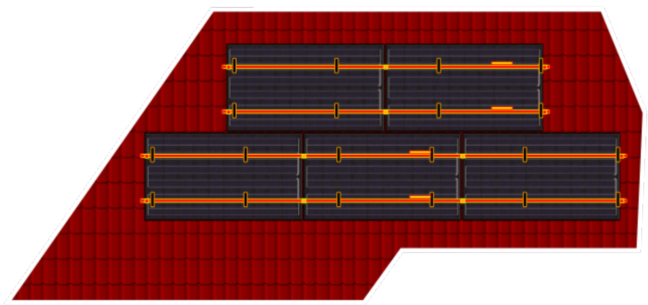
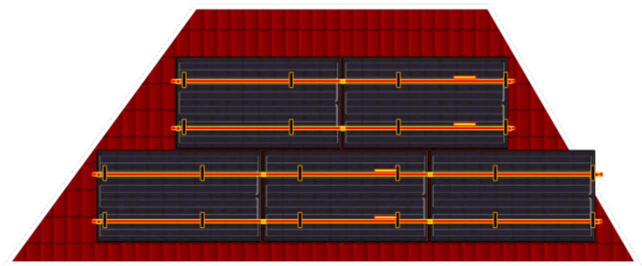
Roof Layout

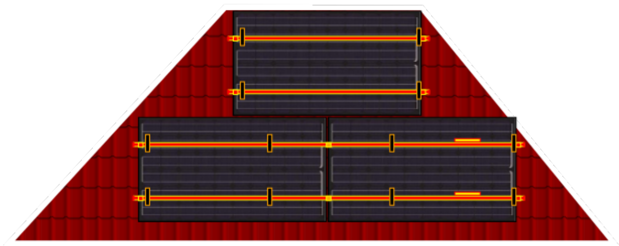
Roof 1



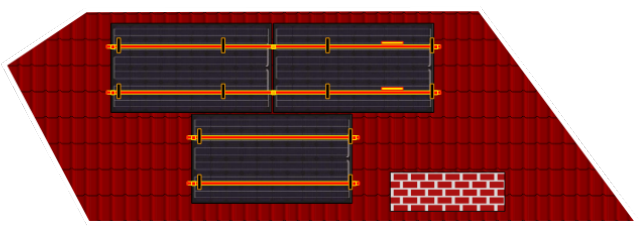
Roof 2



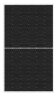
Roof 3



Roof 4



Component list

	Item	Quantity
	Jinko Tiger 410W N-Type Black Framed Mono - 25yr warranty solar panel	16
	Primo GEN24 Plus 6.0 1ph inverter	1
	Label sheet	1
	GivEnergy 100A DC breaker	1
	AC isolator - KN 32A 3-pole	2
	Generic battery 8.0	1
	Pair of MC4 connectors	4
	50m reel of 4mm2 solar cable	1
	Fastensol end clamp (30mm black)	32
	Fastensol mid clamp (30mm black)	16
	Fastensol black end cap	32
	Fastensol portrait concrete tile roof hook	64
	Fastensol rail splice	12
	Fastensol silver rail 3300mm	22

Inverter checks

Primo GEN24 Plus 6.0 1ph

Panels

PV power	**6560**	Rated AC output	**6000**

Input 1: 10 Jinko Tiger 410W N-Type Black Framed Mono - 25yr warranty solar panels in 1 strings

Panels		**Inverter**	
PV power	**4100 W**		
Open circuit voltage at -10° C	**513 V**	Max DC voltage	**600 V**
V_{mpp} at 40° C	**351 V**	V_{mpp} lower limit	**65 V**
V_{mpp} at -10° C	**404 V**	V_{mpp} upper limit	**480 V**
I_{mpp} at 40° C	**11 A**	Max DC input current	**22 A**

Max voltage

The open circuit voltage of the solar panels never exceeds the voltage limit of the inverter.

Max power point range

The maximum power point voltage of the solar panels is always above the lower limit of the inverter MPPT tracker. The maximum power point voltage of the solar panels is always below the upper limit of the inverter MPPT tracker.

Max Current

The maximum power point current of the solar panels is always below the maximum current for the inverter MPPT tracker.

✓

Input 2: 6 Jinko Tiger 410W N-Type Black Framed Mono - 25yr warranty solar panels in 1 strings

Panels		Inverter	
PV power	**2460 W**		
Open circuit voltage at -10° C	**308 V**	Max DC voltage	**600 V**
V_{mpp} at 40° C	**211 V**	V_{mpp} lower limit	**65 V**
V_{mpp} at -10° C	**242 V**	V_{mpp} upper limit	**480 V**
I_{mpp} at 40° C	**11 A**	Max DC input current	**12 A**

Max voltage

The open circuit voltage of the solar panels never exceeds the voltage limit of the inverter.

✓

Max power point range

The maximum power point voltage of the solar panels is always above the lower limit of the inverter MPPT tracker. The maximum power point voltage of the solar panels is always below the upper limit of the inverter MPPT tracker.

✓

Max Current

The maximum power point current of the solar panels is always below the maximum current for the inverter MPPT tracker.

✓

Electrical

Primo GEN24 Plus 6.0 1ph

AC Isolator

A AC isolator - KN 32A 3-pole has been specified for this input

Current

The rated isolator current (32A) is greater than the rated inverter current (26.1A)

✓

Phases

The isolator is suitable for use on a single phase inverter.

✓

Input 1

DC Isolator

Integrated isolator

This inverter contains an integrated DC Isolator.

✓

Cable

10m of 4mm2 solar cable has been specified

Voltage drop

Voltage drop at maximum power point at 40°C will be around **0.94 V (0.27 percent)**

✓

Input 2

DC Isolator

Integrated isolator

This inverter contains an integrated DC Isolator.

✓

Cable

10m of 4mm2 solar cable has been specified

Voltage drop

Voltage drop at maximum power point at 40°C will be around **0.94 V (0.45 percent)**

✓

Structural calculations

Weight loading calculations

For a traditional cut roof with rafters and purlins we recommend also using our rafter calculator to check the load-bearing capacity of the rafters. Even if the increase in loading is more than 15% the rafters may well be able to take the additional weight.

Please note that this method does not calculate the strength of the roof, and if a roof was badly constructed, does not meet existing building regulations, or is in poor condition then it may still not be appropriate to install an array.

Roof 1

Dead load from roof covering	0.45 kN/m^2
Imposed load	0.75 kN/m^2
Total loading without solar array	**1.2 kN/m^2**

Weight of solar panels and mounting	133.2 kg
Area covered by solar array	9.5 m^2
Loading imposed by solar array	0.14 kN/m^2
Total loading with solar array	**1.3 kN/m^2**

Increase in loading due to solar array: 11.7%

An increase of less than 15% in the load imposed on a roof is not considered to be a significant change (The Building Regulations 2010, Approved Document A). ✓

Roof 2

Dead load from roof covering	0.45 kN/m^2
Imposed load	0.75 kN/m^2
Total loading without solar array	**1.2 kN/m^2**

Weight of solar panels and mounting	133.2 kg
Area covered by solar array	9.5 m^2
Loading imposed by solar array	0.14 kN/m^2
Total loading with solar array	**1.3 kN/m^2**

Increase in loading due to solar array: 11.7%

An increase of less than 15% in the load imposed on a roof is not considered to be a significant change (The Building Regulations 2010, Approved Document A).

Weight loading calculations

Roof 2

Weight of solar panels and mounting	133.2 kg
Area of solar array	9.5 m^2
Loading imposed by solar array	0.14 kN/m^2
Dead load from roof covering	0.45 kN/m^2
Total dead load of solar array, mounting and roof covering	**0.59 kN/m^2**
Permitted dead load	**0.785 kN/m^2**

The solar array, mounting system, and roof covering are expected to impose a total dead load on the roof of **0.59kN/m^2**. This is less than the permitted dead load for the roof of **0.785kN/m^2**.

