Active Building FAQs

Version 2.0, August 2020

Frequently Asked Questions

1. Carbon

Has the embodied/upfront carbon been estimated in the Active Building demonstrators?

We have focused mainly on operational carbon to date, although we did try to use low embodied carbon elements where possible, e.g. steel screw pile foundations for the Active Classroom. Concrete pad foundations were used on the Active Office as we had to use the contractor's existing supply chains, due to the timescales of the project as set by the funding. Some of the measures to reduce embodied carbon in the Active Classroom included use of recycled plastic worktops in the kitchen, made by a Welsh company called Smile Plastics; and use of carpet tiles reclaimed from a decommissioned building on the University's other campus.

A PhD student at the University of Bath (one of our academic partners) is currently (2020) undertaking a Life Cycle Assessment (LCA) of both the Active Classroom and the Active Office. We will use learnings from this research to aid future Active Building projects.

Would you describe these buildings as 'Net zero carbon'

No. They strive to be Net Zero in operational carbon but, if we include embodied carbon, we cannot yet class them as completely Net Zero Carbon.

Do these high-tech products and materials = high embodied carbon? Have studies been done to calculate the Carbon Payback Period of the various technologies?

We currently (July 2020) have a PhD student undertaking a Life Cycle Analysis (LCA) of both buildings. The way these buildings were procured meant we were unable to completely influence all the supply chain partners and specifications. The LCA should be available within the next 12 months.

We have a large team at SPECIFIC developing the next generation of printable photovoltaics (PV) that use low embodied carbon materials and manufacturing processes. Whilst mainstream PV and batteries currently tend to have high embodied carbon, studies show that (certainly for PV) the reduction in operational carbon when using PV, outweighs the embodied carbon. In our buildings we have trialled two novel types of batteries, that have lower embodied carbon than the more commonly used lithium-ion batteries – Aquion aqueous hybrid-ion and Redox Flow Batteries.

Have you evaluated embodied energy of steel versus other products?

Steel is an interesting material as most of the embodied energy is in initial manufacture, but the operational lifetime of steel once made is very long, particularly if you consider recyclability, reusability and the energy improvements of that process over time. Some elements, such as the steel screw pile foundations used for the Active Classroom, can be removed and re-used at the building's end of life. Embodied energy of the raw materials is only part of the equation when looking at circular economy and true lifetime analysis, particularly when the building is operationally net zero carbon, as we hope all Active Buildings to be.

2. Cost

Do these buildings cost more?

At the moment, yes, in terms of capital cost to construct. There needs to be more focus on Whole Life Costing (WLC) of buildings, which current procurement routes make very challenging. We are currently undertaking Life Cycle (LCC) reporting on our buildings and are also looking at the different business models around Active Buildings. At present the cost of some of the novel technology adds to the capital cost. However, with further adoption these will inevitably reduce (just look at how the cost of traditional solar panels has reduced in recent years). The balancing act is to ensure that the benefit of the capital costs is realised during the operation. At present this can be a difficult view as the capital and operational costs often sit with different departments or budgets and sometimes even organisations. However, the focus on lifetime cost should go some way to alleviate this dilemma.

Again the role of the demonstration programme is to act as early adopters and identify what the actual realisable benefits might be, what the constraints are and feed back to suppliers where applicable, to improve product performance to accelerate the development of some of these technologies and control methodologies. At present (2020) energy provision is undergoing significant change, time of use tariffs are emerging (such as Octopus Agile) and variable tariff export products are available. These products will help to determine how savings (both financial and carbon) can be made by working with the grid, utilising the generation and, more importantly, the storage capabilities of these types of buildings.

The commercialisation of Active Buildings seems to be challenging, as there are a lot of assets and technology to be implemented and put in place, among others. Are there cost benefit analyses conducted to examine costs and Simple Payback Periods for eg. the Active Building Classroom?

Yes, we have been analysing the costs and are currently undertaking LCC reporting for the buildings. Most of the technologies used on the buildings are already commercialised, so it is more about adopting the concept, rather than commercialising. With storage in particular the benefits will be heavily influenced by the control strategy (especially for larger generators), so we are focused on what those strategies might be, how you implement them, and subsequent assessment of the outcomes.

Frequently Asked Questions

3. Retrofit

Can the Active Building concept be applied to existing buildings?

Yes, there is no reason it could not be applied to existing buildings. However, the first principles are to reduce energy consumption before considering energy generation, so the more thermally efficient the building fabric, the better – this can be challenging on existing buildings. Where renewables are not suitable, energy storage, electric vehicle integration and smart controls could be used to help manage a buildings interaction with the local or national energy network, achieving what Active Buildings set out to do.

