SEANZ
Sustainable Electricity Association New Zealand

SMALL SCALE RENEWABLE ENERGY STANDARDS GUIDE

VERSION: 1.1

A guide to relevant standards in New Zealand
For the design and installation of small scale renewable energy systems

This guide has been produced by SEANZ
for the benefit of the sustainable electricity industry

This guide has been funded by EECA

EECA Energy Efficiency and Conservation Authority
Te Tari Tiaki Pūngao

www.seanz.org.nz

DISCLAIMER

This document is written act only as a guide to the relevant standards that should be consulted in the design and installation of small scale renewable energy systems. Namely grid-connected and stand-alone power systems utilizing photovoltaic, micro wind and micro hydro technologies. Information is provided to help identify the relevant clauses in relevant standards in New Zealand. This guide does not attempt to provide reference to all relevant clauses and all considerations as this is the purpose of the standards in their totality. This guide does not in any way replace the standards or relevant training in the design and installation of these systems. From time to time the standards will be revised and references made in this guide to relevant clauses in the standards may cease to point to the correct clause. Additional clauses may be added that are relevant and clauses deleted.

All those designing, installing and working with the relevant systems should have access to the associated standards and familiarise themselves with the requirements in detail.

SEANZ, the Authors and Reviewers shall not be liable in any way for damages resulting from the use of this guide.

ACKNOWLEDGEMENTS

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THE SUSTAINABLE ELECTRICITY ASSOCIATION NEW ZEALAND (SEANZ)

SEANZ is the industry association that represents the solar photovoltaic, small wind and micro hydro industries in New Zealand. The industry is pro-actively working towards growing capacity and capability.

SEANZ actively:

- Lobbies for increased recognition of the value of these technologies and support through-out all levels of New Zealand Government
- Establishment of a training and accreditation scheme for small scale renewables
- Provision of information

CONTENTS

1.0 INTRODUCTION

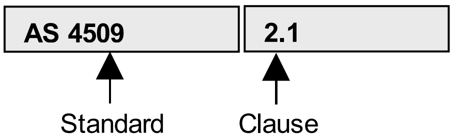
This document has been written primarily for practitioners in the small scale renewable energy industry who are installing stand-alone and grid-connected power systems utilizing photovoltaics, small wind turbine generators and micro hydro.

This document is written to act as a guide to the relevant standards that should be consulted in the design and installation of these systems. Information is provided to help identify the relevant clauses in the standards. This document does not in any way replace the standards and relevant training in the design and installation of these systems.

All electrical installations should comply with New Zealand regulation. AS/NZS 3000 – The Wiring Rules is the key standard for electrical installations. All systems whether they are extra low voltage (ELV) or low voltage (LV) should comply with AS/NZS 3000. This guide discusses the specific standards relating to renewable energy systems.

Working knowledge of the Standards is considered necessary for good practice. All installers should have access to the Standards and refer to these for clarification and requirements.

The document is structured to help you find the information that you require quickly and easily. Where relevant requirements and recommendations are listed, the standard name and clause number will be given in the margin as shown below. Please note that as standards are revised the clause number listed in this document may change in the standard.



The document does not distinguish between requirements (SHALLS) and best practice (SHOULDS) in the Standards as requirements are often conditional and best covered by the standard itself.

The Standards should always be referred to when clarifying requirements.

This document is broken into sections that cover:

- Stand-alone power systems (SPS)
- Grid-connect systems
- Photovoltaics (PV)
- Small and micro wind turbines
- Micro hydro turbines

2.0 NZ REGULATIONS

All electrical installations must comply with the New Zealand electrical regulations. The regulation states:

> "Works, electrical installations, fittings, electrical appliances, and associated equipment must be designed, constructed, maintained, installed, and used so that they are electrically safe"

One way of complying with the regulations is to ensure that the installation complies with AS/NZS 3000 - The Australian and New Zealand Wiring Rules (The Wiring Rules). This includes all standards that have a nominative reference from The Wiring Rules, see section 3.0. There are restrictions of the work that you can carry out if you are not a registered electrical worker

> "Any person, other than a homeowner, **who carries out prescribed electrical work, is required to be registered** by the Electrical Workers Registration Board (EWRB). All

electrical workers who carry out electrical work in return for payment or reward, must hold an annual practising licence. "

– Ministry of Economic Development website.

Prescribed electrical work is any work where voltages are greater than 120V d.c or 50V a.c

Electricians are obliged to issue a Certificate of Compliance (CoC).

"**Electricians must issue a Certificate of Compliance (CoC)** to customers when doing any fixed wiring work, including fitting new power points. CoC's are not issued for maintenance work, such as replacing sockets and light fittings or repairing appliances. The CoC indicates that the work done is electrically safe and has been carried out in accordance with New Zealand's electrical safety standards and codes. It also shows they have tested their work once completed.

Keep your CoC in a safe place as a record of the work done on your property. It is an important document and may be required for **insurance claims** or when you are selling your home.

A CoC guarantees that the work:

* has been completed by a licensed electrician,
* meets safety standards set by law, and
* has been tested."

– Ministry of Economic Development website.

CoC's apply to stand alone and grid-connect power systems.

3.0 THE RELEVANT STANDARDS

The New Zealand electrical regulations reference AS/NZS 3000 as a means of compliance. In turn AS/NZS 3000 references a number of other standards. Where the reference is nominative (shall) the requirements of the referenced standard must be met to comply. Where the references is informative (should) the requirements of the referenced standard are for best practice only, but should only be ignored with good reason.

The main standards and their relationship to each other are shown in Figure 1.

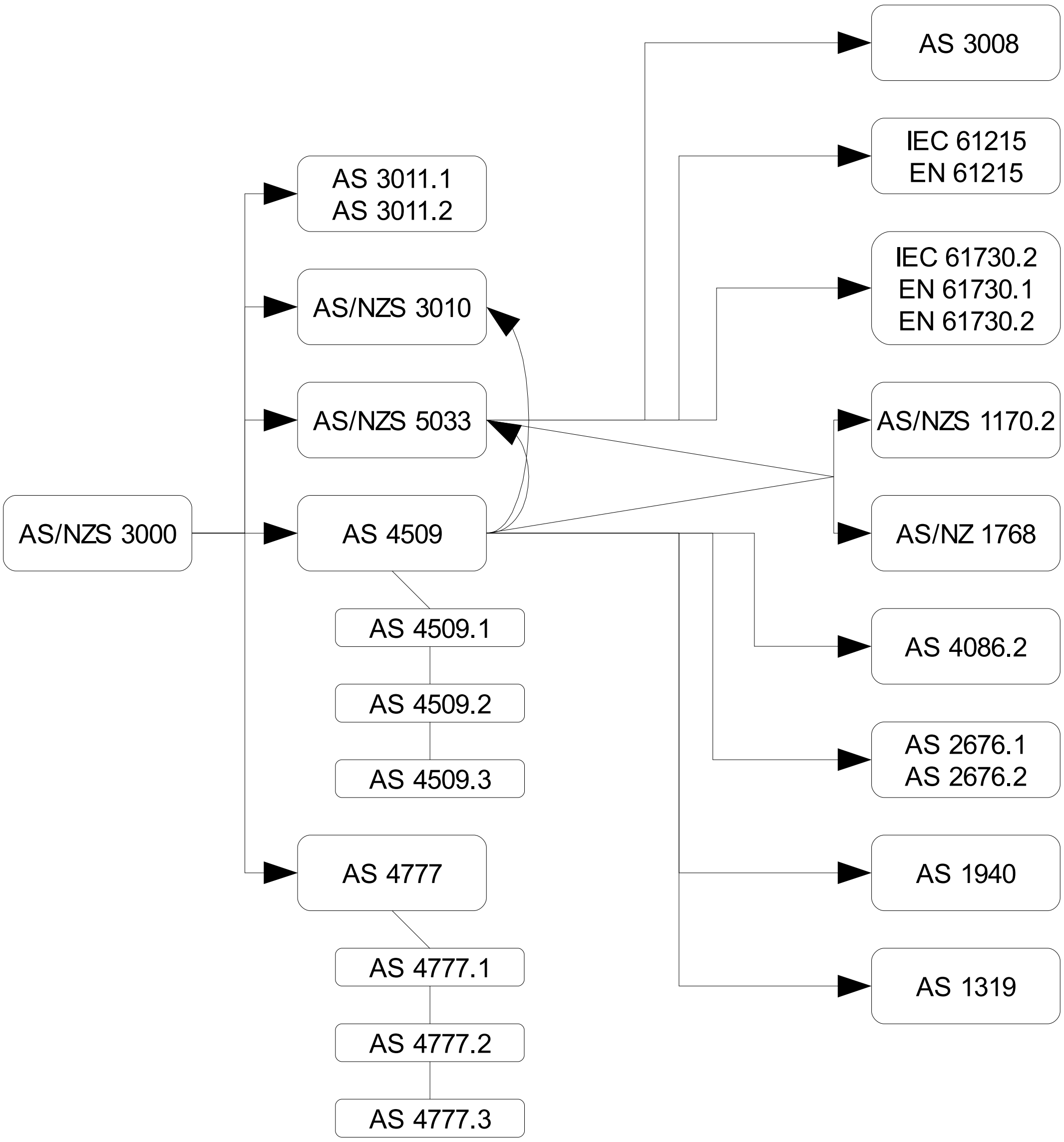


Figure 1: Renewable energy standards map

This document refers to the following version of the standards:

AS/NZS 3000:2007	Electrical installations. Known as the "Australia/New Zealand Wiring Rules"
AS/NZS 5033:2005 Incorporating: Amdt1 (2009)	Installation of photovoltaic (PV) arrays
AS 4509.1:1999 Incorporating: Amdt1 (2000)	Stand-alone power systems - Safety requirements (Revision due August 2009)
AS 4509.2:2002	Stand-alone power systems - System design guidelines (Under revision due date unknown)
AS 4509.3:1999 Incorporating: Amdt1 (2000)	Stand-alone power systems - Installation and maintenance (Will be included in AS 4509.1 when revised (Aug 2009))
AS/NZS 3010:2005	Electrical installations - Generating sets

AS 4777.1:2005	Grid-connection of energy systems via inverters - Installation requirements
AS 4777.2:2005	Grid-connection of energy systems via inverters - Inverter requirements
AS 4777.3:2005	Grid-connection of energy systems via inverters - Grid protection requirements
AS 4086.2:1997	Secondary batteries for use with stand-alone power systems - Installation and maintenance

3.1 What are standards and how do they work

What is a standard and how are they written?

The definition of a standard as given by Standards New Zealand is:

> "Standards are agreed specifications for products, processes, services, or performance.
>
> New Zealand Standards are developed by expert committees using a consensus-based process that facilitates public input.
>
> New Zealand Standards are used by a diverse range of organisations to enhance their products and services, improve safety and quality, meet industry best practice, and support trade into existing and new markets"

Standards are living documents and are frequently revised and updated as experience is gained with renewable energy systems.

Most of the standards referenced in this document were developed by the EL-042 committee, which is joint between New Zealand and Australia. A list of current Member organisations can be obtained from Standards Australia. SEANZ is a member of this committee and can represent SEANZ members concerns at regular meetings. Anyone can make a submission on a standard directly to Standards New Zealand.

Are standards law?

Standards are often referenced in regulations as a means of complying with the law. The Wiring Rules (AS/NZS 3000) is a means of complying with the electrical regulations. Where The Wiring Rules reference other standards as "nominative references" these standards also become part of the requirement to meet the regulation.

Within each section of this standard and the above diagram (Figure 1) demonstrate the linkages between standards.

How do I use standards?

Standards contain requirements and best practice advise. To "comply" with a standard you must meet the requirements, but you may chose to comply with the best practice advise.

Where the standard says that you **shall** do some thing this is a requirement.

Where the standard says that you **should** do something this is best practice and is advisable but optional.

