MCS

STANDARDS DOCUMENT

MIS 3003 ISSUE 4.0 DRAFT

The Small Wind Turbine Standard

(Installation)

This Microgeneration Installation Standard is the property of the MCS Charitable Foundation, Innovation Centre, Sci-Tech Daresbury, Keckwick Lane, Cheshire WA4 4FS. Registered Charity No. 1165752

This Standard was prepared by the MCS Working Group 3 'Small Wind Turbine Systems'.

It is published by The MCS Service Company Ltd on behalf of the MCS Charitable Foundation.

The MCS Service Company Ltd welcomes comments of a technical or editorial nature and these should be sent to *meetings@mcscertified.com*

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ABOUT MCS

Giving you confidence in home-grown energy

With energy costs constantly rising and climate change affecting us all, low-carbon technology has a bigger and bigger role to play in the future of UK energy.

We're here to ensure it's a positive one.

Working with industry we define, maintain and improve quality – certifying products and installers so people can have confidence in the low-carbon technology they invest in. From solar and wind, to heat pumps, biomass and battery storage, we want to inspire a new generation of home-grown energy, fit for the needs of every UK home and community.

About

The Microgeneration Certification Scheme Service Company Ltd (MCSSCo Ltd) trades as MCS and is wholly owned by the non-profit MCS Charitable Foundation. Since 2007, MCS has become the recognised Standard for UK products and their installation in the small-scale renewables sector.

We create and maintain standards that allow for the certification of products, installers and their installations. Associated with these standards is the certification scheme, run on behalf of MCS by Certification Bodies who hold UKAS accreditation to ISO 17065.

MCS certifies low-carbon products and installations used to produce electricity and heat from renewable sources. It is a mark of quality. Membership of MCS demonstrates adherence to these recognised industry standards; highlighting quality, competency and compliance.

Vision

To see MCS certified products and installations in every UK home and community.

Mission

To give people confidence in low-carbon energy technology by defining, maintaining and improving quality.

Values

1. We are expert – ensuring quality through robust technical knowledge
2. We are inspiring – helping to reshape energy in UK homes and communities
3. We are collaborative – working with industry and government to create positive change
4. We are principled – operating in a way that's clear, open and fair
5. We are determined – supporting the UK's drive towards a clean energy future

CHANGES TO STANDARDS

When MCS Standards are revised, the issue number is also revised to indicate the nature of the changes. This can either be a whole new issue or an amendment to the current issue. Details will be posted on the website at www.mcscertified.com

Technical or other significant changes which affect the requirements for the approval or certification of the product or service will result in a new issue. Minor or administrative changes (e.g. corrections of spelling and typographical errors, changes to address and copyright details, the addition of notes for clarification etc.) may be made as amendments.

The issue number is given on the left of the decimal point, and the amendment number on the right. For example, issue 3.2 indicates that it is the third significant version of the document which has had two sets of minor amendments.

Users of this Standard should ensure that they are using the latest issue.

Issue No.	Amendment Details	Date
1.0	First Publication	
2.0	Addition of text under section 4.4 – site specific issue (see 4.4.5) re metering requirements, and also under section 6 – handover with regard to MCS Certificates and the MID, as agreed at MCS Steering Committee meeting of 27/05/2010.	28/08/2010
3.0	Substantial revision including: • Windspeed adjustment for turbine height • Acoustic performance estimate	05/09/2011

	• Updated wind resource correction factors • Change to size limits • Dedicated fuseway change • Revised NOABL link • Commissioning • Responsible siting guidelines • Shadow/flicker guidance • CNS assets • Terrain illustrations	
4.0 Draft	Major changes in line with other MCS installer standards. Incorporation of document (no longer supported): Energy Efficiency Best Practice in Housing - Installing Small Wind Powered Electricity Generating Systems – Guidance for Installers and Specifiers. Document reference CE72. Changes resulting from the MCS Wind Working Group Meeting 30th September 2021. Changes resulting from the MCS Wind Working Group Meeting 13th January 2022.	26/01/2022

FOREWORD

This document contains references to other documents which may be either normative or informative. At the time of publication any editions of those documents, where indicated, were valid. However, as all documents are subject to revision, any users of this document should apply the most recent editions of those referenced documents (unless a dated version is specified).

This issue 4.0 is a significant update to issue 3.5. It is available for reference from the date of publication XX/XX/2021. MCS Contractors certified in accordance with MIS 3003 **may** start working in accordance with this update from the date of publication. Compliance with this update is **mandatory** for MCS Contractors certified in accordance with MIS 3003 from the date of implementation (YY/YY/2021).

This Standard describes the MCS requirements for the assessment, approval and listing of contractors undertaking the supply, design installation, set to work, commissioning and handover of small wind turbine systems by Accredited Certification Bodies. The listing and approval is based on evidence acceptable to the certification body:

- that the system or service meets the Standard
- that the contractor has staff, processes and systems in place to ensure that the system or service delivered meets the standard
- And on:
- periodic audits of the contractor including testing as appropriate
- compliance with the contract for the MCS listing and approval including agreement to rectify faults as appropriate

This Standard shall be used in conjunction with the scheme document MCS 001 and any other guidance and supplementary material available on the MCS website specifically referring to this Standard (MIS 3003).

NOTES:
This MCS Installation Standard makes use of the terms 'must', 'shall' and 'should' when prescribing certain requirements and procedures. In the context of this document:

- the term 'must' identifies a requirement by law at the time of publication;
- the term 'shall' prescribes a requirement or procedure that is intended to be complied with in full and without deviation;
- the term 'should' prescribes a requirement or procedure that is intended to be complied with unless reasonable justification can be given.

Compliance with this MCS Installation Standard does not in itself confer immunity from legal obligations.

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1 PURPOSE & SCOPE

This standard specifies the requirements for MCS Contractors undertaking the supply, design, installation, set to work, commissioning and handover of small wind turbine systems located on dedicated free-standing/guyed towers. They supply permanent buildings and are either connected to the electricity distribution network or off-grid battery charging systems. The scope of this standard is defined as small wind turbine systems with power outputs of between 0W and 50kW, measured at a wind speed of 11.0 ms^{-1}.

2 DEFINITIONS

Refer to MCS 001 (The MCS Contractor Standard – Part 1: Requirements for MCS Contractors) for definitions.

3 REQUIREMENTS OF THE MCS CONTRACTOR

3.1 CAPABILITY

3.1.1 MCS Contractors shall have the competency (see Section 8.1) and capacity to undertake the supply, design, installation, set to work, commissioning and handover of small wind turbine systems.

3.1.2 Where MCS contractors do not engage in the design or supply of small wind turbine systems but work solely as a MCS Contractor for a client who has already commissioned a system design; then the MCS Contractor shall be competent to review and verify that the design would meet the design requirements set out in this Standard and this should be recorded.

3.2 ORGANISATION

3.2.1 MCS Contractors shall organise themselves using policies, procedures and systems which meet the minimum requirements in MCS 001 to ensure every small wind turbine installation meets this Standard.

Note: MCS 001 includes requirements for Quality Management System, Customer Care, Personnel, Continual Improvement, External Documents, Software Control, Customer Requirements, Contracts, Subcontracting, Purchasing, Test and Measurement Equipment, Product Handling, Training and Competence, all of which can affect the quality of installed systems.

4 PRE-SALE INFORMATION, SITING & SYSTEM SIZING CONSIDERATIONS

4.1 PERFORMANCE ESTIMATION

4.1.1 An estimate of the annual energy performance of the system shall be made using the methodology detailed in Section 4.2 below and Appendix A.

4.1.2 This estimate shall be communicated in the prescribed format to the client before the point that the contract is awarded and shall be accompanied by the following text:

*"Important Note: The energy performance estimate is based upon a standardised method using publicly available information. It is given as guidance only and should **not** be considered to be a guarantee. The energy performance of wind turbine systems is impossible to predict with a high degree of certainty due to the variability in the wind from location to location and from year to year."*

*For a greater level of certainty, it is recommended that on-site wind speed monitoring is undertaken for at least a year. **Note:** it may be useful to monitor for shorter periods, especially if the acquired data is then correlated with other sources to estimate an annual mean wind speed".*

4.1.3 Additional estimates may be provided using an alternative methodology, including proprietary software packages, but:

- Such estimates shall clearly describe and justify the approach taken and factors used.
- They shall not be given greater prominence than the standard MCS estimate.
- They shall be accompanied by warning text stating that it should be treated with caution if it is significantly better than the result given by the standard method.

4.1.4 The details of the standardised and any additional estimates of the annual energy performance shall be recorded and retained in the project file.

4.2 CALCULATING THE ANNUAL ENERGY PERFORMANCE ESTIMATE

4.2.1 To calculate the annual energy performance estimate, complete the following steps:

Step	Activity
1.	Obtain Global Wind Atlas (GWA) wind speed data for the site
2.	Determine category of the surrounding terrain of the proposed turbine location
3.	Identify any significant local obstructions

Step	Activity
4.	Correct the GWA data for the surrounding terrain, obstructions, and turbine height
5.	Derive the estimated Annual Energy Performance

Each step is described in detail in Appendix A.

4.2.2 Although small turbines require much lower average speeds than large turbines, the project's technical and economic viability will need to be carefully examined if the annual average speed is less than 4.5m/s.

Note: 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. Therefore, the wind speed distribution – i.e., the 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.

4.3 ACOUSTIC PERFORMANCE ESTIMATE

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

a) Aerodynamic noise from the rotating blades.
b) Mechanical noise from the generator.

Note: 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.

4.3.2 An estimate of the acoustic performance shall be calculated using the procedure detailed in Appendix B.

4.3.3 The acoustic performance estimate shall be communicated in the prescribed format to the client before the point that the contract is awarded and shall be accompanied by the following text:

*"Important Note: The acoustic performance estimate is based upon a standardised method using publicly available information. It is given as guidance only and should **not** be considered to be a guarantee. The energy performance of wind turbine systems is impossible to predict with a high degree of certainty due to the variability in the wind from location to location and from year to year."*

*For a greater level of certainty, it is recommended that on-site wind speed monitoring is undertaken for at least a year. **Note:** it may be useful to monitor for shorter periods,* *especially if the acquired data is then correlated with other sources in order to estimate an annual mean wind speed".*

4.3.4 Additional acoustic performance estimates may be provided using an alternative methodology, including proprietary software packages, but:

- Such estimates shall clearly describe and justify the approach taken and factors used.
- They shall not be given greater prominence than the standard MCS estimate.
- They shall be accompanied by warning text stating that it should be treated with caution if it is significantly better than the result given by the standard method.

4.3.5 As indicated in Section 4.3.3 above it is permissible to give estimates of acoustic performance based on other procedures in addition to the standard estimate. However, an estimate based on the standardised procedure shall be given in all cases to give preliminary information about the suitability of the site, to allow comparisons between different systems, and to provide a reality check for any other estimates that may be provided.

4.3.6 The details of the standardised and any additional estimates of the acoustic performance shall be recorded and retained in the project file.

4.4 SYSTEM SITING & SIZING CONSIDERATIONS

4.4.1 The following factors shall be considered when siting and sizing a small wind turbine and subsequently estimating the annual energy performance:

a) 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 southwest.

b) Obstructions/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.

c) 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.

d) 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 below, which illustrates that the turbine should be sited well clear of obstructions and obstacles.

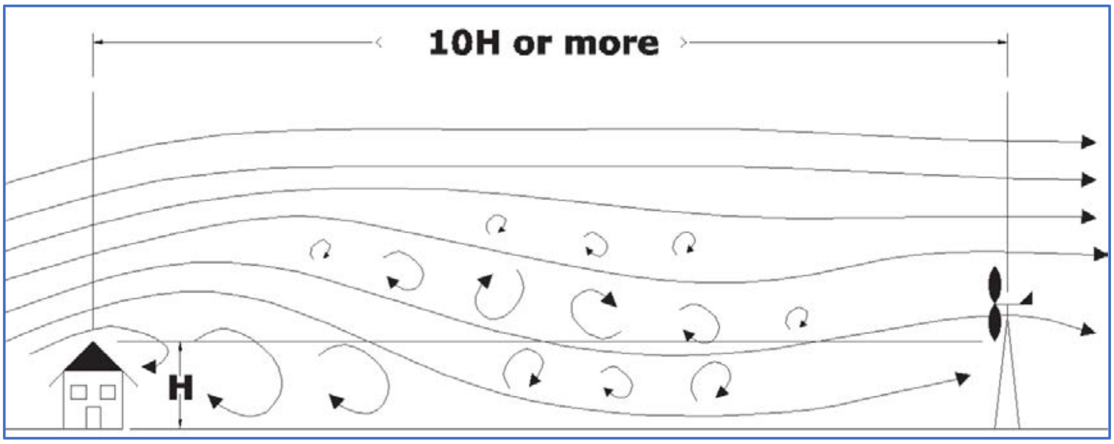


Figure 1: Impact of Siting the Turbine Clear of Obstructions & Obstacles.

e) Shadow and Flicker: Small wind turbines shall **not** be located or mounted in such a way as to cause unacceptable levels of flickering shadows. See Section 5.7.7 for further details and Appendix C for a detailed assessment of shadow and flicker.

f) 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.

g) 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 needs to 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 obstructions and obstacles, particularly in the path of the prevailing wind. This should take account of possible future obstructions such as tree growth.

