

## Episode 172

# The impact of setting your energy target with John Palmer from Enhabit

The show notes: [www.houseplanninghelp.com/172](http://www.houseplanninghelp.com/172)

**Intro:** Many self-builders have heard of the Passivhaus standard but may not know what is necessary to achieve this or whether it is a realistic target for their own project. In this episode we're talking to John Palmer, Managing Director of Enhabit, about improving building performance, efficiency and comfort levels. I started by asking John to tell me a little bit about his background.

**John:** My name's John Palmer. I'm the managing director of Enhabit. We have really tasked ourselves with improving building performance, building efficiency and also the comfort levels within buildings.

My background is a little bit unusual. Prior to getting into the built environment, I spent 16 years in the Royal Navy as a weapon engineer officer. So an engineer. And then when I left the Navy, I stayed as an engineer but transitioned into the built environment, qualifying as a Passivhaus consultant, a SAP assessor and a BRE assessor as well.

**Ben:** Today I want to look at a subject that comes up from time to time. Maybe I bump into someone at one of the shows and they're thinking 'do I want to go to Passivhaus standard?'

Invariably, they've spoken to someone along the way who's perhaps said it's not worth it. They probably haven't done it themselves but class themselves as an expert, which I always find a bit bizarre. If they'd done it themselves and said no, don't go down here then that's fair enough.

I just want to flesh this out a little bit today, what it means if you perhaps don't aim for Passivhaus standard and you aim for something less. I was chatting to one of our hub members, David Langton, and he wants to go a little bit less but he was a bit confused in this area, with what exactly he should be aiming for.

So, where is the logical place to start in this discussion?

John: This is a question we get a lot with our clients, particularly in a retrofit scenario but also in new build as well. It's very understandable because if you look at Passivhaus as a set of criteria instead of numbers, the natural reaction is 'what happens if we don't quite meet those numbers? Is my house going to be any less efficient or any less comfortable?'

Of course, the answer is perhaps, not really, to some degree. It all depends.

I think the first thing to look at is to understand for your particular project, what the implications are of getting to Passivhaus. So you might have already started off with a design. That design will have a certain form factor, a certain shape to the house which in Passivhaus terms is the ratio of your liveable area to your outside heat loss area.

So if you've designed a very fancy shaped building then it's going to be quite hard to get that to Passivhaus which means you've got to perhaps compromise quite a lot on your architectural aspirations on your form. But perhaps that's not the case. Perhaps it's a fairly straightforward shape and maybe the things you've got to look at are the specification of your insulation, your glazing, that kind of thing.

The first thing really to do is look at what you have in mind for your project and get an idea of what the implications are to get to Passivhaus because it might be that if you've taken some good advice from your architect or other advisors and you've put in a very high performing fabric from the start, it might be that there isn't that much more to get to Passivhaus. It might be that you only really need to put in an MVHR – Mechanical Ventilation with Heat Recovery – system and you might be almost there. So there might not be many implications.

However, what might also be the case is that you haven't gone quite far enough with your fabric and you need to make some changes. We find this particularly in retrofit where it is actually quite hard to get down to the levels for Passivhaus. At that point, you then need to start making some decisions.

You'd need to look at what does that mean to your floor space, if you've got to increase the thickness of your walls. It might be that you've come a bit late and your planning permission is already in and you realise that you now need 400mm walls instead of 350mm walls. What do you do? Do you lose some floor space inside? Do

you go back to the planners? Do you say 'I want a bit more?' So there are some decisions there.

Understanding what the implications are and whether they are significant implications that you can live with, I think, is the first stage.

After that stage, you then need to get to the question I posed at the beginning. 'What does that actually mean to me?'

I'll pick one of the Passivhaus criteria. There are a number of criteria but the most significant and most difficult to get to normally is your annual space heating demand. If you're building a Passivhaus, you need to get that down to 15 kilowatt hours per m<sup>2</sup> per year. That's a very specific number.

Let's say you've done some analysis and you've looked at what it would take you to get down there and you've decided that you just can't get there, for whatever reason it might be, and that actually, what your advisors and people who are modelling it for you might tell you is that you can get down to 30 instead of 15 and you think that's a good number.

