Energy Efficiency Best Practice in Housing

Installing small wind-powered electricity generating systems

Guidance for installers and specifiers

- Systems from 500W to 25kW capacity
- Best Practice guidance on system design and installation
- Direct-connected, battery and grid-connected systems

Contents

Note:
This guide outlines industry Best Practice. There are, however, a number of mandatory obligations in this area. Text printed in blue, therefore, refers to mandatory and/or widely recognised standards.

1. Small wind-power systems

This guide aims to provide system designers and installers with sufficient information to ensure that small wind energy systems comply with current UK standards and with industry Best Practice. 'Small' in this context means between about 500W and 25kW output, though most parts of this guide also apply to systems of other sizes.

There has been little previously published on this topic and this document includes new requirements - based on extensive consultation with industry and a review of Best Practice - that are not set down in any other source. The guide also makes extensive reference to the many UK standards (such as the CE mark) which apply to this type of equipment.

Ensuring safety

The long term safety of the wind turbine depends on a number of issues that both designer and installer must address. Potential hazards need to be identified and systematically eliminated or minimised. This does not just include those which may be present during installation but also any that may develop over time. This guidance document is divided into a number of sections. Sections 2 and 3 cover issues that need to be addressed during the design phase of the project. Many of these will have an impact on the installation process, which is the focus of the later sections. These deal in particular with safety aspects of the installation.

System design: long term safety cannot be achieved unless both the system as a whole and each component individually are correctly designed and specified. The design process must include a consideration of normal and faulted operating conditions.

Safe working: poor installation can compromise the long term safety of the system. Equally, unsafe site and working conditions can put installation engineers at risk. Correct design of the system as well as thorough planning of the installation phase will help to ensure the quality of the installation as well as the safety of the work team.

Installers need to take note of their statutory duties under health and safety law and while this guide covers the key issues it makes no claim to be exhaustive. Installers are responsible for ensuring compliance with the law.

The Construction (Design and Management) Regulations may also apply if more than four people will be involved in the construction work at any one time. The project is notifiable to the Health & Safety Executive if it will exceed 30 days or involve more than 500 person-days of work. However, there are exceptions to this.

Commissioning and testing: A comprehensive post-installation system inspection and testing regime will also be required if long term performance and system safety are to be guaranteed.

2. System siting and sizing

This guide is primarily concerned with the installation of small wind energy systems. However, a number of design-related issues, including the siting of the turbine and its size, will impact on its performance and are also likely to affect the installation process.

Keeping the customer informed

It is essential that the customer understands - or at least appreciates - all the substantive issues involved and their consequences. Customer satisfaction depends to an important extent on good communication. In particular, expected output and performance need to be carefully explained. Otherwise the customer could believe the system to be operating below normal and require remedial work, when none is necessary! The customer also needs to be made aware of factors, such as turbulence and obstructions, that may limit the available wind speed and hence the power output.

If the customer is fully involved with the installation process, they will be able to support the project in communications with the local planning authority and the local community.

The checklist detailed in Appendix A covers most of the relevant issues and it should be completed together with the customer.

Planning permission

The height and location of the wind turbine will affect whether planning permission is needed; in general, those with rotor diameters of more than two metres will require consent. If it is to be used purely for agricultural purposes on agricultural land, there may be a farming general consent covering the installation; however, the local planning office should still be contacted.

The planning authority may impose restrictions on the siting of a wind turbine. These are normally for two reasons:

- expected noise output
- visual impact on the landscape

The customer should be made aware of any restrictions that might occur.

In assembling information for the local planning authority, the latest planning guidance and recommendations should be taken into account.

In support of a planning application, installers should:

- advise customers to make contact with the local planning authority themselves
- urge customers to communicate with neighbours and the local community about the project at an early stage
- provide information to the authority on similar installations (location, equipment type, etc)
- provide appropriate drawings (electrical schematics for example)
- provide information on noise levels

Noise levels

Noise from small wind turbines can be categorised in two ways:

- aerodynamic noise from the rotating blades
- mechanical noise from the generator

Whether the noise is intrusive or not will depend on the level of extraneous background sound. Turbine noise increases with operating duty, but background noise is also likely to increase with stronger winds. In building-mounted turbines, mechanical vibrations may be transmitted through the structure and this may be experienced as audible noise.

Performance and output

The power available from the wind is related to the cube of the speed. In practice, this means that a 20% increase in wind strength will almost double the power available. It is therefore very important to maximise the incident wind on the turbine blades. Wind speed increases with height and even small increases in turbine height can produce significant improvements in performance.

The power available is also related to the square of the turbine rotor diameter. Increasing the diameter by 20% increases the available power by 44% for example.

Available power is proportional to the density of the air. Weather conditions and height above sea level will therefore affect output. This effect is, however, very small in comparison with the other two.

Wind speed

The first step is to assess the likely annual average wind speed. The Department of Trade & Industry (DTI) has modelled wind speeds for every square kilometre of the UK (the NOABL model). Although small turbines require much lower average speeds than large machines, the project's technical and economic viability will need to be carefully examined if the annual average speed is less than 4.5m/s.

The DTI figures will only provide an initial estimate, as topological features such as terrain, trees and buildings significantly affect wind strength over a given site.

Furthermore, two sites with the same annual average wind speeds may not produce the same amount of energy. Wind strength varies with the seasons, from day to day and even with time of day. So the wind speed distribution - that is to say, frequency and duration of different wind strengths - will affect output. The site with the greater range, i.e. more high speeds matched by lower speeds over the course of the year, will in fact generate more energy because of the cubic relationship between wind speed and power.

For small scale projects, the use of anemometers and data loggers to measure wind speeds over the course of a year is rarely cost-effective.

Other considerations

Wind direction: a turbine should be exposed to prevailing winds, i.e. the direction with the best overall combination of frequency and strength. In most UK locations, the prevailing winds come from the south west.

Obstacles: wind speed increases with height as the ground and objects close to it disrupt air flow. The 'roughness' of the ground is a measure of the way obstacles such as trees, buildings and the surface topography act to effectively slow down the wind.

Turbulence: the flow of the wind is disrupted when it passes over or around objects, so a turbine should be sited to minimise the influence of obstacles (ideally from all directions). Excessive turbulence may also cause fatigue and shorten a turbine's life.

Tower height: while greater height will increase energy output (higher wind speed and less turbulence, especially at sites of greater roughness), practical considerations such as cost and ease of lowering (for maintenance) also need to be taken into account. See Figure 1.

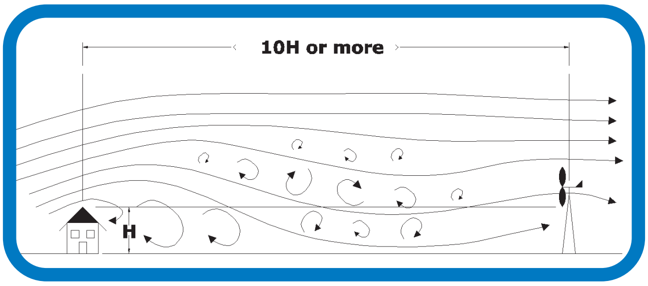

Figure 1: Ideally, the turbine should be sited well clear of an obstacle.

System losses: losses from cables, batteries, conversion in an inverter, etc, will all result in a reduction of overall energy output. Such losses occur in any energy production process.

