

	Technology	2Aa. Scale Suitability	2Ab. Form of Delivered Energy	2Ac. Resource Reliability	2Ad. Fuel Conversion	2Ae. Usability /Convenience	2Af. Estimated Output Cost
High Grade	Solar PV	H,C	Intermittent	Site (at least 4 hrs N sun)		Reliable if sited correctly; proven durability; minimum input to operate	>50
	Wind (20kW)	H,C	Intermittent	Site (5m/s consistent)		Reliable in consistent wind; durability variable in gusts; minimal input	20-50 1kW wind: >50
	Micro Hydro	H,C	Base if summer-safe	Site (head and flow)		Reliable outside droughts; durable, minimal input	<20
	Community Biogas from waste	C	Base if constant feedstock	Region (cheap transportable feed)		Reliability depends on feedstock; durable to date; active input needed for feedstock	<20
	Biofuel Generators	H,C	Base	NZ	Yes	Reliability and durability proven; some input for irregular use	<20
Low Grade	Biomass Burners	H	Heat on demand	Region		Reliability depends on fuel quality; proven durability; active input to maintain fuel feed.	<20
	Solar Thermal	H,C	Seasonal heat	Site (see solar)		Reliable and durable if sited and installed correctly; active input will increase value of output (but can run passively with boost)	20-50
	Boilers	H,C	Heat on demand	Region	Yes	Reliable with long run time; durable; input depends on fuel feed-in.	<20
	Community Heating Schemes	C	Base heat depends on source	Region		All aspects still to be proven in NZ	<20
	Passive Solar	H	Year-round heat	Site (see solar)		Durable and reliable with good design; some input helps retain heat	<20
	Micro CHP	H	Heat and power on demand	NZ	Yes (liquid currently)	Reliable with fossil fuels; durability still proving; some input needed to feed and run for power not heat.	>50
	Electricity Meters and Load Monitors	H,C	Delivered data variable by system	NZ	n/a	Reliability and durability unproven for meters; but proven for load monitors. No active input needed to operate, but action required to use the outputs!!	n/a
	Demand Mgmnt Systems	C	Data high quality and tailored by system.	NZ	n/a	Reliable and durable proven for current customers; active input for best results	n/a

Step 2B: Uptake and Sustainability Criteria (refer to definitions on page 23)

	Technology	2Bai. Uptake Rate	2Baii. Development Required for Uptake	2Bbiii. Economy of Scale	2Bb. Standards	2Bc. Beacon Sustainability–potential issues
High Grade	Solar PV	Low-Dev	Reduce unit cost , Regulations to incentivise uptake	Yes	Install and equipment Ok	Economic (affordability)
	Wind (20kW)	Low	Reduce unit cost ; Regulations to encourage community ownership and manage RMA	Yes	Install and equipment Ok	Economic (affordability), general (regulations around community developments)
	Micro Hydro	Dev.	Education re value of small schemes within the RMA	no	Install OK, equipment – depends on make	Potentially regulatory issues depending on size of system.
	Community Biogas from waste	Low	Technology development; Education and Regulations to incentivise uptake via councils and industry	unsure	OK for existing systems; will develop	Possibly social; general (regulations on emissions; and local government support)
	Bio fuel Generators	Dev	Technology for fuel conversion	No	Install and equipment ok	Environmental (emissions)
Low Grade	Biomass Burners	High	Technology development to reduce unit cost for pellets, improve efficiency for wetbacks.	no	Install OK, equip. depends on emissions standards	Environmental (emissions)
	Solar Thermal	Dev	Education re use; Regulations to drive use in new builds; Reduce unit cost	yes	Install improving, equipment Ok	Economic (affordability especially for retrofit)
	Boilers	Low	Technology development for emissions; Education to increase use	Yes	Install OK; equip. must manage emissions	Environmental (possibly emissions)
	Community Heating Schemes	Low	Technology development to commercialise in more areas; education of industry and councils	yes	Unsure – proven outside NZ	Possibly social; general (regulations supporting such schemes at council level)
	Passive Solar	Dev	Education and awareness of benefits and method	yes	Part of Building Code	none
	Micro CHP	Low	Technology development to reduce unit cost and seek new fuels	yes	Still proving install and equipment for bio fuels	None (if converted to bio fuel)
	Electricity Meters and Load Monitors	Dev	Regulation change to drive meter installation, Education on value of load monitors	no	Developing for meters. Load monitors can usually be done as DIY.	none
	Demand Management Systems	Low	Education for developers and councils for multiple housing use to reduce energy load	yes	Install and equip backed by developer/installer	none

8 Applying the Decision Making Framework for Scenario Assessment

The following scenarios based on house typology and location, have been developed to demonstrate how the decision making framework is applied to technology selection.

Locations: Auckland, Dunedin

Scenario typologies:

1) Retrofit villa, 500m^2 urban section
2) Multi-unit 60/s flat with 6 units
3) New Build, house, urban section
4) New build multi-unit development (6 units)

8.1 Scenario 1: Retrofit Villa

Assumptions:

1) Houses are fully insulated and draught-proofed; and taking reasonable steps towards energy efficiency
2) Sections <1200m2 are likely to have interference for wind from trees and buildings, but PV panels can be sited on mounts that can make the most of available sun.
3) Solar thermal systems are instant-gas boosted.
4) Heat pumps may have to be considered if burners are not an option.

