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Built Environment
Assignment 2

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Renewables.

Introduction

As the world aims to reduce its carbon emissions, more consideration has to be given to the architecture of a building. In creating buildings that make the most of their surroundings, that run on renewable energy, and that need less of that energy to perform, we begin to develop a world that is aimed at, undoing the damage created by burning of fossil fuels, and deforestation. Buildings are one of the main sources of global energy consumption and CO₂ emissions, accounting for on average 40% of global energy usage.

“Global carbon (C) emissions from fossil fuel use were 9.795 gigatonnes (Gt) in 2014 (or 35.9 GtCO₂ of carbon dioxide). Fossil fuel emissions were 0.6% above emissions in 2013 and 60% above emissions in 1990.” (Super User 2019)

Choosing the right renewable for a building is a vital part of the design, selecting one not suitable for the site would lead to reduced performance, and the building would then not work to its optimum level, creating unnecessary carbon emissions to supply power and/or heat to the building.

“The Paris Agreement central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius” (Paris Agreement 2019)

In this report we will focus on Solar Photovoltaic/Building Integrated renewable power, for use on the new development of SA1 Gym and swimming pool that will become part of the University of Wales Trinity St David Campus. We will consider why it may be the best selection for the site conditions and also any negative issues that could be encountered by Photovoltaics, that may not be encountered with other renewable sources. We will then discuss how this energy will be stored on site rather than feeding back into the grid, and the system being added in to via the other buildings within campus that are already running on large Solar PV panels.

Body

The Site

The site in question for the new development sits at the docklands of Swansea City. A historically industrial area of the city, it has undergone large development over recent years. Most recently of which being the construction of two new sites for University of Wales Trinity Saint David Campus. A teaching building and a separate library. Further development of the site including a gymnasium and swimming pool, and a student union building in the future will increase the need for power in the area. Much of the development has already been designed with future proofing in mind, and reducing the University's carbon footprint with solar photovoltaics on the existing buildings roofs.

The site is suitable for a whole range of renewables, from Hydro in the docks, to wind generated coming down from the valley sides, and uninterrupted solar due to Swansea's limited amount of high rise buildings, some consideration for biomass powered district heating system could be given for the future buildings to be added into the network of UWTSD campus.

The Development.

At 6000m² floor area, the development will be a large space with suitable roof space for large Photovoltaics.

Solar Photovoltaics.

The creation of electricity through absorbing sunlight into cells. Photovoltaics have developed over recent years many more options are available, roof mounted panels, integrated tiles, integrated cladding, solar sheets, solar glazing, or placed in larger panels to support either a community or feed straight into the National Grid.

The system is made up of 6 components.

- Solar Photovoltaic Array - A number of PV panels connected to collect sunlight and generate direct current.

- Charge Controller - This regulates the direct current to prevent overcharging of the batteries in off grid systems. Pulse Width Modulation is suitable for smaller domestic systems and battery banks, up to 60 amperes. Maximum Power Point Tracking charge controllers are more suitable for larger commercial systems with a voltage up to 160 volts DC.
- Battery Bank. - Stores the energy produced by the PV which is not being used immediately. This is then used later, during the evening or during cloudy weather.

“With a battery system, your home will be able to use 80% of its generated energy, whereas without a battery system, this would only be 40%.” (greenmatch.co.uk 2019)

- Inverter - Converts electricity from Direct Current to Alternating Current.
- Utility Meter - Measures electricity consumption in the building.
- Electric Grid - Connecting to the grid allows for energy to be stored for use.

