

Net Zero Carbon Statement for Wildwood

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1 Introduction and Background Information

1.1 SMD/2022/0230

A planning application was submitted on 03/05/2022 for an Eco House replacement dwelling at the site Wildwood, Farley Lane, Alton, Staffordshire Moorlands, ST10 4BZ. The dwelling has been designed using Passivhaus principles. Per paragraph 1.4 of the Planning Statement *“the applicant’s intention [is] to replace the existing property with a new eco-friendly dwelling that will deliver a high quality, sustainable form of development, adopting a “fabric first” approach, and aspiring to be net zero carbon”*. Subsequently, planning permission was granted via the Planning Applications Committee on 11/08/2022, subject to several conditions.

1.2 Condition 5

Extract from the Decision document of SMD/2022/0230 dated 12/08/2022

“Prior to the construction of the dwellinghouse hereby approved, details of the sustainable features to be included to make the building net zero and their precise siting and design, shall be submitted to and approved in writing with the Local Planning Authority. The submitted details shall include information as to how the combination of features will achieve a net zero dwellinghouse. The development shall be undertaken in accordance with the approved details and shall be retained for the lifetime of the development.

Reason:- To ensure the dwellinghouse achieves the sustainability credentials outlined within the Planning Statement and to comply with the Design Guide SPD.”

1.3 Defining ‘Net Zero’

There are multiple definitions of ‘Net Zero’, however for buildings the Government tends to lean towards expert sources such as RIBA, LETI and UKGBC. Based on these sources, in the Government Sustainability and Net Zero Design Guide, March 2022, ‘Net Zero’ is defined as:

“When the amount of carbon emissions associated with the building’s operational energy on an annual basis is zero or negative. A net zero carbon building is highly energy efficient and powered from on-site and/or off-site renewable energy sources, with any remaining carbon balance offset.”

Source <https://www.gov.uk>

1.4 Offsetting of Carbon

The Staffordshire Moorlands Climate Change Plan Part 2 defines Carbon Offsetting as:

“A carbon offset is a reduction in emissions of carbon dioxide or other greenhouse gases made to compensate for emissions made elsewhere. This includes things like land restoration or the planting of trees.”

Source <https://www.staffsmoorlands.gov.uk/article/6619/Climate-Change-Emergency-Declaration>

2 Technical Specification of the Dwelling

The house is designed using Passivhaus principles to ensure it offers the highest levels of thermal efficiency and air tightness, whilst making the most of south facing glazing to provide solar gains. The dwelling is also designed to have both low embodied carbon (in its build) and low operational carbon (in its use).

It uses the principle of designing with a “Fabric First” approach to ensure a highly energy-efficient building. This, combined with the meticulous execution of the build details and the use of high-quality components leads to a building with a high level of energy efficiency, which in turn means a low energy demand, that can be met primarily by using onsite renewable energy production. Batteries and a large hot water store will be used to even out supply and demand. The building’s orientation and windows are designed to provide good natural light and optimise winter solar gain/summer shading to prevent overheating - reducing the amount of energy required to heat/run the building. Large, shaded windows on South, East & West elevations with small windows on North elevation.

The following sections detail technologies used in the building.

2.1 Fabric of the Building

The main structure of the building will be an off-site manufactured, high performance insulated timber frame. This will be built in a controlled factory environment to the highest quality levels that are not achievable on site. By adopting a fabric first approach, the building will minimise heat losses and thus, reduce the energy required to maintain a comfortable living environment. To achieve this we will be using a design that is significantly in excess of what Building Regulations demand. The below table details U values for elements of Wildwood versus what Building Regulations limits are both at the point of when the application was submitted, and the subsequent update from June 2022 (the lower the U value, the better – less heat transfer). This shows the U values for Wildwood are significantly better than what is required by Building Regulations.

