Everything you always wanted to know about Passive Houses in New Zealand

PASSIVEHOUSEINSTITUTE
NEW ZEALAND

Certified Passive House in Wanaka. Photo: Simon Devitt

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Cover: Certified Passive House in Christchurch. Photo: Harley Builders

Why do we need Passive Houses in New Zealand?

A core purpose of the Building Act 2004 is to ensure that “buildings have attributes that contribute appropriately to the health, physical independence, and well-being of the people who use them". Our older houses often do not pass muster in this regard, but surprisingly very few new houses are up to the task, either. Too many houses have questionable indoor environmental quality, require large amounts of precious energy to maintain even a substandard level of comfort, and pollute the environment in the process.

From this baseline, incrementalism is not enough. We need a game changer that is proven to meet expectations, and is beneficial to people and the environment. Enter Passive House.

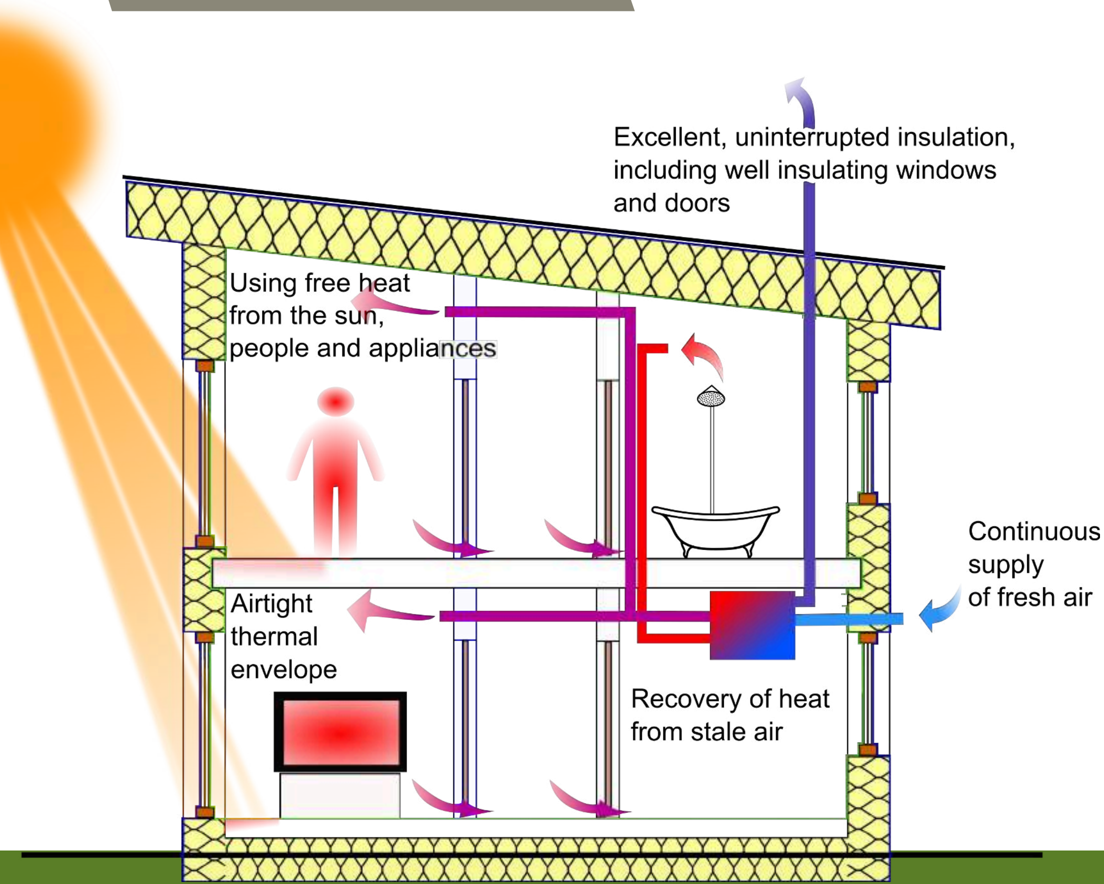
Over the top?