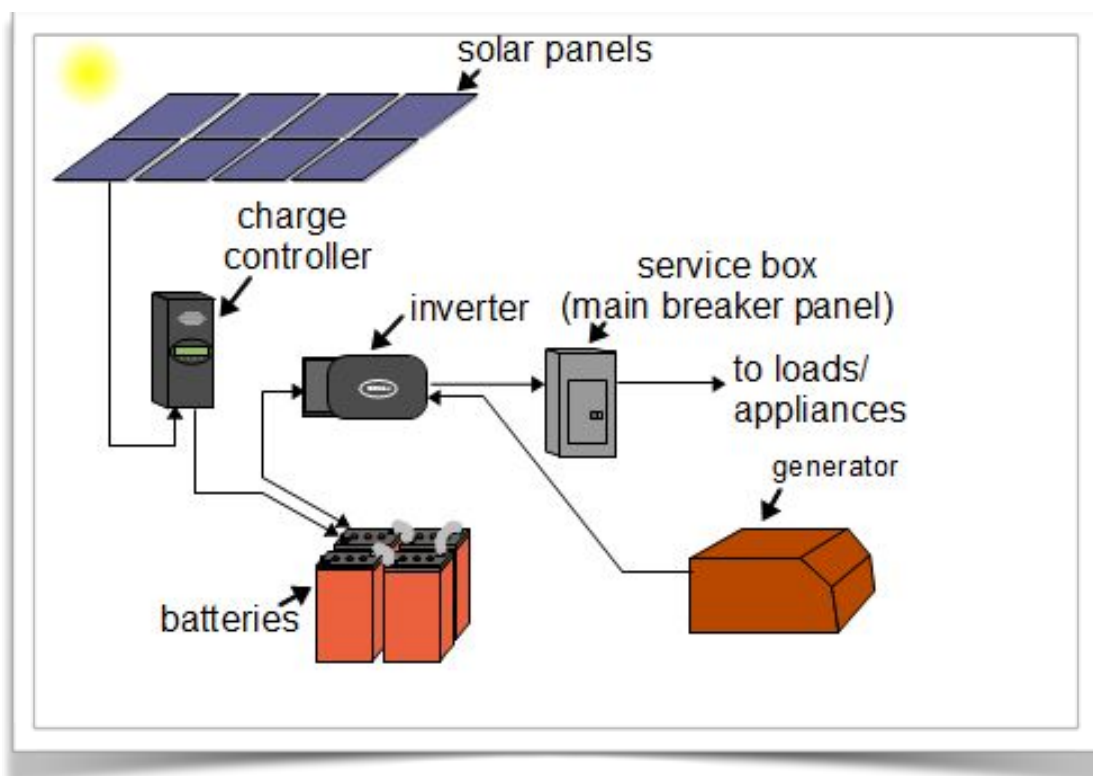


FIGURE 1. SOLAR PV SYSTEM COMPONENTS. (L2CLASSICA.COM)

Building Integrated Photovoltaics.

Like Solar PV, BIPV generates electricity through panels. In BIPV the panels make up the external envelope of the building, windows, cladding, the whole roof, all can be made into BIPV and this helps with build time and cost.

Reducing the need for other cladding, BIPV attaches to the building in a variety of ways.

- Sheeting - a flexible sheet often used on curved surfaces.
- Solar shingle - roofing tiles made of solar panels.
- Glazing - triple glazing glass with solar absorbent materials in the middle sheet.
- Facades - sun shades/rain canopies made from thin solar sheets.
- Roofing modules - large modules pieced together to create a continuous roof.
- Cladding - large panels attached to the exterior of the building that create the building envelope.

The components of BIPV are the same as Solar PV, with the addition of appropriate support and mounting hardware.

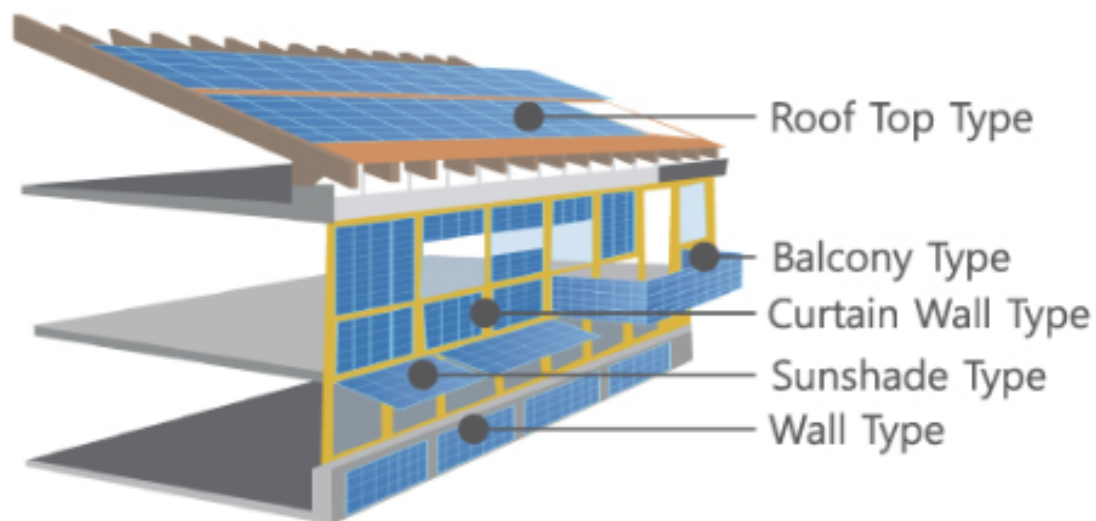


FIGURE 2. BIPV TYPES (WBDG.ORG)

Cost.

