HOUSE PLANNING HELP

Episode 252

How to reduce the embodied carbon of your new home

- with Chris Magwood from The Endeavour Centre

The show notes: www.houseplanninghelp.com/252

Chris: Sure. I've been working in the sustainable building field for the last twenty-five years and most recently, the last eight years now has been with the Endeavour Centre, which is a sustainable building school based here in Peterborough, Ontario.

We do a bunch of things at Endeavour but our main educational programme is a full-time certificate programme where a group of students builds a carbon-storing, high-performance, non-toxic building with us from start to finish. So, we're very much always trying to maintain extremely high standards in all those areas and trying to train the next generation of builders to be able to carry that kind of thing forward.

Ben: Who are you aimed at? Is it the owner-builder sector or just anyone in construction?

Chris: Our student groups tend to be a mix of those. So, in a typical year, we'll have an owner-builder or two who's just looking to really inform themselves well before they do their project. We'll have some people who are in the construction trades and are looking to improve their practices. We'll get some people from the design side of things who want to see some of this more sustainable stuff hands-on in order to be able to know how to design it a bit better.

So, it tends to be a pretty wide range and also, a typical course for us has people from their early twenties to their early sixties and everything in between. So, they're usually pretty eclectic groups.

Ben: And there's a good appetite for it?

Chris: There is, actually, yes. Our courses typically fill up. Interestingly, we get almost as many international students as we get Canadian students. So, quite a few people have come from the UK, quite a few people come from Europe. We've had people from Africa,

Australia, New Zealand, lots of Americans. So, we get a pretty interesting group of students.

Ben: Give us an example of some of the courses and what people might learn in those.

Chris: Sure. So in the sustainable new construction, which is our core programme, people are here for anywhere between four to six months depending on the size of the building we're building. And they will basically do the entire construction project from start to finish and see either low concrete or concrete-free foundations, interesting wall and insulation systems, cladding, interior finishes – basically, the entire build cycle all designed to have a zero carbon footprint, be net zero energy, have no toxins and generate no construction waste.

So, the materials and technologies might vary from project to project, but those core goals remain depending on what kind of building we're building each year.

Ben: We're going to talk about embodied carbon. So, I suppose it would make sense to have a definition of that and how it relates to buildings.

Chris: The definition that I work with is all the carbon emissions that are associated with materials from initial harvesting of raw materials through the entire transportation to manufacturing facility and everything that happens in that manufacturing facility. And then transportation to a job site and the associated emissions with actually doing the installation work on the job site.

Ben: And the energy in use? Because that's the other thing that people focus on, isn't it?

Chris: Yes. So, for a long time, the term that was being used was embodied energy, but it's important to realise that energy isn't necessarily a proxy for carbon. So, two factories could use the same amount of energy, but if one is all solar and one is all coal powered, then the emissions profile of those two things is going to be very different. Even though in embodied energy terms, that number might look the same.

So, this is specifically trying to make emissions the focus and not just energy use.

Ben: And is it a good thing to focus entirely on carbon? Because no doubt there are other things. I know that for climate change, it's always carbon is the focus.

Chris: Well, the way embodied carbon gets measured, we use the word carbon because we're using carbon dioxide as the expression of all greenhouse gasses. So, it's not just looking at carbon. If there are other emissions, if there's methane emitted, then that amount of methane is translated into a carbon dioxide equivalent.

The expression that we use in the calculations is CO_2-E – so, carbon dioxide equivalent. So, if it's carbon dioxide, one molecule equals one. But if it's methane, one molecule would equal twenty-five or whatever the number happens to be.

Ben: So, in your research, how did you go about establishing the best methods of trying to build with low embodied carbon?

Chris: Well, I started with a British database that came out I think around 2008 called the Inventory of Carbon and Energy. I started looking at taking some of our building projects at Endeavour and using those embodied carbon figures.

It just started as a rough, 'I should sketch this out on the back of an envelope' kind of thing, not thinking that it was necessarily going to become such a focus for me. But as I did those rough calculations, I was pretty stunned at the results in that some things had such a huge carbon footprint and I had never really considered that impact being so big before. And then some things were miniscule.

So, when I started looking at how that played out over an entire building project, it pointed out a lot of opportunities where there were a handful of really major impacts that if I could avoid those and then on the flipside try to really focus on the materials that had really low numbers, it was possible to build the same building but dramatically change the carbon footprint of it.