Practical issues

The ideal site for a wind turbine is on a smooth, rounded and exposed hill-top or rise; one clear of any cliff faces and many metres from obstructions such as trees and buildings.

In practice this very rarely happens. A wind turbine must be reasonably close to the point of energy use, or to an electricity connection. Otherwise the cost of underground cabling may prove excessive. Location may also be limited by factors such as land ownership.

The key point is to keep the turbine clear of large obstacles, particularly in the path of the prevailing wind. This should take account of possible future obstructions such as tree growth.

Small wind turbines are sometimes mounted on buildings. In such situations, factors such as local turbulence, wind turbine type and structural issues need to considered. In addition, the associated noise and vibration levels will need to be taken into account, especially with regard to potential resonance that could be induced within the structure of the building.

3. System design

Figure 2 shows diagrammatically the components of the various small scale wind power systems considered in this guide and the order in which they are discussed here.

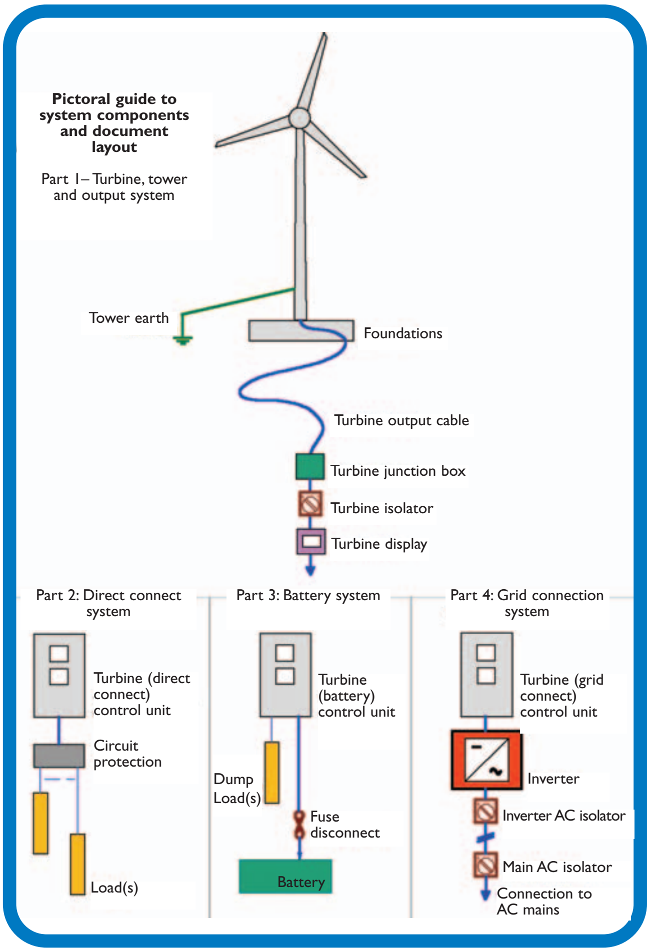

Figure 2: System components

3.1 Wind turbine, tower and foundations

The requirements of this part apply to all installations, whether grid-connected, battery or direct-connected systems.

Mechanical and structural requirements

Wind loading

The UK has a good wind resource, but severe winds occur occasionally. The turbine and tower must not become a health and safety risk due to mechanical failure caused by high winds.

The wind turbine and tower should at least be rated to withstand wind speeds that average 35m/s (78mph) over a 10 minute period without any damage to its operation.

The wind turbine and its support structure should be designed to survive a gust of at least 50m/s (112mph) without suffering any damage that might result in any or all parts of the turbine or tower falling to the ground.

Gusts of 50m/s are rare, but they must not result in catastrophic mechanical or structural damage; although it is accepted that systems may not function correctly afterwards. Manufacturers' instructions will normally require turbine inspection following severe winds. Wind speeds of 35m/s are more common and it is important that the turbine is designed to return to normal reliable operation after such events (in accordance with BS EN 61400-2). Some particularly exposed sites, or installations in public areas, may need to meet more stringent design requirements.

Turbine support structures

(a) General

The support structure is commonly supplied by the turbine manufacturer. This can be expected to be 'fit for purpose'. However, support structures from a third party will require detailed investigation, as well as consultation with the turbine manufacturers in regard to compatibility and suitability as follows:

- the support structure should be suitable for the particular turbine and shall be designed to prevent detrimental effects arising from movement or vibration
- all parts of the tower shall be corrosion resistant (e.g. made from galvanised or stainless steel)
- fixings must not loosen with vibration (use nylock bolts, for example)
- dissimilar materials must be isolated from each other to prevent electrolytic corrosion
- the design must ensure that any exposed moving parts are at least three metres from any point where persons or livestock may stand. it should also prevent unauthorised access
- towers should be designed in such a way as to prevent climbing by unauthorised persons (this is of particular relevance to lattice constructions)

(b) Foundations and anchor points
Concrete foundations must be made according to BS 8004 Foundations and BS 8110-1 Structural Use of Concrete - Part 1: Code of practice for design and construction. Key considerations include:

- the appropriate type and strength of concrete must be specified to suit site conditions and foundation requirements. These specifications are to be provided to the installer in the foundation instructions
- where steel reinforcement is incorporated, the requirements (including concrete cover at the edges) shall be provided in the foundation instructions
- foundations and anchor points shall be proportioned to suit local ground conditions
- foundations and anchor points shall be designed in such as a way as to prevent water pooling around the tower base or the anchors
- concrete must be thoroughly compacted with a vibrator or other means
- concrete must be worked around all parts and into all corners and voids.

N.B. Details of the foundation/anchor design - including size, ground conditions, etc - are to be included in documentation to demonstrate that the turbine support system can withstand the structural forces resulting from a 50m/s wind (see above).

(c) Guys
All shackles, turnbuckles, etc, shall be provided with the means to prevent loosening.

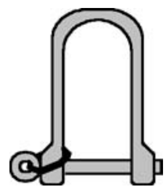

Figure 3: A shackle prevented from loosening.

Electrical requirements

Voltage and current - maximum values
In order to specify any part of the turbine electrical system, it is essential to know the maximum voltage and current output that can be expected - under normal or faulted operating conditions, and across the range of wind speeds it may encounter.

Different turbine designs vary in their response to normal and faulted operating conditions. Some designs may stall when the turbine is short-circuited, but not all. Factors such as generator design, magnet type, furling mechanism, etc, will all have an influence on the output current and voltage at different wind speeds and under different operating conditions.

It is important to note that the exact conditions under which the maximum voltage or current occurs are not important - the value is the key figure and must be known by the system engineer.

The following information should therefore be clearly stated in the turbine documentation supplied by the manufacturer or supplier:

$V_{(max)}$ - the maximum open circuit voltage that would be generated by the wind turbine at wind speeds between 0-50m/s.

$I_{(max)}$ - the worst case, maximum steady-state current (either during normal operation or into a short circuit) that would be generated by the turbine at wind speeds between 0-50m/s.

Turbine output cables
A turbine output cable must be able to withstand the environmental conditions, as well as the voltage and current, at which it has to operate. It must be rated to suit the environmental conditions along its entire route i.e. it should be UV-stable, waterproof, armoured, etc.

The turbine output cable must be rated for at least $V_{(max)}$ and $I_{(max)}$ (see above). This shall be calculated using standard correction factors for installation method, temperature, grouping and frequency, in accordance with BS 7671. Sizing the cable in this way ensures that the maximum potential fault current can be safely accommodated. Correctly sized cables will avoid the fire and safety risks associated with overloading.

