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Matching Renewable Technology to Local Resources at the Household and Neighbourhood Level

Final

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About This Report

Title

Matching Renewable Technology to Local Resources at the Household and Neighbourhood Level

Authors

Mandy Armstrong and Verney Ryan, Beacon Pathway Ltd

Reviewer

Lois Easton, Beacon Pathway Ltd
Roman Jaques, BRANZ

Abstract

This report, which is divided into two main parts and an appendix, provides a repository for information to inform consumers about undertaking a site assessment in relation to the potential for electricity generation at their site (house and neighbourhood). This helps to support Beacon's energy target "to increase the percentage of energy in homes supplied from local renewable sources" by collating available information and presenting it in a unique way for use by consumers. Part I provides an outline of the research undertaken and discusses the context, scope and methodology of the work. Part II sets out the consumer-focussed information in a logical format that will help consumers come to grips with the key issues for individual site assessment. Finally the Appendix provides two examples of how the information might be brought together to deliver a simple checklist tool for consumers.

Reference

Armstrong, M. and Ryan, V. June 2009. Matching Renewable Technology to Local Resources at the Household and Neighbourhood Level.Report EN6590/4 for Beacon Pathway Limited.

Disclaimer

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Part I – Research Overview

1 Introduction

This report collates the activities and steps required to assess the suitability of small-scale renewable technologies at the neighbourhood and household levels by developing a site assessment checklist-type tool. It follows on from the decision-making framework that has been developed under Workstream One of Beacon's renewable energy programme (Armstrong and Ryan, 2009).

This report serves as the repository for the information required to develop a consumer-facing tool that enables decisions to be made relating to the provision of renewable energy in houses and neighbourhoods (in both retrofit and new build scenarios).

There is a need to ensure the final written advice and information is consumer-friendly and able to prepare users for taking the next steps of design, purchase and installation in conjunction with professionals. Although the range of available small scale renewable energy technology options is not extensive, their performance effectiveness can vary widely depending on features of site, climate and house typology.

Elements of the information in this report can be adapted for inclusion in the Home*Smart* Renovations industry renovation tool as that parallel programme develops. Hence this piece of research and the report that follows has an end-user consumer focus as opposed to a strict research focus.

There are a range of potential end-users for the information contained in this report, as well as any tool that may be developed from it. The format may be adapted to suit:

- Residential Energy Consumers
- Local Authorities
- Industry Associations promotion
- Equipment suppliers for Residential users
- Existing websites promoting building sustainability, such as those run by Beacon (HomeSmarts), BRANZ (Level), EECA (EnergyWise homes), and DBH (Smarter Homes).

2 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 18oC), by 2012, thus reducing 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°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.

This report is part of Beacon's research for the second of the three energy targets: increasing 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 installed into a home or neighbourhood is most effective once the energy demand of that home has been reduced as much as possible.

3 Research Context

This working paper is part of a programme of research which extends Beacon's knowledge in renewable energy by providing a process for users to assess how suitable their house and environment (site) may be for using renewable technology. Optimum renewable energy solutions have been identified in an earlier workstream (Workstream One), for households and communities wishing to install renewable solutions. The assessment process outlined in this report is based on an assumption that households and communities utilising this material are **connected to their local electricity network**. The assumption is that increased use of local renewable energy will be supplementing and/or replacing grid-supplied electricity as opposed to developing stand-alone distributed generation systems. This is in line with Beacon's goal of bringing 90% of New Zealand homes and neighbourhoods up to a high standard of sustainability and recognition of the fact that the majority of homes in New Zealand are in urban areas and are grid connected (as outlined in an earlier Renewable Energy report produced by Beacon in Workstream One[1]).

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

- To identify the technical criteria that determine which renewable energy options are best suited to different types of New Zealand homes and/or their climatic/geographic/resource location (contributes to best practice energy retrofit project).
- 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 neighbourhoods 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.

[1] ***Armstrong, M. and Ryan, V. (2008)***

This project is broken into three main work strands

- **Workstream 1: Developing a framework for decision making** 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.
- **Workstream 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, site-specific access to resources and house and neighbourhood typology.
- **Workstream 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 provides an input to Workstream Two above. The intention of this workstream is to determine where the identified technologies are best applied in terms of access to resources when considering a range of site-specific factors. This is unique for each application and understanding what factors can enhance or diminish the suitability of renewable technology is important for ensuring the best possible benefit can be obtained. This includes working with professionals for purchase and installation. The expectation is that the material provided in this report should form the basis of advice and information to New Zealand consumers interested in the potential for renewable energy on their site.

4 Existing Research

Much of the content that informed this research has been drawn from existing Beacon research including TE140/3 (Kane, 2006), EN6590/3 (Armstrong and Ryan, 2009), TE106/4 (McChesney and Amitrano, 2006). In addition to these, a range of existing consumer-facing websites were examined to assist with structuring the approach and informing the research. Of particular relevance are the following information sources, providing supporting detail to extend the concepts put forward in this report:

- SmarterHomes – the sustainable living site managed by DBH (developed by Beacon and Consumer NZ) (www.smarterhomes.org.nz)
- Level – the sustainable building website managed by BRANZ. There are a number of relevant publications available related to this site.(www.level.org.nz)
- Energywise™ – EECA's site for information and grants for energy efficiency and conservation, and factsheets on renewable technologies. This links to a separate site for solar water heating, http://solar.energywise.govt.nz/
- SEANZ – Sustainable Electricity Association of New Zealand's site containing details on quality, standards and accreditation for installation and performance of small-scale renewable generation technology. (www.seanz.org.nz/)
- Consumer New Zealand's Solar Hot Water Systems Guide (downloadable from www.consumer.org.nz)
- The US Department of Energy's Energy Efficiency and Renewable Energy website. This has relevant information on energy use and renewable technologies. http://www.energysavers.gov/your_home/electricity/index.cfm/mytopic=10510
- Ministry of Economic Development. The energy section of the website contains detail on regulations for the installation of small scale distributed generation (www.med.govt.nz).

There may be potential to link the Beacon information to consumers (presented in this report) to one or more of the sources above using co-promotion of material. For instance, the consumer information provided here could be further reinforced and backed up by the advice provided through both Smarter Homes and Level.

5 Research Methodology

The central platform of the research outlined in this report is collation of existing information from credible sources and presentation of this to consumers in a friendly, accessible format.

The research was conducted via the following methodology.