When factoring cost of Solar Photovoltaic it is important to know that the variables of each building. Power consumption requirements depend on the size of the building and its use. How much power a building can harness from solar depends on the type of panel, the size of panel and how large a useable area for the photovoltaic is, whether panels will be used or if the roof will be installed as one large array. The cost of photovoltaic is offset by how much it saves per year by not paying for energy direct from the grid. (in systems connected to the grid there is currently a payback tariff.)

Ensuring there are enough PV to supply the energy needed is vital, on larger buildings this can cost a substantial amount of the budget in an off grid system. In a system that feeds into the grid there are grants towards helping for the initial layout costs for residential customers. Choosing the right PV is also important especially if focus is on the aesthetic design of the building.

Estimated Cost of Photovoltaic System Components in the UK				
System Size	8 m² / 1kW	10 m² / 2kW	12 m² / 3kW	16 m² / 4kW
PV Array	£1,500 - £3,000	£3,000 - £5,000	£5,000 - £6,000	£6,000 - £8,000
Charge Controller	£15 - £175		£60 - 1,330	
Battery Bank	£1,500 - £3,000		£1,500 - £6,000	
Inverter	£800 - £1,000			
Total Cost	£3,815 - £7,175	£5,315 - £9,175	£7,360 - £14,330	£8,560 - £16,330

FIGURE 3: ESTIMATED COST OF PV SYSTEM (GREENMATCH.CO.UK)

Savings.

The savings as with any green energy rapidly pay dividends, the returns will be even greater when a system is off grid. 100% use and no drain from the grid reduces the time it takes to see “Free” energy.

With energy costs increasing yearly despite government promises to freeze prices, renewables are not just good for the environment but also good for the consumer.

Financial savings are not the only great reason for selecting renewables, many consumers select solar not just because they save money, but also because this generation of people are becoming more conscientious about saving the planet.

The savings are greater the more energy a building would consume, as shown below, a typical residential property earns greater savings with the resident being home all day compared to someone who is only home in the evenings and weekends.

For sites with minimal usage the savings would take longer to begin supplying the building with free energy, however the bonus of this in an off grid system would be less likely to run out of energy.

Using BIPV also saves money on other external cladding, it reduces maintenance costs on roofing membranes and eaves as water penetration is eliminated by the roofing modules and cladding sheets. In turn this saves on pollution created by developing materials, transporting them to site, to fit and/or fix when they need replacement.

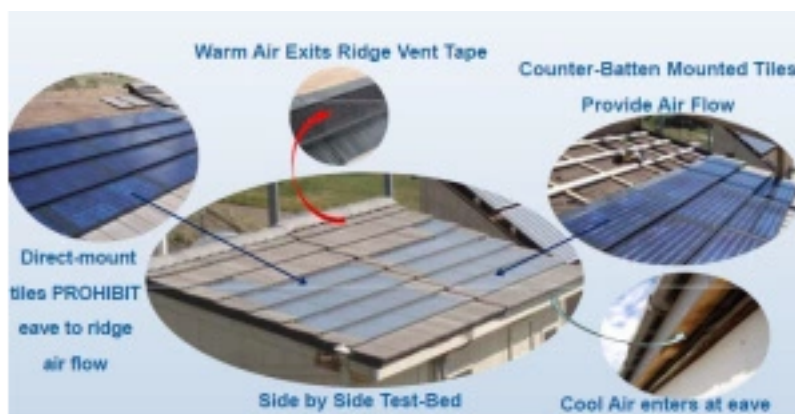


FIGURE 4. BIPV ROOF INSTALLATION REDUCES REPAIR COSTS

Location	Savings on bills (£/year) last updated April 2019				
	Home all day	Home in the mornings	Home in the afternoons	Out all day until 4pm	Out all day until 6pm
London, South England	£240	£195	£175	£120	£100
Aberystwyth, Wales	£230	£185	£170	£120	£95
Manchester, North England	£230	£185	£165	£115	£95
Stirling, Scotland	£220	£175	£160	£110	£90

FIGURE 5. UK SAVINGS PER YEAR 2019 (ENERGY SAVING TRUST 2019)

INVESTMENT VS RETURN.

