Te Tōpūtanga o te Whare Korou ki Aotearoa
PHINZ

Passive House: **Homes where people thrive**

A guide for people planning to build a new home

Choose health, comfort and quality when you build a new home

Building a new home is a big decision. It's exciting but can often feel daunting too, because there are many decisions to make. We all dream of a house that fits, that meets our needs and reflects our desires and individuality. We're encouraged by designers and builders—and the media—to think about aesthetics, what our perfect house *looks* like. But what about how it *feels* to live in?

Certified Passive House* homes are supremely comfortable and healthy. It will be 20-22 degrees inside all year round, in every part of the house. The air is always fresh. It never feels damp. The house has been built well, with quality fittings carefully assembled. All of this is verified. It's a home in which your family will thrive.

The Passive House choice is yours to make.

*Any time this brochure says 'Passive House', we mean a building that has been *certified*.

How does it feel?

There's a palpable sense of calm when you walk into a Passive House home. It's peaceful inside, quiet, regardless of what hubbub might be happening outside. Straight away you notice the comfortable temperature, no matter how hot or cold it is outside. The temperature is consistent, right through every room in the house. (Here, there is no need to close doors between rooms to 'keep the heat in', no cold spots on the south side, no freezing bathrooms you put off using.)

After just a few minutes, you might notice the air quality: it feels fresh, as if all the windows had been thrown open on a spring day. But there are no draughts—and no pollen or other irritants either. A Passive House home is taking care of ventilation for you. Constantly and quietly, stale moist air is removed and filtered fresh air drawn in.

Passive House homes need to be experienced in person to truly appreciate how they feel. Many owners of certified Passive House homes generously host open days, often as part of an international event in June—see passivehouse.nz for details. Or ask a Passive House designer or builder if there is a local home they could arrange for you to visit. It's a perfect opportunity to experience, explore and discuss Passive House with the people who build them and live in them.

Photo: Simon Devitt

> The house feels nestled and cocooned. It's a wonderful place for us to be as a family.
>
> **Wanaka Passive House homeowner**

Reassuring

Temperatures are rising, but winter storms are colder too. Extreme weather events are more frequent and also happening out of season. Fire risk is climbing. Home should be a shelter and refuge. Passive House homes are more resilient and better buffers against climate extremes.

A Passive House home typically uses 90% less energy for heating and cooling compared to a house built to current NZ Building Code minimum requirements that is maintained at the same temperature. A very small, efficient heat pump offers flexibility and back-up, heating on the coldest days of winter or cooling during the summer peaks.

If the power goes out, temperatures in a Passive House home will stay stable for longer. The building envelope and excellent insulation act like a cocoon, buffering temperature changes.

The outstanding air quality in a Passive House home is a huge relief for people with asthma or who suffer from hayfever. The ventilation system also filters pollutants like smoke or exhaust fumes.

The Passive House Plus and Passive House Premium certifications acknowledge those buildings that surpass the Passive House Classic requirements: they are both more efficient and produce renewable energy onsite.

Good for the planet

Choosing Passive House is good for your family and it's also good for the planet. Energy use in buildings contributes to our country's carbon emissions. New Zealand has committed to being a net zero carbon emitter by 2050. A Passive House home is a significant way your family can do its bit towards reaching that goal.

Photo: Svea Pietschmann

Although this booklet focuses on private homes, it's worth knowing that *any* type of building can be built to the Passive House standard.

Around the world, there are Passive House apartment blocks, hospitals, rest homes, fire stations, shopping centres, indoor swimming pools, social housing projects, factories, offices, schools and more. Pictured above is a Passive House co-housing development in Germany.

Expect more

Robust ways to independently verify how a building performs are baked into the Passive House methodology. A certified Passive House reaches objective, quantifiable targets. A specific level of airtightness is one of the best known, but there is also an upper limit to the amount of energy used for heating and cooling and targets that ensure comfortable temperatures and sufficient fresh air. It either meets the standard, or it doesn't.*

The certification process gives homeowners confidence that they have got what they paid for. You can be certain that your new home will deliver on its promise of energy efficiency, comfort, health and durability. And every professional involved in your home's design and construction knows that they have done their part well too. With every building, Passive House professionals are receiving objective feedback that helps them keep learning and keep improving.