Technology Selection: Scenario 1

	Technology (Scale: household)	Resource Reliability and Seasonality				Standards and Regulations	Usability (Suitable options)
		Solar	Wind	Bio-	Micro-		
Intermittent High Grade	Solar PV	Auckland : >4hrs Dun: <4hrs, seasonal				None	Roof sitting must be right
	Wind		Both: unsuitable			Yes (height)	
	Micro Hydro				Both: unsuitable		
Supplementary Low Grade Heat	Biomass Burners			Auckland Pellets Dun: wood pellets Heat on-demand		Dunedin: emissions	Pellets easier than wood
	Solar Thermal	Akld: >4hrs Dun: <4hrs, seasonal				No	Good if well sited. Active input an option
	Biomass Boilers			Auckland : Pellets Dun: wood, pellets Heat on-demand		Dun: emissions	Good if auto fuel feed and regs met
	Passive Solar	Auckland : >4hrs Dun: <4hrs, Year round				no	Good. Low active input needed.
	Micro CHP biodiesel			Both: biodiesel, year round		no	Work required
	Electricity Meters and Load monitors					Meters vary by retailer	Ok. Depends on unit.

SUMMARY for Scenario 1: Retrofit Villa

Attractiveness Assessment: Scenario 1

Technology	Estimated Output Cost c/kWh	Uptake Requirements	Sustainability Issues
Solar PV	>50	Reduce unit cost and improve efficiency (long term)	Affordability in short term
Biomass Burners	<20	Improve wetback efficiency and manage emissions	Environmental
Solar Thermal	20-50	For retrofit: Reduce unit cost, provide education on benefits	Affordability in short term
Biomass Boilers	<20	Manage emissions, develop cost-effective retrofit	Low environmental (more efficient than burners)
Passive Solar	<20	Education re benefits and design options for retrofits	None
Micro CHP biodiesel	>50	Reduce unit cost , new fuels	Affordability in short term
Electricity Meters and Load monitors	n/a	Cost-effective user friendly units	none

Technology Grouping Summary: Auckland

Attractiveness	1 = most	2	3	4 = least
Intermittent Electricity	PV	CHP		
Low-grade heat: Space	Wood pellet burner	Passive solar if retrofit possible	CHP	
Low-grade heat: Water	Solar thermal	Burner wetback		

Note:

- PV is the only high grade energy option
- Solar thermal will provide hot water most of the year in this location

Technology Grouping Summary: Dunedin

Attractiveness	1	2	3	4
Intermittent Electricity	PV only if >4 hrs sun	CHP -due to winter heat load		
Low-grade heat: Space	Biomass burner	Biomass boiler	CHP	
Low-grade heat: Water	Burner wetback ; or from boiler	Solar thermal for summer	CHP	

Note:

- Suitability of solar for Dunedin will be site-specific. If enough sun is present in winter then it should be considered for solar thermal at least.
- Higher space heating needs due to climate make burners a viable option due to wetback possibilities. These can also group with solar thermal for summer water heating.
- CHP units are a viable option to deliver high grade electricity if installed for heating; although cost makes these less attractive.

8.2 Scenario 2: Multi-unit 60/s flat with 6 units

Assumptions:

1) Flats are fully insulated and draught-proofed; and taking reasonable steps towards energy efficiency
2) Flats will be subject to tenant regulations (put in place by the owners or developers), which may restrict options.
3) If a tenant has their own roof area associated with the dwelling, more options exist for use of that roof area.
4) Heat pumps may have to be considered if local regulations mean that wood burners are not an option.

Technology Selection: Scenario 2

	Technology (Scale: household)	Resource Reliability and Seasonality				Standards and Regulations	Usability (Suitable options)
		Solar	Wind	Bio-Fuels	Micro-hydro		
Intermittent High Grade	Solar PV	Both suitable, seasonal				None	Roof sitting must be right
	Wind		Both: unsuitable			Yes (height)	
	Micro Hydro				Unlikely		
Supplementary Low Grade Heat	Biomass Burners			Auckland : Pellets Dun: wood, pellets Heat on-demand		Dunedin: emissions	Pellets easier than wood
	Solar Thermal	Both suitable, seasonal				No	Good if well sited. Active input an option
	Biomass Boilers			Auckland : Pellets Dun: wood, pellets Heat on-demand		Dun: emissions	Good if auto fuel feed and regs met
	Passive Solar	Auckland : >4hrs Dun: <4hrs, Year round				no	Good. Low active input needed.
	Micro CHP biodiesel			Both: biodiesel, year round		no	Work required
	Electricity Meters and Load monitors					Meters vary by retailer	Ok. Depends on unit.

