

Episode 132

What is modular design and how does it work? – with Peter Schneider

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Intro: In my research for this podcast I've been lucky enough to see many different types of houses, but I don't think many of them embrace modular design. So that's what we're going to explore today with Peter Schneider from Efficiency Vermont.

I started by asking him to explain a little about his background and what he does.

Peter: I'm a senior consultant at Efficiency Vermont and the Vermont Energy Investment Corporation.

So Vermont Energy Investment Corporation (VEIC) is a non-profit, 501C3 and our mission is really to reduce the long term and immediate costs of energy. And we provide services internationally. One of our larger contracts is Efficiency Vermont which is the State of Vermont's energy efficiency utility. It's rate-payer funded, so on every electric rate-payer's utility bill there's an energy service fee and that goes to the state and money is allocated to Efficiency Vermont to provide energy efficiency services to all electric utility rate-payers free of charge.

Ben: And we're going to be talking about modular design first of all, because that leads nicely into what you're doing today. So can we start with just what is modular design, when we're talking about architecture and housing?

Peter: Yes. So it was about 8 years ago now I began seeing some very good modular homes which were homes that were built in a factory setting. A number of these were coming out of Canada, Quebec in particular. They met their R2000 programme, they had higher levels of insulation, really great detailing. They typically work within a certain modular framework in regards to their size. Simple geometry. A lot of the characteristics of a modular home lend itself

to sort of a Passivhaus type of geometry, simple geometry, working within 16ft wide modules of varying lengths.

So it was always in the back of my mind that we pretty much build everything in factories outside of homes. And I saw that we could get good homes out of our factories, both coming out of Canada but also in the US.

So about 6 years ago began looking at utilising a modular factory, in this case a local one that is in the north east of the United States, to achieve the Passivhaus energy standard.

Ben: How do modules fit together, if we just talk in general terms first and then some of the complexities of Passivhaus?

Peter: There are all different types of modular homes. Some are a single box and they can be up to multiple boxes, 6 box home for example. But ultimately you have your exterior thermal envelope which is going to have your insulation, air barrier, weather barrier siding. Where the boxes come together if they're on the same level, you'll have a common wall. Typically a 2x4 uninsulated wall where there are interior door openings or just open spaces to move from one box to the next.

And literally those boxes built in the factory are put onto a flatbed trailer and delivered to the site. They're installed off of the trailer with a crane typically. Lifted and set onto a foundation. And then those boxes are slid together, fastened, fixed to the foundation and to themselves.

And then for those boxes that go one on top of the other, you typically, because again you're transporting these and you're picking them up with a crane, putting a good deal of stress on those boxes, you have like a ceiling system, say it's 2x6, 16 on centre, for the ceiling of the first floor box, and then you would also have a floor system on top of that, again for the rigidity in that you're travelling down the road and you're picking these boxes up. So you sort of have a ceiling and a floor system that connect together.

And then there's a whole series of detailing that needs to take place on site with regards to air sealing those boxes together, for airtightness but also the weather barrier.

And then ultimately sometimes you're siding the whole house on site, other times the siding comes partially done and you'll be patching in the siding when it gets to the site.

And then with regards to the roof structure, there are all different methodologies with regards to the roof system. Sometimes they have tilt up roofs, so the homes have roof systems that have a fastener that hinges down along the eave and it can be tilted up. You put a knee wall underneath that and then on another flatbed they deliver the upper roof systems like the gable peak portions and literally these homes are delivered, put together piece by piece, and they're typically airtight, weathertight, after one day of installation.

Ben: Forgive me if I ask some very basic questions here! Is it always four sides? Is it always boxes?

Peter: Well that's a good question. The modular homes with which I'm familiar all resemble your typical home or multi-family building. We've even had some modular construction in sort of low-rise, mid-rise buildings where you have multiple storeys, 6, 10 storeys. But yes, typically you're talking about simple geometry. Not to say that it's limited to that, but if you're taking advantage of the modular build process with regards to cost, with regards to getting a very good performing home to your site or building, you're working in simple geometry and putting boxes together that at the end of the day would form your typical house or multi-family building look.

Ben: Is this really about standardisation or the way the factory is set up, things are just so flexible you press a button on a computer and it'll do it all sorts of different ways?

Peter: You can as I said build anything in a factory. And there's always going to be cost implications, whether it's a complicated dormer or it's complicated geometry in the building shape that's going to have a number of different bump-outs, different levels, different level floor systems, you know a sunken living room. All those have cost implications but they can all be done, whether it's stick built on site, so literally all the materials are delivered to the site and built, or if it's done in a factory.

