The MCS shade evaluation procedure

Part 1 – The procedure explained

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a) Overview of MCS performance evaluation method – and how the shading analysis fits into this
b) Why MCS introduced the new shade method
c) Introduction to Sunpath diagrams
d) The MCS Sunpath chart
e) Rules for using the MCS chart
f) Rules for using and presenting “alternative methods”

Part 2 – How to record shade onto the chart

(next presentation)

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Part 1 – The procedure explained

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Part 2 – How to record shade onto the chart

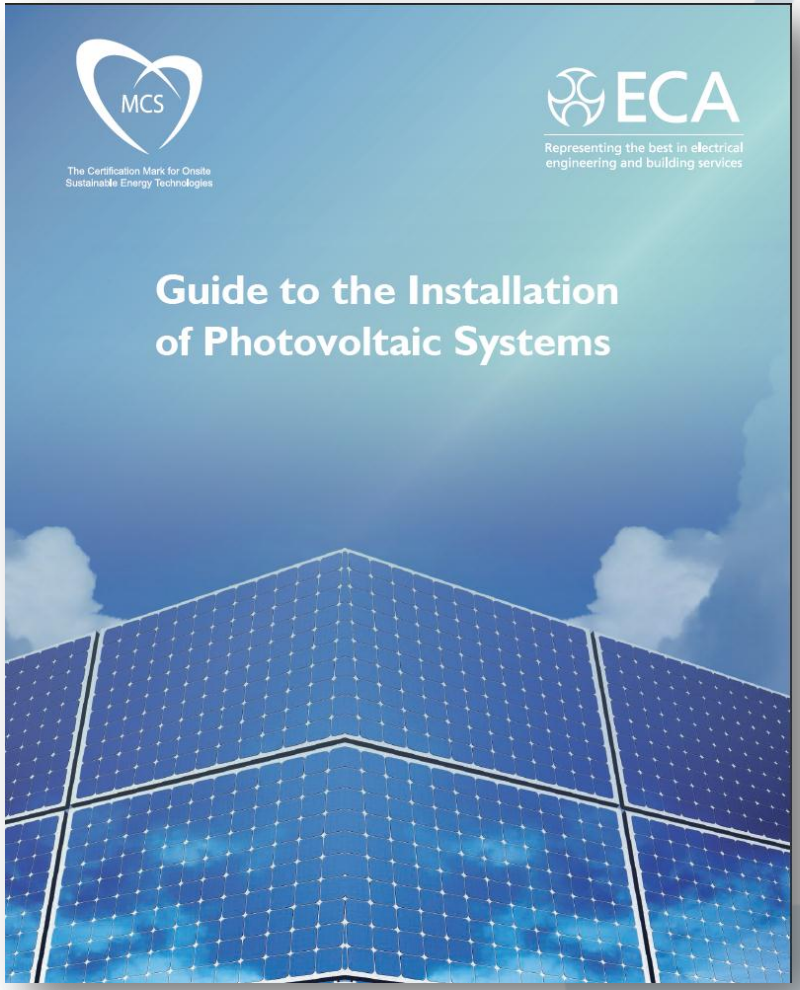
(next presentation)

1. MCS Performance evaluation - overview

PV Guide contains a wholly new procedure to estimate the annual performance (kWh) of PV system

The purpose of the standardised procedure is intended **to prevent miss-selling** and overestimation of PV system performance.

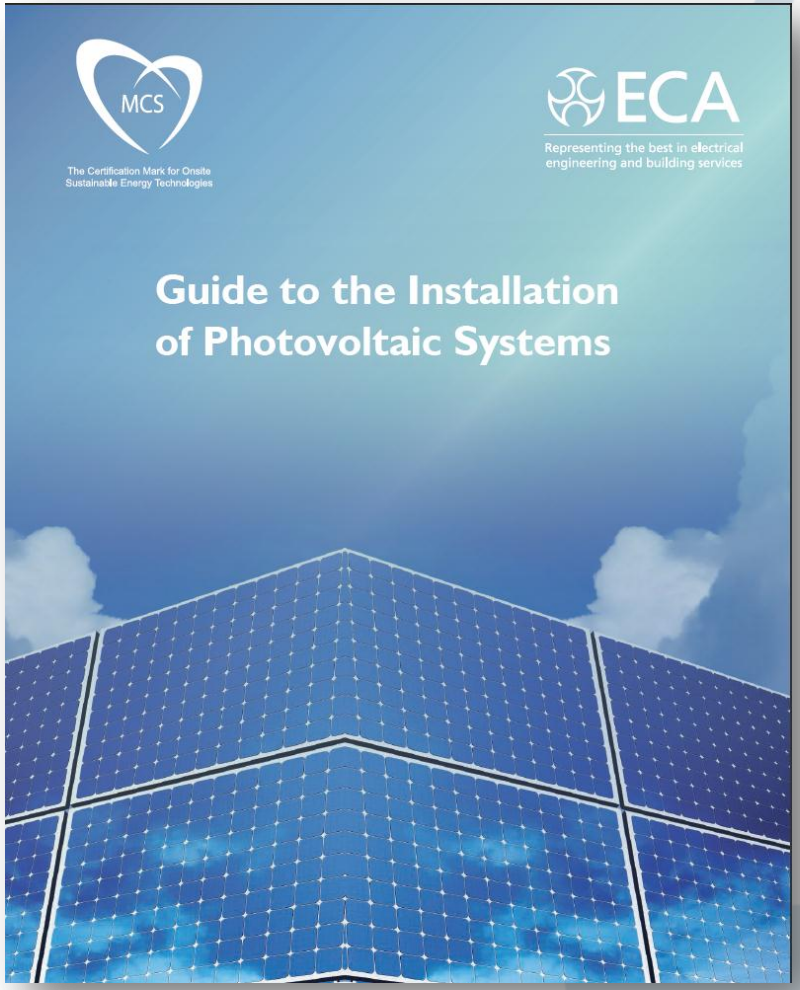
The procedure is designed to ensure that all customers receive a system performance estimation completed using the same method



1. MCS Performance evaluation - overview

Why

- Old (SAP) method did not take into account the geographic location
- Wanted a better allowance for pitch and orientation
- Emerging evidence that systems consistently outperformed the SAP estimate
- **Old shade calculation was far too crude**
- New method designed to be relatively straightforward, and crucially … **auditable**



1. MCS Performance evaluation - overview

PV Guide Section 3.7.2
Standard Estimation Method

The approach shall be as follows:

1. Establish the electrical rating of the PV array in kilowatts peak (kWp)
2. Determine the postcode region
3. Determine the array pitch
4. Determine the array orientation
5. Lookup kWh/kWp (kK) from the appropriate location specific table
6. **Determine the shading factor (SF)**
   Using shade factor procedure set out in 3.7.7

Annual AC output (kWh) = kWp x Kk x SF

If the adjusted performance estimate is worse than originally predicted, the client shall be given the same cooling off period and cancellation rights (to include any right to cancel without financial penalties) that applied to the original quote. This shall apply from the date of issue of the updated performance estimate.

3.7.2 Standard Estimation Method

The approach is as follows:

1. Establish the electrical rating of the PV array in kilowatts peak (kWp)
2. Determine the postcode region
3. Determine the array pitch
4. Determine the array orientation
5. Look up kWh/kWp (Kk) from the appropriate location specific table
6. Determine the shading factor of the array (SF) according to any objects blocking the horizon - using shade factor procedure set out in 3.7.7

The estimated annual electricity generated (AC) in kWh/year of installed system shall then be determined using the following formula:

Annual AC output (kWh) = kWp x Kk x SF

3.7.3 kWp of Array (kWp)

The kWp value used shall be the sum of the data plate value (Wp at STC) of all modules installed (the value printed on the module label).

3.7.4 Postcode Zone

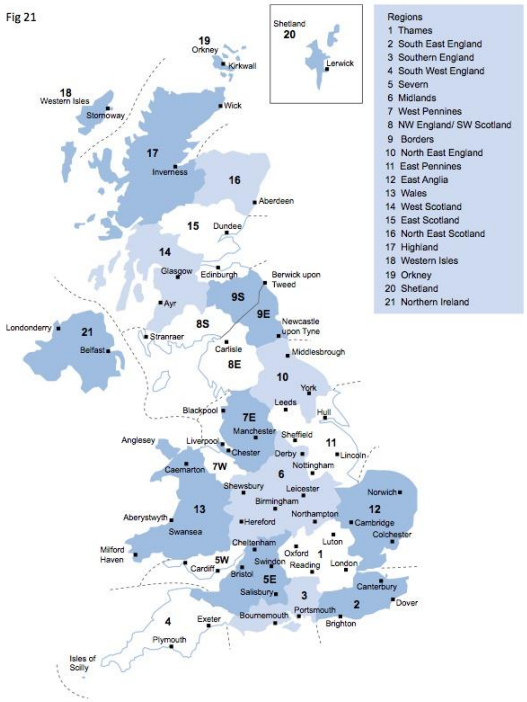
Determine the postcode zone of the site from the map and the table on the following pages. Once this has been obtained, you will be able to select the correct table for the kWh/kWp (Kk) values to be selected.