What that actually means to you in terms of living in that house is then the question you need to ask yourself. In purely energy terms, it's an easy question to answer. Actually, it's going to cost you twice as much to heat that property in any given year than it would've done if it was a Passivhaus.

That might seem a bit of a disaster but if you think about the fact that heating a Passivhaus costs very, very little then doubling very little still isn't that much and still will be significantly better than probably all new-build properties in the UK.

So it's not actually a disaster. It'll cost you a bit more to heat. However, the other factor which is a bit more difficult to get to is Passivhaus is very much also based, in addition to energy, on comfort levels. These numbers aren't just picked out of the air, in most cases they're picked to correspond with issues which affect comfort in the final house. So it might be to do with constant temperatures, no condensation, no mould, thermal bridges or windows, fresh, good air quality, that kind of thing.

All these parameters are thrown into Passivhaus. People naturally assume because they're numbers, that they are associated with the energy demand at the end but actually, they are more closely linked, in many respects, to comfort levels.

Now, doubling your space heating demand from 15 to 30, what does that mean to comfort levels? That's a very difficult question to answer because how have you not achieved Passivhaus? You might have not quite got enough insulation in your walls, for example. So that means overall, your heat loss is a bit high from your walls. But if the walls are still pretty good then you're not going to have issues with feeling cold off the walls, they're still going to work pretty efficiently.

However, if you haven't paid attention to the joints where the walls meet the ground floor or the eaves, then what you might have ended up with there is thermal bridging. What that might lead to, if it's bad enough, is some noticeable cold spots, which could have condensation and mould. You could end up with areas of certain rooms which feel cold.

If, for example, you've compromised on your window specification and you've got quite a lot of glazing which isn't triple glazed or is perhaps not brilliant quality double glazing then, whilst overall you might be maintaining your 30 kilowatt hours or whatever you've got to, in those rooms you actually might feel cold at certain times of the year because you're going to get radiate cold coming off that glazing.

What I'm saying is that you cannot just say 'I've not quite made Passivhaus but it just means my energy bills are going to be that little bit worse.' If you're not going to go for Passivhaus, you actually need to be quite careful in looking at the reasons why you haven't got to Passivhaus and making sure that those specific reasons aren't red lines for you or things that are going to cause you discomfort in your finished house.

Ben: Is cost often what is driving this?

John: Inevitably, yes. When you're talking about Passivhaus, there are basically three areas of cost increase over a normal house.

The first one is insulation because Passivhaus very simply works on improved U-values, improved overall insulation. To get improved U-values, there's no way around it, you need to put more insulation. More insulation costs more. However, that amount of insulation, the cost of putting in let's say a 150mm insulation versus 100mm, the labour costs are exactly the same. It's just your materials cost. Now the materials cost for insulation isn't huge. It's a very small amount. Maybe about half a percent on your overall costs.

The next bit is triple glazing. Any Passivhaus will need to have if not all, the vast majority of the glazing triple glazed. That's a) for your thermal performance, because it purely is better performing than double glazing in terms of keeping your heat in, and b) the fact that because of that extra performance, you will always guarantee surface temperatures of 17° or above at any time of the year. What that means is you won't get condensation and you won't get mould. So that's a comfort thing as well.

There's no denying that triple glazing costs more than double glazing but having said that, the gap is closing and if you are considering going for high quality double glazing, there are products out there now for triple glazing which are not too far away. But there is still a cost premium.

The final area of premium is your ventilation system which obviously, in a typical house, you only need to put in trickle vents in your windows and extract fans in your bathroom and kitchen and that ticks the ventilation box as far as building regs are concerned.

For Passivhaus, that's not going to cut it. You need to put in mechanical ventilation with heat recovery. For an average sized house, that will be maybe £9-10,000 to procure and install.

Those are the three main areas of cost, certainly in a new build. Retrofit gets a bit more complicated but certainly on a new build, those are the three main areas of cost.