Have you done any projects on retrofit using your tech and ideas?

We are focused primarily on new build, as we are keen to prevent more new buildings from being constructed that will need retrofitting in the near future, adding to the already significant burden of retrofitting our existing building stock for Net Zero.

SPECIFIC do have a large industrial building in Margam, which was retrofitted with a Transpired Solar Collector in 2012 and also includes thermal storage. In 2019, a test rig was constructed on the south elevation of the building to test different types of solar PV and solar thermal systems. This is currently being monitored.

The Low Carbon Built Environment at the Welsh School of Architecture are involved in some retrofit projects on housing in South Wales, utilising the Active Building concept.

4. Different Building types

What about different building types?

The Active Building concept can be applied to all building types. So far, we have applied it to residential, educational, commercial, and industrial buildings. The exact solution used can be adapted according to building type.

How easily can the concept be adapted to more high rise/high density built environments?

This is yet to be determined. In principle, a lot of the components could be applicable to high-rise and high-density buildings – elements such as energy storage and intelligent controls. However, in terms of renewable energy generation, it becomes harder to generate sufficient energy from the building envelope, the taller a building is. We have not tried to apply the concept to high-rise buildings yet, although one of the challenges in designing the Office was the additional energy requirements for an office and double the internal floor area of the Classroom, so utilisation of the vertical surfaces was something we were keen to explore. This principle will be key as the surface area to volume ratio decreases.

5. Skills

Are local manufacturers/construction companies ready to support active buildings? Is there something that we as designers/architects can do to help during the designing process prior to construction phases?

The skills gap in construction has been widely documented in recent years - even just the move from gas boilers to ASHPs will cause issues, so we have a job to do in helping to upskill local manufacturers and construction companies. We worked with local supply chains and local installers on our buildings, with the hope of bringing them along on our learning journey. Building designers have a big part to play in this. One of the aims of the Active Building Toolkit is to arm designers with the right knowledge to assist projects in achieving Net Zero. We are also working with other groups within the University to develop courses for installers. These will be delivered by our sister project Metal.

Having an informed client, who shares the same Net Zero aspirations as us, for the installation of novel technologies reduces the risk for the supply chain during the initial stages of roll out. We have as much interest in knowing and understanding why things don't perform as designed as why they do and so are able to work with the supply chain to understand the issues in a collaborative manner, which for more commercial projects may be more difficult.

The main issue is going to be obtaining contractors that are technically capable of commissioning the system (and that are prepared to spend a significant volume of the allocated work programme post completion to optimise the operation). This does, however, contradict the current market trend of installing systems that are not perfect, so an optimisation package can be upsold to the client 18 months later.

6. Risk

Warranties are all well and good, but the day will come when something will need replacing. Has ease of renewal been considered?

All the services in our Active Buildings are left exposed and as such are easy to access, with minimal disruption to both building users and the building fabric. There is a danger that, where innovative technologies are used, it may be difficult to replace, but that is one of the reasons we construct our own demonstrators. We are able to take those risks, hopefully de-risking technologies before they are used more widely in the industry. Where we have used technologies and products for the first time on our buildings, the companies supplying these have benefited hugely from learning about installation methods, safety concerns, interactions with other building systems, etc. The benefit of having the demonstration buildings is that some of the maintenance issues that are identified during the lifetime can be fed into any guidance documents or back to suppliers for product development or installation changes.

Use of service agreements for technologies used could assist with limiting the risk of failure of parts. The company providing the service agreement would be responsible for replacing parts.

Frequently Asked Questions

What sort of component life cycles are expected [particularly with the technology] & how does the building perform with regard to ongoing maintenance compared to more traditional buildings?

Expected life cycles differ for each technology. The BIPVCo roof, for example, offers a 10/25-year warranty on performance. The expected life cycle of some of the newer technologies, such as the Aquion batteries used in the Active Classroom, are less well understood, which is one of the purposes of our demonstrators – to take a risk on innovative technologies and monitor significantly to gather data on their life cycles.

In 2019 we commissioned a Life-cycle Cost Comparison (LCC) Report of the Active Office, which flagged up some ongoing maintenance concerns, mainly with the innovative technologies used. Both buildings are slightly more complex than would normally be required due to the experimental nature of some of the technologies. The buildings had to work, so a certain amount of redundancy of systems was employed. This has increased the potential for maintenance costs. However, to date, no additional costs have been incurred over and above standard maintenance. The PV roof on the Active Classroom, for example, has received no maintenance since installation in 2016. The battery storage systems perform self-maintenance cycles. Much of the equipment used, such as air-source heat pumps (ASHPs), mechanical ventilation with heat recovery (MVHR) units, air-handling units (AHUs), etc, are standard building components.

