

## Episode 280

# A beginner's guide to the Passivhaus standard – with Jon Bootland

The show notes: [www.houseplanninghelp.com/280](http://www.houseplanninghelp.com/280)

Jon: I'm a chemist by training. That's what I did my degree in. But I've worked on buildings ever since I left university. First off as a building services designer and since then on good practice for sustainable low-energy buildings. That's now for nearly thirty years, I'm afraid.

Ben: Wow. And when did you get involved with the Passivhaus Trust?

Jon: Almost exactly ten years ago. 2020 will be our tenth year and I was involved in setting up the Passivhaus Trust right from the very beginning, so in 2010.

Ben: Today is slightly unusual because this podcast has talked a lot about Passivhaus. But I specifically want to bill this episode as an introduction.

What are the foundations of the Passivhaus standard? How did it come about?

Jon: I think there are two ways of looking at this. One is how the Passivhaus standard came into existence.

It was actually invented by probably two or three people. The main one is Wolfgang Feist in Germany, but there were other people as well; someone called Bo Adamson from Norway, and the Canadians had developed a standard themselves called the R-2000 Standard.

So, it's built on a long line of knowledge that was brought into an expert package called Passivhaus and has since then been led by Wolfgang Feist in Germany.

That's one way of looking at it, how it was created.

The other origin is, if you want to create a very low energy building that is comfortable and actually works as it is intended to, so

delivers the performance, does what it says on the tin, there's been many attempts to do that in the past and they've nearly all failed. And actually, this is what started Wolfgang Feist's interest. He, in his typical German way, said that he's offended by the fact that many buildings that try and be high performance don't achieve that. Which is great, isn't it? It's a great way of thinking about what you want to do.

So, the Passivhaus Standard was developed in order to achieve that, to make sure that it actually delivered. Wolfgang Feist is a physicist. It's all about building physics. There's nothing hugely complicated about it. It's just what do we need to do to actually make it work and do what we said it was going to do.

That's the other place where Passivhaus came from.

Ben: What are the fundamentals then? You said that lots of people do this, but how has it come together?

Jon: The first principle probably is that there's quite a lot of insulation on the house. So, the first idea is reduce the energy needed to heat the house.

Probably in a typical house, more than half of the energy will go on heating. The first thing is to reduce that. Insulation is a very important part of that and you might have, say, nearly thirty centimetres of insulation on a Passivhaus home. Maybe not quite that much, but of that kind of size. So, your walls will be very thick.

Once you've got the insulation sorted out, the other parts of the building need to perform to the same level as well. So, you need much better windows, for example, so that there are no cold draughts coming from your windows. In a Passivhaus you'll have triple-glazed windows that have got really good quality frames. And the detailing of how it's all fixed together is also incredibly important. So, there are no gaps, there are no spots that are cold so you won't get any condensation – all of that comes into the Passivhaus package.

Beyond that, once you get the fabric of the building sorted, the airtightness of the building also becomes very important. You need to work out how to stop any draughts coming in or any air and heat leaking out. A lot of attention is paid to what we call an airtightness layer but actually, it's just to stop draughts and stop heat loss from draughts.

So, those are two of the main aspects. Once you've done those, as a by-product, you have to sort out the ventilation. Because you've

made the building draught free, you need to have a really good ventilation source. So, in a Passivhaus we put in a mechanical ventilation system that brings air into the building and as it goes out of the building, it recovers the heat from the air. It gives you fresh air all the time and then just recovers the heat from the outgoing air.

Those are the main fundamentals for dealing with the heat part, and it's all done as a kind of holistic approach to give you strong comfort in the building as well as low energy performance.

There's one more complicating factor that we need to think about which is to do with summer comfort as well as the heating comfort that I've talked about. Passivhaus also deals with summer comfort and trying to keep you cool in the summer by looking at how much sun comes in through the windows, how much heat comes in from people and appliances in the building, and then adding it all up in a magic formula to work out how we're going to keep the temperatures down in the summer as well. So, the ventilation and the insulation, how can we make those work to help keep the building cool in the summer?

I think that in a nutshell sums up the key facets of a Passivhaus.

Ben: Do you need special contractors, special experts to work on a Passivhaus?

Jon: Now then, strictly no, but it is harder. It is harder than building a normal house. So, having somebody in the team who knows what they're doing, I would probably recommend that. I'd think that's the right way to go.

