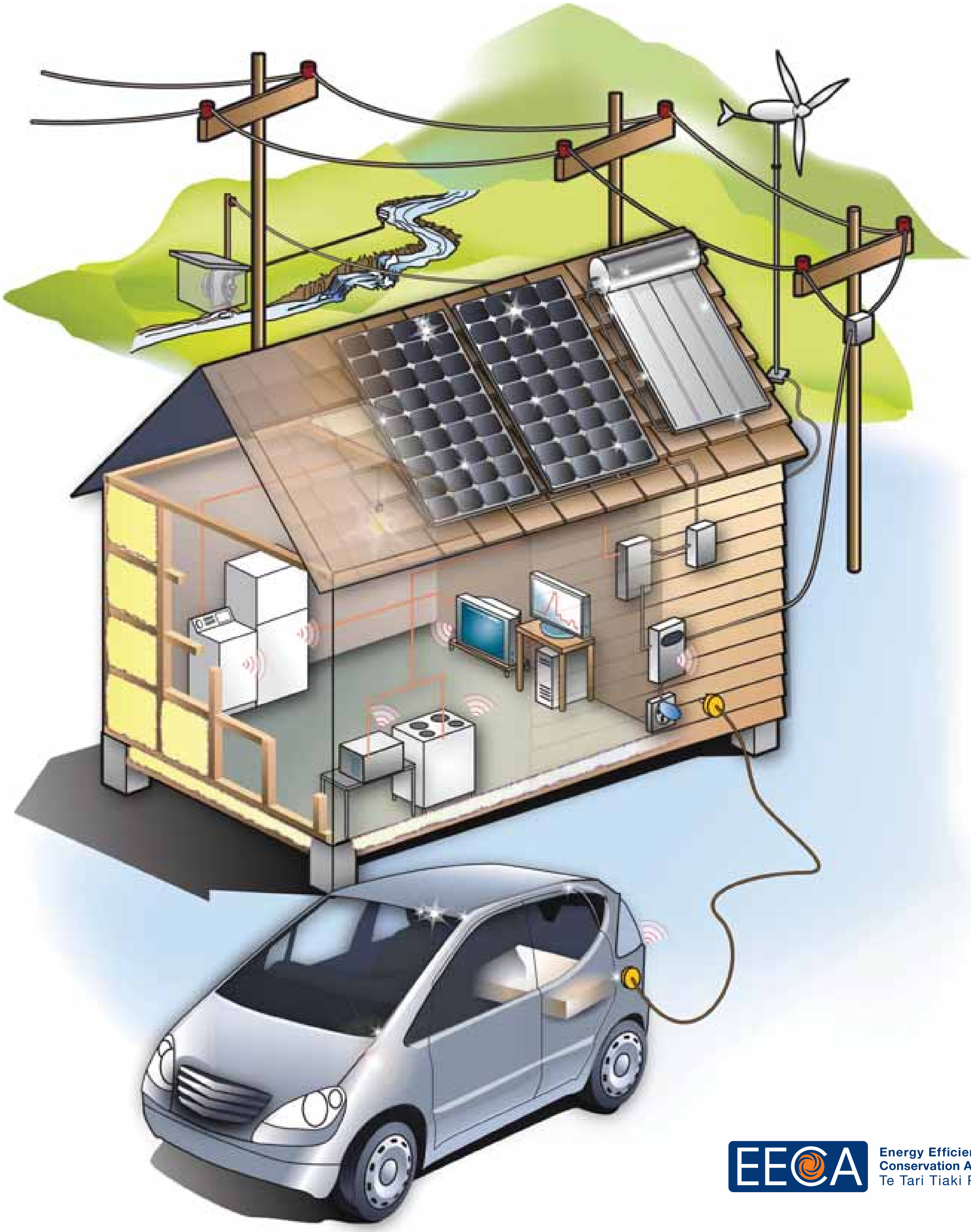
Domestic-scale distributed generation
Guidance for local government



Energy Efficiency and Conservation Authority
Te Tari Tiaki Pūngao

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Acknowledgements

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1. Introduction

1.1 Purpose of this document

This document provides guidance and information to assist with the approval processes and requirements for small-scale distributed renewable energy generation technologies (hereafter collectively referred to as 'microgeneration'), particularly in relation to the requirements of the Resource Management Act 1991 (RMA) and the New Zealand Building Code (NZBC). The guidelines are primarily intended for local authority consenting staff, and project proponents.

This guidance document has been prepared by the Energy Efficiency and Conservation Authority (EECA) in its role to encourage, promote and support energy efficiency, energy conservation and the use of renewable energy sources. The guidance is aimed at assisting the uptake of microgeneration in New Zealand.

The information in this document is provided in good faith, and is not intended to be treated as mandatory, definitive or prescriptive. This guide is not a substitute for professional advice, and should not be solely relied on for establishing compliance with the Building Code or to assist resource consent applications. It may be updated from time to time. The latest version is available from the EECA website (www.eeca.govt.nz).

1.2 Contents of the guidance document

This guidance document covers the following microgeneration technologies:

- Photovoltaics ('PV');
- Micro and mini-scale wind turbines;
- Micro and mini-scale hydro-electric turbines.

Solar water heating systems are also briefly covered in this document. Solar water heating is often used in conjunction with microgeneration, especially in stand alone applications where reducing electricity demand load is paramount. Extensive guidance on the installation of solar water heating is also available in other documents, and Acceptable Solution 2 for Clause G12 of the New Zealand Building Code (G12/AS2) has been developed specifically for solar water heating. See Section 5 for more information.

1.3 The importance of microgeneration

Distributed generation can contribute towards a more secure and environmentally-friendly energy future by potentially:

- using renewable sources of energy
- making our electricity supply more diverse and geographically dispersed
- increasing security of supply by making local networks more reliable and resilient
- improving the efficiency of the electricity system by reducing transmission and distribution energy losses.

Local government plays an important role through the introduction of policies, plans and actions to support the uptake of renewable energy including small-scale, distributed generation technologies.

1.4 Definition of microgeneration

This guidance document is limited to microgeneration technologies. Microgeneration is a subset of distributed generation, and refers to domestic-scale generation. Off-grid generation, or Stand Alone Power Systems (hereafter abbreviated to SAPS), is also included in this document because these systems often use the same technologies. Table 1-1 describes the approximate sizes of different types of generation. Note that there are no industry-defined standards, and this table is intended as a guide only.

Table 1-1 Summary of types of generation

Concepts	Scale	Category	Approx. power rating	Examples and notes
Distributed electricity generation (DG) Electricity generation projects which are connected to the local electricity network instead of the national grid.	Small-scale	Micro	0–5kW	A house could have a 2kWp photovoltaic array or a 1.5kW micro wind turbine. These could typically offset a portion of a house's power bill.
		Mini	5-20kW	Generation in this range could offset a portion of a large household's or small farm's power bill, with some export back into the network.
	Large-scale	Small commercial	20-1000kW	Generation plant of this size is usually used to sell electricity to retailer, other purchaser, or into the market. Some electricity may be used on site. An example is the Southbridge wind turbine (100kW) in Canterbury.
		Large commercial	>1000kW	Large commercial DG, for example the proposed Weld Cone windfarm (1.2MW) in Marlborough, or Mangipihi hydro (1MW), connect to the local network and sell electricity commercially.
Off-grid generation (also known as stand-alone power system - SAPs). Generation not connected to the electricity network.	All sizes	Off-grid generation	0 - unlimited	The size of off-grid generation can range from a domestic-scale SAPS, to much larger systems which provide electricity for whole communities which are not connected to the electricity network. In some situations, such as on Stewart or Chatham Islands, generation sources are connected into 'mini-grids' on the islands which distribute electricity to households and businesses on the 'network'.
Grid-connected generation Large-scale centralised generation is directly connected into the national grid.	Large-scale	Large-scale generation	Usually >10MW	Most of New Zealand's electricity comes from large, centralised, generation plants. Electricity is transmitted around the country via the transmission grid, and distributed to households and businesses via distribution networks. Examples include the Wairaki geothermal plant (162MW), Te Apiti Wind Farm (91MW), or Manapouri hydro (728MW).

There are two primary ways that microgeneration can be used. It can be installed in a SAPS, which is not connected to the local electricity network and therefore batteries and backup generation are often required, or it can be 'grid-connected'. In grid-connected systems, microgeneration can connect to the local electricity network through an inverter, with the agreement with the local electricity network.

1.5 Current barriers

The uptake of microgeneration is currently constrained by a range of barriers. These include relatively high upfront costs, and a lack of guidance and information to help local authorities understand the approval process for microgeneration in relation to the RMA and the NZBC.

The barriers experienced by local authorities and project proponents can include:

- limited understanding of the various technologies
- minimal experience in preparing and processing resource consent applications for microgeneration
- a wide range of processes and fee structures being used by local authorities for resource and building consent applications for microgeneration
- uncertainty about processes and requirements for considering such applications.

This guidance document seeks to provide information to assist in removing some of these barriers.

2. Encouraging the uptake of microgeneration

There are a number of ways that councils can encourage the uptake of microgeneration. This includes specific planning rules, or the use of consistent criteria and checklists to assess microgeneration applications for consent.

2.1 Simplifying the approval process

The tables of effects in the following sections illustrate that, provided microgeneration installations fall within certain standard design parameters, the extent of the potential effects is generally likely to be minor.

The use of consistent assessment criteria, checklists, and application forms by local government may also assist the uptake of microgeneration.

2.2 Specific planning rules

District plans need to provide for flexibility and innovation in the area of microgeneration technologies. As these technologies increase in popularity, new products will be introduced, which may not have been anticipated when the particular plan was written.

The rules provided in the district plan should reflect the nature and scale of the effects associated with activities. Lists of the common and perceived effects of the technologies, and the likely extent of the effects, are included in this document. In many cases it is appropriate for microgeneration to be provided as a permitted activity within a district plan, subject to compliance with certain standards and criteria.

2.2.1 Permitted activities

During the review of district plans, when councils are looking to encourage microgeneration through their planning processes, one suggested option is that microgeneration could be provided as a permitted activity, provided the system design falls within certain design parameters.

The lists of design parameters, standards and criteria in this document may also be helpful to assess a microgeneration application.

It is important to note that the standard design parameters for microgeneration noted in this document will be applicable to most, but not all, applications. This is in part because of the wide range of technologies and products available, and because in some cases they are still emerging technologies. In most cases, minor deviation from the standard design parameters outlined in this document will not give rise to significant effects, and flexibility is advised in this regard.

