Australia's National Science Agency

Seal it tight and ventilate right – Audience Q&A

Disclaimer

The questions in this document were recorded from the audience Q&A function of a webinar held by CSIRO on 8 July 2021. The webinar was moderated by Anthony Wright, research Lead at CSIRO. Speakers were all drawn from industry based on their expertise in either Passiv Haus design or Passive Solar Design. Each speaker's opinion is their own. CSIRO does not endorse the views of any one speaker – in fact, CSIRO must balance the views of not only our speakers (who generously donate considerable time,) but also many other stakeholders when designing and operating the benchmark tool, AccuRate, under the Nationwide House Energy Rating Scheme. CSIRO hopes that by providing access to the wide range of opinions, you our audience, will understand the balance required to get this right across Australian's varied climate zones.

Jesse Clarke – Pro Clima

Is painting the rear of plasterboard and effective way of preventing moisture laden air entering framing?

In an ideal world adding vapour resistance as a paint coating to the internal face of the plasterboard can help to reduce water vapour from entering the structure. However, this assumes the plasterboard layer is completely sealed and airtight. Considering, GPO outlets, light switches, light fixtures etc mounted to the gypsum then it is never going to be an effective air barrier. Vapour control does not work well without air tightness. The more airtight the vapour control layer is the better it works.
In addition, adding too much vapour resistance to the internal side can be catastrophic. Examples of this are vinyl wallpaper which was quite common in Motels in the USA. The vinyl is durable and washable but a high vapour barrier. In more humid regions this created serious mould issues with back diffusion of humidity from outside and getting trapped in the plasterboard. This is a bad idea and highlight the importance of consideration of "back-diffusion" in climates that have high humidity summers.
This then also highlights the necessity to increase the inwards drying potential. Using intelligent vapour control layers behind the plasterboard (& sealed tight) they will not trap moisture in the back-diffusion scenario. This technology responds to high humidity in the back diffusion scenario by becoming more vapour permeable. This is based on the chemical structure of the Intelligent interlayer used in these membranes.

"I'm not sure if this will be covered, but what about using alternate materials like CLT? Can a timber surface help with issues like internal moisture?"

CLT is a great technology. There are various ways it is manufactured. The cross laminated pieces of timber may be edge glued or not depending on the manufacturer. The CLT itself also changes moisture content with the seasons based on average surrounding humidity and the equilibrium moisture content in the timber. It potentially swells and contracts. This can make the CLT achieve different air tightness levels in different seasons when the gaps open up or close up. The hygric capacity of the CLT, i.e its ability to store and release moisture from the interior air make it great for buffering indoor humidity and keeping the indoor conditions comfortable. The CLT itself, due to its moisture buffering capacity and moderate vapour resistance then negates the necessity for an internal intelligent air barrier. Air tightness can be achieved using external membranes..

Most importantly is the type of insulation used over the external side, this should generally be as vapour permeable as possible, such as an external grade rockwool, which also gives fire performance on midrise projects. otherwise, wood-fibre is also a great option on the external side. Foam based materials are generally not the best option, but the higher vapour resistance of these foams may be beneficial in tropical regions. Research is under way on this.

"Jesse, if a NatHERS 6 star compliant house has the 10 star occupants, will it deliver a healthy and efficient home?"

I think any house with 10-star occupants that are willing to make the sacrifice to use less energy at the expense of other things will deliver an energy efficient outcome. The problem with regulations is that we are dealing with not just eco-warriors like ourselves but all other people that may either A) Don't care B) Don't know. These people buy their house and land package based on what they can afford. Then they expect the regulations to deliver A) Comfort B) with very little energy use.

There will always be the extremes that need heating and cooling. It may be that the 6 stars brings the home into comfortable and healthy range in the midseason's but not in the seasonal extremes. To always have thermally healthy conditions you may need to use more energy as to not wake up to excessively cold living rooms in winter or swelter in westerly facing rooms in summer.

"As a builder looking to make changes for the better over and above our existing codes, is there anything that can be retrofitted to newly built homes to reduce condensation and mould issues? HRV?"