Note: See also Section 5.7 for additional site-specific issues.

4.5 CNS ASSETS

4.5.1 The proposed location of the turbine shall be compared with the register of aircraft Communications, Navigation and Surveillance (CNS) assets to establish whether there is a requirement to seek permission for the installation of a turbine in respect of the CNS assets.

Note: This is necessary because CNS assets are important for the safety of aircraft.

4.5.2 An online version of the CNS assets register is expected to be made available by the UK government. The proposed location of the turbine is to be entered into this online tool together with any other relevant information, and the tool will indicate whether permission needs to be sought.

4.5.3 If the online version of this CNS assets register is not available, then an enquiry **must** be made to the Local Planning Authority.

5 DESIGN & INSTALLATION REQUIREMENTS

5.1 LEGISLATION

5.1.1 All applicable legislation and directives **must** be met in full.

Note: the legislation which applies may be different in England, Wales, Scotland, and Northern Ireland.

5.1.2 MCS Contractors shall ensure, and be able to demonstrate, that they are aware of all current applicable legislation.

5.1.3 MCS Contractors shall make their customers aware of all permissions and approvals required for the installation.

5.1.4 Planning Permission - Stand Alone Domestic Wind Turbines

Where an installation is intended to proceed with Permitted Development Rights for small wind turbines MCS 020 Planning Standards **must** be complied with. If Permitted Development Rights do not apply, then planning permission is required.

In support of a planning application MCS Contractors should, as good practice:

- Advise customers to contact their 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.

5.1.5 The MCS Contractor shall ensure the proposed small wind turbine location is assessed by a competent professional experienced in small wind turbine systems to ensure that it is suitable for the installation and, by undertaking the proposed works is compliant with Building Regulations.

5.1.6 As part of standard Health and Safety Practice suitable and sufficient risk assessments (see Section 5.8) shall be conducted before any work on site commences. This is a requirement under the Management of Health and Safety at Work Regulations 1999 and as amended in 2006 (see Section 10.3 for document reference details).

5.1.7 Where work is undertaken that is notifiable under the Building Regulations it shall be made clear to the customer who shall be responsible for this notification.

5.1.8 The MCS Contractor shall ensure that notification under the Building Regulations has been completed prior to handing over the installation.

Note: Self-certification, in lieu of building control approval, is only permitted where installation and commissioning is undertaken by a person or organisation deemed competent and registered with a Competent Persons Scheme (CPS) approved by the *relevant government department for the scope of work being undertaken. Further details can be found at http://www.competentperson.co.uk.*

5.1.9 The MCS Contractor shall ensure the installation is compliant with the Electrical Safety, Quality and Continuity Regulations 2002 (see Section 10.3 for document reference details) and, in accordance with Regulation 22(2)(c), shall follow the technical requirements and procedures:

- In Engineering Recommendation (EREC) G98 (formerly G83) for installations up to and including 16 A per phase.
- In EREC G99 (formerly G59) for installations exceeding 16 A per phase.
- In Engineering Recommendation (EREC) G100 where the export of power is to be limited.

5.1.10 Notification to the Distribution Network Operator (DNO) in accordance with the procedures set out in ENA Engineering Recommendation (EREC) G98 or EREC G99 shall be undertaken by the MCS Contractor.

5.2 MANUFACTURER'S INSTRUCTIONS

5.2.1 All equipment should be installed in accordance with its manufacturer's instructions.

5.2.2 Where the manufacturer's instructions conflict with the requirements of this standard then the requirements of this standard take precedence unless it can be proven that system performance, safety and durability are no worse than if the requirements of this standard are followed.

5.3 EQUIPMENT CERTIFICATION & LISTING

5.3.1 When making installations in accordance with this standard the small wind turbine system shall be listed under the MCS (http://www.mcscertified.com).

5.3.2 All installed equipment:

- Shall be fit for its purpose in the installation
- Must be CE marked in compliance with the relevant European Directives.

5.4 DESIGN & INSTALLATION

Figure 2 below shows diagrammatically the components of a small wind turbine that are discussed in detail in this section.

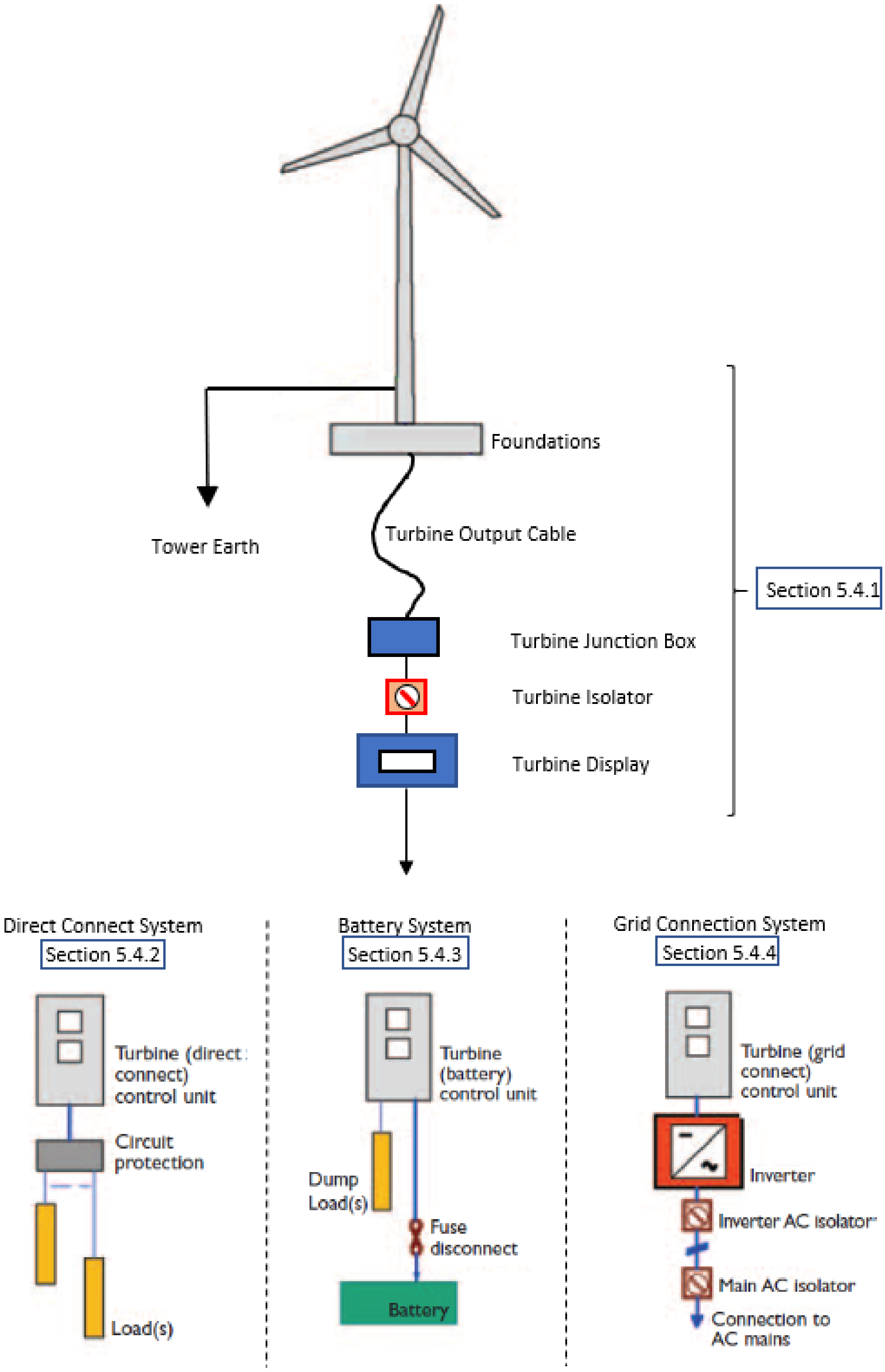


Figure 2: Small Wind Turbine – System Components

5.4.1 Wind Turbine, Tower, and Foundations

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

5.4.1.1 Mechanical and Structural Requirements

5.4.1.1.2 Wind Loading

The UK has a good wind resource, but severe winds occur occasionally. The turbine and tower shall 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.

Note: Gusts of 50m/s are rare, but they shall 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; see Section 10.2 for document reference details). Some particularly exposed sites, or installations in public areas, may need to meet more stringent design requirements.

5.4.1.1.3 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 regarding compatibility and suitability as follows:

a) The support structure shall be suitable for the turbine and shall be designed to prevent detrimental effects arising from movement or vibration.
b) All parts of the tower shall be corrosion resistant (e.g., made from galvanised or stainless steel).
c) Fixings shall be prevented from loosening through vibration (use of nylock bolts, for example).
d) Dissimilar materials shall be isolated from each other to prevent electrolytic corrosion.

e) The design shall 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.
f) Towers should be designed in such a way as to prevent climbing by unauthorised persons (this is of relevance particularly to lattice constructions).

(b) Foundations and Anchor Points

Concrete foundations shall be made according to BS 8004 Foundations and BS EN 1992-1-1:2004 +A1:2014 Eurocode 2: Design of concrete structures (See Section 10.3 for document reference details). Key considerations include:

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

Note: 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. An example is shown in Figure 3 below:

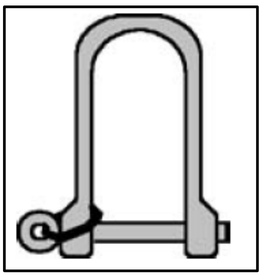


Figure 3: A Shackle Prevented from Loosening

5.4.1.2 Electrical Requirements

5.4.1.2.1 Voltage and Current - Maximum Values

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.

Note: 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 should 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.

5.4.1.2.2 Turbine Output Cables

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

b) The turbine output cable shall 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 (see Section 10.2 for document reference details). 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.

Note: 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 to minimise the risk of faults; Steel Wire Armoured (SWA) cables should be used, or the cables enclosed in protective conduit/trunking.*

c) The turbine output cable shall be sized so that the voltage drop is in accordance with BS 7671 18th Edition IET Wiring Regulations. In any case the drop should be limited to less than 4%.

5.4.1.2.3 Turbine Isolator

a) A turbine isolator manually isolates the electrical output of the turbine. This will be necessary during system installation and 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.

b) The turbine isolator shall be a multi-pole device to electrically isolate all the wires coming from the turbine.

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

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

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

d) 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 shall be clear, easily visible and be constructed and fixed to remain legible and in place throughout the design life of the system. See Section 6.2.5 for examples of the labels required.

5.4.1.2.4 Turbine Junction Box

a) 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.

b) The junction box shall be labelled "Wind Turbine Junction Box - Danger, terminals may come live at any time". All labels shall be clear, easily visible and be constructed and fixed to remain legible and in place throughout the design life of the system. See Section 6.2.5 for examples of the labels required.

Note: The environmental and fault protection provisions in the turbine output circuit shall be maintained in the make-up and construction of any junction box.

5.4.1.2.5 Tower Earth

a) A turbine in proximity to existing lightning protection.
   Where a turbine is to be mounted on a structure with an existing lightning protection system (LPS), the installers of the LPS shall 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 should be bonded to the installation's Main Earthing Terminal, in accordance with BS 7671 (see Section 10.2 for document reference details).

Note: 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:

a) 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.
b) The earth electrode shall be placed as close as is practical to the tower base and it shall 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.
c) The connection between the tower and the tower earth should be made with copper cable (minimum CSA of 16mm2), taking a direct route, and avoiding sharp bends.
d) 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.