Roof 3

Weight of solar panels and mounting	81.7 kg
Area of solar array	5.7 m^2
Loading imposed by solar array	0.14 kN/m^2
Dead load from roof covering	0.45 kN/m^2
Total dead load of solar array, mounting and roof covering	**0.59 kN/m^2**
Permitted dead load	**0.785 kN/m^2**

The solar array, mounting system, and roof covering are expected to impose a total dead load on the roof of **0.59kN/m^2**. This is less than the permitted dead load for the roof of **0.785kN/m^2**.

✓

Roof 4

Weight of solar panels and mounting	81.7 kg
Area of solar array	5.7 m^2
Loading imposed by solar array	0.14 kN/m^2
Dead load from roof covering	0.45 kN/m^2
Total dead load of solar array, mounting and roof covering	**0.59 kN/m^2**
Permitted dead load	**0.785 kN/m^2**

The solar array, mounting system, and roof covering are expected to impose a total dead load on the roof of **0.59kN/m^2**. This is less than the permitted dead load for the roof of **0.785kN/m^2**.

Wind loading calculations

The maximum force acting on a solar array from wind loading is given by the following formula in BRE Digest 489:

$$F = q_p \times C_{p\ net} \times C_a \times C_t \times A_{ref}$$

Roof 1

Q_p		763 Pa
From Fig 34 in Guide to the Installation of Photovoltaic Systems for a building 10 m high, in windzone 1, in urban terrain, at a distance of greater than 20km from the sea		
$C_{p\ net}$	Roof Centre	Roof edge
Uplift	-1.3	-2.2
Pressure	1	1.1
C_a		1
At an altitude of 12m		
C_t		1
When there is no significant topography		
A_{ref}		$9.54m^2$
F	Roof Centre	Roof edge
Uplift	**-9467N**	**-16021N**
Pressure	**7282N**	**8010N**

With 22 roof hooks we should allow for an uplift force per hook in the central zone of **430N**, rising to **728N** at the edges. If 2 screws are used per roof hook, this equates to **215N**per fixing in the central zone, and **364N** at the edges.

Concrete tile roof hooks are fixed with screws that pass through the 5mm plate of the roof hook and are then buried fully into the rafter beneath. So there is approximately 75 mm of thread in the timber. The pull-out force in C16 timber is given by tables and formulae in BS5268 Part 2:

$$18.74 \times 1.25 \times 75 = \mathbf{1757N}$$

The pullout force on the fixings is less than the expected wind loading, even when the fixings are close to the edge of the roof. ✓

Roof 2

Q_p		763 Pa

From Fig 34 in Guide to the Installation of Photovoltaic Systems for a building 10 m high, in windzone 1, in urban terrain, at a distance of greater than 20km from the sea

$C_{p\ net}$	Roof Centre	Roof edge
Uplift	-1.3	-2.2
Pressure	1	1.1

C_a	1

At an altitude of 12m

C_t	1

When there is no significant topography

A_{ref}	$9.54m^2$

F	Roof Centre	Roof edge
Uplift	**-9467N**	**-16021N**
Pressure	**7282N**	**8010N**

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The pullout force on the fixings is less than the expected wind loading, even when the fixings are close to the edge of the roof. ✓

Roof 3

Q_p		763 Pa

From Fig 34 in Guide to the Installation of Photovoltaic Systems for a building 10 m high, in windzone 1, in urban terrain, at a distance of greater than 20km from the sea

$C_{p\ net}$	Roof Centre	Roof edge
Uplift	-1.3	-2.2
Pressure	1	1.1

C_a	1

At an altitude of 12m

C_t	1

When there is no significant topography

A_{ref}	$5.73m^2$

F	Roof Centre	Roof edge
Uplift	**-5680N**	**-9612N**
Pressure	**4369N**	**4806N**

With 16 roof hooks we should allow for an uplift force per hook in the central zone of **355N**, rising to **601N** at the edges. If 2 screws are used per roof hook, this equates to **178N**per fixing in the central zone, and **300N** at the edges.

Concrete tile roof hooks are fixed with screws that pass through the 5mm plate of the roof hook and are then buried fully into the rafter beneath. So there is approximately 75 mm of thread in the timber. The pull-out force in C16 timber is given by tables and formulae in BS5268 Part 2:

$$18.74 \times 1.25 \times 75 = \mathbf{1757N}$$

The pullout force on the fixings is less than the expected wind loading, even when the fixings are close to the edge of the roof. ✓

Roof 4

Q_p		763 Pa

From Fig 34 in Guide to the Installation of Photovoltaic Systems for a building 10 m high, in windzone 1, in urban terrain, at a distance of greater than 20km from the sea

$C_{p\ net}$	Roof Centre	Roof edge
Uplift	-1.3	-2.2
Pressure	1	1.1

C_a	1

At an altitude of 12m

C_t	1

When there is no significant topography

A_{ref}	5.73m^2

F	Roof Centre	Roof edge
Uplift	**-5680N**	**-9612N**
Pressure	**4369N**	**4806N**

With 16 roof hooks we should allow for an uplift force per hook in the central zone of **355N**, rising to **601N** at the edges. If 2 screws are used per roof hook, this equates to **178N**per fixing in the central zone, and **300N** at the edges.

Concrete tile roof hooks are fixed with screws that pass through the 5mm plate of the roof hook and are then buried fully into the rafter beneath. So there is approximately 75 mm of thread in the timber. The pull-out force in C16 timber is given by tables and formulae in BS5268 Part 2:

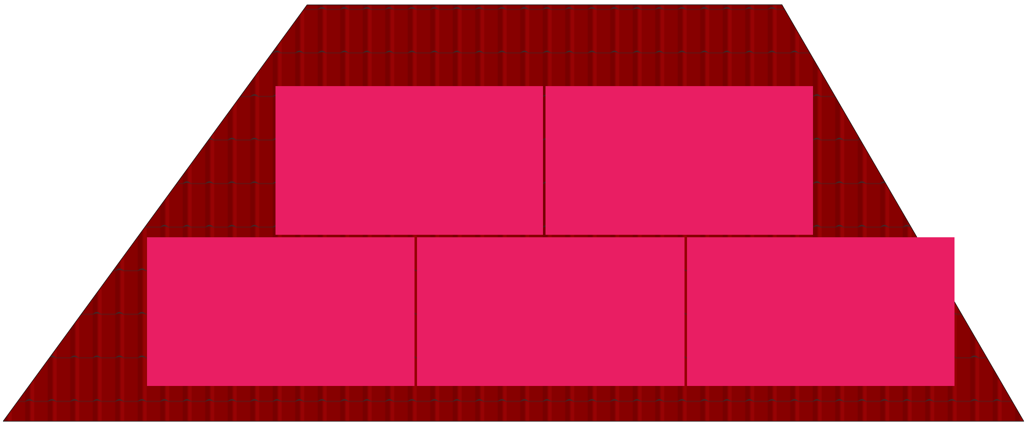
18.74 x 1.25 x 75 = **1757N**

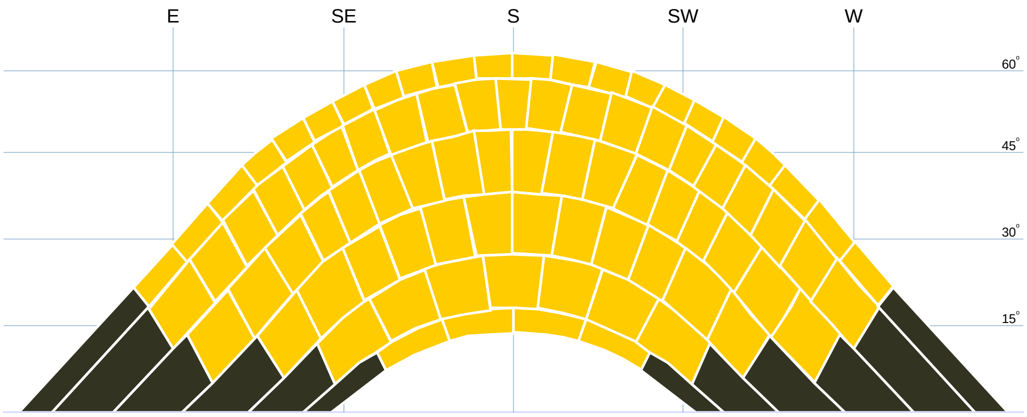
The pullout force on the fixings is less than the expected wind loading, even when the fixings are close to the edge of the roof. ✓

