Easy PV

Solar design made simple

Greg Young

Project Name: 24th January 2022

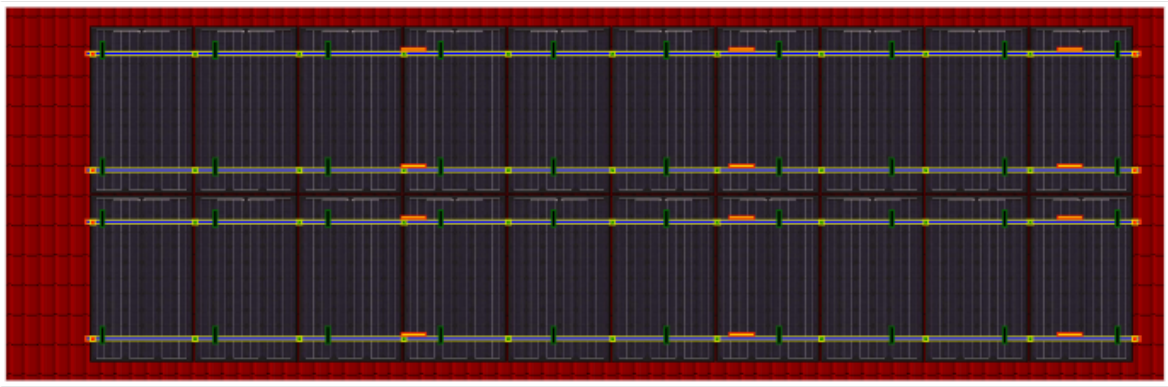
Address: 15 Stowmarket Road, Great Blakenham, IP6 0LJ

Date Created: 24th January 2022

Designer: Nigel Watson

Roof Layout

Outbuilding Roof



Component list

Item	Quantity
 Q Cells G9+ 345W All Black Mono solar panel	20
6 kW Hybrid Inverter inverter	1
 **NET** Emlite Bi-directional Meter ECA2.nv	1
 Label sheet	1
 AC isolator - KN Newbury 20A 4-pole	2
Plyon 2.4 kWh	3
 DC isolator - KG20-4	2
Pair of MC4 connectors	4
50m reel of 4mm2 solar cable	1
Renusol end clamp (black)	8
Renusol mid clamp (black)	36
Renusol end cap (black)	8
Renusol portrait concrete tile roof hook	40
Renusol rail splice	12
Renusol rail 3.3m black	0

Inverter checks

6 kW Hybrid Inverter

Panels			
PV power	**6900**	Rated AC output	**6000**

Input 1: 10 Q Cells G9+ 345W All Black Mono solar panels in 1 strings

Panels		Inverter	
PV power	**3450 W**		
Open circuit voltage at -10° C	**450 V**	Max DC voltage	**600 V**
V_{mpp} at 40° C	**330 V**	V_{mpp} lower limit	**90 V**
V_{mpp} at -10° C	**378 V**	V_{mpp} upper limit	**520 V**
I_{mpp} at 40° C	**10 A**	Max DC input current	**11 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: 10 Q Cells G9+ 345W All Black Mono solar panels in 1 strings

Panels		**Inverter**	
PV power	**3450 W**		
Open circuit voltage at -10° C	**450 V**	Max DC voltage	**600 V**
V_{mpp} at 40° C	**330 V**	V_{mpp} lower limit	**90 V**
V_{mpp} at -10° C	**378 V**	V_{mpp} upper limit	**520 V**
I_{mpp} at 40° C	**10 A**	Max DC input current	**11 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

6 kW Hybrid Inverter

AC Isolator

A AC isolator - KN Newbury 20A 4-pole has been specified for this input

Current

The rated isolator current (20A) is greater than the rated inverter current (18A)

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 **0.85 V (0.26 percent)**

Input 2

DC Isolator

Integrated isolator

This inverter contains an integrated DC Isolator.