In conventional systems, cables are protected by a fuse; this rapidly clears a fault before it becomes a fire or safety risk. With a wind turbine, however, the steady state fault current may be only a little more - or sometimes less - than the maximum operating current. In such cases, sizing a fuse to achieve disconnection under fault conditions is not possible. Instead, cable systems with suitable rating and protection are to be selected so as to minimise the risk of faults; Steel Wire Armoured (SWA) cables may be used, or the cables enclosed in protective conduit/trunking.

The turbine output cable should, in general, be sized so that the voltage drop along it (at the rated output power of the turbine) is less than 4%. In some circumstances, a voltage drop greater than 4% may be justified on economic grounds.

Turbine isolator
A turbine isolator manually isolates the electrical output of the turbine. This will be necessary during system installation and also for maintenance and repair work. A manual brake on the turbine is not sufficient to guarantee supply isolation - brakes may slip or even fail as the wind strengthens.

The turbine isolator must be a multi-pole device in order to electrically isolate all the wires coming from the turbine.

The isolator must be rated for operation at the maximum voltage and current of the turbine (see above).

N.B. Isolators need to be tailored to the machine. Open circuit, short circuit or dump load switching may be appropriate.

Anyone opening the isolator enclosure must be aware that turbine output cables can become energised at any time - indeed they often represent an additional energy source within a building.

The isolator enclosure should be clearly labelled "Danger, terminals may come live at any time". The enclosure should bear the label "Wind Turbine Isolator" with the ON and OFF positions clearly marked. All labels must be clear, easily visible and should be constructed and fixed so as to remain legible and in place throughout the design life of the system.

Turbine junction box

A turbine junction box may be required where turbine output cables are to be joined. It may also serve as a test point or a point of secondary isolation.

The box must be labelled "Wind Turbine Junction Box - Danger, terminals may come live at any time". All labels must be clear, easily visible and should be constructed and fixed so as to remain legible and in place throughout the design life of the system.

N.B. The environmental and fault protection provisions in the turbine output circuit must be maintained in the make-up and construction of any junction box.

Tower earth

(a) A turbine in proximity to existing lightning protection

Where a turbine is to be mounted on a structure or building with an existing lightning protection system (LPS), the installers of the LPS must be consulted so that the turbine can be correctly incorporated into the protection system, checking that no alterations to the LPS need to be made (changes to location or to the height of the air terminations for example).

(b) A turbine within an equipotential zone

Where a turbine is mounted within the equipotential zone of a building or other structure, the tower must be bonded to the installation's Main Earthing Terminal, in accordance with BS 7671.

Equipotential zone is defined in BS 7671 as: a zone in which exposed-conductive parts and extraneous-conductive parts are maintained at substantially the same potential by bonding, such that, under fault conditions, the differences in potential between simultaneously accessible exposed- and extraneous-conductive-parts will not cause electric shock.

(c) All other installations

The following apply in all other cases:

- the turbine tower is to be connected to a dedicated earth electrode. An electrode resistance to earth not exceeding 10Ω should be achieved, though may not be justifiable in some cases
- the earth electrode shall be placed as close as is practical to the tower base and it must be installed in such a way as to permit periodic inspection. Periodic inspection is important as a failure of this earth termination may have a serious impact on the system, not least in the transmission of lightning surges
- the connection between the tower and the tower earth should be made with copper cable (minimum CSA of $16mm^2$), taking a direct route and avoiding sharp bends
- separation between the turbine earth and building earth is to be maintained. This is to ensure that any direct strikes on the turbine (which may be in a particularly exposed location) are not coupled directly back to the building

Where steel wire armour is used for the turbine output cable, this should not intentionally or unintentionally be coupled to the tower earth and so bring the turbine earth inside the building. This could occur if a metal junction box is used to join cables within a steel turbine tower; the metal box would be coupled to the armoured sheath by the SWA gland and also coupled to the tower by direct contact. In such a situation, a non-conductive enclosure must be used.

Lightning protection

BS 6651 Code of practice for protection of structures against lightning describes how to assess the likelihood of damage. This may be caused either by a direct strike or through surges induced in cables from a nearby strike. Tower earthing (see above) provides one element of protection.

(a) Dedicated Lightning Protection Systems

If there is a risk of a direct strike, specialists should be consulted about installing a separate LPS in accordance with BS 6651.

(b) Surge protection

Cabling systems can be designed to provide a degree of surge immunity. The following measures will act to shield the cables from inductive surges and attenuate surge transmission (by increasing inductance):

- turbine output cables should be as short as possible, bundled together and not looped
- long turbine output cables (for example, those over 50m) should have an earth shield, which can be created by using earthed, armoured cable or earthed metal conduit/trunking

Surge suppression devices will give additional protection:

- where these are fitted to the turbine output cable, they should be attached at the tower base. In the case of long cable runs, they should be fitted at both ends
- where surge suppression devices are fitted to protect specific equipment, they should be fitted as close as is practical to the device
- surge suppression devices must be electrically safe and pose no electrical fire hazard

Metering

As a minimum, metering should be installed to display instantaneous power output and to record energy delivered by the wind turbine system. The meter can be fitted at any point in the system (e.g. it can record inverter output in grid-connected systems).

Consideration should be given to placing the meter where the consumer can read it. Not only will it add to customer satisfaction if the output can be viewed, but it should lead to more effective fault detection. A spinning turbine is not necessarily a working turbine and only metering can demonstrate correct operation.

Metering the loads in a battery system should also be considered.

For grid-connected systems to receive payment on exported electricity / ROCs, the installation of an export meter may be required, and this should be discussed with the nominated electricity supplier.

3.2 Direct-connected systems

In a direct-connected system, the turbine output is connected directly to the load. An example would be a wind heating system, where heater(s) run directly from the turbine as and when wind energy is available.

However, a typical direct-connected system will not usually supply the 240V, 50Hz sinusoidal AC for which most common electrical equipment is designed. All parts of such systems therefore need to be specified to the voltage and current maxima (as well as frequency) that can be expected. For example, with DC systems, protection or switching devices must be rated for DC operation; and in high frequency systems, additional de-rating factors may need to be applied to multi-core cables.

Turbine direct-connect control unit

This provides the interface between the turbine and the load. It may provide voltage transformation, rectification and progressive switching of loads as wind speed increases. In addition, it may incorporate other functions such as isolation or metering. Key considerations include:

- the control unit must be rated for the current and voltage maxima (see Section 3.1, Electrical requirements)
- it must be labelled "Supplied from wind turbine. Isolate at turbine isolator before carrying out work. Isolator situated ...."
- if a control unit incorporates specific functions described in Section 3.1 such as isolation, the relevant requirements of that section must be applied
- for wind speeds up to 35m/s, the system must be designed in such a way that no damage results to the control unit - or to the turbine - if all the loads are temporarily disconnected
- for wind speeds up to 50m/s, the control unit must be designed to minimise the risk to itself or the system, from fire or shock

Circuit protection

Conventional cable protection employs fuses to rapidly clear a fault before it presents a fire or safety risk. With a direct connect wind turbine system two issues need to be addressed:

- the steady state fault current may be a little more (or less) than the maximum operating current - hence fault currents may not trip any circuit protection sized to meet the operating current
- there may be no Neutral-Earth bond at the supply. Without such a link, a fault to earth cannot result in an earth fault current and subsequent tripping of circuit protection

A system designer needs to identify and implement a suitable protection method for direct connected circuits. Measures will vary from system to system depending upon the system voltage, turbine and load type. The designer, referring to BS 7671, needs to be clear as to the type of system being created e.g. TN-S, TT, PELV, etc.

