Episode 17

Can a Ground Source Heat Pump Make an Old House Energy Efficient?

The show notes: www.houseplanninghelp.com/17

Ben: I'm with Justin Broadbent from ISO Energy and today we're going to talk about ground source heat pumps and also listed buildings or very old buildings where the fabric of the building is actually quite difficult to adapt. Before we start though, hello Justin.

Justin: Hello, nice to meet you.

Ben: And maybe you could tell us a little bit about your story, how you became interested in this area and took it forward to the company ISO Energy.

Justin: It goes back probably about 14 years now. I had a software company that I sold and semi retired and needed something to do and I live in a house that was built in 1726 or thereabouts, heated on oil, probably as efficient as Stone Henge when I took it on. We quickly realised we needed to do something with it to reduce the running costs really in those days.

I'm an engineer by trade and so I'm interested in these things. I had a father-in-law who was a partial owner in a Swedish manufacturer of heating systems and I started getting generally interested in what could be done to get rid of my dependency on oil.

Whilst I was learning about that, in Sweden of course all houses are hugely more efficient than they are in the UK, I mean embarrassingly so much so and these people started talking about insulation levels and things like that. I was thinking, insulation levels, what's all that about? I quickly realised that there was such a vast difference between what they were doing in Sweden and what we were doing here that I had begun to realise that actually it's not all about plugging in some mechanical thing to try and reduce your running costs, it's also about trying to reduce your heat losses in the first place.

So that's how I got started, really. I started more or less as a consultant to people and then importing in machinery. Then people started saying who installs this for us and so we started doing the installs as well. Now we are fundamentally designers and installers of renewable energy systems of all sorts, but I particularly like heat pumps. That's my own personal favourite, but I have to say it's all horses for courses and we have people in my office that prefer biomass, for example, to heat pumps. I actually think you've got to look at what resources you have available to you and the best match for your requirements is what we're looking for.

Ben: What is a ground source heat pump? Or maybe it should be a heat pump, first of all.

Justin: Well, the glib answer to that is everybody already has heat pumps in their houses. You have a fridge or a freezer - it is actually a heat pump. All that a heat pump does is to compress energy. If you take it to its very basic level, a bicycle pump, if you pump up your bicycle tyre you'll probably feel that at the end of the bicycle pump it starts to get warm. That is because as you are compressing the gas from ambient air pressure of 1 bar through to 5 bar or whatever you're putting into the tyre, the molecules get excited, because they're under pressure and so they get warm.

So a bicycle pump is actually a heat pump, believe it or not, at the time when it's running. Your fridge is a heat pump. You're taking the ambient air pressure out of the kitchen, say at 18 or 20 degrees, and compressing that heat, radiating it out at the back of the fridge, so if you feel the back of a fridge it's normally at about 40 degrees.

In engineering there's always an equal and opposite to everything so if we're generating heat, we're also generating cold. Now with a fridge freezer, you keep the cold but throw away the heat, but it doesn't matter because it's going into the kitchen, which you want to heat anyway. With a heat pump that's going to heat the house, you effectively keep the heat and put it in the house and throw away the cold, which goes outside.

If it's an air source heat pump it goes outside into the air. If it's a ground source heat pump, we put the cold into the ground.

Ben: How would you know when to use one for a house?

Justin: Well, that's a difficult question. It depends on the house. It depends on all sorts of things. At the end of the day most things come down to pounds, schillings and pence. Most people get interested in reducing energy because of the cost. Some people, of course, want to do it because they're green and I think being green is certainly a driving force but most things are driven by cost at the end of the day.

If you have an oil bill that is costing you £5000 or £10,000 or £20,000 – some of our clients are spending £70,000 or £80,000 a year heating their houses – and you're trying to reduce your £3000 a year bill or whatever, you can put in a heat pump and you might typically be able to reduce your running costs by about two thirds, certainly half, for sure, probably more like two thirds. In certain circumstances even more.

So, if you're say spending £5000 a year and we can reduce that down to £1500 a year by putting in a heat pump then it's probably worthwhile doing. That is the driving force in most cases.