2.2.2 Controlled activities

While many microgeneration applications will fall into the standard design parameters outlined in this document, in some cases applications may not comply with these parameters. In most cases, this will only result in minor non-compliance, and it may therefore be appropriate for councils to provide for these microgeneration activities as 'controlled'. Councils could exercise control over those matters which may result in non-compliance with the standards (e.g. height, location, noise and so forth). In this way, councils are able to deal with mitigation on a site-by-site basis via conditions on resource consent, while still allowing the activity.

2.2.3 Restricted or discretionary activities

Where effects that are more than minor do arise with microgeneration facilities, it is usually because the location within which the facility is located is significant or valued in some way (e.g. a landscape, heritage or recreation area). Most activities (including microgeneration) within these areas will give rise to effects, but some may still be appropriate. In these cases, council may want to retain control over where and how these activities occur. This may include the following areas:

- areas of identified cultural or archaeological significance (such as sites and features listed in the district plan)
- areas within identified significant landscapes, ecological or recreation areas (such as wetlands or reserves)
- areas of the built environment that are subject to specific restrictions such as historical precincts and special character areas.

In these cases, it may be appropriate to provide for activities in these areas as 'restricted discretionary' or 'discretionary activities', and the onus would remain on the project proponent to identify potential sites and establish that any adverse environmental effects can be avoided, remedied or mitigated. Councils should specify assessment criteria to address the potential effects on these areas (if not already provided within the plan policies).

2.3 What are the effects of microgeneration?

The construction and operation of microgeneration technologies can give rise to effects. These effects can include:

- positive or adverse effects
- temporary effects
- past, present, and future effects
- cumulative effects which arise over time or in combination with other effects.

The effects associated with microgeneration will differ depending on the particular technology and the specific area where the technology is located.

Therefore the site-specific effects and the effects on the surrounding area of an identical installation in, say, a rural or an urban context will be different. For instance, noise generated by a particular installation may go relatively unnoticed in a rural setting due to low population density and the presence of other noise-generating activities, whereas in an urban context, it may be more of a concern due to the proximity to residential dwellings.

At the same time, these technologies have positive effects and benefits. These potentially include national and local positive effects for the environment and the community through:

- security of supply and greater reliability (by diversifying sources of energy)
- reducing greenhouse gas emissions by encouraging the use of renewable energy
- reducing dependence on fossil fuels, particularly in remote locations
- reducing the reliance on the national electricity grid
- making electricity networks more reliable and resilient
- reducing transmission and distribution losses.

When considering potential effects of microgeneration, particular regard must be had to the benefits to be derived from the use and development of renewable energy.

2.4 Building Code compliance

All microgeneration installations should be safe, strong, and durable. Regardless of whether or not a building consent is required, all systems will need to comply with the Building Code.

The Building Code requirements for individual microgeneration systems will vary depending on specific technologies and various factors associated with the installation. Common considerations will be whether electrical installations are safe (G9 – Electricity), that systems and supports are structurally sound (B1 – Structure), and that components meet durability requirements (B2 – Durability). Where photovoltaic panels are installed on a roof, it is important to ensure that weathertightness is maintained E2 (External moisture). Other clauses may occasionally be relevant depending on the installation being considered.

3. Stand alone power systems (SAPS)

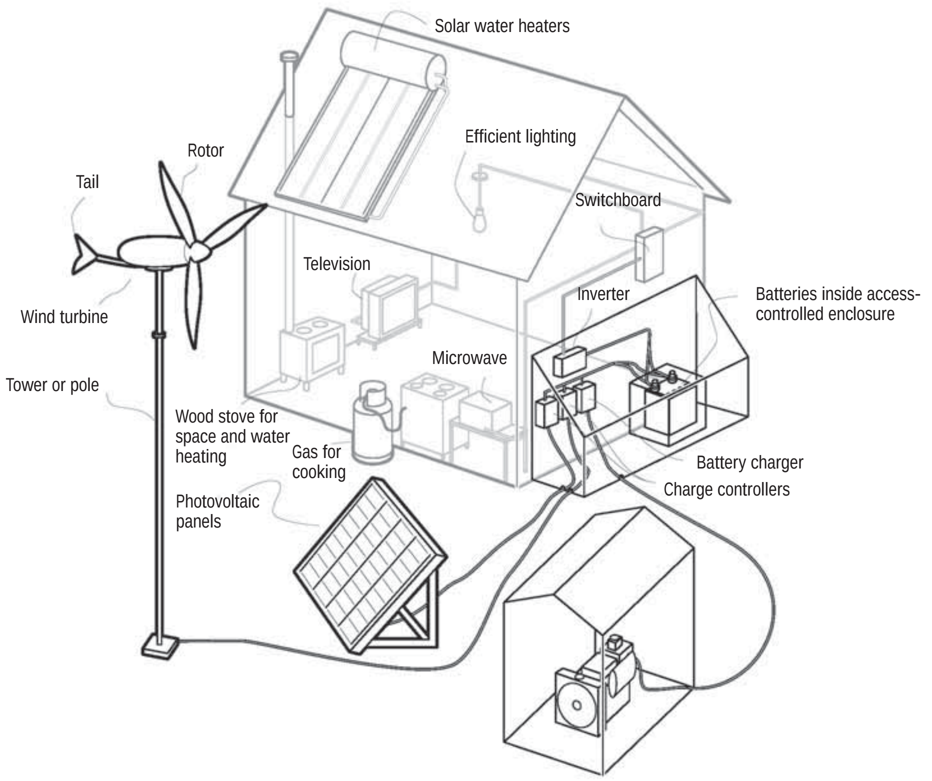
Microgeneration, including solar energy technologies (solar water heating and photovoltaics), micro and mini-scale wind, and micro and mini-scale hydro systems are often used in a SAPS, in situations where there is no connection to the electricity network.

Because SAPS are not connected to the electricity network, batteries are usually required to store the output from microgeneration for later use. Banks of 12V to 48V lead-acid batteries are commonly used. The batteries typically need replacing in 4 to 10 years, depending on quality, sizing and how they are used. Well designed systems using high quality components are likely to last longer. SAPS are often backed up by a diesel or petrol generator.

Table 3-1 Summary of SAPS

SAPS parameters	Comment
Photovoltaics	See Section 6 for more information.
Micro and mini-scale wind turbines	See Section 7 for more information.
Micro and mini-scale hydro	See Section 8 for more information.
Indicative battery size	Banks of 12V to 48V lead-acid batteries are commonly used. Battery size needs to match both the amount of generation and the electricity demand of the house.
Physical and electrical capacity of batteries	A typical battery bank is about 800 amp hours at 24 volts. Individual batteries are usually only between 2 and 12 volts and are arranged in a grid to give the required voltage and current.
Types of enclosure/ room for batteries	Batteries need to be stored in a suitable enclosure or room to avoid unauthorised access, with suitable ventilation.
Generator/backup	A small diesel or petrol generator may be required. The size of the generator can vary considerably. A small SAPS for a bach might have a 1kVa generator, while a large off-grid system may require a 100kVa generator. A typical domestic-scale system may be between 4 and 10KVa, depending on the configuration.
Inverters	An inverter converts electricity from direct current (DC) electricity to alternating current (AC), which most household appliances use. A typical household would require an inverter with a capacity of around 2kW to 5kW.
Charger	A charger allows batteries to be charged from an AC source, such as a generator.
Inverter/charger	Some units allow energy to flow in two directions. They can convert DC into AC (i.e. drawing energy from the battery), or they can charge a battery from an AC source (i.e. a generator).

Figure 3-1 Main components of a SAPS



SAPS are typically used in situations where it is more expensive to connect to the local electricity network than it is to build an electricity generation system. Connecting properties to the electricity network can cost more than $20,000 per kilometre. In these situations, a SAPS can be an economic option.

However, having a SAPS means that more attention needs to be paid to how and when energy is used. It is important to reduce peak electricity demand as much as possible so the size and cost of the generation system required can be minimised.

In a SAPS it is common to use alternative energy sources, such as gas, a woodburner or solar water heating to provide heat for space heating, or water heating respectively. It is also common to use a diesel generator to provide backup power when the other generation plant such as the PV or wind turbine are not operating; for example if it is cloudy or if there is no wind. The use of a diesel generator can result in high levels of greenhouse gas and particulate emissions. To reduce this, greater investment in renewable energy technologies and battery storage is required, so that the diesel generator does not have to be used so often.

Figure 3-2 Photos of components of SAPS

This photo shows a solar water heating system, solar photovoltaics, and micro wind turbine in a SAPS.
Photo: EECA

The batteries for this SAPS are well protected and secured in this box, preventing unauthorised access.
Photo: SEANZ

An inverter installation.
Photo: SolarQuip Ltd.

Examples of controllers for a PV array.
Photo: EcoInnovation

A typical generator used to provide back up power.
Photo: Genkit Nelson Ltd.

Battery bank on a SAPS.
Photo: Genkit Nelson Ltd.

A ground mounted PV array in a SAPS.
Photo: EECA

Another example of a battery bank on a SAPS.
Photo: Genkit Nelson Ltd.

An inverter.
Photo: www.powersmartsolar.com

A ground mounted photovoltaic array.
Photo: www.powersmartsolar.com

3.1 SAPS : Approval considerations

The effects and Building Code considerations for a SAPS depend on the microgeneration technologies being used. Further important information will be found below in the sections relevant to those technologies.

In addition to photovoltaics, micro wind turbines, and micro hydro, SAPS also often utilise battery storage. It should be noted that this information is indicative only and it is recommended that local authorities develop their own flexible approach and interpretation.

4. Grid-connected systems

It is also possible to install microgeneration if the property is already connected to the grid. These types of systems are called 'grid-connected', 'grid-tied' or 'grid-interactive' systems.

The most common form of grid-connected microgeneration is PV, although wind and hydro can also be used. Grid-connected systems usually connect to the local electricity network through an inverter. A special metering installation will also be required to separately measure electricity imported and electricity exported, and an inverter which converts DC into grid-compatible AC.

Table 4-1 Summary of grid-connected systems

Grid-connected systems parameters	Comment
Photovoltaics	See Section 6 for more information.
Micro and mini-scale wind turbines	See Section 7 for more information.
Micro and mini-scale hydro	See Section 8 for more information.
Inverter	Grid-connected inverters must comply with the New Zealand wiring rules and the technical and safety requirements of the electricity lines company.
Meter	The metering arrangement will have to measure both electricity imported into the property, and exported back into the grid.

