Episode 106

An Energy Positive House That Addresses Cost, Performance and Buildability

The show notes: www.houseplanninghelp.com/106

Intro: My guest is Professor Phil Jones from the Welsh School of Architecture at Cardiff University. We're going to be looking at one of their case studies, which they have designed and built themselves and are currently monitoring.

I started by asking Phil to tell me a little about himself.

Phil: I'm Research Professor at the Welsh School of Architecture in Cardiff University. I'm a building physicist by background and I've been working on sustainability and energy in the built environment for some time, and we work at building and urban scale. I also get involved in quite a few design projects, so I've worked on, as an environmental designer really, on a number of projects over the past 15/20 years. Mainly commercial buildings, but also smaller buildings and urban scale projects as well.

Ben: We're going to talk about the first carbon positive house that is a project that's been created there. Maybe you can explain why? Why was that what we wanted to achieve in the first place?

Phil: Well we've been working on these ideas of low energy housing and sustainable housing for some time. And as part of our Low Carbon Research Institute which has been up and running for about 7 or 8 years now, we've been developing a number of new technologies with industry. Mainly in Wales, working with TATA on steel components, working with the timber industry, working with components and we had the chance to design and construct a house. And the aim was to make it energy positive so that over the year it generates more energy than it uses.

So we were able to use a number of these technologies that we were working on at a sort of research and development level, into a real building. And the aim was to try and use a, what we call systems approach, to integrate the technologies together and to integrate the technologies into the architecture.

So the house has renewable energy. The energy demand of the house, both power and heat, has been reduced to round about Passivhaus performance, and we incorporate energy storage for both thermal and electricity.

So we were able to bring these technologies together and demonstrate in this house. So the solar electricity is used for the lights and the small power. It's used to run the heat pump which we use as part of the heating system. Then it charges the batteries, then it heats hot water. If we've got any leftover then we export to the grid, which is usually in the summer time.

The thermal system, we start off by bringing air into the building through a transpired solar collector, which is an air collector wall on the south elevation. When the sun is out that preheats the air. It then comes through a mechanical ventilation heat recovery system where it picks up some heat from the air being exhausted, and then the air is topped up with heat from a heat pump, and that's used to heat the house.

So we heat the house with a ventilation system. The exhaust air comes from the wet spaces, the kitchens, the bathrooms, and that goes through the mechanical ventilation heat recovery system. So it passes some heat to the air coming into the building, and then we have the heat pump which takes heat out of the exhaust air before it's exhausted to the outside. And that then transfers the heat to the supply air for space heating, or if domestic hot water is needed then it switches to providing the hot water.

So it's quite a small heat pump. It's only about 450W. But it's quite efficient because it always works on the exhaust air which is always at internal air temperature. So unlike an air source heat pump, which can work on outside temperatures down to below zero, which is not very efficient, our heat pump operates at a constant efficiency. So the whole thing comes together then.

We optimise at the systems level. The PV panel is the roof of the building, so we don't bolt it on to an existing roof, and the solar air collector is part of the wall of the building. So we integrate the technologies together and then we integrate them into the architecture of the building.

Ben: That obviously looks good from an architectural point of view. Renewables though, they're gadgets that are going to break. So how will you deal with that situation down the line?

Phil: The air collector, the solar air collector, is just a metal sheet with holes in, so there's very little to go wrong. The air is pulled into the building through the mechanical ventilation heat recovery system, and these are fairly tried and tested systems now. PV systems are quite common place, so that shouldn't be a problem. We have batteries for electricity storage. They're lithium batteries and now they're quite widely used. The aim for this project really was to use off the shelf technologies, so we're not using anything that hasn't been tried and tested and is available through the normal supply chains.

Ben: This is buildability that we're talking about here? The ease of making it happen.

Phil: Yes, so all the components are readily available and also we've used existing skills and contractors. All of them really local to construct the house, so it can be constructed with the usual supply chains.

Ben: And did you have any difficulties or challenges to try and get to the standard you were looking at with the existing supply chain?

Phil: Not really. I guess the newest product is the heating system which combines the mechanical ventilation heat recovery, with the heat pump, and with the thermal water storage. That comes as a unit. It's off the shelf but there aren't that many of them around at the moment. So that was probably the most difficult thing to source because you couldn't get it down the local shop so to speak. But otherwise everything was quite easy to get hold of.

Ben: I'm certainly a person who likes the simplicity route, that anything that can make the process simpler, can take away the technology and let the building do all of the work, so I understand why producing renewable energy on site is a good idea, but there's a side of me that says is it really the optimal place to be doing it. Isn't that what solar farms or somewhere where we've got a much better control of the energy we're creating?

Phil: That's a sort of top down view I guess of looking at it. And then you distribute it through the usual grid structures and that's part of the equation if you like. I think the problem comes is when we have too much renewable energy going into the grid at a time when maybe the demand isn't there.