You're absolutely right. When people start getting into their project and the nitty-gritty and budgets are tight and 'am I going to have an extra bathroom down there?' Or 'am I going to be able to pay for the landscaping and groundworks at the end?' Then, every item of the budget is scrutinised.

We will often find that people will compromise, step back and maybe go for a different type of glazing or the ventilation system but the thing I would say is if you are in that situation then the cost saving on insulation is the worst type of cost saving you can have. Because in terms of your return on investment for increasing the insulation, that's the biggest bang for your buck.

The reason is, people get bamboozled in this world by all the technology. They'll get bamboozled by ground source heat pumps, solar panels and all these things which people will attach a green label to and tell you that you must have this for your new eco home.

The first thing I'd say is that all those items have a design life, around 20-25 years. So in 20, 25 years, you will be replacing your

solar panels with whatever the latest and greatest technology is then. You'll be replacing your boiler or your air source heat pump, whatever it might be. You won't be replacing your walls. They will be there for 80, 100 hundred years perhaps. So the extra investment you put into them at the start will repay itself time and time again.

So, to come back to your question, it is about costs. People are forced into making savings. But getting the fabric, the overall levels of insulation right, I think is the most important thing that you should push for.

Ben: A word on complexity. For me, this is an interesting one. David brought this up. He said that this is going to be more complex to get to Passivhaus and I agree with that in some respect. But I also feel, if you're going for Passivhaus, you probably pick that simple form.

So if you take your foot off the gas a bit, does that then allow you to get more complicated and actually you may be spending more on your architectural design? If it's like for like, box-box, then that's obviously not the case but I don't think it always is. I think sometimes, if you're not targeting a low-performance house, you can just relax a bit.

John: Absolutely. Passivhaus is complicated but I'd say that it doesn't have to be complicated at the build stage, the construction stage. It is more complicated at the design stage but not massively complicated. It just requires more thought upfront.

For example, in a normal build, as long as your thermal bridging is good enough to get you through building regs then you don't really need to pay any more attention to it.

What I mean by thermal bridging is let's take an example of your ground floor meeting your external wall. What you are doing there, that's the most obvious thermal bridge where what you are trying to do is transfer your loading of your walls through to your ground structure which means that you need in there some structural elements.

Now, in the main, insulation isn't a structural element. So you have to break your insulation layer somehow in order to allow the loads to be transferred. That's a very, very common problem.

In most cases, you won't really pay attention to that and it'll be good enough. Architects and builders will look at a detail and say 'that's probably going to be fine' and they're absolutely right. It'll be fine.

What you will have is a slightly colder ring around the house at ground floor level but probably not noticeable to you.

If you're doing a Passivhaus build, that's one of the key thermal bridges which you need to either eliminate or mitigate, which means it needs some more careful design. It will probably need some slightly specialist materials in there. But depending on your construction type, most of the time that can be designed out, to give you a slightly unusual detail but one which is thermal bridge free.

At the design stage, that's cost you a bit of extra time with your architect, your designer or your Passivhaus consultant. It may have cost you a very small amount of materials but it might be cost neutral. So, to get to your question of complexity, yes, it is more complex but if you put the time in upfront then it actually almost can be cost neutral further on.

To answer the broader question, can you take your foot off the gas, yes you can. One of the great strengths of Passivhaus is there is no prescription for how to meet it. You don't get a formula which says you have to build your walls out of this material, they have to have this much insulation in them and they have to be this thick etc.

All you need to do is take the building physics footprint of your building and you need to pick out those key parameters which are the Passivhaus parameters and they need to hit the targets. How you do that is completely up to you.

Because it's a holistic approach, then if you have started relaxing some of your criteria then you can choose which elements that contribute to that criteria you would wish to let off on.

Architectural form factor might be one of them. You've decided that you can't quite get to Passivhaus with the shape of house that you want and the orientation that you want, because orientation is important but because of your site etc., you might be constrained. You can't quite get there with these details but if you're going for 30 kilowatt hours per year, that means you can have the shape you want and you don't need to have walls which are 500mm thick.