Owners of grid-connected systems might also be able to sell surplus electricity generated to an electricity retailer. This means that when the system is generating more electricity than what is needed on site – for example, during the day when no one is home – the owner could be paid for the surplus electricity produced. Each electricity retailer will have its own terms and conditions for buying excess electricity. Likewise, the price that they will offer the consumer will also vary. The price they pay per kilowatt hour (kWh) is called the 'buy-back' price.

In order to install a grid-connected system, the homeowner will be required to make an application with the local lines company (sometimes called the 'network' or 'distribution' company). This is the company that manages and maintains the lines that deliver electricity to the house or property. They need to check whether the information provided is consistent with their connection and operation standards.

Figure 4-1 Main components of a grid-connected system (highlighted)

The electric vehicle, advanced meter, and smart appliances may become common in the future but are not widely used at present.

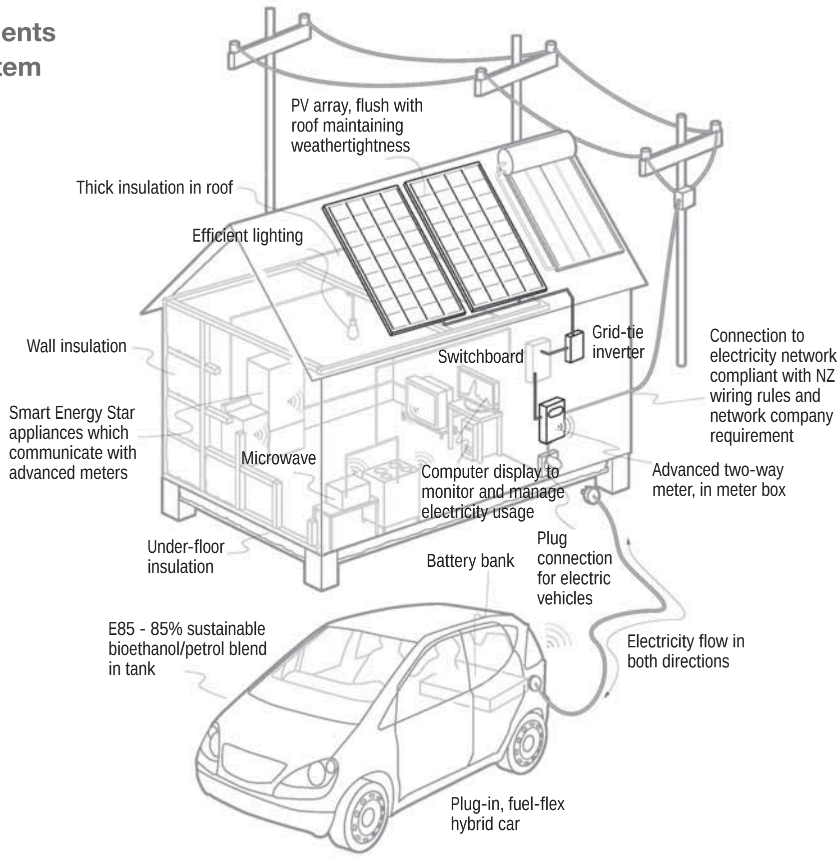
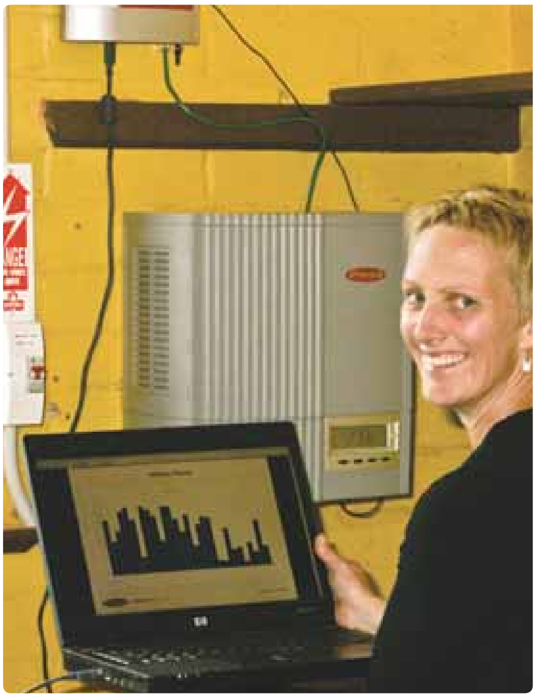


Figure 4-2 Examples of components of grid-connected systems



A grid-connect inverter and data display to show how much electricity has been generated.
Photo: EECA

Photovoltaics are becoming increasingly common in grid-connected systems in urban environments.
Photo: www.solarcentury.com

Frame mounted grid-connected PV system.
Photo: www.solarcentury.com

Grid connected photovoltaic array.
Photo: www.powersmartsolar.com

Example of a display unit on a grid-connected photovoltaic system.
Photo: www.powersmartsolar.com

Grid-connected photovoltaic array in Wellington.
Photo: www.powersmartsolar.com

5. Solar water heating systems

A solar water heating system works by absorbing energy from the sun in collector panels located on the roof. This energy is then transferred to water stored in a hot water tank. At times when there is not enough solar energy to heat the water, 'booster' heating is used to keep the water in the tank at the right temperature. The booster heating can be provided by electricity, gas or a wetback.

Solar water heating systems are often used in conjunction with other microgeneration technologies, and are especially important in stand alone power systems. In these situations it is common to use alternative energy sources for water and space heating to reduce electricity consumption as much as possible – meaning that a smaller and cheaper electricity generation system can be installed.

5.1 Key components of solar water heating systems

There are many different types and variations of solar water heating systems available on the market today, and suppliers typically offer packaged solar water heating systems. Differing types of systems include closed-loop thermosiphon systems, open-looped pumped systems, evacuated tube collectors, and flat plate panels. A packaged solar water heating system is made up of the same basic components and systems:

- a collector - to collect the sun's energy and transfer it to the water or heat transfer fluid
- a hot water storage tank - to store potable water, ready for delivery to the user
- a circulation system – to transfer heat from the collector to the storage tank
- controller or timer and protection devices – these control the circulation system to ensure maximum solar gain, control the use of supplementary heating, and protect the system from overheating, freezing and excessive temperatures and pressures
- supplementary heat source - provides heating when the solar energy collected is not enough to supply the hot water load requirements of the user.

The overall efficiency of a system depends on the perfomance of each component and how well they are matched together as a system.

5.2 Further information

Guidance on the installation of solar water heating systems is provided by the Solar Industries Association (www.solarindustries.org.nz), and the Acceptable Solution to Clause G12 of the Building Code (G12/AS2) deals specifically with the installation of solar water heating.

Further information is also available in 'A Guide to Applying for a Building Consent for a Solar Water Heating System Installation', which is available from the Solar Industries Association.

Figure 5-1 Examples of different solar water heating systems

Frame-mounted solar water heating collector panels installed on a dairy shed.

A commercial-scale solar water heating array installed on the Sky City building in Auckland.

A typical controller for a solar water heating system.

A residential thermosiphon solar water heating system.

A solar water heating system installed with a stand alone power system. The house does not have a connection to the electricity network.

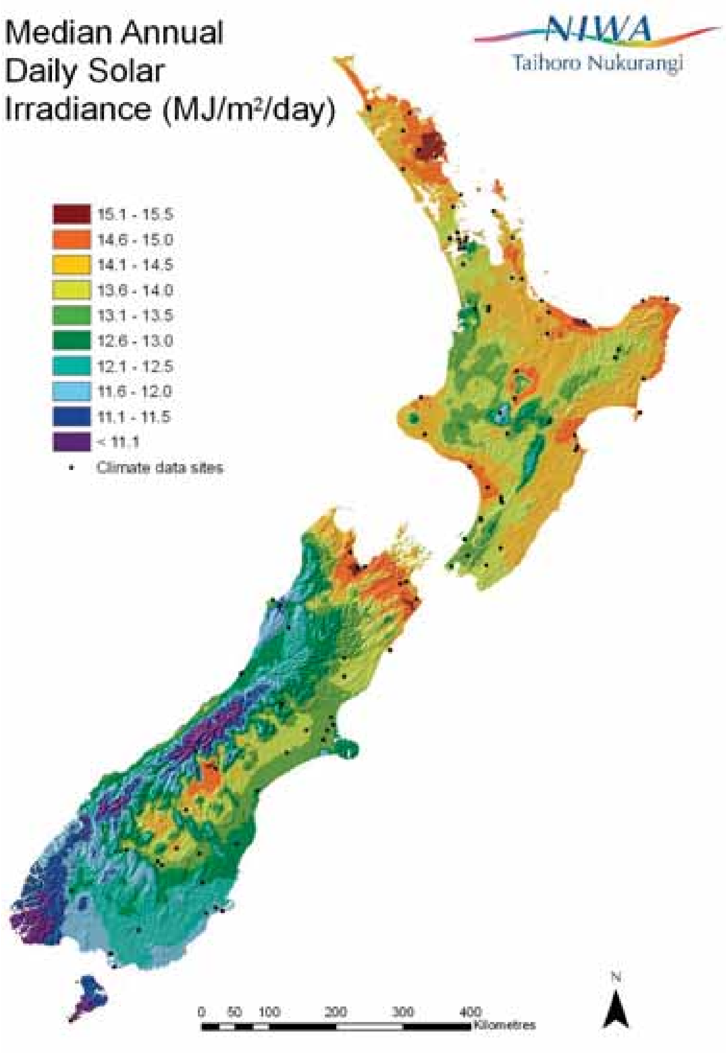
Frame-mounted flat plate collector panels.

6. Photovoltaic systems

Photovoltaics (or 'PV') utilise an abundant renewable energy source, operate without emitting noise and produce no greenhouse gas emissions in operation.

New Zealand has a good solar resource with solar radiation levels equivalent to southern France in many locations. Radiation levels in Invercargill are roughly as high as in Germany, where photovoltaics are used extensively.

Figure 6-1 Solar radiation in New Zealand (NIWA)



PV systems convert energy in light directly into electricity. As such, they are very different from solar thermal systems because they generate electricity, rather than simply absorbing heat to heat water. In New Zealand, PV modules are used extensively to power a range of equipment such as communication systems, water pumps, lights on navigation buoys and electric fences. Larger systems are used on homes, often in remote areas where connection to the electricity network is difficult or expensive, farms, public buildings, petrol stations and lighthouses. They are also becoming increasingly popular in urban environments, in grid-connected applications. The size of the PV system is dependent on the power and energy needs of the specific building or activity or the budget for the project.