Renewables supply free energy, before the energy is free the money spent needs to be earned back through not spending on electricity supply. Dependant on the initial outlay of the system, this can take anywhere between 5 and 20 years, a vague and widespread number but it ultimately depends upon the variables.

- Amount of sun - the site in question has a reasonable amount of sunny days throughout the year.
- Size of system - the bigger the system the more it costs, but the faster it pays that cost back.
- Use of the system - the more the system is used the quicker the return is seen, if a building doesn't use much electricity it will take longer to use the stored energy and longer to make a return.

In the image below it suggests that solar is the most expensive, however with less mechanical parts to go wrong meaning less maintenance costs this can over time outweigh the costs of the other types of renewables.

'The estimates by BEIS show that it will cost £63 to generate a megawatt hour of electricity using onshore wind energy, reinforcing Caroline Lucas's claim.

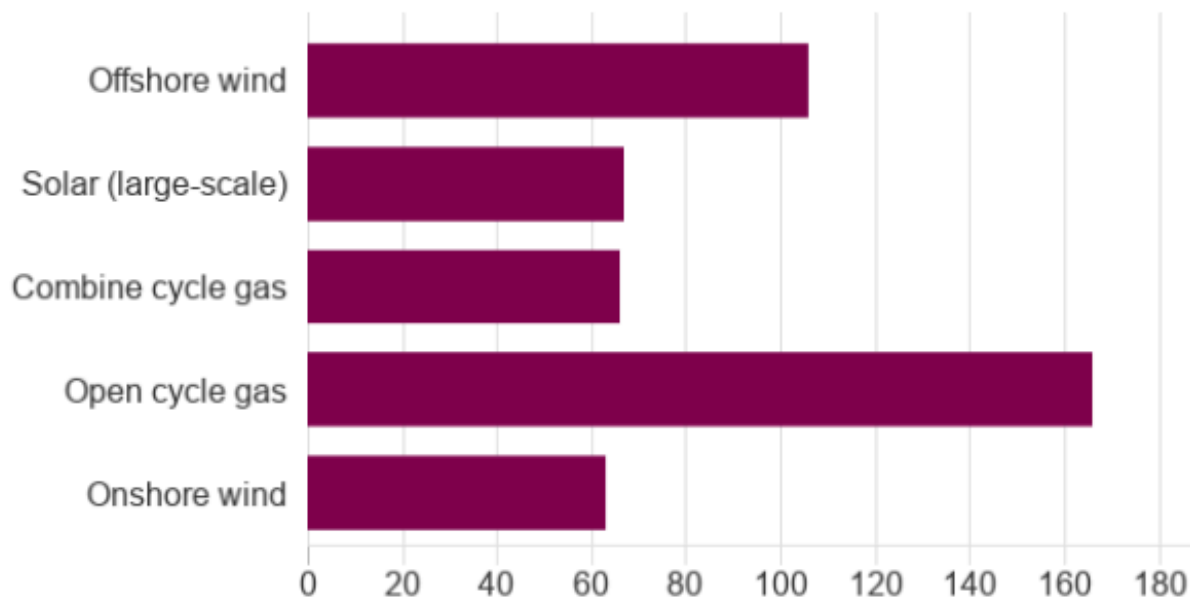
It's the cheapest renewable power source listed, in comparison with £106 for offshore wind.' (BBC.co.uk)

As for solar, First Solar has surmised that "the cost per watt for solar installations at this scale is somewhere around \$1/watt. Therefore, you can assume that a 1 MW solar farm would cost roughly \$1 million to install." (news.energysage.com/solar-farms-start-one/) £769470.00

1MW is big enough to power 200 houses. The SA1 project will require much less than this.

Electricity generation costs

Total cost per MWh (£ per MWh, 2014 prices)



Source: Department for Business, Energy & Industrial Strategy

BBC

FIGURE 3. GENERATION COSTS FOR TOP 5 TYPES OF ENERGY SUPPLY. (BBC.CO.UK/NEWS/BUSINESS)

Why Solar?

With such a range of renewables available why choose solar PV?