It doesn't have to be the builder. It could be a consultant that you've got on board, or an architect who has done this before or has had the formal training. Some people have done it themselves from scratch but it takes a certain particular kind of person.

So, if it were me, if you're not a specialist, I would say have one member of your team who really knows what they're doing and ideally has done one before. Then you're much more likely to get a good outcome from this that doesn't make everyone break down in tears because they're finding it too difficult.

Ben: What do you need to do to make a successful outcome? You've talked about some of those elements, draught free, lots of insulation. A Passivhaus then.

Jon: It's about how it all fits together as a whole. It's the holistic bit. We don't want you to take out the bit that makes it comfortable in the

summer; we don't want you to take out the bit that stops the draughts from the windows. You have to do the whole thing.

There is a tool called the Passivhaus Planning Package that does these calculations for you. Again, you probably need someone who knows what they're doing to fill that in, to help work out the answers to the calculations with you, so that you know you're going to end up with the performance that you want with the comfort that you want.

Ben: What are the key targets then? Maybe you could explain a little bit about that, if you're going to certify it?

Jon: Once you're using the planning tool – this needs to be used right from the very beginning. That's the best way to do it, so that you look at how your shape of your building, the location of your windows, and any balconies and so on that might penetrate into the building. You look at those right from the very beginning so you don't cause yourself problems and puzzles as you go along.

The best way to do that probably is, you've got your advisor on the team and then there's an independent person who sits to one side and checks what they're putting forward and what you're suggesting just to make sure that it is actually going to work in the way intended. So, you won't have overheating in the summer or you won't have a cold room somewhere in the house.

The package should tell you that but actually, we have an expert person to check that, and they're called a certifier. They do certification of the building. They are the most expert people in the country. They've done multiple Passivhaus projects and they can take a view that if your designer has only done one or your contractor has only done one and they think that this idea might work, the certifiers who are the experts they can take a look at it and tell you, 'yes, that is a good idea. That is a good way of doing things' or actually, 'if you tweak it like this, it will be a lot better or a lot cheaper or a lot something.' Because they've done multiple projects, they can give you that kind of expert advice.

Ben: Can you do it without the certifier?

Jon: You certainly can but you can't call it a certified Passivhaus which does have some value in being able to sell the project. So, you can't claim that it's then a certified Passivhaus.

Also, to me it depends on how expert your team are. If you had an architect on your project who's built a Passivhaus before or is a certified designer and you've got a consultant who's done one

before and you've got a contractor who's built one before, then you'd probably have good confidence that you would end up with a Passivhaus at the end of it.

If that's not true and you've got much less Passivhaus expertise in your team, then certification is a good way of ensuring that you're going to get what you want and that it will be comfortable all year around and your bills will be very low and that your house will be exactly what you expect, exactly what it says on the tin.

So, if you don't want certified, make sure you've got more expertise in the team, I think.

Ben: You talked about low bills there. Can you explain that and some of the other benefits?

Jon: Low bills, you're almost guaranteed for this to happen. Once you put the insulation in, that reduces heat loss through the walls and the windows so you don't have to put energy in. You don't have to pay for energy to heat your house in that way. Your energy bills will be much lower.

Exactly the same with the airtightness and removing the draughts. Every time a draught comes into your house now at the moment, it's taking heat out of your house and that's costing you money every time.

So, if we can cut those down then again, you have to pay for less energy for heating so your bills should be lower.

On a typical three-bedroom terraced house that's a Passivhaus, your heating bills for the year might be of the order of eighty to one-hundred pounds. I don't know about you but my heating bills in my terraced house used to be of the order of eight-hundred to a thousand pounds a year. So, it's a massive difference. You're saving a huge amount of money.

But that's only one of the benefits. There are other benefits as I've said in terms of comfort, health, and robustness of the building as well, which we can talk about.

Ben: Let's talk about the health.

Jon: There's a lot of anecdotal evidence, stories, about the benefits to occupants of living in a Passivhaus building. Mostly this comes from mechanical ventilation systems which provide the fresh air and recover the heat from the air going out.

The stories are multiple actually, that it gives you very good indoor air quality. It can extract odours from the house so, if you've got smells, then they get taken out. There's also thermal comfort so you're warm in winter and cool in summer. That also has a health benefit because there's no cold stress on your body because you're comfortable, and no overheating stress in the summer.