U Values W/m ² .K	Wildwood	Building Regs Fabric Maximum Limits	
Element	Submitted April 2022	Building Regs 2010 (2016 Amendment)*	Building Regs 2010 (June 2022 onwards)**
Roof	0.11	0.20	0.16
Wall	0.11	0.30	0.26
Floor	0.10	0.25	0.18
Windows	0.82	2.00	1.60
Doors (inc. Glazed)	0.89	2.00	1.60

Figure 1 - U Values comparison, source *, ** <https://www.gov.uk/government/publications/conservation-of-fuel-and-power-approved-document-1>

2.2 Heating and Hot water System

To provide hot water and heating a 14 kW Air Source Heat Pump (ASHP) will be utilised. To maximise the benefit of the ASHP this will be paired with an underfloor heating system (UFH) to distribute the heat load throughout the building. Domestic Hot Water (DHW) will also be provided for by the ASHP, this will be stored in a highly thermally insulated cylinder which will also be fitted with an immersion element which will use excess solar PV energy generated on site to directly heat water for the house. The ASHP will be located directly outside of the plant room on the north-east (road) side of the building to ensure it operates under minimal solar loading, and is positioned away from opening windows of living rooms and bedrooms to mitigate any potential noise concern.

2.3 Mechanical Ventilation & Heat Recovery (MVHR)

A Mechanical Ventilation & Heat Recovery System (MVHR) will be used in the house to provide complete ventilation and regular air changes. This ensures that high moisture content air and odours can be drawn out of the building and replaced by fresh air. By using a high efficiency heat exchanger, during winter up to 90% of the heat in the stale air being exhausted from the building can be recovered to heat the incoming cold, fresh filtered air. In summer the reverse process also provides cooling. This type of system provides significantly better and controlled ventilation than the typical use of trickle vents in windows and allows the filtration of air entering the house. The MVHR system will be located within the plant room of the house.

2.4 Solar PV Array and Battery Storage

To ensure the property can generate a significant portion of its energy from its own zero carbon energy source, a solar PV array will be installed on the out buildings located on site. This will be a 11.7kW_p array formed of 30x 390W solar PV panels combined with a 17.6kWh battery storage unit. The inclusion of a large battery energy store will allow energy generated during the day to be stored on site and used when the solar PV array is not generating (eg. at night). Any excess energy generated will be exported to the national grid. The location of the solar PV array is shown in the below figure as Ph 1, to be located on one of the agricultural out buildings on the roof facing South-west. A Distribution Network Operator (DNO) letter is in place to allow a solar PV array up to 25kW_p, thus allowing for a potential phase 2 expansion of the array in future.



Figure 2 - Location of Solar PV array at Wildwood

2.5 Power / Fuel Sources

The only grid connections to the house will be mains electric, mains water and telecoms. Despite being available – and currently offering a significantly lower cost solution – mains gas will not be connected to the dwelling. This ensures that it is possible to use zero carbon sources of energy only.

A blanked off supply pipe will be run to the house from the site services hub to provide a potential future connection to a green hydrogen supply if this is ever offered via the grid.

3 Energy and Carbon Performance

3.1 Heat Loss & Gains

The house is designed using Passivhaus principles, as such a universally recognized tool, PHPP, has been used to calculate heat losses and heat gains and thus determine annual heating requirements. An extract from the PHPP calculations for Wildwood is shown in Appendix Section 5.1.

3.1.1 Losses

Transmission heat loss, $Q_T = 11,509 \text{ kWh}$ per year

(heat loss through walls, roof, windows etc)

Ventilation heat loss, $Q_V = 2,563 \text{ kWh}$ per year

(heat loss through leakage and ventilation)

Total heat losses, $Q_L = Q_T + Q_V = 14,072 \text{ kWh}$ per year

3.1.2 Gains

Solar heat gains, $Q_S = 4,897 \text{ kWh}$ per year

(solar gain based on window position, shading and house orientation)

Internal heat gains, $Q_I = 4,101 \text{ kWh}$ per year

(heat generated from use of internal appliances, cooking, people residing in the house)

Utilisation factor for heat gains = 96%

Total heat gains, $Q_G = 96\% * (Q_S + Q_I) = 8,626 \text{ kWh}$ per year

3.2 Energy for Heat Requirements

Annual heating demand is heat losses minus heat gains – this is $Q_H = Q_L - Q_G = 5,446 \text{ kWh}$ per year

Air Source Heat Pumps (ASHP) work on a basis that they create more energy than they use – they are over 100% efficient. This efficiency factor is measured as the Seasonal Coefficient of Performance (SCOP). The SCOP in heating mode for the ASHP to be used at Wildwood is **3.86**, indicating on average throughout the year, for every 1kW of energy used, the ASHP generates 3.86kW of energy.