Circuit protection should be designed to BS 7671 and the circuit protection devices (either fuses or MCBs) must be rated for operation at the voltage, current and frequency as supplied from the control unit.

Loads

Loads should be rated for operation at the voltage, current and frequency supplied from the turbine control unit. Circuit protection will be needed where loads and/or cabling are rated at less then the full turbine output (such as a system where ten 1kW heaters are run from a single 10kW turbine).

Labelling/signage

Where a wind turbine provides an additional source of supply within a building, circuit protection devices, loads and all points of isolation shall be labelled "Supplied from wind turbine. Isolate at turbine isolator before carrying out work. Isolator situated ...."

A circuit diagram marked with the contact telephone number for the supplier/installer/maintainer of the equipment shall also be displayed.

All labels must be clear, easily visible and should be constructed and fixed so as to remain legible and in place throughout the design life of the system.

3.3 Battery systems

In this guide, a battery system is one where the turbine charges, via a control unit, a battery bank. The design of any system connected to run loads from such a battery is outside the scope of this document.

Turbine battery control unit

This provides the interface between the turbine and the battery. It may provide voltage transformation, rectification and battery charge regulation. The unit may also function as a dump load controller, activating loads once the battery is fully charged. In addition, it may incorporate other functions such as isolation or metering. Key considerations include:

- the control unit must be rated for the current and voltage maxima (see Section 3.1, Electrical requirements)
- it must be labelled "Supplied from wind turbine. Isolate at turbine isolator before carrying out work. Isolator situated………………………………………………………"
- if a control unit incorporates specific functions described in Section 3.1 such as isolation, the relevant requirements of that section must be applied
- for wind speeds up to 50m/s, the control unit must be designed to minimise the risk to itself or the system, from fire or shock

Controller-battery cables

A full recharge is important for good battery health. A small size cable between the control unit and the battery - with an associated high voltage drop - may lead to the charge regulation control system prematurely disconnecting the turbine towards the end of the charge cycle.

The cables should therefore be sized for a maximum voltage drop of less than 1% at peak turbine output. For controllers with a separate battery sense function, a fused battery sense cable can be installed.

Battery over-current production

Significant amounts of energy are stored within a battery and these have the capacity to deliver large fault currents. Proper protection must be provided. Key considerations include:

- an over-current device must be installed in the positive wire between the battery and the turbine controller. The length of cable between the device and the main positive terminal on the battery must be as short as practicable
- the over-current device (either a fuse or circuit-breaker) must:
  - be sized so as to have a trip value less than the lowest cable current rating of:
    (i) the main turbine output cable
    (ii) cables within the turbine control unit, or
    (iii) the controller-to-battery cable.
- cable ratings are to be adjusted using standard correction factors for installation method, temperature, grouping and frequency to BS 7671, and must:
  - be rated for operation at DC, at 125% of the nominal battery voltage
  - have an interrupt rating greater than the potential battery short circuit current

Battery disconnection

A means of manual isolation must be provided for the battery, either combined with the over-current device or as a separate unit. The length of the cable between it and the battery must be as short as practicable. Isolation is to be installed and the system designed so that the turbine cannot directly feed the loads when the battery has been disconnected.

Battery selection

There are various approaches to what has been described as the 'black art' of battery selection, sizing and design. However, there are some key considerations:

- is the battery fit for purpose, i.e. appropriately rated for its duties? In the majority of cases a true 'deep cycle' battery will be required
- does it have an adequate storage capacity and cycle life?
- is a sealed or vented battery more appropriate for the particular installation?
- will the battery be made up of series cells or parallel banks? While series cells will generally give better performance, practical considerations may influence the design. In general, though, banks with more than four parallel units are to be avoided.

Battery sizing

For an effective charging regime where a wind generator is the only charge source, the battery would normally be sized so that the output of the turbine falls between the manufacturer's maximum and minimum recommended charge rates.

Charge/discharge rates (C) are commonly expressed as an hourly rate derived from the formula:

$$\text{Rate} = \frac{\text{Capacity (Ah)}}{\text{Time (h)}}$$

For example, a C10 charge rate for a 500Ah battery would take place at 50A.

Charge rates between C5 and C20 are often used in systems with vented lead acid batteries, for example.

Battery installation

In an enclosed location, ventilation must be provided to battery installations with an air inlet at low level and an outlet at the highest point in the room or enclosure.

Sufficient ventilation is needed to remove battery gases. It is particularly important in the case of vented lead acid units as hydrogen is given off during charging - a concentration of more than 4% creates an explosion hazard. Ventilation also prevents excessive heat build up.

BS 6133 Safe operation of lead acid stationary batteries gives a procedure for calculating ventilation requirements.

Battery banks must be housed in such a way that:

- access can be restricted to authorised personnel
- adequate containment is assured
- appropriate temperature control can be maintained

Battery terminals are to be guarded so that accidental contact with persons or objects is prevented.

The ideal operating temperature for a lead acid battery is around 25°C; temperatures significantly above or below this will lead to reduced lifetime and capacity. Indeed, at very low temperatures, discharged batteries may freeze and burst, while at high temperatures, thermal runaway can occur in sealed batteries. Items which could produce sparks (e.g. manual disconnects, relays) should not be positioned within a battery box or directly above one.

Battery gases are corrosive, so cables and other items inside a battery enclosure need to be corrosion resistant. Sensitive electronic devices should not be mounted in, or above, a battery box.

To ensure proper load/charge sharing in a battery bank made up of units connected in parallel, the units need to have the same thermal environment and the same electrical connection resistance.

In larger battery banks, fusing each parallel unit should be considered.

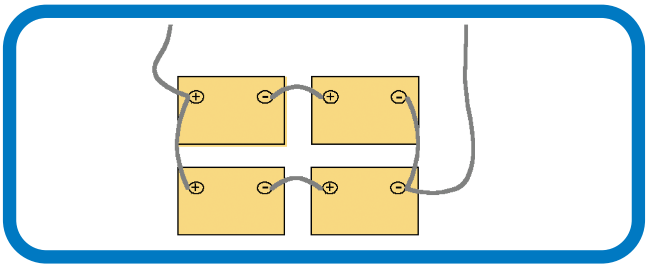

Figure 4: A typical connection configuration for a small parallel battery bank (take-offs are on opposite corners)

The following warning signs are to be displayed:

- No Smoking or Naked Flames
- Batteries contain acid - avoid contact with skin or eyes

All labels must be clear, easily visible and should be constructed and fixed so as to remain legible and in place throughout the design life of the system.

Protective equipment, including appropriate gloves and goggles - together with an eye wash and neutralising agent - should be stored adjacent to the battery installation.

Labelling/signage

Circuit protection, and all points of isolation shall be labelled with "Supplied from wind turbine. Isolate at turbine isolator before carrying out work. Isolator situated: …………………………………………………………"

A circuit diagram marked with the contact telephone number for the supplier/installer/maintainer of the equipment shall also be displayed.

All labels must be clear, easily visible and should be constructed and fixed so as to remain legible and in place throughout the design life of the system.

3.4 Grid-connected systems

Grid-connected systems generate electricity which is synchronised with the public electricity supply. Before connecting to the grid, installers must get written approval from the local Distribution Network Operator (DNO).