Table 6-1 Features of typical PV modules

Solar PV parameters	Comments
Size of typical residential application	Residential PV systems are often between 1 and 5kW in capacity. A good rule of thumb is between 6 and 14m^2 is required per kW installed, depending on the type of PV modules used.
Size of typical commercial application	Commercial PV systems tend to range in size from 5kWp up, although many commercial applications are in the 10s or 100s of kW. The largest PV array in New Zealand is 52kWp, and it covers 416m^2.
Size of typical industrial application	Industrial-scale PV arrays can be very large. Some international PV arrays on industrial roofs are greater than 1MW in size.
Power	Each solar module has a rating specifying its peak electrical output under standard test conditions. Modules are available in sizes from 5Wp to 200Wp. A 1kW PV array could have 6 x 175Wp modules connected together.
Weight	A PV array usually weighs less than 20kg per m^2 of panel.
Reflectivity	While PV panels may cause some reflectivity, this is generally minor. PV manufacturers generally put an anti-reflective coating on the glass to increase the absorption of sunlight and thus the performance of the solar modules. This, in turn, reduces the reflectivity of the panels.
Construction	PV cells are made of several different materials, mainly silicon. PV modules are made up of cells and sandwiched between glass laminate and tedlar, or polyvinyl fluoride. Some newer type of PV cell are created by depositing semiconductor layers as 'thin films' directly onto glass, metals, roofing sheets, or even plastics of various types, including flexible sheets.
Colours	Black, dark blue, grey or brown.
Array types/ configurations	There are many different types of PV arrays and configurations. See the photos and diagrams opposite.
Fixing	There are many different methods of fixing PV to roofs, depending on the roof type. (Note that the Building Code acceptable solution G12/AS2 covers some of these.)

6.1 Key components of photovoltaic systems

PV systems typically comprise these key elements:

- PV modules, frames, cables and mounting or fixing hardware
- an inverter and charge controller
- in off-grid situations, batteries are also required, and PV is often used in conjunction with other generation technologies such as micro and mini-scale wind turbines and/or small backup diesel generators.

6.2 How do they work?

PV cells convert sunlight into electricity by a simple energy conversion process. In most PV cells, photons in the sunlight hit the cells, where electrons are excited in the atoms of a semi-conducting material. Silicon is the most commonly used semi-conductor. The energised electrons result in the generation of an electrical voltage, where electrons flow to produce a direct (DC) electric current.

PV systems can be part of a SAPS that is not connected to the electrical distribution network. In these systems the electricity generated is stored in batteries so that it can be used when the PV cells are not producing electricity. For more information on SAPS, see Section 3.

However, PV panels are becoming increasingly popular in urban environments, where they can be connected directly to the electricity distribution network. These types of systems are known as 'grid-connected', 'grid-interactive' or 'grid-tie' systems. For more information on grid-connected systems, see Section 4.

For more information on photovoltaics, visit www.eeca.govt.nz and the website of the Sustainable Electricity Association of New Zealand www.seanz.org.nz

Figure 6-2 Main components of PV arrays

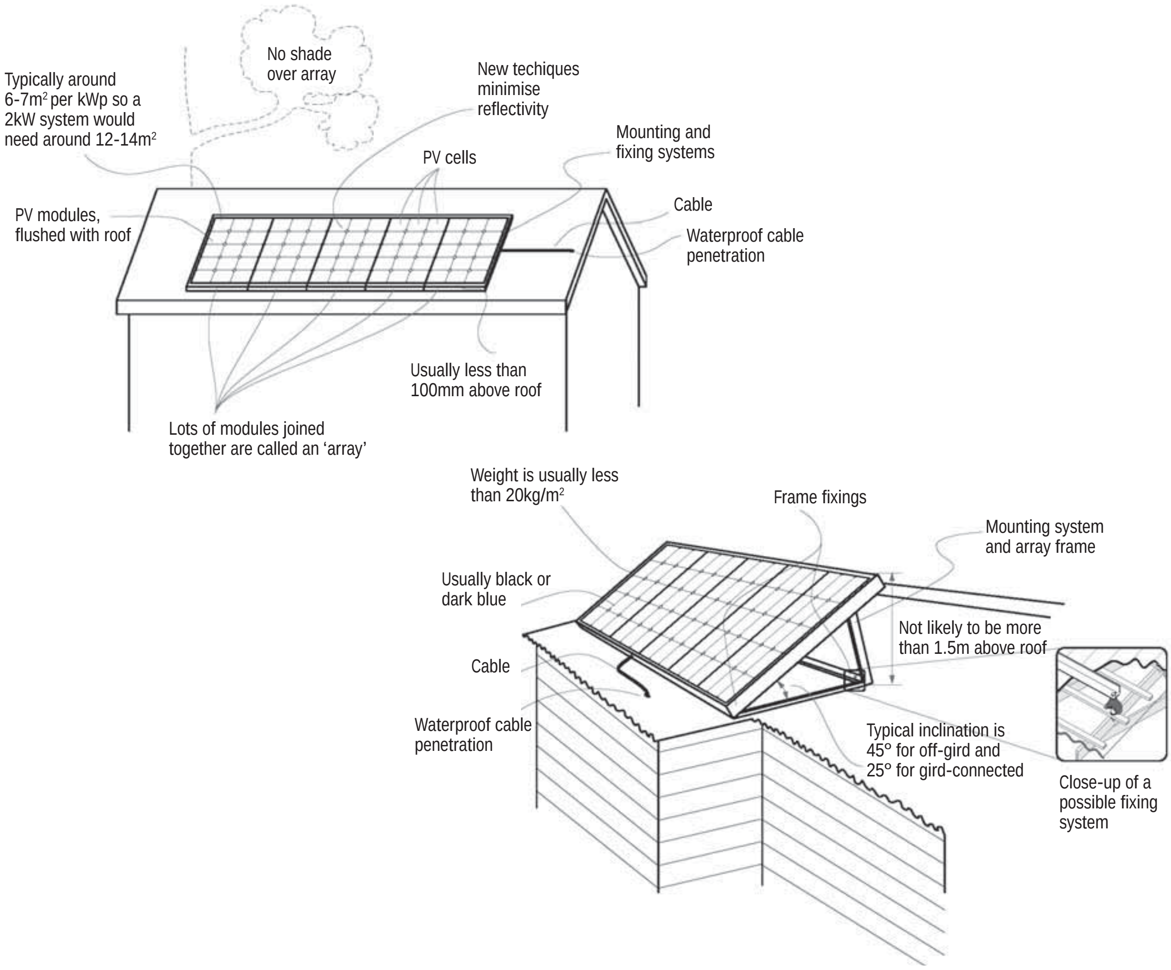


Figure 6-3 Examples of different types of PV arrays

A PV array installed directly onto the roof.
Photo: www.powersmartsolar.com

This photovoltaic array uses an inclined frame mounted on the ground. Photo: Genkit Nelson Ltd.

PV installed at Tapeka Marae.
Photo: EcoInnovation

Photovoltaic 'solar louvres'.
Photo: www.solarcentury.com

An example of photovoltaics with a flexible substrate.
The sheets are rolled directly onto the roof.
Photo: Alice Leney

An example of a frame-mounted PV array on the ground.
Photo: Ecogise

PV modules can replace conventional roof cladding.
Photo: www.solarcentury.com

PV roof tiles.
Photo: www.solarcentury.com

The façade of this building has integrated PV panels built into it.
Photo: www.solarcentury.com

Photovoltaic 'glazing' can provide shade and electricity.
Photo: www.solarcentury.com

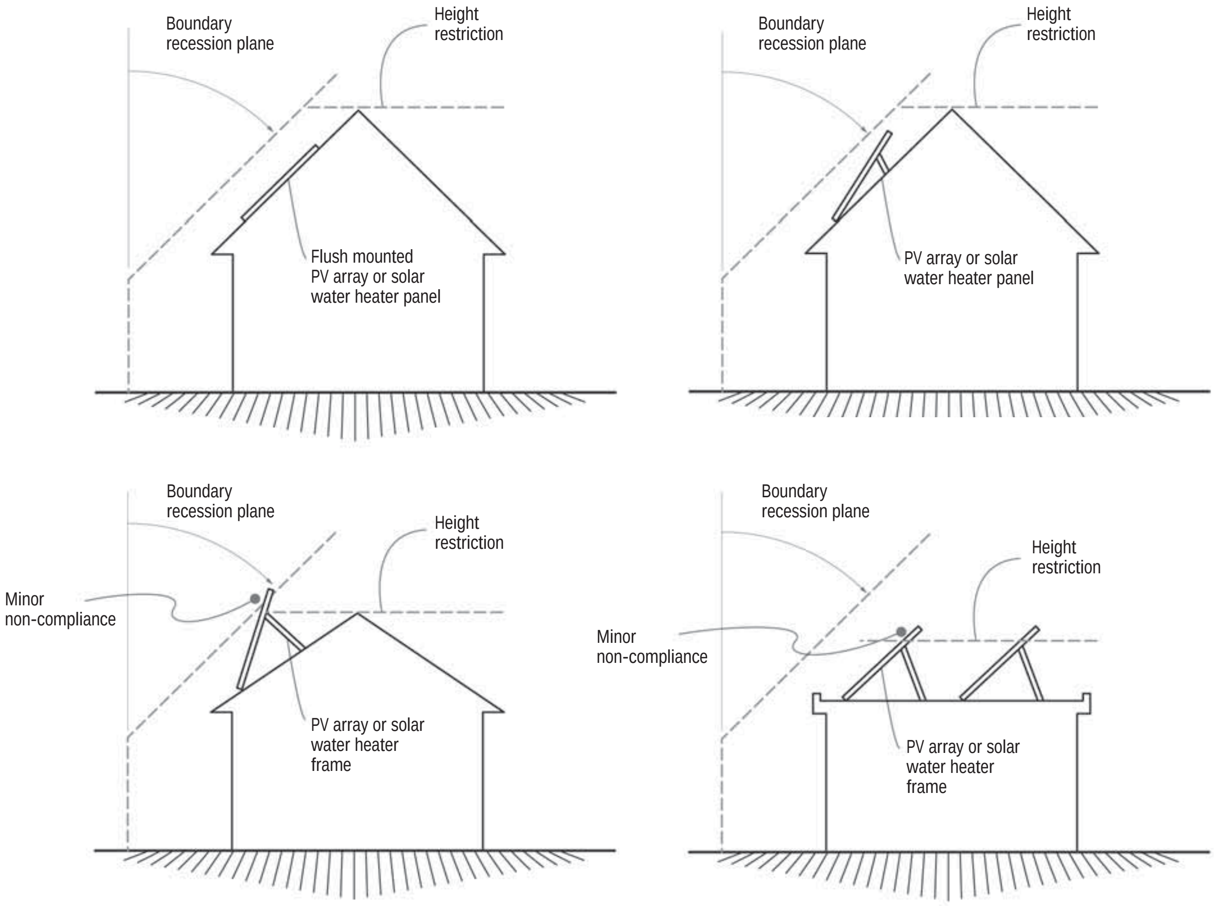
6.3 Photovoltaics – summary of potential effects

The table below provides an assessment of potential effects associated with the installation of PV arrays. Note: From an effects perspective, both solar water heating and photovoltaics are relatively similar. However, a notable difference is that PV panels are much lighter than solar water heating panels and impose lower gravity loads on the roof of buildings or structures.