Therefore, the electricity required to meet the heat demand = $Q_H / SCOP = 1,411 \text{ kWh}$ per year

3.3 Energy for Domestic Hot Water (DHW) Requirements

The domestic hot water (DHW) requirement is determined based on occupancy of 6 persons, using 45 litres of hot water per day. This gives a hot water requirement of at least 270 litres per day. Based on this requirement, this energy for DHW (Q_{DHW}) is expected to be **7,336 kWh** per year. The ASHP will be used to provide the majority of the DHW. The SCOP in hot water mode for the ASHP is **3.23**.

Therefore, the electricity required to meet the DHW demand = $Q_{DHW} / SCOP = 2,271 \text{ kWh}$ per year.

Further calculations for the DHW are provided in the Appendix, Section 5.2.

3.4 Energy for General Electric Use Requirements

Ofgem provides information on the typical use of gas and electricity across the UK for domestic properties per the table below. Based on this it is a worst case assumption that the general electric use of the house will be **4,300 kWh** annually – this excludes heating and hot water. In reality, given this is a new build house that will utilise low energy products, this figure is likely to be significantly lower.

Energy Use	Example – home type and number of residents	Typical annual gas use (kWh)	Typical annual electricity use (kWh)
Low	Flat or 1-bedroom house; 1-2 people	8,000	1,800
Medium	2-3 bedroom house; 2-3 people	12,000	2,900
High	4+ bedroom home; 4-5 people	17,000	4,300

Figure 3 - UK Typical Energy use, source <https://www.ofgem.gov.uk/energy-advice-households/average-gas-and-electricity-use-explained>

3.5 Energy Generation

Utilising local climate and performance data from the supplier the 11.7 kW_p Solar PV array is expected to generate **10,028 kWh** annually per the simulation information in Appendix Section 5.3.

3.6 Energy Use Calculation

To calculate the Total Energy Required we require the sum of all the energy requirements, and the sum of the energy generated.

$$\text{Energy}_{\text{Total Required}} = \text{Energy}_{\text{requirements}} - \text{Energy}_{\text{generated}}$$

Where;

$$\text{Energy}_{\text{requirements}} = \text{Energy}_{\text{Heat}} + \text{Energy}_{\text{DHW}} + \text{Energy}_{\text{General}}$$

$$\text{Energy}_{\text{generated}} = \text{Energy}_{\text{Solar PV}}$$

If Total Energy Required is negative, then this indicates that the property generates more than it uses, and thus acts to top up the national grid.

If Total Energy Required is positive, then this indicates that the property uses more than it generates, and thus requires a top up from the national grid.

Based on the above, the figures and calculations for Wildwood are:

$$\text{Energy}_{\text{Heat}} = 1,411 \text{ kWh annually (Section 3.2),}$$

$$\text{Energy}_{\text{DHW}} = 2,271 \text{ kWh annually (Section 3.3),}$$

$$\text{Energy}_{\text{General}} = 4,300 \text{ kWh annually (Section 3.4),}$$

$$\text{Therefore, Energy}_{\text{requirements}} = 1,411 + 2,271 + 4,300 = \mathbf{7,982 \text{ kWh annually}}$$

Energy_{Solar PV} = 10,028 kWh annually (Section 3.5)

Therefore, Energy_{generated} = **10,028 kWh** annually

Based on the above, Energy_{Total Required} = 7,982 – 10,028 = **-2,046 kWh** annually

As Energy_{Total Required} is negative, it indicates the property generates more energy than it uses, therefore will net export energy to the national grid.

3.7 Annual Carbon Calculation

The composition of the UK electricity grid – the mix of fossil fuels and renewables – means that for **1 kWh** of electricity generated, **0.19338 kg of CO₂e** is emitted, per the table below. However, utilizing green energy suppliers, it is also possible to have energy provided from completely renewable sources which are zero carbon emissions.