Guidance on connecting a small scale embedded generator (SSEG) can be found in Engineering Recommendation G83/1 Recommendations for the connection of small scale embedded generators (up to 16A per phase) in parallel with public low voltage distribution networks. Larger systems are covered in Engineering Recommendation G59/1 Recommendation for the connection of embedded generating plant to the regional electricity companies' distribution systems.

Systems are of two types:

(a) AC generator, connected via dedicated synchronisation and protection relays

(b) inverter connected

(a) Systems using an AC generator

A wind turbine with an AC generator can be connected to the network via synchronisation and protection control systems. These are not normally off-the-shelf or type-tested products.

Design, testing and commissioning of these systems needs to be done in full consultation with the DNO and in the light of G83/1 and G59/1.

The details of such systems are beyond the scope of this document although many sections of this guide (such as isolation and labelling) will apply.

(b) Inverter-connected systems

These commonly rely on a type-tested inverter and this provides the DNO with a relatively straightforward way to assess the system's suitability for connection. While G83/1 does not specifically set out details for wind power, the requirements for inverter-connected PV systems (G83/1 Annex C) are commonly adopted for wind systems.

Turbine grid-connect control unit

This provides the interface between the turbine and the grid-connect inverter. It can provide voltage control as well as rectification. It may also incorporate other functions such as isolation and metering. Key considerations include:

- the control unit must be rated for the current and voltage maxima (see Section 3.1, Electrical requirements)
- it must be labelled "Supplied from wind turbine. Isolate at turbine isolator before carrying out work. Isolator situated…………………………………………………"
- if a control unit incorporates specific functions described in Section 3.1 such as isolation, the relevant requirements of that section must be applied

- for wind speeds up to 50m/s, the control unit must be designed to minimise the risk to itself or the system, from fire or shock

Inverters

Inverters must carry a current Engineering Recommendation G83/1 Type Test certificate and comply with all other parts of G83/1, unless specifically agreed with an engineer who is employed by and appointed by the DNO for this purpose. This agreement must also be in writing.

Where G83/1 applies, inverters must be programmed so that the automatic protection system operates at:

- operating voltage greater than 264V phase to neutral
- operating voltage less than 207V phase to neutral
- operating frequency greater than 50.5Hz
- operating frequency less than 47Hz
- loss of mains

The inverter must also be capable of withstanding the maximum voltage and current output supplied by the turbine control unit for winds up to 50m/s.

A key safety concern is that the wind system should disconnect when the distribution system is not energised. This is to prevent the danger of the wind system feeding the network or local distribution system during a planned (or unscheduled) loss of mains. Such an event is known as 'islanding' and presents a potential hazard to those working on the network or distribution system. Type tests established by G83/1 ensure that an inverter is properly protected against islanding.

Larger systems

G83/1 covers systems up to 16A per phase. Above this level, the system designer will need to consult the DNO in order to determine the appropriate protection scheme. This may include an additional protection relay to the requirements of G59/1. However, G83/1 does give the DNO discretion to "use this engineering recommendation if it is considered more appropriate than G59/1".

AC isolator

Two AC switch disconnectors, in accordance with BS EN 60947-3 Specification for low-voltage switchgear and control gear, switches, disconnectors, switch-disconnectors and fuse-combination units, must be provided between the inverter and the point of interconnection to the supply. One is to be installed adjacent to the inverter and the other next to the point of interconnection. If they are to be in the same room, only the latter is required. They must:

- switch all live and neutral cables
- clearly show ON and OFF positions and be labelled as "wind system - point of emergency isolation"

The disconnector adjacent to the point of interconnection must also be lockable - in the OFF position only - and it must be readily accessible.

When connecting switching devices, the public supply is to be considered 'the source' and the wind installation 'the load'.

AC cabling

The inverter(s) must be connected, via a dedicated circuit, to a spare fuseway in the main distribution unit, or to a fuseway in an additional dedicated distribution board.

AC cables are to be specified and installed in accordance with BS 7671.

When generating, the voltage at the inverter terminals is slightly higher than that at the distribution board. This voltage drop must be kept to a minimum so that the protection systems operate correctly. To do this, the AC cable between the two should be oversized in order to keep the voltage drop small - a 1% drop is acceptable.

AC fault current protection

The short circuit current from an inverter is approximately equal to its full load current. Over-current protection devices cannot therefore distinguish between full load and fault conditions. Therefore short circuit protection is not feasible - or required - at the inverter output.

Short circuit protection for the dedicated feeder cable to the inverter(s) must be provided at the distribution board. This electrical protection is to be specified and installed in accordance with the requirements of BS 7671.

Labelling/signage

Labelling must be provided at the service termination, meter position and all isolation points in order to indicate the presence of on-site generation and to show the position of the main AC switch disconnector. A suitable design for the label is shown in Figure 5.

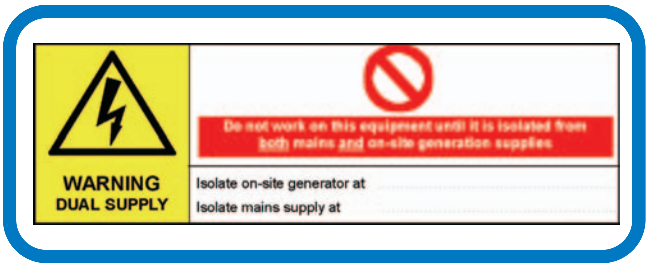

Figure 5: Example of sign showing the presence of on-site generation and the location of the isolators.

At the interconnection point, the following is also to be displayed:

- circuit diagram
- summary of protection settings that have been incorporated in the equipment
- a contact telephone number for the supplier/installer/maintainer of the equipment.

All labels must be clear, easily visible and should be constructed and fixed so as to remain legible and in place throughout the design life of the system.

4. Safe siting and working

Safe siting

The wind turbine should ideally be placed well clear of any buildings, obstructions and places where the public may gather (see Section 2, Practical issues).

It is clearly not always possible to achieve the ideal location. So the additional risks and Health & Safety considerations must be carefully weighed. Some manufacturers do offer extra safety features to minimise the - already small - risk still further.

Regarding safe siting, anchors and guy cables for towers should be well away from roads, tracks, footpaths, etc. If there is livestock on the site, then guyed towers, their cables and anchors should be protected by fencing.

Installation and operation

Health & Safety guidelines and conventional electrical installation practices apply also to the installation of wind turbine systems. Issues such as working at height and standard domestic wiring are covered in other publications and are not dealt with here. The following comments highlight ways to mitigate the particular hazards associated with the installation of a wind turbine system.

As part of standard Health & Safety practice, a Risk Assessment should be completed. This is a legal requirement under the Management of Health & Safety at Work Regulations 1999.