Our approach has been to use more bottom up way of doing things. So we generate locally and you don't get distribution losses for example, you don't get failures which may be a problem in future.

So you're reasonably autonomous and we use as much of the energy in the building as possible. And that's really to also take the stress off the grid system. So at the moment the solar PV systems on buildings tend to just push it into the grid, and I think there's a limit to how long that can go on for.

So our approach is to do as much as we can locally with the energy, provide a reasonable level of autonomy, but also accepting that we will be using the grid for times that we're not generating locally, and we'll be putting back into the grid. But in future we would hope that that could be controlled so that it can take from the grid and put into the grid at the best time for the grid.

Ben: Is this also about resilience? I know that you say that these houses may need the grid at a certain stage, but presumably they have the capacity, or near the capacity, to look after themselves?

Phil: They're about 75% autonomous. That's our predictions. But over the whole year they put in roughly 70% more energy to the grid than they take out. So they're energy positive in that way. Of course when the sun doesn't shine, because these houses rely mainly on solar renewables, we have to take from the grid. So there will be times in the winter when we are relying on the grid when the sun doesn't shine for a few days and the batteries run flat.

Ben: Can I go back to collection for a moment, because that's been one of the big challenges in the past, and I don't know whether things are getting better. You mentioned the lithium battery but as far as I can understand these things are quite clunky, they're big. So how is that technology coming along?

Phil: It's developing at a fast pace really. When we first started to design the house, which was just over a year ago, we were going to use lead acid batteries. We were worried about weight and safety. We beefed up the structure of the roof space because that's where we planned to put them. And they were going to sit on the floor. Lead acid batteries you can only discharge them to about 50% of their capacity, otherwise you reduce their lifetime. So even though they are a particular size, really the capacity is half that.

Lithium on the other hand is much lighter. You can discharge them to about 20% of their capacity, so even though they were more expensive, for the same size of battery you had more capacity to work with. And so the cost was coming down at the time so we went for lithium. They bolt to the wall, so they're not particularly heavy. They're quite neat and tidy, and don't need any real sort of maintenance or anything from the occupants.

Since we've put the batteries in our house they've come down in price again, probably I think we can get them now for half the price that we paid. Tesla are now bringing out, they have a battery that they market for housing and I think it's around 7kWh and that's round about £3500 I think. The costs are predicted to come down even further.

Ben: And the lifespan?

Phil: Well that remains to be seen. We expect to get a reasonable use out of them and we're hoping for about 10 years. But that's one of the things that we need to be looking at of course. At the moment I don't think it's very easy to recycle them, but it is possible to recycle them but at a cost. But I'm sure these costs will come down as the technologies develop.

Ben: So this project, one of the key factors was all about cost. We've talked about buildability, how else have you been able to keep the costs low?

Phil: Well some things have cost more. The heating system has cost more, the battery systems for example add on costs.

But we are able to save costs as well. We don't have a wet heating system so we don't have radiators. We heat with the ventilation system so that reduces costs and it reduces wet services around the building. Also it creates more space in the houses. Radiators often inhibit space use so we've got far more flexibility of space use.

The PV panel, because it's a roof as well as the panel, it fulfils two purposes. So the PV roof is not that much more expensive than a normal roof.

The air collector is part of the wall construction, so there are certain costs that have offset other costs. So cost increases have been offset by cost reductions, so we think we can bring the costs of this in at around about the price of a standard social house, or the price of something that's produced by a quality private developer. We're not competing with the mass house builders because they build at a very low cost, but we're aiming for quality and provide something that doesn't cost the occupiers much if at all in energy.

Ben: And talking about those running costs, do you have an example? Because I have a feeling there's no one living in it is there?

Phil: Well we occupy the building.

Ben: Oh okay, I'm wrong.

Phil: But not as a house. So it's occupied every day. We have office type activities going on there. We use it as a meeting place. I'm usually there a couple of times a week so it is heated and we are sort of aware of the conditions inside and we're monitoring it.

The aim first is to test the technology and its integration into the architecture, so we're monitoring the building quite closely to assess the performance of the various pieces of equipment. We then plan to carry out simulated occupancy to get a better idea of how it performs with a day and night occupancy with using the cookers and small power, but also drawing off hot water etc. So we are planning to do that to see what the energy use is likely to be, or the energy performance, under normal occupancy.

Ben: How much of this is about ticking all these boxes, making it affordable, making it perform well and buildable, and how much is actually about creating something that's architecturally going to work, perhaps on a bigger scale?

Phil: Well the idea is that it can be replicated. It was designed as really for social housing. It's $100m^2$ so it's quite generous spatially. But a lot of private developers have been interested in it as well. So the idea is that it can be replicated.

The architecture of the building, it turns out to be a result of bringing together and optimising at a systems level both the technology and the building construction. Some people think the aesthetic is good. Most of the general public who come there, and we've had hundreds of people come on open days and have seen it on the internet, I don't think we've had any negative response. It's been extraordinary the amount of support that we've had. So generally people like it as it is, but the principles that we're using can be adjusted to suit different aesthetics.