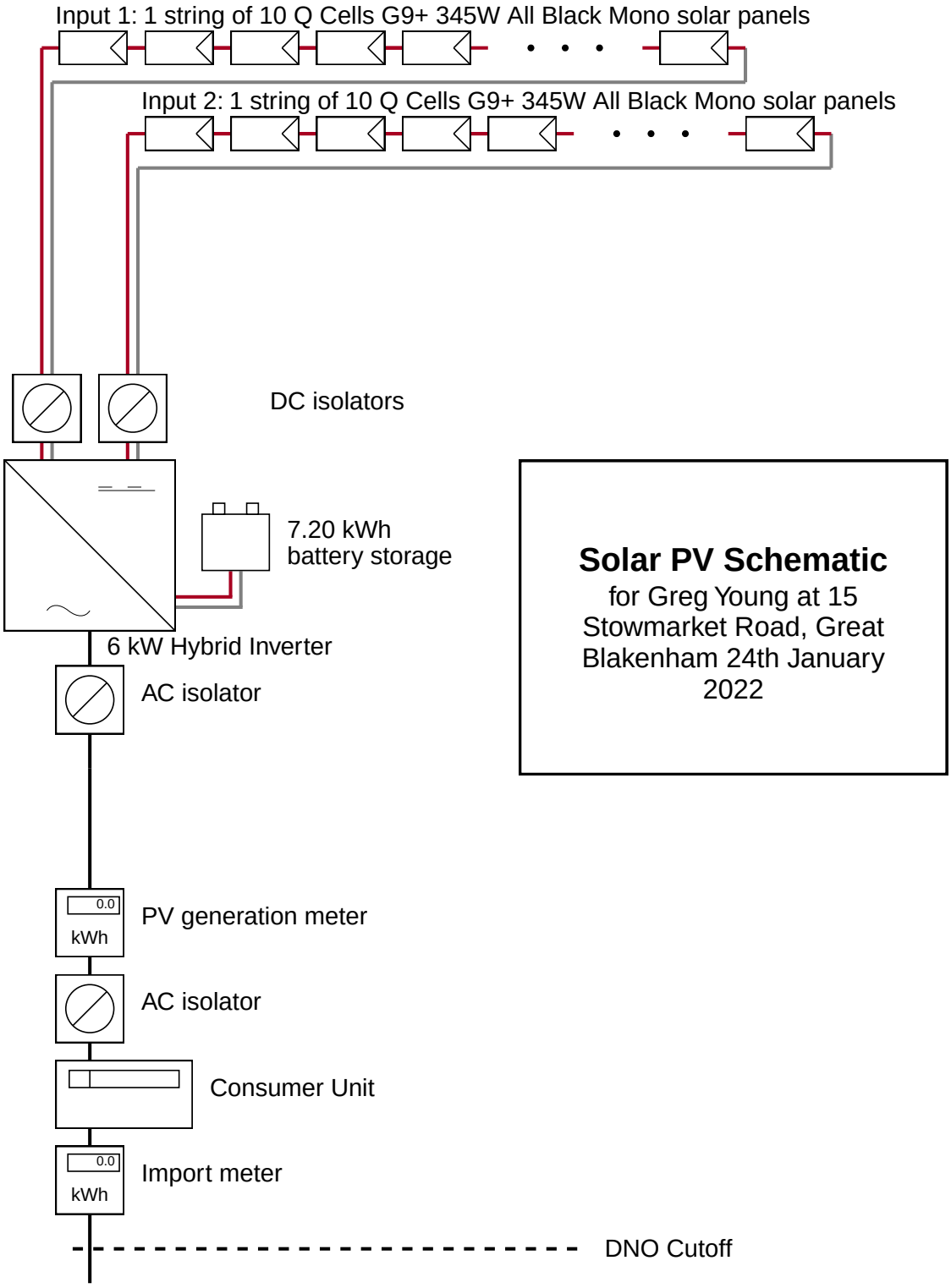
Cable

10m of 4mm2 solar cable has been specified

Voltage drop

Voltage drop at maximum power point at 40°C will be around **0.85 V (0.26 percent)**

Schematic diagram



Structural calculations

Weight loading calculations

Outbuilding Roof

Weight of solar panels and mounting	422.4 kg
Area of solar array	34.5 m^2
Loading imposed by solar array	0.12 kN/m^2
Dead load from roof covering	0.45 kN/m^2
Total dead load of solar array, mounting and roof covering	**0.57 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 **0.57kN/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:

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

Outbuilding Roof

Q_p	994 Pa
in	From Fig 34 in Guide to the Installation of Photovoltaic Systems for a building 10 m high, windzone 2, in urban terrain, at a distance of between 2km and 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}	34.46m^2

F	Roof Centre	Roof edge
Uplift	**-44534N**	**-75365N**
Pressure	**34257N**	**37683N**

With 40 roof hooks we should allow for an uplift force per hook in the central zone of **1113N**, rising to **1884N** at the edges. If 2 screws are used per roof hook, this equates to **557N**per fixing in the central zone, and **942N** 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 65 mm of thread in the timber. The pull-out force in C16 timber is given by tables and formulae in BS5268 Part 2:

$$14.41 \times 1.25 \times 65 = \mathbf{1171N}$$

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.

Performance Estimate

Site details

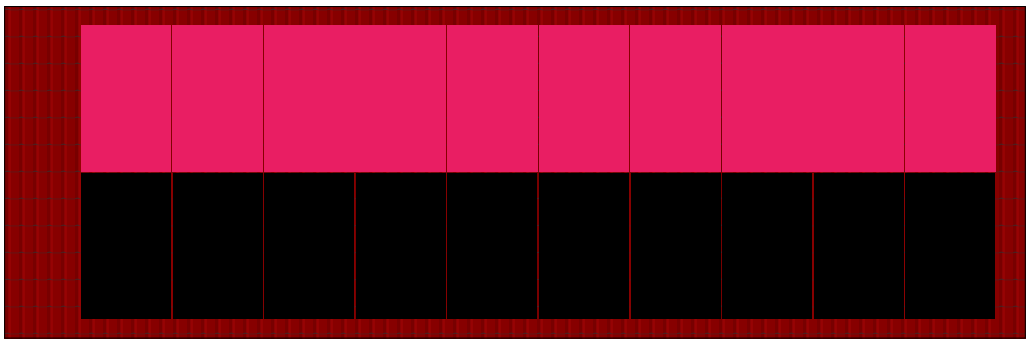
Client	Greg Young
Address	15 Stowmarket Road, Great Blakenham