1) Background desktop research was undertaken to gather appropriate information from a range of credible sources. This included previous Beacon research from the renewables portfolio (including Workstream One) as well as previous background information gathering undertaken as part of the development of the Smarter Homes website. Further sources of information are outlined in the previous section and are referenced throughout the report.
2) The gathered information was developed into consumer-facing language and arranged into a logical order that a consumer might step through in their analysis of renewable resources available to them on site. The ordered, consumer-friendly information is provided in Part II of this report.
3) The background information, once logically ordered, was taken one step further through the development of a checklist, which provides an example showing how the information could be best presented to the consumer. This example checklist is provided in Appendix 1 and 2 of the report.

6 Research Scope

To define the basis of consumer information, the following areas have been explored:

- Network Connection
- Understanding site and location
  - Resource availability and use
  - Climate
- What does the household need?
  - Consumption and usage patterns
  - Finding the best system
- Regulations and standards
  - Local council requirements
  - Consents
- Other Issues
- Getting help
  - Financial assistance and grants
  - Finding information

These areas have been identified as being key to develop consumers' understanding about the main issues that need to be addressed in undertaking a site assessment. These are outlined in more detail in the Part II sections that follow. By necessity, the approach and language in Part II is consumer-facing.

Part II. Renewable Energy Opportunities: Consumer-Facing Information

1 Introduction

Households, neighbourhoods and communities have a range of options for using renewable technologies based on their local resources. These technologies can be used for the provision of low-grade heating (solar hot water, biomass burners etc) or for electricity generation for high-grade energy requirements. In this context, *high-grade* means electricity that is used directly, such as for electric elements or within appliances; *low-grade* refers to the non-electrical heat provided by the sun or using biomass.

With all the options available, you will want to select the most appropriate renewable technology for your household with the best chance of performing well in your home. This guide helps you to understand the main issues that you will need to think about in assessing your site and situation for renewable energy. It is important to seek professional advice, so use this information to be better prepared for working with the appropriate designer, installers and equipment suppliers.

The following key areas will help you assess your site and needs to select the best technology for you:

1) Network connection
2) Understanding site and location
    a) Resource availability and use
    b) Climate
3) What does the household need?
    a) Consumption and usage patterns
    b) Finding the best system
4) Regulations and standards
    a) Local council requirements
    b) Consents
5) Other issues
6) Getting help
    a) Financial assistance and grants
    b) Finding information

Network connection

Most renewable electricity generation can either be developed as a stand-alone system (sometimes referred to as a stand-alone power system or SAPS), or be connected to the local electricity network (referred to as the "network"). Beacon's focus is on achieving a reduction in reticulated energy use in 90% of homes – so the following information optimises solutions that could be connected to the electricity network. The advantages of these systems are that a connection to the grid provides back-up if micro-generation doesn't meet all of your electricity needs all of the time. It also provides you with the ability to sell any excess electricity you have generated back to your energy retailer.

The option of using local resources such as wind, solar photovoltaics (PV) or micro-hydro for electricity generation is often based on being able to integrate these systems into the local electricity network – this is known as "grid-tie" or "grid-integration". It means that households can put in small systems to off-set part of their consumption; and any excess (which is usually minimal) goes back into the network.

Government regulations have recently been introduced to allow this to happen more easily; so local lines companies and electricity retailers have procedures and guidelines to negotiate and manage it[2]. A professionally-accredited systems designer/ installer may be able to manage this process, and must be consulted with as part of this process.

The issue of pricing varies by energy retailer, but in most cases the effect is a reduction in the overall power bill (rather than a large windfall cheque that pays you for electricity generated from your small PV panel!). It is also important to note that the lines charges usually remain the same.

Systems with a capacity of less than 10 kW can follow a simplified process for installation and approval by the lines company. Most houses will find a system smaller than 5 kW will be enough to supplement their activities, if home generation is an appropriate option to consider. A watt is the unit of power, and a kW or "kilo watt" is the same as 1000 watts. A hot water cylinder uses more power to run its 3 kW (or 3,000 watt) element, than a TV that uses 0.4 kW (or 400 watts).

[2] ***The Electricity Governance (Connection of Distributed Generation) Regulations came into force on 30 August 2007 – copies of the regulations and more information is available from MED at http://www.med.govt.nz/templates/ContentTopicSummary____30042.aspx***

2 Understanding Site and Location

Understanding the site where a house or community is located is an important part of making the right decisions for selecting the most appropriate renewable technology with the best chance of performing. In addition to the site-specific factors, it is important to understand more about the general location in terms of climate, seasonal variations and geography; and how they can affect the availability of local resources (such as wood, pellets, other biomass, consistent wind and sunshine hours).

This section will explore:

1) Identifying and understanding the available resources
2) Accounting for local climate conditions

Making the most of climate and available natural resources is a fundamental principle of passive design that complements the decisions that are made on the use of renewable technology. For example, making the most of the sun through appropriate house and site orientation will lead to benefits for using solar technology as well as benefits such as reduced space heating costs in winter, improved daylighting and maintaining comfort levels. Unfortunately, even now in many so-called 'eco-houses', not enough attention is being made to this key design area[3]

Other features of passive design critical to achieving the maximum benefit for effective space heating and cooling include:

- Glazing
- Insulation
- Thermal mass and materials
- Ventilation

These are not covered in this report, but are fully detailed in the listed websites (in particular see www.level.org.nz and www.smarterhomes.org.nz).

[3] ***Roman Jaques, BRANZ, Personal Communication, April 09***

2.1 Resource Availability and Use

Energy resources from solar (sun), wind, micro-hydro and biomass are covered here. From a resource availability perspective, not all sites are suitable for all renewable options.

In general **semi-rural/rural** sites are best suited to:

- Hydro systems
- Small wind turbines
- Solar
- Biomass for low-grade heating and electricity production

In general, **urban** sites are best suited to using:

- Solar technology such as photovoltaic (PV) and solar water heaters (SWH)
- Biomass for low-grade heating

It is important to seek professional advice, so use this information to be better prepared for working with the appropriate designer, installers and equipment suppliers.

Assessments for house and site should be supplemented with resource data from NIWA weather stations monitoring sun and wind characteristics around New Zealand. Options for sourcing resource data include:

- Contacting the National Climate Centre at NIWA for all the options on obtaining climate data from around New Zealand. (http://www.niwa.co.nz/our-science/climate/our-services/all/data)
- Asking an energy systems professional for assistance – they can access this data and apply it to your situation.