Yes, HRV or a properly designed ventilation system. Generally reducing indoor humidity is about having a continuous known air supply. You can't rely on wind to blow fresh air through gaps in your construction. It just does not happen when you need it to.

Retrofitting a fully ducted HRV can be difficult, but not impossible. It depends on your house and possible routing of the ductwork and a suitable location for the main unit. Other options exist like in-wall HRV units that work on alternating airflows using a ceramic core to exchange heat. These may be easier to retrofit.

"@Jesse - ON the duplex example, do you have any running costs comparisons / savings on heating and cooling that we can put in $ savings. Also a ROI value?"

No, not yet. The running cost is a misnomer. If you try to do a simple payback based on energy savings alone, you will get the wrong answer. The economists will always do it this way. That is why they always get the wrong answer. We need to know what the value of the health benefit is of living in a thermally stable building with fresh air. Let's reframe the question: what's the return on investment on your health?

" The use of HRV + purge systems sounds amazing in the scheme of reducing peak load... technically speaking. Realistically speaking, do you view this kind of system as something AUS is ready to start implementing on a wider scale? It seems for the most part we are still having arguments with people over the use of cheap and nasty single glazing. what would it take to bring us up to the level where we can be actively recommending this to the average non- million dollar build?"

Elon musk didn't change thinking by delivering to market something that was mediocre. It was an electric vehicle that outperforms combustion vehicles. Prove the technology works, then make it cheaper. This is known as the industry "learning curve."

If you regulate something, then the market gets flooded by "me too". Then price wars start and the consumer wins. This is the quickest way to make something cheap.

In terms of single glazing, are we still a developing country? There is no reason single glazing should be use anywhere in Australia. If we are insulating our buildings, then we should not be using single glazing. If we are, there is no justification for enforcing insulation requirements as we are allowing massive thermal wounds to be built into the envelope.

The solution is simple, set a floor for U-value that makes it impossible to build with poor performing windows. In developed countries it is more expensive to get single glazing as it is a specialist product, rather than get off the shelf double glazing.

The current regulatory structure has made window specification overly complex.

I also used to think that SHGC was very important. Then I realised that it is much better to use shading devices such that the sun never reaches the pane of glass. Then if this is impossible to achieve reducing SHGC is the last resort.

Re: load shape from heating and cooling - what about heating/cooling during peak solar availability? What effect would that have on health including comfort?

Yes, it makes sense to heat and cool during peak solar availability. Cooling is well suited to this as in summer we have most sun and it occurs in the middle (hottest part) of the day. BUT, considering energy productivity, I would still say that if you can heat and cool using the equivalent power output from a 1kWp PV array rather than a 10kWp PV array then it makes more sense. We save on resource use to use smaller offset technology. Or if you want a bigger array then you are an altruistic exporter of energy. That's great too.

"For Jesse: while I understand the failings of NatHERS occupancy assumptions (not everyone is willing or able to operate their homes), your comment about ""we don't need the sun anymore"" is quite confronting. (what about qualities of pleasure and delight?) Don't you think passive solar design principles could work well in tandem with passive house? i.e. good orientation, controlled solar gain and shade, ventilation paths that work in benign conditions, which all work to reduce artificial heating and cooling demand in the first instance, and then PH can come into play when the building is sealed up (in less desirable conditions i.e. hot, cold, smoky, etc)"

Yep, sitting in the sun with a cup of tea is great. But if that's in your living room with a highly insulated building envelope it won't be great anymore. Or if it is great, you are using excessive cooling to remove the excessive heat while you bask in the sun at the breakfast table.

Maybe what is actually a good idea is to have a sun-drenched deck or veranda, with a nice table. One can quite happily sit outside in cooler temperatures with the warmth of the sun on their back. If it's summer, get out of the Sun!!!

The biggest risk and what I believe the regulators are somewhat concerned about is overheating (undercooling) or driving up the cooling load inadvertently. In Europe overheating is a big discussion point. The difference is that in the northern European countries no one has ever worried about summer cooling as it was traditionally heating dominant climates. They did such a good job a containing heat energy (insulation, air tightness triple glazing etc. etc.) and they forgot about trapping too much heat.