Why should I use standards?

Where standards are referenced as a means of complying with law this is usually the simplest way to ensure that your installation meets the requirements.

Should there be a dispute in the future or damage or injury as a result of your installation designing and installing a system to comply with the standards will provide some protection. If you are asked to defend why you did something a certain way it is easy to show that you have completed your work to the requirements and best practice agreed by experts and the industry as a whole.

Working to the standards gives your customers confidence in the installation and your work.

Where do I buy standards?

Standards can be purchased from:

SIA Global – **www.sai-global.com**

Standards New Zealand – **www.standards.co.nz** (NZS standards only)

It should be noted that the continued support and development of standards is made possible through their sale. Standards are protected by copy right and should not be reproduced without permission.

4.0 STAND-ALONE POWER SYSTEMS

Stand-alone power systems supply electricity without connection to a power distribution network such as the National Grid. Power can be supplied from many sources including photovoltaics, wind turbine generators, micro hydro units and fossil fuel generators. These systems are used in many applications in New Zealand particularly to provide electricity to remote properties.

The document does not distinguish between requirements (SHALLS) and best practice (SHOULDS) in the Standards as requirements are often conditional and best covered by the standard itself.

The Standards should always be referred to when clarifying requirements.

4.1 Relevant standards

The main standard for stand-alone power systems is AS 4509. There are 3 sections in this standard. Figure 2 Shows the relevant standards and the links between them.

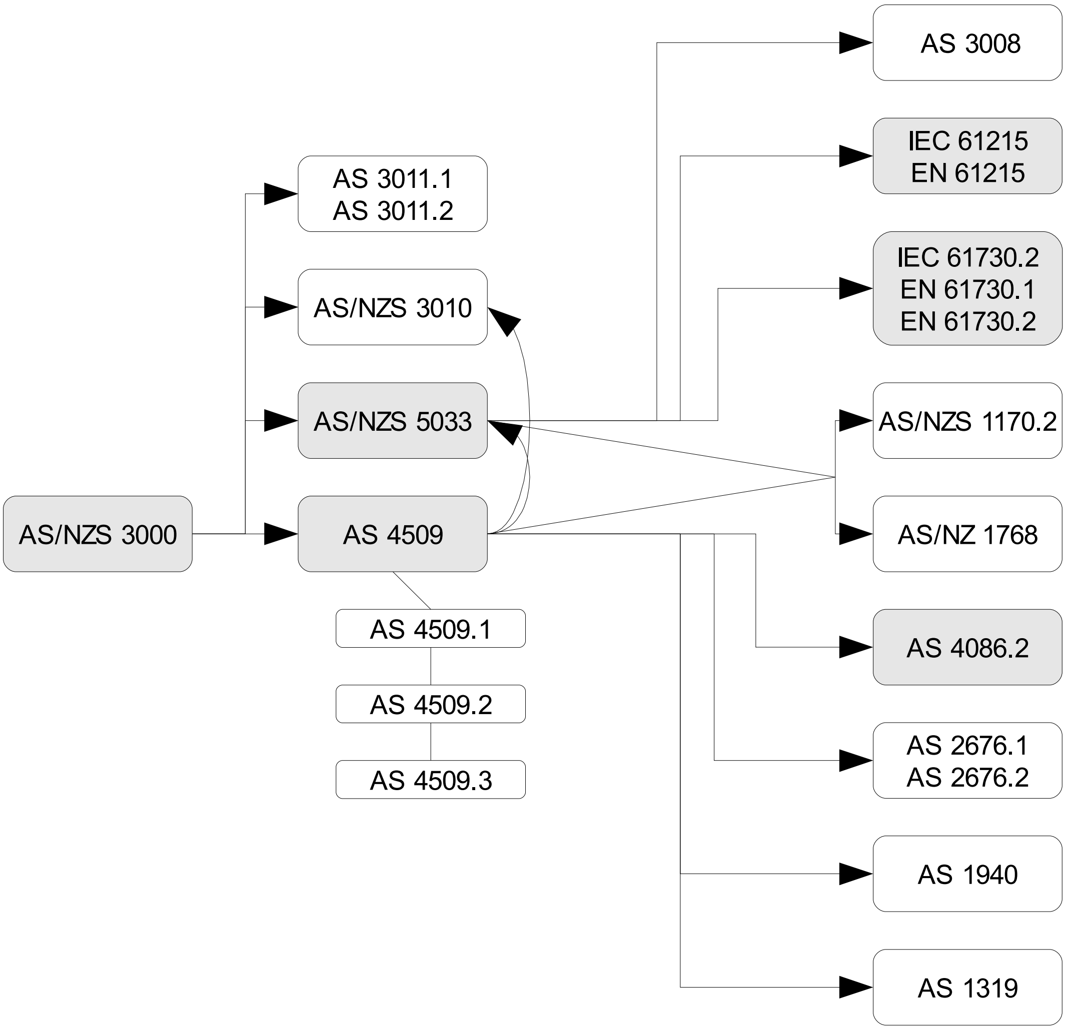


Figure 2: Stand-alone power systems standards map

AS 4509	

AS 4509.1: Stand-alone power systems – Safety requirements

AS 4509.2: Stand-alone power systems – System design guidelines

AS 4509.3: Stand-alone power systems – Installation and maintenance

Note part 1 and 3 will be combined into a new AS/NZS 4509.1 later in the year which will become a joint Australian, New Zealand standard.

AS 4509 references various other standards for particular parts of the system.

AS 4086.2: Secondary batteries for use with stand-alone power systems – Installation and maintenance

AS/NZ 3010: Electrical installations – Generating Sets

Various other standards are references for particular aspects of the installations and these will be noted at the relevant points in the document.

4.2 System sizing and configuration

AS 4509.2	2.0

To ensure that a stand-alone power system performs to the requirements of the system owner it is important that the system is designed to meet the expected energy and peak power requirements, given the available energy resource at the site.

During the design process the following should be considered:

- Energy requirements
- Available renewable resource at the site
- The most appropriate generation technologies
- The system configuration
- Selecting the correct components of appropriate rating
- Wiring, electrical protection and isolation
- Costs and economics

4.3 Assessment of demand

AS 4509.2	3.1

Each system owner will have different energy needs. An assessment of these needs should be carried out at the start of a project. The assessment should determine:

- **The average daily energy needs**. This will inform the required energy generation and help to determine energy storage needs (consideration should also be given to whether usage is full time, seasonal, or weekend only). For larger systems (>1kWh/day) consideration should be given to whether the energy need varies by season. **3.1.4.1 3.1.5**
- **The maximum power demand, both AC and DC**. This will determine the required size of inverters and other electrical equipment **3.1.4.2**
- **The surge demand**. Again this will influence the selection of inverters and other equipment **3.1.4.3**

Consideration should always be given to energy efficiency measures as it is almost always cheaper to conserve energy than generate energy. **3.1.2**

The most appropriate means of generating energy should also be considered, for example it would be more cost effective to heat hot water with a solar hot water system or a wetback on a fire than using solar photovoltaics and a conventional electric water heater. **2.3.4**

4.4 Resource assessment

AS 4509.2	3.2

Accurate renewable energy resource data is very important in the assessment of the most appropriate renewable generation technology for the site and its economic feasibility.

Information about estimating yield provided section 4.7.

4.4.1 Solar radiation

3.2.2

Solar radiation data is available from a number of sources. At a minimum average monthly solar radiation data should be obtained to allow the assessment of available energy over the year. The radiation levels at some sites will vary from average regional weather due to local conditions such as shading from trees, buildings or hills, allowance should be made for these changes. Some sources of weather data are shown in Appendix A.

4.4.2 Wind resource

3.2.3

Wind resource is very site specific. The most robust means of determining specific site wind conditions is to carry out measurements at the site for a period of 12 months or more. However when considering small wind turbine generators the cost of this will often be significant relative to the cost of the turbine making this uneconomic in many cases. Short term site measurements can be taken and should be correlated against long-term data from nearby sources.

w w w .bcse.org.au/default.asp?id=96

If on site measurements are not taken then the effective average wind speed and effect of local topography and obstructions should be carefully considered and recorded for future reference.

4.4.3 Hydro resource

3.2.4

To assess the hydro resource potential for a particular site information about the volume of flow in the stream and the static head available between the water intake and proposed turbine location are required.

Estimates of static head can be made from topographical maps but on site measurements should be used for any design work.

Hydro turbine manufacturers should be consulted on practical methods for on site measurement of flow and head.

4.5 System configuration

AS 4509.2	3.3

There are many possible configurations of stand-alone power systems. Every situation will be different, requiring the person specifying the system to evaluate the site and the customers needs to ensure the most suitable system.

The main considerations when specifying a standalone power system are:

- The energy and power requirements of the system owner (also discussed in section 4.3) — 3.2
- Budget of the system owner
- Availability and choice of energy generation technologies — 3.3.2
- A.C. vs. d.c. bus and inter-connection of the equipment. — 3.3.4
- Equipment to be used (covered in the following sections)
- Location of the equipment (covered in the following sections)

AS 4509.2 discusses 3 possible ways of connecting an a.c. generator to the system and the various merits of each.

AS 4509.3	8.0

The location of equipment should be considered to ensure safe and efficient operation.

4.6 Component sizing and selection

AS 4509.2	3.4

AS 4509.2 gives one method of determining the size of components in a system in a robust manner. Calculations can be completed by hand for each system or through the use of spreadsheets or software packages. The advantage of using the methods presented in the standard is that it provides an agreed and defendable way for a system designer to size components should the system design be questioned in the future.

Appendix A of AS4509.2 provides a worked example of how to apply the information in the standard.

Appendix A

An area not generally covered by standards is the reliability of equipment. Often it is a case of you get what you pay for, however, consumers should be informed of the relative merits of different equipment options, warranties and likely replacement periods.

Information on sizing and selection of system components, including design and installation considerations are provided in the following sections.

4.7 Sizing the renewable energy generator

3.4.2

Wind turbines, hydro turbines and PV arrays are sized to based on the average daily energy use of the consumer for the worst month, i.e. when the ratio between available resource and required energy is the lowest.

3.4.2.6

Consideration should be given to:

- Acceptable backup generator run time (and associated cost) – the renewable energy fraction **3.4.6**
- Budget constraints
- Likely increased energy use in the future
- Losses in the system such as wiring losses due to resistance, inverter, regulator and battery efficiencies **3.4.2.2**

When there is no backup generator it is important to provide some redundancy in the system to ensure that there is always energy available. This is allowed for in the standards through the use of an oversupply co-efficient (f_o).

3.4.2.5

4.7.1 Photovoltaic array

AS 4509.2 | **3.4.3**

The sizing of a PV array should consider the available solar radiation, required energy (as discussed in the above section) and the chosen PV module characteristics. In particular the following:

- Module tilt should be chosen to maximise the available energy, typically in the month with the lowest available solar radiation. The array should be oriented as close as possible to north **3.4.3.3 3.4.3.3**
- Solar radiation used to calculate the energy yield should be determined for the plane of the PV modules. Irradiation data is also discussed in section 4.4.1 **3.4.3.5 3.2.2**
- Shading of the array
- Array temperature **3.4.3.7**
- Power tolerance of the module (i.e. manufacturer's warranted minimum) **3.4.3.6**
- The type of regulator to be used. Available energy will vary between a maximum power point tracking (MPPT) and switched regulators. **3.4.3.3**

AS 4509.2 provides guidance on the above and equations that will allow the array to be sized correctly for both (MPPT) and switched regulators.

The wiring and safety aspects of photovoltaic arrays including product standards are covered in section 6.