Inverter 1

Primo GEN24 Plus 6.0 1ph

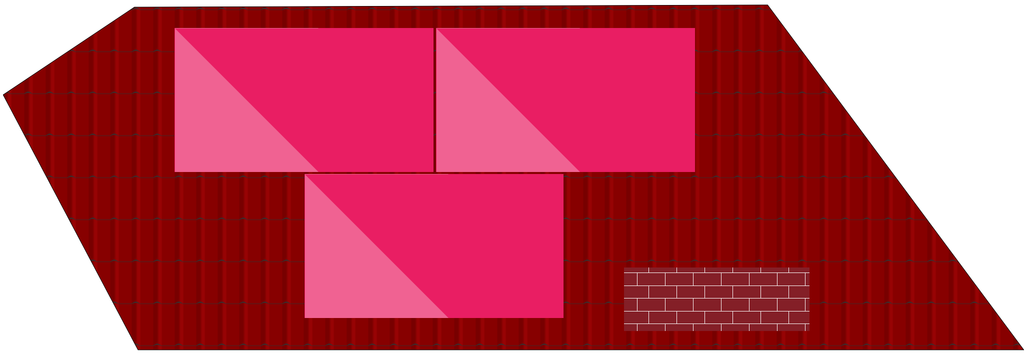
Input 1

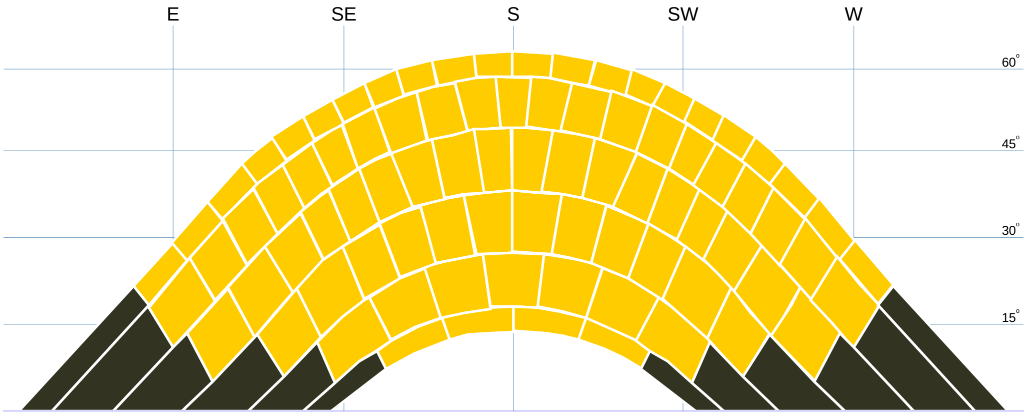




A. Installation data		
Installed capacity of PV system - kWp (stc)	**4.100**	kWp
Orientation of the PV system - degrees from South	**-21**	°
Inclination of system - degrees from horizontal	**40**	°
Postcode region	**11**	
B. Performance calculations		
kWh/kWp (Kk)	**882**	kWh/kWp
Shade factor (SF)	**1.00**	
Estimated output (kWp x Kk x SF)	**3616**	kWh

Input 2





A. Installation data			
Installed capacity of PV system - kWp (stc)	**2.460**	kWp
Orientation of the PV system - degrees from South	**-108**	°
Inclination of system - degrees from horizontal	**40**	°
Postcode region	**11**	
B. Performance calculations		
kWh/kWp (Kk)	**625**	kWh/kWp
Shade factor (SF)	**1.00**	
Estimated output (kWp x Kk x SF)	**1538**	kWh

Performance Summary

A. Installation data		
Installed capacity of PV system - kWp (stc)	**6.56**	kWp
Orientation of the PV system - degrees from South	**See individual inputs**	
Inclination of system - degrees from horizontal	**See individual inputs**	
Postcode region	**11**	
B. Performance calculations		
kWh/kWp (Kk)	**See individual inputs**	
Shade factor (SF)	**See individual inputs**	
Estimated output (kWp x Kk x SF)	**5154**	kWh
C. Estimated PV self-consumption - PV Only		
Assumed occupancy archetype	**home all day**	
Assumed annual electricity consumption, kWh	**4500**	kWh
Assumed annual electricity generation from solar PV system, kWh	**5154**	kWh
Expected solar PV self-consumption (PV Only)	**1597.74**	kWh
Grid electricity independence / Self-sufficiency (PV Only)	**35.51**	%
D. Estimated PV self-consumption - with EESS		
Assumed usable capacity of electrical energy storage device, which is used for self-consumption, kWh	**6.8**	kWh
Expected solar PV self-consumption (with EESS)	**3401.64**	kWh
Grid electricity independence / Self-sufficiency (with EESS)	**75.59**	%

Important Note: The performance of solar PV systems is impossible to predict with certainty due to the variability in the amount of solar radiation (sunlight) from location to location and from year to year. This estimate is based upon the standard MCS procedure is given as guidence only for the first year of generation. It should not be considered as a guarantee of performance.

The solar PV self-consumption has been calculated in accordance with the most relevant methodology for your system. There are a number of external factors that can have a significant effect on the amount of energy that is self-consumed so this figure should not be considered as a guarantee of the amount of energy that will be self-consumed

Self consumption

We model here the performance of a solar PV system with battery storage over the course of a year, using high resolution minute-by-minute generation data for a typical PV system and consumption data for a typical house, and calculating the flow of energy from the solar panels to the house and the battery during the day, and from the storage battery back to the house at night - or from the grid to the house when the battery is empty or loads exceed the discharge capacity of the system.

We provide yearly profiles of generation, consumption, import / export and battery utilisation, along with detailed profiles for a typical spring day.

