SOLAR PLUS STORAGE

Second active building arrives in Swansea

A combination of solar photovoltaic and thermal technologies, plus battery and thermal storage, allows two buildings in Swansea to generate more energy than they use. Now the 'active' concept is to be extended to homes, as *Dr Jonny Williams* describes.

On a bright sunny day in June Swansea University welcomed over 100 people from the energy and construction sectors, academia and government to its Bay Campus to celebrate the opening of the Active Office: the UK's first energy positive office, capable of generating more solar energy than it consumes over a year.

The Active Office is the latest building to demonstrate the 'Active Buildings' design approach developed by the SPECIFIC Innovation and Knowledge Centre at the University. The centre's aim is to turn buildings from passive structures into 'active' ones using a range of functional coatings and integrated technologies to generate, store and release solar heat and electricity.

Buildings are responsible for about 40% of energy consumption and 36% of carbon dioxide emissions in the EU. Any attempt to address the energy trilemma – of an affordable, secure and low carbon energy supply – must tackle the way energy is used in our buildings and homes.

After the formal opening by Secretary of State for Wales Alun Cairns, guests gathered to discuss the challenges and opportunities in rolling out energy positive buildings more widely.

On one of three 'ideas walls' inside the Active Office, visitors were asked to write three words that described their first impressions of the building. They were universally positive: 'clever', 'inspiring', 'visionary', 'beautiful'... 'inevitable'.

With its new low carbon design approach, SPECIFIC's aim is not only to develop an affordable, repeatable technical solution, but also to support the development of market conditions that will allow it to be rolled out at scale.

It is leading change by working with both construction industry partners – to integrate products into new systems and demonstrate that they work – and with government and regulators, whose policies are critical to wider adoption.

Support for this cross-sector collaborative approach is evident in the centre's funding, which comes from the European Regional Development Fund through the Welsh government; from the UK government through Innovate UK and the Engineering and Physical Sciences Research Council; and from strategic industrial partners Tata Steel, Akzo Nobel and NSG Pilkington.

The Active Classroom (to the right) and the Active Office both demonstrate the energy positive concept
Photo: SPECIFIC

Do active buildings work?

The short answer is yes, though of course there is still much to learn. Next door to the Active Office is the Active Classroom, which is based on similar design principles and has been operational for eighteen months. In its first year of operation the Active Classroom generated 6.5 MWh of energy and consumed 8.0 MWh. Had it been connected to the grid and able to export excess electricity instead of sitting idle when its batteries were full, conservative models indicate that it could have generated 13.5 MWh – more than one-and-a-half times its consumption.

During the winter months, when there was not enough solar power, the building operated off a 24-hour trickle charge drawing less than 1 kW, while instantaneous demand was serviced by the batteries. The grid therefore saw a small, constant demand profile, which is easier to predict and manage than the peaks and troughs associated with a typical building's demand.

There is no gas supply to the building – heating is derived from solar energy by a combination of solar thermal generation, air source heat pump and an immersion heater

The 5.5 MWh excess power would be enough to fully charge 138 Nissan Leafs with a range of 168 miles each: 23,000 miles in total. Effectively, the Active Classroom could have provided enough solar power to fuel a car for a year, as well as meeting the needs of the building itself.

The Active Classroom's design has been recognised by many awards, most notably when it was chosen by The Royal Institution of Chartered Surveyors as Wales' Project of the Year in May. The judges said: 'This project is innovative, adaptable and evolving. It takes the latest advances in construction, solar power, battery and associated technologies and combines them into a comfortable, easily useable and flexible building. The techniques used are particularly suited to commercial, domestic, educational, healthcare uses and could be adapted to use across the spectrum of construction including retro-fitting of some of the technologies.'

The Active Classroom finally secured its two-way grid connection in June 2018, just before the Active Office opening event. On that day, the two buildings generated 96 kWh of electricity, of which 20 kWh was used directly, 29 kWh was stored in batteries, and 47 kWh was exported to the grid.

Now fully operational and connected, the two Active Buildings will able to share energy with each other, and with electric vehicles via three charging points. They will be used to test how the concept could be applied in an energy-resilient solar-powered community, which represents the basic building block of a smart, connected city.

The Active Office

While the Active Classroom contains some renewable energy technologies that are still under development, the Active Office uses commercially available technologies and established supply chains – repeatability was a key design consideration.

It was designed by SPECIFIC Innovation and Knowledge Centre and constructed in just eight months by Wernick under the Fusion 21 Framework, using a modular system that was manufactured off-site and erected on-site in less than a week.