Note: 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 should be used.*

5.4.1.2.6 Lightning Protection

BS EN 62305-2:2012 Protection against lightning, risk management (see Section 10.3 for document reference details), 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 EN 62305-2:2012.

(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 shall be electrically safe and pose no electrical fire hazard.

5.4.2 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.

Note: *However, a typical direct-connected system will* ***not*** *usually supply the 240V, 50Hz sinusoidal Alternating Current (A.C.), 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 Direct Current (D.C.) systems, protection or switching devices should be rated for D.C.*

operation; and in high frequency systems, additional de-rating factors may need to be applied to multi-core cables.

5.4.2.1 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:

a) The control unit shall be rated for the current and voltage maxima (see Section 5.4.1.2, Electrical Requirements above).
b) It shall be labelled "Supplied from wind turbine. Isolate at turbine isolator before carrying out work. Isolator situated ...." See Section 6.2.5 for examples of the labels required.
c) If a control unit incorporates specific functions described in Section 5.4 such as isolation, the relevant requirements of that section shall be applied.
d) For wind speeds up to 35m/s, the system shall 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.
e) For wind speeds up to 50m/s, the control unit shall be designed to minimise the risk to itself or the system, from fire or shock.

5.4.2.2 Circuit Protection

a) 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:
b) 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.
c) 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.

Note: 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.

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

5.4.2.3 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 than the full turbine output (such as a system where ten 1kW heaters are run from a single 10kW turbine).

5.4.2.4 Labelling/Signage

a) 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 ………………………………………"

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

c) All labels shall be clear, easily visible and be constructed and fixed to remain legible and in place throughout the design life of the system. See Section 6.2.5 for examples of the labels required.

5.4.3 Battery Systems

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.

5.4.3.1 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:

a) The control unit shall be rated for the current and voltage maxima (see Section 5.4.1.2, Electrical Requirements above).
b) It shall be labelled "Supplied from wind turbine. Isolate at turbine isolator before carrying out work. Isolator situated…………………………………………………" See Section 6.2.5 for examples of the labels required.
c) If a control unit incorporates specific functions described in Section 5.4 such as isolation, the relevant requirements of that section shall be applied.
d) For wind speeds up to 50m/s, the control unit shall be designed to minimise the risk to itself or the system, from fire or shock.

5.4.3.2 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.

Note: 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.

5.4.3.3 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 shall be provided. Key considerations include:

a) An over-current device should 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 shall be as short as practicable.
b) The over-current device (either a fuse or circuit-breaker) should be sized 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.
c) Cable ratings are to be adjusted using standard correction factors for installation method, temperature, grouping and frequency to BS 7671, and shall:
   - be rated for operation at D.C., at 125% of the nominal battery voltage
   - have an interrupt rating greater than the potential battery short circuit current

5.4.3.4 Battery Disconnection

A means of manual isolation shall 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 shall 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.

5.4.3.5 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:

a) Is the battery fit for purpose, i.e., appropriately rated for its duties? In most cases a true 'deep cycle' battery will be required.
b) Does it have an adequate storage capacity and cycle life?

c) Is a sealed or vented battery more appropriate for the installation?
d) Will the battery be made up of series cells or parallel banks?

Note: 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.

5.4.3.6 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.

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

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

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.

5.4.3.7 Battery Installation

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

Note: 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 EN IEC 62485-1:2018 Safety requirements for secondary batteries and battery installations, general safety information (see Section 10.3 for document reference details) gives a procedure for calculating ventilation requirements.

Battery banks should be housed in such a way that:

a) Access can be restricted to authorised personnel.
b) Adequate containment is assured.
c) Appropriate temperature control can be maintained.

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

Note: 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 extremely 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.

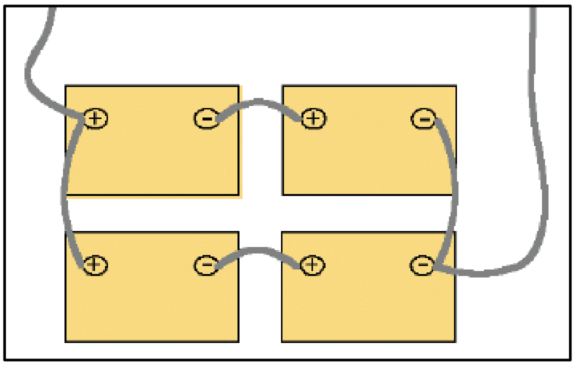


Figure 4: A typical connection configuration for a small parallel battery bank (take-offs are on opposite corners)

The following warning signs shall be displayed:

a) No Smoking or Naked Flames.
b) Batteries contain acid - avoid contact with skin or eyes.

All labels shall be clear, easily visible and be constructed and fixed 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.

5.4.3.8 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 shall be clear, easily visible and be constructed and fixed to remain legible and in place throughout the design life of the system. See Section 6.2.5 for examples of the labels required.

5.4.4 Grid-Connected Systems

Systems are of two types:

(1) A.C. generator connected via dedicated synchronisation and protection relays.

(2) Inverter connected.

(1) Systems Using an A.C. Generator

A wind turbine with an A.C. 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 EREC G98/G99.

Note: 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.

(2) 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 EREC G98 does not specifically set out details for wind power, the requirements for inverter-connected PV systems are commonly adopted for wind systems.

5.4.4.1 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:

a) The control unit shall be rated for the current and voltage maxima (see Section 5.4.1.2, Electrical Requirements above).
b) It shall be labelled "Supplied from wind turbine. Isolate at turbine isolator before carrying out work. Isolator situated.." See Section 6.2.5 for examples of the labels required.
c) If a control unit incorporates specific functions described in Section 5.4.1.2 such as isolation, the relevant requirements of that section should be applied.
d) For wind speeds up to 50m/s, the control unit shall be designed to minimise the risk to itself or the system, from fire or shock.

5.4.4.2 Inverters

Where EREC G98 applies, inverters shall 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 should also be capable of withstanding the maximum voltage and current output supplied by the turbine control unit for winds up to 50m/s.

Note: 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 EREC G98 ensure that an inverter is properly protected against islanding.

5.4.4.3 A.C. Isolator

Two A.C. switch disconnectors, in accordance with BS EN 60947-3 Low-voltage switchgear and control gear - Part 3 switches, disconnectors, switch-disconnectors, and fuse-combination units (see Section 10.3 for document reference details), shall 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 should:

a) Switch all live and neutral cables.
b) Clearly show ON and OFF positions and be labelled as "wind system - point of emergency isolation". See Section 6.2.5 for examples of the labels required.

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

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

5.4.4.4 A.C. Cabling

The inverter(s) should 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. A.C. cables are to be specified and installed in accordance with BS 7671 (see Section 10.2 for document reference details).

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

5.4.4.5 A.C. Fault Current Protection

Note: 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) shall be provided at the distribution board. This electrical protection is to be specified and installed in accordance with the requirements of BS 7671.

5.4.4.6 Labelling/Signage

Please refer to Section 6.2.5 for the labelling required for small wind turbine systems.

5.5 METERING & COMMUNICATION

Metering

5.5.1 As a minimum metering should be installed to record and display instantaneous power output and total power generation.

5.5.2 If required for billing and or payment purposes the means of recording A.C. generation of the system shall be a meter approved under the European Measuring Instruments Directive (MID) showing the serial number on the front panel where it could be photographed alongside the make, model, and actual meter reading.

Note: Installation of a MID approved meter would also satisfy clause 5.5.1.

5.5.3 The means of recording power generation, be it a dedicated meter or otherwise, should be readily accessible and readable by the customer.

5.5.4 Where energy is taken from the grid to be stored in an EESS (Electrical Energy Storage System) and later returned to the grid or installation, that energy shall not affect the veracity of any meters recording energy generated, imported, or exported where those meters are used for billing or payment.

Note: *An example would include the meter recording total generation of the small wind turbine system where the recorded energy is used for payment of financial incentives. Any error in that reading could cause a claim for payment to be inaccurate and fraudulent. For the avoidance of doubt this clause allows for the correct recording by the supply meter of the energy taken form the grid to be stored in the EESS.*

Examples of different metering arrangements which do and do not satisfy this clause are given in the Ofgem document: Guidance for Generators: Co-location of electricity storage facilities with renewable generation supported under the Renewables Obligation or Feed-in Tariff schemes.

5.5.5 See also MCS Metering Guidance document.

<u>Data Communication & Security</u>

5.5.6 The data privacy and security of the site's home area network shall be maintained. Where the installation comprises of any internet connected devices:

- The device's network access credentials (username & passwords) shall be updated in consultation with the customer
- Relevant components in the small wind turbine system should comply with the technical specification ETSI Technical Specification 103 645 Cyber Security for Consumer Internet of Things (see Section 10.3 for document reference details).

5.5.7 Installations requiring local area network, home area network, and/or internet access in commercial and industrial premises shall comply with the client organisation's information technology and information security policies and procedures.

5.6 SAFETY AND DURABILITY

5.6.1 The MCS contractor shall be able to demonstrate that the installation of the small wind turbine can be operated safely.

Note: *This can be demonstrated by:*

a) Operating the small wind turbine brake.

b) Operating the safety cut out/isolation switches.

5.6.2 The MCS contractor shall advise the consumer on any additional measures that may be beneficial to the performance and durability of the system, in terms of cleaning, maintenance, general up keep and good practice.

5.7 SITE SPECIFIC ISSUES

5.7.1 In addition to the siting and sizing issues considered in Section 4.4 the following shall be addressed in the design of the wind turbine system for each location:

1. The suitability of a site shall be assessed by a competent person experienced in small wind turbines, using a site survey form including at least the details given in Appendix D.
2. The class of turbine selected shall be appropriate for the conditions at the proposed site as identified through the site survey (see Appendix D).
3. For ground-mounted or roof-mounted small wind turbines that use concrete foundations or steel support structures, MCS Contractors shall have a documented method of controlling the quality of foundations either:

    - according the turbine manufacturer's specifications,

    or in the absence of these, in accordance with

    - Section 5.4.1.1 Turbine Support Structures, b) Foundations and Anchor Points as detailed above.

Note: An MCS Contractor who has not received sufficient information from the manufacturer should seriously question whether it is the appropriate product for the customer.

5.7.2 Where a third-party contractor is instructed to undertake the design and installation works of the foundation or support structure attention is drawn to the contractual obligations detailed in MCS 001 (see Section 10.2 for document reference details).

5.7.3 When a third-party is instructed to undertake the design and installation, the MCS Contractor shall undertake a quality control assessment, which should take the form of a documented site inspection, photographs of any excavations, reinforcing structure and concrete pouring process, along with a copy of a certificate of conformance for the concrete composition.

5.7.4 The MCS Contractor shall satisfy themselves that both the design and the installation works have been undertaken by an appropriately qualified and skilled person and company and that third parties have been provided with all the relevant information.

5.7.5 Small wind turbines, shall **not** be located in such a way as to have an adverse effect on the performance of any flue that serves fuel burning equipment (e.g., gas fire, wood burning stove, biomass boiler).

5.7.6 Flickering Shadows: Small wind turbines shall **not** be located or mounted in such a way as to cause unacceptable levels of flickering shadows. Shadows from rotating wind turbine blades can be cast long distances from the actual turbine, depending on the tower height and the slope of the ground. The severity and duration of exposure generally decreases with increasing distance. Shadows occur to the North of the turbine at mid-day (most relevant for offices) and to the West and East in the early morning and late evening respectively (more relevant for houses). An exposure limit of up to 30 hours per year has been established as reasonable level of exposure (see Appendix C). Unless a site specific and turbine specific assessment is carried out the small wind turbine shall be sited in accordance with the guidelines in Figure 5 below. Other suitable measures may be applied to mitigate the flickering shadows effect. For example, using a timer system to shut down the turbine during the hours of the day when there might be an issue on a few weeks of the year.

Red area = Significant shadow flicker effects can be expected: windows or other sensitive points are to be avoided in this area.

Pink area = Significant shadow flicker effects may occur: the consequences for any windows or other sensitive points in this area needs to be assessed.

Green area= No shadow flicker effects are expected

White area (> 10 x B_d) = Any shadow flicker effects are expected to be minor and of short duration.