So it's all about tiny compromises. Coming back to right at the beginning where we talked about how close do you want to get to it, it's all about if you let your foot off the gas, how far back you want to go. If you go too far, you end up with a standard house and you haven't really achieved anything. But as you start to get closer, then you will start to get the benefits of Passivhaus without perhaps those final bits which are just going to be too much for you to bear.

Ben: Tied into complexity, I know David was concerned about actually hiring the right people to be able to do this. I think he's based over in Wiltshire or somewhere. I'm sure people could travel. But his point was builders, architects, the cost is going to go up and that is just another contributing factor.

John: Yes, I can completely understand that. Finding people that are knowledgeable about Passivhaus, all through the spectrum from architects, consultants, M&E (mechanical and electrical) engineers, if you've got people to design your heating and hot water system, the need to understand that it's a different type of beast, this building. All the way to your builders. It will indeed be probably something that's new to them, depending on where they are in the country.

That's just a fact of life. Passivhaus is still relatively new to this country and not mainstream by any means. You will have to accept that level of overhead.

However, what I would say, is that particularly from builders, what we found is that builders are really willing to learn and they almost relish the challenge of doing something a bit more exacting and requiring more detail and more thought. They revel in achieving it.

It's interesting. If you look at a finished building and you try and give that a quality score, you can maybe do that to a certain extent on how it looks but if it's a rendered finish, for example, the outer skin and how it looks, it's actually really quite difficult to tell at that point what the building looks like internally, under the skin. So it could be quite shoddily built and you would have no idea. Builders realise that and those that take pride in their work, they are very appreciative of a mechanism of measuring how well they've done.

One of those is airtightness. Obviously, you need to hit a certain level of airtightness for Passivhaus. It's unique in being the only criteria that is not evidenced by just proving that what was designed is what's gone in. So, for your wall U-value, for example, if you show that the correct amount of insulation has gone into that wall, that wall has got that U-value. However, airtightness, you can design whatever airtightness level you want in the model but if you don't hit that level in your final air test then, you haven't got a Passivhaus. You haven't achieved it.

We've worked with some builders who take huge pride in being able to get down to those levels. You have big, hairy builders hugging each other on site when they get their final air test and they've got down to the right levels.

We've just had a recent retrofit where it's even harder to get down to the sort of levels, which on their first forensic air test, came down at 0.7 air changes per hour against a target of one. They were absolutely delighted.

Ben: Can we talk a little bit about quality control as well? If you go for Passivhaus, there is a certain amount of paperwork involved and checking that you've put the work in effectively.

John: Absolutely. This is one of the key features of Passivhaus which often gets overlooked. People tend to concentrate on the front end, the design, the energy levels etc. But people forget that Passivhaus as a standard is effectively a closed loop.

So if you want to get a certificate, in order to get to that certificate, you have to have proved that what was designed was actually what got built. That happens in a number of ways.

There are regular site inspections photographing what goes on, on-site, making sure that the design is being reflected as the building goes up, all the way through to certain levels of detail like providing invoices and receipts to show that the type of insulation that was specified is actually the type of insulation that was bought and went in and then finally, commissioning data, for example, your MVHR systems, that certificate that shows it's been commissioned and shows that the actual flow rates that it's producing are the same as the flow rates that were in the design model at the start.

So all that means – and this has been proven by many years now of Passivhaus in-use monitoring data – that the house performance at the end, in terms of its temperature, humidity, all those factors both in energy and comfort, all those factors perform as they were designed in the original model because you've got this closed-loop quality assurance control system.

This is a really important point because that doesn't exist in normal building. You've got building regulations compliance and your building control officer will come and check various points but that's only some very general boxes, in a way. They aren't going to look in great detail at the energy and comfort factors. It's mostly really a safety and compliance type of service. And that's absolutely fine because that's what it's there to do. So, in a normal build, this closing the loop, this quality assurance is simply not there.

If you are deciding to draw back from Passivhaus, perhaps for some very good reasons but you want to adhere to the Passivhaus principles, you think that building physics etc. and the criteria that

go with it are valid principles to follow, then what you should be doing is making sure that you put back in some of that quality control mechanism with your advisors, with your architects, with your Passivhaus consultants, to make sure that again, as far as possible, the Passivhaus process for making sure that what's designed gets built is followed so that you actually get the results you're expecting.