There are also stories about improvements in asthma in occupants of a Passivhaus. The air is filtered on its way in and whether you're in an urban area, in a city somewhere or a town, you might have air pollution from transport and that can be filtered out as the air comes in. And if you're in the countryside, there might be pollen or grain dust that would also get filtered out. So, the air that comes in will be better quality than the air that's outside. And people have reported that that has led to health benefits including things like a reduction in asthma.

There are no massive studies being done yet, of what those health benefits are. That's something that we're planning for a year or two's time once we've got enough numbers to look at. But there's certainly a lot of stories that people have told us and that are on video that you can see of people talking about those health benefits.

Ben: Because typically there's a lot of moisture in houses. This is something that's also dealt with via the mechanical ventilation, isn't it? And that really helps.

Jon: That's true. Moisture comes from your bathrooms or your kitchen when you're doing the cooking, and from people from breathing. If you've got a cold spot, that can be a real problem because then you'll get condensation. It quite commonly happens on windows. If the window is cold on the inside and you get condensation on the inside of the window, that can cause the window frame to rot and other things. And if it's bad condensation, say on the inside of a wall, you might end up with damp, black mould which is incredibly harmful to health.

In a Passivhaus, all of the internal surfaces should be warm all the time. You shouldn't have condensation at all. Mechanical ventilation, because it both puts fresh air in and takes stale air out, as it takes the stale air out it takes the moisture out with it. So, it reduces the moisture levels in the building. That's another way of protecting your health.

Ben: What is the most effective way of building a Passivhaus when you think about construction systems?

Jon: That's a tricky one. The million dollar question.

Ben: Or I could just go down the simple route of can you build a Passivhaus via any construction method?

Jon: I think some are easier than others actually.

I originally thought that you wouldn't be able to build a Passivhaus with brick and block and a cavity. Then we were proved wrong. Bill Butcher and the Green Building Store built a Passivhaus in brick and block, or stone on the outside actually but the same thing, block and stone with a cavity in the middle. So, you can do that.

My view originally was that it would be easier with timber panels or timber kits. My view was that it would be easier and that may well be true, I think.

The key thing is you have to think of the building differently. Even if you're building with brick and block then it's not brick and block with a cavity, you don't want to think about cavity wall ties and trying to fit a bit of insulation into the cavity. You don't build it in the same way. What you would do is build the blockwork construction, the inside of the house, and then put a continuous layer of insulation around it so that you get this really robust continuous insulation which is quite different to how people fill the cavity in a normal house. So, you get the warmth all the way around the structure. There are no gaps that are going to cause you a problem. Then you put the brickwork or the stonework on the outside of this thermal tea-cosy – you've built a tea-cosy – and then you put the stone or the brick on the outside just as your visual effect.

So, it's kind of the same but it's built in a different way; much higher quality, much more robust and absolutely continuous all the way around to make sure you're comfortable everywhere in the building.

Ben: What does this mean for cost then?

Jon: There are lots of answers to that question. We've done a study on social housing. The problem with individual homes is that the costs of individual homes are so divergent or so varied depending on what you're building. If you're doing a mill conversion of a grade II or grade I listed building, that is going to be significantly different to a refurbishment of a small terrace, for example, in an absolutely standard Victorian street.

Similarly, if you're building brand new, doing a five-bedroom timber frame project with a whole south facing glazing, again that's going

to be quite different to a smaller scale bungalow that's a very normal aesthetic or a very modest aesthetic.

So, the costs of that we found can vary between one-thousand pounds a square metre to four-thousand pounds a square metre anyway. So, it's very hard to compare is what I'm trying to say, when you're looking at private sector individual homes.

We look at social housing as a way to get comparable benchmarks and if you look at comparable social housing projects, the additional cost of building to Passivhaus compared to a normal approach is between four and eight percent more. Quite a bit of that is because of the better quality assurance that happens on a Passivhaus project, and actually we think you ought to do that better quality assurance to get a better quality home on all projects. So, half of that extra cost for Passivhaus you should just apply anyway.