The distinctive copper-coloured cladding is Tata Steel's 'Colorcoat Urban' standing seam roof and wall system manufactured from 'Colorcoat Prisma' pre-finished steel in Seren Copper. Tata Steel also supplied the three 'ideas walls' inside the building, where its 'Coretinium' composite solution product doubles as a giant whiteboard and magnetic noticeboard.

Electricity comes primarily from the 22 kWp curved photovoltaic roof, supplied by BIPVco, and is stored in a 100 kWh lithium ion phosphate battery system from Dulas.

There is no gas supply to the building – heating is derived from solar energy by a combination of solar thermal generation, air source heat pump and an immersion heater. A smart controller will use occupancy and weather forecasting information to optimise charging of a 2,000-litre water-based thermal store, which is capable of storing enough energy to provide space heating for the following day, thus enabling time-shifting of electrical heating demand.

The Active Office also features the first commercial installation of a wall-mounted photovoltaic thermal (PVT) system by Naked Energy – capable of supplying 2.4 kWp electrical energy and 9.6 kWp thermal energy. It is an example of how SPECIFIC supports young companies and technologies by demonstrating products in a real application and de-risking new product introduction, which would be difficult for commercial clients to justify.

The Active Office also features a wall-mounted photovoltaic thermal (PVT) system from Naked Energy
Photo: SPECIFIC

The intelligent systems that manage the building are underpinned by Cisco's Smart Network Architecture. Occupancy detectors and smart sensors will measure building use and deliver location-based services (such as hot-desking) as well as supporting innovative 'Internet of Things' applications. Electric vehicle (EV) charging points are also linked into the system to enable future EV management and energy sharing between vehicles and buildings.

As this list illustrates, partnership was critical for the project. Its highly accelerated design and development required extensive collaboration throughout the supply chain to ensure that deadlines were met without sacrificing innovation or the aspiration to be energy positive.

From a classroom to an office to homes

With each new building project, SPECIFIC aims not only to develop the design, but to test it in buildings with different energy usage profiles. The Active Classroom is applicable to learning environments; the Active Office will be used daily by Swansea University staff; and the next project will be Active Homes Neath, a development of 16 homes in partnership with Pobl Group, Wales' largest social housing provider, and Neath Port Talbot County Borough Council.

The Neath development is due for completion in June 2019. Eight houses and eight flats will use integrated solar roofs and battery storage, with the potential for EV charging. Their water heating will come from a solar heat collector on south facing walls, in combination with an air source heat pump. Waste heat from kitchens and bathrooms will be captured and recycled within the building using a mechanical ventilation with heat recovery (MVHR) system.

As well as reducing carbon emissions, the combined technologies will help to keep occupants' fuel bills down. An analysis by energy consultant Andris Bankovskis, based on the Neath design, estimated that household energy consumption could be cut by more than 60% in Active Homes – saving the average household over £600 a year.

In addition to consumer benefits, Bankovskis' analysis showed the impact that the design could have at national scale. One million Active Homes could:

- reduce peak generating capacity by 3 GW, equivalent to a large central power station;
- reduce carbon dioxide emissions by nearly 80mn tonnes over 40 years; and
- create benefit to the UK economy through investment in a new industry.

At the time of publication in August 2017, Bankovskis said: 'The scale of the potential impacts is compelling and demands that we make considered decisions about how we meet housing needs sustainably. It suggests that if we are prepared to take some bold decisions about the way energy is supplied and used in our homes, the rewards could be significant and lasting.'

How can national impact be achieved?

The technology is rapidly developing and the economic analysis is promising, so what needs to be done to enable wider adoption of solar-powered buildings? Is it 'inevitable', as one of the guests at the Active Office opening wrote on the ideas wall?

Back at the event, the mood was positive, but there were no illusions about the complexity of the challenge. On another wall guests were asked to note the biggest obstacles to changing the way buildings are designed and constructed. There were three recurring themes: cost, industry attitudes, and education. These are not technical challenges but economic, political and social ones.

Clearly, reducing the carbon emissions that come from buildings will require a considerable cross-sector effort. This is the challenge that SPECIFIC is attempting to address through its collaborative partnership approach.

As Ian Campbell, Executive Chair of Innovate UK, said at the Active Office opening: 'It's difficult to overstate the potential of developing a building that powers itself. The concept could genuinely revolutionise not only the construction sector but completely change how we create and use energy... Developing technologies like those demonstrated in the SPECIFIC Active Office can play a strong role in the government's modern industrial strategy to create clean growth and fulfil our mission to halve the emissions of new buildings by 2030.' ●

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