We need to emphasise and focus on the heat balance (in Summer and Winter!!). We know that most of the heat entering a building comes from the sun. It is not a force to be taken lightly. Just a little bit of direct solar can add substantial amounts of heat that need to be removed in some way.

This is where the colonials had worked out that a 1-2m veranda around the house blocked out the sun. Out of necessity as they didn't have fancy machines to keep them cool. We need to drive more shading in general on all housing as priority. Even before we place unrealistic expectations on the occupants to be 10 stars.

once we have limited the solar gains then we can remove any additional heat in the most efficient manner:
If the outdoor air temperature is lower than the comfort condition then purging is the fastest and most effective way to remove heat. The cheapest option is to open a window (as assumed by NatHERS). But, has it's failings for a variety of reasons (common people). Also, ventilative cooling only works in the shoulder seasons, once outdoor temperature rises too high it will not work anymore. Yes air movement and physiological cooling gets some relief, but still has its limits.

The IEA Annex 62 is looking at ventilative cooling strategies to mitigate this issue using "purge" strategies which might include natural or mechanical ventilation strategies. Australia is a participating country.

"could jesse clarify how the modelling was undertaken, specifically did you use AccuRate and adjust airtightness and setpoint temperatures within that?"

Yes, Accurate was used. The air infiltration numbers were modified using an approached developed at the CRC for low carbon living. The purge ventilation was based on a modified chenath engine (by CSIRO) that overrides the NatHERS assumptions for cross with a purge ventilation oof 2100m3/hr across the entire house.

"What do the presenters think about ""trickle vents"" vs mechanical ventilation as a design option."

Trickle vents do not work. I have been warned personally by international researchers. Building an airtight building then poking holes in it is not the same as airtight with a controlled ventilation strategy. Trickle vents are trying to take advantage of "adventitious" ventilation. i.e ventilation that occurs when environmental conditions are right (stack effect or wind). The problem is that conditions are rarely right.

Trickles vents will be the go to position because its cheap to implement. But if it doesn't work on mass scale it becomes very expensive. UK tried it already. Let's not copy.

So, what we need is at least one continuous driving force. A high efficiency fan then forces a continuous low flow ventilation rate. This ensures goldilocks can get what she wants. Not too much air (energy inefficient), not too little (poor IAQ & moisture issues).

Just the right amount all the time for optimum IAQ & Energy....yes, we have circled back to the Health Vs Energy balance. Again.

Peter Hickson – Earth Building Solutions

"What is the star rating for the RE home?"

You would be referring to the home with the conservatory. The assessor said it couldn't be assessed properly. The result it is giving me looks too silly though it will perform very well. We used NSW BASIX DIY Tool for compliance.

"How does natural ventilation work in polluted, dusty, smoky environment?"

External air is generally much cleaner and healthier even in our Australian cities than internal air. You would obviously minimise ventilation in rare events such as dust storms and bushfires.

Curious how much energy (kWh/day) your Earth Home uses?

225m2, 3 persons. Jun-Sep '20 - 7.50 kWh/day, Sep-Dec '20 - 3.91kWh/day , Dec-Mar '21 - 3.61kWh/day, Mar-Jun '21 5.92kWh /day. 20/21 average of 5.23kWh per day (slight>on 4.5kWh/day 17/18 maybe COVID + new electric oven replaced gas one). Plus average 2.5kWh/day from PVs that didn't go to export. Winter we boost Solar HWS. Last 4 quarters 3,066kWh exported less 1,397kWh imported so positive contribution 1,669 kWh fpr 20/21.

"How can earth building adequately respond to dense urban conditions? Examples all seem to rely on large blocks with unobstructed solar access and ventilation paths, benign air quality (and supply of local earth). Does the earth building community have any successful examples on constricted inner urban sites? (Or is their agenda also against our current predominant urban development patterns?)"