Ben: The reason that I was quite keen to do this episode is because of certain properties where you can't adapt the fabric. We've done quite a bit of research into this, looking at insulation. You mentioned it yourself just now, in Sweden they're so much better than we are at doing this. So what do you actually need to make it happen?

Justin: Almost inevitably you can always improve the fabric of a building, funnily enough. Even if it's Grade I listed. I mean I live in a Grade II listed building and obviously the controls are less on that. There aren't that many Grade I listed buildings anyway. Even there, you can insulate the loft. You can insulate the cellar quite often. You can stop cold coming up from the cellar. You can stop the cold ingress from the roof.

Most Grade I listed buildings nowadays have shutters built in, because of course when people were building these buildings there was no free energy like gas and things like that, so it all had to be done manually and you had to keep the house warm. Well, often you had walls that are metres thick and shutters on the windows. Well, shutters on the windows are extremely good insulators. It stops the draughts getting through. It's a windbreak. The wind hits the glass and gets round the glass. It then hits another barrier and by the time it's got through the glass and shutter there's very little power left in that wind. Equally, wood is the second best natural insulation there is, wool being the best, wood is then the second best. So you've effectively got a half-inch layer of insulation, thick insulation, between the outside world and your house.

Generally speaking with these old buildings you should go back to trying to use them as they were originally designed. You should close your shutters at night and those rooms that are sealed off and are not being used very often, if you live in a very large house, keep the shutters closed when you're not using it.

Use the fireplaces. Light them. Some chimneys draw very, very well and don't create any draughts in the house. Some chimneys aren't so clever and you get a lot of draughts in the house, so if you have a very draughty chimney, block up the chimney when it's not being used or try and light a fire in it and get the draught going in the right way.

Secondary glazing. You might or might not be allowed to, depending on your conservation officer or depending on whether you like the idea of secondary glazing or not, but I mean as you see here we are sitting in my drawing room, I have secondary glazing here. I don't think most people would know it's there. When you do point it out to how it is when you take it out, you suddenly realise how good it is. [Justin laughs.]

Ben: It might be worth saying how you've done that secondary glazing.

Justin: Yes, well this we did 20 years ago. Actually not quite 20 years, 18 years ago probably. Our windows are wooden frame rather than stone mullions or whatever. It's a wooden frame window with leaded light windows and sprung-loaded pin hinge windows so there's no normal catches and things like that so really when it is windy it is a little bit like trying to heat Stone Henge here.

In front of the old oak frames we have a very thin oak frame going round with, in this particular case, just a single paned glass but we've taken the whole window area, as you can see, rather than each individual pane. So really it's just one big piece of glass, probably 6ft by 2ft 6. If we're looking at this window here, really until you touch it you can't see that there's a window there, so you think you're looking at the old-fashioned windows but in fact it's another set, 6 inches in front of them in this particular case.

It works very well and the room becomes really quite cosy. No noise, no heat losses – or drastically reduced heat losses.

Ben: So, that's the first step to see what you can do. Are there any situations where you're not sure what to do? Say, for example, the walls. If you wanted to insulate these internal walls here and we know about interstitial condensation and obviously the planning officer's going to say no you can't do that, but how far can you go with all those processes that we've talked about?

Justin: The first thing is insulation. Estate agents go round saying: "Location, location, location". In my mind nowadays I think to myself, *insulation, insulation, insulation*. The reason for that or the glib truth is that the most expensive heat that you put into your house is the heat you're putting in the second or the third or the fourth because you've lost it the first time.

So whatever you can do to stop the heat losses is just a, to use a really horrible term, it's a no-brainer. [Justin laughs.] You should just do that. Having said that, there are limits. We live in these houses because they're beautiful houses. I don't want to have a wall that's just a layer of insulation and is very plain. I like these beams. I like to see them. And indeed the conservation officer would have something to say about it if I tried covering them up.

In some areas here often houses do actually have cavity walls in certain areas. Cavity walls go back a long time but this is an oak-framed house. I refuse to insulate my cavity because these beams have stood here for hundreds of years and if you get any damp bridging in them at all they could rot in a decade. So I'd rather spend an extra 20% heating my house and know that the walls remain secure.