6.3.1 Effect - Increasing the height of an existing building or structure, and the impact of PV on building height in relation to boundary recession plane

Flush mounted panels not elevated by a frame are extremely unlikely to give rise to any effect, as shown in the diagrams below. It is also unlikely to be an issue for frame mounted panels unless the placement of the panel results in the maximum heights for structures in that area/zone being exceeded, or unless the existing structure is close to the limits. The height of the frame is unlikely to be more than 1.5m above the roof, as shown opposite.

Figure 6-4 Possible effects of PV and solar water heating panels in relation to building height restrictions and boundary recession planes



6.3.2 Effect - Reflectivity or glare

This has occasionally been raised as an issue in the past with reflective surfaces for solar panels (water heating and PV). However, solar panels are designed to absorb light, and in many cases cause less reflection than typical window glass. In the majority of cases this is unlikely to be a significant issue.

6.3.3 Conclusion

Generally, photovoltaics give rise to very few effects and resource consent is usually not required. Councils may consider providing for flat mounted panels as a permitted activity within their district plan, or if the array does not exceed the height limit by more than 0.5m.

Consideration during siting and design can eliminate any potential impact on height. Where a height infringement does occur, the effect is dependent on the size of the panels, the scale and bulk of the surrounding area and the resultant effects on shading and views for neighbouring properties. Given the size and nature of the panels and framing, the effect in most locations is likely to be minor. In some very rare instances it may be appropriate to control effects on daylight and sunlight of neighbouring sites.

The height of frame mounted panels is not likely to be more than 1.5m above the roof on which they are mounted. In the majority of cases this is unlikely to be a significant issue.

Where located near activities sensitive to reflectivity, information from manufacturers with regard to reflectivity of the panels may be helpful.

6.4 Photovoltaics : Approval considerations

The tables below provide indicative guidance on potential effects and considerations for a PV installation. It should be noted that this information is indicative only and it is recommended that local authorities develop their own flexible approach and interpretation.

6.4.1 Effects of PV installations

Effect	Possible considerations	Possible means of demonstration
Height	The array does not exceed height limits by more than 0.5m.	Illustrations showing elevation of PV array, and relevant height limits.

6.4.2 Building Code considerations with PV systems

The structural and weathertightness considerations of installing PV panels are similar to those for installing solar water heating panels. However, PV panels are generally lighter (weighing on average up to 10 kg per panel, or less than 20 kg/m2) and consequently have less impact on the structural performance of the building they are attached to.

7. Micro and mini-scale wind turbines

Wind power is a clean, renewable source of energy which produces no emissions while operating. New Zealand has one of the best wind resources in the world and wind farms are increasingly being developed to generate electricity. Micro and mini-scale wind turbines are also available and can be an effective means of generating clean electricity, especially in rural situations.

Table 7-1 Features of typical micro wind turbines

Some common micro and mini-scale wind turbine parameters	Comments
Size	Micro and mini-scale wind turbines range in size from those which have rotors of less than 1m in diameter to much larger devices which have rotors between 8-10m in diameter. Most household-scale wind turbines have rotor diameters of less than, approximately, 5m.
Rotor blades	Wind turbines need only one blade to convert wind energy, however most wind turbines these days use two or three blades. The blades are usually made from composites of fibreglass, carbon fibre, or wood.
Rated power output	The rated power output of micro turbines range from a few hundred watts to up to around 15kW. Typical micro-scale turbines have a rated power output of 1-3kW.
Mounting locations	Micro wind turbines are most commonly mounted on top of towers or poles in rural areas with good wind resources. Some new designs can be mounted directly onto buildings or other structures.
Tower type and height	Towers are usually either free-standing tubular or lattice towers, or tubular masts supported by guy wires. The height is usually between 10 and 20m above ground level. Performance improves with height so most towers are at least 10m high, and towers around 20m in height are preferable. Some towers can be 'tilted' up and down to make it easier to install and service the turbines.
Survival wind speed	Most turbines have a mechanism which prevents mechanical damage in extremely high wind speeds. This is sometimes called 'overspeed control'. Some turbines are designed to continue operating in high winds, or have a feature that allows the blades to twist (or 'feather') out of the wind for protection. Other mechanisms are electrical breaking and pitch control.
Start-up speed	Most micro wind turbines require at least 3m/s of wind before they generate electricity; however, at least 4.5m/s is usually required to start working effectively.
Rotor configuration	The most common rotor configuration is a three-bladed, horizontal-axis turbine. However, numerous other designs exist. For example, single and two-bladed configurations are available, as are many vertical-axis configurations.
Noise	All small wind turbines generate some noise, although generally this will be acceptable if sited carefully. The level of noise depends on the turbine, and the extent to which it can be heard depends on background ambient noise, such as wind whistling in trees, traffic, farm machinery etc.

Households usually use micro wind turbines that are smaller than 5kW, and farms, businesses, small communities or groups of houses might use up to 20kW in size. Even larger turbines may be used for 'island' grids or larger groups of users.

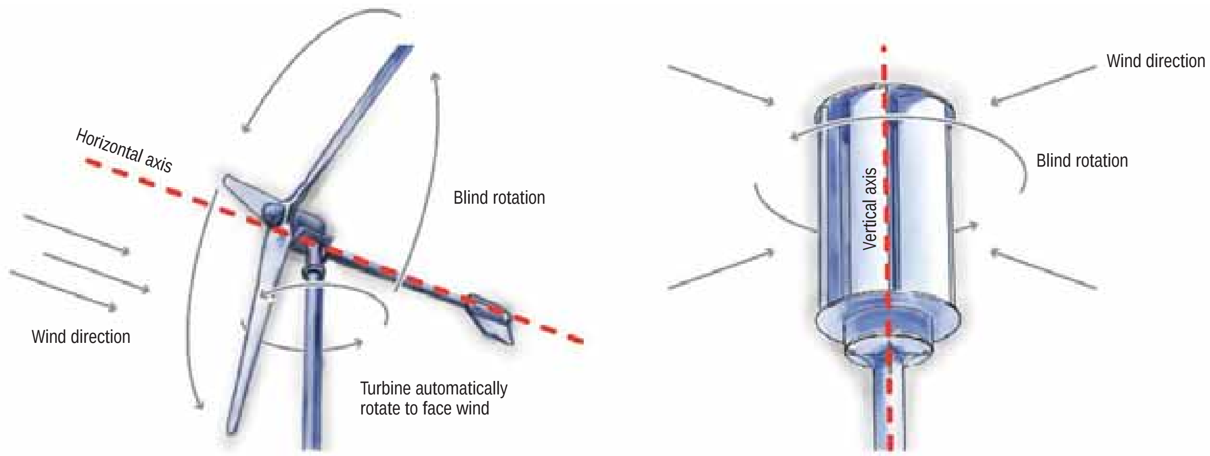
For more information on micro and mini-scale wind energy, please see www.eeca.govt.nz, and the website of the Sustainable Electricity Association of New Zealand www.seanz.org.nz

7.1 How do they work?

The energy in the wind can be harnessed to generate electricity via a wind turbine. The turbine will generate electricity as long as there is a reasonable wind speed; most small wind turbines need an average speed of at least 4.5m/s (16km/h) to operate effectively. In very windy places more wind may be captured but it may also mean more maintenance is required for the turbine, or that it will have a shorter operational life.

The blades of the micro and mini-scale wind turbine must be positioned appropriately so to be exposed to clean airflows: they are usually mounted on towers so they are exposed to more consistent wind with a higher average speed. The wind turns the rotor blades of the turbine, which then spins a shaft connected to a generator. The generator uses magnetic fields to convert the rotational energy into electricity. Most turbines are horizontal-axis, mounted upwind of the tower, and have tail fins or an active yaw system to ensure the blades are constantly facing the wind, however other designs have the blades downwind of the tower.

Figure 7-1 Examples of horizontal axis (HAWT) and vertical axis (VAWT)



Another type of wind turbine is a vertical-axis wind turbine. These are less common than horizontal-axis wind turbines, but they have the benefit of not needing to turn to face the wind in situations where direction varies quickly. Some vertical-axis wind turbines are small enough to be mounted directly on a building, while others are pole mounted on the ground.

7.2 Key components of micro and mini-scale wind turbines

Wind turbines typically comprise these key elements:

- a rotor that converts the kinetic energy in the wind to rotational motion
- a generator to generate electricity from the rotational motion of the rotor (usually contained inside the turbine)
- electronic control to control the electrical output from the rotor and the safe operation of the turbine
- an inverter, usually external to the turbine, to safely convert the power to a compatible format to the electricity network or for household appliances. Some turbines have the inverter built into the turbine nacelle
- a pole, guyed mast, or tower upon which the turbine sits, and the foundations supporting this structure
- some wind turbines have a maximum wind speed above which they will not operate. When winds over this maximum occur, they have an internal brake and lock or furling mechanism to prevent them from going faster than this speed.

7.3 Pole or tower mounted turbines

It is common for micro wind turbines to be mounted on top of a pole or tower. These designs usually require a small area of land for between 4 and 9m2, depending on the particular model and on the foundations and/or guy wires etc. The electricity generated by the turbines is usually fed through wires down the pole or tower, through the foundations and back to the building where it is connected to a distribution board, or into the battery bank.

Poles and towers are often made of steel, and may be guyed or can be self-supporting, either lattice or tubular in construction. Self-supporting poles are more compact and may be visually less intrusive, but tend to be more expensive.