Battery system specification

Primo GEN24 Plus 6.0 1ph with a Generic battery 8.0 battery

Charge rate	**6000 W**
Inverter charge efficiency	**100.0 %**
Inverter discharge efficiency	**100.0 %**
Battery efficiency	**95.0 %**
Round trip efficiency	**95.0 %**
Battery bank capacity	**8 kWh**
Max discharge depth	**85 %**
Usable capacity	**6.8 kWh**

Consumption

Electricity consumed in the property each year

4500 kWh

Generation

Electricity generated by the PV array each year

5170 kWh

Self consumption

Proportion of PV generation used in the property

56 %

Independence

Proportion of electricity consumption provided by PV

64 %

Import / Export

Electricity import / export each year from the property

1630 / 2219 kWh

Utilisation

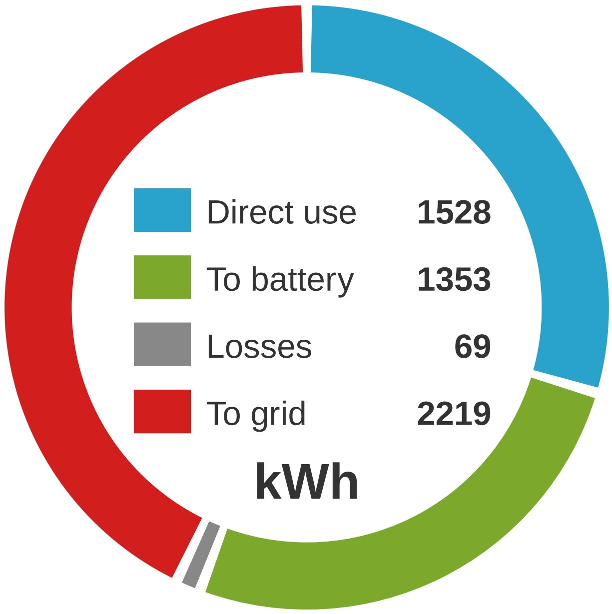
Average daily utilisation of the storage battery

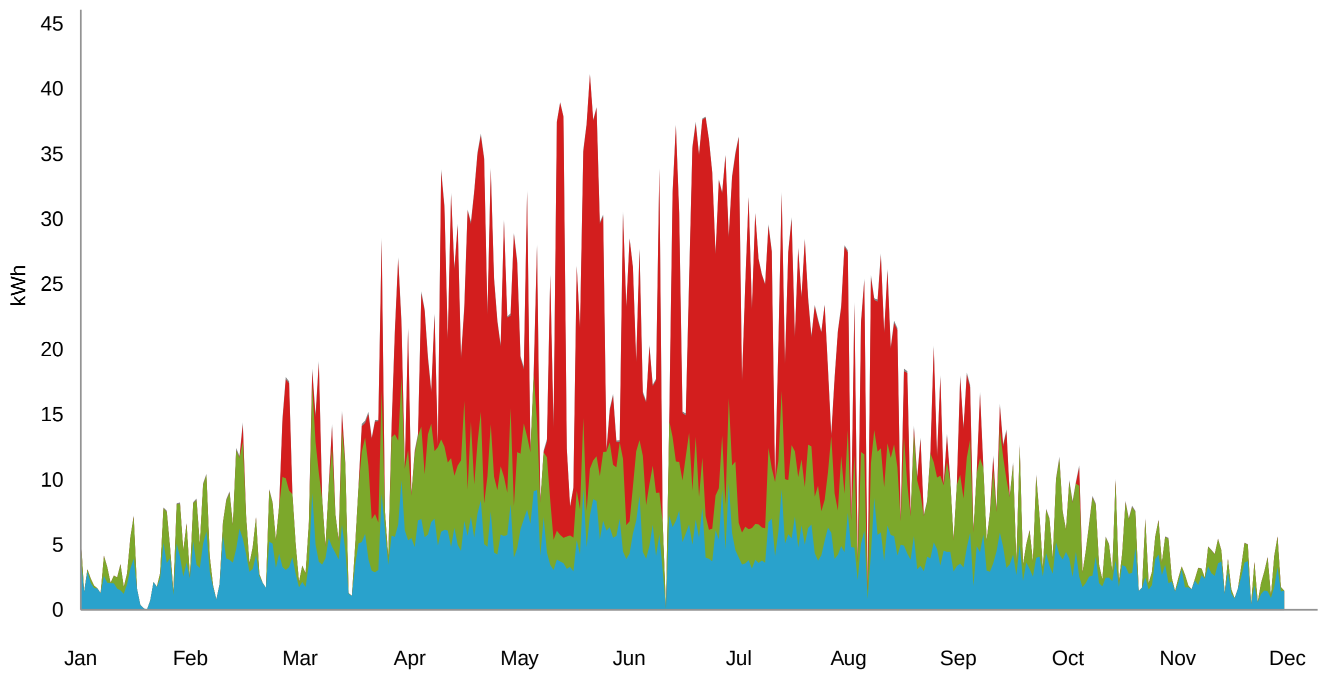
55 %

Yearly generation

The solar PV array is expected to generate 5170 kWh over a typical year. The graph shows whether the generated energy is used directly in the house, used to charge the storage battery, or exported to the grid.

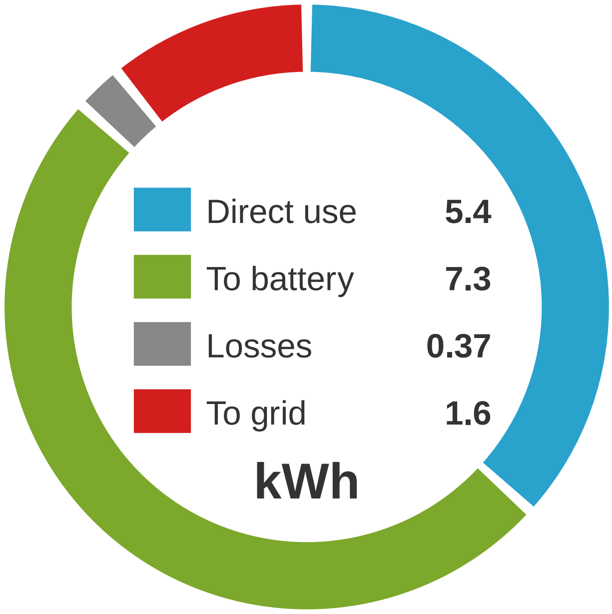
30% (1528 kWh) of the electricity generated is expected to be used directly in the property. 27% (1423 kWh) is directed to the battery for later use, although 69 kWh of this is lost during battery charging and discharging. The remaining generation (2219 kWh, or 43% of the total) is exported to the grid.

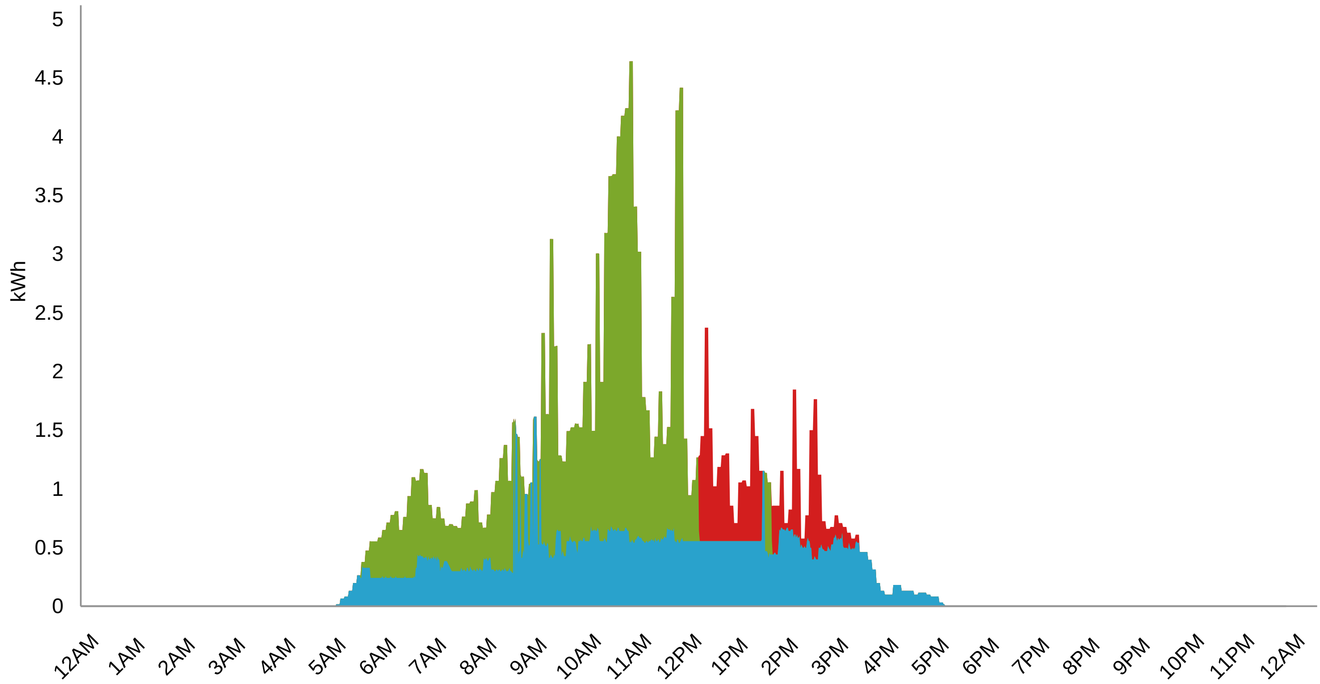




Daily generation

This graph shows the modelled profile of electricity generated by the PV array on a selected day (March 27th). On this day the PV system is expected to generate 14.6 kWh. Of this, 5.4 kWh (37%) is used directly in the property, 7.6 kWh (52%) is stored in the battery for later re-use, and 1.6 kWh (11%) is exported to the grid.