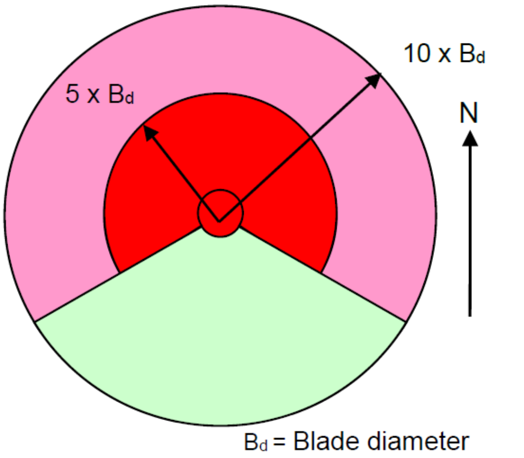


Figure 5: Diagram of Shadow Flicker Zones of Interest for the UK

Note: In Figure 5 above the small wind turbine is at the centre of the circle and North is at the top of the image. It is appropriate for UK latitudes in the Northern Hemisphere where the green sector forms an arc of approximately 100 degrees. It is suitable for small turbines mounted at hub heights of 3-4 times the rotor diameter Bd, where Bd is the ***blade diameter*** *for a Horizontal Axis Wind Turbine (HAWT) or* ***blade length*** *for a Vertical Axis Wind Turbine (VAWT). Reference should be made to Appendix C for other cases/examples.*

5.8 RESPONSIBLE SITING GUIDANCE

5.8.1 As required by the Management of Health and Safety at Work Regulations 1999 (as amended in 2006), see Section 10.3 for document reference details, the MCS Contractor shall undertake a risk assessment for the turbine's operation on the proposed site. This risk assessment shall be in accordance with the manufacturer's siting guidelines unless additional mitigation measures are deployed. The customer shall be made aware of these measures, the risks, and sign an acceptance in such cases.

5.8.2 Risk assessments shall include at least the following risks:

Zone	Extent	Typical Hazard
1	Circle around the base	Fall zone: Hazard if anything fell from the turbine.
2	Hemisphere around the base	Hazard if the mast were to topple.
3	Circle around the base	Ejection zone: Hazard if something were to be ejected from the spinning rotor.
4	Reachable area	Vandalism Lowest point of rotating parts above the ground or easily accessible point.
5	Varies	Impact: Hazard from vehicle impacts.

5.8.3 The risk assessment(s) carried out should consider at least the following, not exhaustive, list of hazards:

Hazard	Description
Falling objects	Anything that could fall from the turbine, including structural or mechanical parts or phenomena (e.g. ice).
Tower/mast failure	The potential for structural failure leading to a full or partial collapse of the tower/mast.
Thrown or ejected objects	Anything that could be thrown or ejected from the rotating blades, including structural or mechanical parts or phenomena (e.g., ice).
Dangerous mechanical parts	Potential of accidental or intentional contact with rotating parts, considering the lowest point of rotating parts and any points that are easily accessible.
Electrical	Potential for accidental or intentional contact with electricity, including underground services. Existing site services (e.g. overhead or underground electric cables) should be identified, and exclusion zones defined.
Slips/trips/falls	Potential for slips, trips, or falls associated with the turbine, including the siting of wires, guy ropes etc.

5.8.4 In conducting the risk assessment, the MCS Contractor should also consider other factors. These include, but are not limited to:

a) The potential risks to the turbine and any supporting structures or equipment from commercial (e.g., contractor) or public vehicles crashing into the tower.

b) Any public rights of way close to the installation site.

c) The local situation should be considered, e.g., the likely presence of children.

d) Temporary signs, notices and barriers should be erected.

e) The local weather conditions should be considered.

f) Environmental phenomena, including lightning, ground stability, trees etc.

g) Vandalism to the structure and/or safety critical components.

h) The potential risks to the turbine and any supporting structures or equipment from adjacent premises or commercial and industrial activities.

5.8.5 MCS Contractors should ensure that the risk assessment(s) are documented and are able to demonstrate compliance with the relevant statutory requirements set out in general and specific health and safety legislation. There is no standard format to record the risk assessment. However, it is good practice for micro and small system installations that in addition to the written risk assessment that the findings can be additionally categorised using a zonal approach, which identifies the hazards and risks as you move away from the base of the turbine tower. This may also be visually presented to the customer, to assist the communication of the risk assessment and any mitigation measures.

5.8.6 Safe Siting and Working - The following sections demonstrate ways to mitigate the hazards identified in the risk assessment:

5.8.6.1 Turbine and Tower – Structural and Mechanical Works

a) Structural and mechanical installation shall be actively managed and supervised by a suitably experienced and competent person.

b) All workers involved in the works should be fully briefed on the sequence of operations before they commence. This is to include the identification of danger areas that shall not be occupied during the erection process.

c) All personnel should wear appropriate personal protective equipment, including high visibility jackets, hard hat, and safety boots.

d) Anyone working at height should work to the requirements of the relevant statutory provisions and are covered in MCS 001.

e) During installation and maintenance works, an exclusion zone shall be established to prevent persons not engaged with erection of the turbine from gaining admittance.

f) 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.

g) Safe siting - anchors and guy cables for towers should be far 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.

5.8.6.2 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. In addition:

a) The turbine should 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 BS EN IEC 60934:2019 and BS EN IEC 60900:2018). See Section 10.3 for document reference details.

b) Subsequently, the turbine isolator should 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.

5.8.6.3 Working with Batteries

a) Appropriate personal protective equipment should 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.

b) Tools for battery installation should be insulated and acid resistant. Spanners should be approved single-ended types.

c) Work on battery installations should be carried out in a pre-planned manner to minimise the number of conductors exposed at any one time.

d) Batteries should be adequately vented during works and any source of spark or open flame avoided.

6 COMMISSIONING, TESTING & HANDOVER

6.1 COMMISSIONING & TESTING

6.1.1 The small wind turbine system shall be commissioned according to a documented procedure to ensure that the system is safe, has been installed in accordance with the requirements of this Standard and the manufacturers' requirements, and is operating correctly in accordance with the system design.

6.1.2 Inspection and testing of the completed system **must** be carried out to the requirements of BS 7671. See Section 10.2 for document reference details.

6.1.3 Accurate performance testing of a turbine is only possible where an anemometer reading at the hub height is available. For most small wind turbine 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.

6.1.4 An installation and commissioning inspection checklist for the whole installation is also included for information in Appendix E. This, or a similar document prepared by the installer, should be completed and a copy provided to the customer.

6.2 DOCUMENTATION & LABELLING

6.2.1 MCS Contractors shall collate a comprehensive document pack and given to the customer which, as a minimum, includes:

a) Turbine support structure specifications – including where appropriate, an assessment of local ground conditions as well as the installation requirements, specification of materials etc. and including any relevant structural engineer's report.
b) Drawings, specifications and instructions for assembly, installation, and erection of the equipment.
c) Copies of all forms and checklists used to commission the system.
d) An operator's instruction manual.
e) The maintenance requirements and maintenance services available.
f) Manufacturer user manuals and warranty details.
g) Any documentation or checklists required for any incentive schemes.

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

(i) Installation

a) Details of all loads, weights, lifting points, special tools, and procedures necessary for the handling, installation, and operation of the system.

b) 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.
c) Details of the manufacturer's recommended erection procedures.
d) Identification of critical fasteners as well as details of procedures for confirming torque and other requirements.
e) A set of field assembly and installation drawings.
f) Minimum design requirements for the foundation and anchor system.
g) A complete wiring and interconnection diagram.

(ii) Operation

a) Details of safe operating limits.
b) A description of start and shutdown procedures.
c) Procedures for functional checks on the protection subsystems.
d) A description of the subsystems and their operation.

(iii) Inspection and maintenance - see also Section 7

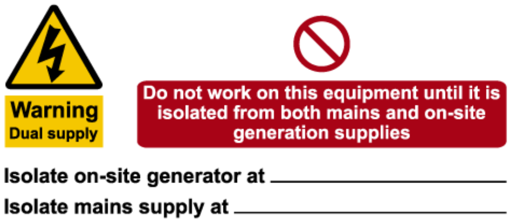
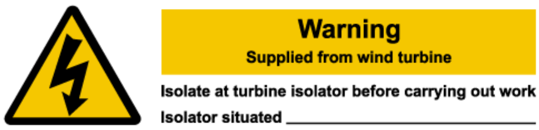
a) Maintenance and inspection cycles and procedures.
b) A schedule prescribing frequency of lubrication and type of lubricant or any other special fluid.
c) Procedures for unscheduled maintenance and emergencies.
d) Schedules for guy inspection and re-tensioning, bolt inspection and torquing (including tension and torque loading details).
e) Diagnostic procedures and a trouble-shooting guide.

6.2.3 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.

6.2.4 System-dependent documentation requirements to be provided include:

a) V(max) and I(max) calculations (see Section 5.4.1.2 Electrical Requirements).
b) Battery maintenance schedules (watering, equalisation, etc).
c) Warranty information.
d) Noise levels (see Section 4.3.1).
e) Design life of system parts.
f) A maintenance record sheet.

6.2.5 The list of labels required for a grid connected system are as follows:

Description	Example
Warning: Dual Supply Label Dual supply labelling must be provided at the service termination, meter position and all points of isolation between the small wind turbine system and supplier terminals to indicate the presence of on-site generation and indicating the position of the main A.C. switch disconnector.	
Warning: Inverter Label In addition to an inverter warning label best practice is also to supply label that reads: "not to block ventilation", to be placed next to the inverter to ensure the customer does not block the vents of the inverter. This can cause a loss in system performance as the inverter will de-rate when it reaches maximum operating temperature.	
Danger: Do Not Disconnect D.C. Plugs Label Connectors readily accessible to ordinary persons shall be of the locking type, requiring a tool or two separate actions to separate and shall have a label attached that reads: 'Do not disconnect D.C. plugs and sockets under load'. Turn off A.C. supply first.	
Warning: Supplied from Wind Turbine Label Attach label to all equipment directly supplied by the small wind turbine.	
Danger: Wind Turbine Isolator Label Attach label to wind turbine output isolator enclosure.	
Danger: Wind Turbine Junction Box Label Attach label to all wind turbine output cable junction boxes.	
Warning: Wind System Point of Emergency Isolation Label For use on all A.C. switches/disconnects. Note: ON and OFF positions should be clearly labelled.	
Wind System Generation Meter Label To identify the wind system generation meter.	**Wind System Generation Meter**

At the interconnection point, the following shall also 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 shall be clear, easily visible and be constructed and fixed to remain legible and in place throughout the design life of the system.

6.3 HANDOVER

6.3.1 At the point at which the small wind turbine system is handed over to the client, the documentation as detailed in Section 6.2.1 shall be provided and explained along with a document signed by the MCS Contractor containing at least the following:

- A declaration, signed by the MCS Contractor's on-site representative, confirming that the installation meets the requirements of this Standard.
- Client name and address.
- Site address (if different).
- MCS Contractor's name, address, contact details etc.
- List of the key components installed.
- The estimation of system performance calculated according to Section 4.1 and Appendix A.
- Advice to the customer that the customer should advise their insurer(s) of the installation of a wind turbine.
- Recommended interval for the first periodic inspection.

Note: See Appendix F for a model handover document.

6.3.2 No later than 10 working days after commissioning, the installation shall be registered by the MCS Contractor on the MCS Installation Database (MID) and an MCS Certificate generated.

6.3.3 The MCS Certificate shall be sent to the customer with instruction to include it within the handover pack.

6.3.4 The generation of the certificate shall be undertaken in full compliance with the terms and conditions of use of the MID[1] and the registration of the system on the MID shall be undertaken only after the system has been fully installed and commissioned and not before.

6.3.5 A "per installation" fee is levied on MCS Contractors for each registration added to the database. Details of any such fee will be advised from time to time through MCS Certification Bodies.

[1] The terms and conditions of use can be found on the MCS Installation Database website.

7 MAINTENANCE

7.1 A preventive maintenance schedule including the checks to be undertaken is given in Appendix G.

7.2 Turbines should be maintained according to the manufacturer's requirements to minimise risk. It is recommended that maintenance is carried out by a suitably trained and competent individual (or individuals), with the appropriate tools and equipment. Where turbines are located in public places, the customer should be encouraged to contract the maintenance with representatives of the manufacturer.

7.3 A maintenance form/report shall be completed by the maintenance engineer, and a copy given to the customer.

7.4 Manufacturers often offer a warranty that includes routine maintenance, with extended servicing available for a fee after it expires.