2.1.1 Sun, or Solar Energy

The sun can be utilised for space heating (passive design), water heating (solar thermal) and electricity generation (photovoltaic). A small amount of sun can help improve energy efficiency and comfort if it can be captured for passive space heating, and several hours a day provides more options for providing hot water and electricity.

Solar resource is assessed by looking at:

1) Orientation and sun angle
2) Available sunshine hours (when and how much)
3) Positioning in terms of shading and aspect

2.1.1.1 Orientation and sun angle

Important points:

- The sun shines from the north, so any surface facing north (preferably in a range of 20°W to 30°E of true north) will capture sun.

- True north can be found:
  - from local maps and street directories
  - by using a rough visual while standing on a site - the line between you and the sun at midday is an estimate of true north.

- Winter sun is lower angled than summer sun, so it sits lower in the sky. This affects the required 'tilt' of SWH and PV systems as well as the amount of winter sun captured for passive heating.
  - Tilt angle is the angle of the panels in relation to the ground. Generally for the best average performance over a year, the latitude of the site is the tilt angle for a PV panel, or solar collector. Latitude varies down New Zealand: Auckland is around 36°, Wellington 41° and Dunedin 45°.
  - Tilting the panels an extra 10 degrees above latitude (so the angle is steeper) will give more electricity or hot water in the winter because the sun is lower in the sky. Decreasing the angle from latitude so the panel is flatter will provide more electricity or hot water in the summer because the sun is higher in the sky.
  - The chosen tilt angle will depend on what the systems are meant to deliver for each situation. (winter hot water may be more important for some, or maximum electricity from summer sun may be needed for others)

  - Buildings can still be designed to maximise use of sun while balancing views and shelter from weather or noise.

Table 1: Orientation and Sun Angle: Passive Heating Systems

Level	Assessment	Explanation
House	Which way does the house 'face'?	It should face north - walls/windows should be longer on the north side. North-facing walls and windows capture sun during the day; west-facing capture afternoon/evening sun and east-facing will capture morning sun.
	Does the house have eaves?	Eaves/overhangs should be of a length to shade during the summer and allow low-angled winter sun in during the winter.
	Do the windows allow enough sun into the right rooms?	Dense or high thermal mass surfaces (e.g. concrete, tiles) inside the house, which can be exposed to sun, will deliver space heating to those areas.
Site	Does the shape of the site allow for buildings to be constructed or changed enabling more sun to be used?	The more area exposed to the north, the more sun is available. Orientation on site depends on what matters most – views, shelter from weather, privacy, exposure to sun or other specific features.

Table 2: Orientation and Sun Angle: Solar Thermal and PV Systems

Level	Assessment	Explanation
House	How much of the roof faces north - is there enough space to place a SWH or a PV panel?	Roofing and eaves can be designed to allow for passive heating and cooling needs *inside* the house, while ensuring maximum access to sun on the roof. Only part of the roof needs to face north to be useful for placing a system - PV needs more room than SWH.
	What is the pitch of the roof?	A flat/low pitch (usually $<15^o$) will capture more summer sun, while a steep roof ($> 40^o$) will capture more winter sun. Roof pitch is part of ensuring the right tilt angle for SWH and PV – because the ideal pitch depends on where in New Zealand you are, a frame can be used to position the system to perform better.

	How robust is the roof structure?	A frame may be required for roof-mounting PV panels to get optimum tilt angle, and/or the roof also needs to be strong enough to take the weight of a SWH system.
Site	Does the shape of the site allow for buildings to be constructed or changed so more sun can be used?	As for passive heating.
	If a roof is not used for PV, is a suitable area available for ground-mounted PV?	For ground-mounted PV a suitable area should be facing north, be big enough to safely position the system without risk of damage, and close as possible to point-of-use to minimise losses.

2.1.1.2 Available Sunshine Hours

Important points:

- More sunshine hours means more available solar energy. Sunshine hours are measured by weather stations all round the country and the data for specific locations can be sourced from NIWA's National Climate Database
- When sunshine is available can be as important as how much, if space/water heating, or electricity, is required at a specific time. System design needs to manage both these factors.

Table 3: Available Sunshine Hours: For any solar system (passive heating, PV, SWH)

Level	Assessment	Explanation
House and Site	How many hours of direct sunshine are available through the year (but especially in winter) - most of the day or only a couple of hours?	The more hours you have, the more space or water heating or electricity can be gained. Solar PV and hot water systems can operate even in dull conditions, but work best with plenty of direct sun. Clouds and haze will reduce available sunshine.
	How much does it vary between summer and winter, and how does this fit with when it's needed most?	Sun path and sun angle change with season, so sometimes hills and other obstacles can provide shade at different times of the year; or weather patterns might affect clouds and haze. Whatever the system used, it will need to be positioned according to the best time for sun in the house, and/or onto the roof.

2.1.1.3 Positioning

Important points:

- Shading from obstacles must be minimised to ensure the best performance of any solar system - in winter, obstacles on the north side cast shadows two to three times their height. (Shade can be designed in for summer cooling while not interrupting performance of roof-mounted systems. Any shading of panels reduces efficiency)
- Slope of a site can affect seasonal access to sun.
- Keeping views and shelter from prevailing weather usually needs to be balanced against positioning for the sun.

Table 4: Positioning: For any solar system (passive heating, PV, SWH)

Level	Assessment	Explanation
House	How close are hills, neighbouring houses and trees – is this likely to change? (i.e. becoming built-out or growing bigger) or can they be reduced or removed?	At least six meters from a single storey to the north is preferable for sun access (more for higher buildings). Aerial photos can help identify neighbourhood features. Removal of overshadowing features is not always practical. For instance, privacy can be a reason for not altering obstacles if you or the neighbours are concerned.
Site	Sloping sites - where does the slope face, and are there options for the best positioning for the sun?	North-facing is best, south facing slopes lose sun early in winter. The steeper the slope the fewer options there are for sun. A narrow site may give fewer options for avoiding shading.
	Is the appearance of SWH or PV important?	If these systems are deemed unattractive, then they may need to be positioned to reduce visual impact as long as they can still work. This can be an issue in some of New Zealand's heritage precincts.
	How does the site change at different times of the day and in different weather conditions?	Understanding this can help strike a balance with sun, wind, shelter, views and privacy.

2.1.2 Wind Energy

The wind can be utilised for space cooling and ventilation (passive design), and for electricity generation using turbines. A breeze can reduce energy use in summer if it can be captured for passive space cooling and reduce the need for air conditioning.