I don't think there's any limitations on building in a factory, but the piece that I like about factory construction which lends itself to high performance buildings, is working within their framework where you can really cost optimise the construction, and if we just speak about homes, of homes, by working within their 16ft modules, by working with simple geometry and by taking advantage of getting as much of the construction done in the factory so when the home's delivered to the site you're minimising the amount of work that needs to be done on-site, because that is where most of the costs

occur, which is on-site. It's more expensive once you move the home out of the factory so if it can be delivered buttoned up in a day's time where all you're doing is patching some air barriers, weather barriers, siding, maybe putting on some decks and porches, that's ideal. As opposed to having a very complicated number of boxes with no siding, no exterior finishes and then a number of different roof systems and so forth that need to be built on site.

Ben: How popular is this in the US? Because I have only actually seen my first modular designed home last week in fact when I was down at BRE and it was following the affordability model. But how popular is it where you are?

Peter: Well I think it's becoming more popular. And I don't know the percentage off hand of what percentage of our new, let's say single family detached homes, are modular. But where I'm working in the north east it's becoming more and more popular where builders as well as homeowners, even architects, are beginning to see the value of working with modular manufacturers.

There's a number of different reasons. One, again we're working in a climate controlled environment. There is a faster build process with regards to getting the home delivered to the site and built for the buyer or prospective buyer if it's a spec home, and the quality is as good if not better than what you can get on site.

Again because it's factory built, there's a very close eye on attention to detail in a lot of factories, I won't say that's across the board, I would say historically and I'd say the industry is still working with the stigmatisation that modular is not as good as custom stick built on site. But we've seen the alternative where modular is exceeding the quality and the creativity and the performance that we're getting with our stick built homes on site. Particularly in an environment like the north east where we have a really harsh climate. If it's not raining sideways it can be sleeting, snowing. It's really hard to keep your building materials dry, to keep your carpenters, sub-contractors happy under all the different conditions that we see here.

So there's a reason that we don't deliver a thousand different car parts into a lot and try to build a car, in this climate, let alone any climate. And it's the same for a house. There are a lot of challenges when you try to build a house piece by piece in the field.

Ben: And are they saying that timber is better, or this argument really because that's what they know in some respect? The building and the construction industry has often just built something and passed it on and not had much interest in the efficiency and so forth. Is that where that argument is coming from or is it just an alternative?

Peter: Well, let me see if I got your question correct. Most modular buildings are timber framing. Here we call it stick built or frame building, so 2x4s, 2x6s, double 2x4 walls, and they're doing all different levels of efficiency. Every modular manufacturer needs to meet our bare minimum, federal building codes and energy codes, and many are exceeding that by a great deal.

At the end of the day from a material perspective as far as embodied energy and overall performance, we're seeing some of our best homes that are timber frame, stick built. Here timber framed just for clarification often means a post and beam home that would be wrapped typically with stressed skin panels which would be like the sheath EPS or XPS foamboards, as opposed to timber frame in Western Europe which would be a stick built home out of dimensional lumber.

Ben: I think all that I was getting at there was that you mentioned people actually going and building out in all weathers. They wouldn't be building modular out there would they? The whole point of it is the factory bit and shipping it out isn't it?

Peter: Well it is but there is a balance there so with all the complexities of building a home, stick by stick, out in the field, the more you incorporate factory built pieces. And that can go I think a step from building it piece by piece in the field would be going to a panelised home where you're getting wall panels delivered that are typically uninsulated. Though now there are a number of manufacturers out there doing fully insulated and wired wall panels, ceiling panels, floor panels. So that's sort of the next step away where you're expediting the amount of site work and the time that site work takes to get a fully enclosed weathertight structure.

But then the next step would be you get a home where it's 50% complete, that are made up of modules and you're maybe doing all the interior / exterior finishes, the roof system, maybe some bump-outs, decks and porches. Again you're speeding up that time and minimising the amount of time in the field working. And then the final step would be where you have a home that's built in the factory and it's completely done, so all that has to happen is it's put on a flatbed trailer, that home is delivered to the site and literally

we're hooking up the water, sewer, electrical and literally that same evening let's say the homeowners could move into that home.

And I won't say that we're 100% there but currently we're working with some small modular homes where we literally are achieving that and short of getting an electrical permit or a certificate of occupancy, those homes could be occupied the same day they're delivered.

Ben: Well let's come on to that in a minute. Just sticking with the Passivhaus side and let's say you want a number of these, was it 16x16ft you were saying on the whole?