SUMMARY for Scenario 2: Multi-Unit Flats

Attractiveness Assessment: Scenario 2

Technology	Estimated. Output Cost c/kWh	Uptake Requirements	Sustainability Issues	Shared community intent
Solar PV	>50	Unit cost may be reduced for communal system; efficiency (long term)	Affordability in short term	
Biomass Burners	<20	Improve wetback efficiency and manage emissions	Environmental	Tenants tend to have an independent approach. They may think more 'communally' if benefits are clear from having some 'communal' systems sized to meet multiple user needs.
Solar Thermal	20-50	Reduce unit cost (as per PV), provide education on benefits	Affordability in short term	
Biomass Boilers	<20	Manage emissions, develop cost-effective option for retrofit (possible for communal system?)	Low environmental (more efficient than burners)	
Micro CHP biodiesel	>50	Reduce unit cost , new fuels	Affordability in short term	
Community Heating Schemes	<20	Raise awareness with industry and councils; develop commercial systems	Regulation needed; social impacts?	
Electricity Meters and Load monitors	n/a	Cost-effective user friendly units	none	

Technology Grouping Summary: Auckland

Attractiveness	1=most	2	3=least
Intermittent Electricity	PV array for 6 units	CHP	
Low-grade heat: Space	Communal pellet boiler	Individual burners (cost and permit dependent)	CHP
Low-grade heat: Water	Solar thermal- sized for all units, or in groups.	Boiler-generated, in tandem with SHW	

Technology Grouping Summary: Dunedin

Attractiveness	**1**	**2**	**3**
Intermittent electricity	CHP -due to winter heat load	PV **only** if >4 hrs sun	
Low-grade heat: Space	CHP	Communal Biomass boiler	Individual burners (cost and permit dependent)
Low-grade heat: Water	Communal Biomass boiler	CHP	

Note: Provision of both heat and energy for a cold climate suggests CHP technology as an option to deliver both. If energy provision is reprioritised, a biomass boiler is the most cost-effective option for low-grade heat.

8.3 Scenario 3: New build house, urban section.

Assumptions:

1) Houses are highly insulated, and designed for maximum energy efficiency.
2) Full passive solar design to make best use of resource – optimised orientation for solar gain to floors and through windows; thermal mass use and placement (insulated concrete slab minimum); double glazing; optimised eave design for winter gain/summer shade.
3) It is feasible for >4 hours winter solar gain for a well-sited new build in Dunedin.
4) An Auckland location combined with passive solar design should significantly reduce the need for supplementary space heating (see NOW Home monitoring results).

An urban location would generally result in a wind resource that is too inconsistent, and affected by close proximity buildings. Exceptions are not the norm, but are possible.

Technology Selection: Scenario 3

	Technology (Scale: household)	Resource Reliability and Seasonality				Standards and Regulations	Useability (Suitable options)
		Solar	Wind	Bio-Fuels	Micro-hydro		
Intermittent High Grade	Solar PV	Both suitable, seasonal				None	Roof siting must be right
	Wind		Both: unsuitable			Yes (height)	
	Micro Hydro				Unlikely		
Supplementary Low Grade Heat	Biomass Burners			Akld: Pellets Dun: wood, pellets Heat on-demand		Dunedin: emissions	Pellets easier than wood
	Solar Thermal	Both suitable, seasonal				No	Good if well sited. Active input an option
	Biomass Boilers			Akld: Pellets Dun: wood, pellets Heat on-demand		Dun: emissions	Good if auto fuel feed and regs met
	Passive Solar	Akld: >4hrs Dun: <4hrs, Year round				no	Good. Low active input needed.
	Micro CHP biodiesel			Both: biodiesel, year round		no	Work required
	Electricity Meters and Load monitors					Meters vary by retailer	Ok. Depends on unit.

SUMMARY for Scenario 3: New build, urban section

Attractiveness Assessment: Scenario 3

Technology	Estd. Output Cost c/kWh	Uptake Requirements	Sustainability Issues
Solar PV	>50	Reduce unit cost and improve efficiency (long term)	Affordability in short term
Biomass Burners	<20	Improve wetback efficiency and manage emissions	Environmental
Solar Thermal	20-50	Reduce unit cost (more cost effective in new build), provide education on benefits	Affordability in short term
Biomass Boilers	<20	Manage emissions, develop cost-effective retrofit	Low environmental (more efficient than burners)
Passive Solar	<20	Education re benefits and design options for retrofits	None
Micro CHP biodiesel	>50	Reduce unit cost , new fuels	Affordability in short term
Electricity Meters and Load monitors	n/a	Cost-effective user friendly units	none

Technology Grouping Summary: Auckland

Attractiveness	1=most	2	3=least
Intermittent Electricity	PV		
Low-grade heat: Space	Passive solar	Pellet burner	
Low-grade heat: Water	Solar thermal	Burner wetback	

Note:

- PV is the only high grade energy option. A house designed for low demand can aim for a smaller PV system.
- Passive solar can provide sufficient space heating assuming design and performance standards are met – but it is still site dependent.
- Solar thermal will provide hot water most of the year in this location. A pellet burner with a wetback would be the best solution to work in with this

Technology Grouping Summary: Dunedin

Attractiveness	1=most	2	3	4=least
Intermittent Electricity	PV **only** if >4 hrs sun	CHP -due to winter heat load		
Low-grade heat: Space	Passive solar	Biomass boiler, with under floor pipes	Biomass burner+ wetback	CHP
Low-grade heat: Water	Solar thermal	Biomass boiler		CHP

Note:

- Suitability of solar for Dunedin will be site-specific. If enough sun is present in winter then it should be considered for solar thermal at least and maximised with solar design.
- Space heating needs due to climate, with a new build make boilers a viable option for space and water heating – easier and cheaper to install radiator systems new.
- A boiler system will combine well with solar thermal for summer water heating, and potentially extra space heating if connected to the radiator system.