Three-blade turbines provide the most common configuration for pole mounted mini-scale turbines, although one and two-blade options are also available.

Because there are many different designs of micro wind turbines available, manufacturers' guidelines and information should also be consulted for information on siting and installation.

Figure 7-2 Main components of tower and pole mounted wind turbines.

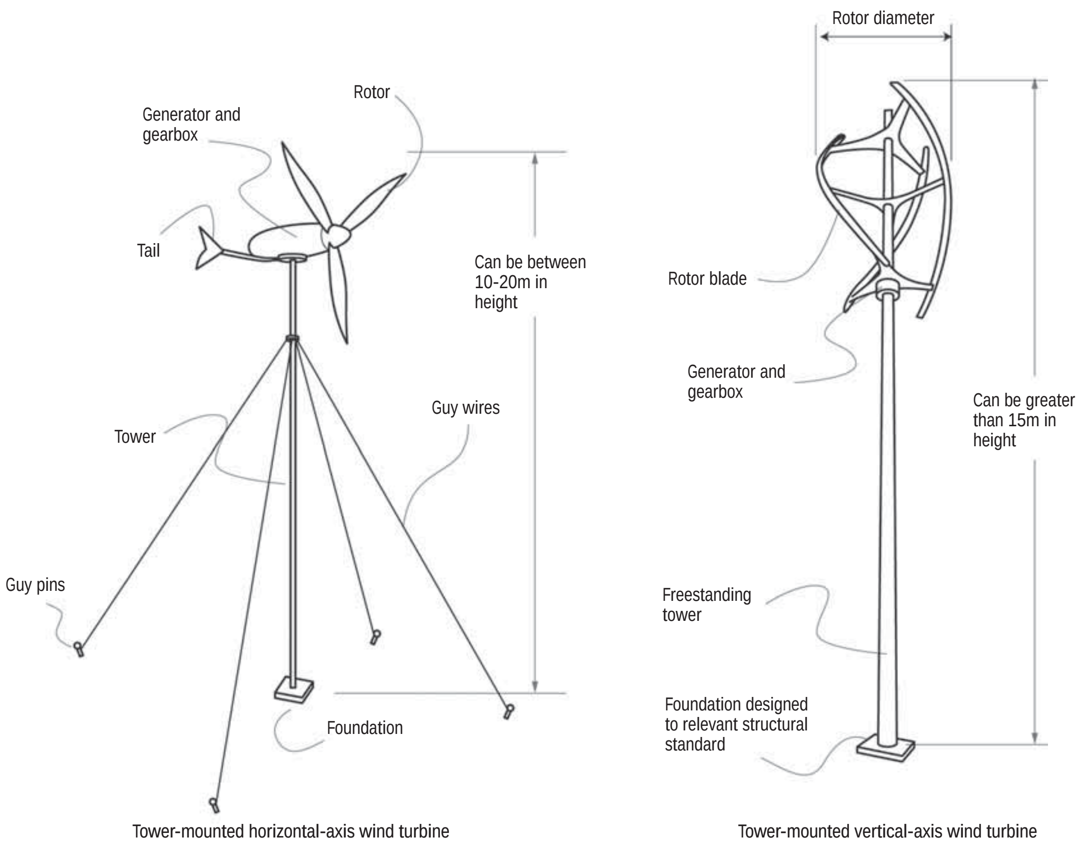


Figure 7-3 Examples of different micro and mini-scale wind turbines

Pole mounted, with guy wires, three-bladed horizontal-axis micro wind turbine with a tilting mechanism.
Photo: Gusto Energy Ltd.

A three-bladed downwind turbine on a 15m high tubular pole.
Photo: Proven Energy New Zealand

Two wind turbines on monopoles, in a grid-connected system near Christchurch.
Photo: EECA

Micro wind turbine on a self-supporting tower next to a house.
Photo: EECA

Self-supporting tubular tower mounted three-bladed horizontal-axis micro wind turbine.
Photo: Elemental Energy

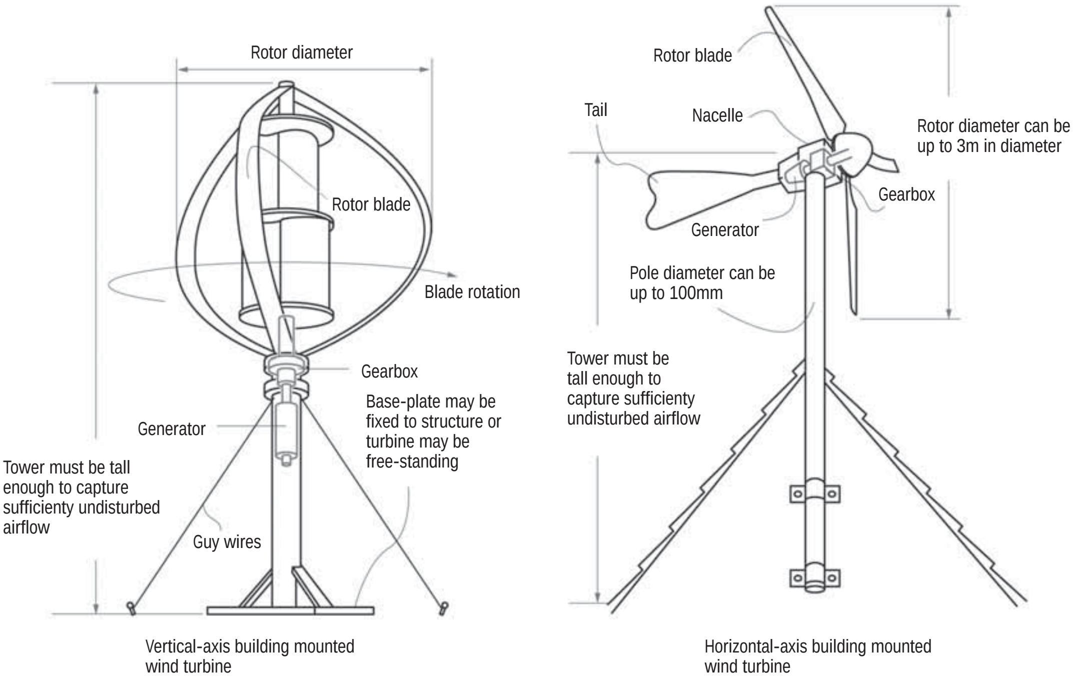
Pole-mounted, with guy wires, three-bladed horizontal-axis micro wind turbine.
Photo: EcoInnovation

7.4 Rooftop or building integrated turbines

Rooftop mounted or wall mounted micro wind turbines are a new and emerging type of wind turbine, and there are many varying designs and types available, and many more are likely to become available in the future. It is recommended that all rules and plans are flexible and do not preclude potential developments and improvements. Manufacturers will often provide information and guidance material about their particular models.

Generally, rooftop or wall mounted wind turbines require a solid section of building at the roof line to directly attach the turbine, providing a sufficient clearance above the apex of the building to take advantage of the wind resource around the building.

Figure 7-4 Main components of rooftop mounted micro wind turbines



7.5 Wind resources

Micro and mini-scale wind turbines can be used in both urban and rural environments, although they are more common in rural environments. However in urban areas, especially on rooftops, turbines are typically less successful because winds tend to be turbulent, weak and erratic due to buildings, trees and other obstructions, although with careful siting these effects can be mitigated for some locations.

To be most effective, wind turbines need to be exposed to as much wind as possible. Turbines should not be sheltered behind trees, buildings, or other obstructions. Disturbed wind flow can reduce the performance of wind turbines in some situations, as seen below

Figure 7-5 Indicative wind flows in a rural area

Pole-mounted turbines should be located away from obstructions such as building or trees. Taller poles or towers are required to position turbines in stronger and more consistent winds.

Figure 7-6 Indicative wind flows in an urban area

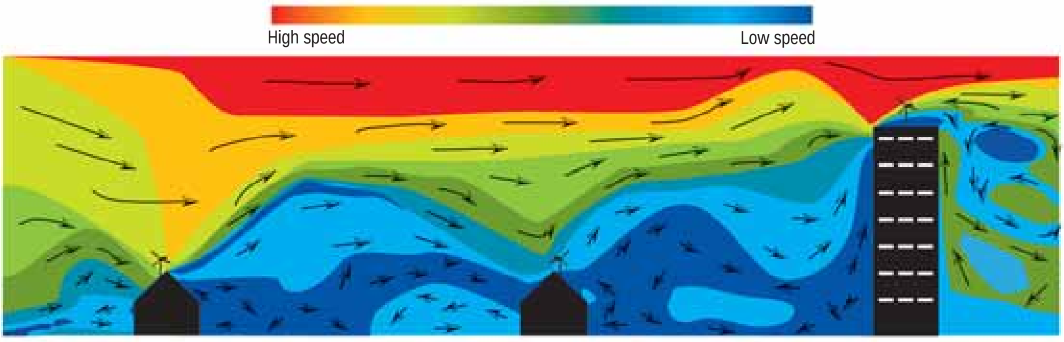


Illustration of wind-flow speeds in an urban environment. It can be more difficult to site a turbine in consistent and strong winds.

7.6 Micro and mini-scale wind – summary of actual and potential effects

This table provides an assessment of actual and potential effects associated with the installation of micro and mini-scale wind turbines.

7.6.1 Effect - Landscape and visual amenity

This effect is largely related to the location, height and design of turbines.

Generally speaking, the higher the turbine is the more power can be generated. Most micro turbines are installed on towers less than 20m in height.

Consideration during siting and design can reduce impacts on landscape and visual amenity. Micro and mini-scale wind turbines should be sited to ensure they provide sufficient power, but also keep environmental impacts to a minimum.

Councils and developers need to be flexible in considering locations to ensure a balance between maximising the power that can be generated and minimising landscape and visual impacts. In rural areas it may be possible for wind turbines up to 20m to be installed with relatively few adverse effects in some locations, while in urban areas an appropriate height will be much lower.

Overall, given the relatively minor effects, councils may consider providing for micro and mini-scale wind turbines as a permitted activity in certain areas, subject to certain standards.