Activity	Country	Unit	Year	Total kg CO ₂ e per unit	kg CO ₂ e of CO ₂ per unit	kg CO ₂ e of CH ₄ per unit	kg CO ₂ e of N ₂ O per unit
Electricity generated	Electricity: UK	kWh	2022	0.19338	0.19121	0.0008	0.00137

Figure 4 - UK grid carbon emissions per kWh, source <https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022>

Based upon the make-up of the UK national grid and as the annual Total Energy Requirement (**-2,046 kWh**) for the property is negative - meaning more energy is exported to the grid than is used - this means that, there will be a net reduction of **395.7 kg of CO₂e** annually in the UK due to the addition of Wildwood.

This compares with the UK average equivalent detached house which based on the energy usage in Figure 3, would generate the following amount of carbon emissions annually:

17,000 kWh Gas @ 0.18 kg.CO₂e/kWh (Figure 10 Natural Gas gross value) = 3,060 kg.CO₂e due to gas usage

4,300 kWh Electricity @ 0.19338 kg.CO₂e/kWh (Figure 4) = 832 kg.CO₂e due to electric usage

Total carbon emissions for a typical UK detached house = **3,892 kg.CO₂e**

Based on the above figures, the house development at Wildwood will offer a carbon saving of over **4.2 tonnes of CO₂e** annually compared to a typical UK house.

(Calculation; 3892-(-396) = 4288 kg.CO₂e = 4.288 tonnes CO₂e)

3.8 Required Carbon Offset

Where required, carbon offsetting is possible in multiple ways, including the planting of trees to act as a carbon sink or the buying of carbon credits through an approved scheme.

Given the calculations in the above sections, there will be a net export of 2,046 kWh of electricity to the grid, therefore carbon offsetting is not required to attain net zero status. However, through the planting of trees across the Wildwood site, additional carbon savings will be made. Figures for carbon savings per tree vary from source to source, and the age / species of the tree, but generally a range of 10-40 kg.CO₂e annually is agreed upon (Source <https://ecotree.green/en/how-much-co2-does-a-tree-absorb>). To date the planting of over 200 trees at Wildwood offsets at least **2,000 kg.CO₂e** annually. Further planting of trees and hedgerows is planned at Wildwood which will only increase the carbon saving. This further bolsters the net zero credentials of Wildwood, whilst also providing biodiversity gains.

4 Conclusion

Based on the above information and calculations as determined by the technical specification of the replacement dwelling, there is evidence to show that the dwelling will achieve 'net zero' through a combination of minimising its energy use, on site energy generation, and carbon offsetting through the planting of trees across the site. Where electricity is required from the grid supply, it will be sourced from a zero-carbon energy supplier. Before carbon offsetting is considered, Wildwood will provide a carbon saving of **395.7 kg of CO₂e** annually. This is a saving of over **4.2 tonnes of CO₂e** per year compared to a typical UK detached house.

Therefore, the definition of 'Net Zero' as outlined in Section 1.3 is met, so condition 5 of SMD/2022/0230 is satisfied.