4.7.2 Wind turbine generators

AS 4509.2	3.4.4
	3.2.3

As discussed in section 4.4.2 wind resource is significantly affected by site conditions. Energy yield from wind turbine generators should be carefully calculated with consideration of:

- Height of tower and expected wind shear at the site
- Turbulence of the wind at the site
- Wind speed distribution – e.g. Weibull or Raleigh type distributions

All calculations should use the power curve for the specific wind turbine generator being considered. Some turbines will have better performance at low speeds or be less affected by turbulent winds (e.g. vertical axis turbines). When selecting the turbine consideration should be given to its suitability to the location where it is to be installed.

If wind resource will be adversely affected for a particular wind direction allowance should be made for this in the calculations.

Some guidance on small wind turbine generators is provided by the Clean Energy Council (CEC), previously known as the BCSE. The guide can be downloaded from the BCSE website. These guides also provide useful information on calculating energy yield.

www.bcse.org.au/default.asp?id=96

Section 7 discusses wind turbine generator installations in more detail, including safety aspects.

4.7.3 Hydro turbines

AS 4509.2	3.4.5
	3.2.4

Provided seasonal variation for hydro resource is allowed for micro hydro turbines will provide predictable and consistent power to a stand-alone power system all year around. Manufacturer's recommendations should be consulted and a turbine chosen to suit the site conditions and available flow and head of the hydro resource.

In summary sizing of hydro turbines should consider:

- Hydraulic losses in the pipe work and losses from fouling over time
- Cable losses between the turbine and batteries
- Seasonal resource variations
- The characteristics of the turbine at the available head and flow, including efficiency

Section 4.4.3 discusses hydro resource in more detail.

Section 8 discussion micro hydro turbines in more detail.

4.8 Batteries

Batteries are the heart of any stand-alone power system and attention should be given to ensure that the batteries chosen are the most suitable.

4.8.1 Sizing and selection

AS 4509.2	3.4.7.1 3.4.7.2

Design decisions are required for the type of battery and its characteristics. Trade off's are usually required between cost and deep cycling duty, expected life, and maintenance requirements. A summary of considerations is provided in AS 4509.2

AS 4509.2	3.4.7.3 to 3.4.7.10

When sizing a battery for energy storage capacity the required autonomy (time energy can be supplied without energy generation charging the batteries) and depth of discharge (DOD) are the most important considerations. Surge demand capabilities should also be considered as well as the effects of temperature on battery life and capacity.

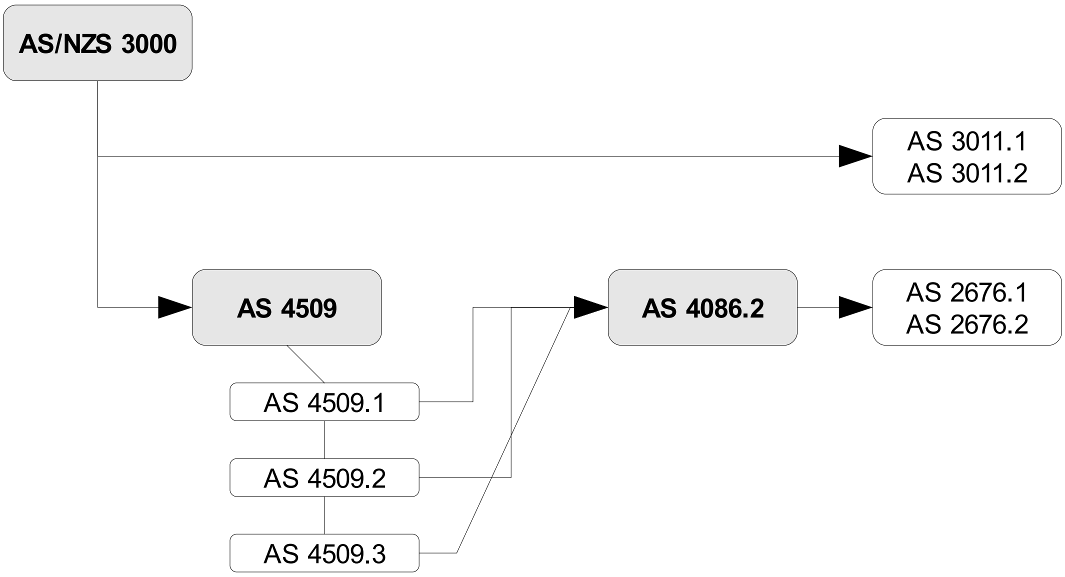


Figure 3: Battery standards map

There are a number of standards that relate to the design, installation and maintenance of batteries in stand-alone power systems.

The considerations relating to batteries are listed below with the standards that should be referenced are shown on the right.

Figure 4: Large battery installation installed to the standards (SolarQuip)

4.8.2 Design and installation considerations

- General advice on the design of a battery enclosure and considerations are given in AS 4509.2

AS 4509.2	**4.6.1**

- Configuration of the battery enclosure can take a number of forms. Namely a battery box for batteries only, an equipment room which may also house electrical equipment (provided that the guidelines for positioning that equipment are followed) or a fenced off area in a larger room. For clarity these options are shown in Figure 5.

AS 4509.2	**4.6.1**
AS 4086.2	**2.6**

- Construction of a battery enclosure

AS 2676.1 **AS 2676.2**	**3.7** **3.6**

- The battery enclosure should prevent unauthorised access, protect the batteries from the environment and vermin

AS 4509.1 **AS 4509.2**	**3.5(c)** **3.6.1**

- Location of batteries and equipment in and adjacent to enclosure

AS 4509.2	**4.6.1**

- Ventilation of battery installations (including sealed batteries) is important for safety reasons. Consideration should be given to exhaust rate and method of ventilation and the location of vents

AS 4086.2 **AS 4509.2**	**2.7** **4.6.3**

- Seismic restraint in New Zealand is important due to the potential for earthquakes and the considerable mass of batteries

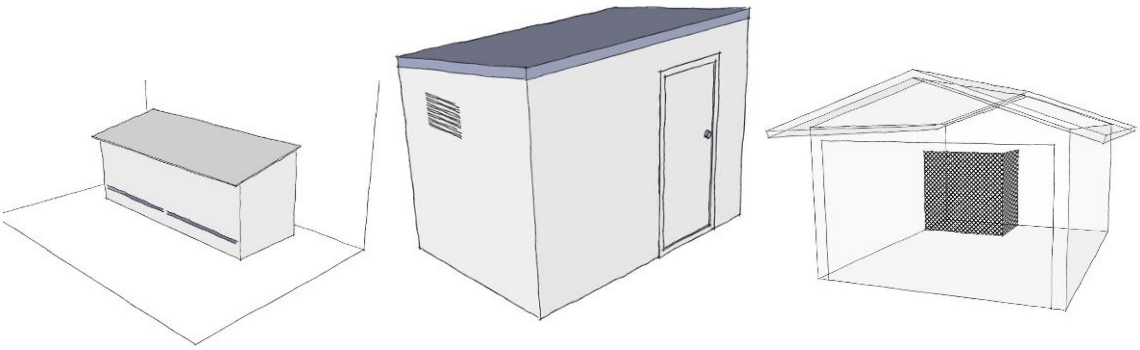
AS 2676.1 **AS 2676.2** **NZS 4219**	**3.12 (f)** **3.10(d)**

- Alarms for battery under voltage are a useful addition to a battery installation. Consideration should also be given to low voltage disconnection

AS 4086.2 **AS 4509.2**	**2.5** **4.6.4**

- Inspection and maintenance are vital to ensure long life of batteries. Log books should be kept for both maintenance and warranty purposes.

AS 4086.2 **AS 4509.3**	**3.0** **6.0**



Battery box (a.k.a. dedicated enclosure) Equipment room Dedicated area (fenced off in a larger area)

Figure 5: Battery enclosure types

A revision to AS 4509.1 will provide more clarification about enclosures and battery installations in general when published in late 2009.

Refer to section 4.15 for information on electrical wiring, protection and isolation.

Refer to section 4.19 for information on **signage** required for battery installations

Note that the standards listed are for the design and installation of batteries with a nominal voltage of <115V d.c. Refer to AS 3011 for install of batteries with nominal voltages >115V d.c.

4.8.3 Transportation

Batteries are recognised as dangerous goods for the purposes of transport.

w w w .ltsa.govt.nz/factsheets/64.html

Batteries used for SPS typically fall into one of two UN dangerous goods categories:

UN 2794 : Batteries, wet, filled with acid, electrical storage	Flooded lead acid
UN 2800 : Batteries, wet, nonspillable, electric storage	VRLA, Gel, AGM

However some batteries such as lithium may fall into a different category

www.nzta.govt.nz

The volume of batteries that you are carrying and the purpose for carrying those batteries will generally determine whether you need a licence to carry the batteries, and your responsibilities. If you carry batteries for hire or reward a dangerous goods licence will be required. Table 1 provides a summary of requirements for each category. For more information you should consult the New Zealand Transport Agency.

Regardless of the battery type that you are carrying you should give consideration to:

- Preventing short circuit including keeping the batteries dry
- Packaging
- Securing the load and preventing the batteries tipping over
- Damage and puncture of the batteries
- Appropriate signage

	Personal use Recreational or domestic	As tools of trade	For hire or direct reward
Does this category apply	Applies to people who carry dangerous goods for domestic or recreational use	Applies to people who transport dangerous goods as tools-of-trade, for agricultural use or for a commercial purpose, but not for hire or direct reward.	If you're transporting dangerous goods for hire or reward
D endorsement required	Not required	Not required if less than 250L volume	When carrying dangerous goods greater than 50kg total in 'small packages'
Responsibilities	• Making sure the goods are properly packaged and identified • Segregating incompatible dangerous goods • Securing the load on your vehicle.	• Making sure the goods are properly packaged and identified • Segregating incompatible dangerous goods (keeping them apart to prevent dangerous reactions) • Securing the load on your vehicle • Carrying emergency response information • Safe handling practices and emergency procedures.	Extensive see factsheet 67
Maximum load	250L	250L	See factsheet 67
Refer to	ltsa.govt.nz/factsheets/69.html	ltsa.govt.nz/factsheets/68.html	ltsa.govt.nz/factsheets/67.html

Table 1: Battery transportation categories and requirements

4.9 Charge regulators & a.c. coupled inverters

AS 4509.2 **3.4.8**

Charge regulators should be sized to carry the maximum current and voltage as defined in AS 4509.2 depending on whether they are connected to a PV array, wind turbine generator or hydro turbine.

- Photovoltaic arrays **3.4.8.2**
- Wind turbine generators **3.4.8.3**
- Hydro turbines **3.4.8.4**

A dump load may be required for wind and hydro turbines to dump excess energy.

The charging regime should be configured to suit the battery type that the regulator is connected to. **3.4.8.5**

A.C. coupled systems will utilised a grid-connected inverter with additional functionality to allow for power regulation. System design utilising these devices is not explicitly covered in the standards. Some guidance is provided in section 5.3.1 in relation to grid-connected inverters.

4.10 Battery inverters

AS 4509.2 | **3.4.9**

Battery inverters should be sized for surge and sustained demand as determined by the load assessment (section 4.3) at the expected operating temperatures. Consideration should also be given to the other factors as listed in the standard, including wave form appropriate to the application.

Further considers should be made for the requirements of inverter-chargers and interactive chargers, including control and auto-start (see section 4.13).

4.11 Battery chargers

AS 4509.2 | **3.4.10**

Battery chargers should be selected and configured to suit the required charging regime to suit the battery type, along with the other considerations as defined in the standard.

Sizing of the battery charger should be based on the battery capacity. **3.4.10.2**

Battery charger input power will usually be provided by the manufacturer, otherwise it can be calculated, and should be reference to the available AC input power.