8 ROLES & COMPETENCY

8.1 All personnel involved in the design and / or installation of small wind turbine systems, either employed by or subcontracted to the MCS Contractor, shall be competent, skilled, or instructed for the activities they undertake.

8.2 Complete records of training and / or qualifications demonstrating the required competencies shall be maintained by the MCS Contractor, in particular:

- Design personnel - Shall be able to demonstrate a thorough technical knowledge of the technologies involved and the interaction of associated technologies and be able to deliver a compliant design to the requirements of this Standard.
- Installation personnel – Shall be able to demonstrate an adequate level of technical knowledge and installation skills, to install systems to the specified designed in accordance with the requirements of this Standard, applicable codes of practice, manufacturer's instructions, and Statutory Regulations.

Note: As a minimum MCS Contractors should have personnel with demonstrable training and / or experience of small wind turbine systems in accordance with the requirements of this Standard. The range of entry level qualifications as shown in Appendix H, may be deemed as suitable for small wind turbine systems.

8.3 The competence criteria to be demonstrated by the MCS contractor, together with guidance on how to achieve compliance can be found in the following documents (see Sections 10.2 and 10.3 for document reference details):

Document Reference	Document Title
MCS 025	MCS Installer Certification Scheme Competency Criteria Guidance
	MCS Guidance Document Competency Guidance
MCS 001	The MCS Contractor Standard. Part 1: Requirements for MCS Contractors

9 REGIONAL OFFICES

9.1 Where the MCS Contractor wishes to design and commission under the Certification Scheme in regional offices, then these offices shall meet the requirements of this Standard to be eligible for Certification.

10 PUBLICATIONS, REFERENCE, & FURTHER READING

10.1 The lists below are provided so that MCS Contractors know which documents have been used as a basis for the development of the requirements of this MIS standard and they are able to further research topics if they need to do so.

10.2 It is a scheme requirement for MCS Contractors to own at least one copy of the following documents in each office or regional office undertaking design and commissioning work:

Document Reference	Document Title	Edition/ Date of Publication	Available From
BS 7671: 2018	Requirements for Electrical Installations (IET Wiring Regulations Eighteenth Edition).	18th Edition 2nd July 2018	British Standards Institution (BSI): www.bsi-global.com or The Institution of Engineering and Technology (IET) ISBN 978 1 785 61170 4

Document Reference	Document Title	Edition/ Date of Publication	Available From
ISBN-13: 978-1-78561-966-3	Code of Practice for In-service Inspection and Testing of Electrical Equipment.	5th Edition 2020	https://electrical.theiet.org/guidance-codes-of-practice/
BS EN 61400-2:2014 (IEC 61400-2:2013)	Wind Turbines – Part 2: Small Wind Turbines.	October 2014 Incorporating corrigendum October 2019	British Standards Institution (BSI): https://shop.bsigroup.com/ProductDetail?pid=000000000030404669 ISBN 978 0 539 06899 3
EREC G98	ENA Engineering Recommendation G98. Requirements for the connection of Fully Type Tested Micro-generators (up to and including 16A per phase) in parallel with public Low Voltage Distribution Networks on or after 27April 2019.	Issue 1 Amendment 4 04/06/2019	https://www.energynetworks.org/assets/images/Resource%20library/ENA_EREC_G98_Issue_1_Amendment_4_(2019).pdf
EREC G99	ENA Engineering Recommendation G99 Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019.	Issue 1 Amendment 6 10/03/2020	https://www.energynetworks.org/assets/images/Resource%20library/ENA_EREC_G99_Issue_1_Amendment_6_(2020).pdf
EREC G100	ENA Engineering Recommendation G100	May 2018	https://www.energynetworks.org/assets/images/Resource%20library/ENA_ERE

Document Reference	Document Title	Edition/ Date of Publication	Available From
	Technical Requirements for Customer Export Limiting Schemes		C G100 Issue 1 Amendment 2 (2018).pdf
MCS 001	The MCS Contractor Standard Part 1: Requirements for MCS Contractors.	Issue 4.2 20/10/2020	https://mcscertified.com/wp-content/uploads/2021/10/MCS-001-1-Issue-4.2_Final.pdf
MCS 001	The MCS Contractor Standard Part 2: The Certification Process.	Issue 4.2 20/10/2020	https://mcscertified.com/wp-content/uploads/2021/10/MCS-001-2-Issue-4.2_Final.pdf
MCS 020	MCS Planning Standards for Permitted Development Installations of Wind Turbines and Air Source Heat Pumps on Domestic premises.	Issue 1.3 01/05/2015	https://mcscertified.com/wp-content/uploads/2019/07/MCS-020.pdf
MGD 001	Complying with MCS 001 Guidance on the MCS Contractor Standard.	Issue 2.1 20/10/2020	https://mcscertified.com/wp-content/uploads/2021/10/MGD-001-Guidance-for-MCS-001.pdf
	Metering Guidance.	Issue 1.1	https://mcscertified.com/wp-content/uploads/2019/07/Metering-Guidance.pdf
MCS 025	MCS Installer Certification Scheme Competency Criteria Guidance.	Issue 1.2 20/06/2019	https://mcscertified.com/wp-content/uploads/2019/07/MCS-025.pdf
	MCS Guidance Document	Issue 1.2 04/07/2019	https://mcscertified.com/wp-

Document Reference	Document Title	Edition/ Date of Publication	Available From
	Competency Guidance.		content/uploads/2019/09/MCS-Competency-Guidance.pdf
	Eligibility for Installation to be MCS Approved when used by Contractors as part of their MCS assessment.	Issue 1.1 04/07/2019	http://mcssco.wpengine.com/wp-content/uploads/2019/07/Eligibility-for-Installation-to-be-MCS-Approved.pdf

10.3 It is not a scheme requirement for MCS Contractors to own or have immediate access to the documents referenced unless this MIS standard does not adequately cover off the aspects required.

Document Reference	Document Title	Edition/ Date of Publication	Available From
ISBN-13: 978-1-83953-041-8	Code of Practice for Electrical Energy Storage Systems.	2nd Edition 2020	https://electrical.theiet.org/guidance-codes-of-practice/
ISBN-13: 978-1-83953-017-3	Guide to Cables and Cable Management.	2020	https://electrical.theiet.org/guidance-codes-of-practice/
ETSI EN 303 645	ETSI Technical Specification 103 645 Cyber Security for Consumer Internet of Things.	V2.1.2 June 2020	https://www.etsi.org/deliver/etsi_ts/103600_103699/103645/02.01.02_60/ts_103645v020102p.pdf ISBN 978-92-9204-236-3
BS 8004: 2015+A1: 2020	Code of practice for foundations.	30/06/2015	https://shop.bsigroup.com/ProductDetail?pid=000000000030403579 ISBN 978 0 539 06626 5
BS EN 1992-1-1:2004 +A1:2014	Eurocode 2: Design of concrete structures. General rules and rules for buildings.	23/12/2004	https://shop.bsigroup.com/ProductDetail/?pid=000000000030286962 ISBN 978 0 580 83726 5

Document Reference	Document Title	Edition/ Date of Publication	Available From
BS EN 62305 -2:2012	Protection against lightning. Risk management.	30/04/2013	https://shop.bsigroup.com/ProductDetail/?pid=000000000030174634 ISBN 978 0 580 61193 3
BS EN IEC 62485-1:2018	Safety requirements for secondary batteries and battery installations. General safety information.	25/05/2018	https://shop.bsigroup.com/ProductDetail/?pid=000000000030369834 ISBN 978 0 580 52171 3
BS EN 60947-3 18/30361074 DC	Low-voltage switchgear and controlgear - Part 3 switches, disconnectors, switch-disconnectors, and fuse-combination units.	13/04/2018 Current, Draft for public comment.	https://shop.bsigroup.com/ProductDetail?pid=000000000030361074
UK Statutory Instruments 1999 No. 3242 2006 No. 438	The Management of Health and Safety at Work Regulations 1999. And as amended in 2006.	No. 3242 1999 No. 438 2006	https://www.legislation.gov.uk/uksi/1999/3242/contents/made ISBN 978 0 110 85625 4 https://www.legislation.gov.uk/uksi/2006/438/contents/made
HSR25 (Third edition) UK Statutory Instruments 1989 No. 635	The Electricity at Work Regulations 1989.	HSR25 (Third edition) Published 2015.	https://www.hse.gov.uk/pubns/books/hsr25.htm ISBN 978 0 7176 6636 2
BS EN IEC 60900:2018	Live Working. Hand tools for use up to 1 000 V AC and 1 500 V DC.	August 2018	https://shop.bsigroup.com/ProductDetail?pid=000000000030392368 ISBN 978 0 539 04072 2
BS EN IEC 60934:2019	Circuit breakers for equipment (CBE).	September 2019	https://shop.bsigroup.com/ProductDetail/?pid=000000000030338982 ISBN 978 0 580 93657 9

Document Reference	Document Title	Edition/ Date of Publication	Available From
HSWA	Health & Safety at Work etc. Act 1974.	C 37 1974	https://www.legislation.gov.uk/ukpga/1974/37/contents ISBN 978 0 105 43774 1
UK Statutory Instruments 2002 No. 2665	Electrical Safety, Quality and Continuity Regulations 2002	24/10/2002	https://www.legislation.gov.uk/uksi/2002/2665/pdfs/uksi_20022665_en.pdf ISBN 978 0 110 42920 5
BS EN 17037:2018	Daylight in Buildings	May 2019	https://shop.bsigroup.com/ProductDetail/?pid=000000000030342286 ISBN 978 0 580 94420 8
	Mathematical Model of the Structure of Strong Winds Harris R I & Deaves D M	May 1978	ISBN 978 0 860 17086 0
	Ofgem document: Guidance for Generators: Co-location of electricity storage facilities with renewable generation supported under the Renewables Obligation or Feed In Tariff schemes	17/07/2020	https://www.ofgem.gov.uk/system/files/docs/2020/07/storage_guidance.pdf
Global Wind Atlas (GWA)	GWA	Last updated April 2021	https://globalwindatlas.info/

APPENDIX A – PERFORMANCE ESTIMATION METHOD

Background Information

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 especially 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, small in comparison with the wind speed and the turbine rotor diameter.

The power that is available from wind is related to <u>three</u> principal factors:

1. <u>Wind Speed</u>: Power is proportional to the cube of the wind speed. This means a small variation in wind speed has a significant effect on power. So, an increase in wind speed of 25% will almost double the power available. Alternatively, a decrease in wind speed of 25% will more than halve the power available. It is therefore especially important to maximise the incident wind on the turbine blades.

   Also, wind speed increases with height above ground level. Wind velocity is reduced near the surface due to surface 'roughness'. Wind velocity profiles are quite different for different terrain types. Rough, irregular ground, and man-made obstructions on the ground, retard movement of the air near the surface, create turbulence and reduce wind velocity. So, it is also important to site wind turbines as high as practicable and as far as possible away from buildings, trees, and other obstructions.

2. <u>Rotor Diameter</u>: Power is proportional to the swept area and is given by the square of the radius or blade length. So, a 25% increase in diameter will increase the power available by over 50%.
3. <u>Air Density</u>: The greater the density of the air the more power is available. So, weather conditions (atmospheric pressure) and height above sea level will affect output. However, the effect is very small in comparison to the factors above.

The freely available Global Wind Atlas (GWA) that was developed by DTU Wind Energy and has been validated against measured data. It is also updated. The GWA can be used to provide an initial assessment and preliminary calculations for a site.

Step 1: Obtain GWA wind speed data for the site

Establish the wind speed data for the site using the GWA. This can be found at: https://globalwindatlas.info/

Step 2: Determine category of the surrounding terrain of the proposed turbine location

Identify and record the category from the list below, which best describes the terrain around the proposed location, paying particular attention to the regions about 1 km upwind and 500m downwind for the prevailing wind direction[2] If these regions include areas described by more than one of these categories then choose the category that is numerically higher.

Category	Description
1	Flat grassland, parkland, or bare soil, without hedges and only a few isolated obstructions.
2	Gently undulating countryside, fields with crops, fences or low boundary hedges and few trees.
3	Farmland with high boundary hedges, occasional small farm structures, houses, and trees.
4	Woodland or low-rise urban/suburban areas (e.g., domestic housing) with a plan area density of up to about 20%.
5	Dense urban areas and city centres (e.g., buildings of four-storeys or higher) with a plan area density of greater than about 20%.