General issues

- Due regard should be given to any public rights of way close to the installation site
- The local situation should be taken into account, e.g. the likely presence of children
- Existing site services (e.g. overhead or underground electric cables) should be identified and exclusion zones defined
- Temporary signs, notices and barriers should be erected
- The local weather conditions should be considered
- Turbines should be maintained according to the manufacturer's requirements in order to minimise risk. It is recommended that maintenance is carried out by a suitably trained individual or individuals. Where turbines are located in public places, the customer should be encouraged to place the maintenance with representatives of the manufacturer

Turbine and tower - structural and mechanical works

- Structural and mechanical installation must be actively managed and supervised by a suitably experienced and competent person
- All workers involved in the works must be fully briefed on the sequence of operations before they commence. This is to include the identification of danger areas that must not occupied during the erection process
- All personnel must wear appropriate personal protective equipment, including high visibility jackets, hard hat and safety boots
- Anyone working at height must work to the requirements of the relevant statutory provisions, including the use of suitable access, fall prevention and fall arrest equipment
- During installation and maintenance works, an exclusion zone shall be established to prevent persons not engaged with erection of the turbine from gaining admittance
- Standard precautions for working with rotating machinery should be taken: long hair should be tied back; loose clothing avoided; rings, necklaces and other jewellery removed

Turbine electrical works

- All work is to be undertaken by experienced, competent and authorised personnel who are fully familiar with standard working practices within the electrical industry and who are acquainted with the maximum voltages present on the system being installed
- The turbine must be verifiably and effectively braked. Live working practices are to be adopted during the initial connection of the turbine to the main output cable (see Regulations 4(4), 14 and 15 of the Electricity at Work Regulations 1989 and also BS EN 6093 and BS EN 60900)
- Subsequently, the turbine isolator must be secured open for all other works on the electrical system. Relying solely on a mechanical turbine brake to prevent against shock is not acceptable

Working with batteries

- Appropriate personal protective equipment must be worn, including gloves and goggles. Metal items such as rings and neck chains should be removed before commencing work. An eye wash should be near to hand
- Tools for battery installation should be insulated and acid resistant. Spanners should be approved single-ended types
- Work on battery installations should be carried out in a pre-planned manner to minimise the number of conductors exposed at any one time
- Batteries should be adequately vented during works and any source of spark or open flame avoided.

5. Commissioning and testing

Inspection and testing of the completed system must be carried out to the requirements of BS 7671.

Accurate performance testing of a turbine is only possible where an anemometer reading at the hub height is available. For most small systems, such data will not be available. Readings from the system display meter will often be the only means to determine how well the system is working.

Test and inspection certificates modelled on BS 7671 and tailored specifically for use with wind systems are included in this guide as Appendix C. An installation and commissioning inspection checklist for the whole installation is also included (see Appendix B). This, or a similar document prepared by the installer, should be completed and a copy provided to the customer.

Grid-connected systems

DNO approval must be obtained in order to operate a grid-connected wind turbine. For smaller systems under 16A per phase, the process for notifying and gaining approval from the DNO can be found in G83/1. Though G83/1 does not specifically address wind systems, the notification requirements cover all small scale embedded generation.

For single systems of less than 16A per phase, the installer must inform the DNO on the day of connection and then provide full details on an Installation Commissioning Confirmation form (G83/1 Appendix 3) within 30 days. See Appendix D of this guide.

For larger systems, or sites where a number of turbines are to be installed in close geographic proximity, prior notification of the DNO is necessary.

6. Documentation

The following must be provided to the customer:

(a) turbine support structure specifications - including, where appropriate, an assessment of local ground conditions as well as the installation requirements, specification of materials, etc

(b) drawings, specifications and instructions for assembly, installation and erection

(c) an operator's instruction manual

(d) a maintenance manual

The following should be included in the operation, inspection and maintenance documentation:

(i) Installation

- details of all loads, weights, lifting points, special tools and procedures necessary for the handling, installation and operation of the system
- requirements for cranes, hoists and lifting equipment (including all slings, hooks and other apparatus) necessary for safe lifting
- checklist to confirm proper lubrication and pre-service conditioning of all components
- details of the manufacturer's recommended erection procedures
- identification of critical fasteners as well as details of procedures for confirming torque and other requirements
- a set of field assembly and installation drawings
- minimum design requirements for the foundation and anchor system
- a complete wiring and interconnection diagram

(ii) Operation

- details of safe operating limits
- a description of start and shutdown procedures
- procedures for functional checks on the protection subsystems
- a description of the subsystems and their operation

(iii) Inspection and maintenance

- maintenance and inspection cycles and procedures
- a schedule prescribing frequency of lubrication and type of lubricant or any other special fluid
- procedures for unscheduled maintenance and emergencies
- schedules for guy inspection and re-tensioning, bolt inspection and torquing (including tension and torque loading details)
- diagnostic procedures and a trouble-shooting guide

Documentation referring specifically to the wind turbine will usually be produced by the wind turbine manufacturer. The installer will make some additions - for example, the wiring and interconnection diagram.

Additional, system-dependent documentation requirements include:

- $V_{(max)}$ and $I_{(max)}$ calculations (see Section 3.1 Electrical requirements)
- battery maintenance schedules (watering, equalisation, etc)
- warranty information
- noise levels (see Section 2)
- design life of system parts
- a maintenance record sheet

Appendix A

System siting and sizing: customer information checklist

System siting and sizing: customer information checklist	Yes	No
Has a wind speed estimate been provided (usually annual average) including information regarding additional effects?		
Has information detailing the source of the wind speed estimate been provided?		
Has an estimate of system energy output (usually annual average) been provided?		
Has information, if required, on the approach used in the calculation of the energy output been provided?		
Is the estimate of energy output provided for the overall system, i.e. including losses?		
Have factors affecting performance and output been explained/understood?		
Has the site been assessed and the actual turbine location been chosen appropriately (based on specific site considerations)?		
Is the turbine out of turbulence zones?		
Is the turbine above nearby obstructions? Have the turbine noise levels been discussed and documentation provided? Has the installer provided information in support of any planning application?		

Appendix B

Installation and commissioning: inspection checklist

Installation and commissioning: inspection checklist

Description of system

(type of turbine and rating, generator, stand alone/grid connected - if stand alone what is the main use of energy, any special features)

	Yes	No
Turbine siting		
Is the turbine generally in a safe location? (e.g. without hazard to nearby buildings and structures)		
Has the recommended safe distance (3m) for exposed moving parts been adhered to?		
Turbine support structure and sitework		
Has turbine support structure wind loading been appropriately calculated?		
Are foundations appropriate to turbine & tower?		
Are foundations appropriately sized using appropriate materials?		
Are foundations protected from water pooling?		
Are turbine support structure fixings secure?		
Are all guy shackles and turnbuckles secured?		
Are guy anchors suitable?		
Is the turbine support structure protected against climbing?		
Is lowering equipment suitable and properly stored?		
Turbine installation		
Is the turbine installed to manufacturers' instructions?		
Is the turbine brake system working?		
Are turbine speed and vibration levels acceptable?		
Output cables		
Are cable sizing calculations provided by the installer?		
Are cables sized to provide voltage drop of <4%?		
If not, has this been justified?		
Are the cables of suitable current rating?		
Are the cables suitable for installation method (e.g. armoured, water resistant, UV stable)?		

Appendix B (cont.)

Installation and commissioning: inspection checklist	Yes	No
Are the cables properly installed and fixed with safe routeing (e.g. at sufficient distance from heat sources and sharp surfaces/edges)?		
Are turbine electrical connections sound and weatherproof?		
Turbine isolator		
Is the isolator correctly rated?		
Is the isolator installed correctly and all electrical connections secure?		
Are labels in place?		
Turbine junction box(es) if appropriate		
Is the junction box installed correctly and electrical connections secure?		
Is the junction box in suitable location, appropriate boxing (IP rating should be noted on documentation)		
Are labels in place?		
Earthing and lightning protection		
Is the turbine support structure earth correctly installed?		
Is lightning/surge protection correctly installed, if required?		
Turbine metering		
Is the metering system installed correctly and are all electrical connections secure?		
Has the metering system been explained to the customer?		
Turbine controller		
Is the control unit suitably rated for current and voltage?		
Is the controller installed correctly and all electrical connections secure?		
Is the controller in a suitable location, with appropriate boxing (IP rating should be noted on documentation)?		
Is any controller requiring heat dissipation suitably ventilated and mounted appropriately?		
Are appropriate labels in place?		
Documentation		
Has an Operation & Maintenance manual been supplied including problem diagnostics, contact details, maintenance schedule/record sheet, etc?		