We don't insulate and we haven't insulated . . . Often I tell people don't believe what you read about insulating cavity walls and things like that. In listed buildings you can't do anything other than that anyway because you wouldn't be able to clad them on the inside or the outside normally. So I haven't insulated my walls.

However you can see how thick those walls are. I mean that wall is 1 and a half feet thick, minimum really, everywhere. So you never want to insulate an internal wall, especially if you're running renewable energy because the way that we heat this house and the way that we advocate our clients' heating is by using weather compensation, which we'll probably talk about in a minute.

Weather compensation means that we try and bring the house temperature up to a temperature of say 20 degrees for argument's sake and then keep it there. What that means is that the whole house gets to 20 degrees and stays there year in year out. That means that my walls are also at 20 degrees. Now if it gets -6 and blowing a gale outside, my inside walls are at 20 degrees now so they actually act as a radiator when it gets cold outside. But if I insulate those walls and I can't actually get that thermal mass that you require and these houses were designed around thermal mass and people have sort of forgotten that. By putting in modern radiator systems with boilers that fire up at 6 o'clock in the morning and put 80 degrees around the radiators and then go off at 10 o'clock and then come back on again at 3 in the afternoon and go off at 11 o'clock.

The buildings are getting warmer and colder, and expanding and contracting all the time, and it actually doesn't do them very much good. What we do is we try to live like they were originally designed to, but the original design required you lighting a fire all day long but you would have had staff that did that. It was easy to do in those days. [Justin laughs.] Not so easy nowadays. But each room would've been used individually and it would've been kept as a relatively low temperature by today's standards but at a fairly constant temperature, probably around 15 or 16 degrees. The only difference nowadays is we all like to walk around in thin shirts and slippers, or no slippers even, and so we want our rooms at 20 or 21 degrees.

Well, what I try and do is emulate how the house was designed but bring it up to modern standards by trying to use the thermal mass of the building. That is quite important. If you insulate badly or in the wrong area you can actually get rid of the thermal mass which is a good quality to have in these old buildings.

Ben: Let me just clarify that for a second because I've only learned this quite recently but there are two approaches that you can go towards a low energy building. One of them is to do with thermal mass and using that, heating it up, and the other is more of a super insulation approach.

Justin: Yes. And you can't get the super insulation approach to work with a listed building. Well, I mean, there are listed buildings that are actually quite modern but 99% of your clients are going to be living in old buildings so you have to go for the thermal mass route. It is the only way but it is incredibly effective. When they built these houses they knew it was cold outside. It was probably colder than it is now, on average, 300 years ago. These houses were built to withstand cold.

Obviously you had staff to help you in those days but the concept of thermal mass works very, very well.

Ben: Getting back to ground source and air source heat pumps, what do we need to do to the house or outside the house in practice?

Justin: Very little is the answer. A lot of people say you have to oversize the radiators and things like that, well, you can see here, I have one radiator over there and one radiator over here. They're not particularly oversized. In fact they're exactly the same radiators that were being used when the house was being heated on oil.

The difference is that with oil, as I said earlier, you tend to switch them on and switch them off, especially if you think you're saving money. What we try and do is put in a lower amount of temperature, lower grade of temperature, lower temperature setting but for a 24-hour period. So all we're trying to do is maintain temperature. Once we've brought the house up to temperature, which is the hard work, so it can do it itself in the summer we just then start maintaining that temperature through the winter.

Rather than the radiators getting up to 70 or 80 degrees, these radiators probably never go above 45 or 50 degrees but they're at 50 degrees all day and all night.

Ben: Why doesn't it overheat in the summer?

Justin: Oh, what we use is weather compensation. Now we don't have, there are no thermostats in the room. What we have is a system whereby the only sensor is not in the room, it's outside. Then we have a series of algorithms in the brain, in a control system, that work out what is the temperature outside, what is the flow temperature to my radiators, what is the heat loss or the return temperatures from the radiators and the algorithms then work out that if it's got a maintaining, lets say a 4 degree Delta T temperature differentiation between what I'm putting into the radiators and what I'm getting back.