Note: These zones are the same as the SAP postcode zones

1. MCS Performance evaluation - overview

PV Guide Section 3.7.2
Standard Estimation Method

Fig 21



Regions
1 Thames
2 South East England
3 Southern England
4 South West England
5 Severn
6 Midlands
7 West Pennines
8 NW England/ SW Scotland
9 Borders
10 North East England
11 East Pennines
12 East Anglia
13 Wales
14 West Scotland
15 East Scotland
16 North East Scotland
17 Highland
18 Western Isles
19 Orkney
20 Shetland
21 Northern Ireland

Inclination (variation from horizontal)	Orientation (variation East or West from South)									
	0	5	10	15	20	25	30	35	40	45
0	735	735	735	735	735	735	735	735	735	735
1	741	741	741	741	741	740	740	740	740	739
2	747	747	747	747	746	746	746	745	744	744
3	753	753	753	753	752	752	751	750	749	748
4	759	759	759	759	758	757	756	755	753	752
5	765	765	765	764	763	762	761	760	758	756
6	771	771	770	770	769	767	766	764	762	760
7	776	776	776	775	774	772	771	769	766	764
8	782	782	781	780	779	777	775	773	771	768
9	787	787	786	785	784	782	780	777	774	771
10	792	792	791	790	789	787	784	781	778	775
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12	802	802	801	800	798	795	793	789	786	781
13	807	806	806	804	802	800	797	793	789	785
14	811	811	810	808	806	804	800	797	792	787
15	816	815	814	813	810	808	804	800	795	790
16	820	819	818	817	814	811	808	803	798	793
17	824	823	822	820	818	815	811	806	801	796
18	827	827	826	824	821	818	814	809	804	798
19	831	831	829	828	825	821	817	812	807	800
20	835	834	833	831	828	824	820	815	809	803
21	838	837	836	834	831	827	823	818	812	805
22	841	841	839	837	834	830	825	820	814	807
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36	865	865	863	860	85					
37	866	865	863	860	85					
38	866	865	863	860	85					
39	866	865	863	860	85					
40	866	865	863	860	855	850	843	835	825	815
41	865	865	863	859	855	849	842	834	824	814
42	865	864	862	859	854	848	841	833	823	813
43	864	863	861	858	853	847	840	832	822	811
44	863	862	860	857	852	846	839	830	821	810
45	862	861	859	855	851	845	837	829	819	808

- Array pitch … 5° steps
- Array orientation … 15° steps

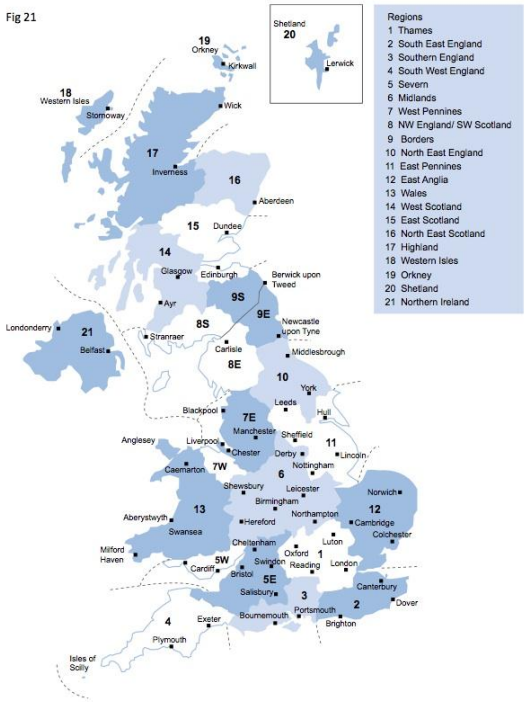
Excel file download on MCS site

Annual AC output (kWh) = kWp x Kk x SF

1. MCS Performance evaluation - overview

PV Guide Section 3.7.2
Standard Estimation Method

Fig 21



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16	820	819	818	817	814	811	808	803	798	793
17	824	823	822	820	818	815	811	806	801	796
18	827	827	826	824	821	818	814	809	804	798
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- Array pitch … 5° steps
- Array orientation … 15° steps

Excel file download on MCS site

Annual AC output (kWh) = kWp x KK x SF

2. Why MCS introduced new shade method

The old SAP option …

Overshading	% of sky blocked by obstacles	Overshading factor
Heavy	> 80%	0.5
Significant	> 60% - 80%	0.65
Modest	20% - 60%	0.8
None or very little	< 20%	1.0

But …

- *"percentage of sky blocked"* - **very** open to interpretation
- 20% shade could have a significant effect on a PV system – yet old SAP method **ignores any shade up to 20%**

2. Why MCS introduced new shade method

MCS received evidence of badly shaded installations …

But an installer could probably argue … *"well actually only 20% of the whole sky is blocked by the tree"*

But an installer could probably argue … *"Definitely less than 20% of the whole sky is blocked by the chimneys"*

2. Why MCS introduced new shade method

MCS received evidence of badly shaded installations …

The rules made it very difficult for MCS certification bodies to police the old shading procedure

The rules meant badly shaded arrays could be installed – yet the installer could still provide the customer with an output estimate that took no account of the shade effect .. They could argue that "less than 20% of the sky was obscured"

2. Why MCS introduced new shade method

MCS received evidence of badly shaded installations …

Some installers seemed to underestimate the effect of near shading (e.g. chimneys, flue pipes, aerials etc)

The SAP rule enforced this misapprehension
(if less than 20% of the sky obscured, SF=1)

NB .. Not only is this system shaded from the adjacent roofs, there is also a soil pipe and a satellite dish shading the array

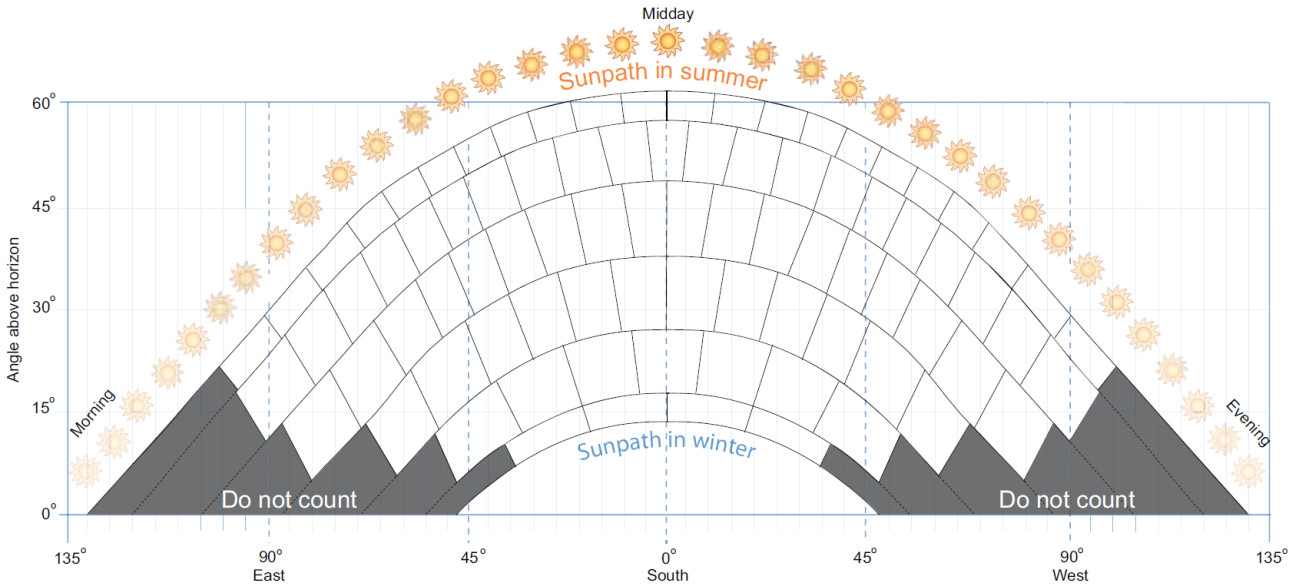
2. Why MCS introduced new shade method

The new MCS shade method has two key features …

1) Designed to better assess the affect of shade on the PV array

2) Ensures the shade assessment is properly documented

   >> *to enable better policing of the system*
   >> *to help the customer understand the suitability of their roof*

