Guidance note 2: Monitoring and maximising the performance of roof-top solar arrays. **Checks and procedures.**

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Contents

1. Background

This guidance note 2, **Checks and procedures**, is preceded by:

- An **introductory** guidance note, ‘Monitoring and maximising the performance of roof-top solar arrays’,
- A **fact-finding** guidance note 1, ‘Monitoring and maximising the performance of roof-top solar arrays’.

The introductory guidance note explains why rooftop solar generation must be **actively managed** if it is to achieve its performance potential. The fact-finding guidance note explains common industry terminology and specifies the data and information needed to manage rooftop solar generation, where to find it and how to validate it.

This **checks and procedures** guidance note, looks more closely at how to interpret and use the data and information you’ve found to analyse and improve the performance of your rooftop solar array. **Terminology defined in the fact-finding guidance note will appear in** blue typeface **the first time it is used in this note.**

2. Pre-requisites

To begin effective checks & procedures, you will need to have the following pre-requisites in place:

- Access to the **factsheet** and **operations manual**, compiled in accordance with guidance note 1.
- Validation of the data and information contained in the factsheet and operations manual, if necessary, in consultation with an energy expert.
- Identification of an appropriate resource to act as the solar array 'operations manager', taking responsibility for management of the operational manual, monitoring and recording performance and taking the necessary actions to ensure generation is maximised. This resource may be from within Energy, Estates, Building Management, Accounts or Sustainability – **enthusiasm is key!**
- Short-term access to a resource who has intermediate Excel skills to create analysis templates.

3. Understanding your electrical system design

Check: Understanding the electrical system design, alongside knowledge of the building's present and predicted patterns of demand and generation, will allow you to make any physical changes necessary to optimise use of generated electricity and minimise the purchase of imported electricity.

An electrical design drawing/s, or single line diagram (SLD), illustrates; which of a building's electrical circuits are fed by the solar array; the kilowatt capacity of the solar array; the location of electrical demand on site and the location of electricity meters and sub-meters.

It is important to refer to an 'as-built' copy of this drawing, rather than a 'design' copy, as technical changes are often made during the construction or installation phase. If you do not have this information, you will need to commission a suitably qualified electrical design engineer to visit site and create a single line diagram.

As a general rule, the greatest financial benefit from generating electricity on-site is reducing the need to purchase electricity from an external supplier. Therefore, an ideal solar array design is sized and wired to match time-of-day generation capacity with the on-site demand for electricity.

If the system is designed for optimum operation, there will be enough electrical demand to ‘ask the solar panels’ to generate at their maximum potential capacity. Maximum potential capacity is dependent on conditions affecting performance such as shading, sunlight, and condition of the physical equipment.

In practice, it can be difficult to achieve a close match in generation and demand. In these cases, excess generation may be sold to the grid, and while less beneficial than consuming the generation on site, it may be preferable to wasting opportunities to generate renewable electricity and receive revenue. Increasingly, there may be a financial case for installing a battery alongside the generation to store electricity for discharge when required.

The SLD will describe one of three possible configurations for use of the solar-generated electricity.