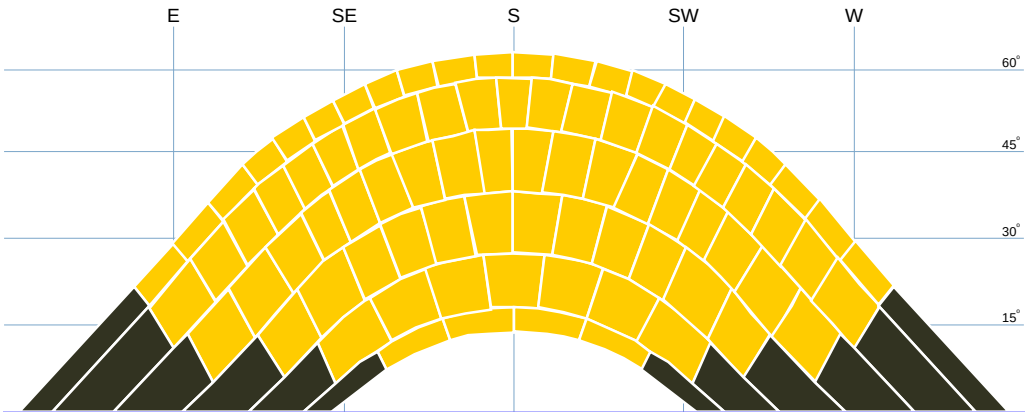
The sunpath diagram shows the arcs of the sky that the sun passes through at different times of the day and year as yellow blocks. The shaded area indicates the horizon as seen from the location of the solar array. Where objects on the horizon are within 10m of the array, an added semi-circle is drawn to represent the increased shading. Blocks of the sky that are shaded by objects on the horizon are coloured red, and a shading factor is calculated from the number of red blocks. The performance of the solar array is calculated by multiplying the size of the array (kWp) by the shading factor (sf) and a site correction factor (kk), taken from tables which take account of the geographical location, orientation and inclination of the array.

Inverter 1

6 kW Hybrid Inverter

Input 1

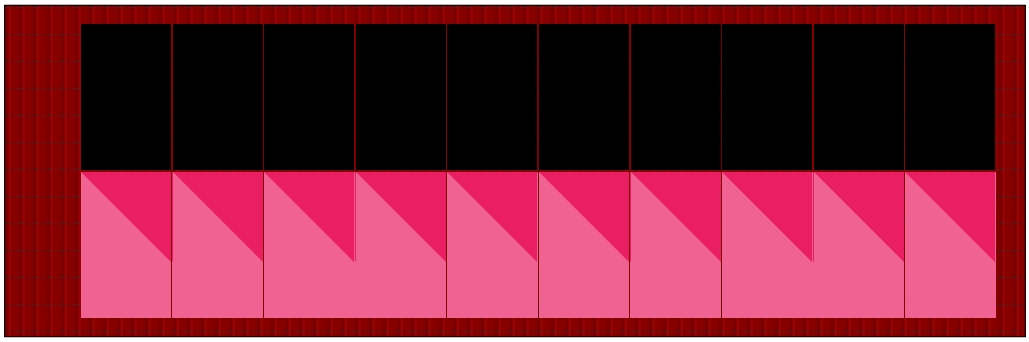


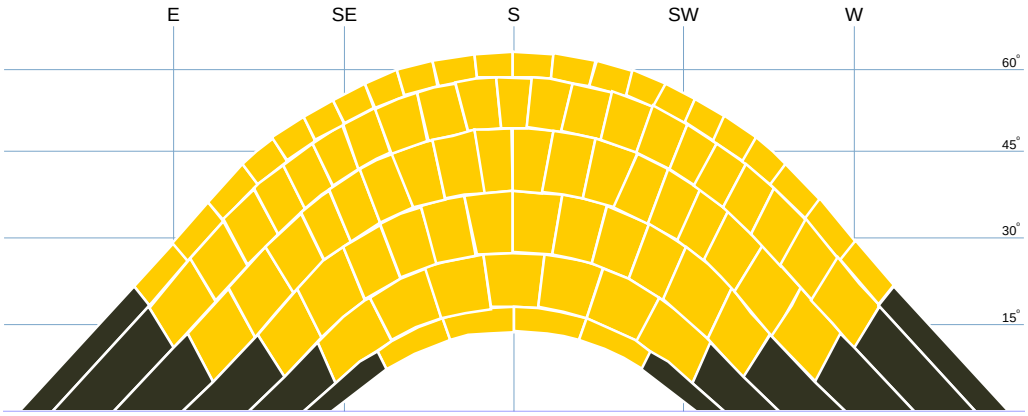


A. Installation data		
Installed capacity of PV system - kWp (stc)	**3.450**	kWp
Orientation of the PV system - degrees from South	**70**	°
Inclination of system - degrees from horizontal	**35**	°
Postcode region	**12**	

B. Performance calculations		
kWh/kWp (Kk)	**834**	kWh/kWp
Shade factor (SF)	**1.00**	
Estimated output (kWp x Kk x SF)	**2877**	kWh

Input 2





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kWh/kWp (Kk)	**834**	kWh/kWp
Shade factor (SF)	**1.00**	
Estimated output (kWp x Kk x SF)	**2877**	kWh

Performance Summary

A. Installation data		
Installed capacity of PV system - kWp (stc)	**6.9**	kWp
Orientation of the PV system - degrees from South	**See individual inputs**	
Inclination of system - degrees from horizontal	**See individual inputs**	
Postcode region	**12**	
B. Performance calculations		
kWh/kWp (Kk)	**See individual inputs**	
Shade factor (SF)	**See individual inputs**	
Estimated output (kWp x Kk x SF)	**5754**	kWh

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.