5 Appendix

5.1 PHPP Heat Requirements

Specific energy for heating (annual method)									
Wildwood / Climate: Sutton Bonnington / TFA: 329 m² / Heating: 15.9 kWh/(m²a) / Freq. overheating: 11% / PER: 23.3 kWh/(m²a)									
Interior temperature:								20.0	°C
Building type:								Residential	
Treated floor area A _{TFA} :								328.8	m²
Building assembly	Temperature zone	Area m²	U-Value W/(m²K)	Temp. factor f _s	G _i kWh/a			kWh/a	Per m² of treated floor area
External wall - Ambient	A	343.3	0.111	1.00	72.3	=		2760	8.39
External wall - Ground	B			0.65		=			
Roof/Ceiling - Ambient	A	271.6	0.097	1.00	72.3	=		1900	5.78
Floor slab / Basement ceiling	B	208.8	0.111	0.65	72.3	=		1086	3.30
	A			1.00		=			
	X			0.75		=			
Windows	A	91.7	0.816	1.00	72.3	=		5414	16.46
Exterior door	A	5.4	0.890	1.00	72.3	=		349	1.06
Exterior TB (length/m)	A			1.00		=			0.00
Perimeter TB (length/m)	P			0.65		=			0.00
Ground TB (length/m)	B			0.65		=			0.00
Total of all building envelope areas		920.8							kWh/(m²a)
Transmission heat losses Q _T								Total	11509
									35.0
Ventilation system:									
Effective heat recovery efficiency		Effective air volume, V _v		A _{TFA}		Clear room height			
Efficiency of subsoil heat exchanger		η _{eff}		m²		m		m³	
Heat recovery efficiency of SHX		η _{SHX}		328.8		2.50		822.1	
		0%							
Energetically effective air changes nV		n _{V,system}		η _{HR}		n _{V,SHX}		1/h	
		0.309		(1 - 0.71)		0.042		0.131	
		V _v		n _v		c _{air}		G _i	
		m³		1/h		W/(m²K)		kWh/a	
Ventilation heat losses Q _V		822.1		0.131		0.33		2563	
				Q _T		Q _V		Reduction factor	
				kWh/a		kWh/a		night/weekend	
Total heat losses Q _L		(11509 + 2563)				1.0		Saving	
								kWh/a	
								kWh/(m²a)	
								14072	
								42.8	

Figure 5 - Wildwood PHPP Heat Losses

Orientation of the area	Reduction factor See 'Windows' sheet	g-Value (perp. radiation)	Area	Radiation HP			
			m²	kWh/(m²a)		kWh/a	
North	0.34	* 0.54	* 18.72	* 116	=	400	
East	0.35	* 0.54	* 12.99	* 293	=	710	
South	0.40	* 0.54	* 49.99	* 330	=	3587	
West	0.26	* 0.54	* 9.99	* 142	=	201	
Horizontal	0.00	* 0.00	* 0.00	* 318	=	0	
Available solar heat gains Q _S						Total	4897
							14.9
		Length heating period	Spec. power q _i	A _{TFA}			
		h/d	c/a	W/m²		kWh/a	kWh/(m²a)
Internal heat gains Q _I		0.024	* 216	* 2.40	* 328.8	= 4101	12.5