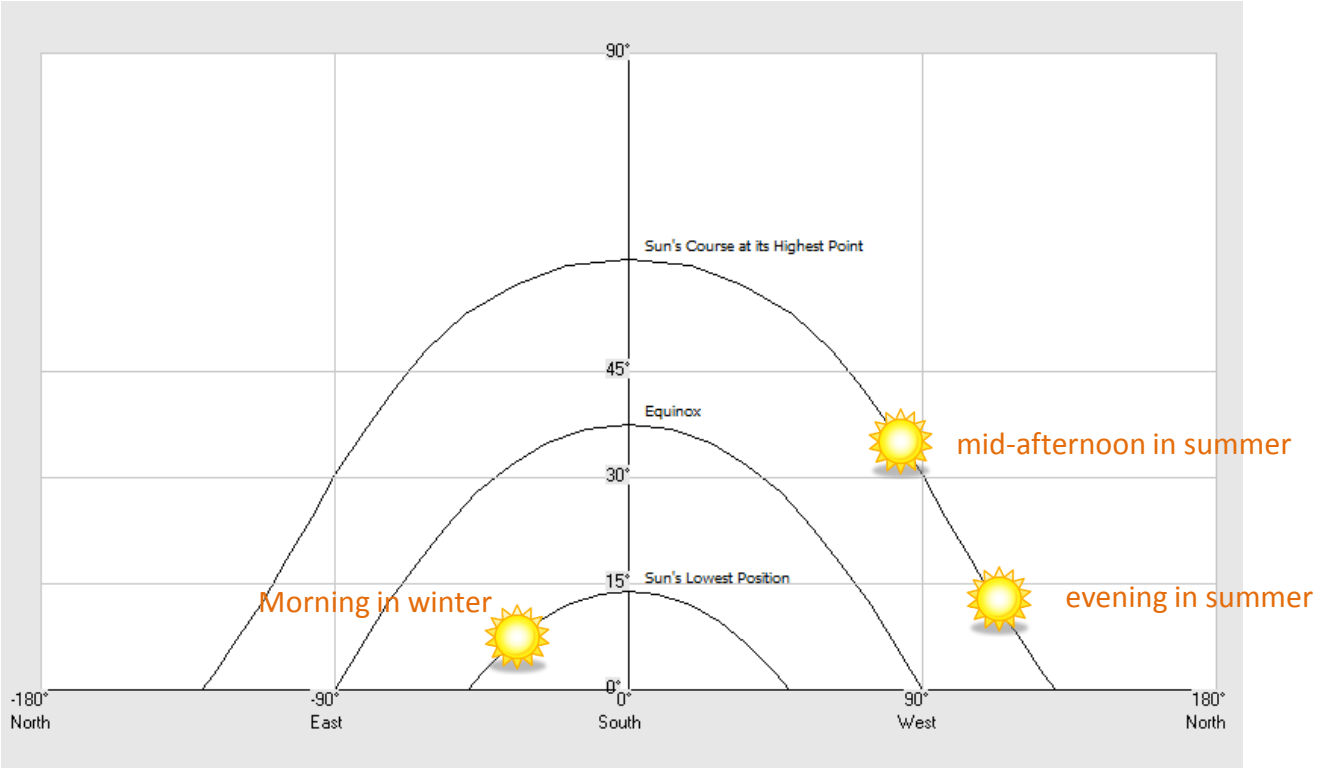


3. Sunpath diagrams

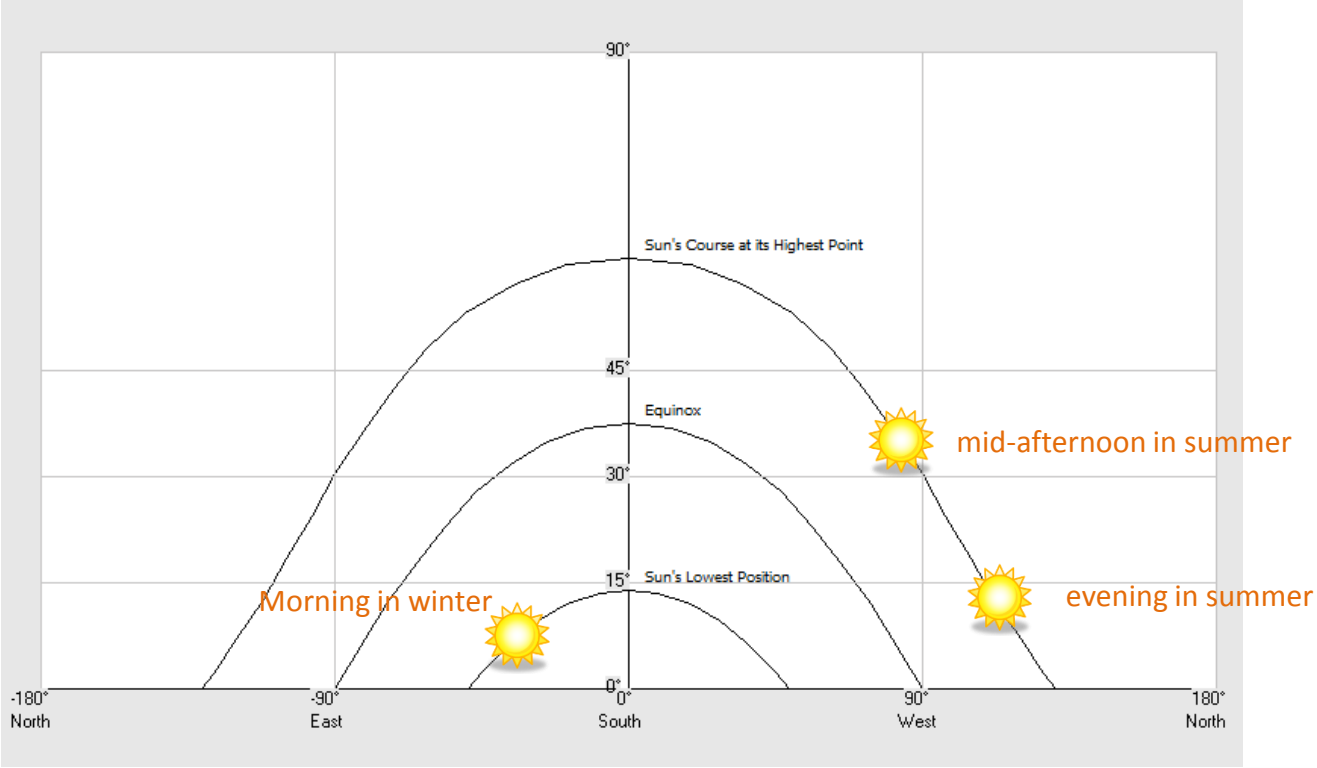
The MCS method is based on a Sunpath diagram

Sunpath diagrams show the location of the sun at:

- ❑ different hours of the day
- ❑ and for the different months of the year



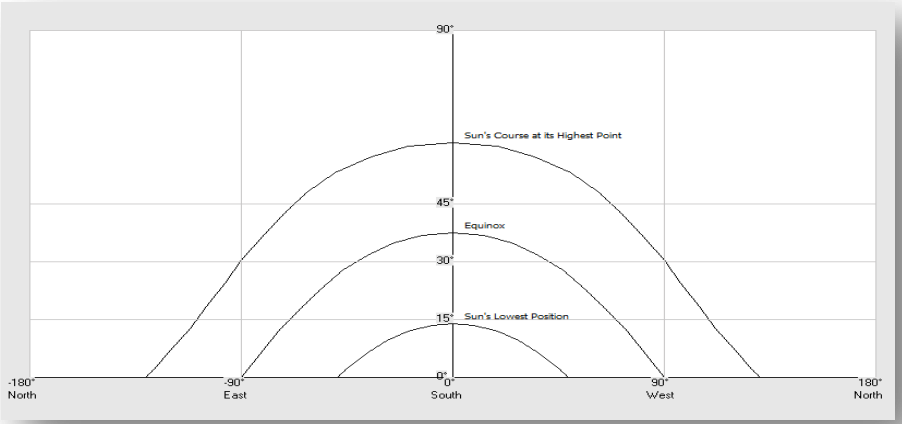
3. Sunpath diagrams



Vertical axis shows sun height

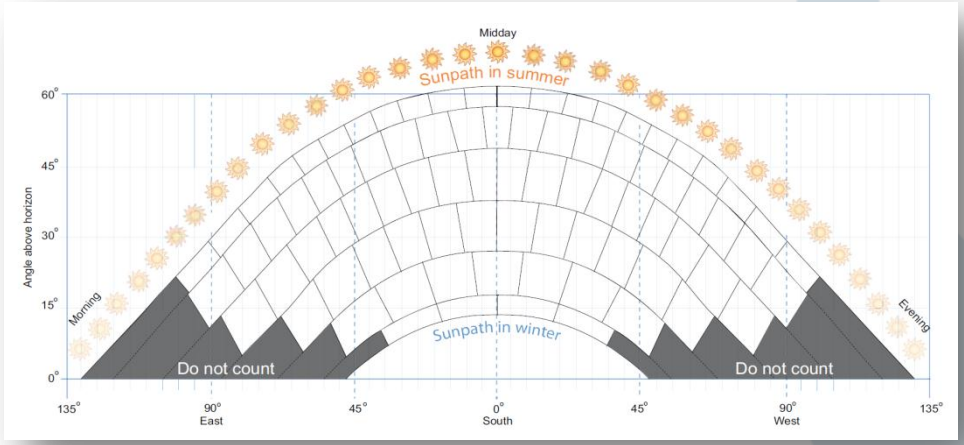
Horizontal axis shows sun direction (azimuth)

3. Sunpath diagrams

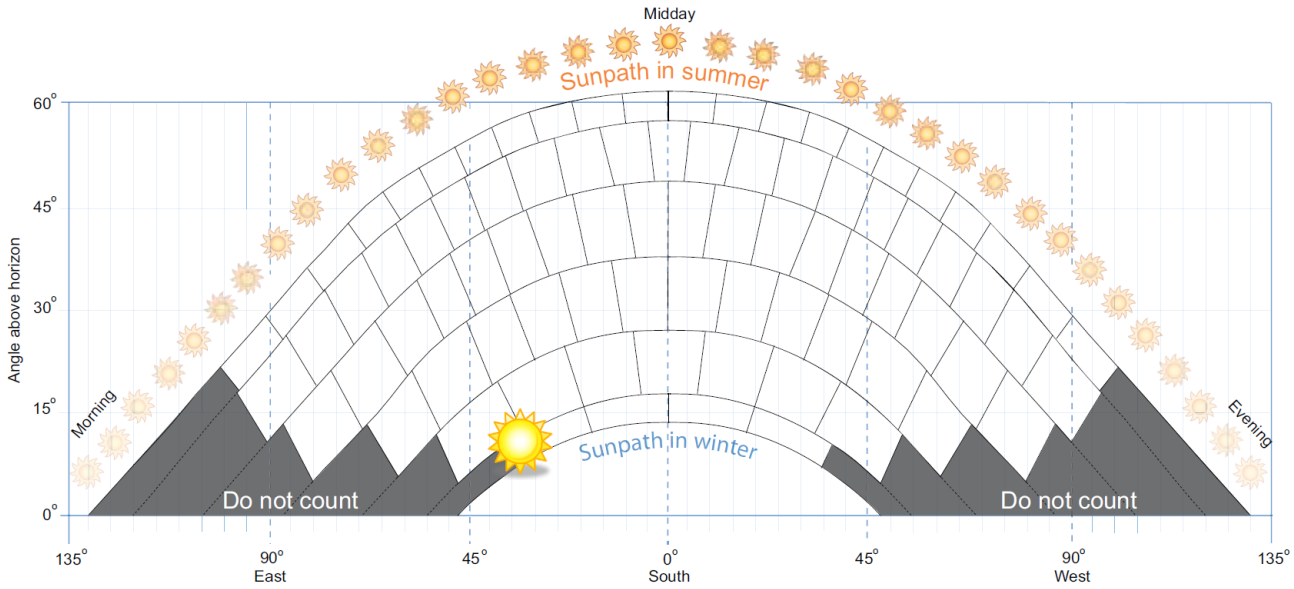


MCS Sunpath diagram

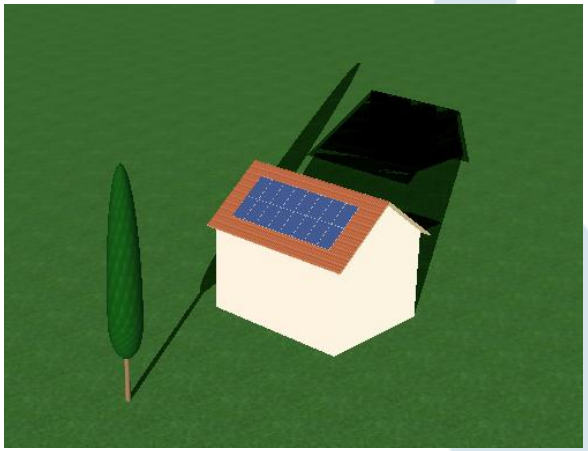
- A variation on the standard sunpath diagram
- designed to enable simple shade assessment