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

6 kW Hybrid Inverter with 3 Plyon 2.4 kWh batteries

Charge rate	**2400 W**
Inverter charge efficiency	**90.0 %**
Inverter discharge efficiency	**90.0 %**
Battery efficiency	**95.0 %**
Round trip efficiency	**77.0 %**
Battery bank capacity	**7.2 kWh**
Max discharge depth	**90 %**
Usable capacity	**6.48 kWh**

Consumption

Electricity consumed in the property each year

11500 kWh

Generation

Electricity generated by the PV array each year

5772 kWh

Self consumption

Proportion of PV generation used in the property

75 %

Independence

Proportion of electricity consumption provided by PV

36 %

Import / Export

Electricity import / export each year from the property

7376 / 1293 kWh

Utilisation

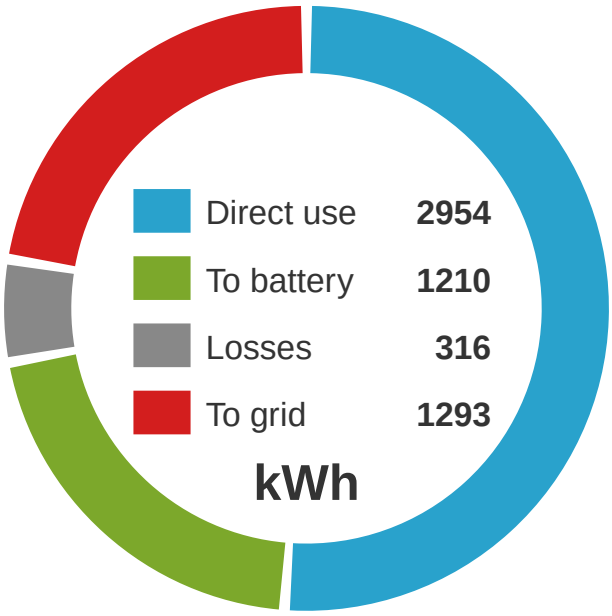
Average daily utilisation of the storage battery

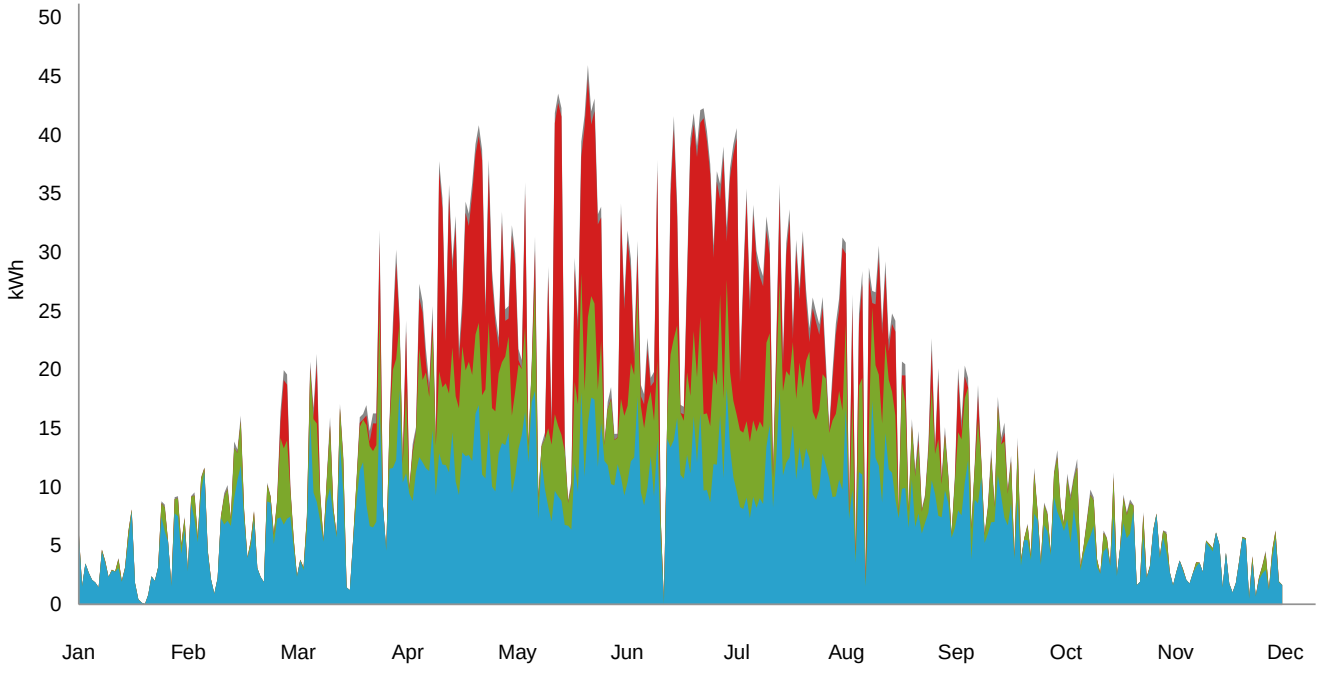
57 %

Yearly generation

The solar PV array is expected to generate 5772 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.

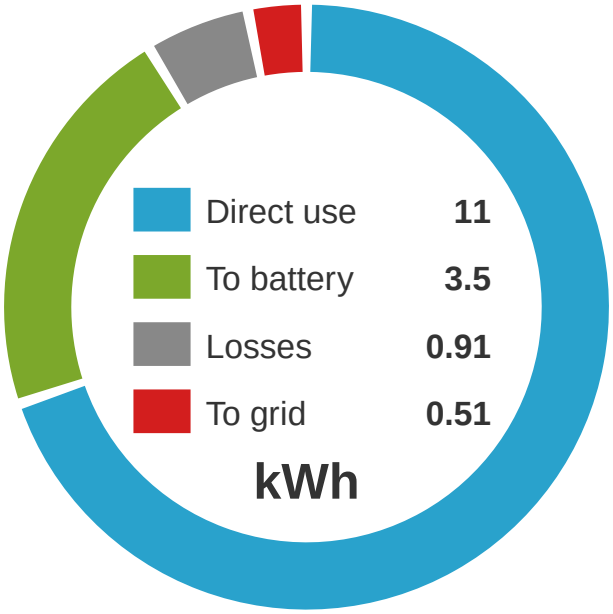
51% (2954 kWh) of the electricity generated is expected to be used directly in the property. 27% (1525 kWh) is directed to the battery for later use, although 316 kWh of this is lost during battery charging and discharging. The remaining generation (1293 kWh, or 22% of the total) is exported to the grid.