Peter: Well typically, and again this varies state by state, at least in the United States so far as the allowable width of the home to travel down the road. In the state of Vermont we're allowed to be at 16ft travelling down the road. I'll apologise I won't even try and put that into metres. And then the length is sort of unlimited, so we're delivering boxes that are up to 70ft long. So over 23m.

Ben: So it will depend on the site as well as to where exactly this is going down, access is it something you need to consider as well?

Peter: Absolutely yeah. This would be the best approach is, before you even start designing these boxes you need to look at the site, because of course you want to take that into consideration with regards to the type of home you're designing. But yes. I've been to a number of modular deliveries where it's been a lot of shuffling, unhooking the truck, pulling in a bulldozer that has a little bit more flexibility, manoeuvrability to get these homes around curves or up steep inclines to get them to where the crane is sitting to actually set the box. So there are limitations, particularly as you get into these much longer boxes. You take a 70ft box with the truck, you're over 100ft long travelling down the road.

Ben: And are you, as you almost said before, trying to limit the amount of boxes that you need and also balance that with the transportation and getting it on site?

Peter: Yeah, the least cost approach is if you do one box. It's finished, you've built a small, compact, smart designed home. Everything is finished in the factory. That's sort of the lowest cost per square foot or square metre with regards to an approach to modular. As you start increasing the number of boxes there's more site work that takes place. It doesn't mean that it still isn't cost optimised because there's all different needs for our residences out there and different

types of buildings, but yes. The simpler the number of boxes, the less work that needs to be done on site, the better cost optimised the modular approach is.

Ben: Now I know this is your business so sometimes it's tricky to get a good answer here, but what are the cons then? What are the downsides of modular approach?

Peter: Well again there are some limitations in regards to a factory build. You are limited to, at least in the north east in particular, a 16ft wide module. So when you're looking at design, say you want to have an 18ft or a 20ft wide home, it really wouldn't make that much sense in regards to doing say a 16ft and a 2ft, or two 9ft boxes. So again, there are some limitations with regards to taking advantage of modular construction.

If you like homes that have very complicated geometry, modular can be done in a factory, you just don't take advantage of the efficiencies of building the home in a factory because a lot of that work does need to be done onsite. But I think that the cons to modular, I think it's getting our modular industry the same way we need to with the stick built industry that a real high performance home is the norm.

So I would say our modular industry is maybe as far along as our custom home builders or stick built builders in the field where there's a small group that are doing the really good homes, and again these are the very low load high performance homes that are incorporating balanced ventilation, high r-value envelopes. Really looking at high performance windows, triple glazing in our northern climate certainly, and achieving that airtightness.

The other piece is communication between the factory and what happens on the site. So when those boxes are delivered to the site they're installed on a foundation, what happens next? How do we ensure that we're not compromising all the good work that happened in the factory, with poor attention to details with tying those boxes together, ensuring that we're completing the airtight barrier and the weathertight barrier the way the factory intended it to be? So making sure that there's a really good user manual for those steps that need to be taking place onsite.

So I've seen where there have been oversights and very common with modular homes is this idea of detailing the marriage wall where boxes come together.

Historically let's say you have a lot of two box modular homes that are sort of what we call a ranch style, low pitch gable roof, two boxes come together and there's this marriage beam that comes down the middle at the ceiling. And I've been back to a lot of homes having done a good deal of post occupancy sort of evaluation from a home performance energy audit perspective, where you're doing a blower door test and you're drawing in a tonne of air through that marriage wall from the attic down into the living space which during the heating season is heat from your home migrating up into your attic and escaping.

So it's really good attention to detail in regards to how these boxes are supposed to come together and so that adds another layer.

You have two different parties. The modular factory, the workers there and then you have the site construction. What we're seeing more is that the factories are offering a turnkey product, so because they only really deliver within a certain radius they often will send a crew that will finish the home completely. So we have a number of factories right here in Vermont that do that. They see the project all the way through. They do all the site work, they deliver the modules and they finish the home. So they know everything is going to be done the way they expect it to. They're warranting the house themselves and any follow up maintenance that needs to be done, punch list items, they're responsible for.

Ben: Just back to that technique that you're using for the airtightness. We know that the joins are going to be the weak point, so how is that continuous airtightness layer achieved?

Peter: Well it starts with really good planning – design drawings that really call out that air barrier and identify for instance that red line that's going to run continuously around your thermal envelope. So that's a key. This isn't something that is being left to the site contractor to figure out. It should be really down on paper, defined and very clear how this one siding, sheathing product is going to tie into the ceiling. How that's also going to tie into the floor system or the foundation.