9 An Economic Perspective

A detailed economic analysis of each technology is not carried out as part of this report. Although it is accepted that capital costs today mean that the cost of delivered energy from small renewable sources is generally higher than supplied through the grid, a longer term view of the economics of renewable technologies is required to be taken into account. A future view of the economics of renewable generation options is outlined in Figure 6 below.

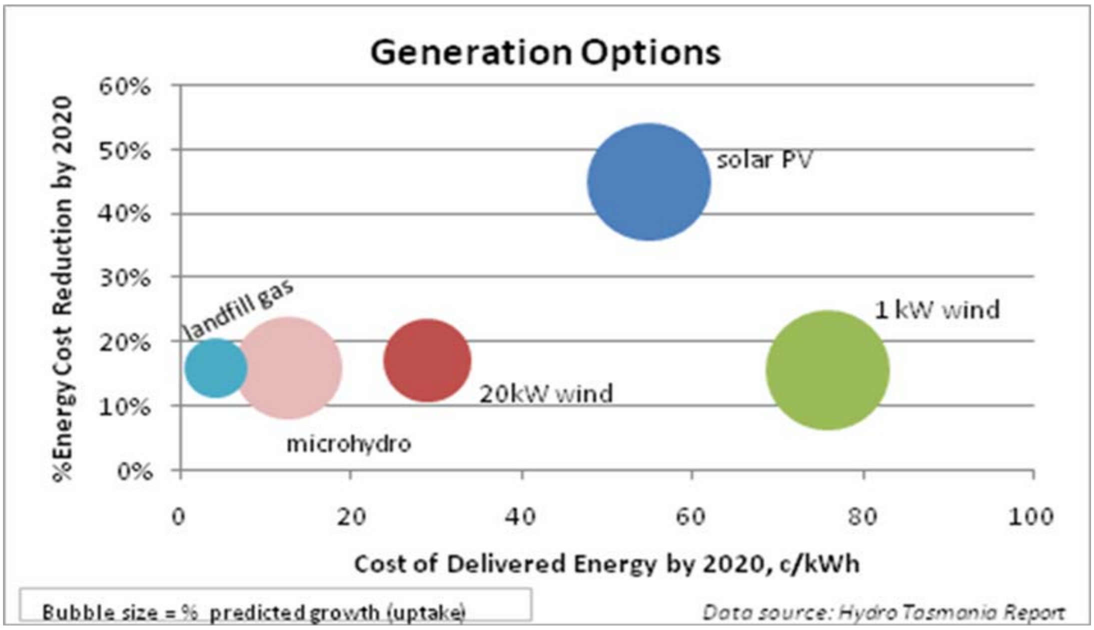

Figure 6: Generation Options – Economic Projection to 2020

For the diagram above, the cost of delivered energy from the network by 2020 is predicted to be in the region of 17 to 20c/kWh – this is the baseline comparison for other generation options. In the reality of a carbon constrained world and peak oil scenarios, this cost may be much higher. Solar is predicted to increase the most in terms of uptake, but still remains one of the more expensive options in relation to delivered cost unless promised economies of scale eventuate. As the scale of the technology increases the cost comes down. Therefore it would be interesting to investigate the comparative cost of larger scale solar installations in an area with consistent resource to see how the costs could decrease.

Further exploration of financial data reflective of the current market environment could be undertaken to update the figures above, if a more in-depth economic assessment is required.

This data also needs to be developed against other criteria to get a perspective beyond economics of delivery; in particular the social and environmental costs of large-scale grid based renewables such as hydro and wind. These are often assumed in the public mind to be relatively benign, wheras the reality is that the effects are significant and far reaching. Articulating these issues is one of the challenges for Beacon in making the case for increasing the use of local renewables by 2020.

10 Benefits Beyond Payback

The benefits for small scale renewables uptake beyond economic criteria are important for raising awareness of the broader challenges of sustainability. Beacon's fundamental business case promotes factors such as health, comfort, security and resource use in the context of economic affordability – well supported by the case for increasing the uptake of local renewables.

10.1.1 Impact of Resource Use

Encouraging the use of local renewables should imply the use of resources that can be sustained on a long-term basis. Small or micro-systems have a much lower site based environmental impact than the construction of large scale generation – including large renewables. Local and national reaction to such schemes is common now, but micro-units can operate with minimal disruption to eco-systems. Reducing the impact of large-scale resource use has a significant long-term benefit for preserving local environments and eco-systems.