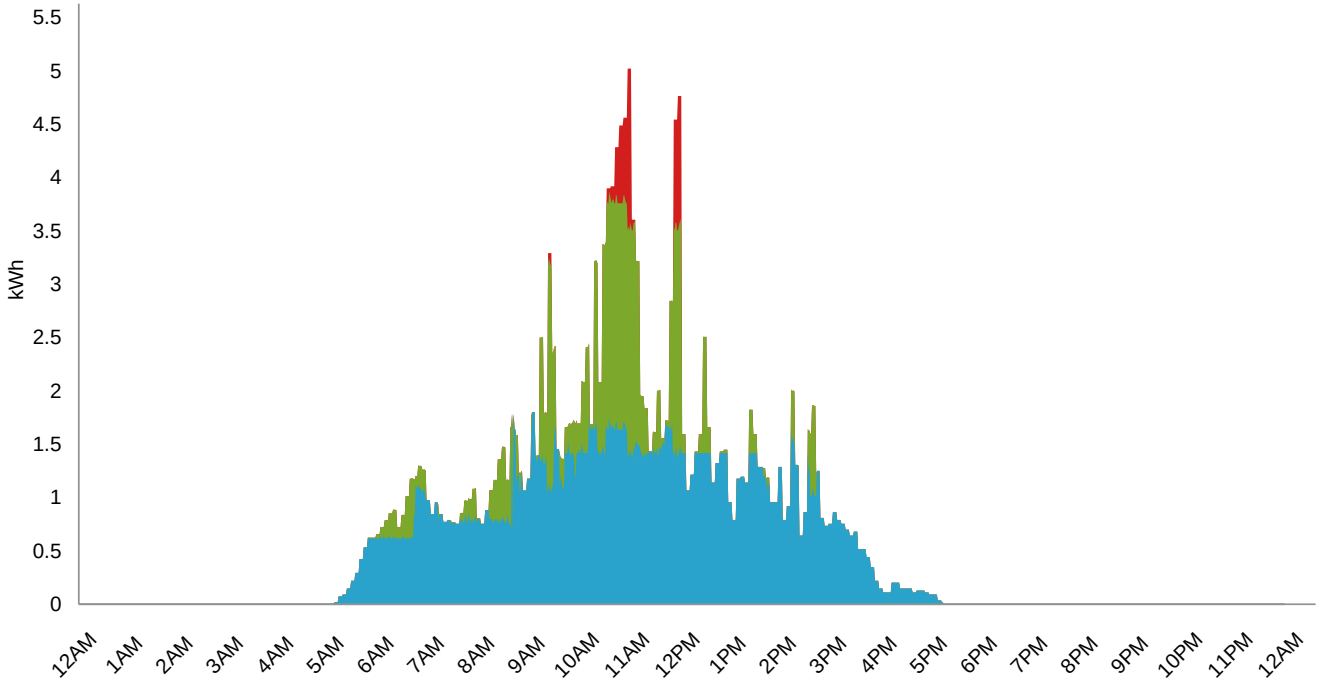




Daily generation

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 16.3 kWh. Of this, 11.4 kWh (70%) is used directly in the property, 4.4 kWh (27%) is stored in the battery for later re-use, and 0.5 kWh (3%) is exported to the grid.