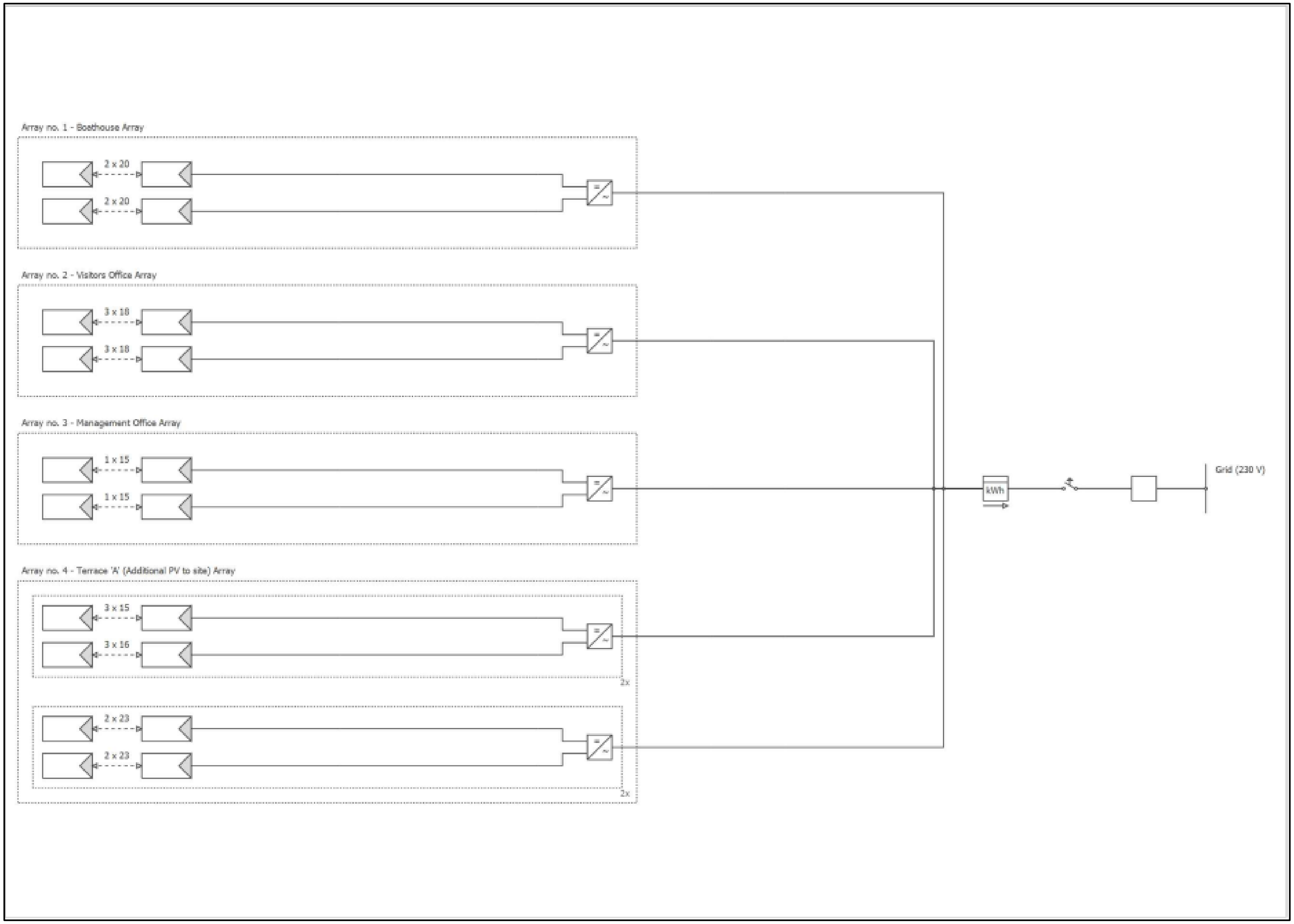
i. Configured for export-only: the electricity generated by the solar panels is measured at a generation meter. It then passes through an export meter **or**, if there is not a separate export meter, the export channel of the electricity supply (import) meter, where it is measured again and then goes on to the local electricity distribution network (grid).

ii. Configured for on-site consumption only: Electricity generated by the solar panels is measured at a generation meter before passing through a circuit to the equipment with the electrical demand. It may be measured again at a sub-meter before reaching the equipment. Consumption may also be measured at point of use (by the equipment itself).

iii. Configured for both on-site consumption and export: The solar array generates, whether or not there is an electrical demand at site, with a preference to meeting on-site demand over exporting to the grid. This hierarchy of use must be enabled by the electrical design.

Note: *To export electricity to the grid, a G100 certificate, or equivalent, should have been issued by the Distribution Network Operator. This confirms the system is correctly and safely configured to connect to their electricity network.*

Figure 1: Example of a Single Line Diagram, (solar array is configured for export only) *Note: an SLD usually has a Legend of symbols included.*



Check: Is the electrical configuration in your building providing optimum value? Does the generation need to be re-routed to give optimum value? Any redesign will no doubt be a budgetary decision. Section 5 describes how to understand the value of generated electricity before making that decision. However, there are other values to consider such as; reputational value, carbon value and Environmental Social Governance value.

An example of the impact of a poor design configuration: *Solar panels are wired to feed an outdoor lighting circuit - the hours of generation do not match the hours of demand. In consequence, the solar generation capacity is unused, the capital invested has been wasted and money is spent unnecessarily buying electricity from a supplier to feed day-time demand from other circuits in the building.*

4. Patterns of electricity demand and generation

Knowledge of a building's expected pattern of demand and generation gives the potential for shifting demand to match daylight hours. Knowing what the 'normal' consumption pattern looks like, enables any diversion from this to be detected. A simple Excel analysis will provide a picture of electricity consumption or demand in your building.