But aren’t Passive Houses a bit over the top for our mild climates?
No – here is why:
Passive Houses are designed specifically for the climate they are build in. As an example: a Passive House in Sweden will need about 40 cm of insulation in the walls, whereas in Auckland, you may get away with a quarter of this, if all other aspects are favourable. Any building has to be modelled accurately within its location and shading situation to get the appropriate response: demonstrated excellent performance.

What is a Passive House?

Passive House is a fabric-first approach to achieving healthy and comfortable buildings. The fabric (or thermal envelope) typically has a long life cycle, so it makes sense to prioritise your planning and investment here. Contrast this with other measures, for example solar panels: they have a shorter life cycle, and are easy to retrofit if technology changes.

Passive House works



Only houses?

The Passive House standard can and has been applied to all buildings that accommodate people: apartments, offices, schools, universities, leisure centres, museums, hospitals and prisons have been certified already.

Whenever it is important to deliver good indoor environmental quality, Certified Passive Houses are the best answer!
In this brochure, however, we will focus on residential Passive Houses.

Certified Passive House in Coatesville.
Photo: eHaus

In buildings people are the best measuring instruments, they are just harder to calibrate.

Gary Raw, UK Director of the Centre for Safety, Health and Environment

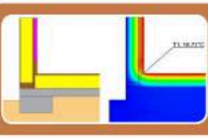
The Passive House standard is first and foremost about delivering on a promise:
a comfortable, well-ventilated home that needs very little energy.

If you don't aim at something, you're not likely to hit anything
The Passive House standards has clear targets, and a great quality assurance process to track the performance of your home from the first pencil stroke.

Getting certified: the only way to be sure!

Concept Design

- Designer produces initial plans for project taking into account building orientation, form and shading.



Developed Design

- PHPP energy modelling software is used to determine what material specifications are required to meet Passive House Standard performance criteria.
- Detailed drawings and technical data are prepared and submitted to a certifier, who then assesses the design to verify compliance with the Passive House Standard.

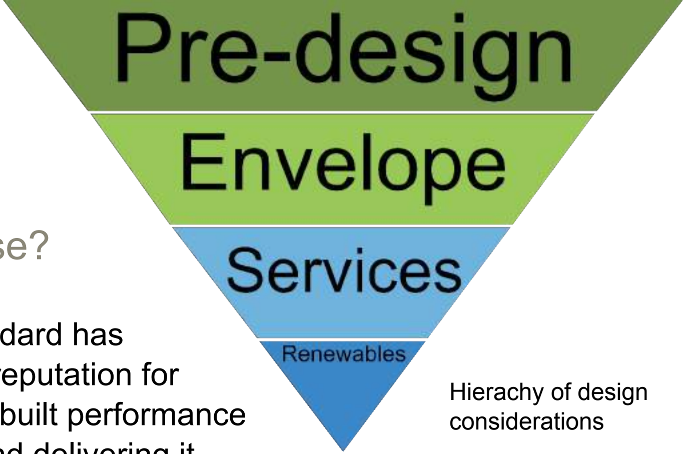
Construction

- Design stage approval is issued and construction begins
- Pressure tests and onsite checks for quality of construction are carried out during construction.

Final Certification

- PHPP energy model is amended if necessary to reflect as-built performance and Passive House Certificate is issued by certifier.

How to design a Passive House?



Hierachy of design considerations

The Passive House standard has gained a well-deserved reputation for accurately predicting as-built performance of all types of projects and delivering it.
Its success hinges on a robust design process, employing proven methods and on-site verification.

Designing a Passive House demands a thorough understanding of energy flows in buildings, and the ability to quantify and balance these with a validated tool.
The Passive House Planning Package (PHPP) is the 'Swiss army knife' of Passive House modelling and design. It enables designers to assess the impact of design changes accurately and instantaneously.

While extra care needs to be taken to safeguard Passive House performance, the steps required to successfully design a Passive House project align closely with those required for any project.