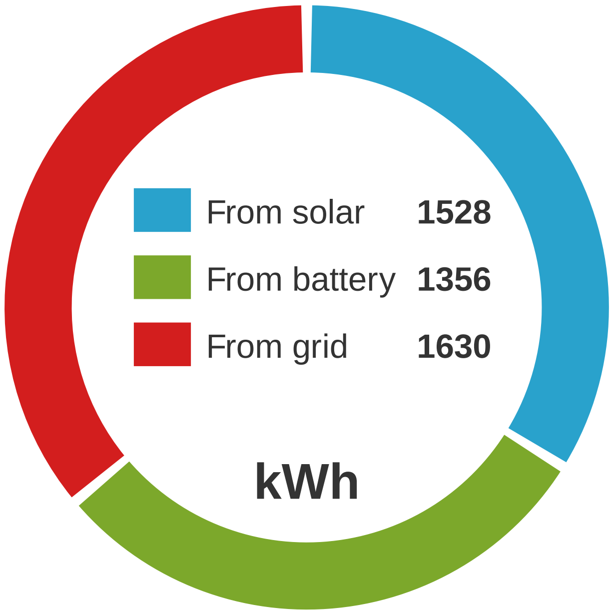


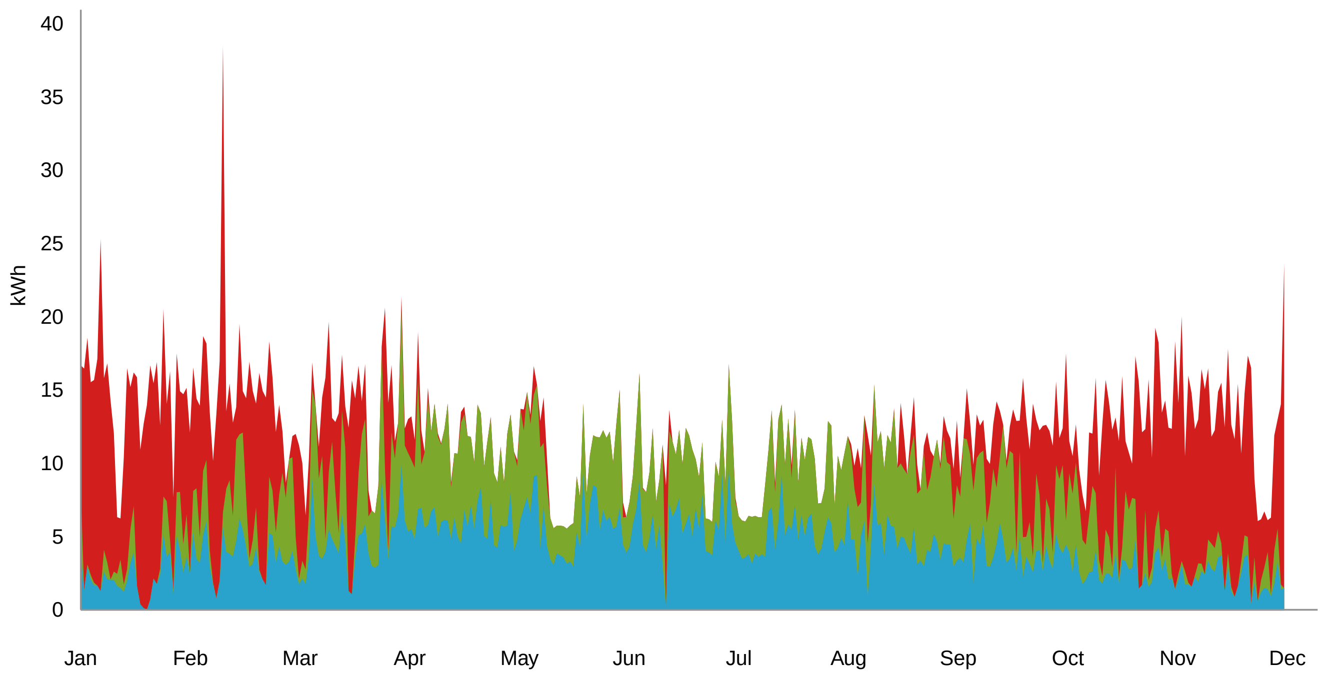


Yearly consumption

The property is expected to consume 4500kWh of electricity each year. Around 34% of this (1528 kWh) is expected to be supplied directly by the solar array. Another 30% (1356 kWh) is supplied from the storage battery. The remaining 36% (1630 kWh) is supplied from the grid.

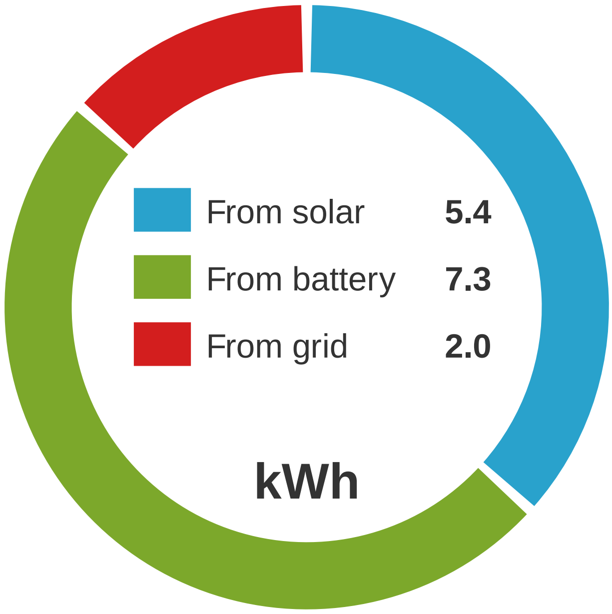
The total self-consumption is expected to be 64% (2884 kWh) with the battery storage system. Without battery storage it would be 34% (1528 kWh).

