Wind and Snow Load Calculations

Introduction

As stated in the MCS MIS 3002 standard for the installation of PV systems;

"The contractor shall ensure that the roof structure is capable of withstanding the loads (static and wind loads) that will be imposed by the PV modules and their mounting arrangements. If there is any doubt, a structural engineer must be consulted."*

The Segen PV Designer software can assist you in determining the wind and snow loads likely to be imposed on a PV system mounting system on a pitched roof and advise on the number and type of roof anchors and mounting rails required to withstand these loads. Calculations are performed according to the MCS and related standards and manufacturer's supplied technical data. The current PV MCS installer standard MIS3002 states that wind loading calculations should be performed according to the guidelines in the new Guide to the Installation of Photovoltaic Systems (PV guide). Schletter also produces a guide System Design 2010 which is similar in principle to the new PV guide.

Both follow a similar process with the new PV guide being more detailed in some aspects with more wind zones defined and a more refined assessment of the location and topography than the previous BRE489 specification and the Schletter methodology is more detailed still.

All methods are simplified methods derived from either BS6399: Part 2 or its replacement EN 1991-1-4:2005 Eurocode 1. The full methods described in these standards are detailed and complex and not practical for anyone other than a full structural engineer to use using specialist software.

The newer more refined PV guide method will tend to produce a lower peak wind load than BRE489 in urban areas as the BRE489 method uses a worst case basis and essentially assumes a rural location. The Schletter guide uses a more refined assessment of wind speed and terrain and can therefore produce even lower figures in some areas.

This document describes both methods and how Segen's PV designer can be used to help calculate the values required. Both methods are supported in the Segen designer with a radio box selection of which method is to be used.

The Segen PV designer only supports standard on-roof installations using Schletter and Renusol mounting systems when calculating wind and snow loads.

For other roof mounting types a message is displayed guiding the user in where to seek additional advice on wind loading as mounting systems such as flat roof mounted systems require a much more detailed site specific assessment due to the complexities of wind interacting with the various types of building structure, size and shape.

* Static loads imposed by the addition of the extra weight of the PV panels on a roof structure should be calculated by a suitably qualified engineer to ensure the existing roof structure is capable of supporting the additional weight. This process is NOT covered by this document or supported by the Segen PV designer software.

Building Regulations

There is currently much confusion and disagreement within the UK PV industry, local authorities, building industry associations and MCS certification bodies as to the requirements to notify a PV installation under the building regulations. The LABC (an organisation representing local authority building control in England and Wales) issue two guidance notes which are now in common use by many local authorities.

http://www.eden.gov.uk/EasysiteWeb/getresource.axd?AssetID=26010&type=full&se rvicetype=Attachment

http://www.eden.gov.uk/EasySiteWeb/GatewayLink.aspx?alId=26579

Each local authority may however interpret the rules themselves and may or may not follow exactly the LABC advice and many publish their own guidance notes on their web sites. Segen's advice is to always seek the guidance of the relevant local authority on a case by case basis and not to believe anything that anyone says about this issue other than an authorised representative of the relevant local authority's building control department.

Structural Surveys

There are a number of fully qualified third-party structural surveyors who will undertake remote structural surveys including, static, snow and wind loading for a modest fee and who Wind and Snow Loads Issue 1.0 16th September 2013 should be able to provide an expert opinion that will normally satisfy the requirements of thelocal building control department and MCS certification bodies and provide an element of protection to the PV installer from any subsequent liability claim.

Attaching Roof Anchors to the Roof Structure

There are many issues* related to the physical attachment of roof anchors to the roof structure which require detailed knowledge of the chosen mounting system and building works in general. It is important for example to ensure that the screws used are of a suitable diameter and length to withstand the loads, don't pose a risk of splitting the rafter and that no increased risk of the roof leaking is incurred.