Certified Passive House in Whanganui.
Photo: eHaus, Black Pine Architects

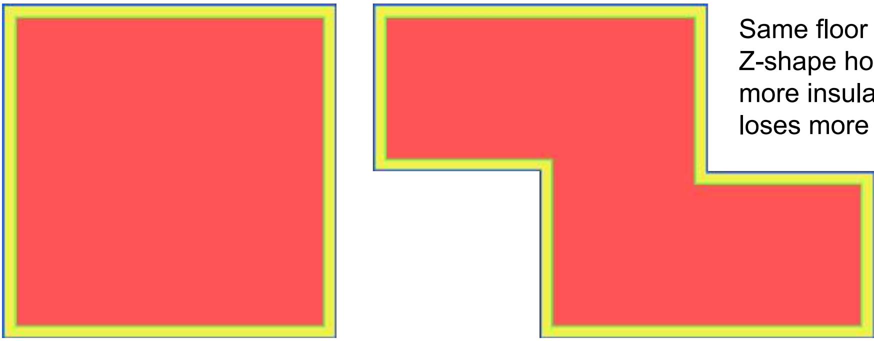
Orientation and shading

Passive House projects are not dependant on solar gains to achieve thermal comfort and energy efficiency, but they still benefit from a careful consideration of the impact of sun paths and shading. The aim is to ensure that any solar gains will make a positive contribution towards meeting Passive House targets without the risk of overheating.

Form factor

The complexity of a building's thermal envelope can have a significant effect on the insulation levels required to meet the Passive House standard.

Firstly, a larger thermal envelope will transmit more heat per usable area, and secondly, a complex shape will involve more junctions that create difficulty and cost. Keep it simple!



Same floor area, but the Z-shape house needs more insulation, as it loses more heat

Work with what you've got

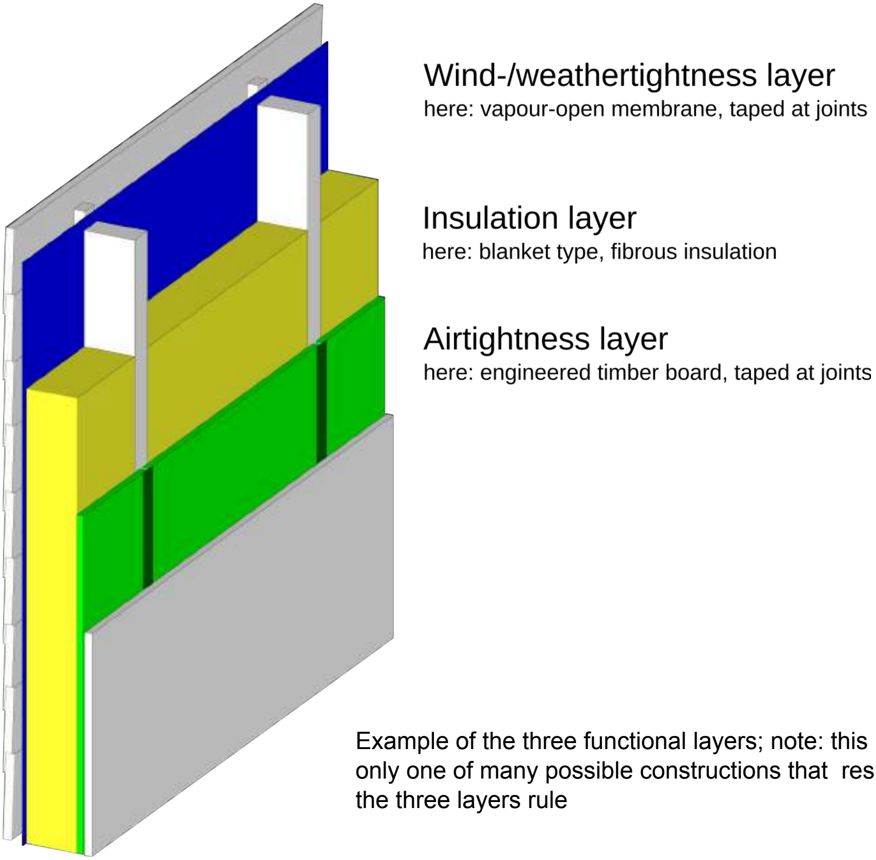
Perfect sites are rare and various other factors can conspire to push your design in the direction of more complexity.