Note: Example pictures of these categories are shown below in section A.2 ILLUSTRATIONS OF THE TERRAIN CATEGORIES.

Step 3: Identify any significant local obstructions

Identify and record if there are any significant obstructions to the wind in the upwind and downwind zones adjacent to the proposed wind turbine location as shown in Figure 6 below. Record the height (h_o) of the highest obstruction within these zones.

[2] Where possible, the direction of the prevailing wind for the location should be found from local met office data. In the absence of any local wind data, the prevailing wind in the British Isles should be taken as coming from the South West. On many sites a significant percentage of winds result from directions other than the most dominant direction. The MCS Contractor should advise about the implications of any obstructions from different directions. Unless specific local wind data is available, the more dominant wind in the British Isles is assumed to be approximately 45% of wind from the compass quarter between South and West, and approximately 25% from the compass quarter between North and East, 20% between West and North and 10% between East and South.

Notes:

- The upwind and downwind directions are defined relative to the prevailing wind direction[2].
- Be aware that the extents of these zones in the upwind and downwind directions are determined relative to the height of the obstruction (h_o), whereas the extent of the zones in the directions perpendicular to them are defined relative to the hub height of the turbine (h_t).
- A significant obstruction is any solid item (e.g., building, wall etc.) or semi permeable item (e.g., trees or bushes) that is greater than 0.5m at its widest part and reaches to a height greater than 0.25m of the hub height of the turbine.

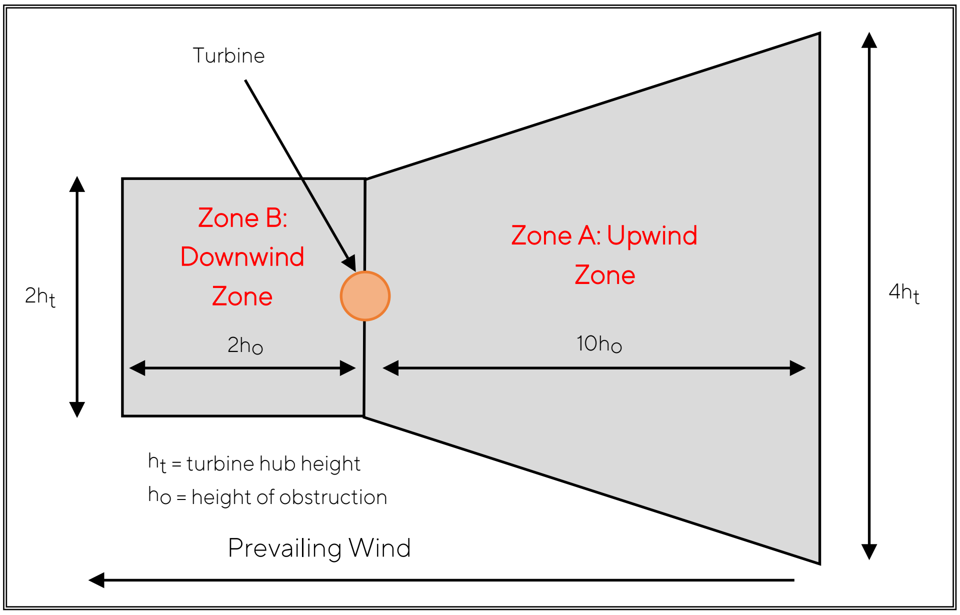


Figure 6: Diagram of Upwind & Downwind Significant Obstruction Zones

Step 4: Correct the GWA data for the surrounding terrain, obstructions, and turbine height

Determine the appropriate correction factor (**C_f**) from Table A.1 below depending on the applicable case below:

Case A:	Where there is/are **NO** significant obstruction(s) identified in Step 3.
	Record the correction factor (**C_f**) from the column for the applicable terrain category identified in Step 1, and the row for **h_c** = **h_t**.
	Where **h_t** is the height of the turbine hub above ground.

Case B:	Where there are **one or more** significant obstruction(s) identified in Step 3.
	Record the correction factor (**C_f**) from the column for the applicable terrain category identified in Step 1, and the row for **h_c** = **h_t** – 0.8 **h_o**.

Where:

- h_t is the height of the turbine hub above ground.
- h_o is the height of the highest significant obstruction within zones A or B (Figure 6).

Having identified the correction factor to be applied, calculate the **estimated mean annual speed (V_e)** for the turbine position as follows:

$$V_e = C_f \times VN_{10}$$

Step 5: Derive the estimated Annual Energy Performance

Apply the estimated mean annual wind speed (V_e) at the turbine from Step 4 to the wind turbine manufacturer's Annual Energy Performance Curve (**note**: this is not the Power Curve) to obtain an estimate of the annual energy output.

At the discretion of the system designer, further factors to reduce the estimated annual energy output, due to turbulence, underlying topography, or obstructions in other directions, may be applied.

DATA FOR THE ESTIMATION FOR THE STANDARD ESTIMATE OF ANNUAL ENERGY PRODUCTION

Table A.1 Correction factors for the GWA mean wind speed data to account for local terrain and obstructions, and the turbine height above ground level.

h_c	Terrain Categories				
	1	2	3	4	5
1	0.74	0.60	0.43	0.24	0.05
1.5	0.80	0.67	0.51	0.33	0.14
2	0.85	0.72	0.56	0.39	0.20
2.5	0.89	0.76	0.60	0.43	0.25
3	0.92	0.79	0.64	0.47	0.29
3.5	0.94	0.82	0.67	0.50	0.33
4	0.96	0.84	0.69	0.53	0.35
4.5	0.98	0.86	0.71	0.55	0.38
5	1.00	0.88	0.73	0.57	0.40
6	1.03	0.91	0.77	0.61	0.44
7	1.05	0.94	0.80	0.64	0.48
8	1.08	0.96	0.82	0.67	0.51
9	1.09	0.99	0.84	0.69	0.53
10	1.11	1.00	0.86	0.71	0.56

h_c	Terrain Categories				
	1	2	3	4	5
11	1.13	1.02	0.88	0.73	0.58
12	1.14	1.04	0.90	0.75	0.60
13	1.16	1.05	0.92	0.77	0.62
14	1.17	1.06	0.93	0.78	0.63
15	1.18	1.08	0.94	0.80	0.65
16	1.19	1.09	0.96	0.81	0.66
17	1.20	1.10	0.97	0.83	0.68
18	1.21	1.11	0.98	0.84	0.69
19	1.22	1.12	0.99	0.85	0.70
20	1.23	1.13	1.00	0.86	0.71
25	1.24	1.14	1.01	0.87	0.72
30	1.24	1.14	1.02	0.88	0.74
35	1.25	1.15	1.03	0.89	0.75
40	1.26	1.16	1.03	0.90	0.76
45	1.26	1.17	1.04	0.91	0.76
50	1.27	1.17	1.04	0.91	0.76
60	1.28	1.18	1.06	0.92	0.78
70	1.28	1.19	1.06	0.93	0.79
80	1.29	1.19	1.07	0.94	0.80
90	1.30	1.20	1.08	0.95	0.81
100	1.32	1.23	1.11	0.98	0.84

Scaling factors derived from data given in Harris R I & Deaves D M, The structure of strong winds, Wind engineering in the eighties, proc. CIRIA conference, 12-13 November 1980, London, 1981.

A.2 ILLUSTRATIONS OF THE TERRAIN CATEGORIES

© Google Earth

Category 1: Flat grassland, parkland, or bare soil, without hedges and only a few isolated obstructions.

© Google Earth

Category 2: Gently undulating countryside, fields with crops, fences or low boundary hedges and few trees.

© Google Earth

Category 3: Farmland with high boundary hedges, occasional small farm structures, houses and trees etc.

© Google Earth

Category 4: Woodland or low-rise urban/suburban areas (e.g. domestic housing) with a plan area density of up to about 20%.

© Google Earth

Category 5: Dense urban areas and city centres (e.g., buildings of four-stories or higher) with a plan area density of greater than about 20%.

A.3 NOTES CONCERNING THE ESTIMATION OF ANNUAL ENERGY PRODUCTION

1. The power available from the wind falls rapidly as the wind speed reduces (power is proportional to the cube of the wind speed). Therefore, the location of a wind turbine is critical to its performance.

2. Any performance estimate calculated using the factors given here is for guidance only and will not be accurate for all situations.

3. The factors take no account of the building shape or size (apart from the height), which can affect the air flow significantly. The wind energy above flat roofs is particularly difficult to predict and is extremely sensitive to the location on the roof.

4. Turbulence of the wind reduces performance (and turbine life). If you suspect high turbulence levels at your site, consult an expert before installing a turbine.

5. Turbines mounted lower than the height of the roof or obstruction are likely to experience extremely low mean wind speeds but high turbulence.

6. Under certain circumstances, the shape of the roof can enhance the wind speed and thus the power available. To take advantage of this effect you will need expert advice and may need to measure the average annual wind at the proposed location on the roof.

7. Accurate measurement over a period of 1 year, or for a sufficient period to obtain accurate correlation with local Met Office data, is the preferred method for determining the actual windspeed in a given location and should be considered where possible.

APPENDIX B – ACOUSTIC PERFORMANCE ESTIMATE

1. Establish a 10m altitude mean wind speed for the proposed location using the Global Wind Atlas (GWA) database (**VN_{10}**, at 10m height)

2. Assume a Rayleigh wind distribution[3] and calculate the 90% wind speed for 10m height as:

$$V_{90,10} = 1.71 \times VN_{10}$$

For a given mean wind speed and the assumed distribution, the wind speed will be less than this value for 90% of the time.

3. Apply a wind correction factor from 10m height using power law (in accordance with IEC 61400-2) to get an estimate of wind at the installed rotor centre, H, as:

$$V_{90,H} = V_{90,10} \times \left(\frac{H}{10}\right)^{0.143}$$

In the above equation, the exponent is an empirically derived coefficient that varies dependent upon the stability of the atmosphere. For neutral stability conditions, the value is approximately 1/7, or 0.143. Note that in places where trees or structures impede the near-surface wind, the use of a constant 1/7 exponent may yield erroneous estimates.

4. Draw a horizontal line on the Emission Noise Map in the BWEA Noise Label (per BWEA Small Wind Turbine and Performance Standard) at the V90, H wind speed.

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[3] In probability theory and statistics, the Rayleigh distribution is a continuous probability distribution for nonnegative-valued random variables. It is essentially a chi distribution with two degrees of freedom. A Rayleigh distribution is often observed when the overall magnitude of a vector is related to its directional components. One example where the Rayleigh distribution naturally arises is when wind velocity is analysed in two dimensions. Assuming that each component is uncorrelated, normally distributed with equal variance, and zero mean, then the overall wind speed (vector magnitude) will be characterised by a Rayleigh distribution.

The cumulative distribution is given by

$$F(b) = 1 - e^{-(b/c)^2}$$

Where F(b) is the cumulative density function [in the case above 0.9 (90%)].

$c = 2 \times VN_{10}$ / sqr.rt п

b = wind speed at 90% which is equal to $Y \times VN_{10}$

Therefore, by substitution Y = 1.71

5. Read off the distance for the acoustic dB(A) values of interest.
6. Compare these distances with the slant distance from the turbine hub to the nearest noise sensitive locations(s) for the planned installation.

APPENDIX C – DETAILED ASSESSMENT OF SHADOW & FLICKER

D.1 SHADOW FLICKER

Northern Ireland's Best Practice Guidance to Planning Policy Statement (PPS18 2009) suggests that "problems caused by shadow flicker are rare".

Under certain combinations of geographical position and time of day, the sun may pass behind the rotors of a wind turbine and cast a shadow over neighbouring properties. When the blades rotate, the shadow flicks on and off; the effect is known as 'shadow flicker'.