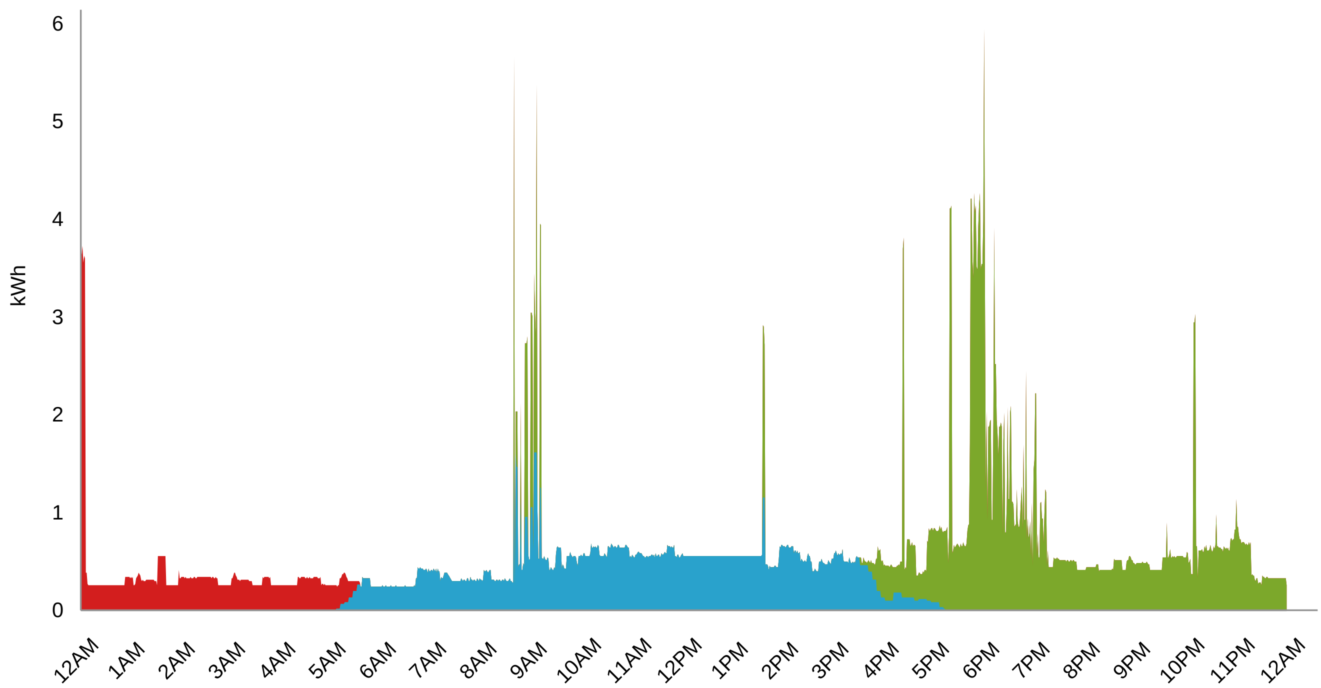


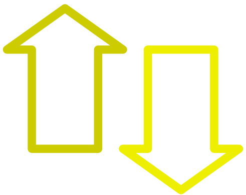


Daily consumption

This graph shows modelled consumption data over the course of the selected day (March 27th). Total electricity consumption on this day was 14.6 kWh, of which 5.4 kWh (37%) is expected to be supplied directly by the solar array, and a further 7.3 kWh (50%) drawn from the battery storage system. The remaining 2 kWh (14%) is imported from the grid.



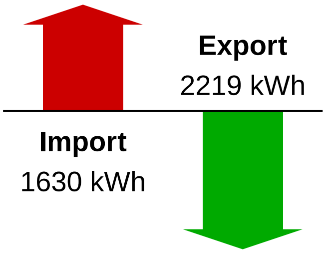


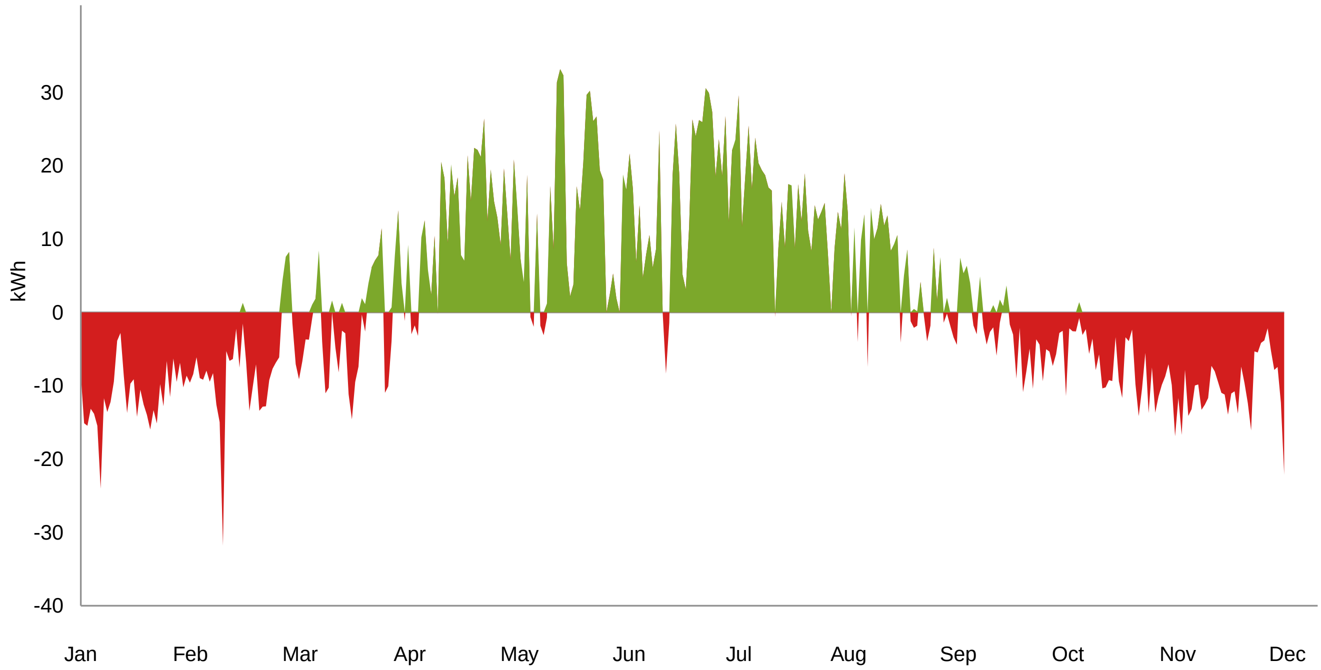


Yearly import and export

This graph shows modelled profiles of electricity imported and exported to and from the grid over the course of a year. The red area above the horizontal axis represents imported electricity, and the green area beneath the axis exported electricity.

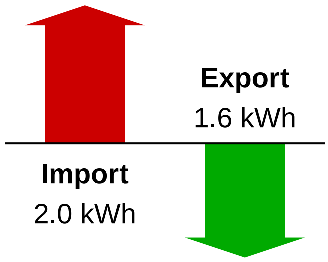
Over the course of the year, a total of 1630 kWh is expected to be imported by the property, and 2219 kWh exported back to the grid.