It can also be adjusted to suit different building types. The system that we're using would be particularly good for schools or care homes for example, or even commercial buildings / industrial buildings. So I think what we have is something that's replicable at scale in terms of housing and to other building types.

Ben: Can you talk through the construction then and exactly what is in the fabric?

Phil: Well we've used a SIPs panel construction which is two layers of timber with insulation bonded between. That's cut off-site, so it's delivered off-site as a sort of flat pack, so it's easy to construct.

The south facing roof is a PV panel. The north facing roof is a standing seam metal panel. That's smaller than the south facing. The roof is biased towards the south. There's a render applied to the outside, except where the thermal air collector is, which is a metal cladding really.

The windows, we've worked quite a bit with big industries. NSG Pilkingtons have helped us a lot with the glazing systems and with the glass for the PV roof. BASF have been supporting us because they provide the sort of thermal insulation and the renders and the paints. TATA steel have been supporting us. They provide the transpired solar collector. We've been working with them for about 6 or 7 years on these technologies.

So the construction methods are fairly standard, but we have had a lot of interest from big industries as well as the small local suppliers. The construction programme itself took 16 weeks from start to finish. If you go into YouTube and type in Solcer House you can see the whole process.

Ben: We'll link it in in the show notes so we can see some of that. It's quite interesting to hear you talk about. Did you start designing it little over 18 months ago and then complete it all in this short space of time? And why, what do you credit that to?

Phil: Well we knew what we wanted to do. We've been working in this field for some time. We've designed and constructed other buildings. If you go back to around about 2000 we did the first BREEAM excellent industrial building on the Baglan Energy Park in Port Talbot, and that was a building that integrated PV renewables into the facade. We worked with TATA and the Welsh government and we designed and constructed a research centre up at Shotton in North Wales, where again we were looking at integrating renewables into a low energy building design. And that has been the centre where we've carried out the research into some of these areas as well. So we've had a history of doing things.

So we knew the sort of technologies that we wanted to optimise into this process. So it's really not optimising at a component level, it's optimising at a systems level, and accepting that some of the components may not be fully optimised at this point in time. But it's only when you put things into a system that you really start to make the benefits in performance and cost and reliability etc.

So we had some funding through the Wales European Funding Office, structural funds, and we convinced the funder that this was a good project to do. We designed it fairly quickly and we had to spend the money fairly quickly, so that was an incentive to get it done! [Ben laughs.] As with all these sort of projects.

So we took control of the construction ourselves, so rather than going out for a turnkey sort of solution, we managed the project but we appointed a construction manager on site to manage the contractors and the site work. It worked out really well because we were able to keep control over the project. Not to be persuaded to change things for various reasons which I think might have happened had we gone out to just one contractor.

And also we were able to keep an eye on the costs and to make sure that we kept within budgets. Although we understood the budgets, so it was a good experience. So the 16 weeks was with us doing it and we're not house builders. If a professional house builder took up these ideas they could probably reduce that time considerably.

Ben: Let's just hang on that for a second. Professional house builders, as you've already mentioned, work to a very low budget. Why are they not trying to embrace better ways of building?

Phil: Well I think there are three types of house builder. One is the mass house builders who follow the building regulations and don't want to change. They won't do anything new until they have to. They have standard house types, they have a culture, they have a product that they sell and this isn't that product. They could do it, and they could probably do it for not much difference in cost. They choose not to. And they actually resist change, so they tend to not be supportive to any change in building regulations for example. But they produce a product and although they've been to see the house, they are interested, I don't think it's something that they will do at the present time.

The social housing, who have a responsibility to the tenants to those issues of fuel poverty, and they tend to build at a slightly higher cost. They're interested because it's not just about the cost of the house, it's about the performance over time and giving people a house that they can afford to live in into the future. So they're interested.

The smaller scale developers I think see this as a market opportunity. I said there's a huge response from the public saying why can't we have this sort of house. And I think these sort of small scale developers will come into the market and provide that demand because there is a demand for these houses. People who see it want it and they're slightly confused about why all houses can't perform like this.

Ben: Finally then, what have you learnt through going through this whole process? Or would do differently?

Phil: Well, what would we do differently? What we've been learning is the way of doing things from the supply chain, so we've worked very closely with the supply chains. They've got the benefits of working on this project and some of them are now replicating it on other buildings, so they're able to get work because they've got this background now. And we've learnt from them about the difficulties or whatever issues there are.

I think we're over 90% there in what we set out to achieve. There are details that we would change but they're usually very minor and often aesthetic. We will be monitoring the building over this heating season and into the future and we will be looking closely at the performance and we do expect to see areas where we can improve things. So further improve the performance. At the moment we're just going into this heating season. The initial results from the components are good but I suspect that there will be areas, I hope that there will be areas where we can get further improvements.

Ben: Phil, thank you very much.

Phil: Thank you very much. Thanks.