Wind for electricity generation is best suited to rural/semi rural sites. Several hours a day of strong consistent ‘clean’ wind provides more options for generating electricity. The more variable the wind, the greater the variability of the electricity supplied. Roof-top turbines are available, but their performance is questionable in built-up areas due to turbulence in the wind created by urban structures.

The challenge with the use of wind is balancing access to ‘clean’ wind, with access to views, shelter, and sun – every site is slightly different. Houses in a high wind zone can have surprisingly little useable wind if the site is sheltered to reduce the wind effect (through planting for example).

Wind resource is assessed by looking at:

1) Characteristics (frequency, strength/speed and direction) of wind
2) Consistency and reliability of wind flow
3) Positioning in terms of terrain, obstacles and exposure

The combination of all these features determines the quality of the wind resource and whether generation is viable. A preliminary site assessment can be investigated using local wind data available from NIWA. This data should show hourly speed and direction as a minimum. However, this data is only indicative and should just be used as a headline guide. Provided that the site looks positive for wind generation a more detailed site assessment should be carried out to determine the wind resource at the same height/location as the intended turbine. Ideally this should be undertaken for a minimum of six months, with a year being more preferable to indicate seasonal differences. In addition, seek the opinion of a wind energy expert who could carry out the specific site wind assessment and advise on suitable wind systems.

2.1.2.1 Characteristics

Important points:

- Frequency is a measure of how often the wind blows. More wind provides more options for using it.
- Strength is a measure of wind speed – higher speed/strength provides more electricity. Usually 4 to 7 m/s (at 10m height) is the minimum speed range for effective generation, because most small turbines are designed to start generating from about 3 to 5m/s, and will not reach their peak output until about 10m/s.
- Factors such as geography, ground roughness, proximity to water bodies, buildings and vegetation affect wind speed.

- Direction that the prevailing wind comes from decides where a turbine can be placed. Wind can come from all directions on a site, but the best wind to use may tend to come from one side of the site.

The NZ Wind Energy website has more information and useful resources on learning about wind (www.windenergy.org.nz).

Table 5:Characteristics: Wind Turbines

Level	Assessment	Explanation
House	Roof-mounted turbines are not recommended as there is limited evidence for their effectiveness in urban areas and they can be problematic to install correctly. If they are to be considered they should only be utilised in situations where the turbine will sit higher than nearby buildings or other obstacles.	Roof-mounted turbines need to be as high as possible without obstruction and very securely attached. There may be planning restrictions covering the height of building mounted wind turbines in some areas.
Site	Are there trees and vegetation that lean in one direction, or show obvious signs of stunted growth from prevailing wind?	This is a quick indicator of prevailing wind strength. Finding out about local Wind Zone ratings from local authorities will provide more detail too.
	Does the site feel sheltered or exposed to wind – are there places where the wind feels stronger (such as ridge tops or open ground)?	Prevailing winds and features that affect wind flow determine if, and where a turbine can be placed.
	Is the site big enough for a ground–mounted turbine tower; or is a roof turbine the only option?	Many urban sites don't have the room for a tower, which is the most efficient way to generate wind power.
	How is the local geography affecting site wind patterns?	Hills, gullies, plains and sea all create wind patterns and prevailing winds that could affect a site.

2.1.2.2 Consistency

Important points:

- Consistent, regular wind at a high enough wind speed is more reliable for generating energy. Gusty, turbulent wind is not as useful.
- The use of a simple wind-monitoring device that has the ability to provided logged data on a computer system will assist with decision making in relation to the consistency of wind on site. Devices such as these can be purchased from electrical retail stores such as Dick Smith and typically cost under $500 (for the device – there may be additional costs required to hook this up to a computer).

Table 6: Consistency: Wind Turbines

Level	Assessment	Explanation
Site	Do the wind characteristics change during the day?	Geographic and water features can contribute to this.
	Do winds vary by season, and in what way?	This helps determine where the best wind comes from, where a turbine may be sited, and when it might be the most productive.
	Are there obstacles that affect wind consistency?	These can be avoided, reduced or may end up preventing the use of the resource.

2.1.2.3 Positioning

Important points:

- Obstacles such as vegetation, buildings and geographic features influence consistency and characteristics – all need to be managed to select the best site for wind generation. If obstacles to wind flow are nearby, the required clean airflow zone can be up to 20 times the obstacle height (in metres) away from that obstacle (e.g., for a 10m tree, the best turbine airflow zone may be as much as 200m away). This is why roof-top turbines are not always ideal and certainly not recommended in urban areas.
- Privacy and neighbourhood concerns can affect where a turbine sits.
- The use of a simple wind-monitoring device will assist with decision-making in relation to the optimum position for a wind turbine.

Table 7: Positioning: Wind Turbines

Level	Assessment	Explanation
Site	As well as noting the appearance of vegetation, how much vegetation is on the site, and is it placed for sun, privacy and/or shelter?	Understanding planting patterns can help with decisions about what is most important through the year in terms of privacy, shade, shelter and sun.
	How big and solid are nearby obstacles?	The more solid the obstacle, the more turbulence is created.
	How much choice is there for siting a tower-mounted turbine in terms of area - can the space allow for a 10m (minimum height) tower?	A tower (often the best option) needs space to access quality wind, firm ground for the tower base, proximity for cabling to point-of-use, and room to raise and lower the system.
	What will be compromised to maximise access to wind?	Think about the bigger picture of what is important in terms of sun (warmth, energy), privacy, being part of a neighbourhood, shelter. Meeting all needs is not always possible.
	Are you in a community where several neighbours could combine to invest in a communal turbine?	It may only be suitable in a limited number of cases , but if space and a common desire allow, it could be well worth considering.

2.1.3 Biomass for Low-grade Heat

Biomass includes resources such as wood, wood pellets, fire logs, and waste streams for biogas production.

Table 8: Using Biomass

Level	Assessment	Explanation
House	Is the house typology suitable for biomass–fuelled burners, central heating or boiler systems? (See Beacon's report on house types, *New Zealand Housing Typologies to Inform Energy Retrofits,* or consult with heating system professionals)	Check for storage space for fuel to stay dry; space to house a boiler or central heating unit and associated pipework; whether several rooms need heating to the same temperature rather than one or two; and if a warm air transfer system is suitable for the house.
Site	What are the regional emission standards for the type of systems that can be used to generate low-grade heat? (Such as wood-burners and boilers).	Talk to the local council for what is allowable. It varies by region and whether a house is new or being renovated. Ministry for the Environment publish a list of wood burners that meet specific standards - and many councils approve burners that meet these.
	Does a cost-effective supply of biomass exist locally?	Local forestry mills and plantations can be a source of wood for merchants and wood pellet manufacturers. Check where local firewood merchants source their wood, and ensure it is seasoned. Check for a local wood pellet manufacturer, or a reliable supply of pellets.
	Does the site have the space to grow fuel trees to provide some/all heating needs?	Not all fuel trees need to be tall; and some sites have existing exotic shelter trees that can be removed and used for fuel.