Check

- Collect the demand half-hourly data for each MID or half-hourly meter on site, including sub-meters.
- For each meter, create a template Excel spreadsheet in which to paste and record half-hourly data.
- Apply a 'colour scale' Conditional Formatting to give a visual indication of times of highest demand. *(See Figure 2, in which lower demand is yellow and higher demand is green and zero demand blue).*
- Compare your present patterns of demand with seasonal daylight hours and peak daylight hours.

Figure 2. An excel spreadsheet formatted to indicate patterns of demand. During January, highest half-hourly demand for electricity is well-matched with times of likely solar generation. However, the solar array is not working so all power is being imported from the grid.

																					Hours of peak generation opportunity			
Time	Hours of darkness									Potential Summer Daylight Hours														
																	Potential Winter Daylight Hours							
HH Period	01:00		02:00		03:00		04:00		05:00		06:00		07:00		08:00		09:00		10:00		11:00		12:00	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
01/01/2023	11	11	11	11	11	11	11	12	15	15	15	15	16	17	16	16	15	13	13	13	12	12	12	12
02/01/2023	10	10	10	11	11	11	11	11	14	14	14	15	15	18	22	65	67	63	44	34	32	34	42	31
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05/01/2023	19	19	19	20	20	20	19	20	20	19	19	21	21	22	26	59	70	64	65	61	69	75	67	60
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07/01/2023	15	16	16	15	15	16	16	18	19	19	19	20	20	22	26	66	78	74	65	57	68	67	69	76
08/01/2023	17	17	18	18	18	17	18	17	17	17	17	19	23	44	49	58	67	72	54	30	30	29	29	28
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11/01/2023	17	16	16	16	16	17	17	16	17	17	17	18	19	20	28	62	62	74	48	32	59	69	64	56
12/01/2023	16	17	17	17	17	17	17	17	17	17	16	18	20	23	23	65	79	83	71	63	71	78	90	81
13/01/2023	22	22	22	22	22	22	22	22	22	22	22	23	25	28	32	69	69	72	68	68	65	64	73	71
14/01/2023	22	22	21	22	22	22	22	24	25	26	25	27	28	31	34	75	68	73	68	66	64	75	79	74
15/01/2023	14	14	13	14	14	14	14	17	18	17	17	19	19	18	19	20	20	28	27	27	27	26	26	26
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17/01/2023	14	14	13	13	14	14	14	15	17	17	17	19	21	21	24	66	74	76	75	67	79	77	86	76
18/01/2023	20	20	20	19	19	19	19	19	19	19	19	22	23	24	29	53	74	76	87	69	84	79	79	73
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21/01/2023	20	20	20	20	20	20	20	20	20	20	20	22	23	25	30	55	67	66	55	57	72	81	79	81
22/01/2023	14	14	15	15	15	15	15	17	18	19	18	19	19	19	18	19	22	30	26	27	26	26	26	27
23/01/2023	14	14	14	13	14	14	14	14	14	16	17	18	18	19	19	19	20	27	24	25	25	25	26	25
24/01/2023	15	15	15	15	15	16	16	18	19	19	18	20	21	23	26	73	79	81	72	62	74	76	77	78
25/01/2023	27	27	26	27	27	27	27	27	26	26	27	28	29	30	34	73	82	75	61	36	72	72	72	76
26/01/2023	19	19	19	19	19	19	19	19	19	19	19	21	23	25	24	66	73	75	71	41	72	79	67	76
27/01/2023	17	16	16	17	17	17	16	16	16	16	16	18	20	23	22	60	61	58	65	36	57	64	66	63
28/01/2023	10	10	10	10	10	10	10	12	13	13	14	16	18	21	20	60	65	61	67	40	80	79	76	73
29/01/2023	13	13	13	13	13	13	13	16	16	16	17	18	21	23	21	22	25	28	28	31	28	28	28	27
30/01/2023	14	14	14	14	14	14	14	14	14	16	18	18	21	22	19	22	24	27	26	26	25	27	26	26
31/01/2023	15	15	15	15	16	16	16	18	18	19	19	19	20	23	26	68	79	70	69	35	77	73	66	64

