Photovoltaic Panels and Planning in the UK

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Abstract

Photovoltaic panels rights in planning are not clearly defined in the UK. There are also no accepted criteria to assess how much is considered an acceptable reduction of solar radiation being enjoyed previously. This has even resulted in legal challenges of planning decisions. Conversely, increased global awareness to the need to reduce carbon emissions, volatile energy prices and shortage of supply, have increased the appetite for the installation of PV panels to generate renewable energy locally. This paper presents a case study of a new development in a terrace house and assesses the impact on an existing PV panel installation on a neighbouring building. Three different methods are discussed and a further detailed method of assessment that better quantifies the impact loss of the PV panels is proposed. Its rationale could lead to more informed decisions made to new developments submitted for planning.

Keywords: Photovoltaic panels, loss of performance, impact of new development

1. Introduction

The awareness of climate emergency and the need to reduce fossil fuel energy has led to an increase in use of photovoltaic panels to generate clean energy. This strategy is even more relevant in the current global energy crisis reinforcing the importance of local generation of renewable electricity. The installation of PV panels is well regulated and under certain conditions can benefit from permitted development and be exempted from planning permission. However, the impact of a new development on an existing PV is not prescribed, either expressly or by implication, in the Planning Acts or any other relevant legislation. But this type of problem can be considered a material planning consideration in the determination of applications. This paper attempts to address this problem and reviews a case study where a new extension may have an impact on a existing PV panel installation. A dwelling has Photovoltaic (PV) panels installed on its roof (referred as pv_roof) and a neighbouring dwelling (referred as new_roof) has put forward a planning application to raise its roof level. There is a concern that the extension of new_roof may potentially reduce the solar admission to the PVs and create a significant loss to the generation of renewable electricity and associated carbon emissions reductions. This paper aims to provide further insights on the case so that a more informed decision can be made on the planning application for the new_roof.

Local authorities have the duty to analyse objections raised against a planning application and decide on its merits and prevent or grant permission to the development. One aspect that has been raised in favour of protecting the solar admission to pv_roof is based on the importance of climate change and the role PV panels can have to reduce carbon emissions. Various national, governmental, local policies, programmes and incentives promoting green systems, reiterate the importance of green electricity to mitigate climate change, to reduce carbon emissions and improve associated co-benefits, e.g. local energy generation, resilience to increasing energy bills.

This was also acknowledged in a Judicial Review case McLennan v Medway Council case (McLennan, 2019) that overturned the planning permission for an extension which would have blocked a neighbour's solar panels. One basis was that the electricity generated by solar PV panels was helping to mitigate climate change.

It is also acknowledged that the 'loss of the impact of development on solar panels is a material planning consideration' and may not only affect the owner of pv_roof but may, in a small way, contribute to mitigating climate change and that the promotion of renewable energy sources is in the interest of the public as a whole.

So, it is important to have regard to the claim, even if later it may be considered not to have material consideration

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or merit. It may be relevant to weigh the impact of the loss for an informed decision to be made on the planning application.

On the other hand, local authorities are under increasing pressure to provide more social housing. It is also worth considering an increasing demand for new build in London boroughs. However, central boroughs have a limited availability of land and a relatively dense urban morphology. Increasing the buildings' height can be seen as a possible option to the housing crisis.

Each case is a case, but the decision on the new proposal for a new_roof may not deny merits to the loss of the energy generated by the neighbouring pw_roof. Equally, there is a degree of pragmatism about how constructions will have an impact on the environment. So, it is important to better assess the case study and quantify the predicted loss by the pv_roof as well as the context and opportunity of the area to expand accommodation.

2. Impact on the energy generation

Three assessments/supporting documentation in association with this case all seem to identify the potential loss on the capacity to receive solar radiation and therefore generate green energy. It is important to weigh the impact of the loss for an informed decision to be made on the planning application.

All assessments vary significantly in methodology and impact. An assessment made by the original installer for the pv_roof claims that the new proposal will reduce by 60% the electricity generated by the pv panels but does not provide a clear methodology that justifies this claim. It is an educated guess based on a review of the original installation calculations.

The promoter of the new_roof has hired a consultant, which estimates a loss of 16% during the whole year and 54% during the winter period. It also claims a reduction of around 15% (i.e. the solar panels enjoy 96% of the sunlight before the development and 81% after the development). It then concludes that the proposed development will have a low impact and sufficiently safeguards the sunlight amenity of the neighbouring building.