And then as I started to research, I also came across the notion that if you're building with a material that actually has atmosphere carbon stored in it, so basically any plant material – so, a plant has pulled CO_2 out of the atmosphere in order to grow; it's released the oxygen and it's kind of put the carbon into its physical structure – that calculation wise, that's a negative emission. That's a drawdown of carbon rather than an emission.

So, once I started working with those numbers, I realised that the way that we had already been building here at Endeavor – so, we use a lot of plant-based materials; we do work with strawbale, we do work with hempcrete, we do work with cellulose insulation, lots of recycled products, all of which are net carbon stores – I started to realise, as I did these calculations in a more serious way, that a lot

of our buildings were actually pretty major carbon sinks rather than being the cause of carbon emissions.

To me, that was such an exciting possibility, that buildings which are among, if not the highest emitters of carbon, the manufacturing of the materials and the transportation of materials, all of the emissions associated with the materials we use, it's such a huge piece of the global climate problem and to think that simply by building with a lot more plant material, we could not only reduce that carbon footprint to zero, we could actually take it into the negative numbers and make drawdown buildings that are actually in their way drawing down climate change rather than contributing to it.

Ben: This is obviously very, very important. I've just built a house and for reasons that I won't go into, it was a masonry house. But I think it's always going to niggle away at me that perhaps I should have tried a bit harder.

There are sometimes pressures; cost can be one of them. But can you just list some of these materials, first of all, that you're talking about? Or is it really anything that has a strong plant base?

Chris: Yes, basically if it's a plant based material.

Now the overall net emissions will depend a lot on how much processing carbon and energy are put into it. So, for example, cork is a plant based material but because there's quite a bit of heat and processing of that material, it still ends up being a net store of carbon but it's got a much smaller storage capacity than, say, straw which has almost no emissions in terms of the harvesting and manufacturing of it, or they're extremely low.

So, even though all of these plants more or less store a similar amount of carbon, the amount of processing energy that's gone into them does change the net profile.

But essentially, any plant based material. And that would include timber although as I've been researching timber more and I think this is starting to show up in a lot of building industry reports, it's much harder to attribute carbon storage to timber because the carbon that's in that tree, depending on when the tree was cut, that tree could have gone on drawing down more carbon as a living tree than it does as a stored tree. And if you only end up using about half the volume of the tree to make a timber product and the rest of the carbon from that tree ends up back in the atmosphere, you actually haven't net stored any carbon. And if you've released a

whole bunch of carbon from the soil of the forest floor, then it may be worse than a draw down. It might actually cause emissions.

Whereas plant materials that come mainly from agriculture residues but also things like cork, those are things that we were already growing, there's already a use for, in the case of grain straws, for the grain to eat, and the carbon that was in those stalks would have just returned back to the atmosphere in fairly short order. We would have either burned them off or let them mould in the field or composted them. But in some way, that carbon would go back into the atmosphere. But if we can grab on to that stuff, the annually renewable carbon plant based materials, then it can be a pretty major draw down effect on the profile of a whole building.

So, your masonry building, depending on what kind of masonry it was, those materials do tend to have a really high carbon footprint. But say you used compressed straw panels for all your interior walls and you used some cellulose insulation, you may have actually brought yourself close to or just a little bit better than zero by balancing those things off.

So, I'm by no means advocating that buildings need to be entirely plant based, but if you can weigh up the carbon storing materials with the carbon emitting materials, you can actually plan a building to land on a target that you're aiming for, whether that's carbon neutrality, storage or a slight number of emissions. But you can actually intentionally choose those kinds of targets and go about hitting them.

Ben: The masonry side for me was really a lot of our industry in the UK revolves around this and I just can't understand why. So, I thought if I built it myself, I would then understand more about why we're so obsessed with this. Another thing that I've heard is that actually, a lot of the masonry is just air. I don't know whether you've got any comment on that.

Chris: Well, yes. There are sort of air-entrained masonry units and the carbon footprint profile of those will be lower than a solid masonry unit. But there is no way at this point – although people are working on it – there is no way to make masonry that's anything but fairly carbon intensive.

So, by filling some of the space with air, you can offset some of that masonry. But whatever masonry you're using does carry a pretty high carbon footprint.