So, really there's a four percent extra on building to the Passivhaus standard. That would then apply to whether you've got a small terrace or a big detached house; you might be looking at four percent. In terms of what that might mean, if you're spending two-hundred-thousand on a new home or four-hundred-thousand on a new home; two-hundred-thousand would be eight-thousand pounds, and on a four-hundred-thousand that's sixteen-thousand pounds.

How much would your kitchen cost? The extra fittings and the uplift that you're choosing for your enhanced, super kitchen might be that much or more. Just for the kitchen or just for the uplift in the spec of the kitchen.

So, say you're going to get a much better quality building that will make you more comfortable, more healthy and perform better for fifty, one-hundred years or more, is a very small amount of money in my book and it's a much better way to spend your money than on a super flashy designer kitchen.

Ben: With a lot of builds you can get out of control with costs. Are there any tips?

Jon: The main one is the expertise in the team which I've already talked about. But there are a couple of quick tips that help as well.

The shape and form of your building is an absolutely crucial factor. For example, if you have got multiple wings or outlying parts of a building, you've got lots of additional roofs, you've gone to one floor in some areas, two in another, three in another, those kinds of things all make it more difficult to make Passivhaus work.

The closer you aim to a square box shape, the easier it is to achieve Passivhaus. Obviously, we don't want you to build a square box and we all want it to have some beautiful design features to it. But adding on balconies, little roofs, corners and odd shapes, they all make it a bit more tricky.

The other thing that I think is a really important tip is starting the planning with the consultant or the Passivhaus expert as early as possible. So, don't think we've got to do quite a lot of design work and then bring in the Passivhaus consultant to do the calculations for us because all of these decisions about where your windows are, what shape the building is, how many extra roofs or balconies we've got, what system we're using, all of those things will affect how easy it is to do Passivhaus and therefore the cost. So, do that as early as possible. Bring somebody in as early as possible to avoid the complicated and costly decisions you might otherwise make.

Ben: How do you heat a Passivhaus?

Jon: There are lots of different ways of doing that.

I'll tell you a story now. One of the developers we worked with very early on building private houses, he didn't believe that you could get away with building a Passivhaus with almost no heat sources. So, he put in a log burner in the main living room. You've got the heat sources of the cooker and so on in the kitchen. He put a radiator in the top bedroom on the north facing wall because he thought that would be the coldest wall, and there was either a small radiator near the front door and I think potentially a towel rail as well. Because he was worried. He didn't believe that you could just have one little heat source in a Passivhaus.

Obviously, the log burner kicks out a huge amount of heat. So, ignoring that one, he found that any one of the heat sources in the house was enough to keep the house warm. And he had four plus a log burner which were therefore completely redundant.

It's quite a common perception or question people ask. Is it really going to be warm enough that I can avoid having a radiator upstairs in the furthest bedroom? And the answer is always yes, it is going to be. But it is quite challenging mentally. It's slightly confusing that that can happen.

So, to answer your question, quite commonly people will put a little radiator near the front door. The reason for that is that as you walk into the house, the perception of being warm is important. So, the

temperature might be twenty or twenty-one degrees which might be ideal or just what you need but if you're coming in from somewhere that's very cold then actually feeling a radiant heat source, quite a lot of people report that they like the idea of a feeling of warmth. That just gives you time for you to adjust and go and sit. Then when you sit, you're comfortable in a normal temperature. The other thing that people quite often like is the towel rail in the bathroom. So, you might do that as well or you might do that instead.

Those typically would be a kind of heat source.

Ben: While we're on that subject, overheating is something that you can control with Passivhaus. So, can you explain that and how we get a look in as a client?

Jon: As we head to much more energy efficient homes in general, the risk of overheating in the summer I think is becoming much more significant. And you have to plan for that. We have to plan one, how much heat is going to come into the house in the summer, and two, how do we take it out?

The heat mainly coming into the house in the summer will mainly come from the sun, probably in the late afternoon/evening. As the sun is going down and it looks really beautiful, the sun is shining straight into your kitchen, front room or wherever you've got your big windows looking out to the south and the west, the sun will shine in and all that sunshine will bring heat with it.

The easiest way to minimise that problem, to avoid that problem, is to stop that heat from coming in. Obviously, you don't want to lose the views and you don't want to lose the sunlight but you don't want it when the sun is hot. So, quite often within a Passivhaus you'll get some kind of shading or some kind of overhang particularly on the south and west facing walls, that stop hot sun coming in until the sun has gone down quite a lot, until it's later in the evening and the temperature has dropped by then. That's how we stop it coming in.