- There is a guide from the National House Building Foundation (NHBC) called **Guide to installation of renewable energy systems of residential buildings.**

http://www.nhbcfoundation.org/Renewableenergysystems/tabid/454/Default.aspx

- And from The National Federation of Roofing Contractors (NFRC) the guidance document **Fixing Solar Panels to Timber Rafters & Battens (Pitched Roofs)**.

http://www.middevon.gov.uk/CHttpHandler.ashx?id=17643&p=0

- A **Schletter Test Report** details the forces capable of being resisted by 6mm X 90mm and 8mm X 80mm Schletter wood screws into a 35mm wide rafter

* Issues related to the attachment of roof anchors to the roof structure should be assessed by a suitably qualified engineer to ensure it is appropriate and doesn't risk weakening the roof structure or its water resistance. This process is **NOT** covered by this document or supported by the Segen PV designer software.

Location, Location, Location …

Both the wind and snow load calculations using either method require essential location information being the grid reference which can be found using the Segen designer from an entered post code. The designer then displays the OS Grid reference code to assist the user to confirm their location.

The wind zone is found using lookup tables derived from the peak wind load maps contained in the PV guide and the snow load data is derived from a map in EN 1991-1-4:2005 Eurocode 1. The data however is only entered to a resolution of a 100km grid square and therefore is only an initial starting point for an accurate assessment.

For a more accurate assessment the Wind Zone and Snow Load values can be entered manually from a selection list based on a visual assessment using the various maps or the default values determined by the postcode lookup can be changed by the user.

Peak Wind Load

Additional information is required for the peak wind load calculation which is;

Ridge Height. How far above the ground the top of the roof is. The higher the roof the windier it will be. The new PV guide supports heights up to 25m. If a height greater than supported is entered then a warning is given and no wind loading calculation is provided and that the full process described in BS6399: Part 2 or EN 1991-1-4:2005 Eurocode 1 as appropriate needs to be followed.

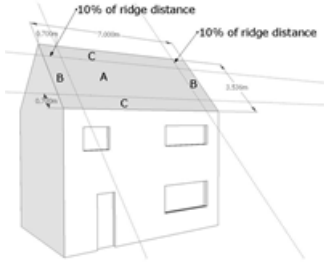
Distance from Sea. How far from the coast the location is. Coastal locations tend to be windier than inland ones. This is only an option with the new PV guide method.

Location Type. Either Rural or Urban. Rural locations tend to be windier than urban ones as the wind is less affected by other buildings. This is only an option with the new PV guide.

Altitude. The higher the terrain at the location the windier it will be. The entered altitude is used to calculate an adjustment to both the peak wind speed and snow loading values and is therefore important to be relatively accurate.

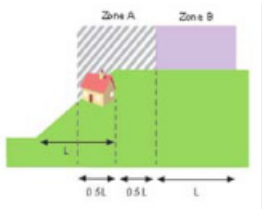
Topography. Locations on or at the top of hill will be windier. The new PV guide uses the angle of the slope and the location of the property relative to the slope to generate a more refined adjustment factor.

Location within Roof. The edge areas of a roof will experience a much higher wind loading than the central area. The edge areas are defined as within 10% of the roof dimensions. E.g. if a roof is 6m wide and 4m tall then the edge area is defined as within 600m of the roof sides and of the roof top and bottom. Wind loads in the edge regions are approximately 70% higher than in the central region. If the array therefore is more than 80% of the width or height of the roof or within 300mm then additional roof anchors may be needed near the edges to ensure the maximum loading on the roof anchors and rails is not exceeded. For the central area a coefficient of pressure of 1.3 is defined whereas for the edge area a coefficient of pressure of 2.2 is used.



PV Guide

This defines 5 wind zones and provides peak wind load figures for all 5 zones with figures provided for 5 different ridge heights, 5, 10, 15, 20 and 25m, Urban or Rural and 3 different distances from the coast, < 2, 2 – 20 and > 20km.



An adjustment of 0.2% per m over 100m is specified using the following equation;

1 + ((Altitude - 100) / 100 * 0.2).