10.1.2 Resilience and Security of Supply

A mix of energy delivery options gives a household or community greater security through avoiding reliance on one energy source in times of shortage. For those concerned about winter illness, or vulnerable family members, an alternative energy source has the capacity to increase peace of mind as well as maintaining health. What price is attached to recurring asthma attacks in winter – when the ability to keep a burner operating can make the difference between having no heating and having a warm house without illness? Security of supply can represent a greater sense of control over personal circumstances, especially when reticulated energy prices go up, or power cuts loom.

10.1.3 Engagement drives Education

For some (less economically challenged) households, the opportunity to directly engage in mitigating their impact on climate change can be seen as an opportunity, especially if choices can be demonstrated (such as rooftop PV or SHW). Installation of such technologies puts users in direct contact with how such systems work and how to optimise them – increasing awareness and promoting a change in behaviour.

10.1.4 National Interest

Ultimately, a greater mix of energy delivery options for households can have the benefit of reducing peak demand on the network during periods of constraint. Shifting demand at these times reduces the need for more large-scale generation investment, which comes at a cost to taxpayers and the environment. However the national benefits in terms of peak supply are currently driven by political and market forces that see residential security and environmental protection prioritised lower than maintaining the market model.

The potential benefits described above are intertwined with the opportunities for uptake covered in the next section.

11 Opportunities and Barriers to Uptake

The opportunities for, and the barriers against, increasing the uptake of local renewable technology at a house/neighbourhood scale are outlined below. These can also be considered alongside the aspects influencing the market environment outlined on page 12 and are more fully covered in a report produced by the Parliamentary Commissioner for the Environment in 2006 called "Get smart, think small: local energy systems for New Zealand". More in depth research and economic analysis would be required to present a full commercial value case.

11.1.1 Opportunities

- Increasing the awareness and education of energy users, to enable informed choices around energy use.
- 'Local renewable' implies readily available and sustainable resources that would be of particular value in periods of energy constraint (winter peaks). Increasing the use of such resources especially for low-grade energy use would also give users a greater sense of control over managing comfort and health in critical times.
- Increasing local commercial opportunities to support the supply and service of resources and technology for local consumption. With sufficient scale, technology costs should reduce over time.
- Improved resilience of local electricity networks by reducing the demand on constrained reticulated electricity at certain times through the use of local alternatives. More power is available for critical uses (e.g. hospitals) and residential users are less likely to be compelled to 'save power' and compromise health (this is particularly important for low-income elderly and families forgoing heating in mid-winter).
- Improved resilience of residential energy options – by having a broader mix of options for low and high grade energy, users can be more confident of meeting year round requirements without completely relying on one source.
- Improved long-term cost stability for non-reticulated energy use – assuming the New Zealand network will remain focussed on a profit model for energy delivery.
- Improved standards for house performance particularly in the areas of better passive design. These represent the cheapest pathway to reducing energy costs and increasing the health and comfort of occupants.

11.1.2 Barriers to Uptake

- Complacency in looking for innovative & accessible options especially for low-grade heat, encouraged by New Zealand's temperate climate.
- Real demonstration that local renewable technology will work effectively without compromising personal health, comfort, security, property value and cost of living. *This also represents an opportunity in terms of implementing a demonstration model in the same manner as the NOW Home.*
- Cost to purchase technology, and perceived time to recover that cost.
- Lack of understanding of system types, suitability and use.

- Inconsistent installation and operation quality standards – although SEANZ and other organisations are putting considerable effort into redressing these. Poor performance due to poor installation will not improve uptake.
- Site-specific constraints: Insufficient available resource due to location of house or local geography
- No perceived benefit of changing energy technologies from a convenience, comfort or cost-recovery perspective.
- Little benefit seen for adding to house value (although this is incrementally changing as real estate marketing is starting to mention energy efficiency).
- Governance, structure and protectionist regulations of the current market that prevent uptake of DG and demand-side management options
- Lack of financial incentives
- Slow implementation of management options such as smart metering, or promotion of demand monitoring devices such as 'Centameters' by retailers.
- Effective structure and operation of community schemes – to deliver a common need to individual households through a shared facility. These are not widespread in New Zealand.

Established studies such as HEEP (Isaacs et al, 2006) also provide a clear recommendation for better utilisation of low-grade energy for heating, in order to free up high grade electricity for other uses.

Examination of the NZ Energy Efficiency and Conservation Strategy (EECA, 2007) SHW promotion programme will provide insights as to how a mature renewable technology has fared in terms of uptake. SHW delivers to a recognised and familiar need (hot water) – uptake results will provide valuable lessons for the more complex scenario of overall energy use with renewable technologies.

Wider influences such as increased publicity around climate change and emissions, global recession, and the new governments' environmental policies may provide both opportunities (people wanting to contribute to reducing climate change; slower turnover of housing stock) and barriers (less money to invest in alternative technology; political retrenchment on energy and environment policies). Further monitoring to track these influences is required.

12 Future Technology Wish List

As part of the exercise in assessing renewable energy solutions and the criteria on which they should be judged, a number of innovations have been discussed. Some of this is future technology, some of it is existing technology that is not available on the market in New Zealand and has not been tested in the local market. Information relating to these products is not central to this part of Beacon's work programme, however capturing this information provides an indication of the areas where technical innovation from stakeholders and shareholders may be possible.