2.1.4 Micro-hydro

Micro-hydro is best suited to rural properties with a stream that flows in dry periods. The amount of available power depends on:

- Volume of flow
- Difference in height between the inflow at the top of the stream and the system outtake at bottom of the stream drop. This is known as the 'head', and needs to be at least 2-3 m to get useful energy.
- Ability to set up a permitted system. This will require investigation with both the local and regional council in the area.

Due to the limited applicability of the micro-hydro resource for the majority of New Zealand's predominantly urban population, this report does not go into more detail for the site assessment potential for this technology. A micro-hydro expert should be engaged to assess the development opportunities of any potential resource.

2.2 Climate

Climate helps determine how much energy is needed throughout the year to maintain comfort and health within the home. Knowing about climate (and at the site level, 'microclimate') can help to prioritise where that energy comes from. For example, sub-tropical areas have a greater priority on summer cooling, alpine areas have a priority on winter warmth, and some areas have climate ranges where both cooling and heating are important.

Climate data from local climate stations can be sourced from NIWA, Metservice, or, in some cases, your regional council.

2.2.1 Local Climate

This is also important for determining how buildings perform, and what can influence energy requirements during the year. Even if a site appears to have a favourable micro-climate, local weather and climate patterns can create conditions that still need to be designed for.

It is useful to understand conditions caused by temperature ranges - both seasonal and diurnal (day/night), rainfall patterns and seasonal wind characteristics (such as spring and autumn equinox winds).

2.2.2 Microclimate (at the site)

The micro-climate of a site can affect site vegetation, house design and placement. This influences building energy efficiency and comfort, especially in terms of the amount of energy needed to perform effectively.

Understand how conditions change (cold, heat, wind, humidity) by day and by season. This impacts renewable energy decisions such as:

- Size of solar systems required to meet heating or energy requirements at the right time.
- Size of wind systems to provide energy when needed.
- Size and type of biomass heating systems to deliver desired comfort levels when needed.

Table 9: Microclimate Considerations

Level	Assessment	Explanation
Site	What areas on the site are colder due to exposure to wind, moisture or shading?	Features like slope, vegetation and nearby buildings contribute to creating microclimates. Earlier assessments for access to sun and wind will help to answer these questions.
	What areas are warmer due to exposure to sun, or to shelter from wind?	

3 What Does the Household Require?

A household needs energy in various amounts at different times of the day. Everyone has slightly different needs created by the number of people in the house, their age and comfort requirements, whether they are at home during the day, their activities, health needs etc. There are two crucial variables that determine how much energy a house uses - the behaviour of the people in the house; and the performance of the house itself. Features such as house age, the type and condition of insulation, weather tightness, orientation, and types of construction materials all contribute to how comfortable a house is and how easy it is to heat and cool.

Assuming the house performance has been addressed through adequate retrofitting; household energy needs also rely on understanding consumption and usage patterns. Putting these together with the understanding of available renewable resources will help the best decision to be made on the most appropriate renewable technology.

3.1 Consumption and Usage Patterns

How much energy is used (consumption), and when it's used sets the usage pattern for a household. Usage patterns can also show the time when the most power is used - known as 'peak' power. For example, in winter, peaks occur with the combination of cooking, heating, lighting and TV use from late afternoon. What a household does to stay healthy and comfortable within their home sets usage patterns, and the peaks in that pattern will decide how big a renewable system needs to be and when it can have the most useful contribution. Knowing how much is needed when will help determine, for example, how big a winter heating system is required; or how much PV electricity could be used in summer to help run certain appliances that use energy during the day.

In most cases, renewable systems provide an alternative to manage usage patterns, but it is not expected they will replace all the energy a household requires. It's a case of fitting resources available to what the household needs so that comfort and health are maintained and improved.

Thinking about the following questions can inform households about consumption and usage. Getting a professional home energy audit is also a good way of learning more. For more information see local councils, energy retailers, and EECA.

Table 10: Consumption and Usage

Issue	Assessment	Explanation
Energy consumption (measured in kWh, the same units as most electricity bills)	What is your power bill telling you about how much energy is used? Has it stayed the same over 12 months or does it change with season?	If wood burners and wet backs are used for winter heating, power bills vary less than if electricity is used. If the variations are big, think about what may be causing it.
	Can you work out a daily energy use from the bill? Do this by: ■ Dividing a monthly bill by days in the month ■ Watching the power meter and writing down how it changes over 24 hours ■ Hiring, buying or borrowing a power meter so you can watch power use as it happens for a day.	This can be a good way of seeing if any efficiency improvements are being made, if done before and after any changes.
Usage pattern (a home energy use checklist can be done in each room – try it as a family exercise)	What appliances are being used when? What is really important for every day? (E.g. fridges, freezers, computers, winter heating) What can be changed, reduced or used at a different time? Is there a usage pattern that would fit well with using a renewable system?	Knowing what the major appliances are will help identify some that can be upgraded to more energy efficient models, turned off more often, or even removed. An obvious need may fit with using alternatives (e.g. biomass for space and water heating; PV for supplying daytime loads).
	What else makes a difference to how much energy is used? Weather (sunny winters, cold summers) Health and wellbeing (asthma, infections, reducing stress etc) Feeling less reliant on 'flicking the switch'. Convenience: efficient heaters are easier to manage than loading wood.	Having a good thermal envelope and high levels of insulation will help manage energy used for heating and cooling. Sometimes having an alternative energy source can help households feel better able to cope with power shortages or increasing prices.

Putting it all together	What opportunities are there to change how energy is used? Can renewable systems replace some electricity use? What about reductions (turning things off; replacing appliances; using seasonal shading instead of air-conditioning)? What about changing usage patterns (e.g. for hot water use)?	This takes a combination of education, desire to change, and applying energy efficiency measures to appliances and behaviour. Don't skimp on the essentials. Sometimes use reductions are not an option, especially if health is at risk.