There are a variety of different topography adjustments between 1 and 1.7 depending on the steepness and location of the property on a slope.

Schletter

Based on the Eurocode standard the Schletter guide starts with the base wind speed (V_b) from the map in Appendix B down to a resolution of 1m/s.

An adjustment (Calt) is then made for the height of the roof and the altitude of the site. For a ridge height <= 10m the equation 1 + (0.001 * Altitude) is used. For a ridge height of > 10m the equation 1 + (0.001 * Altitude) * (10 / Ridge Height)2 is used.

The wind pressure is then calculated using: $Q_b = (Vb * C_{alt})^2 / 1600$.

Five terrain categories are then defined as;

Category	Description
0	Sea, coastal area exposed to the open sea.
I	Lakes or area with negligible vegetation and without obstacles.
II	Area with low vegetation such as grass and isolated obstacles (trees, buildings) with separations of at least 20 obstacle heights.
III	Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest).
IV	Area in which at least 15% of the surface is covered with buildings and their average height exceeds 15m.

Using the graph in **Appendix E** an exposure factor is determined using a combination of the terrain category and ridge height.

Snow Load

The PV guide doesn't give much detail of how snow load calculations should be undertaken however the process is to use a snow load map of the UK to determine the ground snow load and then to apply an altitude and slope adjustment using the formula:

snow load = ground snow load + (altitude - 100) / 525 * U1.

See right, for where the U1 adjustment factor is based on the slope of the roof.

Pitch	Adjustment (U1)
< 15 degrees	0.8
15 – 30 degrees	0.8 + (0.4 * ((Angle - 15) / 15))
30 – 60 degrees	1.2 + ((60 – Angle) / 30)
>= 60 degrees	0

EN 1991-1-4:2005 Eurocode 1 states that at altitudes greater than 1,500m specialist advice from the Met Office should be sought and therefore the Segen designer will not attempt to present a snow load calculation for altitudes greater than 1,500m.

Shown in **Appendix C** is a snow load map that has been taken from the UK National Annex to EN 1991-1-4:2005 Eurocode 1.

It would seem however that snow loading in the UK is rarely the prime determining factor of how strong the mounting system needs to be as snowy areas also tend to be windy which normally takes precedence.

Schletter Mounting System

Schletter provide data tables specifying the minimum number of roof anchors per m2 for a given part number, inclination, wind load and snow load and the maximum span distance of the mounting rails given a part number, inclination, height of modules, wind load and snow load.

The Segen Designer will display a warning if the current design uses too few roof anchors or the span distance between roof anchors is greater than supported by the selected mounting rail for the calculated wind or snow load.

If any part of the array is within the edge zone then a tick box in the designer can be used to specify that an extra 25% roof anchors should be included in the system configuration.