If the temperature drops by a degree then it'll notice that that 4 degree difference inside will maybe go up to 5 degrees, so it puts a bit more energy in to close that gap. So, all it's trying to do is constantly monitor what the temperature is outside and as it drops faster and faster outside it starts putting more and more heat into the building and as the temperature starts going up outside it puts less and less heating into the building.

So when it's -7 and blowing a gale outside my radiators probably get up to 60 degrees but when it's 14 outside they're only running at 32 degrees. It's called weather compensation. The colder it is outside the more energy goes into the radiator. It's much more sophisticated than you can do with a boiler because a heat pump ultimately runs on electricity, so you can run it like a computer and it'll work out what's happening.

Ben: I can tell you're probably a gadget man but having all of this technology, is it a lot to go wrong and it's only because of this particular situation that we'd have this solution?

Justin: No, in fact there's a lot less to go wrong with a heat pump than there is a boiler. A boiler requires all sorts of things to make the oil flow and dirt get trapped and 1000 degrees of flame trying to heat up a heat exchanger and things like that. A heat pump is simply a small compressor that runs almost 24 hours a day.

When people say how reliable . . . When it's done properly and the biggest problem that we have in this country is that there are, I'm afraid, a number of cowboys out there but if it's done properly a heat pump will be as reliable as your fridge. Well, I ask people, if you buy a decent quality fridge, when was the last time it broke down? You probably don't know.

Most people replace their fridges, not because the compressor breaks down but because the door handle falls off or the seal breaks or they don't like the shape of it any more or they're building a new one into the kitchen. Fridges are very reliable. Well heat pumps should be very reliable as well.

The problem comes when you try and push them into areas where they shouldn't be or you install them badly or badly sized groundworks is the biggest problem normally in this country.

Ben: As a client, how do I know that the contractor is going to do all this correctly because it's way above my head?

Justin: Well, um, that is a really, really difficult question to answer. The glib answer is come and see me. [Justin laughs.]

Ben: That's all right!

Justin: But there aren't very many people that know what they're talking about when they're trying to put them into listed buildings. There are only two or three companies that really know what they're talking about and there are only one or two that actually do a decent job. I say that myself. You're here because you've been told we do do a good job so I think I can say that.

The problem that most people have with this is that they don't understand where the energy comes from. They think somehow it's magic. Well, it's not magic. There is an engineering reason why it works and that is that you're taking low-grade heat out of the ground, forgetting out air source heat pumps and concentrating on ground source heat pumps at the moment.

You're taking a low-grade heat out of the ground and if you say for example that your house needs half a million kilowatt hours a year to heat, through the winter period, I've got to somehow get half a million kilowatt hours out of my ground. Well to put that into some sort of scale, a 3 bar electric fire uses 3-kilowatt hours an hour, so if I need half a million kilowatt hours, I'm going to take it out of my garden, it doesn't really make a lot of logical sense, does it?

What that generally indicates is that the scale of these things is misunderstood. On a house of a $1000m^2$, the average house of $1000m^2$, we are probably putting in 5 or 6 kilometres of pipe into people's gardens. The next problem is that the pipe must be broadly spaced because if you put too much pipe too close together, all that's going to happen is that you're going to take half a million kilowatt hours out of a tennis court and it'll turn into a block of ice.

We need to take that half a million kilowatt hours out of a 5, 6, 7, 10, 15, 20-acre field. The larger the better. The more we spread the load on the garden or field, the more efficient it will be.

Ben: We've talked a little bit about how it can go wrong, but are there specific things that you always think, *oh dear, this person has done this wrong*?

Justin: Yes, normally it is all about the civil engineering. It is understanding how much energy you can take out of any area. It matters a lot how much water there is in the ground, how much of a slope there is on the ground, what the ground is – is it shale, is it sand, wet sand, dry sand, chalk, clay? All of these substances have different heating properties and different heat transfer ratios. So, it's important to understand what they are and do the calculations properly.