4.12 Generating sets (Genset)

AS 4509.2 | **3.4.10**

4.12.1 Generating set sizing

Generators are usually used as a backup power source and should be sized to suit the surge and sustained demand which will be determined by the load assessment (section 4.3) and system configuration. Demand requirements will depend on whether the system is a:

3.4.11.2 to 3.4.11.4

- Series system
- Switched system
- Parallel system

The available power of the generator will be affected by the location (e.g. altitude effects) and operating conditions (e.g. temperature) and should be power derated to suit. **3.4.11.5**

Nominal generator run time can be calculated and will be useful in determining fuel costs. **3.4.11.6**

4.12.2 Genset installation

AS 4509.1 | **3.1**
AS 4509.2 | **4.5**
AS/NZS 3010

AS 4509 gives guidance on the installation of generators and the storage of fuel. AS/NZS 3010 should be consulted for electrical installation.

www.ermanz.govt.nz

Generator and fuel storage installations shall comply with the requirements of the Hazardous Substances (Dangerous Goods and Scheduled Toxic Substances) Transfer Notice 2004.

In general considerations should include:

- Location of the genset
- Noise
- Exhaust fumes
- The requirement for automatic starting (also see section 4.5) and safety aspects related to this.
- Safe fuel storage (Note: AS 1940 is not applicable in New Zealand)

AS/NZS 3010	2.5.5

- Generator change over facilities will be required to suit the system configuration.
- Signage (also see section 4.19)
- Earthling and bonding
- Guarding

Hazardous substances and new organisms act requirements

The storage of fuel in New Zealand is governed by the Hazardous Substances and New Organisms Act 1996 (HSNO Act). The detail is in the Hazardous Substances (Dangerous Goods and Scheduled Toxic Substances) Transfer Notice 2004 which sets out the criteria for the design, installation and location of fuel storage systems. A copy of the Transfer Notice can be downloaded from:

www.ermanz.govt.nz/resources/publications/pdfs/DG%20&%20STS%20-%20Summary %20of%20Approvals%20_2008.03.14_.pdf

Small quantities of fuel in packages (for example tins or drums) may be stored in accordance with Table 2, which is an extract from the Transfer Notice. Where the storage capacity exceeds that listed in Table 2, or the type of storage or location is different, reference must be made to Schedule 10 of the Transfer Notice, “Controls relating to the adverse effects of unintended ignition of class 2 and class 3.1 hazardous substances”.

The storage of 3.1D hazardous substances (e.g. diesel) in packages (i.e. up to 450 litres) does not require a separation distance and does not have a quantity limit.

Package size (eg storage container size)	Location	Liquid (Litres)
		3.1 A, 3.1 B, 3.1 C e.g. Petrol
Up to 60 litres	Outdoors, uncovered or in a shed or garage, separated from the building or boundary by a 1 m space.	500
Up to 60 litres	Outdoors, uncovered or in a shed or garage, separated from the building or boundary by a 3 m space	2000
Greater than 60 litres	Outdoors, uncovered or in a shed or garage, separated from the building or boundary by 3 m of space.	250

Table 2: Quantities of fuel stored in packages

Bulk storage tanks for fuels and associated pipework to a generator are required to comply with the requirements specified in Schedule 8 of the Transfer Notice, “Controls for stationary container systems”. This is in addition to the installation requirements specified in Schedule 10.

Table 3 provides a summary of the maximum quantities that may be stored before certification requirements of the HSNO Act are triggered.

	Location test certificate	Stationary container installation test certificate (tank supplying a generator)	Approved handler must be available	Secondary containment required
3.1A (e.g. petrol)	>50 Litres	>50 Litres	>100 Litres	>1000 Litres
3.1D (e.g. diesel)	Not required	>500 Litres	• Not required	>1000 Litres

Table 3: HSNO Act certification threshold requirements

Certification is undertaken by an approved test certifier. A test certifier should be contacted prior to installation to ensure that all HSNO requirements are met.

4.13 Metering and control

AS 4509.2	3.5
	3.5.1
	3.5.2 3.3 3.4.11

Metering should provide information on the operation of the system.

Control used will depend on the system configuration (section 4.5), particularly in relation to the generator and, wind and hydro turbine dump loads.

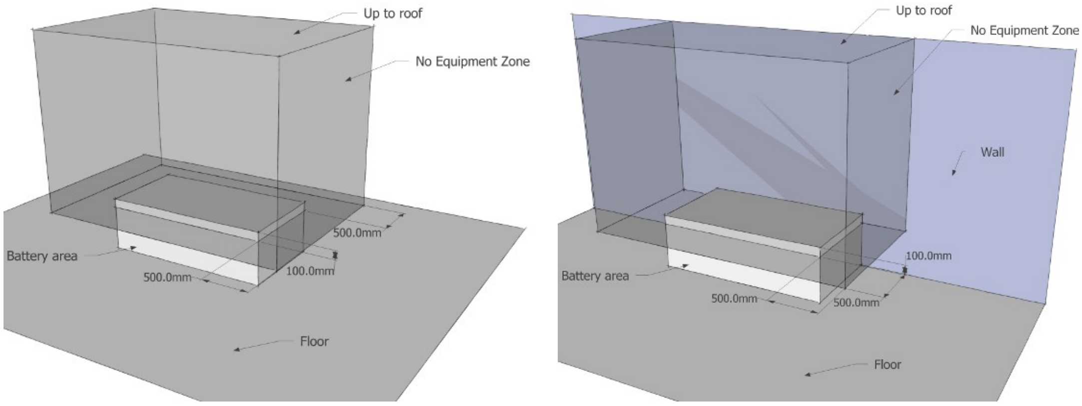
4.14 Electronic equipment location requirements

AS 4509.3	8.0

The location of electronic equipment should give consideration to the environment that the equipment is designed and rated for, including:

- Salt area
- Moisture
- Dust
- Temperatures

Generally no electrical equipment should be located within 100mm of the top of a battery, within 500mm to either side or any where above the batteries as shown in Figure 6. If equipment is located in the same room as batteries then extra special attention should be given to ventilation, especially during equilisation charges. Greater clarification will be given in the revised version of AS 4509.1 when published late 2009.



No equipment area in a room.

No Equipment area when battery area is against the wall

Figure 6: No equipment locations relative to a battery area

Attention should be given to preventing unauthorised access to equipment, especially batteries and euipment that can be tappered with including generators, isolators, and inverters/controllers with adjustable settings.

Equipment should be assessable for maintenance.

Figure 7: SPS equipment installed to the standards (SolarQuip)

4.15 Wiring, electrical protection and isolation

All electrical work should comply with AS/NZS 3000 (The Wiring Rules). In addition to The Wiring Rules specific considerations in the renewable energy standards are given below.

AS 4509.2	**3.4.12** **Appendix C**

Cables should be sized to limit voltage drop to acceptable levels and for current carrying capacity. AS 4509.2 gives guidance on acceptable voltage drop, however, depending on the cost of the generated electricity, relative to the cost of the cable lower (or higher) voltage drops may be economical.

4.15.1 Overcurrent protection

AS/NZS 3000 **AS4509.1** **AS 4509.2**	**7.3.5** **2.2(a)** **3.6** **Appendix D**

Overcurrent protection in stand-alone power systems is vital for safe operation. General guidance on design of protection is provided in AS 4509.2 and AS 4509.1. Specific references to the protection requirements of various components are given below.

It is important to note that auto type and rewireable fuses are not suitable.

AS 4509.2	3.6.5

- **Generators** electrical protection

AS/NZS 3010	2.5.2

- **Batteries** have the potential for very high short circuit fault currents and as such protection means should allow for this.

AS 4086.2 AS 4509.2	2.3 3.6.6 Figures 6&7

- Inverters overcurrent protection design should consider not just the continuous supply of the inverter but also 30min and surge currents.

AS 4509.2	Appendix D

- For **PV array** wiring and protection see section 6.0

4.15.2 Isolation

Isolation is required on all generating sources. The requirements for isolation are given in various places within the standards as detailed below.

AS/NZS 3000 AS 4509.2	7.3.4 3.7

Note: Charge regulators and inverters can be damaged if the battery is disconnected from the regulator before the generator (e.g. PV, wind or hydro). It may be necessary to provide a means of disconnection between the generator and regulator and ensure disconnection is carried out in the correct sequence.

- **Generators**

AS 4509.2 AS/NZS 3010	3.6.3 2.4.2

- **Battery** isolation should be provided and may be combined with overcurrent protection.

AS/NZS 3000 AS 4509.2	7.3.4.2 3.6.7

- **PV arrays**, see section 6.0
- **wind turbine generators**, see section 7.4.3

Stand-alone power systems incorporate both low voltage (LV) and extra low voltage (ELV) wiring. These are determined to have different installation requirements in the standards and as such they should be separated in an installation. **Segregation** should be provided between a.c. and d.c. circuits.

AS 4509.1 AS/NZS 3000	3.4 3.9.8.3

All wiring should be protected from mechanical damage and other "external influences" such as sunlight and heat. This is covered in detail in The Wiring Rules.

AS 4509.3 AS/NZS 3000	2.2 Including: 3.3, 3.9 & 3.10 7.3.5.1

4.15.3 Earthing requirements

AS 4509.1	2.3

Battery earthing arrangements should be considered to suit the equipment in the system. Earthing effects the fusing requirements.

AS 4509.2 AS 4086.2	3.6.6 2.3 Appendix A4

Some equipment may not be able to be used with certain earthing arrangements. The manufacturers requirements should be consulted.

AS/NZS 5033	5.2

PV arrays see section 6.3.4

4.16 Connection of SPS to load

A stand-alone power system supplies power to the "consumer mains". Connection of the SPS to the consumer mains should be in accordance with the relevant standards.

AS/NZS 3000	**7.3.8.3 Figure 7.6**

4.17 Lighting protection

Lightning protection may be required in some parts of New Zealand and is dependent on:

- The type of structure
- The construction
- The height of the building/array
- The topographical situation
- The prevalence of lightning

AS 4509.1 AS 4509.2 AS/NZS 1768	**2.2 (b) 3.8 Appendix E All**

Information on lightning protection of PV arrays – section 6.4

Information on lightning protection of wind turbine generators – section 7.5

4.18 Documentation

Guidance on the documentation that should be provided to the owner of a stand-alone power system is given in AS 4509.3

AS 4509.3	**12.0**

Note: Further clarification will be provided in a revision of AS 4509.1 to be published in later 2009.

4.19 Signs and labelling

Correct and clear signage and labelling is important to ensure safe operation of a stand-alone power system. The standards offer guidance on signs and labels as follow:

General guidance on signage	**AS 4509.1**	**1.5**
Batteries	**AS 4509.1 AS 4086.2**	**3.5 Appendix B**
Generators	**AS 3010**	**3.3.3**
In the case that the equipment starts automatically	**AS 4509.1**	**3.1 (b)**
Shutdown procedure	**AS 4509.1**	**4.0**
Multiple sources of low voltage supply	**AS 4509.1**	**3.7**
Metering alarms and protection	**AS 4509.3 AS 4509.2**	**9.5 3.6.4**
Earthing	**AS/NZS 3000**	**5.5.1.3**
PV arrays. See section 6.5.	**AS/NZS 5033**	**6.0**

4.20 Testing and commissioning

Before any system is operated it should be properly tested.	**AS/NZS 5033**	**6.0**
Information on the commissioning of PV arrays.	**AS/NZS 5033**	**8.0**

4.21 Maintenance

The maintenance of an SPS is important to ensure reliable and safe operation.

The maintenance requirements for an SPS are given in AS 4509.3. The working area and equipment including battery banks should be made safe before work commences.

AS 4509.3	**11.0**

Maintenance of PV arrays

AS/NZS 5033	**Appendix H**

4.22 Software

There are a number of ways to design the appropriately sized renewable energy system.

Software such as PVsol, PVsyst and Homer provide time step calculations that will allow calculation of system size for given load and renewable energy resource to a high level of accuracy. However they do not provide provision to directly assess compliance with the standards.

The Clean Energy Council (CEC) in Australia provides two spreadsheets that calculate system sizes based on the requirements of the standards. These spreadsheets are made available to CEC accredited installers only.