Relax! You can still achieve the Passive House standard. Remember, it is all about the energy balance, and a skilled designer will be able to compensate for a poor orientation or other suboptimal conditions.

It really is possible to 'turn lemons into lemonade' following Passive House methods.

The fabric-first approach of Passive House design prioritises the performance of the components and materials that make up the building shell, before considering the use of mechanical or electrical building services systems. Identifying your thermal envelope, the cocoon that keeps you cosy, is where it all starts. This sounds simple, but can be tricky if there are basements, garages or other spaces adjoining the building.

Wherever you have identified building elements as part of the thermal envelope, you need to be able to detect three functional layers:
an airtightness layer on the inside of the insulation, the insulation layer, and lastly a wind- and weathertightness layer.



Example of the three functional layers; note: this is only one of many possible constructions that respect the three layers rule

Airtightness

Airtightness is central to attaining Passive House certification, but most importantly: it is a key indicator of construction quality.
Everyday language doesn't distinguish clearly between different moisture and heat transfer mechanisms in buildings, so let's clarify what we mean by airtightness. Airtightness refers to the level of control of bulk air movement through the thermal envelope, driven by differences in air pressure and temperature. Think of draughts and leaks around window seals, and other junctions.

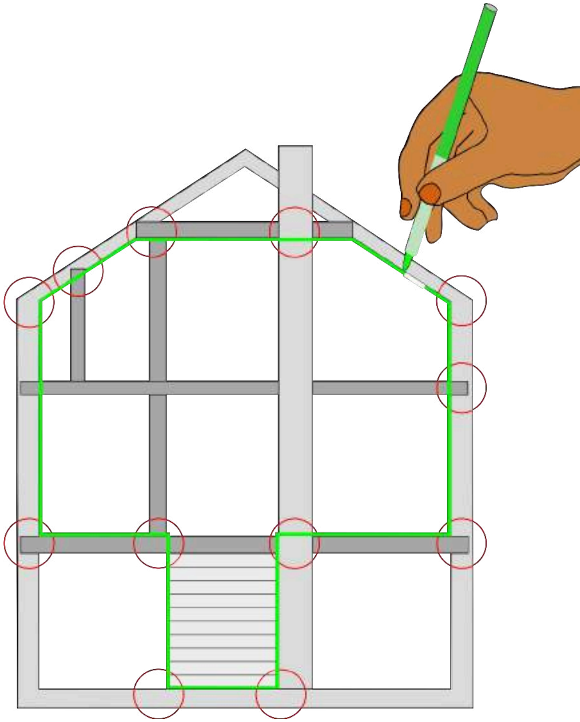
Ventilation on the other hand, covered in more detail later, refers to management of the indoor air quality using openings (such as windows and doors) or mechanical ventilation.

Lastly, vapour diffusion describes the movement of water vapour through a material. Different materials permit different levels of vapour diffusion, sometimes independent of how airtight they are.
In a nutshell: a leaky building is not necessarily a breathable building, and an airtight building is not automatically bad at managing moisture.

Designers need to understand the interaction and independence of these mechanisms when planning the thermal envelope. And once you understand the principles, it's no contradiction having an airtight building with a healthy indoor environment and a robust, 'breathable' thermal envelope.

Blower-door test in progress

How do you achieve airtightness?



In one word: planning.
The first step is to draw a continuous line around the inside of your building. This line represents the airtight envelope of your project. Whenever different materials meet, or where doors, windows or building service are installed, the detail needs to be designed, and any gaps correctly sealed.
Imagine your building as a bath: where could the water (air) leak out?

To verify airtightness levels, pressure tests are carried out by a suitably qualified technician. The tests are performed using a piece of equipment called a 'blower-door'. In simple terms, it’s a fan in a door shaped frame that pressurises or depressurises a building. Undertake the first test once the airtight envelope is completed but still exposed – that way, any leaks detected can easily be fixed. The final test for certification is then performed once works are complete.