Ben: Let's look at David's situation then. If he doesn't want to go down the Passivhaus route now, what's the first thing he needs to do? Does he need to set himself a target? You talked about thirty kilowatt hours but are there any other aspects to that? Does he have to set an airtightness target too?

This is the other thing, that Passivhaus is all tied up in quite a neat bundle. So you've got to replicate this on your own part of the scale and immediately, some of the things like if you want an MVHR system, you've got to make sure that it's paying for itself in terms of energy and costs and so forth.

John: What I would say is if people are interested enough to get to this point with Passivhaus then they've obviously understood a little bit about what it's about. My advice would be if you've got this far, you either really have a guess, try and do the right thing in certain areas and maybe you'll have a stab at some U-values and try to get those down a bit or fit slightly higher specification windows.

But without doing some modelling work, that's all your doing. You're having a guess, a bit of a stab in the dark, and you will have no idea how far or how close to Passivhaus criteria you might be. Really all you're doing is trying to follow a set of general principles at that point.

My advice would be that if you've got to the point where you are interested enough to seriously consider Passivhaus, is to get some modelling work done. So, take your design, get it modelled in the Passivhaus Planning Package, PHPP, and see where you are. See if you are at 30, which actually is not that bad for a first stab, or maybe you're at 90 and miles away, for whatever reason it might be.

At least then that gives you a rough ballpark of where you are and in addition, once you've got that model, we use the Passivhaus model throughout the whole lifetime of our projects from start to finish and we use it to answer 'what if' questions at all points. So we can say 'hang on a minute, the client's got a price for that element and it's a bit higher. Perhaps if we drop the specification in this

area, maybe the gable wall for example, we're going to need to put a little bit less insulation there. But that means we need to increase somewhere else, so how much do we need? Do we need an extra 10mm in the roof?' Or whatever it might be. So we can answer those questions really quickly at that point and provide some answers.

The next stage of the design process is that we can also answer some of the mechanical heating and hot water questions because we've now got a very accurate indication of heat demand for that building. So we can say 'actually, in this case, you've got down to a very low level. We're looking at maybe a high efficiency air source heat pump with a very low output of four or five kilowatts is going to be enough.' Without having done the modelling work, we can't really answer that question.

And then the final bit, which again is really important, is we all know that compromises will happen on site during the construction phase. We will get to a point, even with a new build, where there's a little snag, there's something that's not quite as was envisaged or perhaps the materials that we wanted weren't quite available or in time etc. So we have to make a compromise, we have to make a decision, things have to change during the construction phase.

If things are changing during the construction phase and we haven't got an original model to go back to and refer to then we really don't know what the implications of those changes are. So at that point, we can go back and say 'yes, let's change the insulation here. That only makes a very small difference' or again, we have to compensate or whatever it might be.

So I'd say the important thing is to get a model done up-front. That helps you all the way through the process by answering lots of different questions but it also gives you an idea of where you are in relation to those criteria and whether you've got any chance of getting there with a little bit more effort or materials or whether just at that point, you're just going to use it as a tool in order to guide the rest of the build.

Ben: Have you got any examples, particularly with new-build, that haven't quite gone to Passivhaus, what the reasoning was behind that, how it all come out and whether you hit those targets you set yourself?

John: Yes. We've got a few. In fact, I'd say that probably the majority of our clients won't quite get to Passivhaus for whatever reason.

Ben: Have we covered all of the reasons?

John: I think so, yes. I'll give you this example in a moment but the reasons are generally cost, effort, risk and complexity. That kind of thing.

When I say, they don't quite get there, that's as a conscious decision up-front rather than halfway through deciding we're not going to make it. That's all part of being an informed choice right for the beginning.

We've had a project recently, a typical new-build in that the client wanted a masonry brick and block cavity wall construction with a fairly standard pitched roof. So a typical British build, if you like. Not a huge house. I think it was just over 200m<sup>2</sup>, something like that. A good-sized family home but not a massive Grand Designs type project.