3.2 Finding the Best System

In addition to understanding the details of the on-site resources, it is also important to know about the amounts of energy used and the particular usage patterns. Both of these will be required by professionals when deciding the size and type of system best for a household or community.

Getting to grips with energy use and resources may be best done with a professional – but they will still want to answer the questions raised around consumption and usage patterns, as well as assessing your locally available resources.

The amount of energy that is required by a household or community will ultimately decide the size and performance of a renewable system. Size is a big determinant of cost, so this is considered along with all the other factors that are important for a healthy and sustainable household.

An example of how energy use can vary depending on appliances and heating type is shown below, for a house that is fully insulated, double-glazed and facing north. In the example provided, using a wood burner as a source of low-grade energy for space and water heating (the red line) can make a significant difference to the amount of high-grade electricity used compared to an all electric heating system (the blue line).

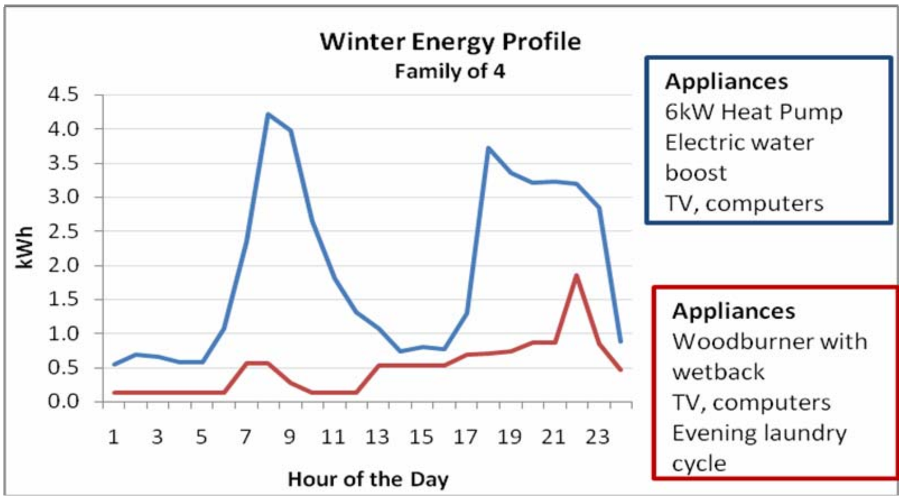

Figure 1: Example Winter Energy Profile

4 Regulations and Standards

Local council requirements, regulations, and consents must all be checked out for any renewable technology system, especially for generation. Councils across New Zealand have different rules and conditions for consents and permits, so ask your local council for guidance, and have a look at the District Plan.

It's important to check the professional standards for equipment warranties, performance and installation. Trade associations and bodies such as the Sustainable Energy Association of New Zealand (SEANZ) can provide more information on these. **SEANZ can also provide details of registered professionals who can assist with consultation and installation**.

Check with EECA, and with the local council for subsidies and assistance available for installing renewable technology. These schemes are updated regularly.

Important points:

- Check District plans for rules on:
  - Building proximity to boundaries
  - Height restrictions
  - Maintaining sun access
  - Protection against loss of outlook, too much shading, loss of privacy
  - Development plans
  - Rules for adjacent sites

- Check regulations for installing small scale generation – local lines companies, energy retailers, accredited electricians and SEANZ can assist with this

- Building consents are generally required for:
  - Solar hot water systems (easier for a new house)
  - Wind generation systems
  - Wood burner installations (must also comply with national environment standards on sites less than 2 hectares)
  - Solar PV in some cases

- Resource consents are generally needed for:
  - Wind turbines
  - Micro-hydro

5 Other Issues

Other issues that need to be considered when assessing the most appropriate renewable options are provided in overview below:

- Neighbours and adjacent properties – what zone is the site in and what is it used for, what is the built environment surrounding the site (height, scale and style), and what is the impact of the proposed renewable technology on neighbours?
- Services infrastructure – do cabling and power connections exist, and are there any size restrictions on the type of system that can be installed?
- Line and power company requirements for any generation systems – use professionals to help with this when designing and installing the system.
- Does an existing house have full insulation and energy efficient features already? These should be pre-requisites to ensure the house is performing well and the energy demand has been reduced as much as possible .
- Site latitude and longitude (Grid reference) is useful to have on hand for professionals designing solar systems, including those incorporating passive heating.
- What are the economic considerations and drivers for installing the technology – to save money on power bills; to invest in new technology; to play a part in climate change?
- Consider using a professional to help with decision-making as well as installing renewable technology. They should be a member of a professional body such as SEANZ or the Solar Industries Association representing the solar hot water industry.

6 Getting Help

Financial assistance

A variety of grants and financial assistance is available for homeowners installing systems for energy efficiency and renewable energy. Check with your local council, community energy trusts, and with EECA for more information.

Table 11: Examples of Energy Grants and Financial Assistance

Organisation	Grant	Description
Wellington City Council	Sustainable Energy Fund	For installing sustainable energy technologies in new homes or retrofits.
EECA	Energywise Grants	Insulation and energy efficiency installations for low and middle income households.
Regional Community Trusts	Contracted providers of Energywise grants	Locally-based options for supporting low middle income households to improve energy-efficiency.

Finding Information

- Refer to the websites listed under 'existing research' and throughout the text.
- Use local directories, local councils, personal references, trade associations and professional industry bodies to find suppliers and professionals.
- Aerial images can be sourced from local councils, or Terranet (online property information with links to Terralink mapping services)
- The Consumer New Zealand website has a section under Home and DIY containing extensive information on heating and energy that is particularly useful for exploring the combinations of appliance, fuel type, ease of use etc. as they apply to individual households. Being a member helps get access to more of the information.

Summary Parts I and II

The aim of this report is to bring together a range of information important for households and communities considering how to use local renewable energy resources, before engaging professionals. A number of options exist for how this information may be presented to end-user, and these have potential to be explored in other Beacon workstreams such as the existing homes Home*Smart* Renovations programme, the Home*Smart* Homes stream; and at a community scale, within the Neighbourhoods stream.

The decision process has been summarised in the diagram below, to show how the main areas of energy use and understanding site and location combine to identify potential renewable technologies that use local resources.

