PHOTOVOLTAICS IN BUILDINGS

LARGE SCALE FIELD TRIAL

Case Study 2: OpTIC Centre

Clear sighted business incubators

The OpTIC Centre in St Asaph, North Wales, was built by the Welsh Development Agency to provide research and development facilities for the opto-electronics industry. It has the largest CIS (copper indium diselenide) photovoltaic array in Europe, and it was the first application of this type of cells in the UK.

Photovoltaics (PV) were part of the project from the initial design stage. The idea of a large, visible illustration of one aspect of the centre's work, mounted in a prominent position outside the building, was attractive to both client and architect.

The whole of the south façade is covered in PV modules, at 70° to the horizontal. This façade merges into the roof, and creates a large colonnade which gives access to the workshops and laboratories beneath. This is not simply an integrated PV system, but one which inspires the whole shape of the building.

Architect Capita Percy Thomas curved this 'solar wall' from the roof line down to an ornamental pool. The wall serves not only to collect energy from the sun, but doubles up harvesting rainwater to use in the building and for irrigating the grounds.

Innovation in this unusual building didn't stop at the roof feature: 'solar siphons' allow passive ventilation of an internal street. These are rotating chimneys that use solar radiation and wind to move air around and draw stale air out of the building.

This wasn't the only unusual feature of this building, for before the OpTIC Centre was built the site was occupied by Great Crested Newts. These were removed to neighbouring land, one by one, at significant cost. The project team had to build 100s of metres of 30 cm-high fence to stop the newts from breaking back in.

The Optronics Technology and Incubation Centre, or OpTIC for short, provides 4,200m² of facilities, including:

- a business support unit to give advice to start-up companies
- an incubator centre of 24 units for businesses
- a technology centre with a state-of-the-art clean room, aimed at promoting innovation.

The striking solar wall makes a statement for all to see about the high technology optical work this building houses.

Photos: Capita Percy Thomas

The Centre aims to link the University of Wales' centre of excellence with the business community, and in the process create 460 new, high-quality jobs.

The elegant sloping wall design, integrated into the roof structure of the building, uses Shell ST36 copper indium diselenide thin-film modules, which are mounted on a custom-made framing structure.

The project team's original advisers at a major supplier recommended thin-film PV rather than a crystalline cell because they thought thin-film would supplant the older technology in the future. There were two other reasons for choosing thin-film ahead of crystalline cells: first, the cost per m² is lower; and second, the opto-electronic industry often uses thin-film.

Only a year later their chosen supplier withdrew from the thin-film marketplace. In its place, the project team decided to use copper indium diselenide modules – among the most efficient forms of thin film PV, but with a limited selection in the UK. The available panels could not be integrated into a curtain wall system, so they were instead mounted on an aluminium skin.

Putting it together

The PV system, consisting of 2,368 modules, was mounted in 400 bespoke frameworks in the factory before delivery on site. Each panel is 1,400 x 350 mm, giving a combined area of solar roof/façade over 1,000 m², and making it the largest installation of CIS modules in Europe.

The curved profile called for a complex stringing arrangement to safeguard maximum power output. The

Energy efficiency

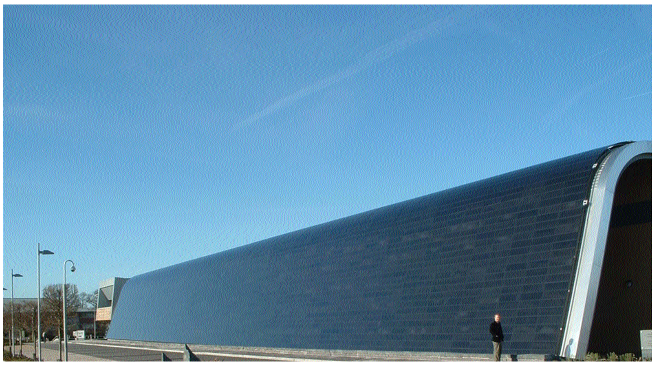
The building achieved an 'excellent' rating under BREEAM assessment, which includes broader sustainability criteria like transport, water use, materials and site ecology.

It has insulation 15% better than the requirements of the Building Regulations. It also had a pressure test, going beyond what was required by the Building Regulations at the time.