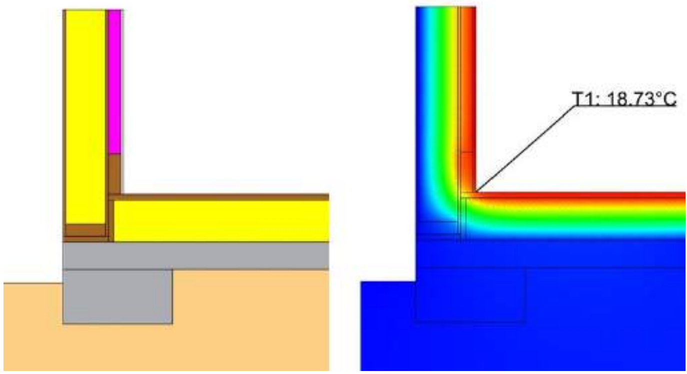
The Passive House requirements for airtightness is less than 0.6 air changes per hour at 50 Pascal. 50 Pascal equates to a wind speed of about 5 on the Beauford scale, in other words: a pretty windy day.

Insulation

Insulation comes in numerous forms, from strawbale to batts, SIP panels to vacuum panels. The decision on what type to use on a project is up to you: remember, Passive House is a performance standard, it'snot prescriptive. Insulation is typically an inexpensive building material.
For Passive House projects, the most important factor to consider is the availability of accurate, independent information on the performance and longevity of the product. Depending on your material choices and the local climate, the thermal envelope may be thicker when compared to a project built to minimum code standard.

How much insulation?

The necessary thickness of the insulation layer will depend on the form of the buildings, environmental factors, and the type of insulation used. To give you an idea: it is possible 90 mm of typical wall insulation may suffice for a compact, multi-storey apartment building in Auckland. Whereas 300 mm of typical insulation in your walls may still not be enough for a sprawling single-storey house in Lake Tekapo.



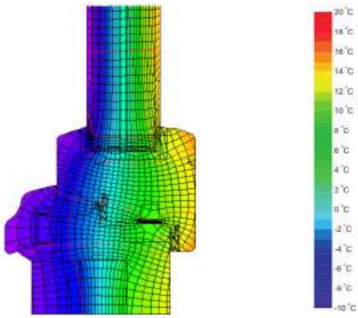
Thermal bridging

Thermal bridging occurs where the thermal envelope is compromised by higher conductivity materials. In the Passive House standard all thermal bridges must be included in the PHPP model. Energy flow and surface temperature are assessed to ensure heat loss is minimised and that thermal comfort criteria are met. Common junctions that require particular attention are the perimeter of foundations and where windows join with other construction elements.

Wind- and weathertightness

The last of the three functional layers keeps wind and water out of your thermal envelope. Keeping water out is relatively easy, but you also want to avoid air circulating around the insulation, so the windtightness layer needs to be a snug fit to your insulation.

Windows and doors



Isotherms, certified window, Thermadura, Mosgiel

Highly-performance windows and doors are a marvel of engineering and arguably the single most important component to get right in any Passive House project. Passive House certified windows are available in a number of different frame materials that satisfy strict criteria on thermal performance and airtightness. Particular attention must be paid to the glass specification, installation position relative to the thermal envelope and shading from adjacent and nearby objects. As with insulation, the availability of accurate, independent information on performance is crucial. A range of products certified for Passive House projects are available, including a window manufactured in Otago.

Thermal mass

Thermal mass is often publicised as a necessity for energy efficient buildings, to even out peaks and troughs in solar gain and moderate the internal temperature. In the Passive House modelling process the effects of solar heat gain are readily apparent. And, if overheating is an issue, mitigating factors are easily identified and tested to find a successful design solution. Consequently, irrespective of whether Passive House projects include massive materials, they all possess a quality often referred to as 'thermal inertia' where a comfortable indoor environment is easily maintained regardless of external conditions.