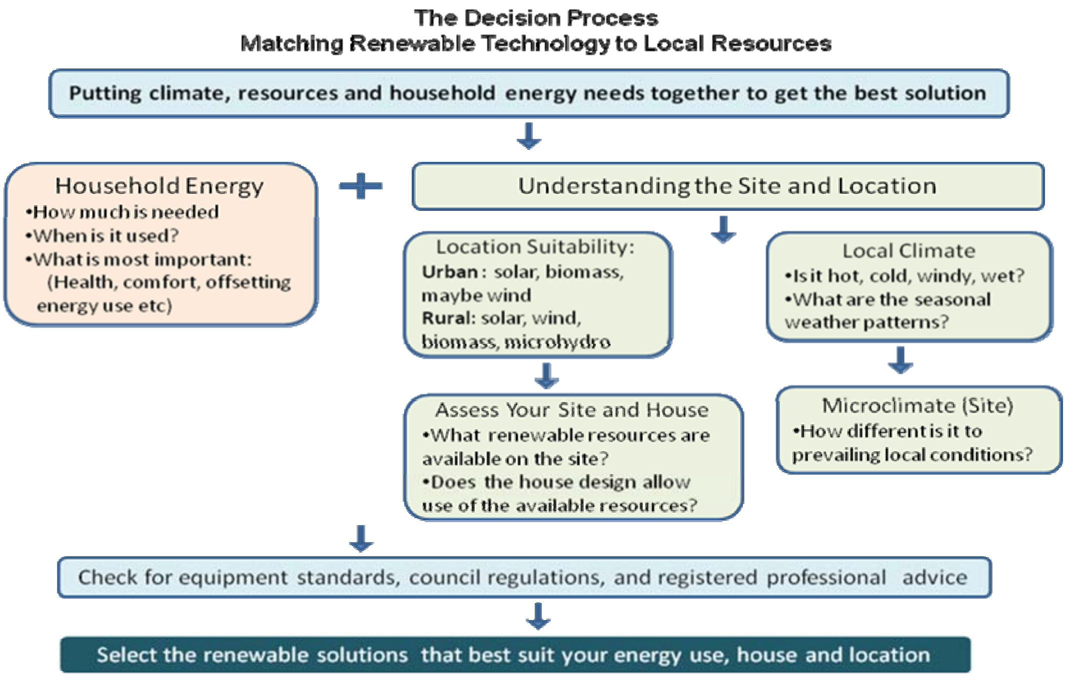

Figure 2: Matching Local Renewable Technology to Local Resources – The Decision Process

Two draft checklists are provided in the Appendix as examples of how this information could be used to provide consumer-facing information:

1) A draft resource availability checklist for users to work through assessing local solar resources.
2) A Home Energy Use Checklist, that could be further adapted for end-users

These particular consumer-facing checklists could be further developed within the current remit provided by the Home*Smart* Renovation programme; particularly for those interested in installing renewable energy generation technology as part of their renovation plan.

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Appendix 1: Draft User Checklist Example

This provides an indication of how the information from the main report (Part II) could be developed into a consumer facing checklist tool.

CHECKLIST: Resource Availability for Solar

What is important to check?

Seek professional advice if there is any doubt or difficulty with the assessment, and before any system decisions are made.

CHECKLIST 1a: Solar Feature: Orientation and Sun Angle

Important points:

- The sun shines from the north, so any surface facing north (preferably in a range of 20° W to 30°E of true north) will capture sun. True north can be found from local maps and street directories; or use a rough visual while on the site - the line between you and the sun at midday is an estimate of true north.
- Winter sun is lower angled than summer sun, so it sits lower in the sky. This affects the required 'tilt' of SHW and PV systems, as well as the amount of winter sun captured for passive heating.
- Tilt angle is the angle of the solar panels in relation to the ground. Generally for the best average performance over a year, the latitude of the site is the tilt angle for a PV panel, or solar collector. Latitude varies down New Zealand: Auckland is around 36°, Wellington 41° and Dunedin 45°.
- Tilting the panels an extra 10 degrees above latitude (so the angle is steeper) will give more electricity or hot water in the winter because the sun is lower in the sky. Decreasing the angle from latitude so the panel is flatter will provide more electricity or hot water in the summer because the sun is higher in the sky.

- The chosen tilt angle will depend on what the systems are meant to deliver for each situation (winter hot water may be more important for some, or maximum electricity from summer sun may be needed for others).

Orientation and Sun Angle Checklist

Level	Assessment	Explanation	User Notes
System:	**Passive Space Heating**		
House	Which way does the house 'face'?	It should face north - walls/windows should be longer on the north side. North-facing walls and windows capture sun during the day; west –facing capture afternoon/evening sun and east -facing will capture morning sun.	Good: All day sun especially in winter Possible: Sun for about 4 hours/day Not good: Sun for less than 4 hours, morning or evening only MAKE YOUR NOTES IN THIS SPACE
	Does the house have eaves?	Eaves/overhangs should be of a length to shade during the summer and allow low-angled winter sun in during the winter.	Good: Standard eaves that let in winter sun Not good: Long eaves/ verandahs that block winter sun
	Do the windows allow enough sun into the right rooms?	High thermal mass surfaces inside the house that can be exposed to sun will absorb heat and deliver space heating to those areas.	Good: Windows let in sun onto heat absorbing surfaces Possible: Some windows, or wall space to retrofit them Not good: No option to retrofit windows or alter floor surface
System	**Solar Hot Water (SHW) and Photovoltaic Electricity (PV)**		
House: All these factors should be considered together	How much of the roof faces north - is there enough space to place a SWH or a PV panel?	Roofing and eaves can be designed to allow for passive heating and cooling needs *inside* the house, while ensuring maximum access to sun on the roof. Only part of the roof needs to face north to be useful for placing a system - PV needs more than SWH.	Good: Need at least 5-8m^2 facing north for SHW and at least twice that for PV panels Possible: Less than area above ,or option for a frame to be placed facing North Not good: Roof shaded most of the day with no option to place a frame either.
	What is the pitch of the roof?	A flat/low pitch (usually <15^o) will capture more summer sun, while a steep roof (> 40^o) will capture more winter sun. Roof pitch is part of ensuring the	Good: For solar thermal, north-facing roof pitched between 30-40^o Possible: SWH as above or steeper, will give better winter options

