PHOTOVOLTAICS IN BUILDINGS
DOMESTIC FIELD TRIAL

Pinehurst, Liverpool

This housing estate in Liverpool has undergone refurbishment as part of a regeneration process within the area. Plus Housing Group therefore decided to install roof integrated PV on the new-build properties benefiting low income families.

Project Team

Plus Housing Group
PV contractor – SunDog
Standard site activities – Bardsley Construction
Monitoring – Technical Associate employed by Plus Housing Group

Site Description

Within the estate's renovation programme, nine of the 55 houses were deemed to be beyond economic repair. Hence the decision was taken to build nine new properties incorporating photovoltaics (PV). The Redland PV700 tile system was chosen because the rest of the estate uses conventional Redland tiles. There are 40 PV tiles (1.4kWp orientated 55^{o} W of S) on five smaller houses and 48 tiles (1.68kWp orientated 24^{o} W of S) on four larger ones. One PV tile displaces four conventional tiles. All roofs are at an angle of 35^{o}. The PV tiles are designed to fit in with the conventional tiles' horizontal lines resulting in flushness with the roof. Also the contrast in colour between the red tiles and blue PV modules was deliberate. The overall result is an uncluttered roof with an eye-catching PV system.

- **Nine new build single family houses**
- **14 kWp installed capacity**
- **Redland PV700 tile system (BP Solar SRT 35 laminates), roof integrated**
- **Average annual yield 777 kWh/kWp (best 845 kWh/kWp)**
- **Average annual savings 4.7 tonnes CO_2**
- **Average Performance Ratio – 72% (best 80%)**

Installation & Commissioning

The PV installation was completed by conventional roofing contractors who received initial training by the PV contractor in handling the modules and inter-connecting them. Sundog, the PV contractor had fixed and labelled the DC cabling prior to the PV installation itself.

Installing the Redland mounting system was generally straightforward. Once the battening was completed the PV tiles were installed in a two stage process. Firstly, the proprietary mounting system was attached to the battens allowing the plastic trays to be fitted. These mesh with the Redland tiles, ensuring weather tightness of the assembly and ensuring back ventilation. Secondly, the modules are connected together electrically and clipped into place. One concern with this system highlighted by some installers was that access to failed panels or to connectors for testing was only possible by removing the panels from the top down, potentially resulting in some onerous maintenance work if the bottom panel needs replacing.

Plastic tray installed with PV module about to be placed on it

Making the electrical connections using the straight forward Multi-Contact plug system

There was some minor problems with the PV integration, for example on the first completed roof the roofer placed the felt between the counter battens and battens instead of underneath both, therefore reducing the ventilation air gap. Emphasising the correct sequence of the counter battening here is crucial as this will be unusual practice to roofers. The battens at Pinehurst had to be re-done causing a slight delay, although this did not affect the overall scheduling. Visual integration of the rooflights was also less straight forward than anticipated.

Counter battens (verticals) installed correctly for cooling, beneath battens

Mounting brackets being installed

Here the conventional tiles had to be cut to fill-in the gap between the rooflights and fixed length PV modules. At closer inspection these cuts were slightly unequal and in these

circumstances all that could be done is to make the shapes around the rooflights as balanced as possible.
The roofers made the electrical connections between the modules as they progressed, using Multi-Contact (MC) connections which are touch-safe. The connections were made as straightforward as possible by installing the modules in columns to form a string from bottom to top. The strings comprised ten or twelve modules depending on the site. The PV contractor returned to test the continuity of the strings after the modules were installed and before the scaffolding came down.

Connection to the grid

Permission to connect the systems was obtained by the local District Network Operator (DNO) Manweb, which showed good support for the project. It is considered that early contact helped to ensure a positive relationship with the DNO. Information was provided to the householders on different electricity suppliers who might purchase the electricity produced at a premium rate. However, as far as is known, this has not been taken forward by the householders.

System Costs

A breakdown of the system costs for Pinehurst is shown below:

	Cost £ / Wp
Module installation	0.07
Electrical installation	0.36
Monitoring costs	0.88
Inverter costs	0.67
Module costs	5.07
Total costs excluding management costs	7.06
Total costs excluding management and monitoring costs	**6.18**

The design of the PV system and its various installation stages ensured that these stages could easily be combined with the normal construction schedule and also that non specialist work could be undertaken by site subcontractors employed by the Building Contractor. An example of the benefits of this is that scaffolding was available at no additional cost.

The average electricity cost (excluding management costs for the project team and monitoring costs specific to the DFT) over a predicted 25 year lifetime is estimated to be 31.8p per kWh.

PV operation, maintenance and end-user acceptability

There were some initial, although minor, problems with an export meter and one of the tenant's display meters, all of which were promptly rectified. One tenant was questioning her high electricity bills but monitored data confirmed that her electricity use was high and that her power meter was not faulty.

A severe thunderstorm, during which lightening struck nearby overhead power lines, was thought to be responsible for two modems switching off. The modems were responsible for transmitting performance data as part of the DFT and any outage meant a reduction in the amount of data available for analysis. However once the

Tenant display meter (top left) mounted next to the consumer unit

problem was identified the modems very easily reset.

Tenant Interviews

Initial feedback suggests that the tenants like their systems and think that PV should be more widespread. Plus Housing Group has kept tenants well informed about the PV systems and some tenants noted that they try to save money by using electrical equipment at times when the PV is providing electricity, i.e. during the day. Also most householders do check the display panel at least occasionally, offering a good spot check to see whether the system is operating.

Performance

The PV systems on this site show good and reliable performance, but analysis showed that the smaller systems gave a reduced output in the winter months compared to the larger systems. This was traced to the operation of the inverter, where low irradiance levels caused the voltage of the strings on the small systems to fall below the input range for the inverter. In turn, this led to a problem with tracking of the maximum power point of the PV array and hence reduced system output. This behaviour is also related to a relatively high grid voltage at this site, which affects the input voltage range of the inverter.

The ability to compare two different system sizes on this site has allowed the identification of this issue and will be addressed in the system design recommendations arising from the Field Trial, which will suggest an additional allowance on the inverter string voltage within the system design.

Conclusions

Overall integrating the PV700 system installation within the construction process was found to be exceptionally easy. The design and modular scale of the PV system meant that site subcontractors could be trained to perform part of the installation work. Also access was required to fit inverters, data loggers (as part of the DFT monitoring phase) and commissioning of the PV and monitoring systems. Trying to arrange access can often cause lengthy delays, however at this site householders were very cooperative possibly due to the fact of minor fixes being completed in relation to the overall build.

Overall the Project Team is very positive about the PV installation and pleased that it has provided the Plus Housing Group with its first portfolio of PV properties. The housing group felt that the key to its success has been good teamwork and a positive approach from every team member including the main building contractor. This was very important especially in regards to problem solving and being able to deal with the few that did occur effectively and efficiently.

Further information

- www.pv-uk.org.uk
- Publications available from DTI website: Photovoltaics in Buildings – Guide to the installation of PV systems, Good Practice Guide Part 1 – Project Management and Installation Issues

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