Another consultant commissioned by the council suggests that the PV panels simulated individually receive between 1028 and 1140kWh/m^2 solar radiation per annum. On average, this existing scenario has a 10% reduction against an ideal unobstructed scenario with panels having the same tilt and orientation (e.g. unobstructed solar irradiance of 1210 kWh/m^2). With the proposed extension new_roof the solar radiation on the PV panels is indicated that would drop to between 830 and 1012 kWh/m^2. This is considered a loss between 11 and 21% against its current value. The average of the proposed scenario would reduce to around 25% the unobstructed scenario and 16% against its current value. An assumption is made that if some incremental solar radiation reflected from surrounding surfaces is to be added, the overall reduction (existing versus proposed) is considered to average 13%.

3. Methodology

The initial three approaches differ in their methodology, and it is therefore reasonable to assess their reasoning. A new approach further attempts to come up with further insights to a more informed decision. Its rationale is also presented here.

The pv_roof installer's claim presents no calculation to how the loss is derived. However, it is worth considering that he is an accredited installer with many years of experience. So, with eventual knowhow to provide 'an educated guess'.

The consultants acting on behalf of the new_roof proposer has based their approach in estimating the Annual Probable Sunlight Hours (APSH), (Littlefair, 2001). APSH is a fairly simplified model that considers only sunlight. It is the long-term average of the total number of hours during the year in which direct sunlight reaches the unobstructed ground. A geometrical plot of 100 dots in a sky hemisphere is proportional to the probability of the sun shining from a particular area of the sky. It only assumes the sunlight contribution and its loss expressed as a percentage. No consideration is given to the angle of incidence on the PV panel nor its intensity reduction. No contribution is taken from the diffuse sky (skylight) nor any reflected contributions from nearby surfaces of influence. The variability of the diurnal daylight hours for different days of the year is also not accounted for.

For sunlight planning studies, the APSH criteria developed assumes that the loss of sunlight should be lower than

5% in winter and 25% for the whole year, or less than 0.80 times its former winter or annual value, respectively. Also that the reduction in sunlight received over the whole year is lower than 4% of annual probable sunlight hours. A recent update of the most used publication in planning for daylight and sunlight: the Building Research Establishment, BRE, Site layout planning for daylight and sunlight: A guide to good practice (Littlefair et al, 2022) suggests that where the annual probable sunlight hours received by a solar panel with the new development in place is less than 0.90 times the value before, a more detailed calculation of the loss of solar radiation should be undertaken.

It is also worth highlighting that the using the APSH criteria for solar availability on pv studies should not distinguish the winter season but consider the whole year, as PVs are expected to take advantage of most of the solar radiation available. The plots for the APSH were originally developed for vertical windows oriented south (Littlefair and Aizlewood, 1999), but can be accepted for other tilts and orientation for basic initial assessments. Lastly, it is relevant to consider that the variation of the daylight hours for different seasons (nearly 8 hours at the winter solstice versus 17 hours at the summer solstice) is not taken in consideration in this simplified assessment.

The third assessment adopts a method based on simulations using the BRE average sky. Representative sun positions at different times of the day and days of the year (1300 measures) are thoroughly assessed. Simulations also account for the diffuse sky distribution to estimate the total solar radiation reaching the two scenarios (and its loss). The sky model defined has been thoroughly validated for daylight studies, both with theoretical and real measurements collected originally in Berlin and at BRE Watford (Littlefair, 1994). This method is a significant improvement to the previous APSH method as it more accurately considers both solar geometry (i.e. position of the sun and angle of incidence) and the sky distribution (e.g. diffuse radiation) contributing towards solar irradiance. The proposed daylight modelling adopted does not consider the reflected sunlight/daylight contribution. For this case, a 3% (reduction in the loss) is put forward. The separate modelling of the eight modules in the PV array is considered important to assess the solar distribution over the various panels. But no information is given about the geometry considered nor the actual software used is presented.

The fourth proposed model attempts to estimate the annual solar radiation on the PV panels for the existing and proposed scenario based on annual simulations, with 4 time steps (i.e. every 15 min) undertaken with the weather file for Gatwick from the Energy plus software (Energyplus, 2022). This is a Test Reference Year (TRY) weather file based on statistical measurements for the location for a representative period of usually 15 years. These types of files are widely used and accepted for dynamic daylight and thermal modelling.