Installation and commissioning: inspection checklist	Yes	No
Has an Operation & Maintenance manual been supplied including (where relevant) documented procedures for stopping turbine and lowering tower safely, battery maintenance?		
Have manuals for all specific equipment been passed to the customer (including controller, inverter, etc, as appropriate)		
Has all warranty information been passed to the customer, including system and all parts i.e. turbine, wiring, inverter/batteries?		
Has information on the system design been supplied to the customer, e.g. $V_{(max)}$, $I_{(max)}$, noise levels, electrical schematics and site layout / civil works drawings, design life of system parts?		
Has the installation certificate & test sheet (BS 7671) been supplied (as appropriate)?		
Grid-connected systems only: Has signed approval from DNO been passed to the customer?		
Grid-connected systems only: Has a print out of protection settings been supplied?		
Direct-connected systems **General design**		
Is the load suitable for intermittent operation and direct connection?		
Are the turbine voltage and current maxima within load limits?		
Is the controller suitable for application?		
Installation		
Are the dump heaters suitably mounted to prevent fire/burns and installed with high temperature cables?		
Are suitable fuses/isolation installed?		
Labelling/signage		
Are loads, fuses and points of isolation labelled?		
Are the system schematic and installer's contact details displayed?		
Are all signs suitably fixed and durable?		

Appendix B (cont.)

Installation and commissioning inspection checklist

	Yes	No
Battery systems		
General design		
Is battery over-current protection provided within the design?		
Is manual isolation of the battery (battery disconnect) provided within the design?		
Battery specification		
Has the battery manufacturer been contacted or their data reviewed for system recommended charge rates?		
Installation		
Is battery isolation installed such that turbine cannot directly feed the loads when the battery is disconnected?		
Is the battery in a secure, vented and appropriate location?		
Is the battery housed suitably and terminals protected?		
Are all the cables to the battery fused, with fuses as close as practicable to the battery?		
Are battery fuses rated for DC?		
Is the fuse rating less than (de-rated) cable rating?		
No fuse in common between wind turbine and DC load? (Where DC loads used)		
Are inverter and controls suitably housed, mounted and ventilated?		
Are DC cables sized for safety and voltage drop (particularly inverter cables)?		
Are DC cables safely installed/routed?		
Is AC wiring to BS 7671?		
Is there an isolator between battery and controller/inverter?		
Are battery voltage and turbine output meters installed and visible?		
Are dump heaters suitably mounted to prevent fire/burns and installed with high temperature cables?		
Labelling/signage		
Are battery installation labels present (no smoking etc)?		

Installation and commissioning inspection checklist

	Yes	No
Are fuses and points of isolation labelled?		
Are the system schematic and installer's contact details displayed?		
Are all signs suitably fixed and durable?		
Grid-connected systems		
General design		
Is the inverter suitably sized?		
Does the inverter carry a current Engineering Recommendation G83/1 Type Test certificate or has agreement been reached, in writing, with DNO?		
Installation		
Is the inverter suitably installed for heat dissipation?		
Is there a local AC isolator (double-pole) installed adjacent to the inverter?		
Is there a double-pole AC isolator (lockable in the off position only) installed adjacent to at the point of interconnection with the supply?		
Is AC cable suitably specified and installed in accordance with BS 7671 and suitably sized (calculations provided by installer)?		
Is cabling suitably selected and secured/routed?		
Is suitable AC fault current protection provided at the distribution board (specified and installed in accordance with BS 7671)?		
Labelling/signage		
Are dual supply notices installed at the service termination, meter position and all points of isolation?		
Is the point of AC isolation suitably labelled?		
Is a system schematic displayed?		
Are protection settings and installer's contact details displayed?		
Are all signs suitably fixed and durable?		
Has disconnection if grid fails been checked?		

Appendix C

This certificate is courtesy of the Institution of Electrical Engineers and can be downloaded from www.iee.org/Publish/WireRegs/Forms_2004.pdf. Note: Only the certificate is shown here. A schedule of items inspected, together with a schedule of test results, are to be appended to this form.

ELECTRICAL INSTALLATION CERTIFICATE (notes 1 and 2)

(REQUIREMENTS FOR ELECTRICAL INSTALLATIONS - BS 7671 [IEE WIRING REGULATIONS])

DETAILS OF THE CLIENT (note 1)

....
....
....

INSTALLATION ADDRESS

....
....
.... Postcode ....

DESCRIPTION AND EXTENT OF THE INSTALLATION Tick boxes as appropriate

Description of installation: ....

Extent of installation covered by this Certificate: ....
....
....
....
....
....
....

New installation ☐

Addition to an existing installation ☐

Alteration to an existing installation ☐

FOR DESIGN, CONSTRUCTION, INSPECTION & TESTING

I being the person responsible for the Design, Construction, Inspection & Testing of the electrical installation (as indicated by my signature below), particulars of which are described above, having exercised reasonable skill and care when carrying out the Design, Construction, Inspection & Testing, hereby CERTIFY that the said work for which I have been responsible is to the best of my knowledge and belief in accordance with BS 7671 : ……., amended to .... (date) except for the departures, if any, detailed as follows:

Details of departures from BS 7671 (Regulations 120-01-03, 120-02):

The extent of liability of the signatory is limited to the work described above as the subject of this Certificate.

Name (IN BLOCK LETTERS): .... Position: ....
Signature (note 3): .... Date: ....
For and on behalf of: ....
Address: ....
....
.... Postcode .... Tel No: ....

NEXT INSPECTION

I recommend that this installation is further inspected and tested after an interval of not more than .... years/months (notes 4 and 7)

SUPPLY CHARACTERISTICS AND EARTHING ARRANGEMENTS Tick boxes and enter details, as appropriate

Earthing arrangements	Number and Type of Live Conductors	Nature of Supply Parameters	Supply Protective Device Characteristics
TN-C ☐ TN-S ☐ TN-C-S ☐ TT ☐ IT ☐ Alternative source ☐ of supply (to be detailed on attached schedules)	a.c. ☐ d.c. ☐ 1-phase, 2-wire ☐ 2-pole ☐ 1-phase, 3-wire ☐ 3-pole ☐ 2-phase, 3-wire ☐ other ☐ 3-phase, 3-wire ☐ 3-phase, 4-wire ☐	Nominal voltage, U/U_o (1) .... V Nominal frequency, f (1) .... Hz Prospective fault current, I_{pf} (2) .... kA (note 6) External loop impedance, Z_e (2) .... Ω *(Note: (1) by enquiry, (2) by enquiry or by measurement)*	Type: .... Nominal current rating ....A

Appendix C (cont.)