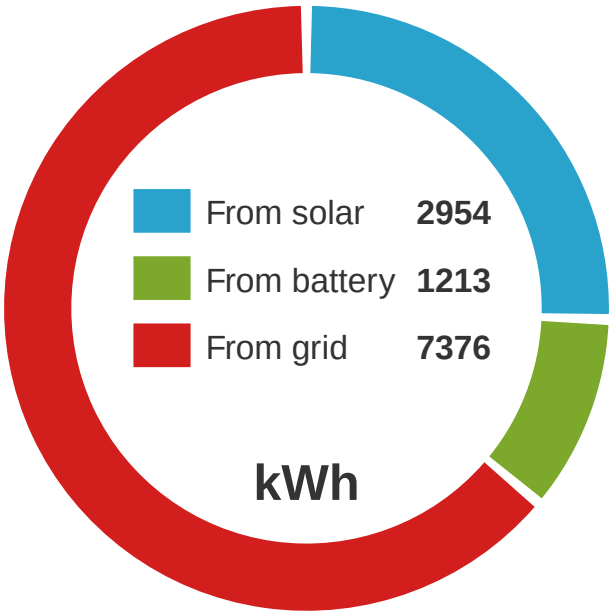


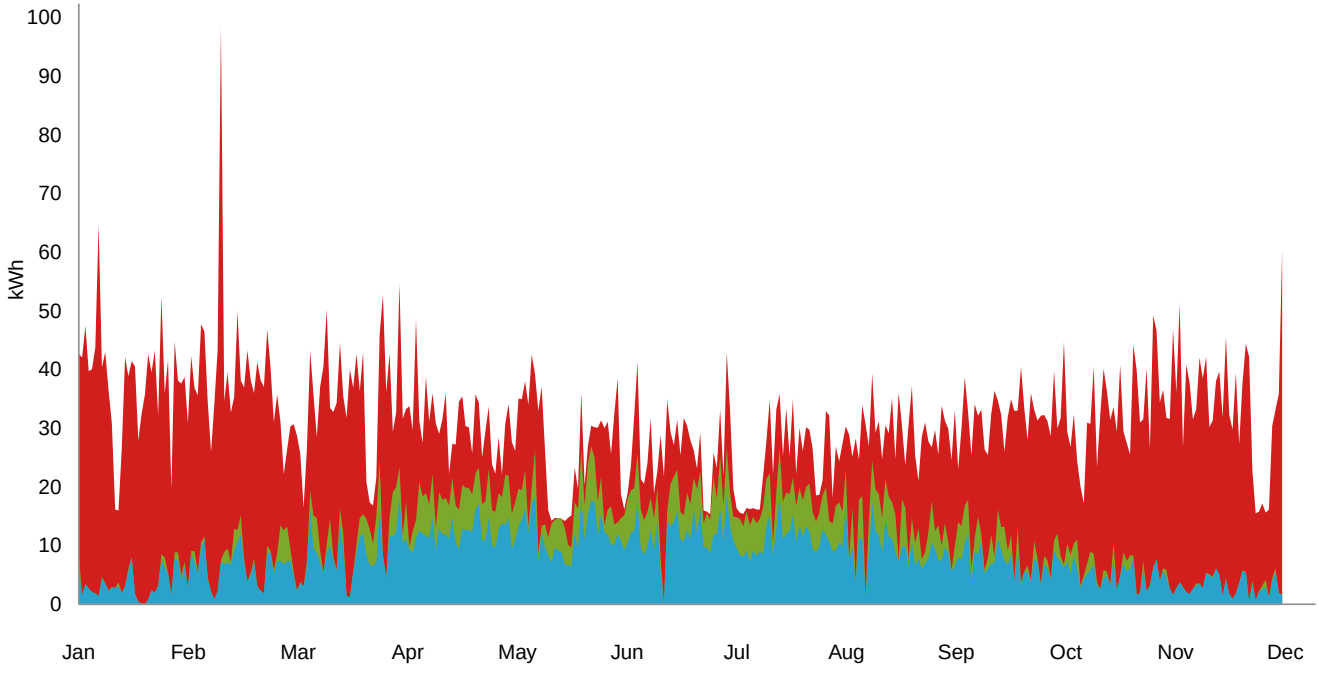


Yearly consumption

The property is expected to consume 11500kWh of electricity each year. Around 26% of this (2954 kWh) is expected to be supplied directly by the solar array. Another 11% (1213 kWh) is supplied from the storage battery. The remaining 64% (7376 kWh) is supplied from the grid.

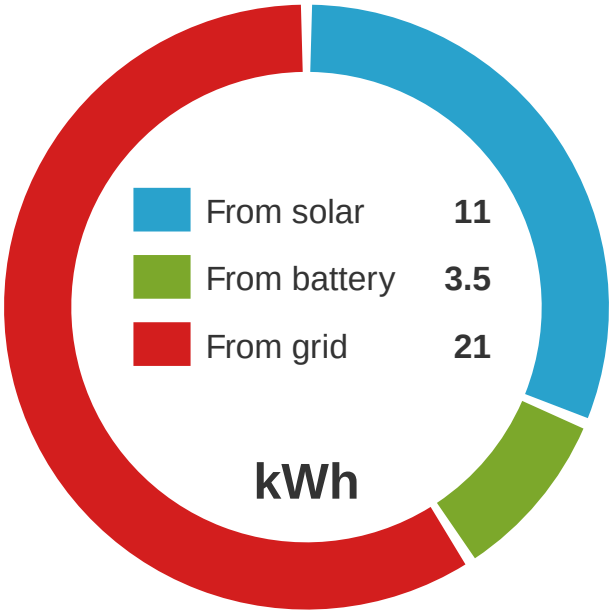
The total self-consumption is expected to be 37% (4167 kWh) with the battery storage system. Without battery storage it would be 26% (2954 kWh).