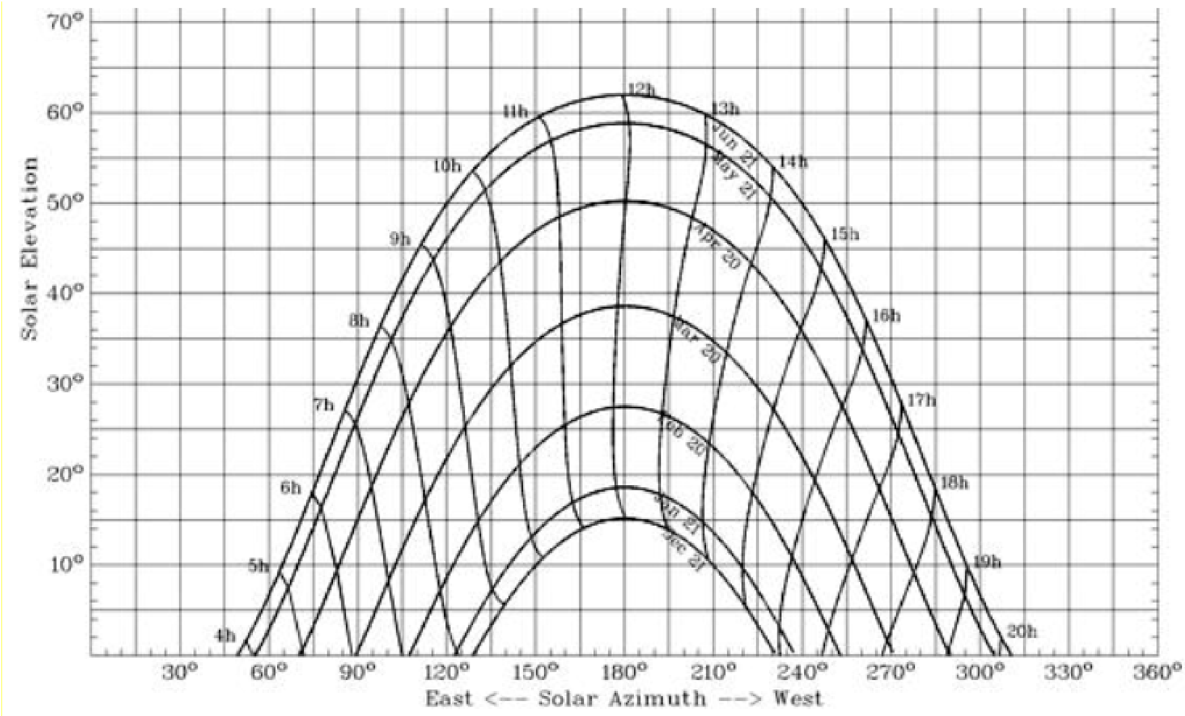
For a person in a property to experience flickering from a wind turbine the property would need to have a narrow window facing a wind turbine. The sun would need to be relatively low in the sky and be behind the tower. The turbine nacelle would need to be facing a certain direction so that the turbine blades were turning and casting the shadow in the direction of the property. Any flicker effect would only last while the sun is behind the tower and while the nacelle was facing in that one direction.

The seasonal duration of this effect can be calculated from the geometry of the machine and the latitude of the site. A single window in a single building is only likely to be affected for a few minutes at certain times of the day during short periods of the year.

The likelihood of this occurring and the duration of such an effect depends upon:

1. The direction of the residence relative to the turbine.
2. The distance from the turbine.
3. The turbine hub-height and rotor diameter.
4. The time of year.
5. The frequency of bright sunshine and cloudless skies (particularly at low elevations above the horizon).
6. The prevailing wind direction.
7. Any obstructions in the relevant direction.

In the UK it is only true for the equinoxes (Mar 21, Sept 21) that the sun rises in the East and sets in the West. During the summer, the sun rises North of East and sets North of West; in winter it rises South of East and sets South of West.



The sun path vertical projection diagram shows the sun path monthly, and the maximum and minimum annual declination for London.

A turbine mounted at +/-45degrees from North will never cast a shadow on to the observer. Even within the potential shadow region the following shall be considered:

1. Is there a window facing that direction? A single window in a single building is only likely to be affected for a few minutes at certain times of the day during short periods of the year.

2. Will anyone be awake (or in the office)? The sun path diagram can be examined and may show any potential flicker could be occurring at 5am

The further the observer is from the turbine the less pronounced the effect will be. There are several reasons for this:

1. There are fewer times when the sun is low enough to cast a long shadow.

2. When the sun is low itis more likely to be obscured by either cloud on the horizon or intervening buildings and vegetation.

3. The centre of the rotor's shadow passes more quickly over the land reducing the duration of the effect.

Even if the potential for flicker is considered in "greenhouse mode" i.e., an open aspect in all directions, the size of small turbines means that flicker will be imperceptible at distances greater than 10 times the diameter of the turbine.

At closer distances, the sun will still pass through the rotor area very rapidly meaning any potential flicker will be for a noticeably short period.

To estimate the number of hours where both the wind is blowing, and the sun is shining a calculation is made. This calculation is termed "the de-rating factor". To determine the de-rating factor, historical meteorological data are used. In the UK, the number of hours where both the wind is blowing, and the sun shining is typically only 30% of daylight hours.

D. 2. PHOTOSENSITIVE EPILEPSY

Causes of photosensitive epilepsy are numerous; it is much more complex than simply flickering light.

About 1% of the population suffer one or more epileptic fits during their lifetime. Of those only about 4% suffer with epileptic fits that are triggered by photosensitivity. This equates to approx. 23,200people in the UK, or 0.04% of the population. A town of 80,000 people will have approx. 32 people at risk.

For a wind turbine to present a potential hazard to someone who is at risk from photosensitive epilepsy, all the following shall be true:

1. The wind shall be blowing and in the right direction.
2. The sun shall be shining.
3. The observer shall be within the flickering light field
4. A large percentage of the individual's visual cortex shall be stimulated [over 25%]
5. The rotor shall be spinning at a speed that affects the specific photosensitive range of the observer.
6. The rotor spinning speed shall stay in the specific range long enough to trigger a reaction.
7. The background illumination shall be low
8. The contrast between shadow and light shall be high
9. The colour spectrum of the light shall be in the correct range to affect the individual

10. There shall be nothing blocking out the flickering light, such as blinds or a tree outside the window.

11. The individual does nothing to remove themselves from the flicker light source before it begins to affect them.

D. 3. MITIGATION

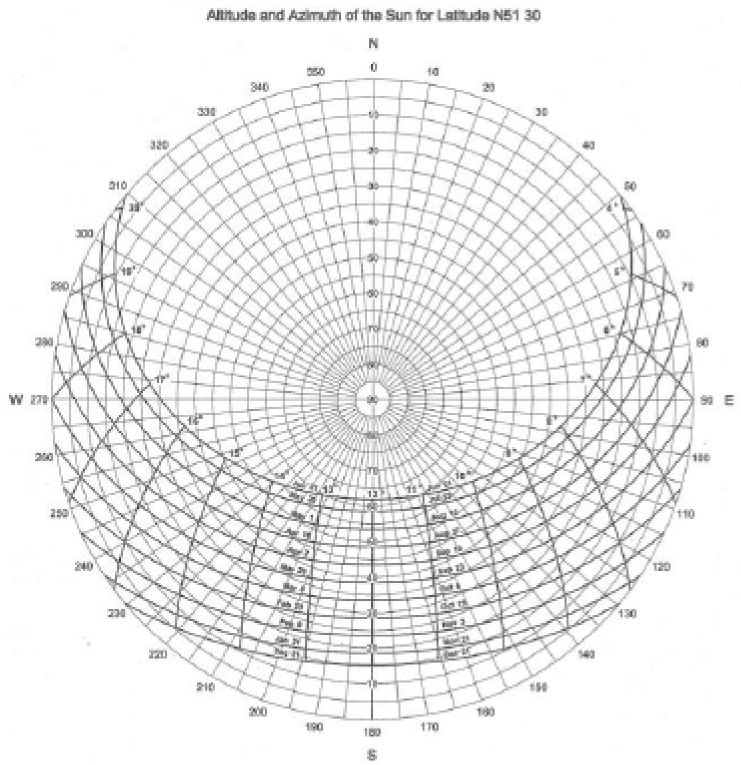
Shadow flicker effects on properties are very rare and, due to their rotor size, will be even rarer with small wind turbines.

A rule of thumb has been adopted that 30 hours of shadow flicker per year is acceptable[4]. This is based on those times being when:

1. The building affected is likely to be occupied

2. The occupants are likely to be awake

The size of small turbines means that flicker will be imperceptible at distances greater than 10 times diameter and unlikely to be of concern at greater than 5 times diameter. However, if nuisance occurs; a sensor can be retrofitted which shuts down the wind turbine on the rare occasion the sun and wind direction conditions both occur at the appropriate time.



[4] The only known shadow flicker regulation to date was enacted in Germany, where a court ruled that the maximum allowable flicker would be 30 hours per year (Klepinger, 2007). In addition, Dobesch and Kury (2001) recommended that shadow flicker should not exceed 30 hours per year, and the guidelines for wind power development in the State of Victoria, Australia state that shadow flicker may not exceed 30 hours per year at any dwelling in the surrounding area (Sustainable Energy Authority Victoria, 2003).

D. 4. SUN PATH DIAGRAMS FOR SHADOW FLICKER

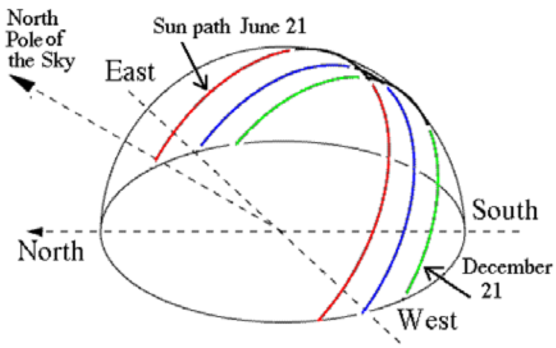
Ref: BS EN 17037:2018 Daylight in Buildings, which contains sun path diagrams for London. The diagrams are all correct for solar time. In London this is the same as GMT, but it will vary across the width of the UK.

In all cases the diagrams are assuming the observer is at ground level. Upstairs windows and turbines on roofs are more difficult to evaluate.

Shadow flicker evaluation programs:

http://solardat.uoregon.edu/SunChartProgram.html

http://www.satel-light.com/core.htm



APPENDIX D – SITE SURVEY FORM

The site survey form used by MCS contractor prior to the preparation of a quotation shall include at least the following elements:

1. Customer's name, address, and contact details.

2. Site address, grid reference and site usage (e.g., residential, agricultural, commercial, school etc.).

3. Client expressed preferences, where applicable, to include:

- Make / model of wind turbine.
- Electrical connection type (grid connect, battery charging etc.).
- Location on site.
- Comment regarding limitations of client preferences as discussed with the client.

4. An assessment of the wind resource to include:

- Average wind speed according to the Gobal Wind Atlas (GWA)for the height above ground nearest to the proposed hub height (10m or 25m).
- Appropriate highest class of wind turbine in accordance with EN 61400-2, from the following table:

Class	I	II	III	IV
V_{ave} (m/s)	10	8.5	7.5	6

Note: V_{ave} is the average annual wind speed at hub height and the highest class means a Class I would be suitable for all sites but Class III would not be suitable where the average annual wind speed is likely to be greater than 7.5 m/s. Please refer to EN 61400-2 for the full table of information.

- Prevailing wind direction or wind rose.
- Details and distances to any obstructions to the wind.

5. An assessment of the site for mechanical installation to include:

- Full details of ground conditions, cable distances and necessary types (e.g., armoured for buried cable runs).

6. An assessment of the electrical systems to include:

- Method of connection to consumer unit (e.g., need for a dedicated fuseway).

- Earth testing.
- Proposed location of inverter.
- Metering arrangements (location, meter type).
- Details of electricity supplier and network operator.

7. Planning considerations

- Proximity of proposed location to nearby residents and assessment of potential nuisance from noise or flicker.
- Details of listed buildings or if conservation area.
- Ecology (e.g., impact on bats' roost, flora and fauna).

8. Health and Safety considerations necessary for a risk assessment to include:

- Access arrangements for working at height.
- Electrical hazards such as live overhead cables.
- Underground utilities (e.g., gas, electric, water, telephone).
- Details of public access and any congregation zones.
- Locations of any flues serving fuel burning equipment.

9. A place for both the surveyor and the customer to sign off the document.

APPENDIX E – INSTALLATION & 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)*

Check Required	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)?		
Are the cables professionally 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 all labels in place?		
Turbine Junction Box(es) if Appropriate/Applicable		

Check Required	Yes	No
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 all 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 all appropriate labels in place?		
Documentation		
Has an Operation & Maintenance manual been supplied including problem diagnostics, contact details, maintenance schedule/record sheet, etc?		
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 printout of protection settings been supplied?		

Direct-connected Systems		
Check Required	Yes	No
General Design		
Is the load suitable for intermittent operation and direct connection?		