Using the guidelines in Appendix B of AS 4509.2 it is possible to create a spreadsheet that will complete these calculations.

Other simulation packages are available see Appendix B for more information.

5.0 GRID-CONNECT INVERTER SYSTEMS

Grid-connect inverter systems are starting to increase in popularity in New Zealand. It is important for the safety of the system owner and those working on the electrical system in the house and the distribution grid that the system is connected to, that these systems are installed in a safe manner.

The document does not distinguish between requirements (SHALLS) and best practice (SHOULDS) in the Standards as requirements are often conditional and best covered by the standard itself.

The Standards should always be referred to when clarifying requirements.

5.1 Relevant standards

There a number of standards relevant to the installation of grid-connect inverter systems, as with all electrical systems, the installation should meet the requirements of The New Zealand Wiring Rules AS/NZS3000. Figure 9 shows the linkage of AS/NZS 3000 to the relevant renewable energy standards that are discussed in this chapter.

The standards that relate to grid-connect inverter systems are shown in grey in Figure 9. Grid connect inverter systems that incorporate battery backup will not be covered in this chapter. For more information see section Error: Reference source not found Error: Reference source not found.

Figure 8: Grid-connect inverter installations to the standards (SolarQuip, solarcentury.com)

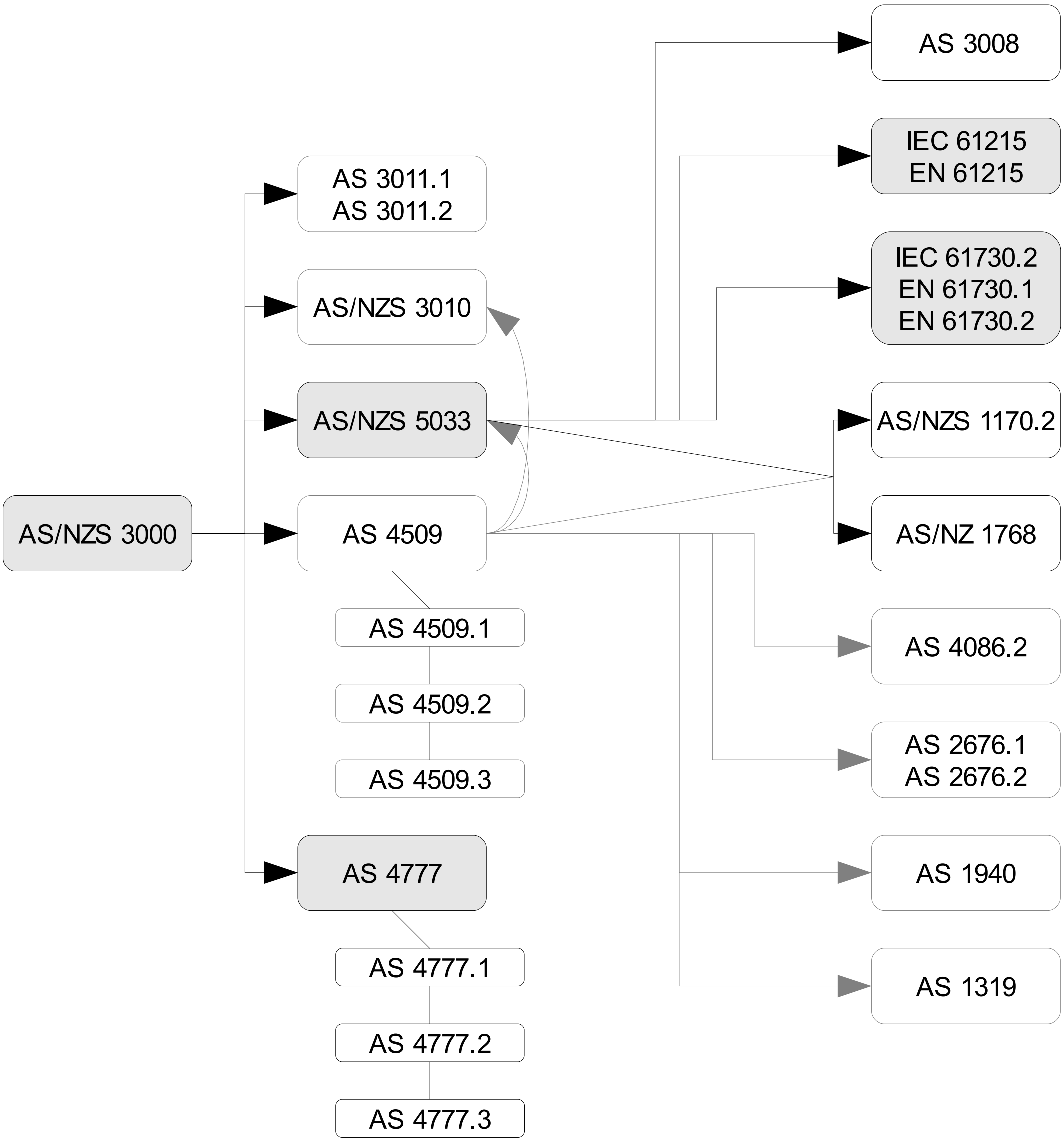


Figure 9: Grid-connected inverter systems standards map (note: grey objects and links only apply to systems with battery backup)

5.2 Inverter installation

AS 4777.1 covers the installation of grid-connected energy systems using an inverter.

AS 4777.1 **AS/NZS 3000**	**General** **General &** **7.3.8.2**

5.2.1 Inverters and grid protection

AS 4777.1	**5.2**

Grid-connect inverter systems consist of two specialist devices; an inverter and a grid protection device to disconnect the inverter from the grid in case of out of range voltage, frequency, or if the grid in not present. Most often the inverter will incorporate the grid protection device.

These devices should comply with the standards. The electricity distributor who maintains the electricity distribution grid to which the inverter is connected to will request that the inverter meets these standards as required by AS/NZS 3000.

- Inverter
- Grid protection device

AS 4777.2	**General**
AS 4777.3	**General**

The Clean Energy Council maintains a list of devices currently certified to AS 4777

www.bcse.org.au/default.asp?id=233

5.2.2 Wiring and protection

All cables should be sized for current carrying capacity and voltage drop. Voltage rise from the grid to the inverter due to resistance in a cable can result in the inverter operating outside of its allowed voltage range causing the grid protection device to trip.

AS 4777.1 **AS/NZS 3008**	**5.3.2** **5.1 (b)** **General**

All wiring should be protected from mechanical damage and other "external influences" such as sunlight and heat. This is covered in detail in The New Zealand wiring rules.

AS 4509.3 **AS/NZS 3000**	**2.2** **Including:** **3.3, 3.9 &** **3.10**

Overcurrent protection devices may be required for protection of the cabling or inverter.

AS 4777.1	**5.3.5**

The location of the inverter point of connection should consider the location of RCDs.

AS 4777.1	**5.3.4**

5.2.3 Isolation

Isolation of the inverter from the switchboard and from the energy source should be provided. Attention should be given to the location of the switch, if it is lockable and its rating. (e.g. In public access areas, within view of the inverter)

AS 4777.1	**5.3.3** **5.4**

There has been confusion over requirements for DC isolators to be installed adjacent to a PV array (e.g. on the building roof). This has arisen particularly in Victoria, Australia, but has recently been clarified.

"Isolators are not required adjacent to the PV array"

5.2.4 Signs and labelling

Labelling of grid-connect inverter systems is important so that people working on the installation and emergency services who attend the property are aware that there are multiple supplies and which circuits are effected by this.

AS 4777.1	**5.5** **Appendix A**

In addition to the signs required by the standards it is good practice to ensure the following is visible adjacent to the switchboard and any sub distribution boards on the same circuit:

- Shutdown procedure
- As built schematic showing point of emergency disconnection of the inverter supply

There are particular requirements for solar PV arrays, see section 6.5.

5.2.5 UPS systems

There are additional requirements for grid-connect inverter systems that operate as a UPS. i.e. a backup system, these should be considered in addition to the relevant information that is provided in section 4.0 Stand-Alone Power Systems of this guide, particularly in relation to battery installations.

AS 4777.1	**5.6** **Appendix B**

5.3 Basic sizing/design guidelines

Grid-connect systems can be sized to meet a number of different requirements including:

1. Yearly energy use
2. Available roof space

3. A fixed budget.

5.3.1 Solar PV

There are no standards for calculating grid-connected solar energy yield. Considerations should be given to:

- Solar radiation in plane with the collector field, including localised weather effects such as mist. Section 4.4.1 discusses solar radiation data and some possible sources of data are provided in Appendix A.
- PV module characteristics including, rated power, manufactured power tolerance
- Cell operating temperature and cell temperature coefficients
- Module soiling
- Inverter characteristics including, efficiency at MPP operating voltage
- Effects of array shading on a daily and seasonal basis
- Wiring losses in the PV array and inverter to point of connection cabling

Typically energy yield for a grid-connected photovoltaic array will be calculated on an annual basis. It may be necessary to compare daily generation profiles with daily load profiles if import and export tariffs for electricity vary in order to calculate the expected financial gains from the system. Grid-connected arrays differ from SPS arrays in that there is effectively an unlimited load and all energy generated can be utilised or exported (SPS yield is limited to the amount of energy generated that can be used directly or stored).

AS 4509.2	3.4.3

Much of the information provided in AS 4509.2 with regards to the estimation of energy yield for SPS arrays connected to maximum power point tracking charge controllers is applicable and can be used as a guide.

The voltage and power of the PV array should match the inverter. Many inverter suppliers provide tools to assist in correct sizing. Allowance should be made for the effect of temperature on the PV module output.

w w w .bcse.org.au/default.asp?id=96

PV array sizing and energy yield estimation guidelines are provided by the Clean Energy Council (CEC). The guide can be downloaded from the BCSE website.

A number of software packages are available and are discussed in section 5.6.

AS/NZS 5033	3.2

The array voltage should not exceed maximum module voltage.

See section 6.0 for further information on solar PV arrays.

5.3.2 Wind

There are no standards for the calculation of grid-connected small wind turbine generator yield. Allowance should be made for the local wind resource as discussed in section 4.4.2 including the effects of obstructions and local topology.

Software tools area available that will allow estimations of yield against a certain wind distribution given the power curve of a turbine.

Care should be taken to ensure that the power and voltage input limits of the inverter are not exceeded, especially under no load conditions. For example when the inverter is disconnected from the grid due to a grid failure. Overvoltage input into the inverter can cause damage and may void the warranty.

A dump load may be required to dissipate excess energy in the case of disconnection from the grid. Some wind turbine generators may include this functionality in the turbine control system.

See section 7.3 for information on regulation and control of wind turbine generators.

5.3.3 Hydro

There are no standards for the calculation of grid-connected micro hydro turbine energy yield. Allowance should be made for the local hydro resource as discussed in section 4.4.3.

Care should be taken to ensure that the power and voltage input limits of the inverter are not exceeded, especially under no load conditions. For example when the inverter is disconnected from the grid due to a grid failure. Overvoltage input into the inverter can cause damage and may void the warranty.

A dump load may be required to dissipate excess energy in the case of disconnection from the grid. Some hydro turbine generators may include this functionality in the turbine control system.

See section 8.2 for information on regulation and control of hydro turbines

5.4 Connection to grid and metering

Connection to the grid shall be in accordance with the New Zealand electrical regulations (distributed generation), The Wiring Rules (AS/NZS 3000) and any additional requirement of the distribution company responsible for the local grid to which the inverter will be connected.

Approval to connect to the grid will be required from the distribution company. To identify the relevant distribution company refer to the ENA website. Information should be available on the website of every electricity distributor. The information on the Orion website is particularly useful.

www.electricity.org.nz/?page=networkMap

www.oriongroup.co.nz/your-network/connecting-to-the-network/distributed-generation.aspx

A contract will be required between the owner of the grid-connected system and the electricity retailer for the purchase of any electricity that is exported to the grid.