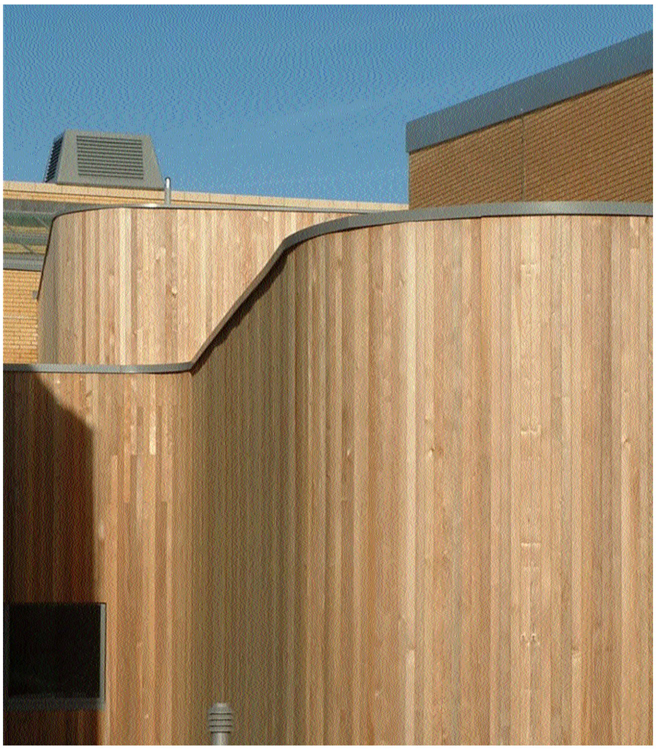
Energy consumption estimates during design were 65 kWh/m²/y (electricity, of which around 17 kWh/m²/y should come from the PV) and 100 kWh/m²/y (gas).

High efficiency variable speed fans and pumps for ventilation and air conditioning were fitted to reduce overall energy consumption.

OpTIC's incubator units use a combination of chilled beams and displacement ventilation. This is an energy-efficient form of air conditioning.



Gentle wooden cladding around the entrance is an effective counterpoint to the high technology glass and steel elsewhere.



PV sub-arrays were prefabricated off site, using Uni-rac mounting rails and proprietary brackets. They were connected up, and tested before delivery on site.

Roof contractor Roofdec attached brackets to the roof, with checks to ensure they were correctly positioned. Then photovoltaics installer PV Systems Ltd fixed the mounting rails to the roof, paying particular attention to alignment. The mounting design allows a clear ventilation space behind the panels, cooling them and helping to keep the panels at optimum operating temperature.

The sub-arrays were connected starting with the bottom row, and a vertical column at the centre of the roof. This meant that PV Systems could check the alignment again before all sub-arrays were installed.

Finding new solutions

Some panels were left out of each array initially to allow access to the fixing bolts beneath. Each row of panels was wired into a string, and tested to confirm voltage once the string was complete. This ensured that all panels were connected the right way around, and continuously. In all, installing the sub-arrays took four weeks.

Each series string was routed along a cable tray at the top of the array, and through one of nine penetrations to a junction box. Each junction box has its own isolator, and is linked in turn to an inverter in the plant room.

There are 15 groups of inverters, with each group made up of one master and one or two slaves. A single sub-main cable routes the power through existing trunking to the main building switch panel.

The electrical subcontractor BKB installed the distribution board and a relay contactor, while PV Systems did all the AC wiring from the inverters. The electrical installation was completed in December 2003.

A G59/1 generation relay connects the OpTIC Centre to Manweb/Scottish Power's network. The building has a 24-hour electricity load to run its clean rooms, so under normal conditions electricity is not exported from the site.

The project team had to change the PV technology mid-way through the design of the building. The team had intended to use cadmium telluride cells supplied by German firm Antec, but Antec ceased trading, so they decided to substitute Shell's CIS cells instead.

This, in turn, meant that the original design for fixing the cells could not be used. They had to come up with special brackets, fixed to a water-proof 'standing seam' layer. Inevitably, this pushed up cost.

Technical specification

Module type:	Shell ST36 CIS (thin film glass-tedlar)
Power rating:	36 Wp
Module efficiency:	10 %
Active module area:	0.49 m² (1,400 x 350 mm)
Sub array arrangement:	One continuous array
Sub array sizes (kWp):	6 x 4.6, 1 x 5.04, 7 x 6.48, 1 x 7.2
Array inclination:	various
Array orientation:	due south
Inverter type:	Siemens Sitop
Mounting clips:	Alumasc
Total number of modules:	2,368
Total area:	1,176m²
Total system size:	85 kWp

On top of this came scheduling problems in the construction stage, leading PV Systems Ltd to revisit the site. This meant that the project was not completed on schedule.

However, on the positive side, none of the PV panels were broken during installation on site. Twelve panels were rejected during off-site assembly, but PV Systems had ordered extra panels as a contingency for this, so it did not affect the programme.

The total cost of the building was some £11 million, of which £4.9 million came from the European Development Fund via the Objective 1 Programme and £4.2 million was secured from the Welsh Assembly. This funding was instrumental in realising the project. The remaining funding came from the Welsh Development Agency's own budget.

The total cost of installing the PV system was £411,000. The cost of installing a simpler non-PV glazed curtain wall system was estimated at £87,500.

The cost/kW of the PV system rose from £4,273 to £4,835, largely because of the forced change in PV technology. The DTI provided funding of £360,000 towards the cost of the PV system, covering 88% of the PV costs (excluding commissioning and monitoring).

Lessons learnt

Important lessons relating to design, logistics and installation emerged over the course of this project. On the design side, the client emphasised how important it is to involve the PV contractor as early as possible - ideally during detail design and before components are specified. This helps to ensure that the PV design integrates smoothly with other aspects of building design.