The model of the existing buildings with and without the proposed roof extension were modelled in Rhino. The geometry was modelled based on drawings submitted with associated planning applications. Daylight analyses were made with the widely validated RADIANCE v5.4a (Radiance, 2022) software via grasshopper, honeybee and ladybug tools v1.1.0 interface (Ladybug, 2021). IEA/SHC Task 63 (2022) has recently publish a report on existing tools for solar neighbourhood planning. The fourth method and tools indicated above align with this report and the tools adopted are widely validated. The report also highlights the lack of agreed metrics, a concerted approach on various countries or even regions in the definition of key performance indicators, KPIs, for planning with solar energy. Littlefair et al (2022) have put forward an advisory recommended minimum ratio based on the tilt of the PV (see Table 1)

Table 1 Recommended minimum ratios of solar radiation received (Littlefair et al, 2022)

Slope of solar panel in degrees to horizontal	Recommended minimum ratio of radiation received after/before
0-30	0.90
30.01-59.99	0.85
60-90	0.80

The fourth model was simplified to only include elements that may have an impact on collecting solar radiation. These include chimneys, parapets and ridges on top of the roofs. Other elements of the building at a level below the roof line, where the PV panels are located, do not contribute to the solar radiation reaching the panels, were therefore not modelled. This will significantly reduce the simulation time without reducing the accuracy of the results. The PV panels were modelled individually, and each include a grid of 96 sensors, that can highlight the spatial variances as seen in Figures 4 and 5. Other methods only considered the centre point of the panels.

However, for this initial assessment the annual cumulative results were averaged for each panel and later results averaged across the 8 panels.

All external surfaces with exception of the PV panels, were modelled as Lambertian perfect diffusers with an average reflectance of 20%. This estimation may even overestimate the real situation, as materials used on roof, walls and parapets, are dark and old and may have a lower reflectance. Nevertheless, it is relevant to assess the eventual contribution of reflected sunlight.

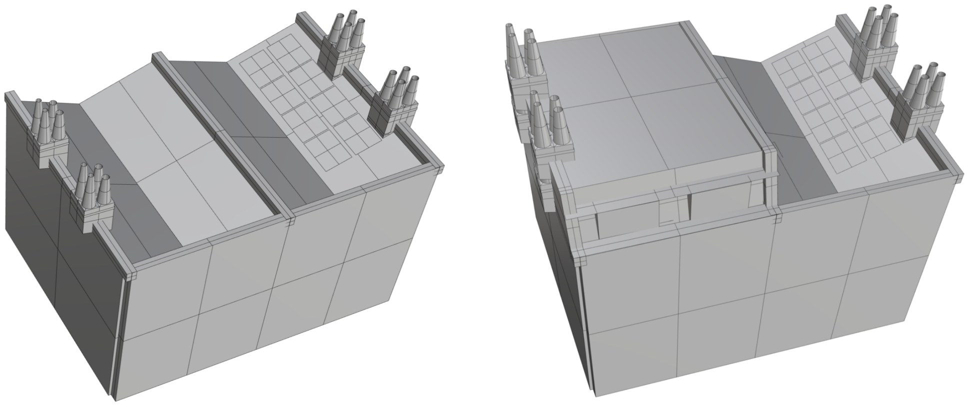

Figure 1. Volumetric scheme of buildings pv_roof without (left) and with the new_roof extension.

A desktop analysis of the urban site, based on google maps (2022), bing maps (2022) as well as views from vu-city (2022) were considered reliable to assess the volumetry and buildings surfaces that may act as reflectors or obstructions to the solar radiation reaching the panels.

Both figures 2 and 3 highlight that the neighbourhood has a low density with predominantly terrace houses. The landscape does not have significant tall volumes that may affect solar radiation reaching the PV panels. It is also relevant to highlight for planning purposes that several other terrace houses in the street and surrounding areas have already been raised by one floor. From the street view they seem acceptable.

Figure 2 : VuCITY view of the neighbourhood.

Figure 3: Street view.

4. PV panels technology

Solar photovoltaics (PVs) convert solar energy into electricity using a semiconductor material such as silicon. When solar radiation hits the semiconductor, the energy in the solar radiation is absorbed, ‘exciting’ the electrons in the semiconductor so that they break free from their atoms. This allows the electrons to flow through the semiconductor material producing electricity. There are different types of PV panels with different efficiencies but the ones installed at pv_roof are monocristaline and are by catalogue expected to have an efficiency of around 15%. This is an ideal ‘theoretical’ scenario estimated under laboratory-controlled measurements. In real life situations there are several environmental and man-made variables that may affect the overall performance of the PV panels. (Sick and Erge, 2013; Boyd and Coonick, 2015)

Maximum solar radiation is received by surfaces that are perpendicular to the solar rays. As such the orientation and tilt of the panel should therefore be adapted to the latitude of the place and position of the panel. Solar PV panels are best mounted on an inclined plane within the quadrant of the south orientation (northern hemisphere). Further orientations and tilts are still possible but with a reduced total irradiance (Littlefair et al, 2020). However, for structural aspects, to reduce problems with wind load issues as well as to promote a good visual integration, it is common to install PV panels coupled to the roof surface even if the orientation and tilt are not optimal for energy production (Holden and Robinson, 2014; Boyd 2015).