A meter (or meters) will be required that can measure the energy flow both to and from the property as required by New Zealand regulations. These requirements should be discussed with the electricity retailer. More information is also provided on the SEANZ website.

www.seanz.org.nz/documents/doc_download/23-dg-metering-guide

5.5 Required documentation

While the standards do not require any specific documentation to be supplied with the installation the following would be useful to the system owner:

- Operation manual, including:
- Equipment manuals
- Shutdown procedure
- As built schematic
- Maintenance schedule and guidelines
- System power rating
- Expected average daily energy yield by month

5.6 Software packages

There are a number of ways to design the appropriately sized renewable energy system.

Software such as PVsol and PVsyst provide time step calculations for solar PV that will allow calculation of energy yield and simulation of shading effects.

The Clean Energy Council (CEC) in Australia provides a spreadsheet that calculate system sizes based on the requirements of the standards. These spreadsheets are made available to accredited CEC members only.

Most inverter manufacturers will supply proprietary software for the electrical conformance checks on inverters with a specified PV array. It is important to note that the yields provided within these simulations are typically indicative only and should not be relied upon as a specific yield.

Other simulation packages are available see Appendix B for more information.

6.0 PHOTOVOLTAIC ARRAYS

The document does not distinguish between requirements (SHALLS) and best practice (SHOULDS) in the Standards as requirements are often conditional and best covered by the standard itself.

The Standards should always be referred to when clarifying requirements.

6.1 Relevant standards

All photovoltaic (PV) arrays should be installed to The Wiring Rules (AS/NZS 3000). AS/NZS 3000 references AS/NZS 5033 for specific requirements relating to the installation of arrays (in some cases the requirements of AS/NZS 5033 will override the requirements of AS/NZS 3000). In turn AS/NZS 5033 references a number of other standards including product standards, standards relating to wind and snow loading, lightning and signage. Figure 10 illustrates the links between these standards.

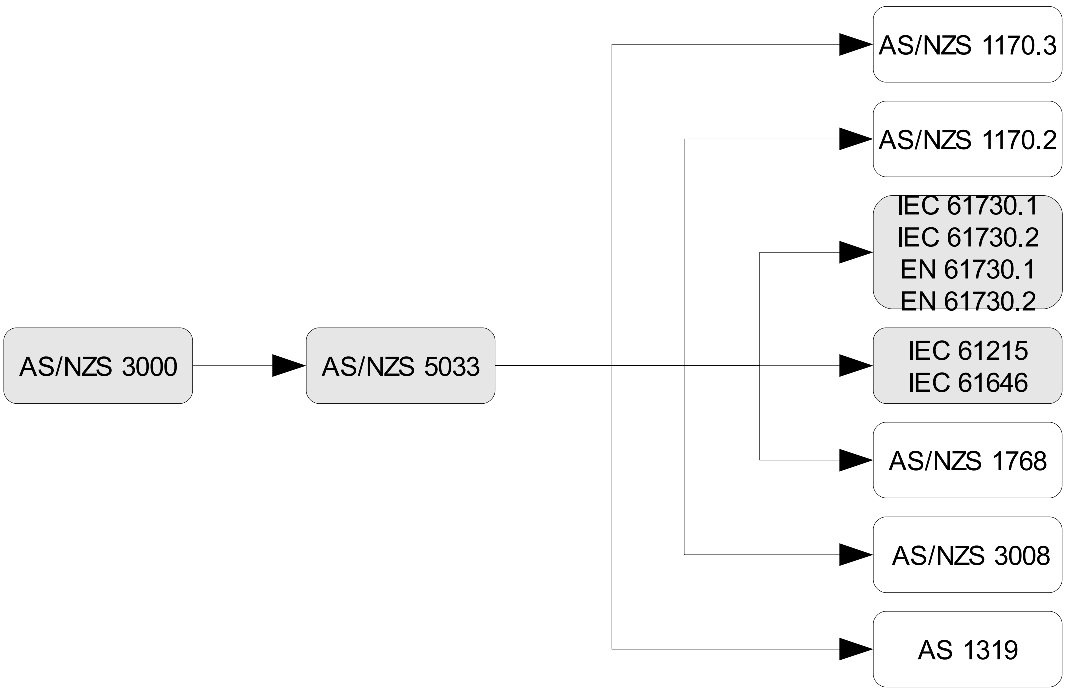


Figure 10: Photovoltaic (PV) array standards map

6.2 Sizing and energy yield estimations

The average daily expected energy yield of a PV array can be reasonably accurately calculated from average meteorological data. It is important to obtain the most accurate weather data available for the site. Section 4.4.1 discusses solar radiation data and some possible sources of data are provided in Appendix A.

Sizing and energy yield estimation for PV arrays are discussed in the relevant sections of SPS and grid-connected inverter systems.

6.2.1 Grid-connected

The sizing of grid-connected PV systems and calculation of annual energy yield are discussed in section 5.3.1

6.2.2 Stand-alone Power System (SPS)

The yield of a PV array in a SPS is not typically calculated for an annual basis. The focus when designing a SPS system is to size an array to meet the desired or optimal percentage of daily energy requirements for the worst time of year, i.e. when the ratio between energy generation and energy demand is the lowest.

Further discussion of the sizing of SPS PV arrays is provided in section 4.7.1.

6.3 Array wiring and protection

Photovoltaic arrays can be comprised of one PV module or many PV modules connected together in series and parallel to obtain the required array voltage and power as shown in Figure 11.

To ensure safe and efficient operation electrical protection and wiring should be correctly designed and installed.

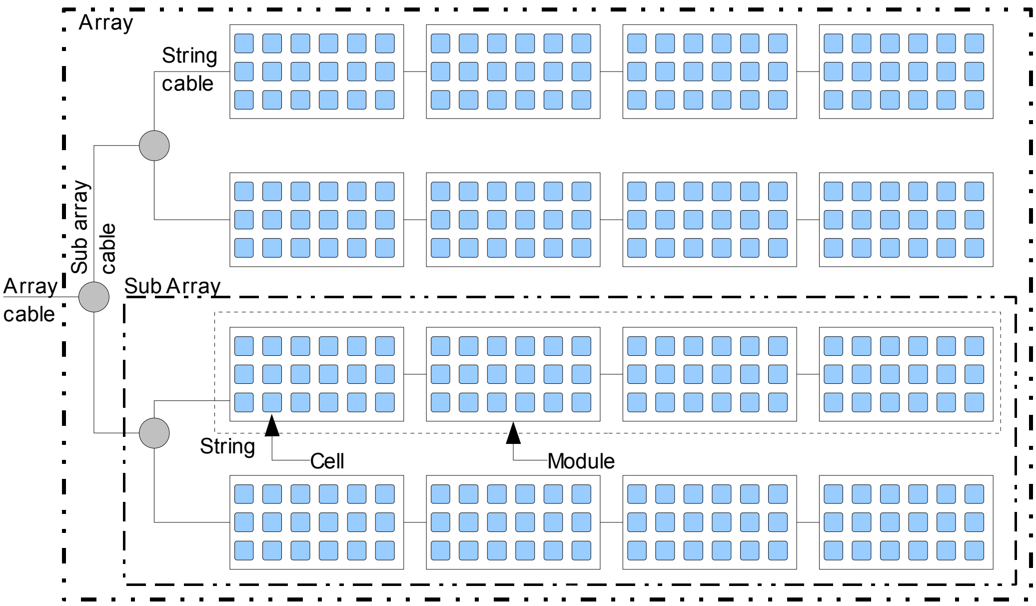


Figure 11: PV array configuration and naming conventions

6.3.1 Matching power conditioning unit to array

The device that converts or regulates the power produced from a PV array (generically known as a “power conditioning unit” in the standards) should be sized to suit the voltage and power output of the array. This is discussed in more detail in previous sections:

- Standalone power system – charge regulator for d.c. coupled systems or inverter for a.c. coupled systems. Section 4.9
- Grid-connected inverter systems – grid-connect solar inverter. Section 5.3.1

6.3.2 Protection

6.3.2.1 Diodes

AS/NZS 5033	**2.2**

Diodes are commonly installed with-in PV modules to reduce the effects of cell shading and to protect cells from damage caused by reverse currents. Generally these diodes are installed by the PV module manufacturer but if they are installed by a system installer then the guidance in the standard should be followed.

Diodes can also be used as a blocking device to prevent reverse current from a battery (usually integrated into the charge controller) or from other PV strings. They are not a substitute for string fault current protection covered in section 6.3.2.2.

If using blocking diodes installers should consider:

- The appropriate rating and other considerations of the standard

AS/NZS 5033	2.3

- The energy losses that will result from a diode
- The energy yield loss as a result of a failed diode

6.3.2.2 Fault current protection

AS/NZS 5033	2.4.1 & Table 2.1 4.0

For arrays with multiple modules or strings of modules connected in parallel fault current protection may be required in the string cables dependant on the number of parallel strings and the maximum allowable reverse current of the module ($I_{MOD\ REVERSE}$). Using Table 2.1 in the standard the allowable number of parallel strings without fault current protection can be determined (N_P).

Table 4 Summarises when fault current protection is required in each part of a PV array. This table should be read in conjunction with the standard.

	LV array	ELV array	Clause
String cable	Required when number of parallel strings or modules is **greater** than N_P	Required when number of parallel strings or modules is **greater** than N_P and the array is **not** fire safe	**2.4.3 Table 2.1**
Sub array cable	Always required	Required when not fire safe	**2.4.4**
Array cable	Required when connected to batteries	Required when connected to batteries	**2.4.5**

Table 4: Requirement for fault current protection

Fault current protection devices should be rated according to the requirements of the standard. Special attention should be paid to the characteristics of a fault current protection device. PV arrays are current limited devices meaning that fault currents will be limited, some fuse types may not trip at the expected fault currents.

The location of fault current protection devices can be determined from Table 2.2 in the standard.

AS/NZS 5033	2.461 & Table 2.2

6.3.3 Disconnection

A device to disconnect the PV array from the “power conditioning unit”, i.e. the inverter or charge controller will be required in most situations. Consideration should be given to:

- The location of the device — AS/NZS 5033 | Table 2.4
- The type and rating of the device — AS/NZS 5033 | Table 2.3 4.0
- Combination of disconnection and overcurrent devices — AS/NZS 5033 | 2.5.2
- Segmentation of LV arrays — AS/NZS 5033 | 2.5.4

Note:

- There is some confusion about the requirement for a PV array disconnection device on the roof of a building adjacent to the PV array. This has recently been clarified by the EL-042 Standards Committee and **it is not required**.

- It is necessary to disconnect some charge controllers from the PV array before the battery is disconnected from the controller to prevent damage to the controller. This should be considered in the design and installation of the system.

6.3.4 Earthing

AS/NZS 5033	**5.0 2.6 Appendix C, D & E**

The complete system should be considered when determining both protective earthing and equipotential bonding requirements of PV arrays.

6.3.4.1 Protective earthing

AS/NZS 5033	**Appendix D**

There are various views on this internationally with the United States requiring earthing of all arrays while European countries prefer floating arrays. Discussion of the merits of various earthing options are presented in AS/NZS 5033.

AS/NZS 5033	**Appendix C**

Further discussion is provided on the analysis of earth faults.

AS/NZS 5033	**Table 5.1 Figure 5.4 Figure 5.8**

While there is no specific requirement in the New Zealand Standards to earth a PV array, it should be noted that in some configurations earthing of the array is prohibited or considered dangerous. Depending on the PCU used some configurations may result in the array effectively being earthed.

There are no specific requirements to earth a PV array. If an array is to be earthed consider the following:

Point of connection of the earth	**AS/NZS 5033**	**5.1.2**
Sizing of the earth cable	**AS/NZS 5033**	**5.1.3**
Earth fault protection requirements for different array voltages and earthing configurations.	**AS/NZS 5033**	**2.6 Table 2.5**

6.3.4.2 Equipotential bonding

AS/NZS 5033	**5.4 Figure 5.9**

Dependant on the PV modules used in the installation and the configuration and characteristics of the cabling equipment, earthing (bonding) may not be required. The decision tree in the standard can be used to determine the requirements.