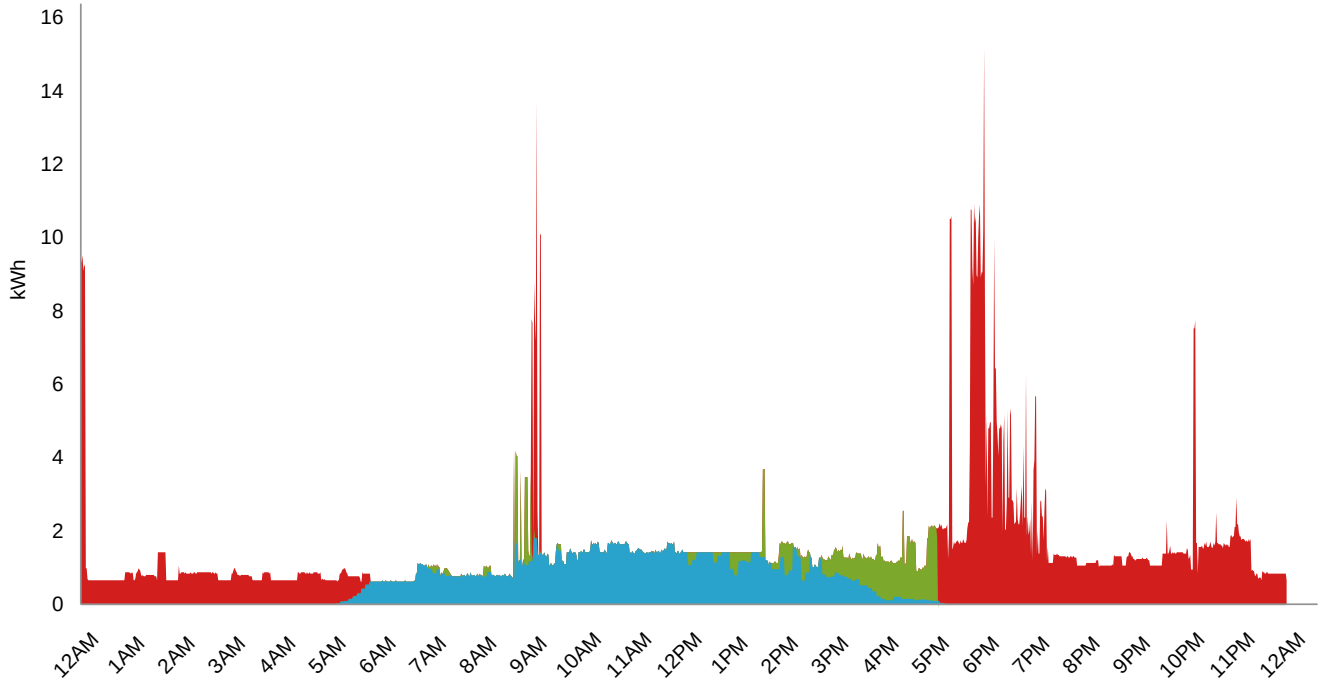




Daily consumption

This graph shows modelled consumption data over the course of the selected day (March 27th). Total electricity consumption on this day was 37.3 kWh, of which 11.4 kWh (31%) is expected to be supplied directly by the solar array, and a further 3.5 kWh (9%) drawn from the battery storage system. The remaining 21.5 kWh (58%) is imported from the grid.

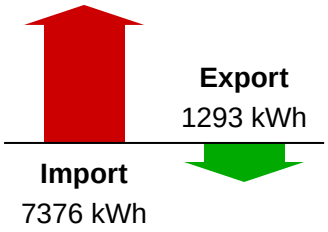


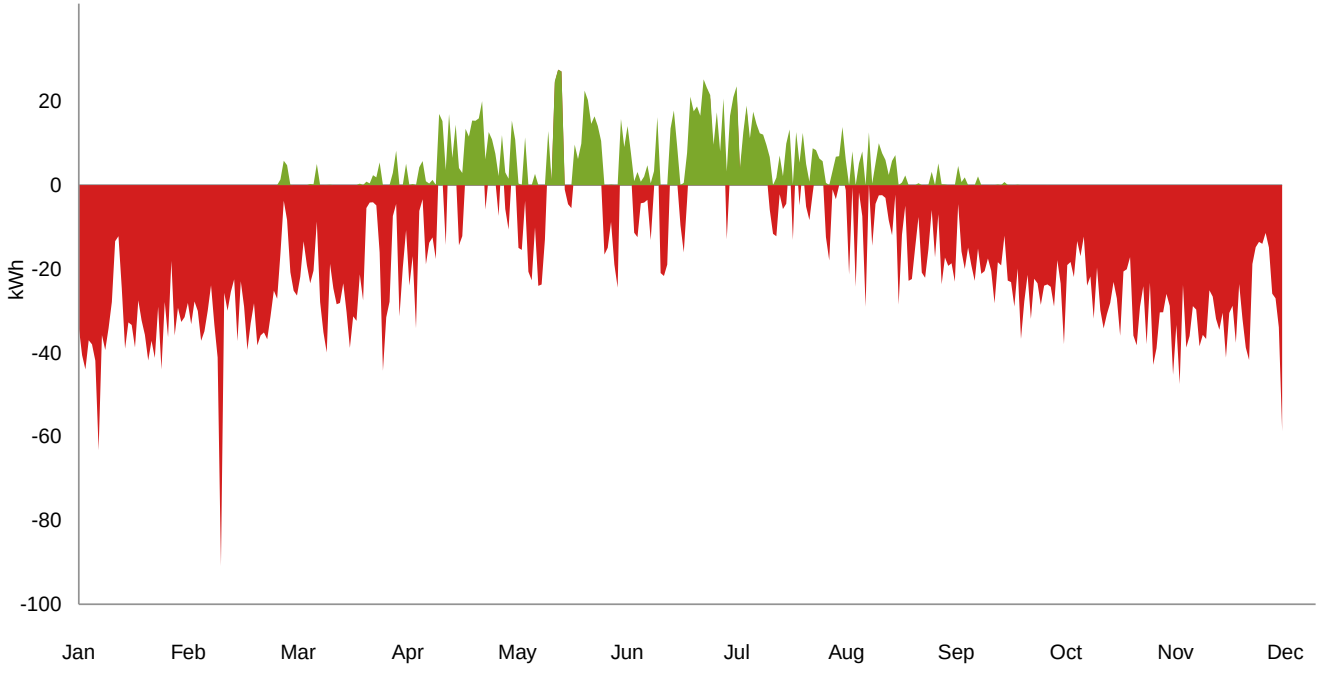


Yearly import and export

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.

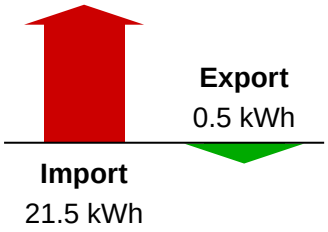
Over the course of the year, a total of 7376 kWh is expected to be imported by the property, and 1293 kWh exported back to the grid.