Solar PV doesn't take up any extra space, it sits within the site plan of the building, usually on the roof. No extra expense is required for preparing the site for the installation of the PV and in cases like the solar settlement at Schlierberg Germany where the whole roof is made of solar panels rather than the PV being attached to the roof as an accessory, the modules can produce even more energy and reduce roofing costs, and the need for time consuming awkward repairs to roof materials over time. When used as a cladding or in a glass application it again is replacing a vital part of the building that would otherwise be taken up by standard materials, having no extra benefits to the energy capacity of the site.

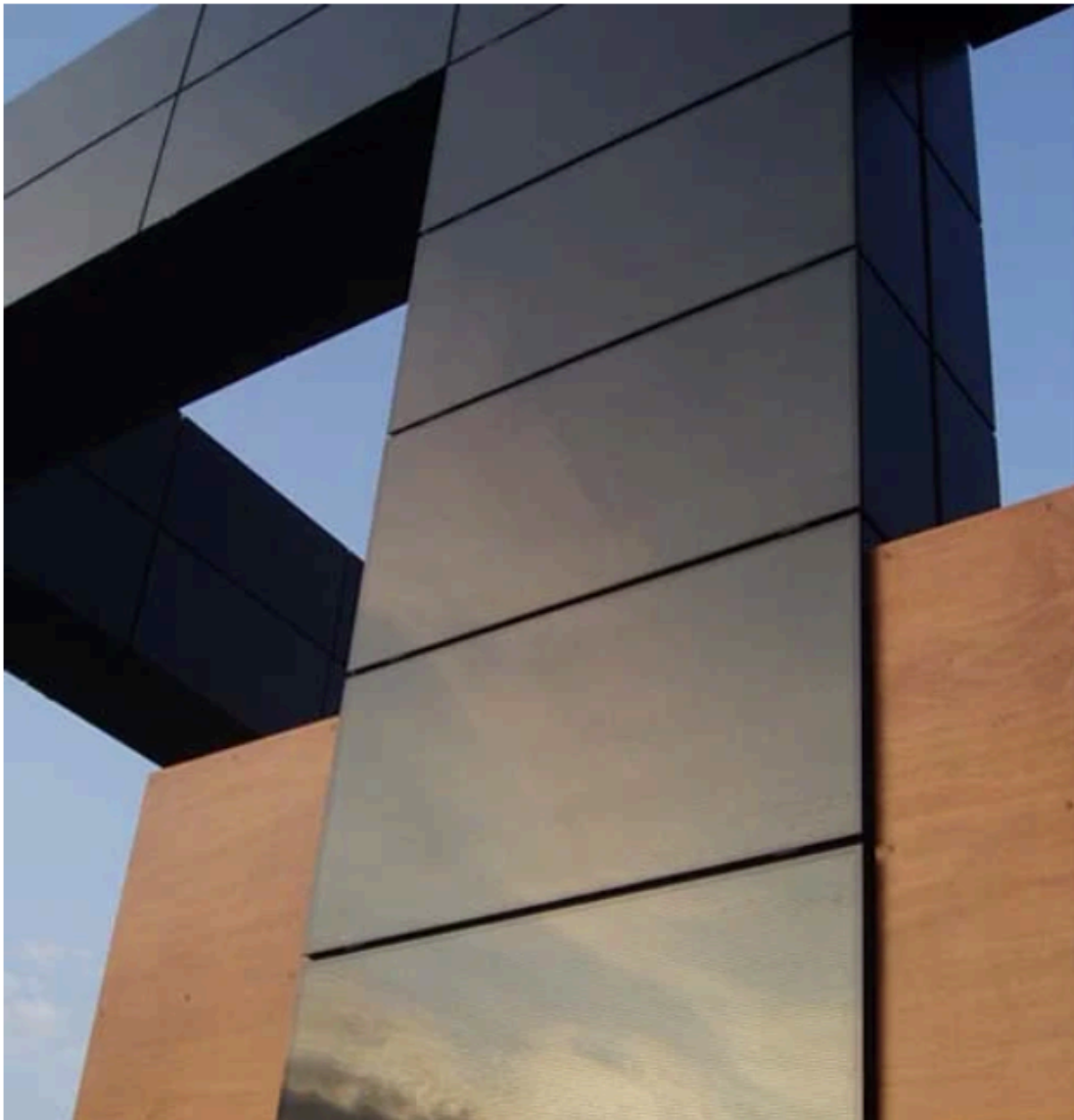


FIGURE 4. SULFURCELL SOLAR CLADDING (CLEANTECHNICA.COM)