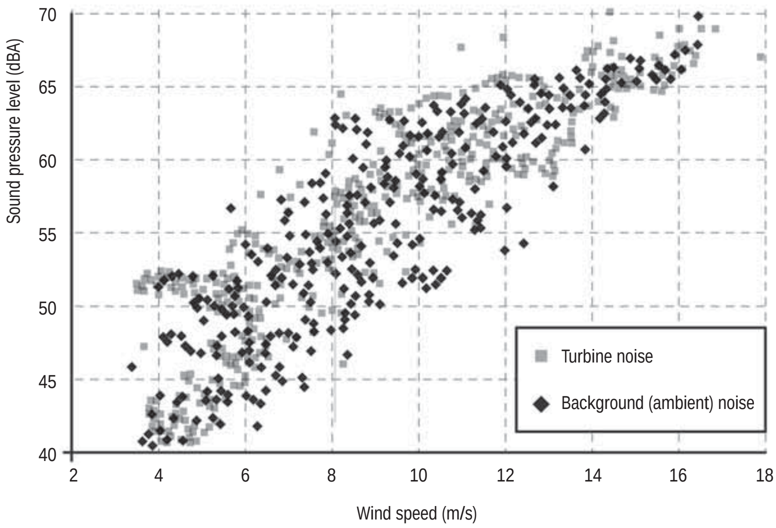
7.6.2 Effect - Noise generated by turbines

Turbines give rise to aerodynamic and mechanical noise, although modern designs have largely eliminated the mechanical noise of earlier turbine models. Many mini-scale wind turbines do not have gear boxes, which also reduces mechanical noise.

The noise from a micro wind turbine is likely to be acceptable, especially in a rural environment where installation is some way from habitation. However, it could be an issue where an installation is located near to noise-sensitive activities or the installation exceeds the noise limits specified in the district plan. To protect neighbours, if nearby, a condition controlling the level of noise may be attached to the consent.

NZS 6808 – The Assessment and Measurement of Sound from Wind Turbine Generators provides methods for the prediction, measurement, and assessment of sound from wind turbines. The methods in the Standard are commonly used on large-scale wind farms, and are not usually required or suitable for micro wind turbines installations.

Figure 7-7 Example plot of wind turbine noise and ambient noise



Example plot of turbine noise and ambient noise

Wind turbine noise increases as wind speed increases. However, it should be noted that background (ambient) noise also increases as wind speed increases, which can help mitigating this effect. This means that the noise from the wind turbine is often masked by the background ambient wind noise.

In most case a detailed assessment of noise from a micro wind turbine should not be required. However, information from manufacturers can be used to demonstrate compliance with district plan noise limits for a zone/area. Most designs and installations are unlikely to exceed district plan noise limits.

7.6.3 Effect - The risk of bird and bat strike resulting in injury and fatality

This is often raised as a concern with larger turbines, however only a few bird fatalities have ever been recorded in New Zealand. Smaller turbines may be less likely to result in risks to birds or bats due to their location close to human activity such as dwellings, buildings and other man-made structures. This is unlikely to be a significant issue.

7.6.4 Effect - Shadow flicker from the turbine

Shadow flicker is unlikely to be an issue with micro wind turbines due to their small diameter, and the likely location where they are installed.

In the majority of cases this is unlikely to be a significant issue. Additional information on shadow flicker can generally be sought from the turbine manufacturer if required.

7.6.5 Conclusion

Generally, micro and mini-scale wind turbines are only likely to give rise to effects in relation to height and noise.

Given that wind turbines should be positioned as high as possible to be effective, councils may consider providing micro or mini-scale wind turbines as a permitted activity in certain areas within their district plan.

In terms of noise, manufacturers should be able to provide acoustic information about their turbine. Noise measurement should be relative to the boundary of the property, and to the levels of background (ambient) noise that occur naturally in windy conditions.

7.7 Micro and mini-scale wind turbines : Approval considerations

The tables below provide indicative guidance on potential effects and considerations for a micro or mini-scale wind turbine installation. It should be noted that this information is indicative only and it is recommended that local authorities develop their own flexible approach and interpretation.

7.7.1 Effects of micro and mini-scale wind turbines

Effect	Possible considerations	Possible means of demonstration
Height	(In rural areas) the turbine does not exceed 20m in height.	Illustrations showing height of the wind turbine, and relevant height limits.
Noise	The installation complies with relevant noise limits at the property boundary.	Manufacturers may be able to provide acoustic information, to be compared with relevant noise limit. Note that as wind speed increases, background ambient noise also increases.

8. Micro and mini-scale hydro-electric generators

Most of New Zealand's electricity is generated from hydro power stations. This principle of converting the energy of falling water into electricity is the same for the generation of electricity for thousands of houses or a 1kW system suitable for one house. Micro and mini-scale hydro has numerous benefits especially as it utilises a renewable energy source and does not produce any greenhouse gases while operating. Micro and mini-scale hydro can be a viable option for many farms, lodges or other rural properties and businesses.

Micro and mini-scale hydro schemes vary considerably, and are always designed according to the location and user.

Table 8-1 Summary of micro and mini-scale hydro generators

Micro and mini-scale hydro parameters	Comments
Turbine types	The two main types of micro-hydro turbines are 'impulse turbines', (such as the Turgo or Pelton wheel) or 'reaction turbines'. In an impulse turbine, a high-speed water jet strikes and rotates the turbine buckets (runner), while a reaction turbine has the runner fully immersed in the water flow.
Power	Micro-hydro turbines tend to be sized from a few hundred watts to a few kilowatts. The amount of electrical energy able to be generated depends on the flow of the river, and the available head. Turbines less than 5kW in rated capacity are less likely to require water storage, meaning that they are run-of-river schemes.
Maximum flow diverted	Generally, the maximum flow diverted from the stream should be no more than 50% of the minimum flow of the particular water source.
Required head and flow	Both head and flow can vary considerably. Generally, the higher the head (or the vertical drop between the intake and the turbine), the more effective the hydro scheme will be. However, even a small head of less than 5m could be adequate, as long as there is sufficient flow in the stream.

Small-scale hydro-electric facilities are generally classified into three sizes:

- micro-hydro is up to 5kW
- mini-hydro is between 5 and 20kW
- small-hydro is between 20kW and up to around 10MW

Most micro-hydro systems for houses and buildings are less than 5kW, and in many cases less than 1kW.

Micro and mini-scale hydro systems, especially those less than 5kW in rated capacity, are usually run-of-river, which means that they do not require water storage in the form of a dam or weir. Instead of storing water, a portion of the stream or river is usually temporarily diverted to and through the micro-hydro generator, and then returned to the same stream. If the micro or mini-scale hydro scheme does require a dam or other form of water storage, additional civil works and engineering requirements will need to be met. This document does not cover systems which include a dam and is limited to run-of-river schemes.

Guidance for hydro-electric facilities of greater than 100kW capacity is provided in EECA's 'Small Hydro Planning Guidelines' www.eeca.govt.nz

For more information on micro and small-scale hydro, see EECA's factsheet 'Small-hydro' and the website of the Sustainable Electricity Association of New Zealand www.seanz.org.nz

8.1 How do they work?

Micro and mini-scale hydro systems use the force of moving water to turn turbine blades, which spin a shaft connected to a generator. The generator uses magnetic fields to convert this rotational energy into electricity. Micro and mini-scale hydro systems are best suited to rural sites close to a source of flowing water. They can be set up wherever water falls from a higher level to a lower level, such as a waterfall, hillside, stream or where a reservoir discharges into a river.

8.2 Key components of run-of-river micro and mini-scale hydro-electric

The type of turbine used will depend on the head and flow of the site. Impulse turbines are usually used in high-head schemes, while reaction turbines are normally used on low-head schemes.

Most run-of-river schemes comprise these key elements:

- an intake and diversion structure
- headrace and/or penstock (channel or pipe)
- generator.

Figure 8-1 Main components of a run-of-river micro hydro scheme

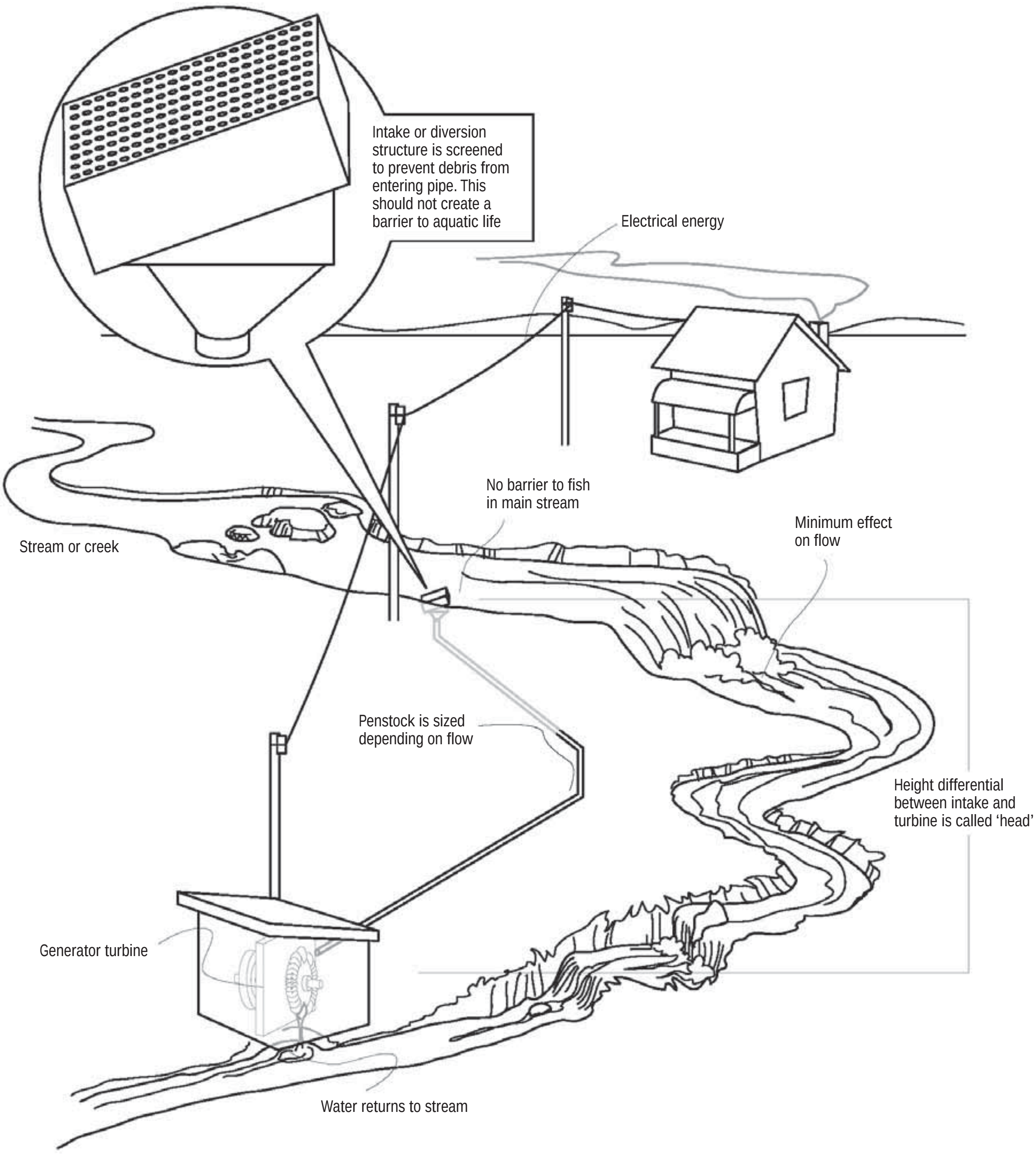
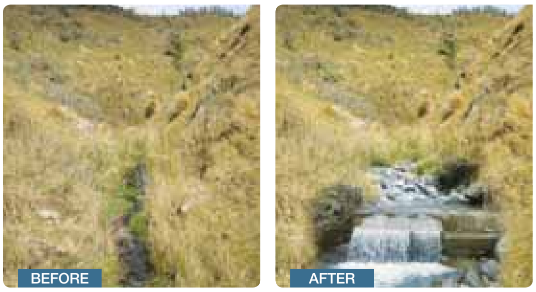