PV panels strongly rely on direct solar radiation from the sun but may also capture to a lower order of magnitude solar radiation from the sky dome. Cloud cover and shadowing can significantly reduce the amount of solar radiation and therefore the generation of electricity. Likewise, both sunlight and daylight may be reflected from obstructions and still contribute to the overall irradiance on the PV panels. The reflected contribution will strongly be affected by the reflectance of the surfaces, their specularity and roughness, the distance to the panels and the way the two surface elements ‘see each other’ and exchange radiation.

Sunlight availability is not that abundant in the UK (in comparison with some other locations), therefore reducing the overall performance of PVs. High capital investment needed to install PV technologies, can result in long payback periods. To promote its wide installation, there have been some government incentives in the past, namely the ‘Feed in tariff’ (FIT). This incentive included a payment for generation in addition to an export fee. However, FITs had become less of an encouragement to install PV panels and more of an incitement to profit from excessive subsidies. Following a significant reduction in the cost of the PV panels, there was a reduction in both the incentive and the regular payment to generate renewable electricity.

The performance of the PV system can also be significantly affected by dust, leaves, snow or any element that covers the PV cell. Also, in a PV system, each panel has an individual maximum power point. Differences between panels introduce power losses and can lead to underperformance of the entire system over time (Pillai et al, 2022).

With traditional inverters, the weakest module reduces the performance of all modules. Newer smart systems with module-level power electronics (MLPE), e.g. microinverters and integrated power optimizer, each module produces the maximum energy, and power losses are eliminated (DOE, 2015; US DE 2015).

According to details submitted by the installer, the PV panels measure 895mm x 1320mm which results in a total area of 9.45m^2. The FIT assumed at the time of installation is 5 pence per kWh exported to the grid. No indication of the generation fee is provided. Table 1 identifies the layout of the PV panels for the results presented.

Table 1. Layout of the PV panels

A	B	C	D
E	F	G	H

5. Results and discussion

Table 2. Comparison of results from the different approaches

	INSTALLER (1st method)	PROPOSAL CONSULTANT (2nd method)			INDEPENDENT CONSULTANCY (3nd method)			NEW APPROACH (4nd method)		
	LOSS	YEAR (WINTER) EXISTING %	YEAR (WINTER) PROPOSED %	LOSS %	EXISTING kWh/m^2	PROPOSED kWh/m^2	LOSS %	EXISTING kWh/m^2	PROPOSED kWh/m^2	LOSS %
Unobstructed	1350	100%			1210			1161		
A					1140	1012	11.2	1109	1023	7.8
B					1111	955	14.0	1089	971	10.9
C					1120	950	15.2	1086	950	12.6
D					1091	927	15.0	1072	935	12.9
E					1099	941	14.4	1059	946	10.7
F					1073	879	18.1	1031	877	14.9
G					1056	850	19.5	1015	839	17.3
H					1028	830	19.3	988	811	17.9
AVERAGE	**60**	**96 (28)**	**81 (13)**	**16 (54)**	**1090**	**918**	**15.8**	**1056**	**919**	**13.1**

Results between the different methods vary significantly. Different calculations and limitations not included in the modelling have been presented previously.

These methods also generate different amounts of global solar radiation. The installer considered a global radiation 1350 kWh/m^2 (not clear if at the panel or horizontal), which is considered above 10 and 14% the global contribution at the PV panels from the BRE average sky (adopted by the third method), and the London Gatwick

E+ sky distributions (4th method), respectively.