Have you identified risks associated with battery storage and how have you alleviated potential hazards?

Fire is the biggest risk with battery storage. The buildings we have constructed to date are low-rise and well-monitored, so we have not experienced any issues. In terms of Building Regulations approval, Building Control Officers were happy to sign off the buildings as long as the batteries were contained in 1-hour fire rated enclosures and had appropriate extinguishers adjacent to the systems. The batteries also have their own safety cut-out measures built into them. So, we believe our battery storage is as safely managed as possible.

One of the interesting elements for battery storage is looking at the performance of non-lithium-ion storage, so the original Aquion batteries had no significant fire risk associated with them (at the cost of energy density). Similarly, the Flow batteries now installed currently do not have any thermal control issues. So alternative chemistries which, due to size or weight, are not suitable for EV or mobile storage applications, do not necessarily have the same potential hazards as their higher energy density cousins. For static storage, different requirements may result in different chemistries being more suitable and these have to be assessed and accounted for.

However, as with all innovative technologies, it will take some time for the regulations to catch up, and there may well need to be other measures brought in for different building types, such as high-rise buildings.

Although we did pressure the contractors on the Active Office to provide assurances of the low fire risk, due to the batteries being in individual steel enclosures, which they did, this is a bit of a grey area and some guidance documents state that a fire suppression system would be required whatever the size. However, this would be assessed on a case by case basis.

Have you identified barriers between building regulations and innovative technology used in active buildings? How would you tackle this throughout the designing process?

We worked closely with Building Control Officers on the design of our Active Buildings but have not experienced any significant barriers. The main issue is safety in buildings and our buildings incorporate all the necessary safety measures to satisfy Building Regulations. However, there is further research work needed to inform Building Regulations on the Net Zero solutions being developed for the built environment – renewable technologies, energy storage, off-site construction methods, etc.

7. Link to Energy Networks

Have you considered the practicalities of these types of buildings 'living' on the existing electricity network? Have you discussed with the Distribution Network Operators at all?

We have experienced some challenges with the Distribution Network Operators (DNOs) in terms of adding our buildings on to existing grid connections and are aware that there will be more challenges ahead. One of the anticipated benefits of the managed renewable generation is to support the grid, by managing the storage assets such that, during high solar generation, little to no export occurs. The energy generated is all stored locally and reduces the grid demand when the amount of solar is reduced. Another scenario may be to reduce the connection size required - where upgrades of the connection may be cost prohibitive and the demand profile is sufficiently variable, the local storage can be used as a buffer to limit peak demand by utilising local storage. In this way a much flatter demand profile could be presented to the grid, that is more predictable and lower than unbuffered usage. These scenarios can be trialled on demonstrator buildings and confidence gained in the control algorithms and performance optimised. The ability to control the renewable generation export should provide benefits for the DNO in the fact that the export or consumption is not entirely at the whim of the weather.

We are using our Active Office as a test-bed for other systems, such as operating as a Virtual Power Plant within a project called FRED, a collaborative project with Evergreen Smart Power; and an OpenLV project, which acts as a platform to explore ways that assets can interact with the grid utilising the technologies incorporated, such as heat pumps, EV chargers, battery storage and thermal storage.

The FRED Project (Flexibly-responsive energy delivery) SPECIFIC is taking part in aims to explore Demand Side Response (DSR) and its place in a low carbon energy system, using the Active Buildings to demonstrate Evergreen Smart Power's Virtual Power Plant platform with MyEnergi's zappi and eddi devices to mimic domestic heating and vehicle charging to enable flexibility in domestic energy supply.

The DNOs will need to adapt to enable solutions such as Active Buildings to operate with their existing systems if we are to reach a truly zero carbon society.

Are there thoughts of implementing Peer-to-Peer Energy Trading and Blockchain Technology?

Our Active Building demonstrators are part of the campus wide electrical network and so paid for energy trading is not possible. However, shadow trading trials using pricing or carbon data have been looked at. During these periods, the buildings would import power during either low cost or lower carbon periods and export during periods of higher cost and carbon. This ability to force import or export make the systems capable of peer-to-peer trading technically, but the use of an aggregator or standalone business models do not yet exist for what is a relatively low power asset. The real benefit of these capabilities is when there are many buildings able to work in concert to have a real benefit for the grid and surrounding infrastructure. Block chain is not something we are actively looking at, but we are aware of some of the research and activities by potential aggregators and are looking to ensure, where possible, we have the flexibility to try out scenarios with relevant partners as required.