And I wouldn't say that that's necessarily bad or the wrong thing to do, but it's the kind of thing that you can then intentionally go about balancing that with some carbon storing materials to negate the effects of the carbon you've emitted for those types of materials. For example, our buildings, we use a lot of steel roofs and sometimes steel cladding on the side. The building still ends up with a carbon storing net profile. We've just used enough carbon storing materials to offset the intense materials like the steel roofing.

Ben: How are you calculating that then? Because it's again a little bit of a picture, isn't it? And you've given a few examples of how, with trees, it gets very difficult to know what the right thing to do is.

Chris: Yes. So, my approach to it has developed and gotten better. I went back to school to do a Masters degree in this so that I could convince myself that I was doing it properly and well. But essentially, most of the data that I'm using now comes from environmental product declarations which are an ISO standardised way of reporting on the environmental profile of a material.

So, it's a third party document where the third party goes in and looks at a manufacturer and traces the entire chain of that product and essentially does a calculation to look at its global warming potential from harvesting of the raw materials through the entire manufacturing process. And so, I'm basically using those numbers to then multiply out on my own buildings.

So, if a particular environmental product declaration says there are two kilograms of CO_2-E per kilogram of this material, then I figure out how many kilograms of that material are in my building and then I can multiply that out and do that for all of the materials and then total that up and get a net, emissions or a net storage. Figure out what the total is for the building.

Ben: For someone that's coming in fresh on this who would like to do that, to have some evidence behind their choices, but maybe they've got a hundred-and-one other things that they're thinking about, is there a way to do that? Can you be intuitive, do you think?

Like, strawbale was what I wanted to do for this house but I chickened out a little bit on doing that. So, can you guess a bit or is that a very foolish thing to do?

Chris: No. In fact, I've been on this three year trail of doing a Masters and diving really deep into these numbers and doing the extremely accurate calculations to arrive at the answer that I kind of knew

going in, which is that there are a handful of materials that we use really commonly that have a really big carbon footprint.

So, concrete, glass, foam, and steel, those all have really significant carbon footprints associated with them. And essentially, any plant based material – that could be straw, it could be hemp, it could be wool, it could be cork, it could be recycled paper, it could be any number of materials that are essentially plant based, and especially if they are residues or waste stream materials – those have a really large carbon storing component to them. And so, without actually having to do the calculations, you can be pretty sure that if all your walls are made of straw, you're probably offsetting the concrete in your foundation and maybe the tile or the steel on your roof by using that much plant based material.

Ben: You've mentioned cork a couple of times. Cork is quite a good example because if I'm right, it takes a few years to be able to get the cork. So, how are we with supply chains? I like your waste materials from farming, agriculture, all of that sort of thing, but what about materials that really, they're still quite tricky, aren't they? Some are easier than others.

Chris: Oh, absolutely. I think that a good hierarchy, and there are a lot of academics who've got charts and graphs on this, but the shorter the regrowth cycle for a material, the better its carbon storing profile looks. So, if the annually renewable resources that I've mentioned – straw, hemp, even wool; things that aren't as common here but bamboo, we had a student from Africa who was using a lot of palm kernel shell and palm kernel ash and palm kernel fibres – so any agricultural residue, especially the ones that renew annually, those are the best things, the ones with the best carbon storing profile.

Things like cork, that do take eight to ten years to regenerate, its profile is less ideal but still better than materials that emit. And then when you get to longer cycle materials like timber where you're looking at forty to sixty years, it's pretty hard to attribute any meaningful carbon storage to using those materials.

Although, even if you don't look at timber as a carbon storage medium, it's a lower embodied carbon material than concrete or steel which it is often used to replace. So, it's not like using timber is a bad thing, but it's just not a carbon storage strategy.

Ben: What will it take to make this full on mainstream? It seems in the mind that it's all easy, just it makes sense. But why is it not happening?

Chris: Well, I think partly it's not happening because collectively we haven't really thought about it before. The paper that I just finished for my Masters I think is the first paper to actually look at the possibility of buildings being carbon storing mediums.

There's been maybe in the last ten years a growing pool of research into embodied carbon footprint and how to reduce that, but the notion that we can go beyond reducing that footprint and actually driving it into draw down territory is really new. And so, I just think it certainly hasn't had a chance to filter out into academia let alone the construction industry.