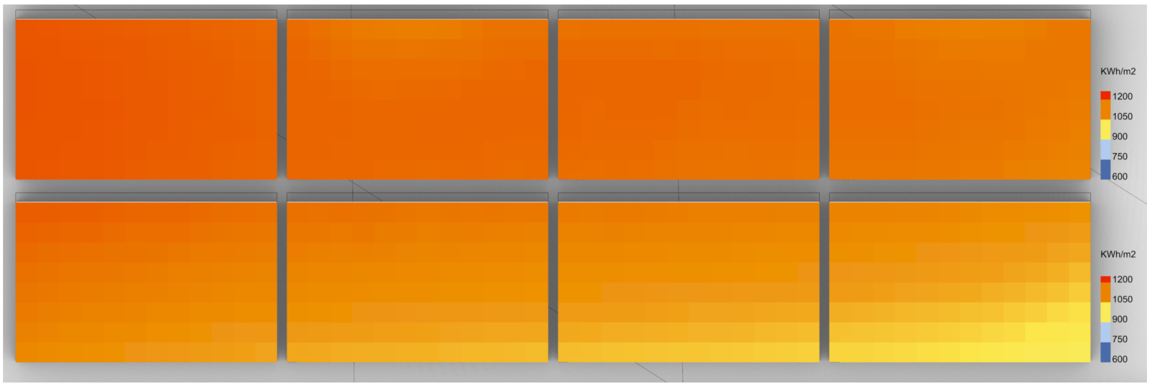

Figure 4: Total solar irradiance on PV panels at the existing scenario

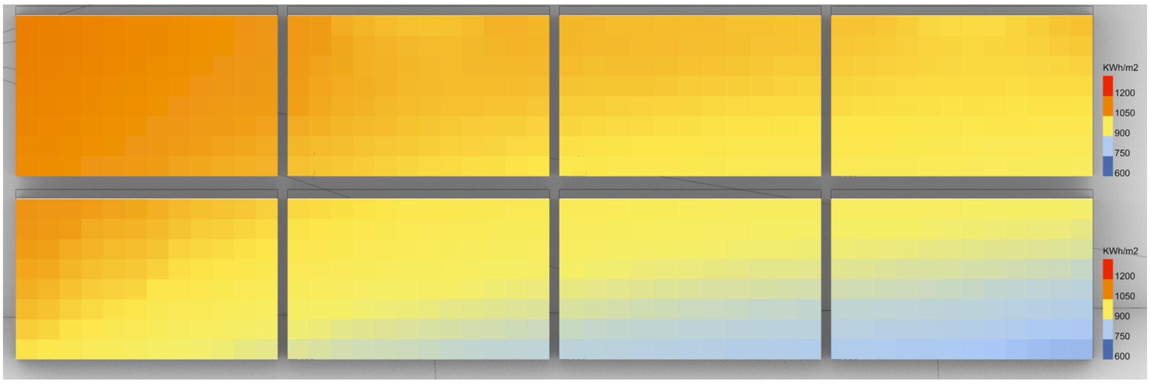

Figure 5: Total solar irradiance on PV panels at the proposed scenario

Table 3. Difference between unobstructed and average values for the different models

	3rd Method	4th method	DIFFERENCE
Unobstructed	1210	1161	4.0
Average EXISTING	1090	1056	3.1
Average PROPOSAL	918	919	-0.1

Both third and fourth results seem realistic and in a similar order of magnitude. The former third gives a higher unobstructed radiation but the loss between the existing and the proposed scenario is higher (as well as for the unobstructed) than the fourth model.

The third model did not account for the solar energy reflected by the surrounding walls, parapets and roof. It is however difficult to clearly identify further variables of influence, namely the accuracy of the modelled geometry of the proposed extension and the chimneys.

Further analyses undertaken for the fourth model with and without the contribution of reflected sunlight/skylight showed that the gain in the former model averaged less than 2%. It is worth mentioning that there are no significant obstructions on the southern side and the ground does not have an impact on the PVs. This is consistent with the educated estimation by the third consultant.

Panel H of the fourth proposed model has the lowest annual solar radiation incident, as 811 kWh/m^2. While this is an estimated reduction of 18% it is still considered an acceptable amount to produce a reasonable amount of green energy. A PV array with 1 peak power (kWp) and considering the 20% losses of the system would still generate 649 kWh of electricity per annum, above the minimum 600 kWh threshold suggested (IEA/SHC Task 63, 2022). The third worse case would for the same PV power capacity, generate slightly more electricity, estimated as 664 kWh/yr.