PARTICULARS OF INSTALLATION REFERRED TO IN THE CERTIFICATE Tick boxes and enter details, as appropriate

Means of Earthing

Distributor s facility ☐

Installation earth electrode ☐

Maximum Demand

Maximum demand (load) .... Amps per phase

Details of Installation Earth Electrode (*where applicable)*

Type (e.g. rod(s), tape etc)	Location	Electrode resistance to earth
....	....	.... Ω

Main Protective Conductors

Earthing conductor: material .... csa ....mm^2 connection verified ☐

Main equipotential bonding conductors material .... csa ....mm^2 connection verified ☐

To incoming water and/or gas service ☐ To other elements ....……………………………….

Main Switch or Circuit-breaker

BS, Type .... No. of poles .... Current rating ....A Voltage rating V

Location .... Fuse rating or setting ....A

Rated residual operating current $I_{\Delta n}$ = ... mA, and operating time of .... ms (at $I_{\Delta n}$) (applicable only where an RCD is suitable and is used as a main circuit-breaker)

COMMENTS ON EXISTING INSTALLATION: (In the case of an alteration or additions see Section 743)

....

....

....

....

....

....

....

....

SCHEDULES (note 2)
The attached Schedules are part of this document and this Certificate is valid only when they are attached to it.
.... Schedules of Inspections and .... Schedules of Test Results are attached.
(Enter quantities of schedules attached).

GUIDANCE FOR RECIPIENTS

This safety Certificate has been issued to confirm that the electrical installation work to which it relates has been designed, constructed and inspected and tested in accordance with British Standard 7671 (The IEE Wiring Regulations).

You should have received an original Certificate and the contractor should have retained a duplicate Certificate. If you were the person ordering the work, but not the user of the installation, you should pass this Certificate, or a full copy of it including the schedules, immediately to the user.

The "original" Certificate should be retained in a safe place and be shown to any person inspecting or undertaking further work on the electrical installation in the future. If you later vacate the property, this Certificate will demonstrate to the new owner that the electrical installation complied with the requirements of British Standard 7671 at the time the Certificate was issued. The Construction (Design and Management) Regulations require that for a project covered by those Regulations, a copy of this Certificate, together with schedules is included in the project health and safety documentation.

For safety reasons, the electrical installation will need to be inspected at appropriate intervals by a competent person. The maximum time interval recommended before the next inspection is stated on Page 1 under "Next Inspection".

This Certificate is intended to be issued only for a new electrical installation or for new work associated with an alteration or addition to an existing installation. It should not have been issued for the inspection of an existing electrical installation. A "Periodic Inspection Report" should be issued for such a periodic inspection.

Appendix D

This form is courtesy of the Energy Networks Association (ENA) and can be downloaded from www.energynetworks.org/word/ER_G3-1_Appendix_3.doc

Engineering recommendation G83/1. SSEG installation commissioning confirmation

Confirmation of commissioning of a SSEG unit connected in parallel with the public distribution network - in accordance with Engineering Recommendation G83/1. One Commissioning Pro-forma per installation is to be submitted to the DNO.

Site details

Property address (inc. post code)	
Telephone number	
Customer supply number (MPAN)	
Distribution Network Operator (DNO)	

Contact details

SSEG owner	
Contact person	
Contact telephone number	

SSEG details

Manufacturer and model type	
Serial number of SSEG	
Serial number / version numbers of software (where appropriate)	
SSEG rating (A) and power factor (under normal running conditions)	
Maximum peak short circuit current (A)	
Type of prime mover and fuel source	
Location of SSEG unit within the installation Location of multi pole isolator	

Appendix D (cont.)

Installer details

Installer	
Accreditation/Qualification	
Address (incl post code)	
Contact person	
Telephone number	
Fax number	
E-mail address	

Information to be enclosed

Final copy of system schematic	
SSEG Test Report (Appendix 4) or web address if appropriate (not necessary if already provided e.g. under stage 2 connection)	
Computer print out (where possible) or other schedule of protection settings	
Electricity meter(s) make and model	

Declaration - to be completed by installer

The SSEG installation complies with the relevant sections of Engineering Recommendation G83/1	
Protection settings have been set to comply with Engineering Recommendation G83/1	
The protection settings are protected from alteration except by prior written agreement between the DNO and the Customer or his agent.	
Safety labels have been fitted in accordance with section 6.1 of Engineering Recommendation G83/1	
The SSEG installation complies with the relevant sections of BS 7671 and an installation test certificate is attached	
Comments (continue on separate sheet if necessary)	

Name	Signature	Date

Further reading

Energy Efficiency Best Practice in Housing publications
These publications can be obtained free of charge by telephoning the Helpline on **0845 120 7799** or by visiting the website at **www.est.org.uk/bestpractice**

Building a sustainable future - homes for an autonomous community (GIR53)
Renewable energy in housing - case studies (CE28)
Renewable energy sources for homes in rural environments (CE70)

Regulations and guidance
Construction (Design and Management) Regulations 1994. Approved code of practice. HSE. 1994, ISBN 0 71 760792 5
Engineering Recommendation G59/1: Recommendations for the connection of embedded generating plant to the public electricity suppliers' distribution system. Electricity Association, 1991, Amendment No.2 1995.
Engineering Recommendation G83/1: Recommendations for the connection of small-scale embedded generators (up to 16A per phase) in parallel with public low-voltage distribution networks. Electricity Association, September 2003.
Guidelines for Health and Safety in the Wind Energy Industry, BWEA, 2002. ISBN 1 87 006430 5
Requirements for electrical installations: IEE Wiring Regulations 16th Edition. BS 7671, 2001.
Wind turbine generator systems - Part 2: Safety of small wind turbines. BS EN 61400-2 1996 (IEC 1400-2: 1996). ISBN 0 58 026383 5
Health & Safety at Work Act 1974 (Chapter 37). HMSO. ISBN 0 10 543774 3
Management of H&S at Work Regulations 1999, Statutory Instrument 1999 No.3242. The Stationery Office. ISBN 0 11 085625 2
Health & Safety Regulations (First Aid) Regulations, 1981: Health and Safety, Statutory Instrument: 1981:917. HMSO. ISBN 0 11 885536 0
Electricity at Work Regulations 1989, Statutory Instrument 1989 No.635. The Stationery Office. ISBN 0 11 096635X

Wind energy - general
It's a breeze: A guide to choosing windpower, Hugh Piggott, 2001. ISBN 1 89804 932 7
Noise from Wind Turbines: The facts, BWEA, 2000, Factsheet.
Wind energy basics: A guide to small and micro wind turbines, Paul Gipe, 1999. ISBN 1 890132 07 1

Sources of funding
Grants for projects using renewable energy technologies are now available. Details of these can be found at:
www.clear-skies.org for wind energy, biomass, ground source heat pumps, micro-hydro and solar water heating projects in England & Wales.
www.est.org.uk/schri for wind energy, micro-hydro, ground source heat pumps, automated wood fuel heating systems and solar water heating projects in Scotland.

Useful websites
British Wind Energy Association: www.bwea.com
Danish Wind Energy Association: www.windpower.dk
Distributed Generation Co-ordinating Group: www.distributed-generation.gov.uk

Energy Efficiency Best Practice in Housing

CE72

Installing small wind-powered electricity generating systems

Energy Efficiency Best Practice in Housing
Helpline: 0845 120 7799
Fax: 0845 120 7789
Email: bestpractice@est.org.uk
Web: www.est.org.uk/bestpractice

Energy Efficiency Best Practice in Housing is managed by the Energy Saving Trust on behalf of the Government.

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