There are other sources of heat as well. People themselves are sources of heat, the dog might be a source of heat, and the appliances you're using. The washing machine and computer all kick out heat. So, there are other things that we have to look at as well.

Within the Passivhaus tool, we add-up all of those heat gains and work out how much heat we're going to have to take out to keep you cool. Normally, the keeping you cool bit, taking the heat out, is done by either the mechanical ventilation system, so that then takes

the air out, takes the heat out with it and in the summer we don't reclaim the heat because we don't want to keep it; we want to get rid of it. The other way of doing it is through opening the windows particularly overnight.

The temperature will gradually increase slowly during the day. It only increases slowly because of all the insulation we've got keeping the heat out in the summer. Then as you open the windows at night or you boost the ventilation, that takes more heat out because the air temperature outside drops, it gets cooler as the night goes on, you bring in more cool air and gradually the temperature in the house drops again slowly during the night to the amount you want. Then again, you start the next day when the sun comes up at a slightly lower temperature than you were the day before. That's how we manage your summer temperature.

But the extra insulation and the extra performance of the windows, the doors and so on helps in the summer. Just as much as it helps in winter in keeping the heat in, in the summer it keeps the hot air out.

If you've ever been to the big old stone buildings either in the UK or particularly overseas if you go to Spain, you get buildings that have got really thick walls, very heavyweight stone, they put shutters on the windows to keep the sun out during the day, and the heavyweight building stops the heat penetrating all the way into the building during the day. It's exactly the same kind of idea with a Passivhaus. The extra insulation, the thickness of the fabric, the robust windows, they stop the heat coming in during the day in the summer as well. That all helps.

So, in a Passivhaus you tend to get a remarkably even temperature throughout the year. It doesn't vary a huge amount. In a normal old Victorian house for example, your temperature will fluctuate massively during the day. And at night-time when you turn the heating off, the temperature will drop significantly. And getting out of bed in the morning, until you've put the heating on, is quite a daunting ask; cold toes, cold fingers. That fluctuation doesn't happen within a Passivhaus. You get a variation of a few degrees but not ten or fifteen degrees overnight. It doesn't happen.

Ben: How many Passivhauses are there around the world?

Jon: Lots around the world. Sixty-thousand at the last count. And that includes all kinds of buildings not just individual homes.

In the UK, we've got over twelve-hundred now and probably over two-hundred of those are individual owner-occupied homes. So, there's probably over two-hundred people who have actually had one built. Some of them have done it self-build.

So, quite a few now, even in the UK.

Ben: Is the rate increasing?

Jon: Yes, almost exponentially. The first one was built and completed in 2010. There was only one; maybe two but of that order. Then gradually, it picked up very slowly in the UK. So, there was two, then ten, then fifty. And then I think we were over five-hundred completed last year. We know of about a thousand that are in the pipeline already, they've already started to build them, or plan and build them.

So, the numbers are increasing very significantly and by next year there'll probably be two-thousand-odd and so on every year.

Ben: What do you do then at the Passivhaus Trust?

Jon: We're very busy. That's what we do.

At the moment, we look after the standard. The standard was invented or developed by the German Institute but we look at how that applies in the UK. We've got slightly different weather patterns over here, a different culture. So, how do you apply the Passivhaus standard in the UK? How do we make it work? That's one of our jobs.

The second job is to promote the adoption of the standard. So, we do a lot of engagement with central government, with local authorities, just to try to get people to adopt it.

Then we do research on specific aspects of things that need to improve. It's a great standard but it's not perfect and there are things that we can improve and change over time. For example, we've done more guidance on the summer comfort standard, how to keep temperatures comfortable in the summer.

Again, a tiny story, in Scotland there are potential risks of overheating from planning people to open their windows at night-time to do the cooling. So, if you assume that people in Scotland will open their windows to allow cool night air in to reduce temperatures, that might be a bit of a risk. And it's for a reason that we would never have thought of, which is that there are midges in

Scotland. So, if you open the windows, midges come in. And people don't want to open their windows at night for that reason.

So, in the west coast of Scotland you have to come up with a slightly different answer for the night-time cooling. If people are going to open the windows, you need a mesh on the windows or some kind of grill with mesh in it so that people don't have to open the window for the night-time cooling.