Figures 4 and 5 show the variation of solar radiation reaching the different panels with and without the proposed extension. The existing scenario (Figure 4) shows a more even distribution of solar radiation across all panels A-

H. It is noticeable the maximum reduction of 121 kWh/m^2 between panel A (top left) and panel H (bottom right), likely a result of the influence of the facade parapet casting a shadow on to the nearest panels. But overall all panels seem to receive a fair amount of solar radiation. For the proposed scenario the reduction between panels A and H of 212 kWh/m^2 is more significant. This would be a result of the cumulative influence of the proposed extension at the new_roof. For the lowest row E to H the reduction for the existing scenario amounts to 71 and for the proposed 135 kWh/m^2. In case of old PV panels installations it can be argued that the lowest PV panel is likely to restrict the conversion of solar radiation captured by others located in a less obstructed position.

6. Limitations

Both third and fourth models modelled the amount of solar radiation reaching the 8 individual panels. One limitation of this approach is not accounting for a loss of performance of the whole array if one PV panel is in the shadow. New developments of smart technology and improved invertors may minimize this problem. But for the panels in the study, installed in 2005, it should be assumed that if a panel in either top or lower row is obstructed and receives a reduced amount of solar radiation, then the 3 others in the row will not generate electricity above this threshold.

So, an initial estimation based on the table above should look only at the lowest solar radiation received between panels A to D and E to H or simply assume the panel that is performing worst. For the fourth model that would indicate the total solar radiation would be reduced from 988 to 811 kWh/m^2. And a loss of 18% would be reported.

This assumption should be taken with caution and the performance may be further reduced as it does not consider for the annual cumulative values estimated for each PV panel the synchronous reduction that could occur at each time step of the simulation that could affect the total output of the PVs connected in series. This study may be pursued at a later stage to estimate this loss more accurately.

7. Criteria of assessment

Rights of light are considered an easement, i.e., a right acquired by one party over another one's land. In the UK (RICS, 2016). 'Rights of Light' legally protects individuals in their access to daylighting against threats from new constructions or extensions to existing neighbouring constructions. The prescriptive right takes effect if it has been enjoyed for 20 years without interruption of a year or more, unless the right has been waived by express agreement. However, unlike rights of light that may be subject to legal remedy, access and retention of the right to solar energy does not explicitly exist in the UK law. Only recently Littlefair et al (2022) have put forward a maximum reduction considered acceptable for PV panels. However, there is no clear explanation for the criteria and how to assess how much is considered an acceptable reduction of solar radiation being enjoyed previously.

This study aimed to propose more insights to the definition of KPIs. Can we define some assessment and criteria that seem reasonable? Is an absolute value beyond which the reduction is not deemed acceptable, a valid approach? or is it a percentage of reduction versus the previous value? What could be a reasonable reduction?

Ideally a reduction of green energy generation should be minimised as much as possible. There are clear immediate benefits to generate free, clean and renewable energy. Reducing carbon emissions and mitigation of climate change, minimise the potential demand from the grid, especially at peak times, promoting resilience to the impacts of shortage of supply or be less vulnerable to the market rise of energy prices. Last but not the least, if the owner has invested in the PV infrastructure at some point in the past there is an expectation in a return of the investment. A positive return of investment may also be of more importance at later periods of life, especially when salaries/pensions may be reduced and result in an inability to pay the energy bills. PV panels providing free energy can be very important to avoid fuel poverty.

As indicated previously the price of installing a PV array has dropped significantly in the past years. But so has the payment for exporting the electricity. The Smart Export Guarantee (SEG, 2021) is the Government's successor to the FIT scheme. SEG came into force in January 2020. It applies to businesses and homes that generate solar power and other renewables on a small scale. Unlike the FIT that considered a generation and export fee there is only an agreement to pay for export electricity. The Smart Export Guarantee scheme allows companies to decide their own rates, as long as it's more than zero. Market value currently indicates between 1.5-11p/kWh (OFGEM, 2021). However, for the purpose of this estimation the price of this assessment is calculated as 5.3p/kWh of electricity exported to the grid based on the Standard Assessment Procedure, SAP10.2 (SAP 2022). Whilst the small payment for exporting energy from the SEG is claimed to allow a return on investments at a reasonable rate, installations will remain for most an environmental rather than a financial decision. However, the recent energy crisis and the increase of energy price is changing the perception that PV panels can be a cost effective way to generate electricity against purchase form the grid.

So, responding to the question what is a recommended threshold for PVs? In a crude approach we can assume that a reduction that goes beyond a cost per kiloWatt peak (kWp) that no longer allows a reasonable positive investment is considered to have a significant negative impact. PV panels have a life time expectancy of 25 years (that excludes consideration of maintenance and replacement of other parts, namely inverters or batteries). So, a simple payback (not considering any changing value of money over time) should not go above 15 years.