Many very dense earth cities and towns exist across world including in Europe so no problems. Lets get started here. I choose to live and work in country so my homes often rural though quite a few are suburban also. Many in Perth on inner urban sites. My son is building 2 Rammed Earth homes in Sydney now. Enough soil coming from tunnelling and excavations in Sydney to build thousands of new buildings/yr . Instead it is being removed from the city at huge cost. Mountains of recycled glass that could be turned into foamglass to reduce density and improve winter performance also. Air quality in our cities is better than inside buildings. AQ will improve further with EVs. I **personally** prefer regional areas. In towns and cities prefer the terrace, town house and residential to max 4 stories. I don't **personally** believe high rise apartments are a good idea for too many reasons. Proven to be not a bad opinion. EBAA (association) certainly doesn't have a position.

Given that our climatic conditions are heading into extremes that are far beyond the performance range of solar passive systems how do we keep cool/safe in those extreme conditions? Can solar passive still deliver a viable solution in extreme conditions and how does it translate to high density urban settings (eg high rise/lmr)?

PLEEA works through mass-linked ventilation and conditioning. It balances the best of night and day and day to day up to several days. Extremes and wild fluctuations is where PLEEA excels. Modelling of PLEEA with 2020 to 2090 predictions shows improved overall performance. Modelling and lived experience shows safety in extreme conditions without power because we are reliant on air conditioning - if you manage your PLEEA building simply and effectively. The projected 4.5 billion ac units in use by 2050 will alone add 0.5C to global temps. Avoiding their use is a great place to start though it is mass and not insulation that achieves this best.

"Do you feel that earth buildings (optimised to their local climate when designed) will remain healthy and comfortable in a +3degree world. If so, why/how? Longer heatwaves in particular"

We need to address Climate Change as quickly as possible and also build resilient builds. PLEEA can achieve full LCD zero carbon immediately. The modelling I am talking about was a home optimised for 2019. I used CSIRO Analogue Town predictions, 2020 -2090 and the Emissions Scenario was RCP 8.5. Maximum Consensus with a 3.8C increase in temperature. In 28 years after a three-day heatwave my 3.2 star mudbrick home maxes at 28C on the last day with no cooling. We had a 4 day one recently and the result was the same. I would definitely install ceiling fans if they become more frequent and more intense. I still have leeway in safety. Thicker and denser walls give you greater reserves.

"What is the average internal temperature for this house? And is there any data on the performance of a similar style home in a colder climate?"

I enjoy what is called Adaptive Comfort. I enjoy living inside outside and comfort is related to time of year and time of day and whether I am sleeping or awake. I don't like changing everything to go outside or come inside. Just take off or apply a layer to move between inside and out. Put on a hat in summer during the day. Put on a coat with scarf in winter to go out at night. I like sleeping with cool fresh air. So, in winter I enjoy anything from 17-20 when home in living areas. We light a fire to achieve this as the sun sets in winter. I guess being surrounded by radiant surfaces and still air helps. At night it will be slightly cooler in bedrooms. The fire goes out and temperature returns to 17 in living areas. During colder weather if it falls to 15 by morning, we use a fire all day to get it back to 17-20 range. Half of the year it is perfect around 19 -22. In summer 20 - 24. Lyrian Rose Daniels, University of Adelaide did an extensive study in Eltham. Average is related to season and time of time as it should be.

"There are lovely examples of Passivhaus standard rendered strawbale homes in Victoria. Natural materials and high levels of comfort/health. What insulation do the earth homes use?"

Everywhere but walls - whatever is recommended. Windows double glazed. I guess you are talking specifically about the earth walls. This would vary with where in Victoria. Victoria has cold winters and extremely hot summers, heatwaves and bushfires. Solar radiation is often less than Hobart depending where you are. Weather fluctuates dramatically. It isn't all about heating loads in Victoria. As the Melbourne climate will move upwards and northwards on an inland route I would do modelling first before advising. I will say this though. It is a huge mistake to think energy efficiency equates to insulation. That it is everything and the higher the rating the better. Heavyweight walls have a dynamic performance . Depending where you are perhaps an additional 0.5 to 1 makes a huge difference to a mass wall. Reduced density and thicker walls work well in a colder climate and probably would cope well enough with extreme summers. Perhaps even lighter on the southern side. Don't forget the importance of internal thermal mass. A modelling tool that can model the dynamics of thermal mass would help you optimise design for climate.