Frequently Asked Questions

Would it be possible to integrate heat sharing networks and micro-grid Active Building designs creating two different energy flows?

In principle yes. This would be especially useful where a member of the network has either high electrical generation and low demand, or access to waste heat and low demand. Balancing the networks would be complex and storage of both would be needed to account for different time requirements – i.e. you would be very lucky if all the spare heat corresponded to when the peak demand was required, so some form of buffer would be needed. This applies to both heat and electricity (although the grid can act as a buffer in most cases.) Moving from spare electricity to heat is relatively straight forward, the opposite direction (heat to electricity) is less straight forward at low temperatures, so separate networks with limited transfer between the two is possible.

We have not yet included a heat network in any of our projects, but they do have a place in the right area with the right resources.

8. Future Climate Change Scenarios

How do the buildings relate to climate projections in the future - in 2030 or 2050?…. and overheating? Will there be pressure to retrofit cooling/ air conditioning for the comfort of occupants? And with housing in the social sector there could be a higher proportion of older adults and those with health conditions that would make them more vulnerable to summer heat waves?

They have been designed using overheating tools. A CIBSE TM54 study was undertaken on the Active Office at design stage. We advocate use of tools, such as the Good Homes Alliance Overheating tool in the design of new homes.

The air distribution system in the Active Office has been designed to take a cooling loop if required in the future. Overheating studies initially showed a small risk of overheating using the future scenario weather files, so a sensible precaution was to incorporate the ability to simply add air-conditioning at a later date using the existing building infrastructure. Air-conditioning or other cooling devices could be linked to PV systems, as cooling will be needed most on hot, sunny, summer days. Passive cooling measures, such as ceiling fans, could also be implemented (these are often overlooked as a viable measure to help reduce overheating).

During its first summer the Active Office coped reasonably well using natural ventilation and an MVHR north bypass, with only 1 or 2 days where the temperatures became slightly uncomfortable. In the research space there are technologies that can use heat to drive cooling, so having solar thermal systems that can generate sufficiently high temperatures to drive these processes is somewhere we can provide some input. We have also previously considered the use of cool stores which, while not as immediately effective as air-conditioning, would be able to cool the building and maintain comfortable levels.

We have a partner project called SUNRISE, which is looking at constructing similar buildings in India and considerations for cooling in this instance are also required.

9. Usability

Feedback on renewable tech from end users is it is complicated to operate and costly to maintain. Comments please.

As renewable technologies evolve, controls will be improved, optimised and simplified. Also, as their use increases, people will become more used to using, installing and maintaining them as standard technologies. Providing some guidance for designers, users and installers will also reduce fear and lack of awareness around renewable technologies. In addition, as with most technologies, the early implementation is often complex and of interest to a few keen individuals. However, as the technology evolves and, through the work us and others are doing, we would hope that user involvement becomes optional and the systems themselves operate either automatically or are controlled externally for revenue generation, such as aggregated grid services.

Frequently Asked Questions

How many technicians are required to maintain all these technologies? Are they practical for the average UK home?

Clearly technology can add complication to a building, but most of the technologies featured in our buildings are commercially available with a supply chain and maintenance service to support their lifetime usage. There is a skills gap in terms of the integration of systems and the interaction between smart systems, but this is something which can and is being overcome through demonstrators like ours and the data we are collating.

Current technologies which support fossil fuels and grid energy from any source also require maintenance, and we have grown accustomed to those requirements, including annual servicing of gas appliances, for instance. We have not had to maintain or even touch the solar BIPVCo roof since its installation in 2016, and it is warrantied to the industry standard. By way of a domestic example, we partnered on a project with POBL housing and Neath Port Talbot Council to design and build 16 homes incorporating these technologies. You can find more about the Active Homes Neath project here. So, yes they are practical for the average new build home, if the design incorporates Active Building principles from the start. Retrofit is more challenging as we would encourage a fabric first approach, ensuring that efforts have been made to increase insulation and building performance before retrofitting technology “solutions” without full consideration of their performance parameters and how the energy will be utilised.

10. Electric Vehicle Integration

Electric vehicle provision makes for a very vehicle orientated external works area. If public transport is used in preference, then external spaces could be more pedestrian and cycle friendly.

Not necessarily. EV charging can be designed within a mainly “green infrastructure” oriented external landscaping scheme. While we would advocate use of public transport and active travel (including e-bikes), there will always be the need for some cars and vans and incorporating EV charging will encourage use of electric cars and vans. These can then be used to help balance the energy loads between the building and the grid. Even the most sustainable housing schemes incorporate EV charging spaces, some also including e-pool cars for use by residents (see Sero Homes).