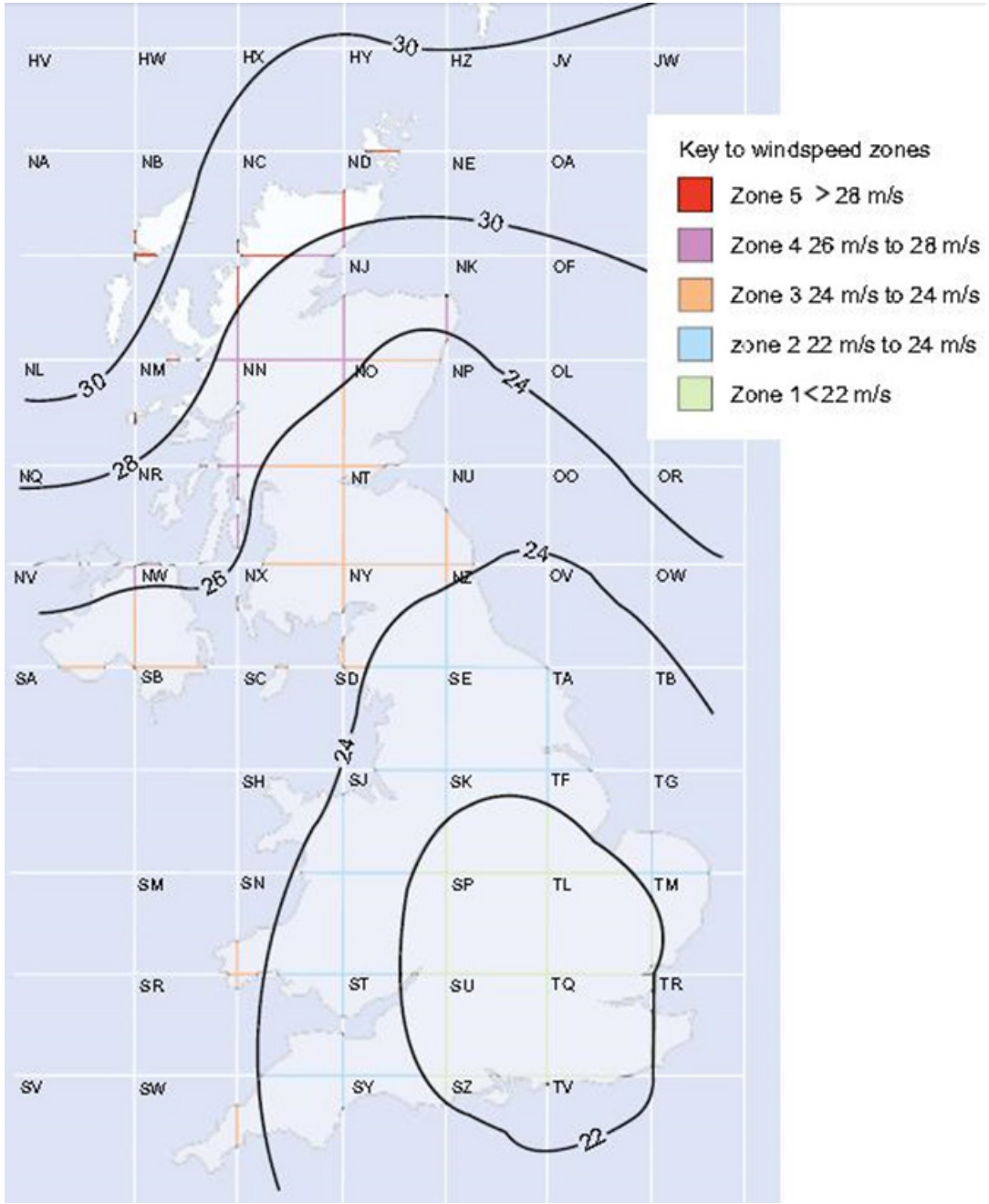
These should be used to half the spacing between anchors in any part of the array which is located within the edge zone.