Equipotential bonding is an important aspect of lightning protection when required. See section 6.4.

Note: The construction of some PV module frames can result in each side of the aluminium frame being insulated from the other. As a result it may be necessary to bond each side of the module frame in some instances.

6.3.5 Wiring

AS/NZS 5033 AS/NZS 3008.1.2	**3.0 General**

All PV array wiring should comply with AS/NZS 3000. AS/NZS 5033 provides guidance on how to comply with AS/NZS 3000 and also has additional requirements specific to PV arrays. For general cable sizing and selection requirements AS/NZS 5033 refers to AS/NZS 3008.1.2.

For general wiring design and installation consider:

- The minimisation of line to line, line to earth faults and conductive wiring loops
- Mechanical protection of cables

Sizing and specification of cables and components should consider

- Current carrying capacity

- Voltage drop
- Required physical properties of cables for insulation and environment conditions

Useful summaries and case studies are provided in the standard.

AS/NZS 5033	Table 3.1 Appendix J

Earth fault protection requirements should be considered when selecting cable for PV arrays. A summary of requirements is given in the standard.

AS/NZS 5033	Table 2.5

Consideration should be given to the component and product requirements, see section 6.7.

See section 6.5 for labelling requirements.

6.4 Lightning protection

AS/NZS 5033 AS/NZS 1768 AS 4509.2	2.8 General 3.8 Appendix E

Lightning protection may be required in some parts of New Zealand and is dependent on:

- The type of structure
- The construction
- The height of the building/array
- The topographical situation
- The prevalence of lightning

Generally a PV array will not increase the risk of lightning strike and if a building is not required to have lightning protection, in most situations a PV array will not require protection.

The appendix of the standard gives guidance on lighting protection measures the ways to reduce the effects of lightning such as the minimisation of d.c. wiring loops, surge arrestors and equipotential bonding, also see section 6.3.4.2.

Appendix F

6.5 Signs and labelling

In addition to the requirement for labelling and signs for stand-alone power systems the are additional requirements for PV arrays. Labelling should include:

AS/NZS 5033 AS 1319 AS/NZS 3000	6.0 General General

• PV array wiring	AS/NZS 5033	3.5
• Earthing conductors	AS/NZS 5033	5.1.3 5.1.4
• Junction boxes	AS/NZS 5033	6.2
• Disconnection devices	AS/NZS 5033	6.3
• Emergency services	AS/NZS 5033	6.4
Some examples of signs are provided in the standard.	AS/NZS 5033	Appendix G

6.6 Documentation

See the relevant sections in SPS and grid-connected inverter systems.

Stand-alone power systems – section 4.18

Grid-connected inverter systems – section 5.5

6.7 Product and component standards

General requirements for components used in PV arrays are provided in AS/NZS 5033.

AS/NZS 5033	**4.0**

In particular, the requirement that PV modules comply with the reliability and equipment classes of the referenced international product standards. Amendment 1 of AS/NZS 5033 has added additional requirements for equipment class that will be effective from June 2009.

Note: The product standard requirements are dependant on the voltage and power of the PV array.

AS/NZS 5033 **IEC 61730.1** **IEC 61730.2** **EN 61730.1** **EN 61730.2** **IEC 61215** **IEC 61646**	**4.1.1** **4.1.2**

The Clean Energy Council maintains a list of modules that are sold in Australia and are currently certified to the appropriate standards. While not all brands distributed in New Zealand are distributed in Australia this list should provide a useful reference.

www.bcse.org.au/default.asp?id=233

6.8 Structural

AS 4509.2 **AS/NZS 5033**	**4.2.2** **Appendix B**

Photovoltaic arrays need to be capable of with standing the forces that are applied to them over the installed life of the array and the environmental conditions where they are installed. The following loads should be considered:

- Wind load - The greatest force will usually be a suction force from wind flowing over the array. The Wind Code can be used to calculate this force.

AS/NZS 1170.2	**General**

- Snow load – In some locations snow loads may be significant and should be considered

AS/NZS 1170.3	**General**

- Dead load (weight of the array and framework)
- Thermal expansion and contraction

The worst case combinations of these load scenarios should be determined and the ability of the array to withstand them checked.

- The array frames structural ability to withstand the loads discussed above can be determined by a structural engineer or similarly qualified person. Consideration should also be given to dynamic loads and vibrations particularly as a result of wind loading and thermal expansion.
- PV modules are tested to either 2400kPa or 5400kPa as part of certification to IEC 61215 or IEC 61646. The design pressures should be compared to the test pressure for the PV module. PV modules should be attached to the array frame as specified by the manufacturer or warranty may be voided. Drilling holes in the module frame or attaching to the module frame may result in higher stresses that could cause failure of the module in extreme circumstances.

Figure 12: Wind rated solar PV array frames (Elemental Energy, Powersmart)

Often the most practical and cost effective solution is to use a pre-engineered framing system that has been design to withstand the expected snow and wind loads.

Roof penetrations and attachment of the frame to a building or another structure should be considered.

- Roof penetrations should be waterproof and durable. Guidance on some acceptable roof penetrations are provided in the solar water heating acceptable solution.

NZBC	**G12/AS2**

- The fixing of an array frame to a building rafter, purlin or similar can impose loads on the structure that it would not otherwise see. Some guidance on this is provided in the solar water heating acceptable solution. If in doubt a structural engineer should be consulted.

NZBC	**G12/AS2**

- Areas of high pressure on a roof (e.g. near the ridge and edges)

6.9 Maintenance

AS/NZS 5033	**Appendix H**

Guidance on safely carrying out maintenance on a PV array and the maintenance that should be periodically completed is provided in AS/NZS 5033.

6.10 Commissioning tests

AS/NZS 5033	**8.0 Appendix I**

There are specific requirements for the testing of PV arrays before operation. Guidance on commissioning tests that should be carried out before handing over a system to the owner are provided in the standard.

7.0 WIND TURBINE GENERATORS

Small and micro wind turbine generators are commonly used in stand-alone power systems and increasingly in grid-connect inverter systems where there is a good wind resource.

This guidance document covers micro wind turbine generators only.

The document does not distinguish between requirements (SHALLS) and best practice (SHOULDS) in the Standards as requirements are often conditional and best covered by the standard itself.

The Standards should always be referred to when clarifying requirements.

7.1 Relevant standards summary

There are no New Zealand standards that exclusively cover small wind turbine generators. Relevant standards are shown in Figure 13.

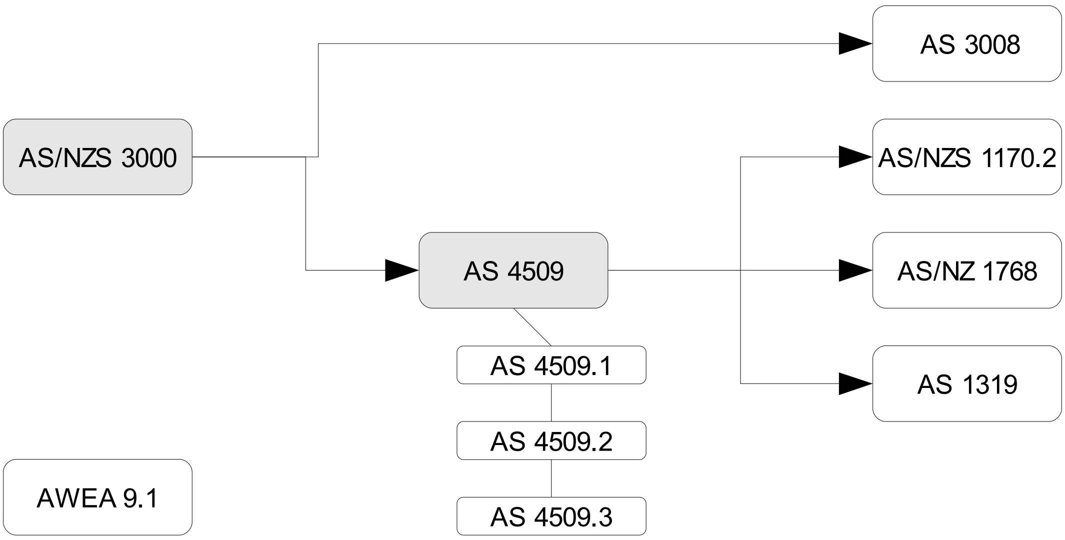


Figure 13: Micro wind turbine generators standards map

A standard developed by the American wind energy association for micro wind turbine generators has been adopted in America and the United Kingdom and may be useful as a reference for those involved in micro wind turbine generators in New Zealand.

7.2 Siting and energy yield estimation

AS 4509.2 **AS 4509.3**	**4.3** **4.2**

Geographic locations around the country will have varying average wind speeds, while of some use in determining expected energy yield average wind speeds will be significantly affected by siting of the turbine. To ensure optimal performance the affect of local obstructions such as hills, trees and buildings which can reduce the average wind speed and increase turbulence should be considered. Turbulence will also affect turbine life and noise levels.

Obtaining accurate weather data for the site is important to accurately predict performance of the turbine. Further guidance on weather data is provided in section 4.4.2 and in Appendix A.

Using the power curve for the turbine (which can be provided by the manufacturer) and the wind characteristics average daily energy yield can be determined for each month.

w w w .bcse.org.au/default.asp?id=96

Further guidance on siting can be found in the BCSE Design Guide and Wind Energy Conversion Systems training material (see section 9.0)

Sizing and energy yield estimation for wind turbine generators is discussed in the relevant sections of SPS and grid-connected inverter systems.

AS 4509.2	4.7

Local council district plans will have requirements on maximum height limits and noise levels. The turbine's noise characteristics as provided by the manufacturer can be compared to the council's noise limits. Comparison should be made at the boundary of the property and consideration given to the ambient noise levels at the site for various wind speeds.

EECA Council Guidance Document..

Further information on resource consent considerations is provided in council guidance document produced by EECA.

7.2.1 Grid-connected

The sizing of grid-connected wind turbine generators systems and calculation of annual energy yield is discussed in section 5.3.2

7.2.2 Stand-alone Power System (SPS)

The yield of a wind turbine generator in a SPS is not typically calculated for an annual basis. The focus when designing a SPS system is to size an wind turbine generator to meet the desired or optimal percentage of daily energy requirements for the worst time of year, i.e. when the ratio between energy generation and energy demand is the lowest.

Further discussion of the sizing of SPS wind turbine generators is provided in section 4.7.2.

7.3 Regulation and control

The device that converts or regulates the power produced from a wind turbine generator (generically known as a “power conditioning unit” in the standards) should be sized to suit the voltage and current output of the turbine. This is discussed in more detail in previous sections:

AS 4509.2	3.4.8.3

- Standalone power system – charge regulator for d.c. coupled systems or inverter for a.c. coupled systems. Section 4.9
- Grid-connected inverter systems – grid-connect inverter. Section 5.3.2

Overvoltage devices may be required to prevent damage to controllers and inverters. For example if a turbine or turbine regulator relies on a connection to a battery bank to clamp voltage below a safe level a means to protect the turbine and regulator should be provided in case the battery bank is disconnected. Warranties of regulators and inverters may be void if the input voltage is exceeded. In this situation overspeed protection for the turbine may also be required, this may be incorporated into the turbine or a suitable component should be recommended by the manufacturer.

7.4 Wiring, protection and isolation

All wind turbine generator wiring, protection and isolation should comply with AS/NZS 3000.

7.4.1 Wiring

For general cable sizing and selection requirements refers to AS/NZS 3008.1.2 or AS/NZS 3000 clause C4.1-

Generally for wiring design and installation should consider:

- The minimisation of line to line, line to earth faults
- All wiring should be protected from mechanical damage and other “external influences” such as sunlight and heat. This is covered in detail in The New Zealand Wiring Rules.