We are also working on designs for Active Bike Shelters, which will incorporate charging points for e-bikes, charging sockets for bike lights, pumps, etc.

Also, while our charging infrastructure is close to the buildings, with sufficient planning and ductwork, the charging infrastructure could be linked to, but physically remote from the buildings (with some limitations based on cables sizes and cost, etc) – the systems visibility of the charging infrastructure is all that is needed for the building and charging systems to be able to work together, making use of spare capacity when available, or turning down charging when constrained; and in the future, as more vehicle to grid (V2G) assets exist, maybe even loaning power to the building during periods of peak demand or short term high cost.

11. Technical

What output in W/m^2 can you get from the radiant panels? (Referring to the underfloor heating in the Active Classroom)

The panel is designed to provide up to $200W/m^2$. The ink formulation and resistor pattern has been engineered for this application. Different formulations and patterns can provide different power densities. The system is also fully modulated through a control mechanism to provide thermostatically controlled room temperatures for your chosen set point. More information on this resistive heating system can be found here.

Is there cooling behind the integrated solar panels?

No, the PV system we used doesn't suffer from the same overheating problems that silicon in glass panels do, so there is no need to cool.

How much output W/m^2 from the solar wall? (answered for both the TSC and Naked Energy VirtuPVT)

Transpired Solar Collector (TSC), Active Classroom – more information about this cladding/heating system is available on Tata's website here and here . They say typically 200-250kWh/year per m^2, with a seasonal variation in peak from zero to $600Wm^2$. We have seen temperature differentials as much as +20C from ambient external.

Naked Energy VirtuPVT, Active Office - It generates both electricity and heat, more details here. The W/m^2 varies depending on angle of inclination, etc. In our system, we have 40 tubes, which provides the opportunity for up to $9.6kWp_{th}$ and 2.4kWp electrical generation, totalling approximately $500W/m^2$ combined. Obviously, this is entirely dependent on available energy from the Sun.

It is worth noting here that we de-tuned the angle on inclination for summer generation – the angle we have chosen is better suited to autumn / spring months where you need heating and stand some chance of still having Sun. This flattens and broadens the annual generation profile. This means they are less efficient in summer than they could be – but generate more in shoulder months when we are more likely to need the energy for heating.

Are there thoughts of deploying and testing advanced thermal storage technologies? e.g. related to phase change materials or even thermochemical storage materials?

We have a very established research group investigating thermochemical storage. Details on our website here. Much has been done with this already on our demonstrator buildings, particularly the SHED (Solar Heat Energy Demonstrator). We deployed a working demonstrator of this material at scale, and since then have been working in the lab refining and investigating the material characteristics and limitations to improve efficiency.

12. Pandemic Response

How does the Active Building concept consider the challenges of epidemics and pandemics, given that the occurrence of epidemics and pandemics are becoming recurring issues?

Designing for a post-pandemic world is not a new phenomenon, as an article written for The Guardian in April 2020 explains – since the 19th century, diseases such as cholera, the bubonic plague and tuberculosis have all helped shape the built environment we know and live in today.

The main way Active Buildings respond to pandemics is through ensuring buildings are well-ventilated and maintain excellent indoor air quality (IAQ). Active Buildings promote provision of good IAQ through high levels of controlled ventilation and monitoring of HVAC equipment, to ensure air handling systems are always operating efficiently and effectively. In an Active Building either natural ventilation, mechanical ventilation, or mixed-mode ventilation strategies can be adopted, depending on the building type, location, activities within a building, or storey height, for example. Where mechanical systems are used, it is critical that they are maintained properly, and filters changed regularly, to minimise pollutants and spread of germs. This can be factored into planned maintenance strategies. Robust data monitoring will flag up any issues with ventilation levels and provide reminders for changing filters or servicing equipment.

The Active Building concept also promotes the creation of good quality places between buildings and the inclusion of as much green infrastructure as possible. All buildings form just one part of communities of buildings that make up our built environment. Therefore, careful consideration of the places formed in the spaces between buildings is just as important as the internal spaces. External spaces should include provision of green or blue spaces – grass, trees and other vegetation; and water features – on, or around a building, to benefit physical and psychological wellbeing, improve air quality, and ensure the built environment is resilient to climate change and associated extreme weather events, as well as pandemics.

For more thoughts on the future design of buildings, see Active Architecture blog post:
http://designingactivebuildings.blog/2020/06/26/39building-design-for-the-future/