"Given you have said earth built homes struggle to/ cant be built to the required minimum efficiency standards, and are more costly to build than conventional construction how do you propose this be replicated into the volume building industry in Australia?"

NatHERS was designed to minimise air conditioning loads in effectively thermal light weight buildings. It is mostly good at modelling though has problems with assessing passive low energy buildings. I think case studies I showed highlight that. In some climates earth buildings excel as they are. The thicker and denser the walls the better in some climates. In some colder climates earth buildings struggle because though we have a way to improve this. Europe and UK researchers are working on making earth walls compliant in much colder countries. If mass-marketed buildings were improved they would become dearer. I actually built a fairly standard framed home for friends using similar materials with a better result through passive low energy design, not earth though it performs well it was more expensive to build. You get what you pay for though scale, repetition, competition always reduce costs. The average life of an Australian home is 25 years and it all goes to landfill because nothing is worth recycling, all glued together and basically toxic waste. That may be cheap, but it isn't sustainable. Affordable to build or economical to operate.

Is it possible to usefully include thermal mass (such as a rammed earth wall) inside the thermal envelope of a well-sealed passive house building?

Of course, I imagine it would help dramatically with temperature stability and humidity control. You may be able to add more windows without overheating. It would help summer performance and perhaps you could naturally ventilate more often and for longer even when external temperatures weren't perfect.

"How do you make a rammed earth wall earthquake resistant? How thick are the walls, compared to conventional brick veneer, and what proportion of the building needs such walls?"

Rammed Earth walls are close to earthquake and cyclone resistant as they are normally constructed in Australia. Walls are generally 300 thick whereas BV is 250 thick. An engineer could consult the NZ standards to improve design if building in earthquake prone areas. In regards cyclones it is a matter of imbedding tie down rods in the wall from slab to top of wall plate.

"How does the cost of a finished (with services) rammed earth wall compare with framing and siding, per lineal metre?"

You can get these costs in Cordells or Rawlinsons or by calling a rammed earth contractor. I don't subscribe to these publications though I wouldn't compare one with services to one without services and the rates in both vary greatly with wall height. When comparing to stud walling you must include linings, fixout, painting, framework, insulation wrap and brickwork or cladding and painting and a unit rate to be fair. A RE contractor will be quoting the entire finished wall including fitting of conduits and wall boxes for lights and switches.

"Peter, thanks for the great presentation. Are there any resources you can direct us to to find more information about PLEEA?"

You are most welcome and thank you for your patience. My first webinar experience wasn't great. My presentation will be synced with slides when finally online in a few weeks time. Look up Earth Building Association of Australia - website, facebook page. We are there to help and encourage. EBAA usually conducts an annual conference though looking not so good for 2021 with COVID. My Earth Building Solutions website is being modernised at present and I'll have information there as well. Heaps of great books on Earth Building and Passive Low Energy Architecture as well. There is a whole world of earth building out there. I support and recommend the combination of the two.

Kylie Mills – APHA

What happens to an all electric house in an extended power outage like we just had in regional Victoria. How do you stay warm, get fresh air (and stay warm), feed yourself?

Great question. As is the how does a solar passive building (or any building for that matter) work without electricity would be applied. People are adaptable and would need to open windows if it became too warm inside (this can be done anytime) a passive house. There would be a far less reliance on heating and cooling and comfortable conditions would be maintained for a substantially longer period than a standard dwelling. As far as cooking goes, gas cooktops have been preferred by some in the past due to the ability to control the heat better, not as a back-up cooking option during power outages. Induction cooktops are now recognised and in some case preferred for cooking and during power outages there is an abundance of fresh food options that will keep people sufficiently nourished without the need for cooking.

Does PH allow uPVC window like it allows Thermally Broken?

Yes it does, they would still need to be thermally broken. Thermally broken is the frame design which provides a joint where the materials in the frame are not letting heat travel from one side to another easily. Aluminium, Timber, UPVC windows are available thermally broken in the market place.