Equally important is to estimate the degree of what is lost. This is important to estimate the net loss or decreased profit. It may also serve as an indication for the estimation of a possible compensation payment and a carbon offset payment to minimize the carbon emissions that would have been saved for a certain period of time.

8. Loss in FIT and reduction in carbon emissions

For this PV scheme, an area of 9.5m^2 and an efficiency estimated as 15%, results in a peak capacity of 1.425 kWp. This is considered a very small installation and therefore may be more susceptible to a higher price than an economy of scale. An estimation of a cost around £2000 for a full installation without battery is hopefully not too far from the current market. For the purpose of the following calculations a system loss that would account for cable, PCU, inverter, metering and interface losses, typically 20%, has been made.

Table 4. Simple payback analysis for the fourth model for the existing and proposed scenario

FOURTH MODEL					
		EXISTING		PROPOSED	
		Min	Average	Min	Average
Solar irradiance (kWh/m^2)		988	1056	811	919
Power rating of PV array (kWp)	1.425				
Installation cost of PV system (£)	2000				
PV generation (kWh/yr) 0.8 system losses		1126	1204	925	1048
PV export tariff (£/kWh) (SAP10.2)	0.0559				
Electricity standard tariff (£/kWh) (SAP10.2)	0.1649 (it should be noted that this cost has increased significantly in the recent months with the removal of the Energy cap and the energy crisis. But for the purpose of this assessment the price indicated at SAP is still retained)				
Annual income from PV export tariff (£)		63	67	52	59
Annual savings if all electricity is consumed (£)		186	199	153	173
Estimated PV system payback time (Years)	export	**32**	**30**	**38**	**34**
	consumed	**11**	**10**	**13**	**12**

Table 4 suggests that neither the existing nor the proposed scenario make sense from an economical point of view under the new SEG scheme to export energy generated. This is considering an export tariff of 5.59 p/kWh (no generation tariff has been included). Payback times are above 30 years. However, if we take into consideration the savings in terms of purchasing electricity at a nominal value of 35.796 p/kWh (as per indication of the unit rate of a current standard tariff from 1st Oct 2022, supplied by a mains energy company) then the PV system could have a return of investment around after 5 years. The extension of new_roof would increase the payback time by

1 years compared to the existing scenario pv_roof. No interest rates are assumed in these models.

Taking the previous scenario of the minimum and average PV solar capture, the estimated loss in FIT can be found. Estimating the carbon emissions is based on SAP 10.2 conversion factors (i.e. 0.136 kg CO_{2e} per kWh). But for ancillary purposes conversion factors from SAP 2009 and SAP10.0 (i.e. 0.591 and 0.233 kg CO_{2e} per kWh, respectively) are also presented. Much lower values are a result of the decarbonisation of the grid which has the benefit of reducing the carbon emissions associated with the consumption of electricity, but equally has the drawback of reducing the impact of green electricity generated by PV in mitigating carbon emissions. See Tables 5 and 6.

Table 5. Estimation of the total energy captured by the PV panels and the equivalent Carbon Emissions savings based on the minimum result for the fourth model

MINIMUM	TOTAL ENERGY GENERATED kWh/yr	CARBON EMISSIONS SAVINGS kg CO^2/yr [1]		
		SAP2009	SAP10.0	**SAP10.2**
EXISTING	1126	665	262	153
PROPOSED	925	547	216	126
DIFFERENCE	201	119	47	**27**
DIFFERENCE for 30 Years	**6030**	3564	1405	**820**

Table 6. Estimation of the total energy captured by the PV panels and the equivalent Carbon Emissions savings based on the average result for the fourth model

AVERAGE	TOTAL ENERGY GENERATED kWh/yr	CARBON EMISSIONS SAVINGS kg CO^2/yr [1]		
		SAP2009	SAP10.0	**SAP10.2**
EXISTING	1204	712	281	164
PROPOSED	1048	619	244	143
DIFFERENCE	156	92	36	**21**
DIFFERENCE for 30 Years	**4680**			**630**

Accounting for the minimum PV panel performance the existing scenario would generate 1126 kWh annually and 0.15 tonnes of CO_2 would be saved. The proposed scenario could reduce the energy generated annually to 925 kWh and would save 0.13 tonnes of CO_2 per annum.

The difference between the existing and the proposed scenario, of 201 kWh generated annually, is to be used for the estimation of the loss of export tariff with the proposal. For a price of 5.59 pence per kWh of electricity generated exported to the grid this amounts to £11 per year. For a price of 35.796 p/kWh of energy generated and assumed saved in energy bills this would amount to £72 per year.