(For further background refer to Appendix 3 Local Renewable Energy Systems – Summary of the initial research scoping exercise). The wish list at the time of publication of this report includes:

12.1.1 Generation

- Cost-effective small-scale generation – either through new cost models (alternative supply chains, economies of scale), technological advancements, or interventions such as a subsidy for particular technologies or feed in tariffs.
- CHP systems adapted for bio fuels and biomass. There are currently CHP systems running on LPG and natural gas that are being investigated for bio fuel suitability. Other options may arise from adapting domestic boiler systems to include a turbine for power generation. Wood-fuelled CHP systems have been used in the UK (BED Zed) and the authors are aware of at least one woody biomass gasifier under investigation in New Zealand.
- Building-integrated solar PV panels. Efficiency is currently lower than that of standard PV, but it is becoming more widespread internationally. This technology could enable a better cost / benefit equation in relation to the marginal costs of the added technology compared to standard cladding or roofing systems.
- Developments for Biogas systems (based on utilising methane from digestion of waste) for communal/home heat generation; and for home energy.
- Hydrogen fuel cells for the home/neighbourhood (IRL has initiated research)

12.1.2 Storage

- New battery technologies - Deep cycle, hydrogen fuel cells
- Thermal wall systems (solar capture using metal, trombes). BRANZ has initiated work in this area.
- Thermo-chemical storage
  - Storage stations for electric car charging – allowing excess power to be exported to this as well as to the grid.
  - Low grade solar energy capture and storage for space and water heating (designing for lower temperatures that require less sophisticated collection systems)

12.1.3 Heating

- Small ‘urban’ wood pellet burner for apartments and small rooms
- Acceptable wetback solution for wood pellet burner/wood burners which does not overly affect efficiency of the unit
- Turnkey solution for combined wetback/solar water and space heating to provide renewable heating throughout the year
- Solar energy harvesting for low-grade pre-heat systems (see Storage points above)

This research paper provides the opportunity to capture the desire for these ‘wish list’ technologies and in time further work could be undertaken to cluster them according to their system potential.

A Comparative View: IEA Energy Technology Perspectives, a publication produced by the International Energy Agency (IEA) in 2008, presents scenarios and strategies to 2050 for a clean energy future that includes reduction in carbon emissions. Key points of interest to this paper on research, development and deployment targets are shown below. There appears to be a strong emphasis on promoting low-energy buildings and new fuel sources as a means of carbon reduction, which corresponds closely with the directions put forward in this report and other research conducted by Beacon.

Key Technology Area	RD & D target
Photovoltaics	Design and operational performance of PV power systems; and applications such as building integrated PV, hybrid systems, mini-grids and very large scale PV
Heating and Cooling: Heat Pumps	Quantify energy saving potential and environmental benefits; thermally driven heat pumps; retrofit heat pumps for buildings; ground-source heat pumps
Passive Housing	Sustainable solar housing with passive solar design; improved day lighting /natural cooling/ solar control; cost-optimisation of concepts
Solar Heating	Advanced storage concepts for solar thermal systems; new solar thermal materials

Source: IEA Energy Technology Perspectives 2008: In support of the G8 Plan of Action, Scenarios and Strategies to 2050

13 Future Research Questions

The process of assessing renewable technologies has raised a number of research questions that may require addressing in future work. These questions are particularly pertinent to the implementation of research that looks at residential renewable energy systems under trialled and monitored conditions (potentially as part of HomeSmart Homes or HomeSmart Renovations projects). (For more background refer to Appendix 3 Local Renewable Energy Systems – Summary of the initial research scoping exercise).

The following points should be considered for monitoring of installed systems:

- What combination of economic incentives, policy, regulation and education would adequately support a change in how residential energy is sourced and utilised?
- Does the installation of Renewable Energy Technology (RET) into a house change:
  - The understanding and awareness of how RET works?
  - Acceptance or rejection of the value of RET in daily life?
  - Energy use behaviour, in particular:
    - Does overall energy use increase or decrease?
    - Is this due to a change in end-use?
- Assess impact of demand management 'protocols' or features on household demand before RET are introduced? i.e.
  - Will users look at reducing energy demand as is promoted through nation-wide energy saving campaigns without the introduction of new technology?
  - How does the use of RET change these behaviours <u>if at all?</u>
  - Do users even want to contemplate behaviour change?
- Provision of education and training packages alongside the technology packages to best:
  - Use the technology
  - Change behaviours in order to achieve desired comfort and health for the same or reduced energy use.
- Does the provision of smart meters and/or load monitors that display data have an impact on overall energy use? Does time of use data have an impact – or does it need to be linked to tariffs?
- Would there be any value in exploring various tiers of household packages, i.e.:
  - House with RET only
  - House with RET +information/education pack
  - House with RET +information/education pack + a smart meter + a load monitor
  - High performing house with little access to local RE sources
- Match technology features with load patterns and regional resource
- Over a number of houses, assess amount of grid energy that can be displaced by local RET. Power factor and power quality should be assessed as well, as these can be significant arguments against changing the energy mix.
- Assess value of social sustainability

14 Conclusions

This report has demonstrated a viable decision making framework approach to identifying renewable technology options that can be applied at a household, and community scale. The process of technology selection, technology assessment and the evaluation of the options against a series of scenarios has illustrated that a variety of renewable energy options exist to satisfy energy demands at each scale.