So there are all different strategies out there with modular builds for basically creating that nice continuous air barrier. One system to describe would be working with a sort of zip system where you're actually using a sheathing product that not only acts as your structural sheathing but it's also your air barrier and your weather barrier. It comes with proprietary tapes so every 4x8 sheet on your walls at your ceiling plane and at your floor plane say, they're all

taped and sealed together. So your windows go in, let's say it's a flanged window that's adhered to the outside which is very common in North America, you'd be using those same tapes to tape around the windows in a shingle style fashion. And you've really created this airtight box.

But again there's a number of alternatives to that approach where they're relying on membranes that are rolled out. Very common it's like a Tyvek or Typar product that's taped hopefully and doesn't do as good a job as that rigid air barrier but then there are some other great products that are coming out of Western Europe, Scandinavia, which are vapour permeable, weather air barriers that again use proprietary tapes that can be used to wrap the homes.

So one thing with modular construction is you have to travel down the road. These homes have to be lifted up by a crane so there are some different structural implications of that. So we need to keep that in mind when we think about how the home is going to be built. Some things that are done on site that work very well as a high performance wall system, roof system, may not be applicable to modular, because you couldn't pick that home up, put the stress on it that you do with say 4 picking points over a 60ft box and set that on the foundation without having structural implications.

Ben: It's interesting as well that when we first talked about this, and I have very limited experience of modular design, I was thinking that perhaps you're going to end up with a lot of steel in these. And from what I understand you've just been talking timber the whole way?

Peter: I have. There are modular manufacturers that are relying on steel to create greater open expanses for living spaces and I would have to say that I don't have first hand experience of how they're dealing with that steel. From an energy efficiency perspective that can turn into a fairly significant thermal bridge – a highway that's going to allow either heat into the building during the cooling season, or allow heat out, or cold in, during the heating season.

But my experience has been timber frame and all the modular manufacturers with whom I've been working are focussed on timber frame and we're not incorporating any steel into those structures. It can be utilised and I'm sure it can be detailed to ensure a good thermal envelope, but I don't have direct experience with it.

Ben: Well let's ask one more question and maybe you can allow this to lead you into what you're currently doing. Cost effectiveness. I think

you've said that this is one of the benefits, so why is it cost effective?

Peter: It is and there are ways in regards to incorporating modular design in a factory built structure that will allow you to reduce the cost when compared to that equivalent house being stick built in the field.

Again weather can play a role in that, cost of site building a home can play a role in that. A lot of these modular factories are moving a lot of boxes out their door on an annual basis. They're buying a lot more of the product at a lower cost. But there's also transportation costs of getting those boxes to the site. There's the crane. So definitely if you were to look at modular construction there's an opportunity to reduce the cost when compared to the alternative stick built approach. That's not to say that there aren't great modular builders out there building really high end, high performance, homes that we need to see more of, that maybe meeting cost equivalency with that same home built on site – stick built. So again there's a large spectrum.

There's no question that you can get a home that's built in a shorter period of time, maybe at a lower labour rate, to the same quality but at a lower cost out of a factory than you would be if it was site built.

But that is a really important piece of this which is we have a real shortage of affordable housing in the United States. I'm focussed right now particularly in the North East but we're continually looking for new ways to provide better affordable housing.

Historically affordable housing has been lower first cost. But we have seen particularly as we're seeing more severe weather events, of course higher energy costs, that often those lower initial costs, that is basically a cheaper home, worse air infiltration numbers, lower insulation values, poor windows and doors, those aspects of lower cost construction lead to higher operation costs, higher maintenance costs, and actually make it very difficult for those lower income residents to build wealth.

Sometimes those homes actually won't appreciate over time. They may depreciate and not hold their value, again because of the quality of construction. So what we've been doing is re-thinking affordable housing and not just looking at the initial cost of the home which I think was, in a historical perspective on this, still is often reflected in affordable housing. But instead looking at life cycle costs and looking at how we can help the homeowners or the

tenants, if they're actually low income rental units, how we get them into better housing, healthier housing, but also housing that's going to protect them from energy cost escalation down the road, is going to reduce their operation costs, reduce their maintenance costs and hopefully we're putting them into a home that's going to help them build wealth.

That is this is a home that's as good as any custom built home that's market rate housing that is going to actually appreciate over time. Maybe even more so than our typical construction because it's utilising these characteristics that are common in Passivhaus but higher insulation levels, great airtightness, real high levels of comfort and superior indoor air quality when compared to our typical homes that are out there today.