Time																			Hours of darkness					
HH Period	13:00		14:00		15:00		16:00		17:00		18:00		19:00		20:00		21:00		22:00		23:00		00:00	
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
01/01/2023	12	12	12	12	12	12	13	14	14	11	11	11	10	10	10	10	10	10	10	10	10	10	10	10
02/01/2023	30	31	39	34	18	17	17	18	18	18	17	17	17	17	17	17	17	17	17	17	16	16	16	17
03/01/2023	40	19	18	16	15	14	16	17	17	18	18	17	16	16	16	16	16	16	16	16	16	16	16	16
04/01/2023	70	55	74	78	59	42	27	32	26	23	21	20	19	19	19	19	19	19	19	19	19	19	19	19
05/01/2023	72	58	66	65	67	61	36	31	31	27	26	25	24	21	19	19	19	19	19	19	19	19	19	19
06/01/2023	63	43	68	61	64	58	33	33	32	23	22	21	19	17	15	16	15	15	15	15	16	15	16	15
07/01/2023	71	61	77	73	51	35	35	33	26	21	20	19	18	18	18	18	18	18	18	18	17	18	18	18
08/01/2023	27	24	24	23	24	24	25	26	27	19	19	17	15	15	15	15	15	15	15	15	15	15	14	15
09/01/2023	25	24	25	24	24	24	24	24	20	20	19	19	15	14	14	14	15	14	14	15	15	14	14	14
10/01/2023	70	60	78	74	64	59	42	31	27	20	19	17	17	16	16	16	17	17	16	16	17	17	16	17
11/01/2023	55	26	39	45	45	34	22	22	24	18	17	16	16	16	15	16	16	15	16	17	17	17	17	16
12/01/2023	77	37	68	60	64	50	32	34	34	23	24	23	22	22	22	22	22	22	22	22	22	22	22	22
13/01/2023	69	62	72	69	68	65	38	34	36	30	28	28	27	27	24	23	22	23	22	22	22	22	22	22
14/01/2023	62	33	73	67	52	29	31	28	24	19	19	18	17	16	15	15	14	14	14	14	15	14	14	14
15/01/2023	24	24	24	24	24	24	23	23	19	19	19	18	15	15	14	14	14	14	14	14	14	14	14	13
16/01/2023	23	21	22	23	22	23	22	23	22	17	16	14	13	13	13	13	13	13	13	14	14	14	14	14
17/01/2023	82	75	79	81	75	58	39	34	31	25	21	20	19	19	19	19	19	19	20	19	20	20	20	20
18/01/2023	76	39	70	69	74	61	35	36	31	24	21	20	19	19	19	19	19	19	19	19	19	19	19	19
19/01/2023	53	31	64	64	60	51	29	28	27	21	22	22	21	21	21	21	20	20	21	20	21	20	21	20
20/01/2023	56	38	59	67	58	32	36	33	31	22	20	20	20	20	20	20	20	20	20	20	20	20	20	20
21/01/2023	84	68	84	82	56	35	31	30	28	20	20	19	18	16	15	15	14	15	15	15	15	15	15	15
22/01/2023	26	26	25	25	25	25	25	25	18	17	19	18	15	14	14	14	14	14	14	15	15	15	14	14
23/01/2023	25	24	23	23	23	23	24	23	23	18	19	18	16	16	16	15	16	16	16	16	15	15	15	15
24/01/2023	70	63	79	84	76	65	33	33	32	28	29	28	27	27	27	26	27	27	27	26	27	27	26	28
25/01/2023	80	49	82	70	58	50	33	31	28	21	21	20	19	20	19	19	19	19	19	19	19	19	19	19
26/01/2023	74	60	70	65	65	59	37	26	25	19	18	18	17	17	17	17	17	16	17	16	17	17	18	17
27/01/2023	51	30	69	58	50	36	21	17	18	14	14	14	14	12	10	10	10	10	10	11	10	10	10	11
28/01/2023	60	36	60	59	40	29	27	23	21	16	17	17	17	16	14	13	13	13	13	13	13	13	13	13
29/01/2023	27	27	25	25	25	24	24	24	22	16	17	17	14	14	14	14	15	14	14	14	14	14	14	14
30/01/2023	25	25	25	24	24	24	24	24	24	17	18	16	16	16	16	15	15	15	16	15	16	16	16	16
31/01/2023	66	51	74	75	67	47	31	30	28	18	18	18	18	17	17	17	17	17	17	17	17	17	17	17

Figure 3: During February, the 50kW capacity solar array is working and generating (at 32kW) between 8:30 and 17:00. Electrical demand from the building is identical to January, but consumption of solar generation reduces the need to import power from the grid by 18,235 kWhs. How much is that worth?