How would you ever think of that from London let alone from Germany?

These are the kinds of adaptations that we need to work on to make sure that the standard really works in the UK.

Ben: How has it changed over time?

Jon: It's been pretty consistent for the main standard.

There are two main standards. One is for new build and one is for refurbishment. The refurbishment one is slightly easier to achieve than the new build one because there are difficulties on retrofit projects.

Your building is already fixed in place, you can't change its direction – if it's facing south, it's facing south. That's just the way it is – dealing with internal floors is very tricky because there may well be beams that go into the walls, either on a first floor or a ground floor. All of those things we make some kind of allowance to say if you can't change those and those are fixed, then you can still get to a Passivhaus. We just relax things slightly to acknowledge those difficulties.

But those are the two main standards. The new build one and the retrofit one. The retrofit one as it happens is called EnerPHit – it doesn't really matter; it's just a retrofit standard – the new build one we now call Passivhaus Classic. That's classic because it's been there now for thirty-some years in Germany and nearly ten years in the UK.

There are two new standards as well that relate to the Passivhaus Classic one. One is called Passivhaus Plus and one is called Passivhaus Premium. They are just the Passivhaus Classic standard effectively, plus some renewables as well.

So, as your demand for energy drops markedly, there's a point where it's not worth going beyond that really. The cost of going further than that would be too significant. But there is a value in

adding renewables at that point. So, you focus on reduced energy and improved comfort. That's where you start. And then your bills are down to maybe eighty or a hundred pounds a year and you look at adding renewables on as well. Then hopefully at that point your energy generated by the renewables will exceed the energy demand of the house. And hence, Passivhaus Plus, you will get to zero carbon or they'll balance out. So, your energy generated will be equal to or more than your energy used during the year.

And then Passivhaus Premium is if you want to go a long way down that line and put a lot of renewables in and you could end up with an energy positive house.

Ben: Is it something on the horizon that the materials of the building could be taken into account in some respects, or other factors like this lifecycle? I don't know, just ideas here.

Jon: For sure. Within the planning tool we are looking at add-ons now to consider the embodied energy of the materials that you use. Some people already do this. You can do what you want with a Passivhaus.

Some people already choose to have natural materials mainly focused on, say, timber and wood fibre insulation. For some people, that's important. And in that case, great. You can do a Passivhaus with that and then your embodied energy will be low. And as I said, with this new tool, people are starting to work out how to calculate that and it can just be done as part of your standard Passivhaus calculations, so that's great.

For others who don't want to go down that route yet, you can still use traditional materials and you might want to calculate your embodied energy with that. It's completely up to you. We are developing the capacity to do it. You're not forced to do it; we're just enabling people to have a go.

Ben: Is it really the comfort that is at the heart of this?

Jon: ... yes.

Ben: That was a good pause.

Jon: Well, it's the main benefit. It's always tricky because we're looking at a holistic standard that delivers lower bills, lower energy use, greater comfort in winter and in summer, and better air quality. It's not one or the other of them. They all have to come together.

There's no point in having a very low energy house that you can't live in because it overheats in the summer or because it's got poor air quality. That's not a win for anybody. So, it really is this holistic approach that's important, I think.

But if it's not comfortable, why would you build it? So, yes. Let's start from there.

Ben: Finally, what would you suggest to people that are just starting to think that this sounds like a good idea, I want to do one of these?

Jon: Do it. Let's get it done. Lots of people are phoning us up at the moment, from individual property owners or people thinking about refurbishing or building their own Passivhaus, to local authorities declaring a climate emergency. Passivhaus is being seen as a way of helping them deliver on that.

There are lots of people around now to help you do that. There's a good supply chain of people who can do it, good designers, lots of systems that you can choose from.

So, don't be frightened. Have a go. Remember that it is better than a normal home, a normal building. So, you do have to do things slightly differently. You do have to get people to help you with the advice ideally. So, get a good team to help you. But have a go. Don't be frightened about it. You're not the first. It's unlikely to go terribly wrong. Get people on board to help you properly then it'll be great and you'll end up with this fantastic building that really looks after you for the rest of your life.

It'll be great. Have a go.

Ben: Jon, thank you very much.

Jon: You're welcome Ben. Very fun, thank you.