Site Survey Check List

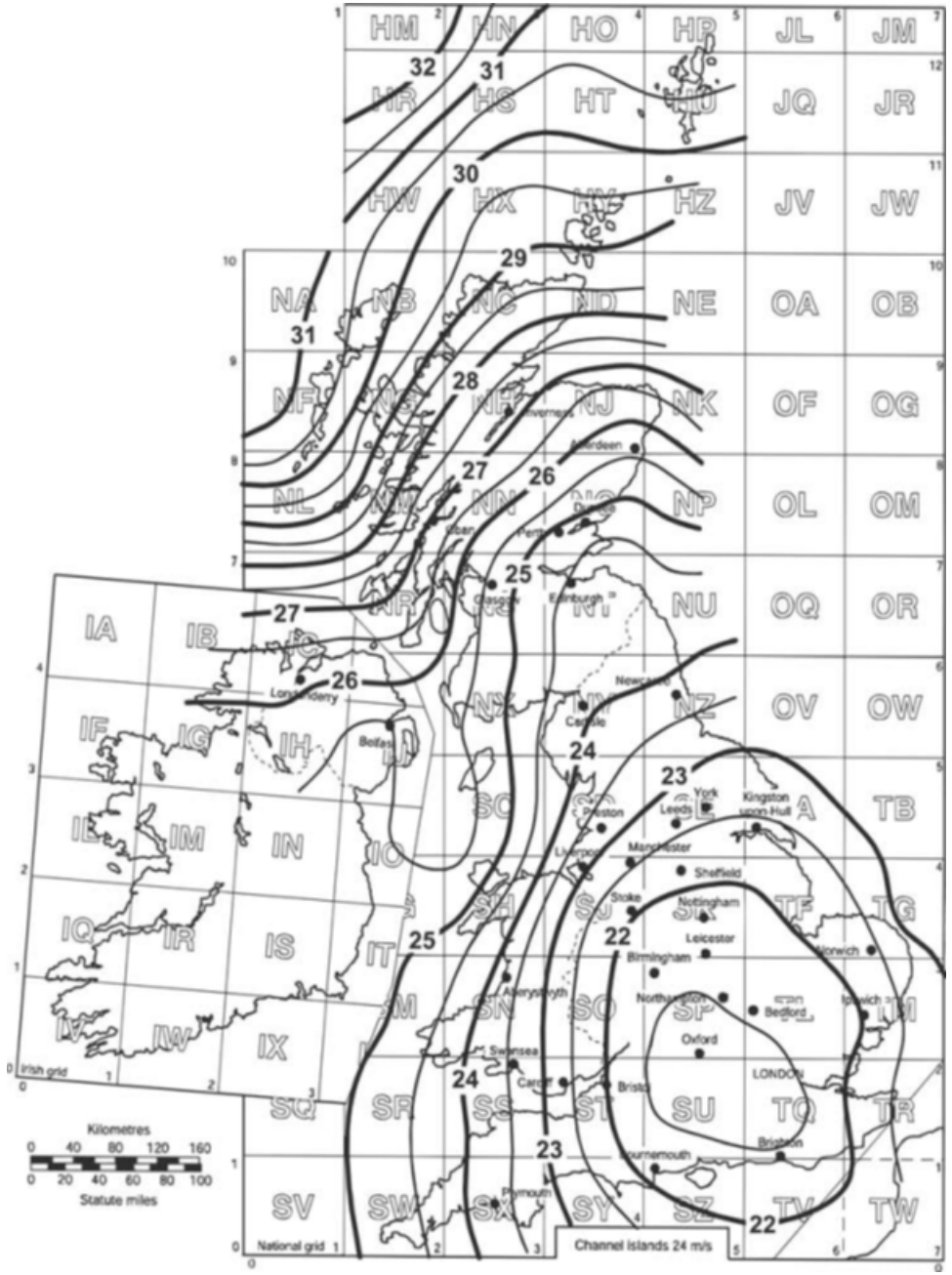
The following information needs to be obtained on a site survey to enable a full wind and snow load calculation to be performed.

Parameter	Value	Notes
Site Location	Postcode	Alternatively record the wind area and snow load by finding the location on the relevant maps.
Altitude	Height in meters above sea level	Obtained either from a detailed OS map, altimeter or smart phone application.
Ridge Height	The height in meters from the ground to the highest point of the roof	Obtained from building plans or trigonometry
Distance to the sea	The distance in km to the nearest point on the coast	Obtained from a detailed OS map or on-line mapping tool, e.g. Google Earth.
Type of location	Rural or Urban	Select the best location type that best describes the location, especially in the direction of the prevailing wind.
Topography	Zone and slope in degrees	If the property is on a slope of greater than 5 degrees then select the zone whichbest describes the property's location relative to the slope and the angle of the slope.
Roof size	Horizontal and vertical dimensions in meters	Based on the size and location of the proposed PV system evaluate if any part ofthe PV array will be within the edge zones.