																					Hours of peak generation opportunity																											
Time	Hours of darkness									Potential Summer Daylight Hours																																					Hours of darkness	
																	Potential Winter Daylight Hours																																	
HH Period	01:00		02:00		03:00		04:00		05:00		06:00		07:00		08:00		09:00		10:00		11:00		12:00		13:00		14:00		15:00		16:00		17:00		18:00		19:00		20:00		21:00		22:00		23:00		00:00	
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01/02/2023	17	17	17	17	17	17	17	17	16	17	17	19	19	21	25	30	20	27	0	26	29	31	34	29	0	27	26	23	23	7	0	0	22	17	18	17	16	16	16	16	16	16	16	16	16	16	16	16
02/02/2023	16	16	16	16	16	16	16	16	16	15	15	19	20	19	19	37	33	30	7	29	32	39	35	33	3	39	29	24	11	0	0	0	23	18	16	16	14	14	14	14	14	14	14	14	15	14	14	14
03/02/2023	15	15	15	15	15	15	15	15	14	14	15	17	18	20	23	30	32	29	1	39	32	37	50	31	0	19	19	7	0	0	0	0	22	18	18	19	17	17	17	17	17	17	16	16	16	16	17	17
04/02/2023	17	17	17	17	17	17	17	17	17	17	17	18	17	18	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21	18	18	19	18	18	15	15	15	15	15	15	15	15	15	15
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07/02/2023	18	18	18	18	18	18	17	17	17	17	18	20	21	25	30	29	18	20	0	29	38	38	29	31	0	34	44	18	8	0	0	0	23	19	17	17	17	17	17	17	17	17	17	16	16	17	17	16
08/02/2023	17	16	17	16	16	16	17	17	17	17	18	20	20	21	25	28	30	24	5	24	25	24	28	25	0	24	42	30	12	0	0	0	18	16	15	16	16	16	15	15	15	14	14	14	14	15	14	14
09/02/2023	14	14	14	14	14	14	14	14	14	14	15	15	16	19	23	37	37	28	8	44	38	34	37	26	4	0	0	0	0	0	0	0	19	17	16	17	16	16	16	15	15	15	15	16	16	16	16	16
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12/02/2023	13	13	13	14	14	14	14	17	17	17	18	19	18	18	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24	21	22	21	19	19	19	19	19	18	18	17	17	18	18	18
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14/02/2023	15	14	14	14	15	15	15	18	18	18	18	18	19	20	24	52	51	43	16	48	57	42	34	27	3	35	47	30	12	0	0	0	26	19	18	19	18	18	17	17	17	17	18	18	18	18	18	17
15/02/2023	18	18	18	18	18	18	18	18	17	17	18	19	20	23	27	30	30	24	0	37	31	32	37	13	0	18	16	7	4	0	0	0	21	17	16	16	17	17	16	16	17	17	17	17	17	17	17	17
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18/02/2023	11	11	11	11	10	10	11	13	14	14	14	15	15	16	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	15	15	15	15	12	12	12	13	13	13	12	12	13	13	12
19/02/2023	12	12	12	13	13	13	13	15	16	16	16	17	17	15	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	18	18	17	13	13	14	13	13	13	14	14	14	14	14	13
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22/02/2023	16	16	16	16	16	16	16	16	16	16	16	17	19	21	19	36	36	28	0	27	34	36	30	25	0	24	22	22	7	0	0	0	23	16	16	16	16	18	16	16	16	16	16	15	16	16	16	16
23/02/2023	16	16	16	16	16	16	16	16	16	16	16	17	19	21	19	17	26	36	7	41	47	42	34	33	8	37	43	30	12	0	0	0	19	19	18	18	18	18	18	17	17	17	17	17	17	18	17	17
24/02/2023	18	17	18	18	17	18	17	18	18	17	18	19	21	24	23	40	41	31	2	28	35	31	27	21	0	30	17	3	0	0	0	0	23	18	16	15	16	16	16	17	17	17	17	17	17	17	17	17
25/02/2023	17	17	17	17	17	17	17	17	17	17	17	18	20	23	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17	15	14	14	15	12	12	12	12	12	12	12	12	12	12	12
26/02/2023	11	11	11	12	12	12	12	13	15	16	15	16	17	17	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	15	13	13	14	14	14	14	14	14	14	14	14	14	14	14
27/02/2023	14	14	14	14	14	13	14	13	14	14	15	15	14	16	16	38	36	26	0	42	37	26	24	33	1	37	34	29	22	0	0	0	17	15	15	15	16	16	16	17	16	16	16	16	16	16	16	16
28/02/2023	15	15	16	16	16	16	15	15	16	16	16	17	18	22	24	43	45	35	1	31	30	24	23	33	3	42	42	32	6	0	0	0	25	21	20	19	19	19	20	19	20	20	20	20	20	20	20	19

5. Know the value of your solar-generated electricity

Electricity is metered, bought, and sold in half-hourly portions. Buy and sell prices differ according to season and time of day, and so may the value of your generated electricity. Knowing the financial value of generation can alter operational decisions.