Although the Passive House standard is primarily concerned with the design of the thermal envelope, building services factor strongly in the modelling to ensure that energy efficiency achieved in the thermal envelope is not compromised by lack of planning in other aspects of the design.

Ventilation

While a well-designed thermal envelope is key for achieving thermal comfort, getting the ventilation right is similarly important for feeling cosy and fresh inside.
Mechanical ventilation is not mandated by the Passive House standard, but it is the easiest way to meet the energy goals in hot and cool climates, and a precondition for reliable indoor air quality in all climates.

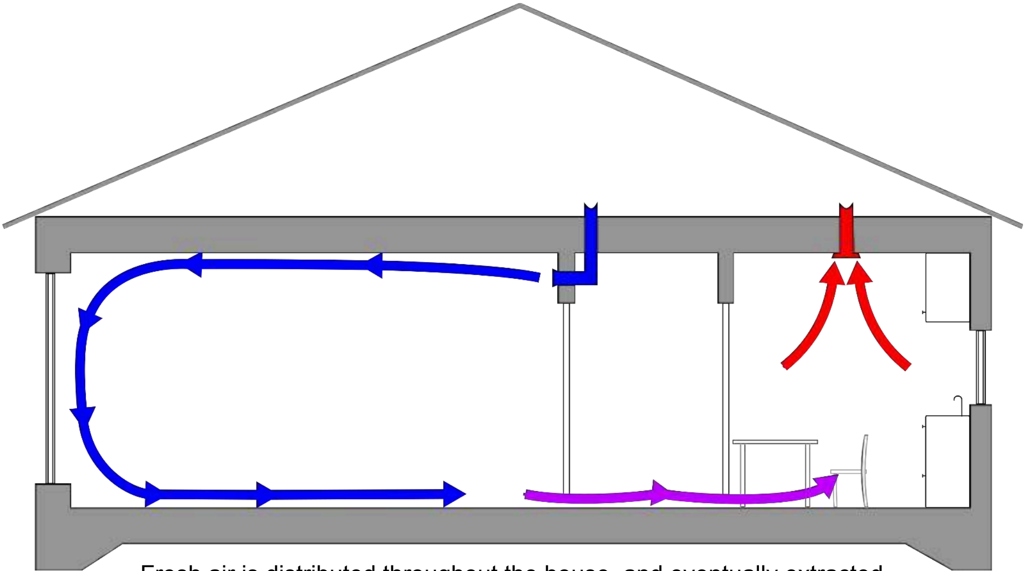
What about simply opening windows?

Opening windows you say?
I thought they were banned under the Passive House standard?

This is a common misconception.
Passive House projects are designed to provide good indoor air quality regardless of external conditions and occupancy. High or low outdoor temperatures, more or less wind, noise, outdoor air pollution, and occupancy patterns mean that window opening regimes seldom deliver required ventilation rates. Air temperature, humidity and CO_2 levels all suffer as a result.
Nonetheless, Passive Houses have windows, which can be opened and closed whenever you wish, without compromising fresh air - unlike in a standard house.

Air handling unit in utility room of a Certified Passive House

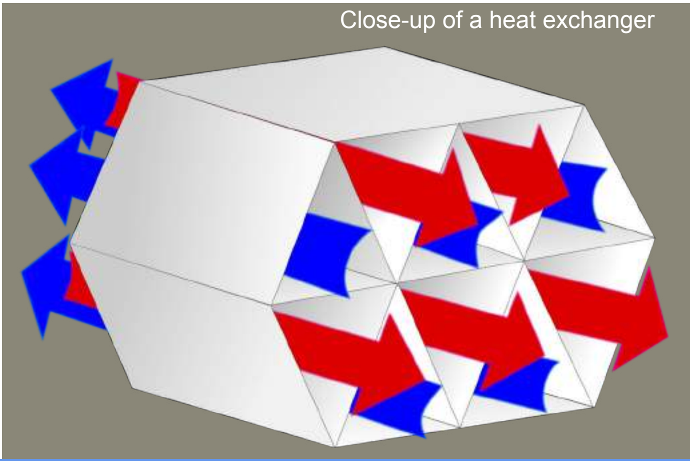
In Passive House projects mechanical ventilation takes the form of a highly efficient system with heat recovery. It operates continuously (and quietly) to extract moist, stale air from kitchens, bathrooms and utility rooms and supply fresh air into bedrooms and living spaces.