Equally it's important to make sure that the turbulence in the pipe is right so that you can extract the heat properly and that the flow pressures are right. For example, I often see people, you know, that might even have fully understood that you need 3, 4, 5 kilometres of pipe in the field but the flow and return is also in this 40mm pipes, say, but they've done the flow and return in 40mm pipe out to the field so the pressure losses are so large that you need a 3 kilowatt circulation pump to push the stuff around.

Well, the idea is to try and be green so we don't want a 3 kilowatt circulation pump we want a quarter of a kilowatt circulation pump but that then means that you need transfer pipe that's 130mm, 160mm in diameter which is like a drainpipe which is of course a lot more expensive to lay than 30mm or 40mm pipe, so it goes on.

It's all about understanding pressure losses, understanding heat curves, understanding the algorithms you need to do. As I say, I'm an engineer so I think it's fun. I'm a rather sad, really. [Justin laughs.]

Ben: And they're all different, aren't they? There's not just one heat pump.

Justin: No. Gosh no. There are 15, 20, 30, 100 different manufacturers of heat pumps. Suitable for the sort of work that we do, there are 3 or 4.

Ben: For the work that you do, there are only 3 or 4?

Justin: The sort of houses we're talking about here. There are only 3 or 4 manufacturers that build heat pumps that are the sort of diesel engines of the heat pump world because what we have here is a large load that's going to be spread over a long time and some of your listeners will live in four bedroom 3 up, 3 down houses, well insulated and they probably start their heating in the end of October and they switch it off again in the middle of March or whatever.

Often these houses that we live in, the heating season starts at the middle of September and goes through to the middle of May. [Justin laughs.] Forget turning off the heating in March. It's at its peak almost by then so it's a very long season. It's a lot of energy coming out over a very long period and these heat pumps are going to work hard so you've got to have commercial heat pumps, really, I guess, is the way to think about it.

Ben: Let's just finish with, if you have a top bit of advice for a person who's got their listed property or something that they feel they've done as much as they can with the fabric, what should they be thinking about next?

Justin: Well, if you've done all that you can with the fabric. I mean lifestyle of course is the main thing apart from fabric. Try as I say, shut the shutters up, learn to live economically, I think is the best thing to do. If you've then got past all that and you think you've done as much as you want to do and, of course, what you want to do, some people want to live at 25 degrees in a room, in which case that's what they should be allowed to do. I'm not saying . . . Be aware it's a lot more expensive to do that than if you're prepared to live at 18 degrees. I actually like to live at 20. This is set at 20 and that's where it stays all the time, which means I can sit and watch television in a shirt.

After you've done all that then you've actually got to analyse how much you're spending on oil, if you're on oil at the moment, how much you're spending on oil. Are you happy with that? Because if you are, just carry on paying it unless you're wanting to be really green. If however you want to be green and if you're not happy with the amount you're paying on oil, then you've got to evaluate your circumstances to what is the best solution for you and there are lots of solutions out there.

There's ground source heat pumps that we've been talking about and I'm obviously a fan of, air source heat pumps, I'm not quite such a fan of those but they do have a place, biomass boilers which means burning logs or woodchip or worst case scenario wood pellets. Do you have a stream running beside with a good flow and a good drop in it? In which case a hydro system is a good idea. They really can pay back enormously quickly.

Obviously the other thing to be aware of is government grants. Everyone's seen PV panels going up on people's roofs and the feed-in tariff that you get from that. There are also feed-in tariffs for hydro systems, so if you have water wheels and things like that and the government is bringing out the renewable heat incentive which will pay people to replace their oil fired boilers with heat pumps and biomass boilers to heat their houses. Those grants are actually looking like they're going to be particularly generous.

So we're rubbing our hands together with glee as business people but as a taxpayer I object to subsidising everybody else's houses. [Justin laughs.] No, the heat incentive is one of the things to really keep an eye on because it will mean that you will be able to heat your house, not only for free but you'll be paid to heat your house for the next 7 years, the way it's looking at the moment. There is, of course, an upfront cost of putting in the equipment in the first place.

Ben: Well, Justin, some great information today. Thank you very much for your time. And that's something else that we've got to take on board.

Justin: No problem at all. Nice to speak to you.