Uninformed decision: *A building manager does not monitor solar generation closely but knows a rooftop solar array has stopped working. Prior to solar engineers accessing the roof to repair the solar array, £12,000 will need to be spent to make the roof safe. The building manager decides this is low priority and puts off the repairs until the next budgetary period.*

Informed decision: *A building manager monitors solar generation closely and is aware a rooftop solar array has stopped working. Prior to solar engineers accessing the roof to repair the solar array, £12,000 will need to be spent to make the roof safe. The building manager knows that during the current budgetary period, purchasing electricity from an electricity Supplier to replace the lost generation will cost £16,000. The building manager decides repairing the roof is a high priority as it will enable the solar array to recommence generating free electricity.*

Check 1. Import supply contract price, cost (pence per kilowatt hour) *e.g.* **25.3p/kWh.**

Check 2. Export revenue, payment (pence per kilowatt hour) *e.g.* **6.3p/kWh.**

Check 3. Export subsidy, payment (pence per kilowatt hour) *e.g.* **19.5p/kWh.**

Check 4. Generation subsidy, payment (pence per kilowatt hour) *e.g.* **3.4p/kWh.**

Check 5. The *levelized cost of operation and maintenance (O&M) *e.g.* **13p/h-h.**

This is the annual cost divided by the number of half hours in the calendar year. If the annual O&M cost were £2,300, in 2023 the levelized half-hourly cost would be 13 pence.

*(**Notes:** these costs are examples and should not be used as benchmarks. Export or generation subsidies may not be applicable as revenue)*

Examples of calculations of the financial value of rooftop solar generated electricity -

1. A kilowatt hour of exported solar generation equals export revenue plus generation and export subsidy payments, minus the levelized cost* of operation, maintenance, and management of the solar plant.

[(6.3p + 19.5 + 3.4p) - [13p] = **16.2p/kWh**

2. A kilowatt hour of solar generation consumed on site equals the import supply contract price, pence per kilowatt hour, minus the levelized cost* of operation, maintenance, and management of the solar plant.

(25.3p) - (13p) = **12.3p/kWh**

6. Basic analysis of rooftop solar generation

Check 1. Collect generation, export, and import data *daily: Calculate kilowatt hour generation data from manual meter readings, half-hourly data collected by the power purchaser or supplier or seen via a performance monitoring device or app. Metered data may be also available from an Energy Management System or Building Management System. Short meter data time periods, i.e.; half-hourly, are a more impactful analysis tool than daily or monthly time periods.

*Solar monitoring platforms may not have the capacity to store half-hourly data for more than a few days.

Check 2. Compare against benchmark data: Compare kilowatt hour generation data against installed kilowatt capacity, and the expected or actual kilowatt hour performance for a similar time period.

Check 3. Cross-reference with operating conditions: Is there an environmental factor affecting generation performance? For example; the level of sunlight, the length of daylight hours, the plant being offline for maintenance; power outages; electrical system faults, tree cover/new buildings, dirt on the panels.

Check 4. **Consider system capability:** The installed kilowatt capacity indicates the kilowatt generation capability of the plant under optimum conditions. In practice, performance at full kW capacity will only be achieved if the electrical demand on site is larger than, or equal to, the installed kilowatt capacity of the array.

A small percentage of electricity may be lost between the generation measuring point (meter) and the source of demand on site, or the point of export to the grid, depending on the system design. This should amount to around 2% and may be far less. If losses are greater than this, consult a solar operation and maintenance provider, an electrical design engineer and/or and Energy Management System engineer (if there is an EMS on site).

Check 5. **Reach a conclusion:** Is the generation as expected under the operational circumstances?

Check 6. **Take appropriate remedial action:** The action may be to clean the panels, contact the operation and maintenance contractor, contact the telecoms provider, contact the meter operator etc.

7. Interpreting generation data using Excel

Whether or not a solar monitoring platform is used, carrying out simple Excel analyses each day will provide a fast holistic picture of electricity generation, consumption, and demand in your building, giving you all the information needed to maximise the benefit of on-site generation.