Regarding logistics, it was possible to engineer out the variability of site work by part-assembling the PV panels in segments, off-site. This resulted in a remarkably defect-free assembly when the contractors came to carry out their work on site.

In addition, there was insufficient storage space on site for all of the PV components, so these were delivered in lockable containers, which protected them from theft or damage until they were installed.

As for installation, the project team had been concerned that the complex shape of prefabricated sections might not align perfectly with the substructure built to support them on site. However, appropriate care during construction meant that the components did fit together properly, and proved that building in this way can contribute to high quality PV systems.

Another issue to surface during installation was the danger of appointing a main contractor with little experience of PV. If the main contractor is daunted by the prospect of working with a PV system, this inevitably

Costs

	£	
Equipment		
PV modules	232,000	
Inverters	43,000	
Monitoring equipment	26,000	
		301,000
PV sub-structure		78,000
Other installation materials		32,000
(Roof mounting materials, sub-array mounting frames and fasteners, cabling, junction boxes and isolators.)		
Total*		411,000

*Excluding monitoring and commissioning costs.

The project team's effort in design and construction (below) was rewarded by the construction press: the OpTIC Centre picked up Building's Sustainable Building of the Year award in November 2005.

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delays the solar installer's work, which may have implications for the completion date.

Monitoring

Monitoring at the OpTIC Centre includes sensors for ambient temperature, cell temperature and irradiance. There are also six PV reference cells, fitted to provide insolation data for comparison .

Additional meters were fitted as a cross-check because of inaccuracies with inverter electricity metering. The output from three sub-arrays was measured with Class 1 kWh meters. All of the monitoring data feeds into a PC in the plantroom.

People using the building have immediate access to information about the PV system's output. There is a large plasma display screen in the reception, updated in real time, showing how much electricity is being generated.

Overall the system operated well over the monitoring period. With the exception of a few teething problems in the first two months and intermittent hitches with the monitoring software, the installation has been a major success.

The project team estimated annual energy generation from the PV system at about 70 MWh, compared to estimated energy use in the building of 1,324 MWh. Thus annual electricity generation was expected to meet around 5% of the building's total energy consumption.

The actual output for 2005 was 68 MW (see graph, opposite). PV met 6.5% of the building's electricity demand for the year, which was lower than expected, and so the renewable contribution exceeded the anticipated proportion.

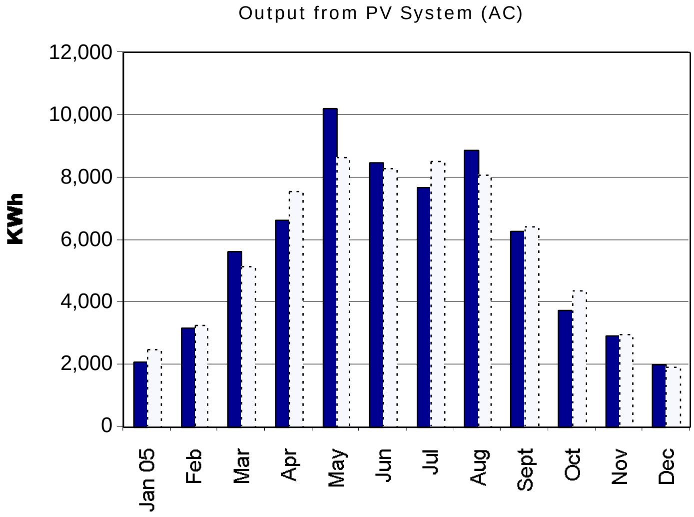
The exceptional performance in May - when the output for the month was more than 10,000 kWh - was due to unusually sunny weather. A total of 205,000 kWh of solar energy struck the PV array in May 2005, compared to only 154,000 in May the previous year.

The annual CO_2 savings from the PV at design stage were estimated at around 30 tonnes. Actual savings for 2005 were more or less on target at 29 tonnes.

References

Cross B (2004) OpTIC Centre, St Asaph, N Wales, UK Renewable Energy World, March-April 2004

The copper indium diselenide modules wrap around part of the roof and the south facade.



Total electricity output for 2005 was 68 MWh. The dotted columns show predicted output, and there is a close match.

Contract details

Client:	Welsh Development Agency
Architect:	Capita Percy Thomas
Project Management	Bucknall Austin
Engineers & sustainability:	URS Corporation
Main contractor:	Shepherd Construction
PV contractor:	PV Systems
Roofing contractor:	Roofdec
Electricity distribution company:	Manweb/Scottish Power

Key dates

Building completed:	February 2004
PV work carried out:	November-December 2003

Summary in numbers

Total PV system output 2005	67,635 kWh/y
Power used in building	1,035,830 kWh/y
Power imported to building	968,193 kWh/y
Gas consumption in building	208,161 kWh/y
Proportion of power generated by PV	6.5%

Further information

Information available on:
www.dti.gov.uk/renewables

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