Level	Assessment	Explanation	User Notes
		right tilt angle for SWH and PV –because it's not always the same as site latitude a frame can be used to position the system to perform better.	Not good: Flat roof will give limited success, a frame would be needed *Note: for PV it depends on when/how much electricity is needed*
	How robust is the roof structure?	A frame may be required for roof-mounting PV panels to get optimum tilt angle, and/or the roof also needs to take the weight of a SHW system.	Good: Structurally sound and able to take weight of panels and possibly a frame Not good: Old unsound roof, or limited strengthening options
System	**Passive Space Heating, SHW and PV**		
Site	Does the shape of the site allow for buildings to be constructed or changed enabling more sun to be used?	The more area exposed to the North, the more sun is available. It depends on what matters most – views, shelter from weather, privacy, exposure to sun or other specific features.	Good: North-facing site with room to meet all needs Possible: Access to sun requires building redesign or sacrifice of other features Not good: Few options to access sun or other needs prioritised higher.
	If a roof is not used for PV, is a suitable area available for ground-mounted PV?	For ground-mounted PV a suitable area should be facing North, be big enough to safely position the system without risk of damage, and close enough to point-of-use to minimise losses from long cables.	Good: Enough area close to point of use and safe to use Not good: Not enough area.
Summary: Solar potential based on assessment of Orientation and Sun Angle			
Good:	The house and site generally fit the 'Good' criteria above. A North facing site is best especially for a new build if it allows for whole house to be designed for passive space heating and other solar systems.		
Possible:	The house and site have a mix of the criteria above. If there is access to sun but other features are possible or not good, then seek professional advice to properly assess the options.		
Not Good:	The house and site criteria are generally 'Not Good' especially if there is little option to get access to sun through either retrofitting or changing site features.		

CHECKLIST 1b: Solar Feature: Available Sunshine Hours

Important points:

- More sunshine hours means more available solar energy. Sunshine hours are measured by weather stations all round the country and the data for specific locations can be sourced from NIWA's National Climate Database
- When sunshine is available can be as important as how much, if space/water heating, or electricity, is required at a specific time. System design needs to manage both these factors.

Available Sunshine Hours Checklist

Level	Assessment	Explanation	User Notes
System: Passive Space Heating, SWH and PV			
House and Site	How many hours of direct sunshine are available through the year (especially in winter) - all day or only a couple of hours?	The more hours you have, the more space or water heating can be gained. PV's operate all day, but work best with plenty of direct sun. Clouds and haze will reduce available sunshine.	Good: At least 6-8 clear hours, preferably all day Possible: At least 4 hours during the middle of the day in winter Not good: Less than 4 hours or at either end of the day (sun is weaker) MAKE YOUR NOTES IN THIS SPACE
	How much does it vary between summer and winter, and how does this fit with when it's needed most?	Sun path and sun angle change with season, so sometimes hills, and obstacles can provide shade at different times of the year; or weather patterns might affect clouds and haze. Whatever system is used will need to be positioned according to the best time for sun in the house, and/or onto the roof.	Good: No significant seasonal weather or obstacles for 6-8 hours sun a day Possible: Obstacles to sun can be removed or allowed for to get at 4 hours as above Not good: Seasonal weather, obstacles to sun cannot be removed or allowed for
Summary: Solar potential based on available sunshine hours			
Good:	The house and site fit the 'Good' criteria above. All day sun with clear winter days is best, if winter heat and electricity is a priority.		
Possible:	The house and site can access around 4 hours of sun. Orientation and sun angle criteria would have to be good.		
Not Good:	The house and site 'Not Good' especially if there is little option to get access to sun through either retrofitting or changing site features.		

CHECKLIST 1c: Solar Feature: Positioning

Important points:

- Shading from obstacles must be minimised to ensure the best performance of any solar system - in winter, obstacles on the north side cast shadows two to three times their height. (Shade can be designed in for summer cooling while not interrupting performance of roof-mounted systems. Any shading of panels reduces efficiency)
- Slope of a site can affect seasonal access to sun – clever design of new build or retrofit features can sometimes overcome this.
- Keeping views and shelter from prevailing weather usually needs to be balanced against positioning for the sun.

Positioning Checklist

Level	Assessment	Explanation	User Notes
System:	**Passive Space Heating, SHW and PV**		
House	How close are hills, neighbours and trees – is this likely to change? (being built-out or growing bigger);can they be reduced or removed?	At least six meters from a single storey (more for higher buildings) to the north is preferable for sun access. Aerial photos can help identify neighbourhood features. Removal is not always practical! Privacy can be a reason for not altering obstacles if you or the neighbours are concerned	Good: Large obstacles more than 6 meters away with no risk of change Possible: Obstacles exist but can be altered, or house redesign can reduce effect Not Good: Large obstacles are too close and cannot be removed
Site	Sloping sites - where does the slope face, and are there options for the best positioning for sun?	North-facing is best, south-facing slopes lose sun early in winter. The steeper the slope the fewer options there are for sun. A narrow site may give fewer options for avoiding shading.	Good: North-facing site, or options exist to position rooms /systems for sun access Possible: Narrow site but north-facing; slope facing east or west but options exist to position rooms /systems for sun access Not Good: Narrow south-facing slope, with no options for system placement or house redesign
	Is the appearance of SHW or PV important?	If these systems are deemed unattractive, then they may need to be positioned to reduce visual impact as long as they can still work. This can be an issue in some of New Zealand's heritage precincts.	Good: Appearance not an issue Not Good: Appearance is an issue; for position where system will work best
	How does the site change at different times	Understanding this can help strike a balance with sun, wind, shelter, views and	Good: Site can deliver for all needs while allowing a solar system to perform

	of the day and in different weather conditions?	privacy.	Not Good: Site changes with time and weather means other needs are prioritised above the value of solar performance.

Summary: Solar potential based on positioning	
Good:	The house and site fit the 'Good' criteria -there are plenty of options for accessing sun by managing slope and obstacles
Possible:	The house and site meet a mix of criteria with some thought needed to ensure the best positioning for rooms and/or systems
Not Good:	The house and site have few or no options for positioning, or other needs are more important than accessing sun.

Appendix 2: Draft Home Energy Usage Checklist

The following table indicates the potential for providing a simple home energy usage checklist for consumers as part of the information that they could access through Beacon's resources.

Table 12: Home Energy Usage Checklist

Room	Appliance	Watts	Hours Used	Time of day[1]	kilowatt hours	Importance[2]
Bedroom 1	Computer	50	3	evening	0.15	Yes Homework
	Oil heater	2000	4	Evening (winter)	8	Yes -warmth
	Lights (non CFL)	3at 60W	4	Morning + evening	0.72	Yes
etc						

Note 1: Time of day definitions

- Night (midnight to 6am)
- Morning (6am to midday)
- Afternoon (midday to 6pm)
- Evening (6pm to midnight)

Note 2: Importance - how essential is the appliance? Does it have to be on all the time, or can it be used flexibly?