The results and analysis presented in this report serves as a valuable base for discussion moving forward. The identification of a range of potential opportunities for future research and technology development that can improve the commercial availability of options for New Zealand consumers has also proved worthwhile.

The technologies options produced for the chosen scenarios indicate that the range of options for houses to increase their use of local renewable energy is readily available. This report identifies that the most readily applicable high grade electricity option for the majority of houses in New Zealand is photovoltaic systems. The research has further identified the most applicable low grade heat option is solar thermal and biomass. Passive solar should also be prioritised in new build and also in retrofit (depending on typology). It is seen as an undervalued option in New Zealand for delivering low-grade heat, and is worth promoting as a viable technical solution.

The technologies identified in this report are predominantly known, are mature internationally, and are ready to be applied in the New Zealand context. However, this country has a variety of economic, political, regulatory and educational barriers to overcome in order to achieve better utilisation and uptake of renewable technology. At a community level the options of community heating schemes and biogas from waste deserve further investigation in order to improve economic and technical feasibility; and to overcome current barriers as to how they can be applied in the New Zealand context.

There are significant opportunities to be gained by increasing utilisation of low grade heat (including passive solar) but our temperate climate has ironically meant we have been slow to develop effective solutions.

The decision making framework encouraged identification of multiple options, illustrating that a significant shift in the proportion of local renewables used is possible; and better quantified if more is known about resources available on-site.

Beacon's vision of increasing the percentage of energy supplied by local renewable resources can be met now by the options identified – however, bridging the gap between current uptake and potential uptake (90% of houses) requires more than just Beacon to have the strategic vision to do this. Therefore the biggest challenge is whether Beacon can muster the means to overcome current barriers of education, awareness, incentivising policy and regulation to bridge the gap.

Beacon sees value in increasing use of distributed generation and local renewable energy. However, part of the challenge is in how Beacon can meet its goals in an environment where increasing the use of renewables at the local level is not a priority. If it was a priority we might see feed-in tariffs, local authority interest, feasibility and case studies, incentives, education and regulation to support it.

Converse to international trends, there is no clear indication that the New Zealand Government and its agents have any desire to drive these kinds of initiatives and increase the uptake of local renewable energy at a residential level. This can, and will, be explored further in future value cases.

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16 Appendices

16.1 Appendix 1 Experts

The general approach, prioritised technologies and assessment criteria set out in this report have been reviewed by a selection of experts knowledgeable in New Zealand renewable energy solutions. Beacon acknowledges them and thanks them for their support. The current experts list suggested is as follows:

Name	Input
Andy Duncan/Attilio Pigneri Massey University	Provided input to assessment criteria and technologies
Bob Lloyd University of Otago	Provided input to assessment criteria to ensure all technologies adequately covered. Review of draft report
Bob Shula Scion	Provided input to assessment criteria and performed review of draft report
Lisa French BRANZ	Performed review of draft report and highlighted areas of parallel research from BRANZ

16.2 Appendix 2 Case studies

As part of the development of this report several case studies of community scale renewable energy generation were investigated. Two of these are provided below as background to demonstrate the value of the 'neighbourhood' in delivering workable solutions at this scale.

16.2.1 Blacktown Solar City Case Studies

The Blacktown Solar City consortium is working with industry, businesses and the local community to rethink the way they produce and use energy.

Practical benefits for the local community
Blacktown, in Western Sydney, is a rapidly growing part of Australia. One of the key energy issues in Blacktown is the high summer energy demand to power major appliances such as air conditioners and pool pumps.

- Energy options being trialled through the Blacktown Solar City include:
  - **860 solar photovoltaic panels** will be installed on private and public housing and on commercial and iconic buildings - this equates to over one megawatt of solar energy.
  - **Help to finance their solar systems** will be available to consumers.
  - More than **2,100 solar water heaters** will be installed in private and public housing.
  - **3,500 energy efficiency consultations** for households and businesses.
  - **30,000 energy efficiency packs** will be available for households and commercial customers, to support their energy efficient choices.
  - 1,000 customers will be offered the opportunity to adopt pricing structures that allow them to save money by changing the times they use energy.
  - 200 households will receive **discounted ceiling insulation packages** to participate in a trial to measure energy savings from properly installed insulation.
  - A trial will be conducted to allow customers to more efficiently manage their air conditioners and pool pumps during periods of peak electricity demand.
  - **4,000 smart meters** will give residential customers timely information on energy use.

- One of the unique trials underway in Blacktown is a solar energy kit which combines two sets of solar panels - one set to heat water and the other to create electricity. This new combined installation takes up less roof space and is cheaper to install than conventional individual systems.