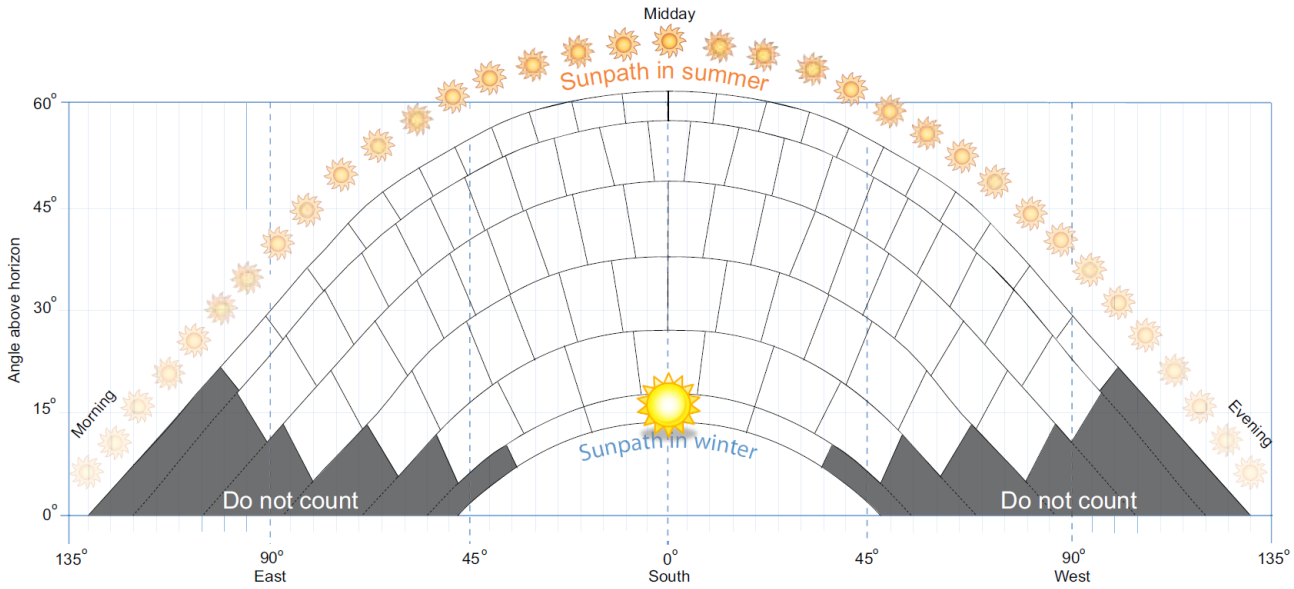
3. Sunpath diagrams



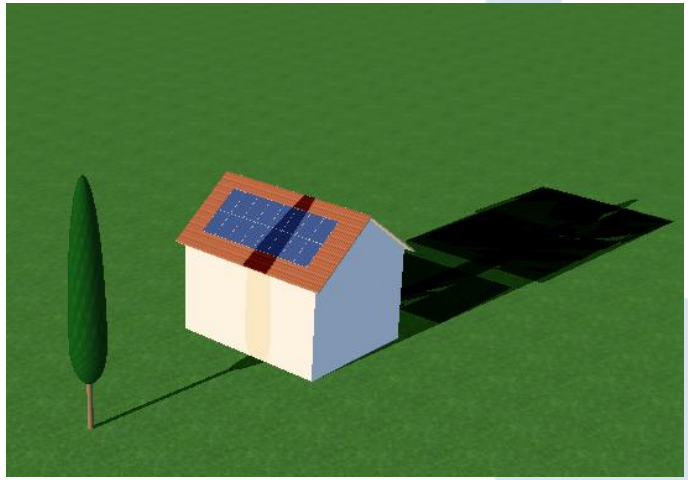
Sun low in the sky on a winters morning



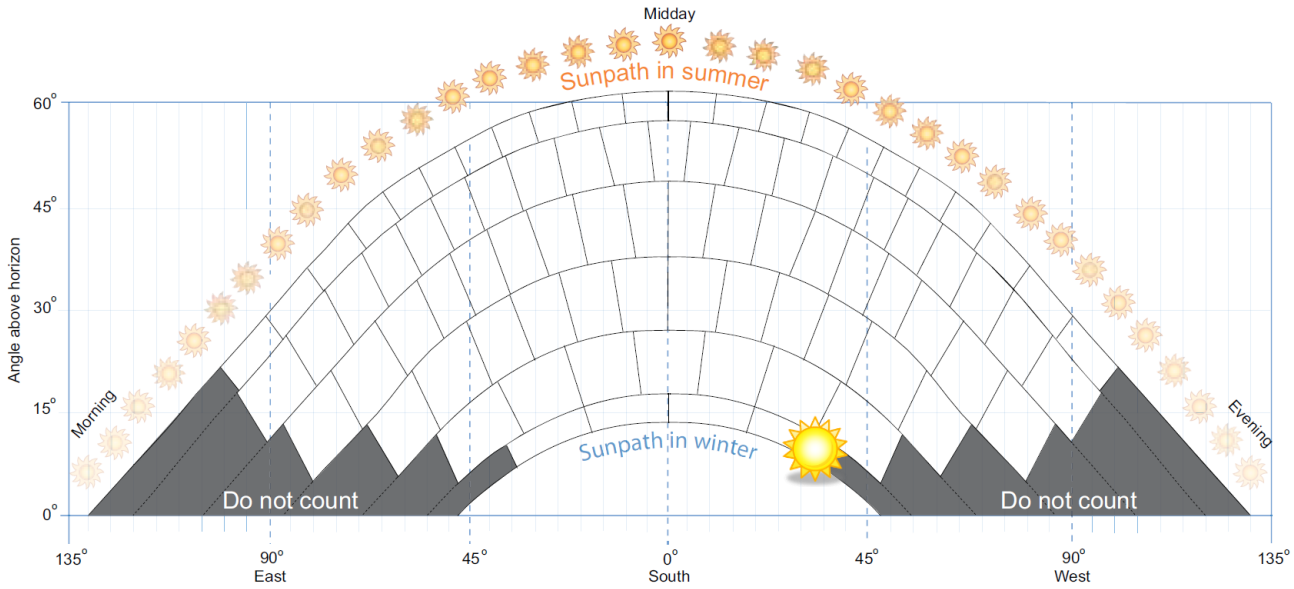
3. Sunpath diagrams



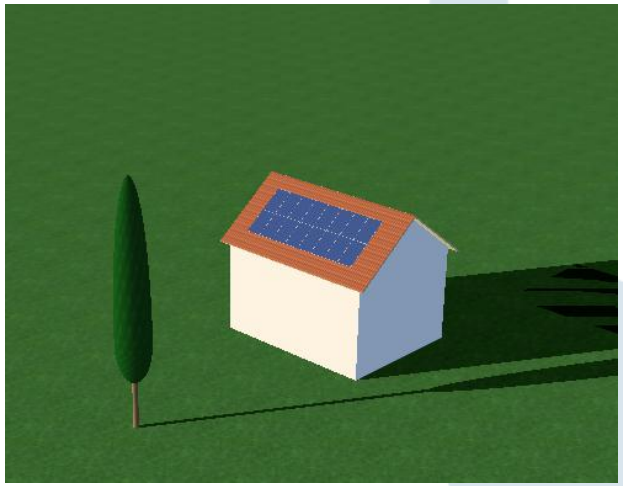
Midday - winter



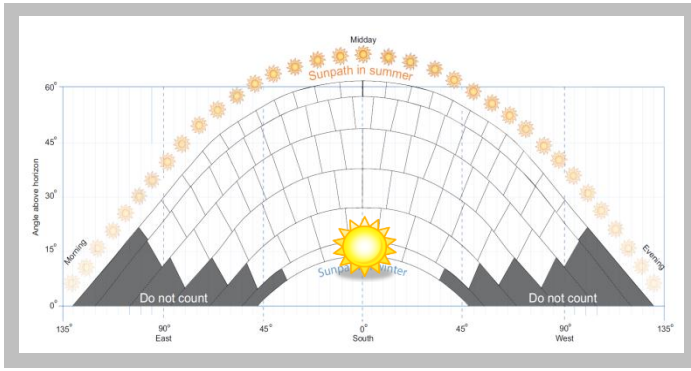
3. Sunpath diagrams



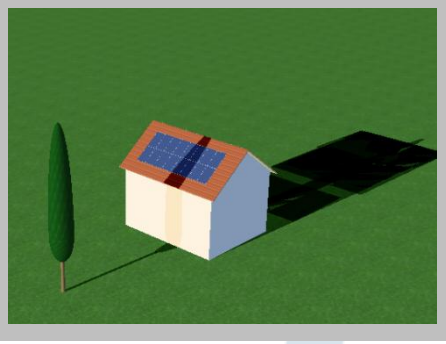
Sun low in the sky on a winter afternoon