Check Required	Yes	No
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?		

Battery Systems		
Check Required	Yes	No
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 D.C.?		
Is the fuse rating less than (de-rated) cable rating?		
No fuse in common between wind turbine and D.C. load (Where D.C. loads used)?		
Are inverter and controls suitably housed, mounted and ventilated?		
Are D.C. cables sized for safety and voltage drop (particularly inverter cables)?		
Are D.C. cables safely installed/routed?		
Is A.C. 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		

Check Required	Yes	No
Are all battery installation labels present (no smoking etc)?		
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		
Check Required	Yes	No
General Design		
Is the inverter suitably sized?		
Does the inverter carry a current Engineering Recommendation (EREC) G98/1 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 A.C. isolator (double-pole) installed adjacent to the inverter?		
Is there a double-pole A.C. isolator (lockable in the off position only) installed adjacent to at the point of interconnection with the supply?		
Is A.C. 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 A.C. 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 A.C. 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?		

Comments

Sign Off	
MCS Contractor Company Name	
Certification Number	
MCS Contractor Signature	*MCS Contractor Signature here*
Print Name	*Print Name here*
Job Title/Position	
Contact Telephone Number	

Contact Email Address	
Date	

APPENDIX F – MODEL HANDOVER DOCUMENT

Small Wind Turbine Model Handover Document	
Client Details	
Client Name	
Client Address	
Site Address (if different)	
Client Email Address	
Client Telephone Number	
MCS Contractor Details	
MCS Contractor's Name	
Certification Number	
MCS Contractor's Address	
MCS Contractor's Email Address	
MCS Contractor's Telephone Number	
System Details	
Small Wind Turbine System Installed	*Description of system*
Installation Date	
Commissioning Date	
System Type: Direct Connected Battery System Grid Connected	*State which type of system installed*

Key Components		
Manufacturer		
Type & Model		
Serial Number		
Inverter(s): Type and Model		
Inverter Serial Number		
Meter Type & Model Fitted		
Meter Serial Number		
System Performance		
Estimated System Performance	*Taken from calculations as per Appendix A*	
Document Handover Checklist *Items required in the handover pack*	Yes	No
MCS Certificate		
Copy of Invoice *Marked 'paid in full'*		
Turbine Support Structure Specification		
Drawings (e.g. wiring), specification, and instructions for assembly installation and erection of equipment		
All commissioning forms & checklists e.g. Test & Inspection Certificates DNO Micro-generator documentation		
Operation & Instruction Manual including: Installation Operation Inspection & Maintenance *See Section 6.2.2 for expected content*		
Additional installer documentation – see Section 6.2.3 for expected content		
Additional system dependent information – see Section 6.2.4 for expected content.		
Manufacturer's User Manual		

Manufacturer's Warranty information		
Manufacturer's maintenance schedule		
Planning Permission Decision Notice *If applicable*		
Building Regulations Approval Notice/Completion Certificate		
Documentation required for any incentive scheme.		
Comments		
MCS Contractor Declaration		
MCS Contractor Company Name		
I/We confirm that the above small wind turbine system meets the requirements of the MCS MIS 3003 standard	*MCS Representative Signature here*	
Name of MCS Representative	*Print Name here*	
Job Title/Position		
Contact Telephone Number		
Contact Email Address		
Date		
Handover Sign Off		
MCS Contractor Company Name		
MCS Contractor Signature	*MCS Contractor Signature here*	
Print Name	*Print Name here*	
Job Title/Position		
Contact Telephone Number		
Contact Email Address		
Date		

APPENDIX G – MAINTENANCE SCHEDULE

Note: A preventive maintenance schedule/checklist from the wind turbine manufacturer should be provided and followed, so scheduled servicing can take place. A typical preventive maintenance schedule (not exhaustive) will consider and include the following tasks:

Maintenance Task	Comment
Post Installation	
Visual inspection of the turbine and tower – check for excessive noise and vibration.	A short period after installation (e.g., a month). Also, after storms or high winds.
Manually check and tighten to the correct torque any bolts/fixings for the following mechanical equipment: Foundation fixings, turbine tower joints/connections, guy wire/cables fixings, rotor blades, rotor hub, nacelle, rudder, mechanical brake, generator, gearbox.	
Mark/re-mark all bolts where necessary.	
Manually check and tighten all electrical connections.	
Scheduled Preventive Maintenance	
Wind Turbine Tower & Fixings	These preventive maintenance tasks are **advisory/illustrative only**. The task details (including tolerances, torque vales, settings etc.), the relevance and application of them will depend on the size, model, and type of small wind turbine installed. The size, model, and type of small wind turbine will also determine the interval/frequency of the maintenance tasks.
Visual inspection of the turbine tower – check for excessive noise and vibration.	
Visual inspection of the turbine tower – manually check welded elements for cracks and corrosion.	
Visual inspection of the turbine tower – check for paint damage.	
Visually inspect and manually check turbine tower bolts/fixings. Tighten to the correct torque where necessary.	
Visually inspect and manually check turbine tower foundation bolts/fixings. Tighten to the correct torque where necessary.	
Re-mark all bolts (where necessary) that are re tightened/torqued.	
Visually inspect and manually check guy ropes/cables/wires for proper tension. Re-tension where necessary.	
Visually inspect and manually check guy shackles and turnbuckles for condition and damage. Adjust and correct where necessary.	

Maintenance Task	Comment
Visually check for excessive corrosion/cracks/wear of all turbine tower support cables/wires and foundation components.	
Wind Turbine	All tasks where applicable depending on the size, model, and type of small wind turbine. In addition to the comments above, the types, quantities, quality of replacement parts and other materials required will also depend on the size, model and type of small wind turbine installed.
Rotor, Hub & Blades	
Visually inspect and manually check the condition and correct operation of the hub, including the nose cone.	
Grease the hub.	
Check the hub oil level. Refill as required. Change oil as required.	
Visually inspect and the condition of the lightning rod.	
Visually inspect and manually check the rotor blades (particularly the leading edge) for damage, condition, pitting and corrosion.	
Visually inspect blade stud condition.	
Clean the rotor blades where required.	
Manually check the rotor blades for lamination.	
Visually inspect and manually check the condition and correct operation of the rotor.	
Visually inspect the rotor shaft for damage, corrosion, and condition.	
Check the correct operation of the variable pitch.	
Grease the bearings in the variable pitch.	
Visually inspect and manually check the correct operation of the rudder.	
Nacelle	
Visual inspection of the nacelle – check for damage and water leakage.	
Visually inspect and manually check the nacelle bolts and fixings for damage, corrosion, and looseness. Re-tighten and re-mark where necessary.	
Visually inspect the anemometer/wind vane fixings for damage and corrosion.	

Maintenance Task	Comment
Main Bearing	
Visually inspect the main bearing housing for damage, cracks, and corrosion.	
Visually inspect and manually check the main bearing housing bolts for condition and looseness. Re-tighten and re-mark where necessary.	
Grease the main bearing (remove old grease).	
Gearbox	
Visually inspect and manually check the correct operation of the gearbox.	
Visually inspect the gearbox housing for damage, corrosion, and condition.	
Visually inspect and manually check the gearbox housing mount bolts for condition and looseness. Re-tighten and re-mark where necessary.	
Visually inspect and manually check all gearbox components (e.g. pump, hoses, teeth, oil, and oil filter). Refill and change oil as required.	
Brake	
Visually inspect and manually check all brake components for damage, corrosion, looseness, and condition (e.g. disc, hoses, pads, calipers. Correct as required.	
Visually inspect and manually check brake housing for cracks and corrosion.	
Perform a brake function test.	
Yaw	
Visually inspect and manually check the condition and correct operation of the yaw, including the yaw drive, drive housing and yaw bearing.	
Grease the yaw bearing.	
Check oil in the yaw drive system. Refill as required. Change oil as required.	
Grease yaw drive system bearing.	
Generator	

Maintenance Task	Comment
Visually inspect and manually check the correct operation of the generator.	
Visually inspect the generator housing for damage, corrosion, and condition.	
Grease the generator bearing.	
Visually check the generator alignment.	
Electrical Equipment	
Visually inspect and manually check all electrical connections. Check for damage. Tighten where necessary.	Includes the generator connections/
Visually inspect and manually check the turbine tower grounding cables. Retighten where required.	
Visually inspect and manually check all earthing connections. Retighten where required.	
Visually inspect and manually check the turbine controller cables, clamps, terminals, and components.	
Visually inspect and manually check the inverter is mounted securely. Re-secure where necessary.	
Visually inspect and manually check the inverter is ventilated correctly – unobstructed airflow, fans operating correctly. Remove any obstructions if necessary.	
Externally mounted inverters – visually inspect and check for water ingress.	
A.C. and D.C. isolators – carry out functional check and visually inspect and manually check for damage and ingress.	
D.C. junction boxes – check for damage an ingress.	
Test D.C. circuits (V_{SC}, I_{SC}, Earth leakage).	
Visually inspect and check integrity of fuses and surge protectors.	
Visually inspect and manually check all cables, cable holders, cable glands, and cable ducts are free from damage and correctly supported.	
Check the function of the electrical brake.	
Visually inspect and manually check all sensors installed.	For example, rotor speed, generator speed, yaw, anemometer, wind vane, and vibration sensors.

Maintenance Task	Comment
Visually inspect power generation/export meter(s).	
Battery Maintenance	
Visually inspect all battery connections.	Where applicable.
Visually check batteries for damage and leakage	
Visually check battery housing(s) for damage and leakage.	
Carry out battery maintenance in accordance with manufacturer's instructions.	Observe safety requirements for battery maintenance.
Other Maintenance Tasks	
Carry out a functional test of the safety system.	
Visually inspect and manually check the safe method of access to the wind turbine.	For example, this would involve either a check of the condition of the connection ladder(s) to the tower and/or the operation (clean and lubricate) of the mechanism (e.g. hoist) to lower the turbine tower for maintenance purposes.
Check and assess that the turbine power generation is in line with thew predicted energy production.	
Visually check and manually inspect the condition and security of any fencing around the wind turbine.	

APPENDIX H – ENTRY LEVEL QUALIFICATIONS

Wind Turbine Technician/Engineer – Design

Methods (career paths) to becoming a qualified wind turbine technician/engineer include:

- A university course.
- A college course.
- An apprenticeship.

The following qualifications are deemed suitable for the design of small wind turbine systems:

University

Type of Course/Qualification	Entry Level Requirements
Foundation degree, higher national diploma (HND) or degree in: • Renewable energy engineering. • Electrical or mechanical engineering. • Electrical power engineering.	• 1 or 2 A levels, or equivalent, for a foundation degree or higher national diploma (HND). • 2 to 3 A levels, or equivalent, for a degree.

College

Type of Course/Qualification	Entry Level Requirements
College course, which can lead to a trainee job with a wind turbine engineering company. Courses/qualifications include: • Level 3 Certificate in Mechanical or Electrical Engineering. • Level 3 Diploma in Maintenance Engineering Technology.	• 5 GCSEs at grades 9 to 4 (A* to C), or equivalent, including English, maths, and science.

Apprenticeship

Type of Course/Qualification	Entry Level Requirements
Advanced apprenticeship: Engineering technician, or maintenance and operations engineering technician.	• 5 GCSEs at grades 9 to 4 (A* to C), or equivalent, including English and maths, for an advanced apprenticeship.
Higher apprenticeship in manufacturing engineering: wind generation.	• 4 or 5 GCSEs at grades 9 to 4 (A* to C) and A levels, or equivalent, for a higher or degree apprenticeship

Wind Turbine Technician – Installer

The following skills are deemed suitable for the installation of small wind turbines:

- Competent mechanical installer. Ability to understand and follow design specifications, manufacturer's instructions and design drawings, codes of practice, Statutory Regulations, the requirements of this Standard and other relevant MCS Standards.
- Competent electrician – qualified to BS 7671 18th Edition IET Wiring Regulations (usually City and Guilds Level 3). Ability to understand and follow design specifications, manufacturer's instructions and design drawings, codes of practice, Statutory Regulations, the requirements of this Standard and other relevant MCS Standards.

Previous Experience

Qualifications and experience in electrical or mechanical engineering from another industry, or from the armed forces would also be deemed suitable for the installation of small wind turbine systems.

Note: The above courses and qualifications can help demonstrate competency, but a single qualification should not be presumed to prove an individual competent for all situations.