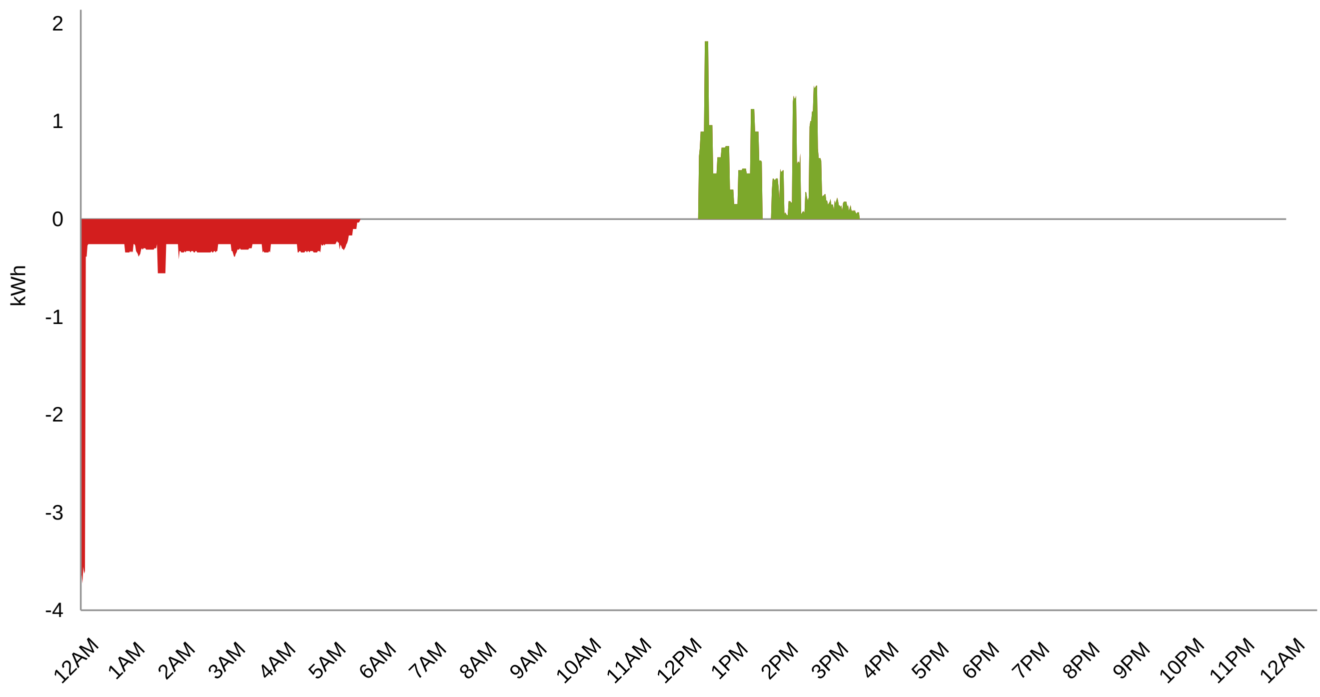




Daily import and export

This graph shows the modelled import and export of electricity over a selected day (March 27th). On this day 2.00 kWh is expected to be imported from the grid, and 1.6 kWh exported.At times when no import or export is shown the battery storage system is charging or discharging.





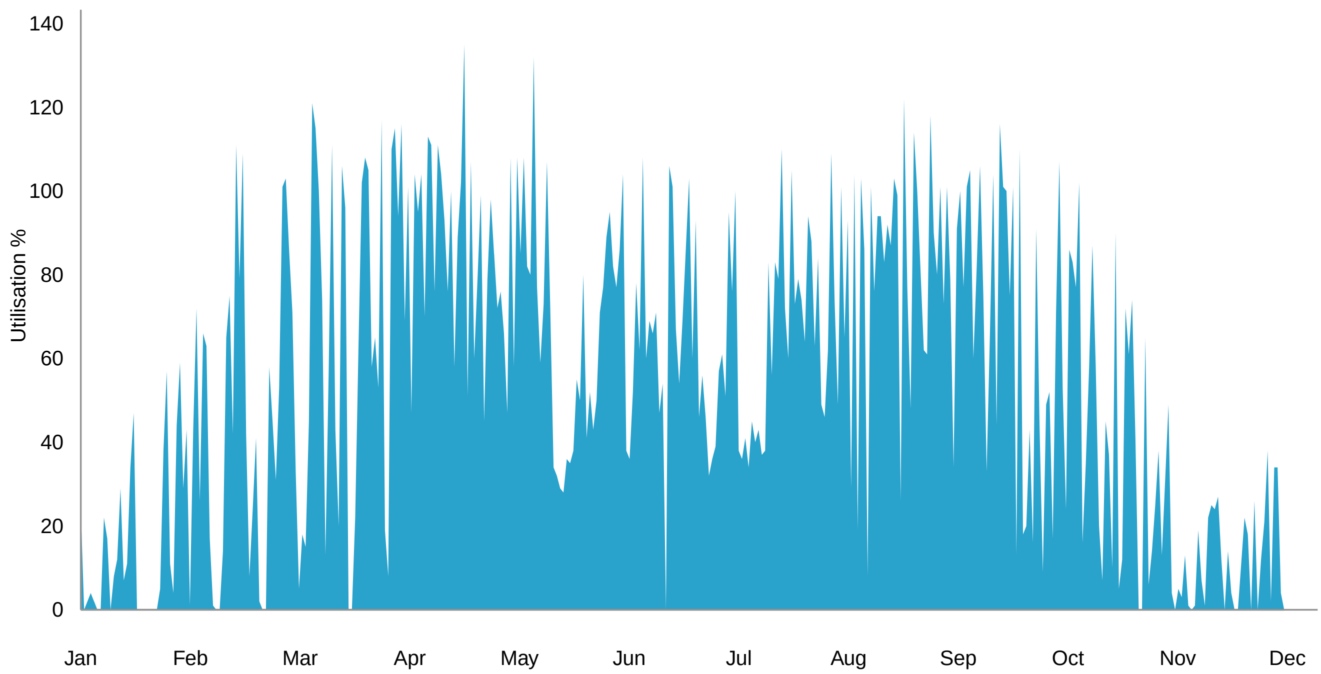
Yearly battery utilisation

The graph shows the modelled utilisation of the battery over the course of the year - the fraction of the available battery capacity that is actually charged and discharged each day. Utilisation of over 100% is possible at times where a battery is charged and discharged more than once during a day.

Low battery utilisation can be due to either insufficient spare PV generation to charge the battery (often the case in winter, or on cloudy days), or because loads are small overnight and the battery does not fully discharge.

Average battery utilisation

55%

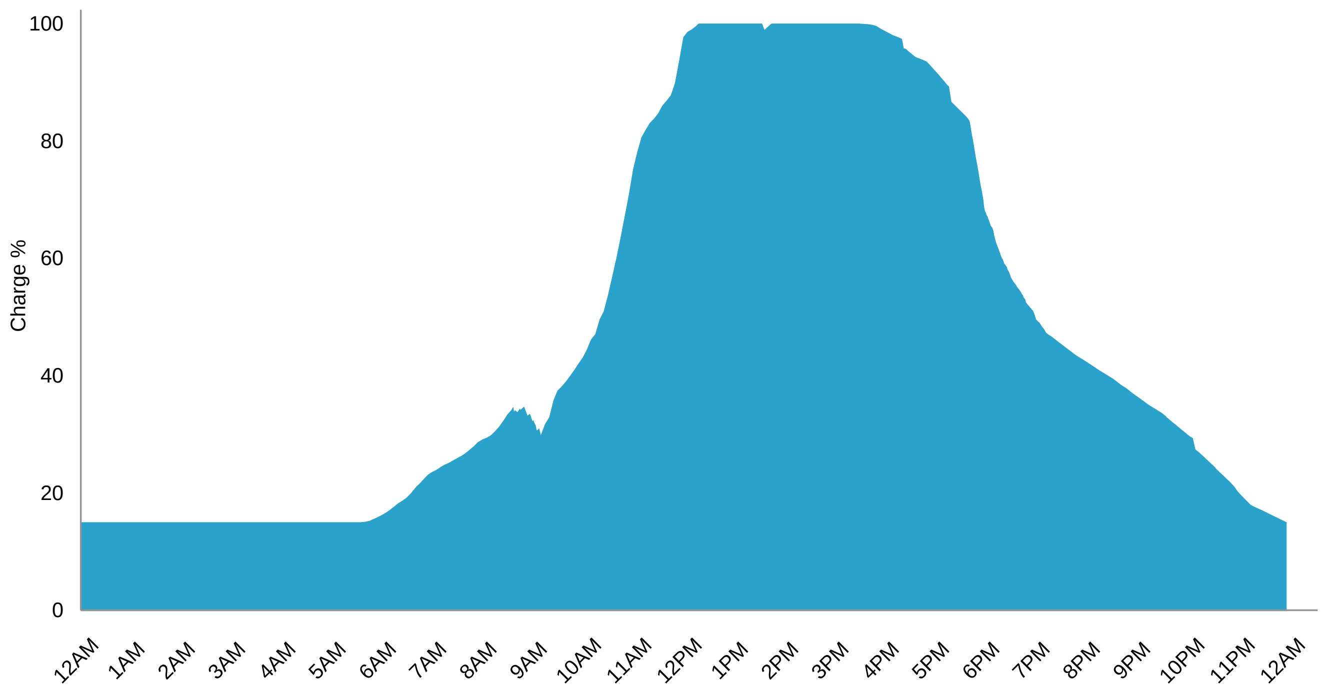


Daily battery utilisation

The state of charge of the battery over a selected day (March 27th) is shown in the graph below. The battery discharges overnight or when there is heavy demand during the day, and charges when there is excess solar PV generation during the day. On this day, 109% of the battery capacity was utilised.