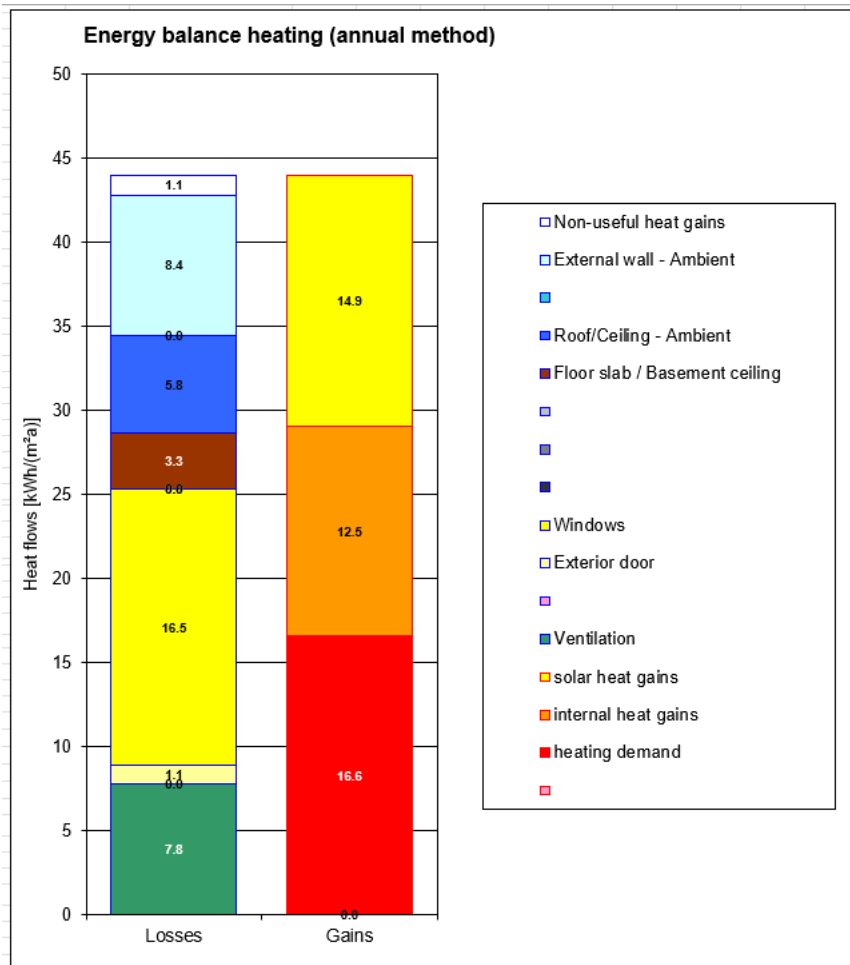


Figure 7 - Wildwood PHPP Heat Loss / Gains Energy Balance

5.2 Domestic Hot Water Requirements

Domestic Hot Water Calculations (DHW)

The information below is an estimation of your hot water requirements and the associated hot water tank required.

DHW Design Calculations	
Project Reference: Wildwood Project	
System Details	
Hot Water Temperature Required (°C)	50
Heat losses associated with hot water storage (°C)	5
Incoming water temperature (°C)	10
Pipework Efficiency from HP to Cylinder (%)	75
Legionella purge	Yes
Legionella purge frequency	Weekly
Legionella purge hours (per day or per week)	1
Legionella total purge hours	52
Legionella purge demand (Annual) (kWh/yr)	0
Legionella purge demand (Daily) (kWh/yr)	0
Total annual demand (kWh/yr)	7336
Heat supplied by primary heat source (kWh/yr)	7336
Heat supplied by auxiliary heat source (kWh/yr)	0
Heat supplied by immersion heater (kWh/yr)	0
Primary & Auxiliary Heat Source Details	
Output Capacity of Primary Heat Source (kW)	14
Flow temp while providing hot water (°C)	55
Efficiency of Auxiliary Heat Sources (%)	0
kW Capacity (kW)	0
DHW Cylinder Details	
Make	Stiebel Eltron
Model	588 300
EN8558 DHW capacity calculation (litr)	270
DHW chosen cylinder capacity (litr)	300
Electric immersion heater size (If required)	0
DHW Cylinder Recovery Rate (mins)	67

Figure 8 - Domestic Hot Water calculations, source Total NRG quotation

5.3 Solar PV Simulation

Simulation Results

Results Total System

PV System

PV Generator Output	11.70 kWp
Spec. Annual Yield	861.42 kWh/kWp
Performance Ratio (PR)	89.06 %
Grid Feed-in	10,091 kWh/Year
Grid Feed-in in the first year (incl. module degradation)	10,028 kWh/Year
Standby Consumption (Inverter)	12 kWh/Year
CO ₂ Emissions avoided	4,737 kg / year

