The Solcer House and solar panel installation

The Solcer House is a research construction project by Cardiff University that has delivered an affordable dwelling that utilises a number of integrated low carbon technologies. These features include photovoltaic panels, a transpired solar collector and a high thermal performance fabric constructed using structural insulated panels (SIPS).

The building is located at Parc Stormy, near Bridgend where Cenin Renewables have set up a 'renewable energy business cluster' (ceninrenewables.co.uk).

Site Layout - North up the page

Aerial View (Source - Google maps)
Solcer House circled red

Site plan (Source - ceninrenewables.co.uk)
Solcer House circled red

The focus of this assignment is on the photovoltaic installation. The panels at Solcer House are integrated with the roof structure and form the finish to the roof.

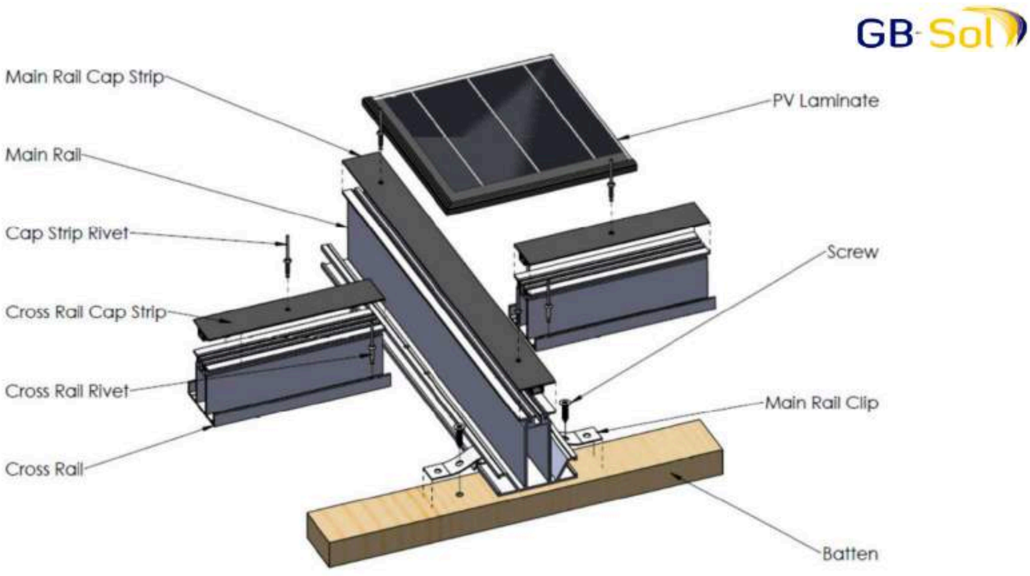


Figure 1 - Image of system components. (Source - www.GB-Sol.co.uk)

Site photos. (Source -Jones, P. HBF Technical conference 2016)

The array is made up of 34 m^2 of monocrystalline solar cells and manufacturers data advises 4.3 kWp performance (Jones, P. Xiaojun, L. Coma, E and Patterson, J. 2017).

Energy from the panels goes to a battery for storage and is used by the house systems (lighting, small power, heating, ventilation and hot water.) When the battery's energy is used up the house takes energy from the grid.

The site is an open plot and the building is not affected by any nearby shading.

Outline Monitoring Plan

In establishing the plan it is important to understand **why** it's being undertaken, **what** it aims to achieve, **how** results will be obtained and **when** and for how long the plan should be undertaken. **Who** the plan is for is also a consideration?

Why?

The aim of the exercise is to obtain first hand data that demonstrates the efficiency of the PV panels such that manufacturers claims can be tested. Focusing on a number of elements the hope would be to build up a picture of where efficiencies are lost - to what extent is it through the components of the installation? Does the efficiency decline over time? Do climatic factors have an impact.

With knowledge of their efficiency, an off shoot of this analysis would be to understand the value they have over the life of a building when compared to a non PV traditionally roofed dwelling in a similar climate and orientation.

What, how and when?