Average battery utilisation

109%



Equipment and Services

Equipment Costs

Panels	£3,380.00
Mounting	£1,695.40
Batteries	£2,543.13
Inverters	£2,684.50
Electrical	£431.40
Total equipment cost	**£10,734.42**

Services Costs

Total services cost	**£0.00**

Totals

Total before tax	**£10,734.42**
VAT at undefined%	**£0.00**
Total including tax	**£10,734.42**

Financial

Generation

The system is expected to generate 5154 kWh per year initially, decreasing gradually as the solar cells degrade. Over the 25 year term of this financial projection the total generation is expected to be 121104 kwh, of which 64486 kWh will be consumed on site and 56618 kWh exported.

121 MWh

Payback

After adjusting projected costs and benefits for inflation, and applying a discount rate of 4%, the initial system cost of £10,734.42 is expected to be recouped after 10 years.

10 years

Net Present Value

The total present value of future benefits and costs, using a discount rate of 4% per year, is £22,392.15. The cost of the PV system is £10,734.42. The net present value of the project is therefore £11,657.73. A positive net present value is a good indication that the project is financially worthwhile.

£11657.73

IRR

The Internal Rate of Return is a useful measure for comparing the relative profitability of investments.

11.4 %

Disclaimer

Our financial model calculates the benefits of a solar PV installation (such as savings in electricity, or payments for exported electricity) and costs (the initial purchase cost, and any future maintenance costs if entered), over the projected lifespan of the system. Values are corrected for inflation, system degradation, and discount rate - a measure that accounts for the fact that a promise of a monetary sum in the distant future is usually considered less valuable than the promise of the same sum in the near future.

A model is only as accurate as the assumptions it makes. You should consider whether the values chosen are appropriate for your situation. There are many variables that dictate the financial return of a solar installation and we cannot forecast how they may change in the future. This financial projection shows a likely scenario for future financial returns. Actual returns may vary significantly from this forecast.

Assumptions

Inflation rate	2%
Cost of electricity	£0.4 /kWh increases with inflation
System size	6.56 kWp degrades at 0.5% per year
Discount rate	4%
Projection length	25 years

Income and savings

The projected income from the system over the project lifetime in payments for generated and exported electricity, along with electricity savings, are shown in the table and graph below.

These figures assume an inflation rate of 2 percent.

	Export payments	Electricity savings	**Total**
Year 1	121	1106	**1227**
Year 2	123	1122	**1246**
Year 3	125	1139	**1264**
Year 4	127	1156	**1283**
Year 5	129	1173	**1302**
Year 6	131	1191	**1322**
Year 7	133	1209	**1341**
Year 8	135	1227	**1361**
Year 9	137	1245	**1382**
Year 10	139	1263	**1402**
Year 11	141	1282	**1423**
Year 12	143	1301	**1444**
Year 13	145	1321	**1466**
Year 14	147	1340	**1488**
Year 15	149	1360	**1510**
Year 16	152	1381	**1532**
Year 17	154	1401	**1555**
Year 18	156	1422	**1578**
Year 19	158	1443	**1602**
Year 20	161	1465	**1626**
Year 21	163	1487	**1650**
Year 22	166	1509	**1674**
Year 23	168	1531	**1699**
Year 24	171	1554	**1725**
Year 25	173	1577	**1750**

£3644

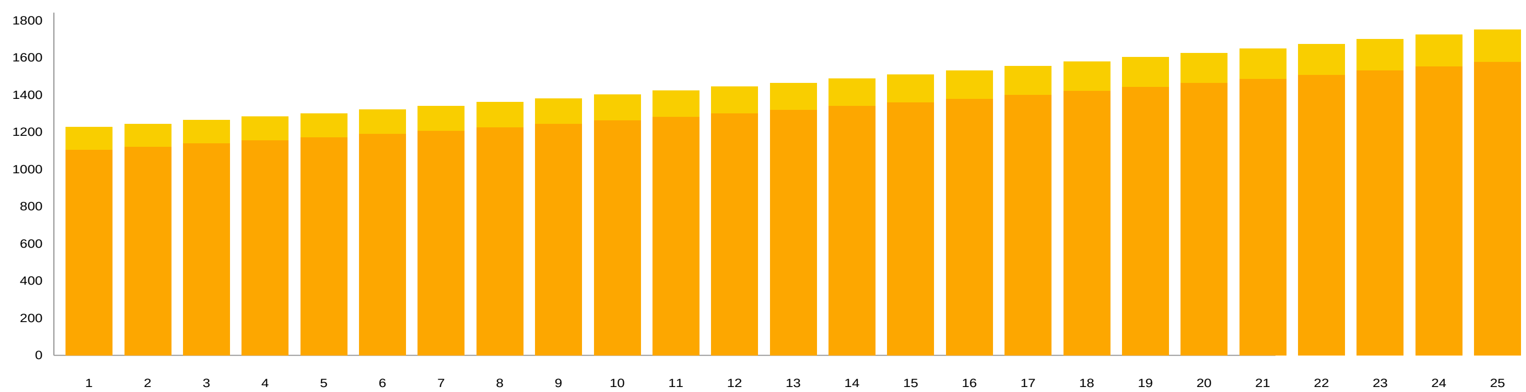
Total Export Payments

over 25 years

£33207

Electricity savings

over 25 years



The bottom line

The table and graph below show the discounted costs for the project (including the initial capital required for the installation), against the total discounted benefits from income and savings on electricity bills.

The system pays for itself in 10 years.

	Discounted benefits	Cumulative benefits	Discounted costs	Cumulative costs	**Cashflow**
Year 1	1203	1203	0	10734	**-9532**
Year 2	1172	2375	0	10734	**-8360**
Year 3	1142	3517	0	10734	**-7218**
Year 4	1112	4629	0	10734	**-6105**
Year 5	1084	5713	0	10734	**-5022**
Year 6	1056	6769	0	10734	**-3966**
Year 7	1029	7798	0	10734	**-2937**
Year 8	1002	8800	0	10734	**-1934**
Year 9	977	9777	0	10734	**-958**
Year 10	952	10728	0	10734	**-6**
Year 11	927	11656	0	10734	**921**
Year 12	903	12559	0	10734	**1824**
Year 13	880	13439	0	10734	**2705**
Year 14	857	14296	0	10734	**3562**
Year 15	835	15132	0	10734	**4397**
Year 16	814	15946	0	10734	**5211**
Year 17	793	16739	0	10734	**6005**
Year 18	773	17512	0	10734	**6777**
Year 19	753	18264	0	10734	**7530**
Year 20	733	18998	0	10734	**8264**
Year 21	715	19713	0	10734	**8978**
Year 22	696	20409	0	10734	**9674**
Year 23	678	21087	0	10734	**10353**
Year 24	661	21748	0	10734	**11014**
Year 25	644	22392	0	10734	**11658**