AS 4509.3 AS/NZS 3000	2.2 Including: 3.3, 3.9 & 3.10 7.3.5.1

Sizing and specification of cables and components should consider

AS/NZS 3008.1.2	general

- Current carrying capacity
- Voltage drop
- Required physical properties of cables for insulation and environment conditions.

7.4.2 Protection

Cable and devices should be protected against overcurrent

AS 4777.1 AS 4509.2	Figure 2 3.6.4

Overvoltage devices may be required to prevent damage to controllers and inverters. For example if a turbine or turbine regulator relies on a connection to a battery bank to clamp voltage below a safe level a means to protect the turbine and regulator should be provided in case the battery bank is disconnected. Warranties of regulators and inverters may be void if the input voltage is exceeded. In this situation overspeed protection for the turbine may also be required, this may be incorporated into the turbine or a suitable component should be recommended by the manufacturer.

7.4.3 Isolation

AS 4509.2	3.7.2

The wind turbine generator should be capable of being isolated from the system.

See section 5.2.3for isolation requirements for grid-connect inverter systems.

See section 4.15.2 for isolation requirements for SPS.

7.5 Lightning

Lightning protection will normally be required for wind turbine generators and is dependant on:

AS/NZS 1768 AS 4509.2	General 3.8 Appendix E

- The type of structure
- The construction
- The height of the building/array
- The topographical situation
- The prevalence of lightning

AS/NZS 1768 provides a means to assess the risk and if required a guidance on the design and installation of a lightning protection system.

7.6 Structural

Wind turbine generators need to be capable of withstanding the wind forces that are applied to them over their installed life and the environmental conditions where they are installed. Expected maximum wind speeds can be determined from the wind code.

AS/NZS 1170.2 AS 4509.2	General 4.3.3

The worst case wind speed should be determined and the ability of the wind turbine generator and tower, including its foundation to withstand this wind speed checked.

Component	Requirements	How to determine compliance
Wind turbine generator	The survival wind speed of the turbine is greater than the maximum expected site wind speed	Compare wind turbine generator manufacturers survival speed to maximum expected site wind speed
Tower or mast Guyed	Tower, guy wires and guy wire attachment to ground capable of withstanding load applied from turbine and wind at maximum site wind speed	1. Designed by structural engineer 2. Pre engineered design supplied by tower or turbine manufacturer/ supplier
Tower or mast Free standing	Tower, and foundation capable of withstanding load applied from turbine and wind at maximum site wind speed	1. Designed by structural engineer 2. Pre engineered design supplied by tower or turbine manufacturer/ supplier

Table 5: Structural requirements of wind turbine generators and towers

Often the most practical and cost effective solution is to use a pre-engineered tower and foundation that has been design to withstand the expected wind loads.

Towers and foundation design should also be resistant to fatigue stress and non-resonant under normal operating conditions.

7.7 Product standards

There are no specific micro wind turbine generator standards in New Zealand. All electrical devices are required to comply with New Zealand regulations. They should operate in a safe manner both electrically and mechanically.

AS 4777.2 **AS 4777.3**	**General**

Where a wind turbine generator incorporates an inverter the inverter and grid protection device should comply with AS 4777.2 and AS 4777.3

w w w .aw ea.org

The American Wind Energy Association (AWEA) has published a draft standard " AWEA Small Wind Turbine Generator Performance and Safety Standard". This standard has also been adopted by the British Wind Energy Association. This standard provides a means to assess the safety, reliability and performance of small wind turbine generators. It includes:

- Performance testing
- Acoustic sound testing
- Strength and safety
- Duration tests
- Reporting
- Labelling

This standard can be downloaded from the AWEA website.

www.awea.org/smallwind/standard/Small_Turbine_Standard_Draft_Document.pdf

Generally wind turbine generators including their control systems should provide a means of preventing overvoltage and overspeed of the wind turbine generator in high wind or no load operation.

There have been cases of poor quality turbines and turbines with exaggerated performance claims. Turbines should be robust and operate to the specified power curve. The theoretically maximum power of a turbine at a given wind speed is 59% of the available power of the wind over the area of the blades.

$$Maximum\ power = \frac{C_p}{2} \times \rho \times A \times v^3$$

$$Where:$$

$$C_p = coefficient\ of\ performance\ (Betz\ limit = 0.593)$$
$$v = wind\ speed$$
$$\rho = air\ density$$
$$A = swept\ area\ of\ rotors$$

Note: Small wind turbine generators are likely to have a C_p = 0.4 or less

8.0 HYDRO

Micro hydro turbines can be a very effective means of generating power when a suitable water resource is available. When installed correctly they can operate reliability and have little or no effect on the environment.

The document does not distinguish between requirements (SHALLS) and best practice (SHOULDS) in the Standards as requirements are often conditional and best covered by the standard itself.

The Standards should always be referred to when clarifying requirements.

8.1 Siting

AS 4509.2 AS 4509.3	5.0 4.4.1

The turbine location should be chosen to obtain maximum head and be a practical distance from the dwelling where the power will be used.

EECA Council Guidance Document..

The use of water in New Zealand comes under the Resource Management Act. Consent may be required from the regional council that administers that area. Some guidance on the RMA and council consenting is provided by EECA. Consideration should be given to:

- Provision for fish to move up and down the stream where fish are present
- Flood levels
- Scouring from outlet water or as a result of the intake structure
- Not significantly affecting the flow of the watercourse
- Diverting less than 50% of the flow of the stream when it is at its driest
- Returning water to the same natural catchment from where it was diverted

8.2 Regulation and control

The device that converts or regulates the power produced from a micro hydro turbine (generically known as a “power conditioning unit” in the Standards) should be sized to suit the voltage and current output of the turbine. This is discussed in more detail in previous sections:

AS 4509.2	3.4.8.4

- Standalone power system – charge regulator for d.c. coupled systems or inverter for a.c. coupled systems. Section 4.9
- Grid-connected inverter systems – grid-connect inverter. Section 5.3.3

Overvoltage devices may be required to prevent damage to controllers and inverters. For example if a turbine or turbine regulator relies on a connection to a battery bank to clamp voltage below a safe level a means to protect the turbine and regulator should be provided in case the battery bank is disconnected. Warranties of regulators and inverters may be void if the input voltage is exceeded. In this situation overspeed protection for the turbine may also be required, this may be incorporated into the turbine or a suitable component should be recommended by the manufacturer.

8.3 Estimating energy yield

AS 4509.2	3.4.5 3.2.4

Provided seasonal variation hydro resource is allowed for micro hydro turbines will provide predictable and consistent power to a stand-alone power system all year around. Manufacturer's recommendations should be consulted and a turbine chosen to suit the site conditions and available flow and head of the hydro resource.

In summary sizing of hydro turbines should consider:

- Hydraulic losses in the pipe work and losses from fouling over time
- Cable losses between the turbine and batteries
- Seasonal resource variations

- The characteristics of the turbine at the available head and flow, including efficiency

More information is provided on hydro resource in section 4.4.3

Information on sizing hydro generators for SPS is provided in section 4.7.3

Information on estimating yield of hydro generators in grid-connect systems is provided in section 4.7.3

8.4 Structural

The installation of all equipment should be designed to be capable of withstanding the likely operational loads, flooding and other environmental conditions.

8.4.1 Pipes

AS 4509.2	4.4.2

Consideration should be given to:

- Designing for the static pressures in the pipe and others loads likely to be experienced. Pipe manufacturers should be able to give rated pressures for pipes
- UV and other environmental factors
- To avoid creating a syphon or areas that could result in air pockets
- Adequately supporting the pipe

8.4.2 Water intake

AS 4509.2	4.4.3

The water intake should be designed to prevent fish, invertebrates and other objects from entering the penstock. Where there are fish in the stream the intake structure should not prevent free movement up or down the stream.

8.5 Product standards

There are not specific product standards for micro hydro turbines in New Zealand. All electrical devices are required to comply with New Zealand regulations. They should operate in a safe manner both electrically and mechanically.

8.6 Software

See Appendix B

9.0 OTHER SOURCES OF INFORMATION

SEANZ – **www.seanz.org.nz**

BCSE design guides - **www.bcse.org.au/default.asp?id=96**

Manufacturers' information and guides

Books:

Wind Energy Basics – A Guide to Small and Micro wind systems – Paul Gipe Chelsea Green

Wind energy conversion systems – Resource book for training modules NUER 06 & 14 (distributed by Qld Textbook Warehouse, Brisbane, ISNB 1 876 880 11 2. this can also be purchased from www.standards.com.au)

Planning and Installing Photovoltaic Systems: A Guide for Installers, Architects and Engineers (Second Edition, **By Deutsche Gesellshaft Fur Sonnenenergie (DGS)**, Eathscan

Photovoltaics for Professionals: Solar Electric Systems Marketing, Design and Installation **By Falk Antony, Christian Durschner and Karl-Heinz Remmers**, Eathscan

Planning and Installing Micro Hydro Systems: A Guide for Installers, Architects and Engineers, **By Gavin D. J. Harper**, Eathscan

Stand-alone Solar Electric Systems: The Earthscan Handbook for Planning, Design and Installation, **By Mark Hankins**, Eathscan

APPENDIX A RENEWABLE RESOURCE DATA SOURCES

Source	Solar	Wind	Hydro	Notes
National Institute of Water and Atmosphere (NIWA) – Cliflo	Varies by site. Normally at least global radiation in the horizontal plane	Varies by site. At least an average monthly wind speed.	Rainfall	**cliflo.niwa.co.nz** Weather data can be downloaded for a number of sites around the country. The system designer should attempt where possible to gain average data from this site as solar radiation levels will vary on an annual basis.
NASA	Global radiation in the horizontal plane			**eosweb.larc.nasa.gov/sse/** Satellite weather data can be obtained for specific latitude and longitude Note: Satellite weather data may vary from ground measurements.
Meteonorm	Hourly, global, diffuse and direct radiation. With the ability to be synthesised for other sites			**www.meteonorm.com** Weather data for over 8000 sites internationally with the ability to interpolate for any site in the world.
Retscreen	Monthly average global radiation	Average monthly values		**www.retscreen.net** Combination of satellite and ground measurements for many sites around NZ
HERS weather files	Hourly direct, diffuse and global radiation	Hourly averages		**www.seanz.org.nz** Hourly normalised weather data for 16 centres around the country. Available from EECA and from the SEANZ website in text file format

APPENDIX B SOFTWARE TOOLS

Software		Solar		Wind		Hydro		Notes
	Free	SPS	G.C.	SPS	G.C.	SPS	G.C.	
Retscreen								**www.retscreen.net** Retscreen is an excellent free tool for feasibility simulation and basic design
Homer								**analysis.nrel.gov/homer/** HOMER is a computer model that simplifies the task of evaluating design options for both off-grid and grid-connected power systems for remote, stand-alone, and distributed generation (DG) applications. Homer provides tools to evaluate the financial performance of various options as well as energy yield.
PV watts								**www.nrel.gov/rredc/pvwatts/** NREL's PVWatts^{TM} calculator determines the energy production and cost savings of grid-connected **photovoltaic (PV) energy** systems throughout the world.
AEP tool								**http://www.smallwindindustry.org/index.php?id=124** Excel based tool for calculating energy yield of grid-connected wind turbine generators
PVsyst								**www.pvsyst.com/** PVSYST 4.35 is a PC software package for the study, sizing, simulation and data analysis of complete PV systems. It is suitable for grid-connected, stand-alone, pumping and DC-grid (public transport) systems, and offers an extensive meteorological and PV-components database.
PVsol								**www.valentin.de/** A Dynamic Simulation Programme for the Design and Calculation of Stand-Alone and Grid-connected Photovoltaic Systems