Assuming a very generous life expectancy of 30 years for the PVs, the total loss of income from exporting would be £337 and a loss of £2,159 could be associated in the energy bill. These do not consider any changing value of money nor the energy price over time.

In a similar manner the loss of carbon emission savings could be estimated with a carbon offset payment, considered by the Great London Authority, currently at £95 per tonne of CO_2 accounting for a period of 30 years. This would estimate a carbon offset payment of £78.

Accounting for the average PV panel performance, in absolute values both the existing and proposed scenarios would generate higher carbon savings, but the difference between models would be lower than the difference identified accounting for the worse PV performance (i.e. minimum). A smaller difference for the average makes sense as the worst case will be more sensitive to the variation, albeit in absolute terms has, by definition a lower value, in energy generated and associated carbon emissions savings. The average quantification would reflect a lower loss of income (export £261 and £1,675 in the energy bill) and a lower equivalent carbon offset payment of £60.

[1] The carbon emission factors are 0.591 kg CO_{2e} per kWh for SAP 2009, 0.233 kg CO_{2e} per kWh for SAP10.0 and 0.136 kg CO_{2e} per kWh for SAP10.2.

9. Conclusions

As a first principle, enshrined in local, national and international policies, local boroughs should ensure that opportunities to maximise on-site generation of green electricity is pursued and maintained throughout a reasonable period.

The decarbonisation of the grid has reduced the impact PV has on carbon emission savings, but there are still several co-benefits to be considered. Reducing carbon emissions and mitigation of climate change, minimising problems with grid capacity, especially at peak times, promoting resilience to the impacts of shortage of supply or being less vulnerable to the market rise of energy prices. Last but not the least, if the owner has invested in the PV infrastructure at some point in the past there is an expectation of a return of the investment. A positive return of investment may also be of more importance at later periods of life, especially when salaries/pensions may be reduced and result in an inability to pay the energy bills. PV panels providing free energy can be very important to avoid fuel poverty.

A comparison of various methods presented from the Installer (1st method), the Consultant for the proponent of the extension new_roof (2nd method), an Expert commissioned by the borough (3rd method) or this last approach (4th method), highlight several discrepancies and a significant variation in the quantification of the loss of solar access for the PV panels of the neighbour pv_roof. However, both third and fourth methodologies seem to be more realistic and provide results in a similar order of magnitude. The other two methods are either unknown or based on simplified assessments.

Overall the loss between the existing and proposed scenario is estimated by the Installer as 60%, by the Consultant of the new_roof as 16%, and on average across all panels as 16% by the third and 13% by the fourth method.

Concerns were raised by the fact that a PV panel in shadow will affect the performance of the overall array and these potential synchronous reductions, not accounted for in the models, may further aggravate the difference between the two scenarios. New installations with module-level power electronics will mitigate this impact.

Criteria to assess the loss of energy generated by the PV panel has been put forward. However, some caution should be taken to ensure the effect is more widely tested. These highlight that the reduction in absolute terms is still considered viable to generate useful energy and possibly offset a capital investment in a reasonable payback time. This is the case for a payment of around 36 p/kWh, either saved on the energy bills, or possibly negotiated as a FIT/SEG payment, resulting in a payback of around 5 years. A reduced payment of around 6 p/kWh would not be economically viable (i.e. more than 30yrs payback time).

Further estimations of the energy generated by the fourth model for the least performance panel suggests that the loss in terms of profit is around £11 or £72 per year, depending on the price of kWh, for exporting or saving on the energy bills, is considered. Assuming a generous life expectancy of 30 years for the PVs that would result in a loss of income from the export tariff of £337 and a loss of £2,159 in the energy bill.

In a similar manner the loss of carbon emission savings could be estimated with a carbon offset payment, considered by several local authorities and the GLA, currently at £95 per tonne of CO_2 accounting for a period of 30 years. This would estimate a carbon offset payment of £78.

The estimation of the impact of the proposed development, identified as a loss of income and carbon savings reductions may be seen as low. However, significant co-benefits further associated with the local generation of green electricity should not be underestimated. Equally, lack of methods and criteria of assessment of the impact on PV panels should not give grounds for ignoring the important role that renewable energy may have, even if it is a small contribution to mitigating climate change.

An overview of the neighbouring area with similar roof extensions already permitted, may also give grounds for the acceptance of the proposed roof extension.

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