The client came to us asking for some advice as to what sort of things they should be doing in order to get this down to be a low energy house. And again, they were in a typical space that we find people at that stage in their projects, where they had probably been around a few self-build shows, got 8,000 leaflets for air source heat pumps and been told that they have to put solar panels on and then there are these other boxes which are going to do things for them. So, all of these technology add-ons which really, in my mind, whilst many are important, they come second. The first thing is to get the fabric right.

So say we're in this kind of space and we provided them with some initial advice as to what they might want to consider. They commissioned a design review with us and what that is, is where we build a Passivhaus model of the current design as it stands. And then, after a conversation with the client, we play tunes on the model and we say 'this is where you are right now. Let's see what happens if you put triple glazing in, instead of double. Let's see what happens if we drop the airtightness from five, which is typically where we'd put a normal building regs house, down to three which is the crossover point for where an MVHR comes in, or even lower, down to 0.6 for a Passivhaus. Let's see what happens if we increase the insulation in the walls.'

All these things we play tunes on and we provide them with four or five different graduated options, with option one being just a little bit more than they were planning to do anyway, option four or five being let's throw the kitchen sink and everything else at this project and have fantastic airtightness, lots of insulation, an MVHR etc.

What that allows them to see is this is what's possible with their house, their design and this is how close they'll get to Passivhaus. We also try and give them some indications of cost for adding those extra bits and pieces on.

In this particular case, the client decided that they didn't want to go down to Passivhaus and it was, I think, a combination of issues for them. Cost was definitely a factor. The cost of the triple glazing was a factor there and also the cost of some of the extra insulation and detailing that would've been required. But also, I think it was a complexity type issue in that they had a very good local builder but a builder that hadn't done Passivhaus before. They did want to get down to under two as their target for airtightness but felt that the risk of going to 0.6 or below, which is what they'd need for Passivhaus, with an untested team, would perhaps be a bit too far and would've required an awful lot of assistance from us with on-site advice and that kind of thing, which would have started to push budgets up.

They did decide to go for an MVHR and we could spend a whole podcast session on ventilation. Personally, if it was my house, I would put MVHR in, no matter what you would achieve with airtightness and what you were doing with it. Because actually, ventilation and air quality is a completely separate discipline which Passivhaus buys into but actually is worth doing on its own. But that's perhaps for another time.

So this client decided that that's what they were going to go for. They got us to provide an airtightness strategy. We worked with the architect and the builder to decide how the airtightness was going to work. We worked with the architect to change some of the details. So we changed the external wall to ground floor junctions, put in a course of foam glass blocks which provided that thermal break between the structural layer, and we also advised them to widen the cavity by 50mm and put in a full-fill fibrous material insulation rather than what is perhaps typical, which is a solid insulation with a ventilated cavity.

So that presented one of these difficult decisions which I mentioned earlier, which is that was outside the planning application at that point, which had already come through. In that particular case, because this was a detached property on its own plot, they went back to the planners and said 'do you mind if we get 50mm bigger all the way around, to give a better cavity so we can have a better insulated house?' And in that particular case, the planner said that's fine. So it was easy to do.

We did that, we really concentrated on airtightness, a little bit of extra insulation, better detailing and an MVHR system. And the modelling for that particular client on that particular property got them down to about 37 kilowatt hours per m<sup>2</sup> per year. Which obviously is not as good as Passivhaus, but it's within the AECB Silver Standard, which is another similar criteria but measured differently. It will undoubtedly give them a very comfortable and very cost-efficient house.

Ben: Comfort you mentioned right at the end there. This is getting close to my last question. Things like comfort, acoustics, it's going to be very difficult to say how more comfortable is this, compared to a Passivhaus. But there will be something in it, won't there?

John: There will, yes. I think we touched on this right at the beginning in that comfort, the numbers, the criteria, because they're mathematical, are very easy to say if you've hit them or not and where you are. And you can work out that it'll cost you X pounds extra per year to heat.