Ben: You mentioned rent in there, so who are the landlords here? Is this something that is done, in the UK we'd have Housing Associations. Is it a similar sort of thing or are you talking about private landlords?

Peter: It's both. We have non-profit housing trusts that build and manage affordable dedicated affordable rental housing and we also have private landlords that manage rental housing as well. Our focus is on both groups in regards to getting them to invest in housing that is going to serve their tenants better. And to be honest, because they're owning the building for them reducing operation and maintenance costs for the landlords is important as well. And then of course what is that asset value over time? They don't want to be getting into something that's going to be a burden down the road. They're going to be looking for a home or a multi-family building that's actually going to be building value over time because of the quality of construction.

Ben: So when we talk about mobile homes specifically, I know there's one particular programme that you're up to, do they just go into landfill all the old ones and hopefully you're going to tell me that this next generation of mobile homes is a lot better, that we'll have a proper circular life?

Peter: Right. So we are talking about homes that are manufactured in plants right now. Well we've talked a lot about modular homes. Some of the stigma around factory built homes is a result of the what's called the manufactured home or mobile home industry. And that gave factory built housing a bit of a black eye. It still does to this day.

So historically, and this goes all the way back to around the 1930s, there was a real shortage of affordable housing then, just like there is now. They started literally building these mobile homes which were delivered and set at the perimeter of cities for lower income residents. And this is carried right through. Land fairly cheap in the US, development costs fairly cheap, very different than what you'd find in the UK, and so having a factory build very inexpensive home delivered to a very very inexpensive development is a great approach to serve low incomes renters, on the surface, or homeowners.

But what's happening is these homes are built in say one fifth the time at half the cost. You get what you pay for. These homes are very poorly built. They're delivered on a steel chassis and they actually stay on the steel chassis. They're built to an alternative code. So modular homes have to meet our states and federal guidelines for building code and energy code. Manufactured homes, which are mobile homes, they changed sort of the terminology back in 1976 when there actually became a code for these manufactured mobile homes.

So today they're known as manufactured homes. They're not modular. They stay on a steel chassis. They're often delivered and installed on undisturbed earth, put up on cinder blocks, or un-frost protected slabs with jack stands, and these homes have very high energy costs, poor indoor air quality due to poor ventilation and poor product choices and while they may be very low cost up front they're very high cost for the homeowner with regards to operation maintenance and over time these homes are known to depreciate. So they actually lose value day 1. Kind of like buying a car and driving it, or a new car and driving it off of a lot.

So yes, we're looking at our low income sector and we're not quite 1 out of every 10 homeowners in the country living in a manufactured home, but we're not far under that. So we have a lot of people living in these manufactured homes and they're burdened by living in a home that's losing asset value over time, and a home that's very hard to build wealth and actually get out of. So we have a lot of residents who will be in these homes 20/30 years until they're really uninhabitable.

Ben: So just finally, maybe you could round this off. Looking towards the future, is this a positive sign? Are we going in the right direction or is it still a case of actually it's hard to persuade some of the owners to go down this route?

Peter: Well there's a very sharp learning curve for our homebuyers, our lenders, our appraisers, our developers. In regards to what a high performance home is and what the value of that home is to the homebuyers.

And then again being able to market. There needs to be a demand for it. So we really need to educate the public that they should be demanding this level of housing.

But no, I see a light at the end of the tunnel. We've had a lot of success in Vermont getting homeowners, and in this case many very low income homeowners, to not look at first cost but to understand the life cycle cost of that home. We're looking to give them an opportunity to build themselves up out of poverty and do that in a very healthy home that has low energy costs and ultimately is going to be something that is going to help them build wealth over time.

Even more importantly is this idea that we all need to be reducing our carbon footprint. We have a comprehensive energy plan for the state of Vermont that says we want all of our buildings to achieve zero energy by 2030.

Right now we're showing that in the lowest income sector, that is sort of our mobile homeowners, we can deliver a home that on a monthly basis is going to cost less than the alternative home that is a manufactured home, mobile home, it's going to cost less month one. That is its energy plus mortgage cost. And this doesn't even factor in all the non-energy benefits like the health implications that you have living in a home with poor ventilation and high off-gassing materials.

We're getting folks into homes that have really healthy air day one, very high levels of comfort which increases productivity and then again protecting them from energy cost escalation. We're doing that and month one they're paying less for energy and their mortgage than they would getting into a home that's far inferior with regards to its performance and health implications.

Ben: Well Peter, keep up the good work. It's been great to have a chat. Thank you very much.

Peter: Absolutely, I appreciate the time Ben.