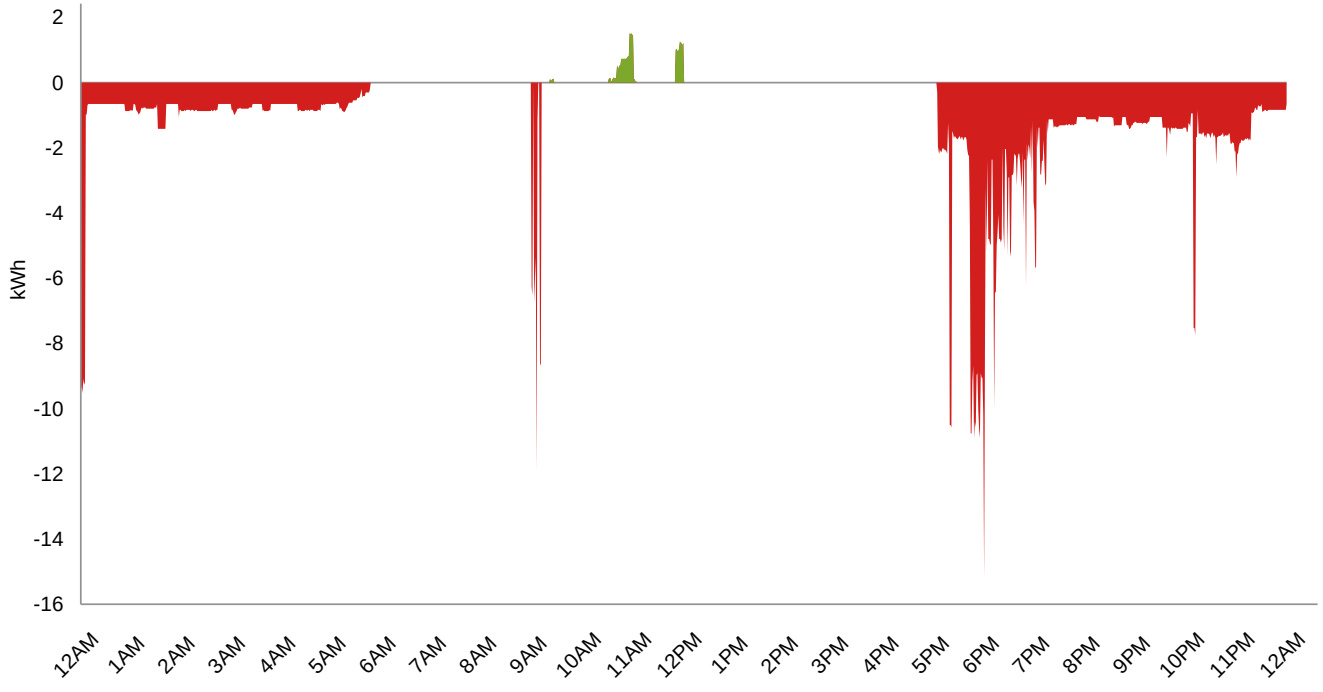




Daily import and export

This graph shows the modelled import and export of electricity over a selected day (March 27th). On this day 21.50 kWh is expected to be imported from the grid, and 0.5 kWh exported.At times when no import or export is shown the battery storage system is charging or discharging.





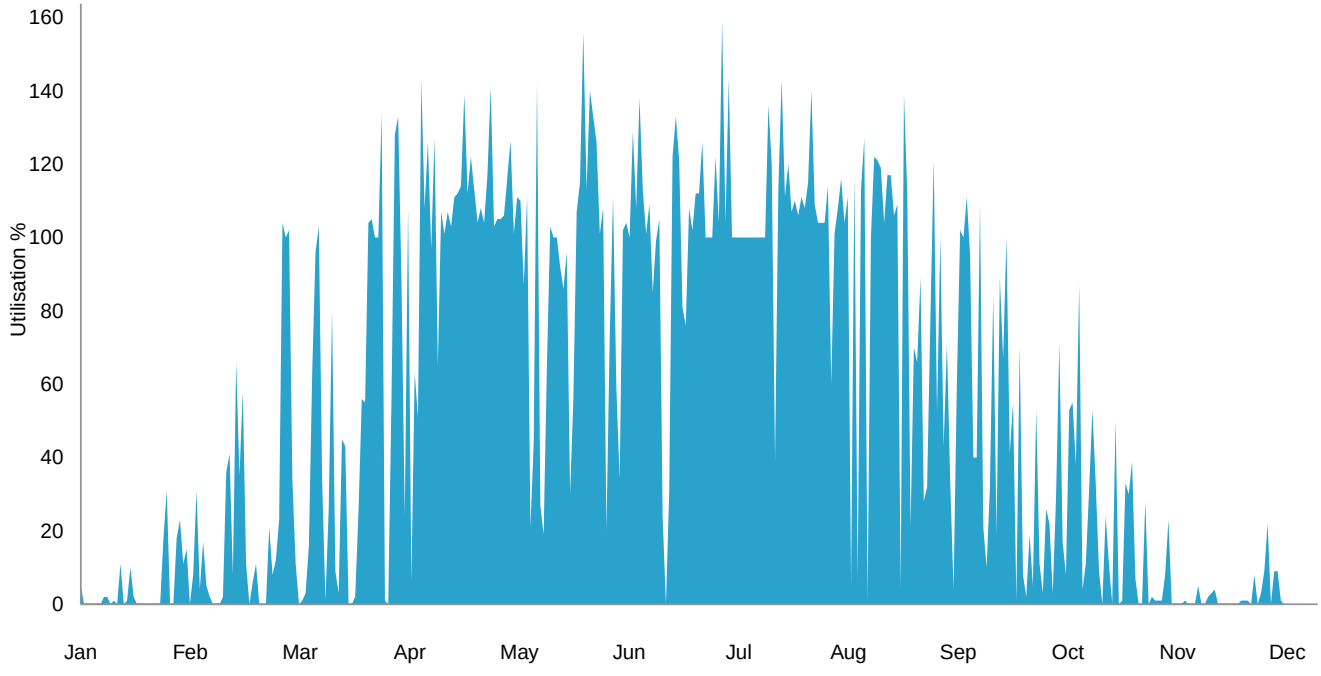
Yearly battery utilisation

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

57%



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, 60% of the battery capacity was utilised.

Average battery utilisation

60%