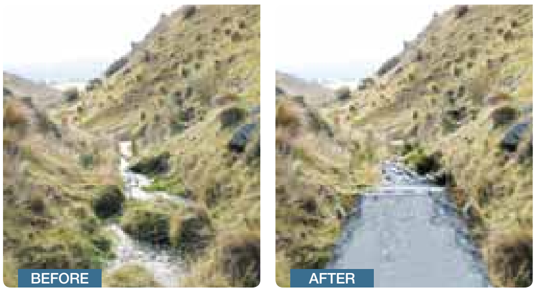
Figure 8-2 Photos of components of different micro and mini-scale hydro schemes

Close-up of a Pelton wheel impulse turbine. The water returns to the same catchment that it was diverted from.
Photo: EcoInnovation



Simulation of the impact a micro (2-5kW) hydro scheme could have, looking upstream. A small weir is constructed to divert a portion of the stream into a penstock.
Photos: Genkit Nelson Ltd.

A Turgo impulse micro hydro turbine.
Photo: Alternative Power NZ Ltd.



Simulation of the impact a the impact a micro (2-5kW) hydro scheme could have, looking downstream.
Photos: Genkit Nelson Ltd.

Another example of a run-of-river micro hydro scheme.
Photo: EcoInnovation

Another example of an intake structure. The stream flows over the metal screen, which prevents leaves or debris from entering the white plastic penstock.
Photo: EcoInnovation

8.3 Run-of-river micro and mini-scale hydro - summary of actual and potential effects

8.3.1 Effect - Impact on the flows and volume of water within watercourses

Run-of-river (where there is no storage like a dam or reservoir) micro-hydro schemes can have significantly less impact on flows and the volume of water within watercourses than larger schemes that require storage. They are also unlikely to give rise to effects given the small volume of water diverted via a run-of-river scheme, except where watercourses have low flows.

A case-by-case assessment is required. A permit may be required for diverting water depending on the volume of water and the nature of the watercourse involved.

8.3.2 Effect - Impact on fish and aquatic invertebrates

Not an issue for run-of-river schemes which do not create barriers to fish, and where the intake is suitably designed to prevent fish and aquatic invertebrates from entering the penstock.

8.3.3 Effect - Impact on other users (recreation, water available to others)

Potentially an issue for large systems on waterways with public and recreational access/values. Any structures need to be compatible with other users. Unlikely to be an issue for micro-hydro.

Only gives rise to potential effects when locating in areas with recreational access/values.

8.3.4 Conclusion

Generally, run-of-river micro-hydro systems are only likely to give rise to effects related to the impact on the flow of water and the impact on fish and other aquatic invertebrates. These effects can usually be mitigated through careful siting and design, including the design of appropriate intake protection structures, and ensuring that water is returned to the same catchment as it was diverted from.

Run-of-river micro hydro schemes that are less than 5kW in rated capacity are likely to be smaller, and divert less flow, than larger schemes. They are also less likely to require civil works such as storage facilities. Hydro schemes less than 5kW are also less likely to require permanent structures to be built in or near the stream, which also reduces the chance of the scheme causing flooding.

In situations where consents exist for a particular use, such as irrigation, it may be appropriate to add microgeneration as an additional use of the resource, without altering the impact on the resource use.

8.4 Micro and mini-scale hydro : Approval considerations

The tables below provide indicative guidance on potential effects and considerations for a run-of-river micro or mini-scale hydro installation. This guidance does not cover hydro schemes with water storage such as dams or weirs.

It should be noted that this information is indicative only and it is recommended that local authorities develop their own flexible approach and interpretation.

Table 8-2 Effects of run-of-river micro and mini-scale hydro systems

Effect	Possible considerations	Possible means of demonstration
Impact on the flows and volume of water within watercourses	The scheme does not significantly affect the flow of the watercourse. The scheme is run-of-river scheme. The scheme diverts less than 50% of the flow of the stream when it is at its driest. The water is returned to the same natural catchment that the water was diverted from. The rated capacity of the turbine is less than 5kW.	Manufacturer's specifications. System diagram. Comparison of required flow to be diverted with flow of watercourse at driest time of year.
Impact on other users (recreation, water available to others)	The proposed installation does not disadvantage other users.	Manufacturer's specifications. System diagram.
Impact on fish and aquatic invertebrates	The scheme does not prevent fish or invertebrates from moving along watercourse, or draw them into water intake.	Intake is suitably designed. Fish pass provided if fish present in stream.
Effects on flooding	There are no permanent structures built in the stream that could cause flooding.	Manufacturer's specifications. System design.

Appendix 1: Example case studies of microgeneration

Visit www.eeca.govt.nz for copies of these case studies and other information about microgeneration in New Zealand.

CASE STUDY

High country home generates its own power

When Maree Handy built on a remote property near Fairlie in South Canterbury, she had the choice of connecting to the nearby electricity lines or building her own stand alone power system. Being independent from the grid and never receiving another power bill was appealing – so she opted for her own 'little power station'.

Luxury lodge goes off-grid

CASE STUDY

Key features

- 3.2 kW micro hydro turbine generates lodge's electricity in a stand alone power system
- 27 kW back-up diesel generator

Key benefits

- Less expensive option than connecting to electricity network
- Minimises greenhouse gas emissions
- Environmental benefits align with company's environmental values and brand

Connecting to the electricity network was not a viable option for a luxury lodge in the Waihopai Valley, in Marlborough. Instead, the owners of this exclusive tourist destination saw the opportunity to install a hydro generator to power their first-class guest experience with clean renewable electricity.

CASE STUDY

Holiday home generates own clean, green electricity

Like many rural or remote properties, connecting to the electricity grid was not an option for this remote island holiday home the Bay of Islands. Instead, a stand alone power system generates the electricity needed for a relaxing getaway with all the comforts of home.

Lodge turns energy into revenue

CASE STUDY

Key features

- Highly energy efficient building design and heating/hot water systems to reduce electricity needs.
- Good wind energy resource harnessed by two 2.4 kW wind turbines to generate electricity for lodge.
- Wind turbines grid-connected, to enable export of excess electricity back into network.

Key benefits

- Reduced electricity demand means lower running costs for business.
- Owners paid for excess electricity generated and exported into network – lower electricity demand means a greater proportion can be exported.
- Owners have control of both electricity supply and demand in their home and business.

By reducing their electricity needs and installing two small wind turbines, owners of this lodge have eliminated their power bill – and they're getting paid for the excess electricity they generate.

Appendix 2: Useful resources relating to distributed generation

Reports

Developing Small-Scale Renewable Energy Projects in New Zealand
www.eeca.govt.nz/node/1535

This report provides high level guidance to independent renewable energy project developers who wish to investigate and progress distributed generation projects. The report focuses on geothermal, hydro and wind projects in the range of 10kW to 20MW.

Costs and Benefits of Connecting Distributed Generation to Local Networks
www.eeca.govt.nz/node/1532

This paper provides a summary of the report ‘Costs and benefits of connecting distributed generation to local networks’. EECA commissioned this work to help quantify the economic impacts of distributed generation (DG) on local distribution networks.

Costs of small scale distributed generation
www.eeca.govt.nz/node/1478

This paper briefly reviews unit costs for a range of small scale electricity generation technologies up to 15MW in capacity. Unit cost for a generation project can be defined as the price of electricity required to recover all costs over the life of the project while providing an acceptable financial rate of return. Unit costs are often used to compare the relative economics of different generation technologies.

Distributed generation: study of alternative energy supply options for remote communities
www.eeca.govt.nz/node/1480

The report examines the potential for small scale generation and energy management in five remote sites in South Canterbury. Technical information and economic costs and benefits for a variety of options in each location are presented. The report illustrates that - with the right set of conditions - small scale generation can be a viable alternative option for lines companies in certain applications.

Get smart, think small: Local energy systems for New Zealand (Parliamentary Commissioner for the Environment).
www.pce.parliament.nz/reports_by_subject/all_reports/energy__and__climate/get_smart_think_small

This study considers the potential, and benefits, of local energy systems in New Zealand.

Websites

Consumer information on microgeneration
www.energywise.govt.nz/how-to-be-energy-efficient/generating-renewable-energy-at-home

This website has useful information on photovoltaics, micro wind turbines, micro hydro turbines, off-grid and grid-connected systems.

Technical information on distributed generation
www.eeca.govt.nz/efficient-and-renewable-energy/distributed-electricity-generation

The Sustainable Electricity Association of New Zealand (SEANZ)
www.seanz.org.nz

The Electricity Commission
www.electricitycommission.govt.nz

The Ministry of Economic Development
www.med.govt.nz

This website has information on the Electricity Governance (Connection of Distributed Generation) Regulations 2007.

For more information contact The Energy Efficiency and Conservation Authority:

EECA HEAD OFFICE:
PO Box 388, Wellington, (04) 470 2200

EECA AUCKLAND:
PO Box 37444, Parnell, Auckland, (09) 377 5328

EECA CHRISTCHURCH:
PO Box 13983, Christchurch, (03) 353 9280

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