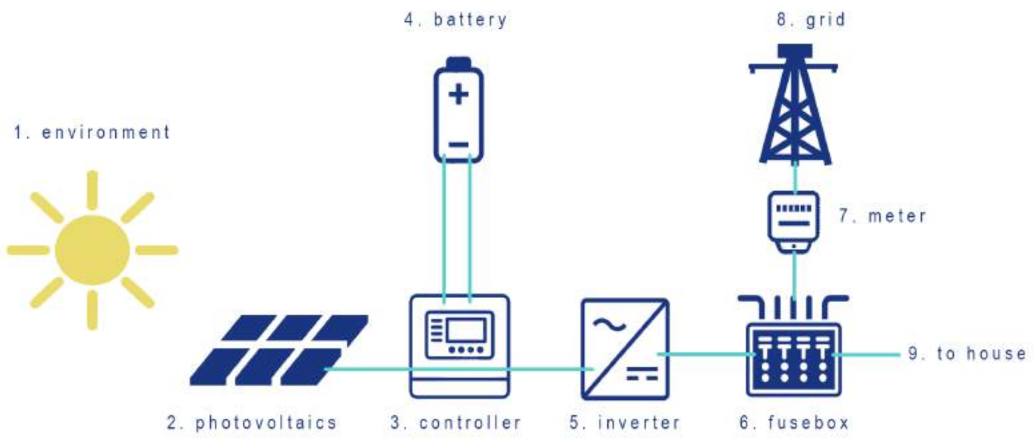


Figure 2 - The PV system. (Source - based on Jones P, 2016, HBF Tech Conference)

Breaking down the process of the system as per the diagram, the elements for monitoring can be identified:

1. Environment - Whether through sensors or climate station data obtain daily solar radiation levels, temperature, humidity, daylight and wind speed data. Panel cleaning and maintenance should be recorded should any occur during the monitoring.
2. Photovoltaics - An energy and power meter at the panel position would confirm the initial levels of power from the PV and energy generated in the first part of the process.
3. Controller - Measuring energy to and from this unit would establish how it impacts on efficiency as well as understanding the distances the DC current has to travel.
4. Battery - The performance of this element can be checked. The energy going to and from it will confirm if it stores as much charge as it should and whether or not this declines over time.

5. Inverter - Measure how much energy is lost in the changing the DC current to AC for use in the house and by the grid.
6. Fusebox - Energy passing from the fusebox will confirm the amount used by the house. Taking away the energy supplied by the grid (7) will confirm how much comes from the panel.
7. Meter - Readings here will confirm the energy drawn down from the grid. (Along side monthly bills this would give useful insight into the value of energy produced.)
8. Grid - Linked with (7) it would be good to understand tariff costs for linking to and paying back to the grid.

Given PV performance is so dependant on climate, any test duration should cover the four seasons such that you test over a full range of conditions. To ensure the results are not anomalous we would propose a test over 36 months. This would reduce the chance of results being skewed by extremes. A typical years performance can hopefully be established.

Who?

To ensure the data is presented in an appropriate manner it is important to consider who the audience is? (Groat, L.N and Wang, D. 2013)

As noted in the introduction the target audience would be fellow construction professionals who would welcome data that confirms the efficiency of a technology and what that causes of inefficiency might be so lessons can be learnt.

A wider question for this audience would be one relating to value. How this could be established is discussed in the final section.

Background research and literature review

Research into and around the installed system will help set expectations with regards its performance and where losses in efficiency might be known to exist.

Research into previous building monitoring will inform knowledge of the range of appropriate instruments that could be used to obtain the required data. (Sani, A. Warman, E. Pranata, A and Suherman, S.D. 2018).

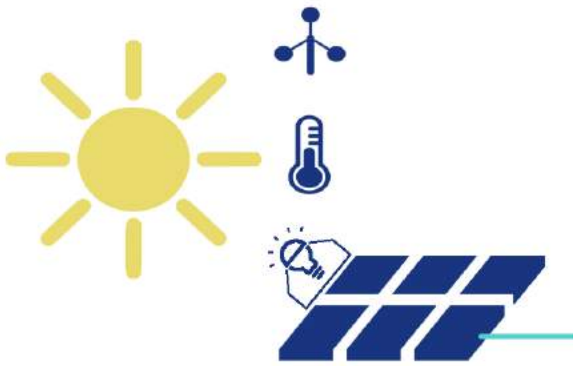
Another avenue for research would be understanding the history of PV installations and their current rate of improvement as a technology. Given more will be invested in renewables in the future it will be important to be aware of the direction of travel for this technology. (Messenger, R and Goswami, D.Y. 2016.)

Assumptions

It is assumed for the purposes of this exercise that the Solcer House is being used as a dwelling and not in it’s current guise as an office.