Comfort is much more subjective. As you draw away from the Passivhaus criteria, trying to work out at what level you will begin to impact comfort starts to get quite hard. The way that we look at it is we divide comfort into a number of areas.

You've got thermal comfort. That's all about constant, even temperatures. In my house, which isn't a Passivhaus and is a leaky old Victorian end of terrace, I have really poor thermal comfort because I get stratification of temperature. The rooms tend to be hot at the ceilings where the radiators are pumping in heat but then you've got drafts and no insulation below the ground floor, so it's cold at that level.

If I'm sitting in that room in winter, typically I'll have cold feet and a hot head, which is not comfortable. Even though the average air temperature in that room will be 22°.

If you've got your all-round insulation in a Passivhaus and you've got that to a pretty good level, I'm probably talking about maybe levels slightly above what you'd expect at building regs, and you've paid attention to your thermal bridges, then you're probably going to achieve quite good temperature stratification.

So you've got temperature as an element of comfort. The next area is air quality. This is even more subjective than temperature because we're pretty good at feeling temperature, as individuals, but we aren't really very good at air quality. We can pick up on

some smells and we can normally work out when the rooms are a bit stuffy, but 'stuffy' is a non-scientific term and we don't really recognise when things are happening.

In actual fact, if you go back to the building physics that underpin Passivhaus, if you want to achieve levels of ventilation that are good enough to deal with humidity, volatile organic compounds, odours, nitrogen oxide levels, all those nasty things that we actually produce mostly ourselves within buildings and are all pollutants, then you actually need about 30m<sup>3</sup> of fresh air per person per hour moving through that property.

You're not going to get that with trickle vents and extractor fans unless you start opening windows, and that's really what the building regs modelling is based on, that it relies on people opening windows in order to get those levels of ventilation. Whereas, if you put in an MVHR system, you will get those levels of ventilation because that's what's designed into the system.

I think that my view on comfort would be that if you look at the criteria in Passivhaus in a bit more detail and maybe get someone who's experienced in this area to help you look at them and judge whether are your thermal bridges, are your details quite good or have you got some real shockers in there which are going to cause you issue? Have you got an airtightness strategy? Are you going to be able to get your airtightness down to at least below three, which is achievable for most builders even if they've got no experience? And have you actually thought about your ventilation and fresh air mechanism? It doesn't have to be an MVHR. There are other mechanisms out there which are superior to just extract fans and will give you extra ventilation and maybe not cost as much.

That would be my advice when it comes to comfort. Look at it in a bit more detail, almost forget the numbers for a little bit and see if you've done a good job on picking up on those cues that Passivhaus is giving you and see if you've reflected them in your final design.

Ben: Finally, is there anything we're missing in this conversation or anything that needs underlining?

John: Well, I think we've covered most things. My normal soap box is ventilation, closely followed by the quality assurance process. So, closing that loop.

I think that my closing piece of advice, if people are scared of Passivhaus, or not even scared of Passivhaus but they've looked at

it and decided maybe it's not for them, would be shouldn't get too involved in the numbers before understanding what Passivhaus delivers for you.

Once you've started to look at the comfort side of things, ideally – and I know it's not easy to do in this country – but ideally, having visited a Passivhaus or maybe spoken to someone who lives in a Passivhaus, to understand what it is like to live in that house.

It's interesting. We talk to people who live in a Passivhaus, the first thing they say to us is not 'you'll never guess how low my energy bills were last year' ...

Ben: 'I'm never going to live any other way again', is that what you're coming to?

John: Exactly.

Ben: I've heard that as well.

John: It's 'living in this house is amazing. It's fantastic. The air is fresh and clean the whole time. I can walk around in my bare feet without underfloor heating' etc. So it's all about the comfort experience of living in that house is what people rave about once they live in a Passivhaus, not about energy efficiency. Whereas time and time again, we get people who are interested in building to Passivhaus levels and they are talking about the numbers, the figures and the energy efficiency side of things.

So, my advice would be that energy efficiency is obviously hugely important and a great benefit of Passivhaus but it's not the be all and end all. Understand what Passivhaus can deliver from a living experience and then start making these decisions about 'is Passivhaus for me?'