Fresh air is distributed throughout the house, and eventually extracted

In the heat exchanger most of the warmth from the outgoing air is donated to the incoming air. Outgoing stale air however never comes into contact with incoming fresh air.

Heat exchanger efficiency and electricity consumption must be considered during product specification.



Close-up of a heat exchanger

Lighting & Appliances

It goes without saying that if you are investing in building energy efficiency, it's worth selecting the most efficient lighting and appliances available at the time on construction. LEDs are the most efficient source of lighting and also have the advantage of giving off the least amount of waste heat.

The most energy hungry appliances are those that need heat or cold to operate, and it's worth investigating the best possible options for fridges, freezers, clothes dryers and washing machines.
Energy labels are a good start for your research.

Certified Passive House in Wanaka. Photo: Simon Devitt

Hot Water & Heating

Whatever your hot water system, pipes and tanks must be well insulated and pipe runs should be as efficient as possible.
Heat pumps that use CO_2 as a refrigerant are currently the state of the art for efficient hot water delivery.

Heating systems in Passive House projects are generally a lot smaller that people expect!
There are many different options available: small heat pumps, direct electric or conventional boilers.
Ensure that the person responsible for design and installation of the heating system understands the specific heating requirements of a Passive Houses. Oversizing the heating system can be a waste of money and efficiency.

Fires are challenging to integrate into Passive House projects, due to the amount of heat they produce in one space, detailing around the flue to maintain airtightness and interaction with the ventilation system.

You need very little heat in a Passive House – so keep the heating system small, efficient, responsive and simple!

This 400 W panel heater keeps all the rooms in a 138 sqm Certified Passive House in Whanganui cosy. Photo: eHaus

Getting building consent for your Passive House

Passive House certification is not currently a replacement for complying with any part of the Building Code in New Zealand.
All Passive House projects must meet the performance standards set by the Building Code, independently of the Passive House certification process.

Kitchen in a Certified Passive House on the Kapiti Coast. Photo: eHaus

So, what do you need to be aware of when submitting a Passive House project for building consent?
Allow additional time for the consent process. Despite their increasing popularity, many councils and consent officers have never processed a consent for a Passive House before. Though councils usually require only 20 working days to process a consent, it’s likely that they will request further information concerning elements of the project associated with meeting the Passive House standard.

As the Building Code has only a narrow range of accepted solutions which closely match typical construction materials and methods, it’s possible that some aspects of your Passive House project will need to demonstrate compliance as alternative solutions. If you are working with a local manufacture or supplier, they will assist you by providing the evidence required to demonstrate compliance with the relevant Building Code clauses.
Lastly, consent officers are aware that the Building Code is not the last word when it comes to healthy and comfortable buildings, so may well be supportive of your Passive House project as an example of building better.

Who can help with designing and building a Passive House?

Achieving the Passive House standard is not difficult in principle, but is does require knowledge and planning. The best way to become competent in all things Passive Housing is to gain a Passive House qualification and then build Passive Houses!

There are a number of Certified Passive House Professionals who practice in New Zealand. Refer to the listings on the Passive House Institute New Zealand website.

Certified Passive House Designers or Consultants often have a design background, so if an architect or architectural designer is not yet appointed to the project, perhaps consider an architect/designer who is also a Certified Passive House Designer or Consultant.
Passive House Consultants may also have an engineering background, and can help with challenges there.

Certified Passive House Tradespersons are trained to translate a Passive House design into built reality. All Certified Passive House Professionals have passed a very demanding examination.
Passive House Academy New Zealand offers courses to prepare professionals for this examination.

What's it like to live in a Passive House?