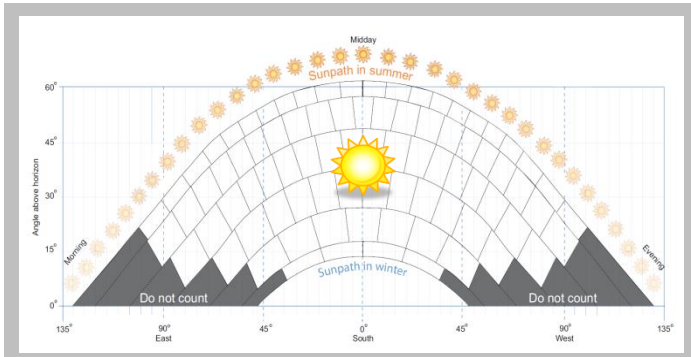


3. Sunpath diagrams

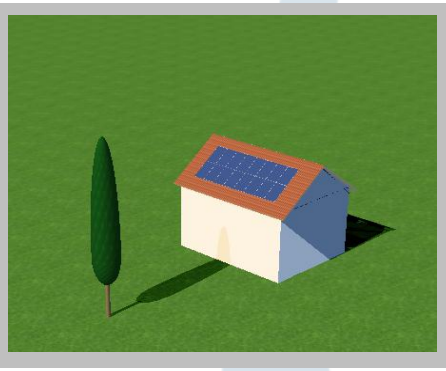


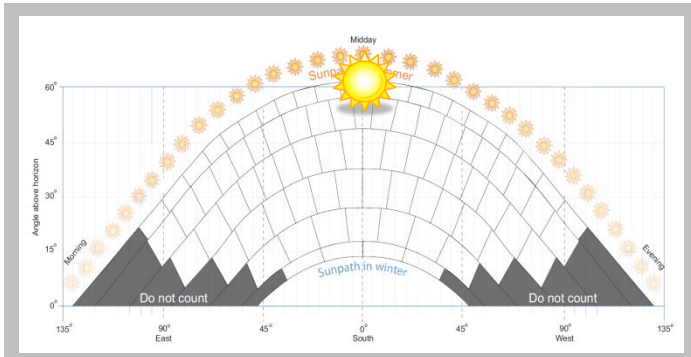
Winter sun at midday
Sun low in the sky >>> long shadows
Tree casts shade on roof



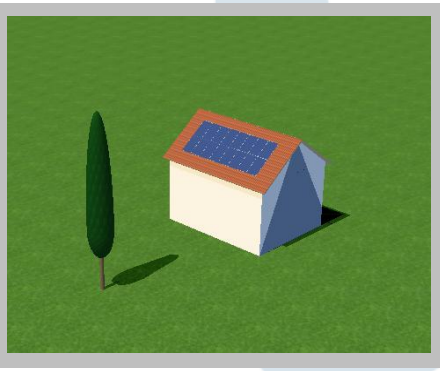


Spring & autumn sun at midday
medium shadows
Shade on building, but not on array

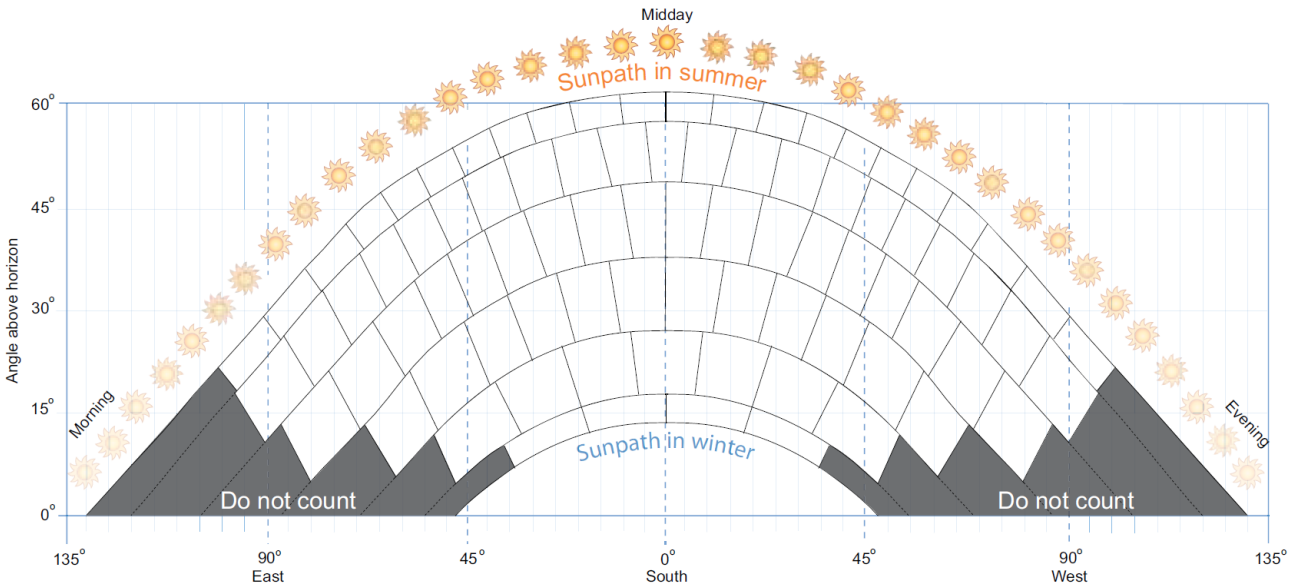




Summer sun at midday
Sun high in the sky – small shadows
No shade on building or array



4. The MCS sunpath chart

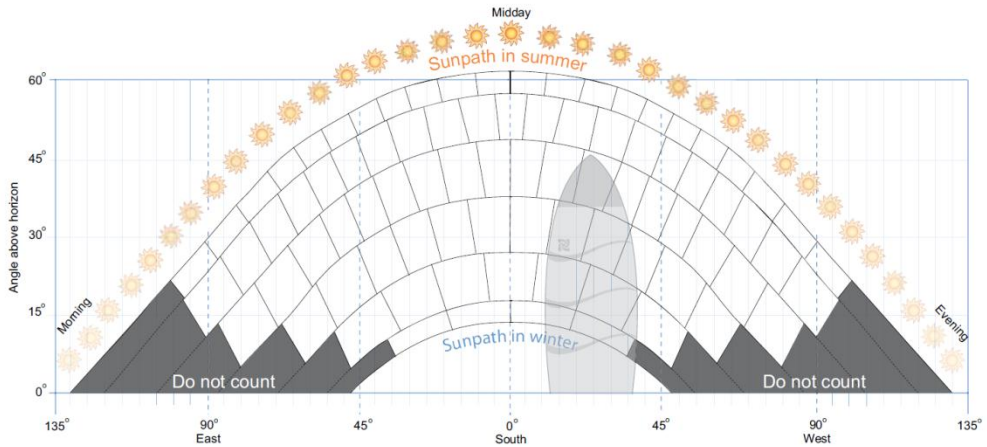


The MCS sunpath chart is split into a series of 84 segments (blocks)

The idea is to draw shade objects onto the chart … and then count the number of blocks affected

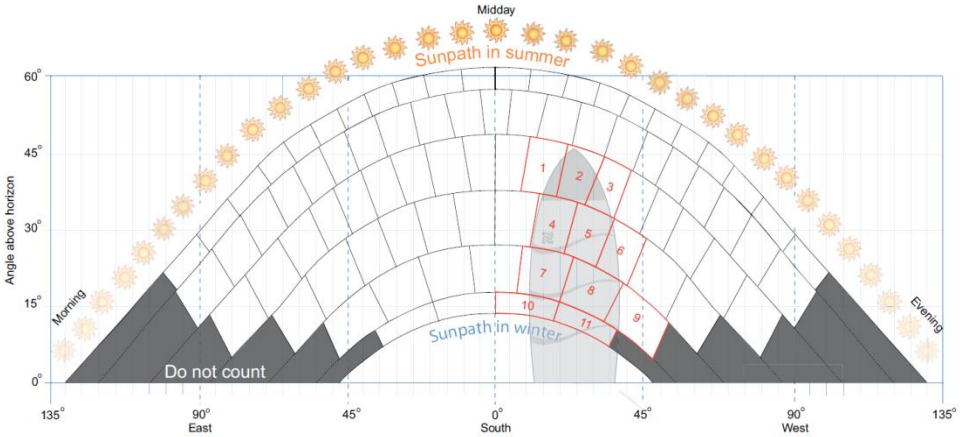
NOTE: The process (and options) for capturing the shade landscape and drawing it on the chart is not covered here - see the next presentation

4. The MCS sunpath chart



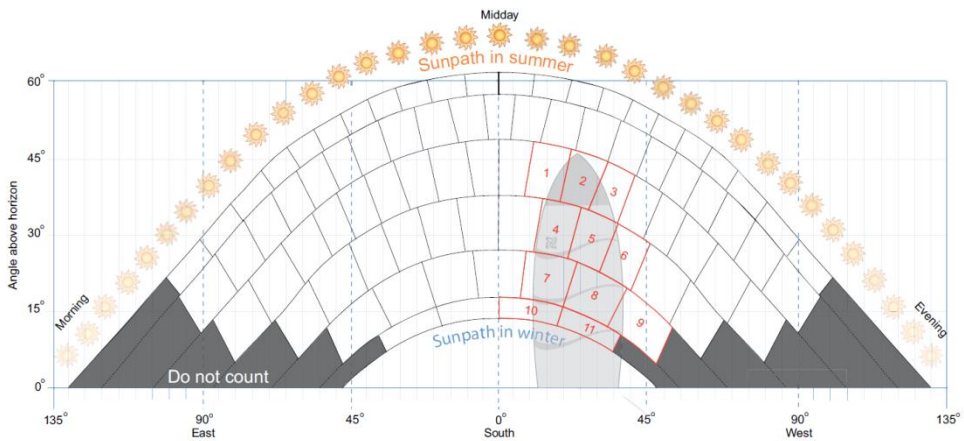
All blocks covered or touched by the shade object(s) need to be counted

In this example, 11 blocks are affected



4. The MCS sunpath chart

The maths …



Shade factor (SF) = 1 – (0.01 x number of affected blocks)

In the example above, 11 segments are affected by the object …

SF = 1 - (11*0.01) = 1 – 0.11 = 0.89

This equates to an estimated 11% reduction in output due to the shade object

4. The MCS sunpath chart

The background (you don't need to know this, but it may help) …

a) The chart was developed by first modelling a series of different shade scenarios using proprietary software. The shade factor for each case was recorded. The initial model assumed a 3kWp system, pitched at 30°, facing due south, located in Birmingham.

b) Shade factors from various different iterations of an MCS chart design were then compared to the model results

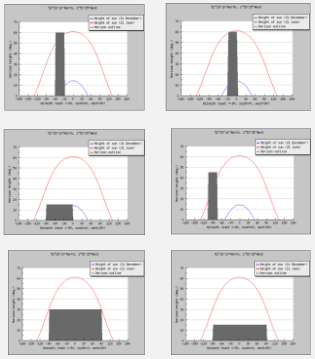
c) Once a draft design was established, more modelling was done to see how the chart coped with arrays of different pitches and orientations, and also for other geographic locations

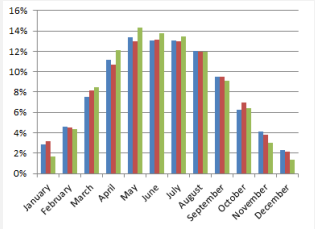
The resulting chart is clearly a compromise … as stated in the PV guide it "*yields results within 10% for most systems".*

Yes, a series of charts for different geographic locations was considered. However, it was decided that the whole process inherently is not that precise … and that the simplicity of having one chart for the whole of the UK was an acceptable compromise. After all, installers are free to use modelling software and present an alternative estimate to the customer if they wish.