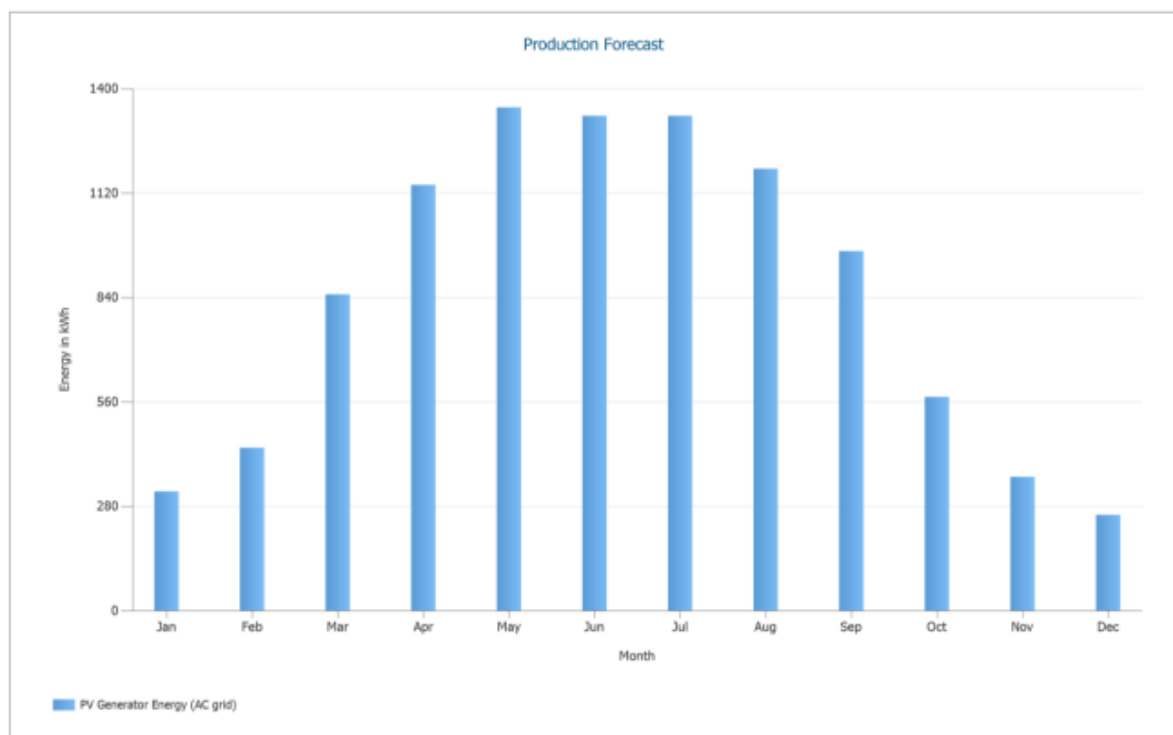


Figure 9 - Energy forecast for Solar PV array, source Solar Star

5.4 UK Fuel Carbon Emissions

Activity	Fuel	Unit	Total kg CO ₂ e per unit	kg CO ₂ e of CO ₂ per unit	kg CO ₂ e of CH ₄ per unit	kg CO ₂ e of N ₂ O per unit
Gaseous fuels	Butane	tonnes	3033.32	3029.26	2.25	1.80
		litres	1.75	1.74	0.00	0.00
		kWh (Net CV)	0.24	0.24	0.00	0.00
		kWh (Gross CV)	0.22	0.22	0.00	0.00
	CNG	tonnes	2539.25	2534.47	3.44	1.34
		litres	0.44	0.44353	0.00060	0.00023
		kWh (Net CV)	0.20	0.20188	0.00028	0.00011
		kWh (Gross CV)	0.18	0.18219	0.00025	0.00010
	LNG	tonnes	2559.17	2554.39	3.44	1.34
		litres	1.16	1.15583	0.00156	0.00061
		kWh (Net CV)	0.20	0.20347	0.00028	0.00011
		kWh (Gross CV)	0.18	0.18362	0.00025	0.00010
	LPG	tonnes	2939.29	2935.18	2.28	1.83
		litres	1.56	1.55491	0.00121	0.00097
		kWh (Net CV)	0.23	0.22999	0.00018	0.00014
		kWh (Gross CV)	0.21	0.21419	0.00017	0.00013
	Natural gas	tonnes	2539.25	2534.47	3.44	1.34
		cubic metres	2.02	2.01193	0.00274	0.00107
		kWh (Net CV)	0.20	0.20188	0.00028	0.00011
		kWh (Gross CV)	0.18	0.18219	0.00025	0.00010
	Natural gas (100% mineral blend)	tonnes	2559.17	2554.39	3.44	1.34
		cubic metres	2.03	2.02774	0.00274	0.00107
		kWh (Net CV)	0.20	0.20347	0.00028	0.00011
		kWh (Gross CV)	0.18	0.18362	0.00025	0.00010
	Other petroleum gas	tonnes	2578.25	2575.70	1.17	1.39
		litres	0.94	0.94348	0.00043	0.00051
		kWh (Net CV)	0.20	0.19897	0.00009	0.00011
		kWh (Gross CV)	0.18	0.18305	0.00008	0.00010
	Propane	tonnes	2997.55	2993.40000	2.31000	1.85000
		litres	1.54	1.54140	0.00119	0.00095
		kWh (Net CV)	0.23	0.23225	0.00018	0.00014
		kWh (Gross CV)	0.21	0.21381	0.00016	0.00013

Figure 10 - UK fuel carbon emissions per kWh, source <https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2022>