Additional benefits

- Additional benefits of the Blacktown Solar City include:
  - Savings of over 22 gigawatt-hours of electricity annually
  - Greenhouse gas emissions reduced by more than 24,000 tonnes each year
  - Annual savings of approximately $3 million in electricity bills for the Blacktown City community
  - Valuable information and lessons learned will inform energy and greenhouse policies.

16.2.2 Adelaide Solar Cities Rates Trial

This is interesting as a demonstration of how policy environments can work to encourage domestic demand management. These types of trials have also been conducted in California.

Smart Time of Use

By making a few changes to the times you use high energy appliances like your pool pump, air conditioner and washing machine, you can take advantage of special off-peak electricity tariffs.

- Electricity is priced at two levels, depending on the time of day
- The rates are lowest during off-peak periods: all weekend and weekdays from 9pm to 7am.
- Rates are higher from 7am to 9pm weekdays.
- There are two options to choose from: All Year and Seasonal

Smart Time of Use - All Year

Electricity is priced at the two levels depending on the time of day, all year round. So with a cheaper off peak rate charged all year, you could make real savings on your bill each and every day.

Smart Time of Use – Seasonal

Pay a cheaper rate for electricity during off peak times all year round, but pay a little more during peak times during the months of January, February and March. During these months, the peak rate is higher than other months of the year, but the overall potential savings can be great.

This was promoted in conjunction with Origin Energy.

16.3 Appendix 3 Local Renewable Energy Systems – Summary of the initial research scoping exercise

Conducted October 2007

- Context for the scoping exercise:
  The proposed research is concerned with increasing the percentage of energy in homes that is supplied from local renewable sources. The work aims to develop a framework for decision making by summarising the existing research in New Zealand and international best practice related to renewable energy options at the household and neighbourhood level. Beacon's research indicates that neighbourhood scale renewable energy supply has been somewhat overlooked despite the variety of benefits that it could offer. These range from an increased security of supply, better efficiencies in transmission, an engaged local community, improved cost benefit ratio / paybacks for various technologies, and a more sustainable transition to renewable energy.

  With these factors in mind Beacon is seeking to map local renewable energy generation options in order to develop an understanding of 'the best technology, in the right place, at the right scale'. We hope that this will lead onto the development of several targeted value cases to encourage enhanced uptake of suitable renewable technologies. As a result of the project Beacon hopes to identify the technical criteria that determine which renewable energy options are best suited to different types of New Zealand homes and neighbourhoods and/or their climatic/geographic location.

16.3.1 SUMMARY OF KEY POINTS (based on input from 9 Industry respondents)

Technology and house typology

- Direct heat production should be part of the scope of home generation (considering that 30%+ of energy use goes on space heating.). Heat provision is economic compared to other energy generation options – which are seen as limited for local provision.
- Only IRL, NIWA and MUCER to a lesser extent have direct experience at a community level.
- Community/neighbourhood schemes require management and ownership structures – there are few/no models in NZ for what can be a complex situation.
- There are a number of options for 'demonstrating sustainability' in a broad sense, that could all add value once people see them in action and buy into it. These include the known options around solar, wind and biomass.
- Apartments and institutions have potential, but the network interface remains a major barrier
- The strongest message is that NZ still has not got the basics right, or understood by the majority in terms of house design and performance, insulation etc. As a result, renewable or energy efficient technologies are installed poorly, and misused, contributing to poor performance and low buy-in.

Resource mapping

- Energyscape appears to be the biggest current initiative, with some feeling that EECA had already done the work. A couple of responses suggested investing in resource mapping was a waste of money and time, in light of bigger issues around house performance, technology cost and market barriers. Only Andy Duncan felt it needed more effort.

Barriers and Research priorities

- Barriers to uptake were varied, but the strongest contenders were around capital costs; the governance, structure and protectionist regulations of the current market that prevent uptake of DG and demand-side management options; lack of financial incentives; blocking of smart metering; low education and understanding across the board; politics and agreements around grid-connection.
- Demonstration sites and ownership models were the most common choices for research priorities. Large enough demo sites can be used to address technical and market network interface issues on a scale that could effect change. It was generally felt that the 'doing' was important, as much to address issues like DSM and education as to demonstrate technology.
- Future technologies centered around grid-connection and metering, hydrogen fuel cells and exploring technology combinations. However, there was as much emphasis on addressing structural and supply-side barriers to local generation and encouraging the uptake of intelligent power systems.
- IRL probably offer the best chance of developing innovative solutions for the New Zealand environment.

From interpretation from conversations, and emails – there is appetite for Beacon to address more than just the technology questions around the uptake of renewable generation. Most of the technology is known, and used around the world – so international learnings can be applied at a technical level.

Where New Zealand is unique appears to be in the governance and structure of the market; and the dominance of the supply-side of the industry. Combine these with technology costs, low implementation of demand-side management and the technology to support this, and the general lack of awareness around energy management at a household level – and a complex environment is created for Beacon to realise its energy goals.

The strength of the Beacon model is to create real-life demonstration sites with real people, combined with technology and monitoring to provide evidence for real change. It may be that the current uptake goals cannot be met, but it could facilitate ways of generating and managing residential energy for New Zealand, that puts the 'power' back with the consumer.