Check:

- For each meter, create a template Excel spreadsheet in which to paste and record half-hourly data.
- Apply appropriate Conditional Formatting to the content to give visual indications of performance status.
- Collect half-hourly generation and, where relevant, export meter data at day+1, paste it into your Excel template/s to produce tailored visual analyses.

  *(**Note:** Day+1 is the day after the data is recorded.)*

Figure 4: Example of Excel template to for daily interpretation of half-hourly generation data**.**

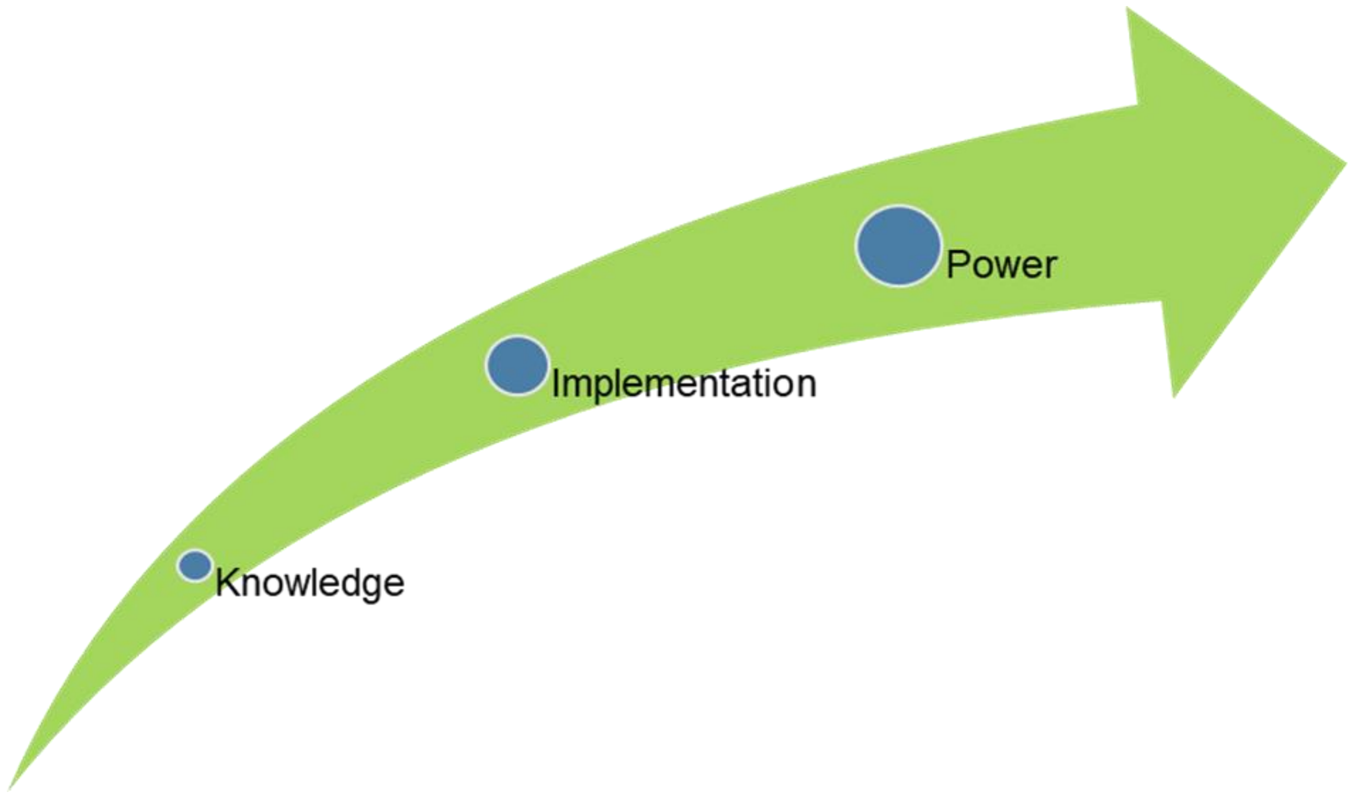
																						Hours of peak performance opportunity			
300 kW Installed Capacity	**Time**	Hours of darkness									Daylight Hours														
		01:00		02:00		03:00		04:00		05:00		06:00		07:00		08:00		09:00		10:00		11:00		12:00	
Generation Meter data	**HH Period**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**
Array Example 1	**15/06/2023**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Array Example 2	**15/06/2023**	0	0	0	0	0	0	0	0	0	26	20	45	65	85	100	165	210	230	235	235	251	274	**298**	297
Array Example 3	**15/06/2023**	0	0	0	0	0	0	0	0	0	23	**0**	**0**	20	32	64	89	90	90	54	90	**90**	**106**	**120**	**123**
Array Example 4	**15/06/2023**	0	0	0	0	0	0	0	0	0	24	27	27	43	67	120	165	210	230	235	235	269	274	274	-
Array Example 5	**15/06/2023**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