And yes, the option of adopting one of the software packages as the "MCS method" was also considered – however this was rejected due to commercial issues and perhaps most significantly, the difficulties of auditing this approach. It was also felt that the MCS chart may help prevent miss-selling, as it has to go to the customer.

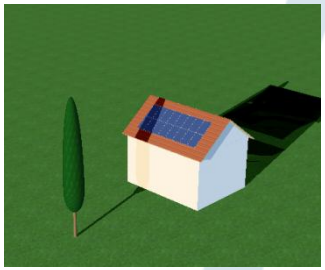
Finally, eagle eyed observers will have spotted that if the whole chart is obscured SF = 0.16 While we hope that no installations will ever be put in these locations, this result reflects the output from diffuse light – ie even a wholly shaded array still has a very small output.

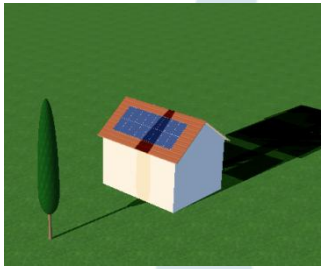


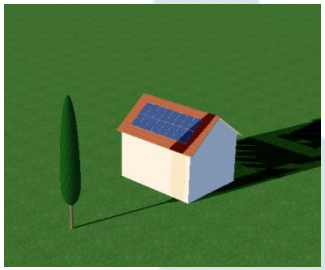


4. The MCS sunpath chart

Near shading







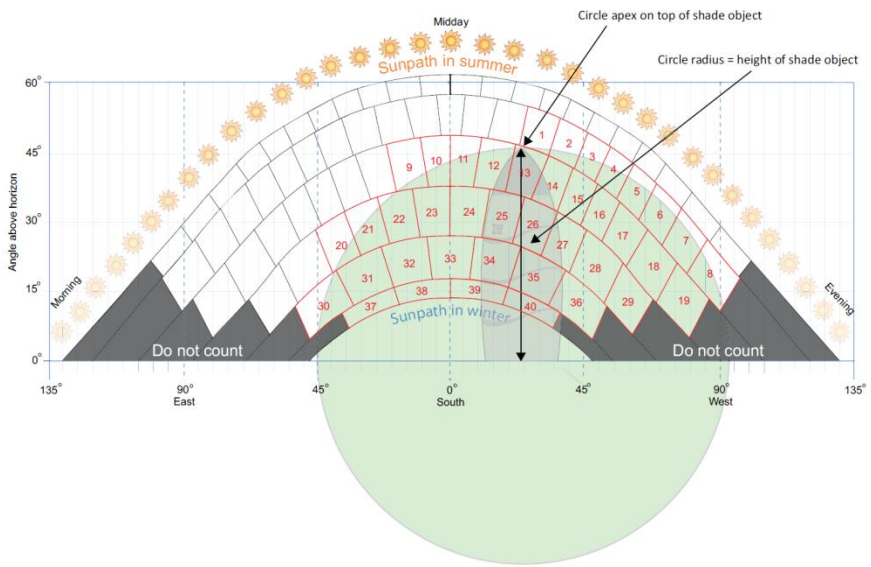
One of issues noted when developing the MCS chart was how it under-estimated the affect of near shade

The shadow from near shade objects is more significant … as the shadow moves, as the sun travels across the sky (think sundial)

This was seen as a particular issue due to the number of installations that seemed to be going ahead with near shading objects affecting them

4. The MCS sunpath chart

Near shading



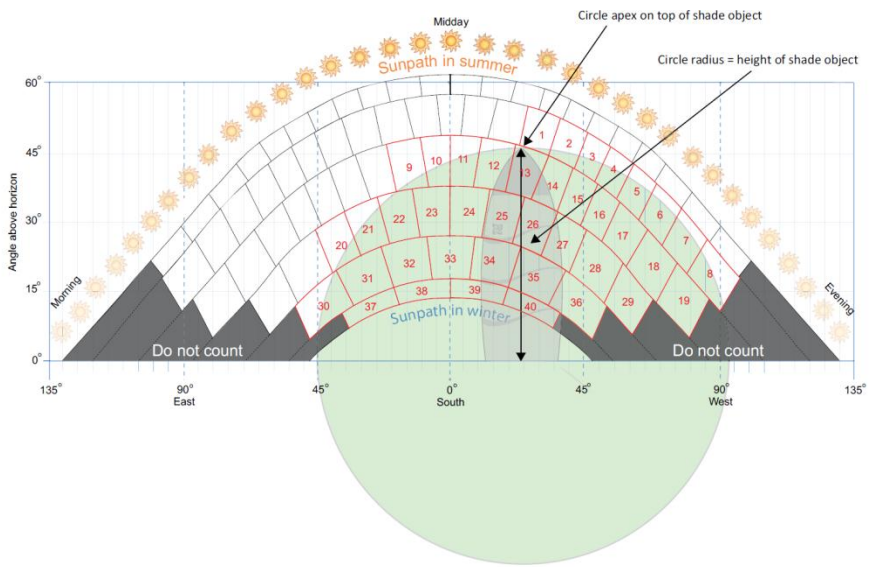
To address this issue, as the guide states …

"Any objects on the horizon diagram that are 10m or closer to any part of the array, shall have a shade circle added to the diagram to reflect the severe impact that these items may have on the array performance. Where there are multiple objects within 10m, then multiple circles shall be drawn – one for each object."

"The shade circle shall have a radius equal to the height of the object. The shade circle should be located so that the apex of the circle sits on the highest point of the shade object."

4. The MCS sunpath chart

Near shading



This is a big stick approach!

The best option is to move the near shade item or avoid sites with significant near shade

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4. The MCS sunpath chart

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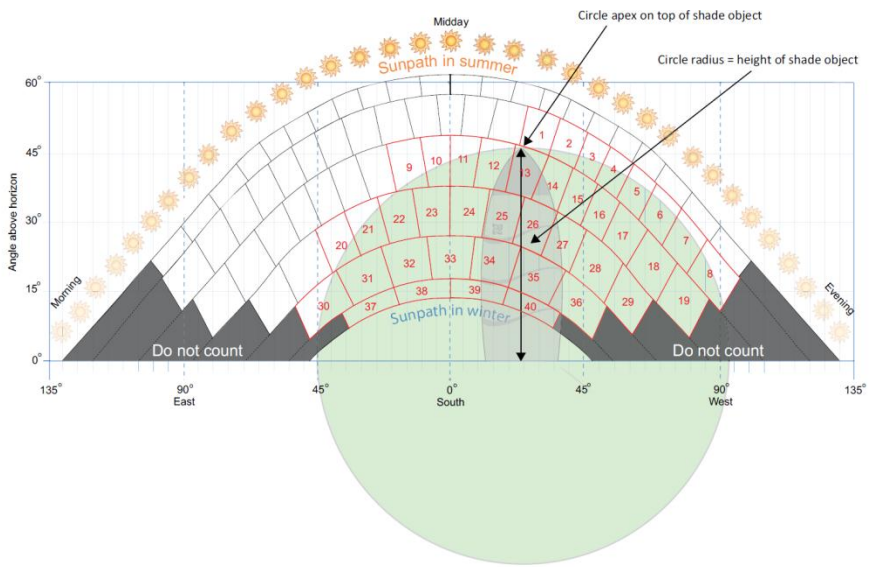

This is a big stick approach!

The best option is to move the near shade item or avoid sites with significant near shade

This is the same shade object as previously. But, treating as near shade …

40 segments are now affected by the object (was 11) …

SF = 1 - (40*0.01) = 1 – 0.4 = 0.6 (was 0.89)

This equates to an estimated 40% reduction in output due to the shade object (was 11%)

5. Rules for using the MCS sunpath chart

In this section, we will cover the following 5 rules …

A) Where to take the readings
B) Arrays with separate inverters or MPP trackers
C) Drawing the near shade circle
D) Estimates from plans (new build)
E) What information to supply to the customer

Note: as mentioned previously, how to perform the shade measurement is not covered in these slides

- *See the next presentation*

5. Rules for using the MCS sunpath chart

A) Where to take the readings

Where to take the reading depends on whether there is any near shade …

No near shade

The reading should be taken from the **midpoint of the array lower edge** of the proposed array e.g. through an upstairs window

Near shade

The reading should be taken from the array location worse affected by shade

See next slide

5. Rules for using the MCS sunpath chart

A) Where to take the readings … continued

Where there is near shade, choosing the point in the array potentially most affected by shade can be slightly complicated, but will usually mean the array location to the south of the shade object

Shade reading should be taken behind (to the North) of the satellite dish

This array faces exactly due South – so the shade reading could be taken either side of the dormer window.