"Kylie, would you mind making comment on how passive house works in the deep tropics?"

This question is popular, as Passivhaus is newer to the warmer climates and its application. The Passivehaus Institut recommends the following: "Recommendations and guidelines for Passive House design in hot & humid climates can be summarised in five basic steps: 1 Optimisation of orientation, North-South being ideal, and a compact shape; 2 Very airtight (Passive House value of 0.6 h-1) and insulated thermal envelope; 3 Solar protective double glazing; 4 External shading devices; 5 Efficient building services. The measures applied are: Ventilation unit with energy and humidity recovery, double glazing with solar protection, wall insulation, solar DHW heater, roof insulation, efficient household appliances, external shading elements, floor slab insulation, insulation of DHW pipes within the thermal envelope, insulation of partition wall to neighbour, tankless boiler, airtight building envelope and thermal bridge reduced design. To achieve cost-efficient solutions, the resulting insulation thicknesses call for optimised compactness of the building shape. Windows should meet the comfort and energy requirements, and the designer should be aware of the influence of their optimal orientation." More in following link, including peer reviewed paper and other studies https://passivehouse.com/02_informations/05_ph-mediterranean/05_ph-mediterranean.htm

"Accepting that PH can achieve good thermal and humidity control, and help to improve occupant comfort while reducing operational energy demand... How does APHA address the high resource / materials intensity of their builds, and the embodied energy impacts of this?"

In my opinion this is not a question limited to Passivhaus, however to all aspects of many industries. The selection of materials should be considered carefully by designer. As an architect it is part of training to be aware of the impacts of embodied energy and life cycle of materials among many other things including regulations, health, safety and design and clients brief - there are many aspects to building and Embodied Energy is one. (see previous answer)

"Passivhaus puts a huge focus on airtightness. I am not a PHPP assessor. What does PHPP tell us is the percentage heat loss of going looser. Say 5 ACH (tight standard construction on a slab), or 10ACH (approx. NatHERS assumption.)"

Airtightness is one of the five key principals to achieving Passivhaus certification. By completing an airtightness test on a building you can verify it has been built as designed. Remember you cannot improve what you cannot measure. The PHPP would inform you that you had not reached a Passivhaus certifiable designed outcome if the ACH was a larger figure than 1ACH@50Pa. The outcome of achieving a tighter building envelope than what is typically achieved in Australia presently (approximate average of 15ACH@50Pa) would increase the risk of mould growth internally to both the interior face of the walls and inside the constructed wall envelope. This is bad for health - and not worth risking, particularly if you already have allergies, asthma, or other respiratory health issues. This is the primary reason the cliché "build tight, and ventilate right" is important. There is no OR it must be an AND, particularly as mould needs food, oxygen and water to grow. Though a consistent temperature on surfaces and interior combined with continuous ventilation it prevents mould occurring. The Passivhaus building standard is voluntary and has benefits beyond tools that encourage better design and building practices however do not test outcomes. Passivhaus has been studied as been proven to perform as designed with energy efficient outcomes with bonuses for occupants in health, and significate reduction in what cost to achieve this outcome.

"Given that most people live in cities, are passive houses plausible and sustainable at scale in dense urban settings? And what changes would be necessary in the construction sector, materials manufacturing, mining, forestry, etc.?"

Totally applicable. New York has been applying passive house now for some time with terrific outcomes. Some links here for reference: https://www.nytimes.com/2020/12/29/business/new-york-passive-house-retrofit.html https://www.nypassivehouse.org/resources/step-by-step-retrofits-with-passive-house-components/ Canada has been making terrific advances also. https://energyrates.ca/passive-houses-in-canada-your-complete-guide/
What would be required to change - primarily upskilling of designers and tradespeople to

continually improve what they do best.   Would it have an impact on materials manufacturing, forestry: in my opinion if technology can assist in improving methods of recycling/providing materials that are used regularly to the construction industry then everything benefits. Including climate and future generations by becoming more efficient in all things humans need to continue to advance the way they currently use resources and treat the natural environment.
https://www.youtube.com/watch?v=wVi3vMgLMXM