		Hours of peak performance opportunity																							
300 kW Installed Capacity	**Time**	Daylight Hours																		Hours of darkness					
		13:00		14:00		15:00		16:00		17:00		18:00		19:00		20:00		21:00		22:00		23:00		00:00	
Generation Meter data	**HH Period**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**	**41**	**42**	**43**	**44**	**45**	**46**	**47**	**48**
Array Example 1	**15/06/2023**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Array Example 2	**15/06/2023**	291	290	288	290	267	198	194	238	214	198	180	152	124	162	101	63	25	12	0	0	0	0	0	0
Array Example 3	**15/06/2023**	**189**	**230**	256	256	**10**	0	0	**59**	**174**	198	180	152	124	162	101	63	25	12	0	0	0	0	0	0
Array Example 4	**15/06/2023**	-	-	-	-	-	-	-	238	214	198	180	152	124	162	101	63	25	12	0	0	0	0	0	0
Array Example 5	**15/06/2023**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Key		**Performance analysis of generation half-hourly data**	**Remedial Action**
Not generating due to darkness	0	As expected	None
Not generating during daylight hours	0	1. Power outage? 2. Maintenance outage? 3. No demand for electricity from the building circuit? 4. Distribution system operator has remotely switch off the generation? 5. Data Collector error?	1. Investigate the cause of the power outage so it's not repeated. 2. Confirm the hours of mainatenance and the technical necessity to switch off generation. 3. Confirm if there was no demand or whether there is an electrical fault. 4. Confirm the Distribution system operator has this facility in the terms of connection. 5.Contact the Data Collector.
No meter data recorded	-	1. Meter fault? 2. Data collector hasn't loaded the meter data onto the web portal? 3. Telecommunications fault? 4. If continuous, telecom/SIM disconnection due to unpaid bill?	1. Contact electricity supplier or meter operator. 2. Wait 24 hours before contacting Data collector. 3. Contact telecoms service provider/s. 4. Confirm account payment is up to date and arrange reconnection.
Generating at installed capacity at peak sunshine	**298**	Evidence the array works as expected in optimum conditions. Full sunshine, sufficient demand (not usually achieved in the UK).	None
NOT generating at installed capacity at peak sunshine	**120**	1. Cloudy? 2. Not enough demand? 3. An inverter is faulty? 4. Dirty panels?	1. Confirm weather conditions. 2. Confirm operational drop in demand. 3. Check inverter's display panel or monitoring system for fault flags and arrange maintenance. 4. Arrange panel cleaning.
Generating at full capacity for time of day	238	Monitor output under similar weather conditions and season to understand if the output is better or worse than usual.	Establish the cause of any drop off in performance.
NOT generating at expected capacity for time of day	**59**	1. Cloudy? 2. Not enough demand? 3. An inverter is faulty? 4. Dirty panels?	1. Confirm weather conditions. 2. Confirm operational drop in demand. 3. Check inverter's display panel or monitoring system for fault flags and arrange maintenance. 4. Arrange panel cleaning.

8. Management tips

It is useful to support the solar factsheet and operations manual, with an electronic operations calendar to avoid breaching health and safety regulations, missing opportunities to contract at optimal prices, or breaching terms of insurance.



An operations diary can take the format of appointments created in an electronic calendar for **cyclical data** events such as;

- Power purchase agreement end date.
- Smart Export Guarantee end date.
- The date Feed-in-Tariff payments are uplifted.
- Import supply contract end date.
- Statutory Safety Test due dates.
- Cleaning and maintenance schedules.
- Insurance end dates.

It is practical to add a reminder to renew or tender a couple of months prior to the end date of each entry. Each time new terms are entered into, update the factsheet, operations manual and operations calendar.

Once set-up, managing your rooftop solar takes just five or ten minutes a day. The processes can be adapted to larger solar installations and other renewable technologies. The operations manual is easy to handover when an operations manager changes.

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