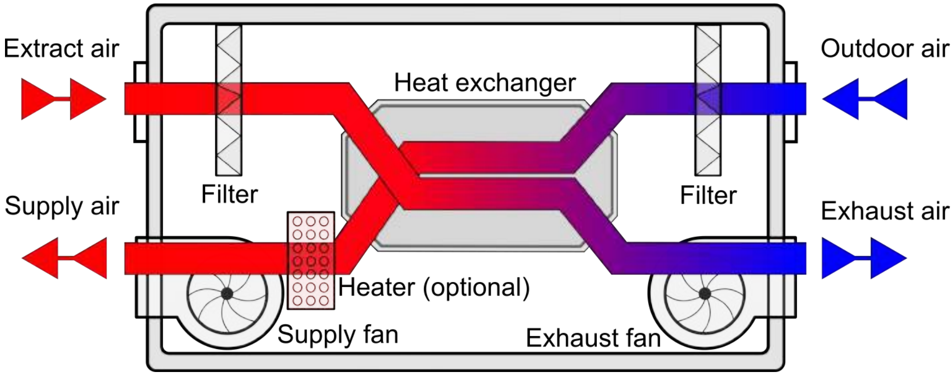
You are warm but never too warm in a Passive House, and surrounded by a constant supply of lovely, fresh air. As a positive side-effect of the way Passive Houses are insulated and ventilated they are also very quiet. In a Certified Passive House, you could in fact live close to an arterial road in peace, and with good indoor air quality. Passive Houses are designed for indoor temperatures between 20-25°C. If you want it colder, that can be arranged, but most people prefer a warm environment if it comes with an ample supply of fresh air.

Summer overheating is to be avoided by design, for example movable exterior shading devices on all North, East and West facing windows. Overhangs alone won’t do!

Richard, Passive House owner

We had no intention of a Passive House originally but we wanted a warm, healthy and energy efficient home.
The build process has been fantastic, it has been fast and I would not describe it as stressful at all, working with a group of people that have been prepared to push the boundaries has been a very enlightening experience. The house is looking great and a testament of all those involved.

All this comes at a very low running cost. The maximum energy you may to spend on heating per year in a Passive House is 15 kWh per square meter conditioned floor area. Many Passive Houses require less, but let’s use the maximum allowed for an example. Assuming you have 100 sqm of living space to heat, this will amount to 1,500 kWh per year at the most. Multiply with the cost of the energy form you use to heat your home, for example about 30 cents for electricity, and you have your annual heating bill. But wait, there is more: if you heat with a small heat pump with a seasonal performance factor of 3, your bill will only a third of that again.



Schematic of a typical Passive House ventilation unit

The heat recovery ventilation system for a small house has two fans that in total need about 40 W.
If you run the system on 300 days per year, assuming that for the remaining 65 days the weather is neither too cold nor too warm, so that you can keep most windows open as your ventilation system, you are adding 288 kWh to you power bill. Hot water generation will in fact likely be the largest single item on the bill, but with a new generation hot water CO_2 heat pump, the running cost for hot water can also be kept in check.

The small amount of overall electricity needed to live healthy and in comfort can furthermore easily be provided by solar cells on your roof. While they are not a required feature of a Passive House, they complement the optimised fabric nicely, and can also be installed at a later date, if the budget does not allow for the installation right away.

Building a Passive House doesn't have to cost more than building any good house would. And in cases where it turns out to be a bit dearer, the additional interest on your mortgage may very well be covered from the savings on energy. However, note that all economic considerations need to be based on specifics, so your case may be different.
Your Certified Passive House Designer is trained to do the math for you.

Certified Passive House in Wanaka. Photo: Simon Devitt

Where do I get more information about Passive Houses?

The Passive House Institute New Zealand - a charitable trust - is happy answer Passive House specific questions. Our website and Facebook page contain a wealth of Passive House information:
www.phinz.org.nz

Professionals find courses at Passive House Academy, a project of the Passive House Institute New Zealand:
www.phanz.ac.nz

Passipedia is the international Wiki just for Passive Houses:
www.passipedia.org

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