NB In this case the O is drawn on the right hand side … as some shade is also expected from the adjacent roof

5. Rules for using the MCS sunpath chart

A) Where to take the readings … continued

Where there are multiple near shade objects affecting the array, choosing the most appropriate location to take the readings can be difficult - there is also a lot to draw - in these circumstance ask yourself …
Is this really a suitable location for a PV array – or do I only use part of the roof?

In the example shown here (providing the satellite dish was moved), the a smaller array to the upper section of the roof may have been the best solution.

MCS

A) Where to take the readings … continued

Do we need to go onto the roof to take the reading ?

This question has been asked by many installers, and the answer is:

No, as long as you are confident that the shade chart is representative of that property

- For roofs with no near shade: This means that an upstairs window is probably fine (see previous slide)
- For roofs with near shade: This means either:
  a) Getting on the roof
  b) Performing a series of measurements / calculations that allow you to produce a chart that is representative of the array location worse affected by shade

MCS

A) Where to take the readings … continued

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- For roofs with near shade: This means either:
  a) Getting on the roof
  b) Performing a series of measurements / calculations that allow you to produce a chart that is representative of the array location worse affected by shade

Methods are available to accurately undertake a reading from ground level … These methods are explained in the second of these two presentations

The Guide to the Installation of Photovoltaic Systems, highlights the need to minimise risk and specifically identifies the hazards of working at height. The responsibilities of employers, employees and contractors are clearly defined in the Health and Safety at Work Act. Guides to the Work at Height Regulations 2005 and other guidance are published by the HSE and are free to download from http://www.hse.gov.uk/falls/

5. Rules for using the MCS sunpath chart

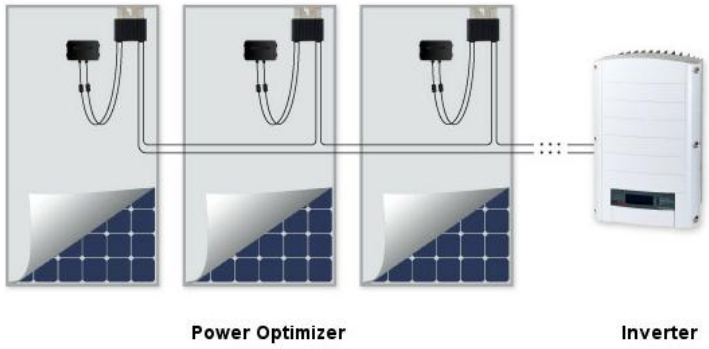
B) Arrays with multiple inverters or mpp trackers

In an effort to minimise the effects of shade, arrays can be either:

- Installed with multiple inverters
- Use inverters with multiple (independent) mpp tracker inputs
- Use module level power optimisers – or micro inverters

In these circumstances the PV Guide states:

"For systems connected to multiple inverters, or a single inverter with more than one MPP, it is acceptable to do a separate calculation of SF for each sub array (each array connected to a dedicated MPP tracker)."



5. Rules for using the MCS sunpath chart

C) Drawing the near shade circle

The following four rules apply to drawing the shade circle:

1. Only shade items within 10m of the midpoint of the array lower edge need to be considered
2. Items behind the array – No shade circle required
3. The shade circle shall have a radius equal to the height of the object. The shade circle should be located so that the apex of the circle sits on the highest point of the shade object
4. The shade circle apex does not need to extend above the top of the sunpath chart

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These are new and are not contained in the PV guide

5. Rules for using the MCS sunpath chart

C) Drawing the near shade circle

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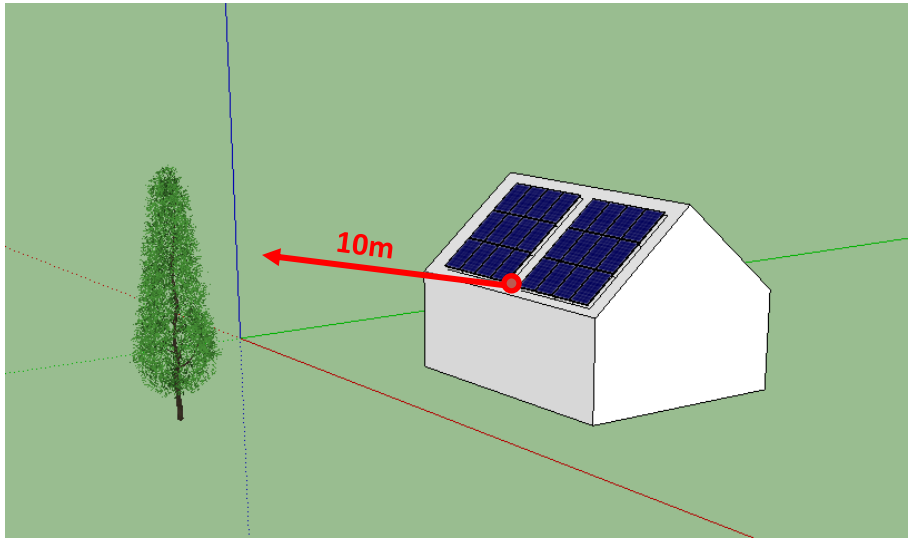
The PV guide slightly contradicts itself on this issue … but for the avoidance of doubt:
Only shade items within 10m of the **midpoint** of the array **lower edge** need to be considered …



5. Rules for using the MCS sunpath chart

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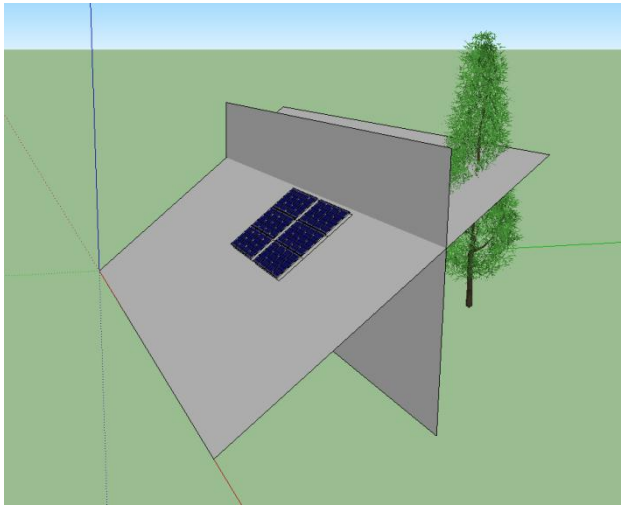
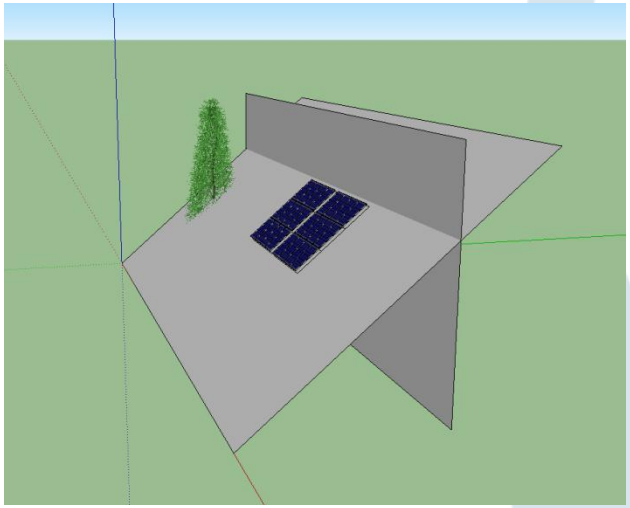
Item behind array
Draw item onto shade diagram as normal
But do NOT draw shade circle



Item in front of array
Draw item onto shade diagram as normal
AND draw shade circle



5. Rules for using the MCS sunpath chart

C) Drawing the near shade circle

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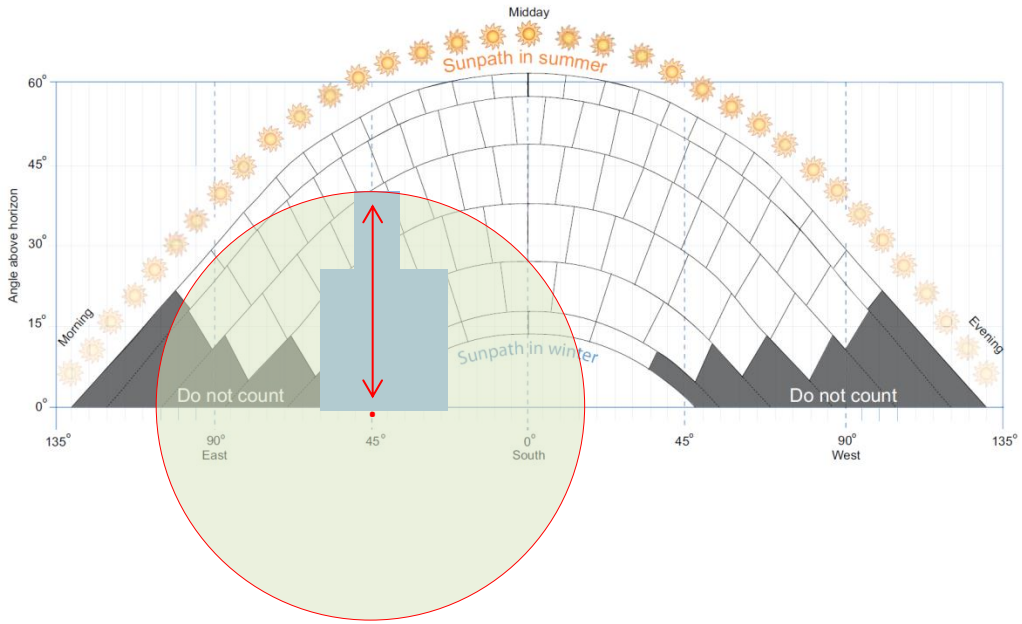

(this was covered earlier)