Many buildings that have full solar modules generate much more electricity than they actually need, using an off grid system, this will store the unused energy for the winter months, when less energy is harnessed. It is silent running so is usable in quiet residential areas, as well as on commercial and industrial estates. Using solar in every possible way through the building from, passive, modules, and glass allows much more energy to be produced than if just roof panels were used. Advances in technology is also reducing the carbon cost of solar, as technology advances, less silicone is required for the panels and modules, this then helps the indirect carbon footprint reduce and enables Solar PV to be even more economically beneficial.

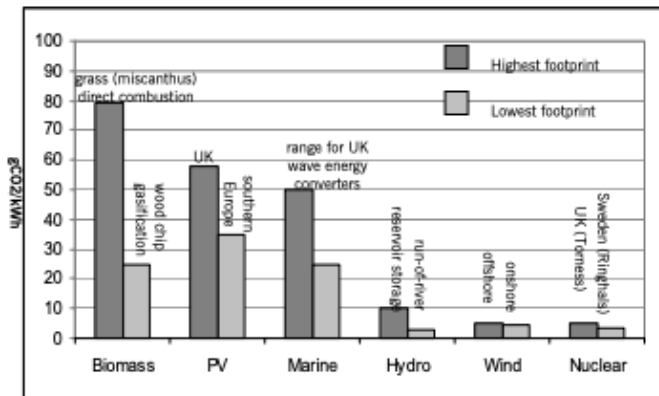


FIGURE 5. CURRENT CARBON FOOTPRINT

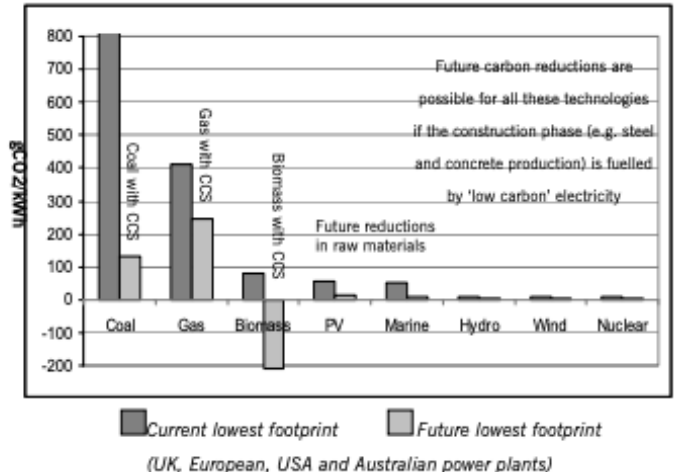


FIGURE 6. PREDICTED CARBON FOOTPRINT
(WWW.PARLIAMENT.UK/DOCUMENTS/POST/POSTPN268.PDF)

Solar PV lasts 25 years, after this time the panels need replacing, the parts from those panels/modules can be recycled. Recycling helps reduce the waste going to landfill. As technology advances this may or may not go even further to all parts being recycled.

It does have its limitations, while it only needs light (not sun) to produce energy, it does need a lot of it and in wetter, more northern climates this may prove problematic to providing enough energy to sustain larger buildings off grid.

Of all the renewables solar is in the higher in the embodied carbon but its longevity and low maintenance costs aid in reducing that further. *“Life cycle CO₂ emissions for UK photovoltaic power systems are currently 58gCO₂eq/kWh”* (www.parliament.uk/documents/post/postpn268.pdf)

Toxic chemicals cadmium and arsenic are used in the manufacturing of PV. The environmental impacts of these can be safely controlled by recycling and proper disposal.

In feed in tariffs the consumers roof becomes the property of the company they have had install the panels.

Conclusion.

Solar PV/BIPV have come a long way technologically since their inception, and they continue to improve year upon year, with more companies entering the solar market, more and more types of solar are being brought onto the market, this is good for the Solar PV market, the consumer and the architectural industry.

As long as careful consideration is made to ensure there is enough PV to absorb sunlight even its biggest drawback becomes almost negligible.

Unusable land has become usable with installations of Solar PV, and consumers have earned back money spent on the installation of them on their roofs.

Its lack of requirement for space is ultimately one of its most attractive benefits, and its versatility allows for many people to use its easy form of free energy.

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