Proposed Methodology

Collecting Environmental Data



To record the solar irradiance on the panels, the use of a Pyranometer is proposed. Tilted to account for the pitch of the panels this will give real time data of the solar energy falling on the PVs (W/m^2). The device records direct and diffuse levels of solar energy.

Energy totals for each day could be recorded in kWh.

The following instruments will be used to measure other environmental related data:

- Temperature sensors on and around the panel will record the air and surface temperatures. (°C)
- A psychrometer would be used to record relative humidity around the panel. (% ratio)
- An anemometer would record wind speed and direction.

To ensure the full range of daily conditions are observed the equipment will be set up to record hourly data, every day from 1 hour either side of sunrise and sunset.

Temperature and humidity measurements in the vicinity of the electrical equipment will also be taken to establish if internal conditions impact on performance.

Collecting System Data

The primary purpose for the data taken from the equipment will be establishing the overall system efficiency and that of each component.

The solar data collected above will confirm the amount of energy reaching the panel.

2no. devices are proposed to measure energy and power converted through the system. (See figure 3.)

Firstly a power analyser (eg. Keysight PA2201A IntegraVision) to be used instead of volt and ammeters to check the power in and out of each component:

Efficiency (%) = Power out ÷ Power in x 100. (Keysight technologies, 2017)

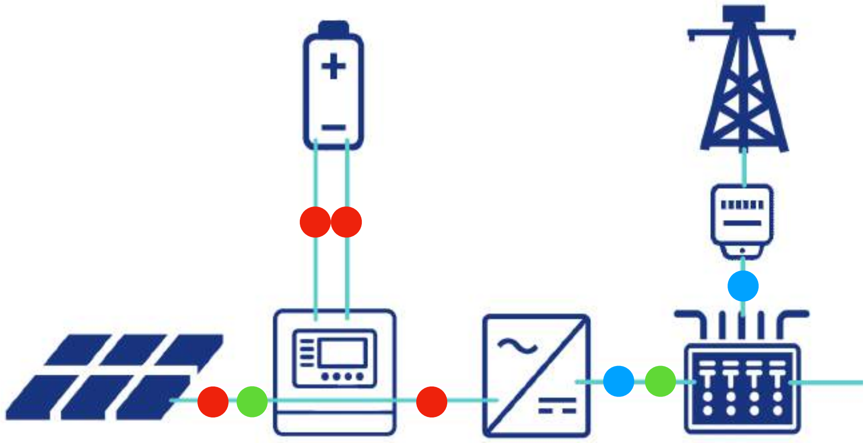


Figure 3 - Proposed system monitoring

- Power analyser (measuring DC current)
- Power analyser (measuring AC current)
- Energy metering device

The second instrument would be an energy metering device such that the energy drawn direct from the panels can be recorded as well as the amount at the end of the system going into the house (kWh). A pulse counting sensor could be used in this instance. This records energy use (kWh) and notional carbon costs (McGeary, S and Novakovic, O. 2014).

The existing meter already picks up energy going to and from the national grid.

The energy meters would record daily, monthly and annual energy use. The power analyser data would be planned to coincide with the environmental monitoring timings.

All monitoring devices would be discretely positioned so not to interfere with inhabitants of the house. Equipment would be set up such that readings could be observed remotely. Length of cables and the relative positions of equipment will be recorded.

Benchmark data

Manufacturers data is available for the system and their efficiency claims can be noted.

Prior to testing, predictions could be made using known manufacturers data, available nearby climate data and equations based on the research of others (MSc Lecture notes, 2019):

$E = A * r * H * PR$

E = Energy (kWh)
A = Total solar panel area (m^2)
r = solar panel efficiency

H = Annual average solar radiation on tilted panels (kWh/m^2.y)
PR = Performance ratio, coefficient for losses

If available, obtaining data for similar tests will be of interest in comparing energy use and component efficiencies.

Other data

Because the monitoring plan is over such a long duration the following should be recorded:

- Maintenance works on the system or any changes to hardware or software.
- Any cleaning of the panels.
- Power cuts or surges.
- Snowfall or hail.
- Any force majeure.

The question of value

The data from this exercise could form the basis for a value analysis of PV panels in this climate. To that end, cost and life cycle information for all components would need to be obtained such that it could be compared to an equivalent property without PV and a more traditional roof finish. Tariff costs for the PV would also need to be understood.

Carbon footprint data may also influence the value discussion. Data for the embodied carbon of the system components for both Solcer and more traditional dwelling types could be obtained for comparison.