5. Rules for using the MCS sunpath chart

C) Drawing the near shade circle

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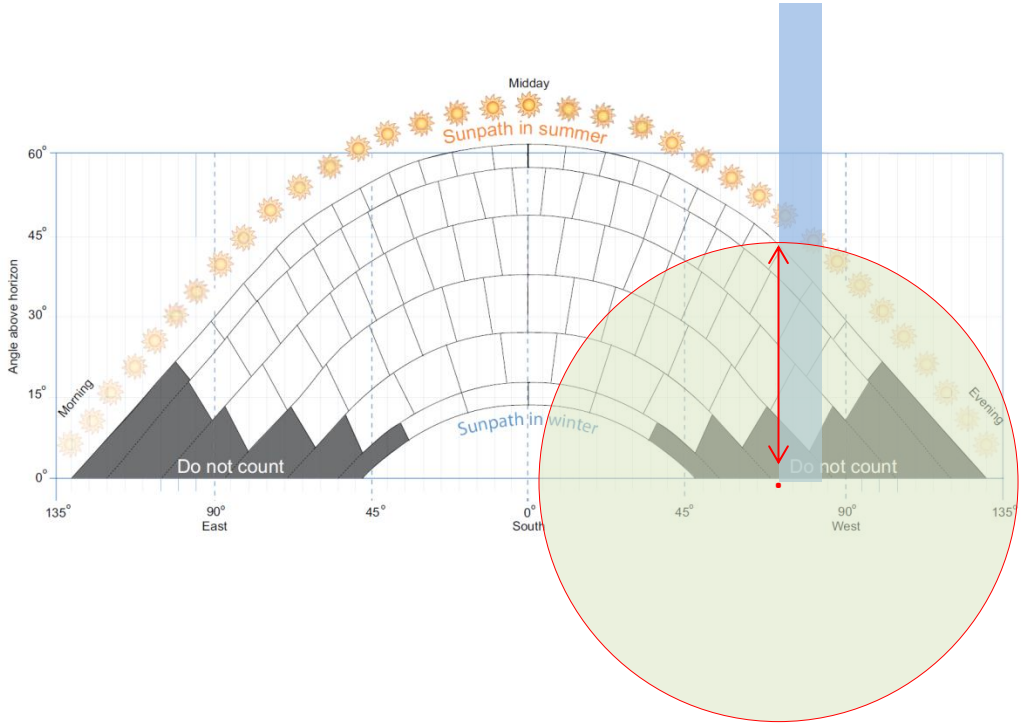
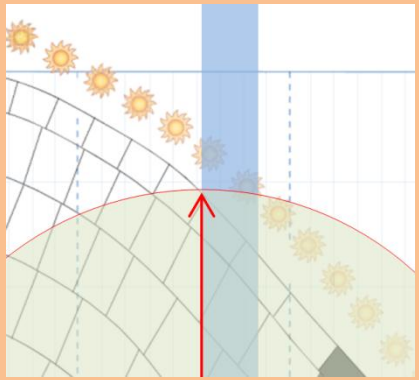


Where the shade object extends off the top of the chart, the circle apex can be limited to the top of the chart



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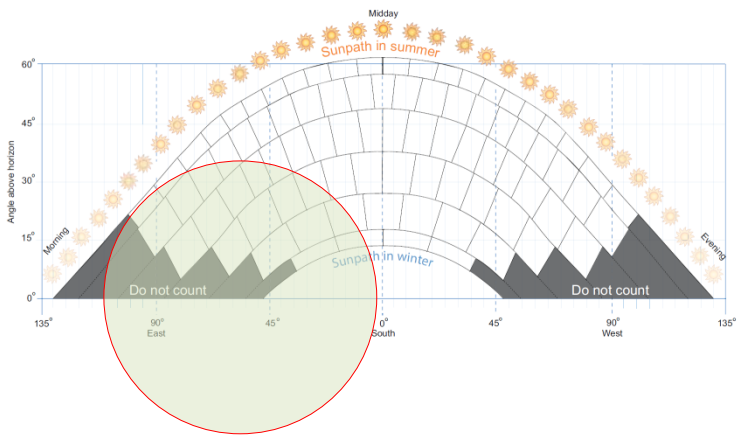
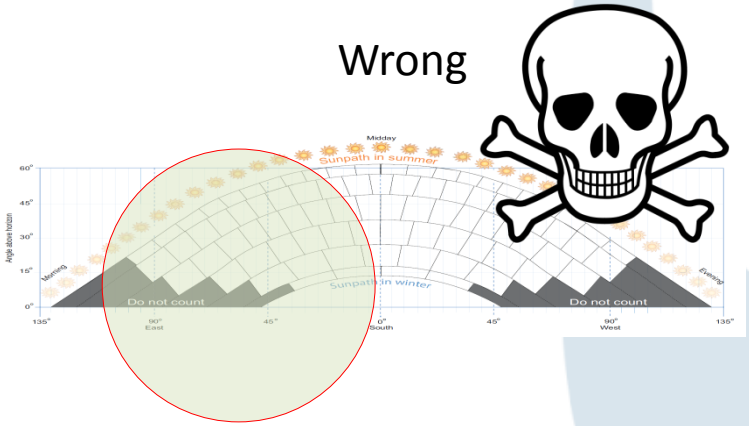
A final point …

If you are manipulating the shade diagram on the computer, make sure you maintain the proportions.





5. Rules for using the MCS sunpath chart

D) Estimates from plans

Obviously, where a building does not exist, it is not possible to record the shade scene. In these cases the PV Guide states:

In some circumstances however, data may need to be estimated or taken remotely. In such circumstances, any performance estimate provided to a customer should include the following statement:

"This system performance calculation has been undertaken using estimated values for array orientation, inclination or shading. Actual performance may be significantly lower or higher if the characteristics of the installed system vary from the estimated values."

In all cases where inclination, orientation or shade has been estimated at quotation stage, e.g. for a new build development, a site survey shall be undertaken before installation commences.

Following the detailed site survey, where any factors do not match those given in the original performance estimate, the installation company shall recalculate the performance estimate and supply this in writing to the client. If the adjusted performance estimate is worse than originally predicted, the client shall be given the same cooling off period and cancellation rights (to include any right to cancel without financial penalties) that applied to the original quote. This shall apply from the date of issue of the updated performance estimate.

5. Rules for using the MCS sunpath chart

E) What information to supply to the customer

- The client needs to be supplied with a copy of the Sunpath chart
- If there is no shade then a copy of the chart with "NO SHADE" written across it should be provided
- Where the shade factor is less than 1 (i.e. when there is some shade recorded), the PV Guide states that the following disclaimer needs to be added to the quote: "This shade assessment has been undertaken using the standard MCS procedure - it is estimated that this method will yield results within 10% of the actual annual energy yield for most systems."

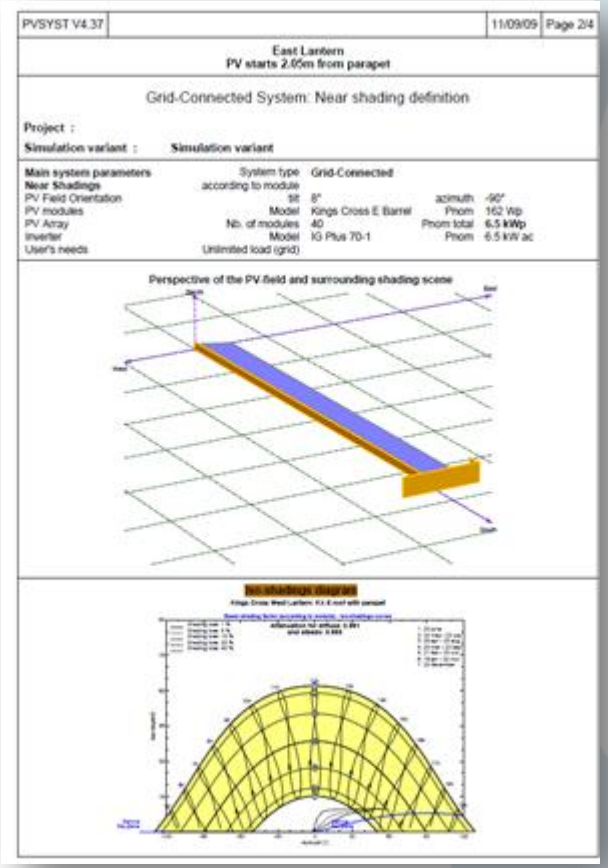
5. Rules for presenting alternative estimates

It is recognised that installers may want to present an alternative estimate of system performance to the client – particularly where they are concerned that the MCS method is not as accurate as they would like.

In such circumstances, the PV Guide states:

"Additional estimates may be provided using an alternative methodology, including proprietary software packages, but any such estimates must clearly describe and justify the approach taken and factors used and must not be given greater prominence than the standard MCS estimate."

"In addition, it must be accompanied by a warning stating that it should be treated with caution if it is significantly greater than the result given by the standard method."



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East Lantern
PV starts 2.05m from parapet

Grid-Connected System: Near shading definition

Project :

Simulation variant : Simulation variant

Main system parameters	System type	Grid-Connected			
Near Shadings	according to module				
PV Field Orientation	tilt	8°	azimuth	-90°	
PV modules	Model	Kings Cross E Barrel	Pnom	162 Wp	
PV Array	Nb. of modules	40	Pnom total	6.5 kWp	
Inverter	Model	IG Plus 70-1	Pnom	6.5 kW ac	
User's needs	Unlimited load (grid)				

Perspective of the PV field and surrounding shading scene

No shadings diagram

The MCS shade evaluation procedure

Part 1 – The procedure explained

a) Overview of MCS performance evaluation method – and how the shading analysis fits into this
b) Why MCS introduced the new shade method
c) Introduction to Sunpath diagrams
d) The MCS Sunpath chart
e) Rules for using the MCS chart
f) Rules for using and presenting “alternative methods”

Part 2 – How to record shade onto the chart

The next presentation …