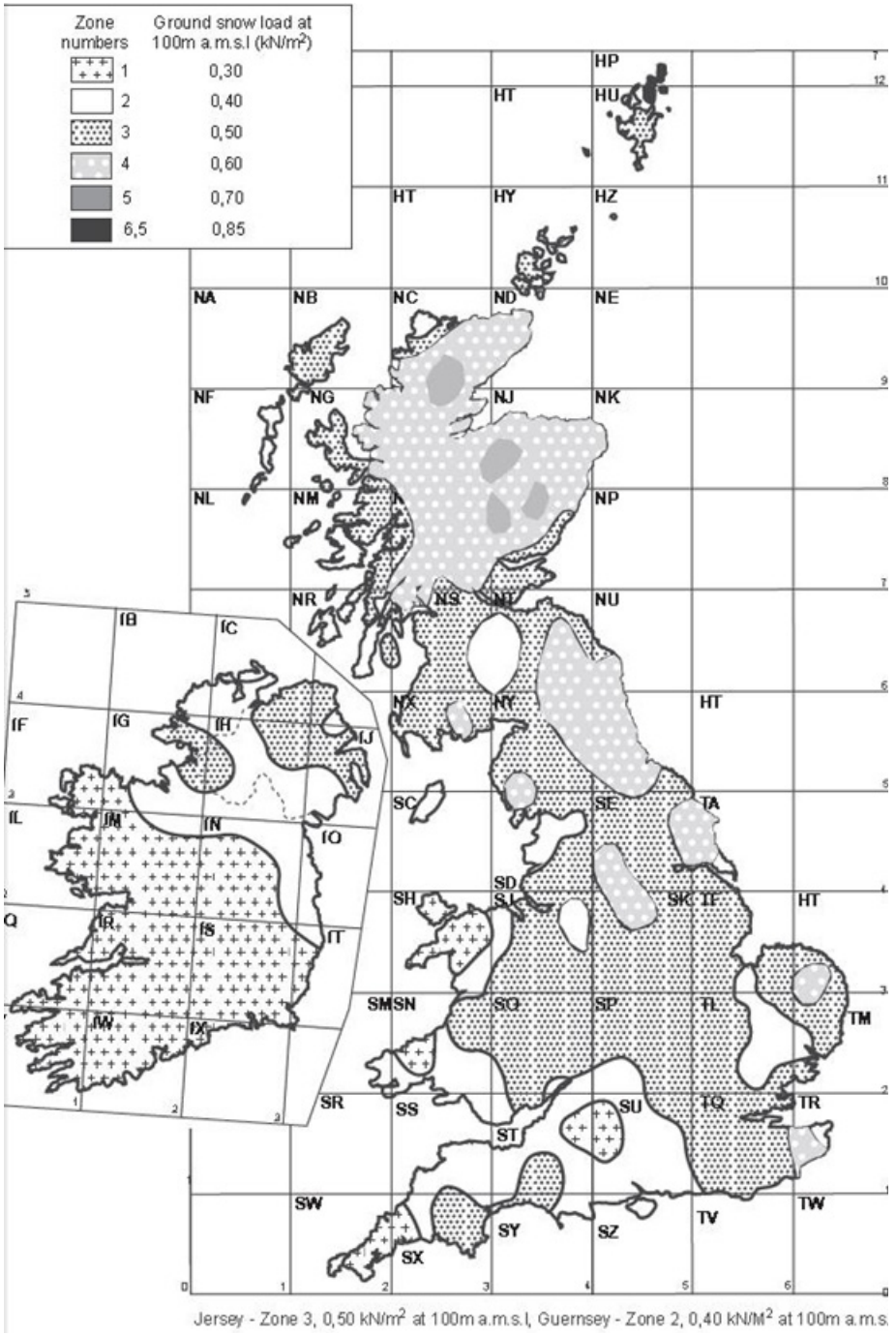
Appendix A PV Guide Wind Areas



Appendix B – Eurocode Wind Speed Map



Appendix C - Eurocode Snow Load Map



Appendix D: Terrain Categories