Although that's going to be the focus of my work and my career from here on in, is trying to figure out the solution actually is pretty straightforward, it's not that hard to incorporate reasonable amounts of plant material into buildings in a cost effective way, so how do we do that? I think that's what I'm going to be working on from here on in.

Ben: Well, good luck. I think that's a very important mission.

I live in a passivhaus. So, that was a side that drew me in from the perspective of obviously energy efficiency, comfort, health and wellbeing. But I'm well aware that without also the low embodied energy, it's again another good step but if we're thinking about climate change, how do you balance these things also thinking about renewables at the end as well?

Chris: Well, that was a big part of the study I did. So, I did the embodied carbon side of things. I did a couple of sample buildings and modelled them using all kinds of different material profiles to see what the carbon footprint would be. But then I also did an energy study where I looked at what will these building use, and depending on what their source of energy is, what's the carbon profile of that.

It was really interesting because the way a lot of people will achieve Passivhaus standard here in Ontario, Canada, is they'll throw a whole bunch of foam insulation at that building. And when I modelled that, the embodied carbon footprint, the upfront emissions of making that building, don't ever get paid back by the energy reductions. So, if somebody was using that strategy because they thought they were doing something for climate change, they've actually done exactly the opposite.

Again, we tend to use energy as a proxy for carbon, but it's not. So, here in Ontario, we shut down our coal plants a few years ago, and so our electrical grid is actually relatively carbon free. And so,

savings in energy efficiency, especially moderate ones, our code is now pretty good in terms of baseline energy efficiency. Going from that to Passivhaus, while it may have good implications for the owner in terms of lower bills and comfort and all that kind of stuff, from a carbon emissions profile, it's almost meaningless with the difference between a code built house here in Ontario and a passivhaus in terms of the emissions profile of operating that building, it's negligible because the carbon profile is so clean on the grid.

If you export that same model to, I have colleagues who work in the north-east of the US where there's still a lot of coal power, then that kind of Passivhaus strategy starts to make a bit more sense from a climate change point of view.

So, it has to be quite specific in terms of understanding the carbon profile of your energy grid and just making sure that you're aware that carbon and energy are not the same thing. A grid that has a lot of renewable energy on it doesn't have the same carbon emissions as a grid that is using a lot of fossil fuels. And so, making a building more energy efficient has a much bigger impact on the dirty energy grid than it does on the clean energy grid.

Ben: And what are your thoughts then on having renewables on site?

Chris: Again, I think there are lots of reasons why people might want to do that. Here in Ontario, we had almost twenty years of having a really great rebate programme where you got paid quite well for the renewable energy supplied to the grid. There can be a whole host of reasons why you might want to do renewables.

But again, if you're doing it in terms of a climate change initiative, you have to think about again, here in Ontario, if we have a relatively clean grid, I have five kilowatts of solar on my roof, but I'm not really offsetting any carbon emissions. I am making decent money by offsetting my bills, but because I'm not really displacing any fossil fuel energy, then I'm not really having much of a carbon impact.

And even if you're on a grid that does still use a lot of fossil fuels, you have to understand how that renewable energy is going to be used. Is it actually offsetting a significant amount of fossil fuels? So, if the base load is all supplied by coal and your PV on your roof is offsetting some of the peak use where they might be firing up a natural gas plant, if you're just shaving a little bit off that natural gas amount with your PV, you're probably not having that big an effect.

So, I think if you want to approach these things and do the right thing from the climate, there are no easy answers. It's not just PV is good or Passivhaus is good. You actually have to think about it and do some calculations to see, am I actually having a climate impact or am I actually, in the case of a foam based passivhaus here in Ontario, you're actually doing exactly the wrong thing for the climate.

Ben: And your thesis, has it manifested itself on the website? Is it just for you?

Chris: It's about a few weeks away from manifesting itself on the web. It's just gone through all the processes at the university and it's about to emerge in public. So, it'll be out there soon.

And I've already been out there actively presenting the results, even though the thesis isn't complete. On my website, there are videos of various presentations I've given at different conferences and stuff like that, that are based on those results.

Ben: Fantastic. Chris, thank you very much for your time. I really appreciate it, and good luck. Keep on going.

Chris: Okay, thank you very much.