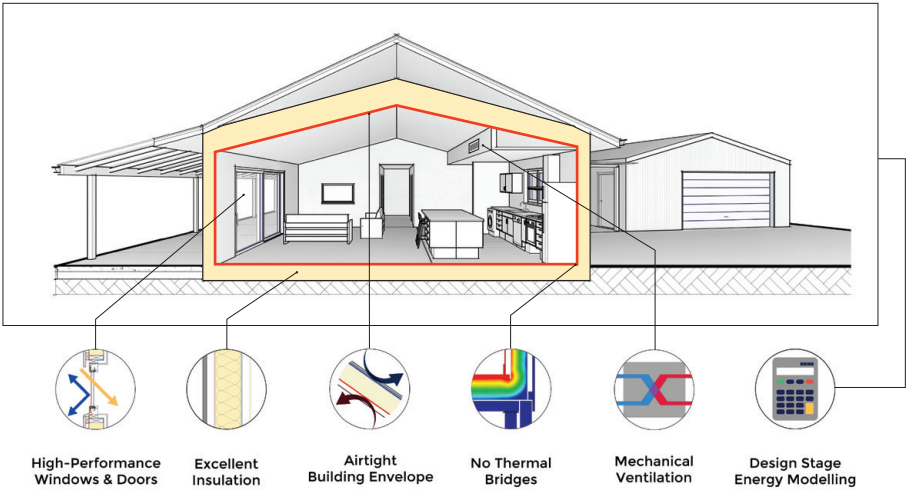
There's also the security that comes with lots and lots of real-world experience. There are certified Passive House homes the length and breadth of New Zealand, with many more under development.

The Passive House standard is backed by rigorous building science and over 30 years of evidence from tens of thousands of buildings around the world.

New Zealand has architects, designers, engineers and builders with specialist training in the Passive House methodology. This community is growing steadily and shares insights and best practice through conferences, continuing education and professional networks. There is an increasing range of material choices (including for instance, locally made high-performance windows and doors).

* For more detail about Passive House requirements, see page 6 of the PHINZ document, *Claiming the Passive House Standard*, available at passivehouse.nz

Airtightness is measured by a portable device called a blower door, which provides a reading in real-time. As well as confirming the building is below the 0.6/h upper limit, it usefully serves as a proxy for quality of construction. A number of homes have now been built to less than 0.3/h, which is a truly impressive achievement.



What sets **Passive House** apart

When you walk into a Passive House, you'll notice the quality of the doors and windows and the innovative ways they operate. You can find the ventilation system tucked away in a small cupboard and see the air inlets and outlets discreetly positioned in the ceiling.

What you *won't* see is the energy modelling process that is the hidden heart of these supremely comfortable, efficient buildings. But you are experiencing it—because the data the energy modelling relies on and the decisions it guides have shaped every part of the home's design and construction. Passive House is not just a standard to meet, it's a process. Every step is considered and carefully evaluated and checked.

Keep reading for a description of each key element that you'll find in every Passive House: excellent insulation, an airtight building envelope, high-performance windows and doors, a ventilation system and a lack of "thermal bridges" (thermal bridges are like highways conducting heat out of a building).

Design-stage energy modelling

Energy modelling is the single most important part of the Passive House design process. That's because great performing buildings don't come about by accident or by randomly combining elements. Certified Passive House homes are by design greater than the sum of all their parts: they work because of how all those parts interact with each other as a whole.

Passive House designers use a software suite called the Passive House Planning Package (PHPP) to model the different components and the ways they interact with each other, thus accurately predicting overall building performance. This is done while a home is still being designed. The modelling might predict a cold corner on the south side of a house or that a home will overheat like an oven in summer.

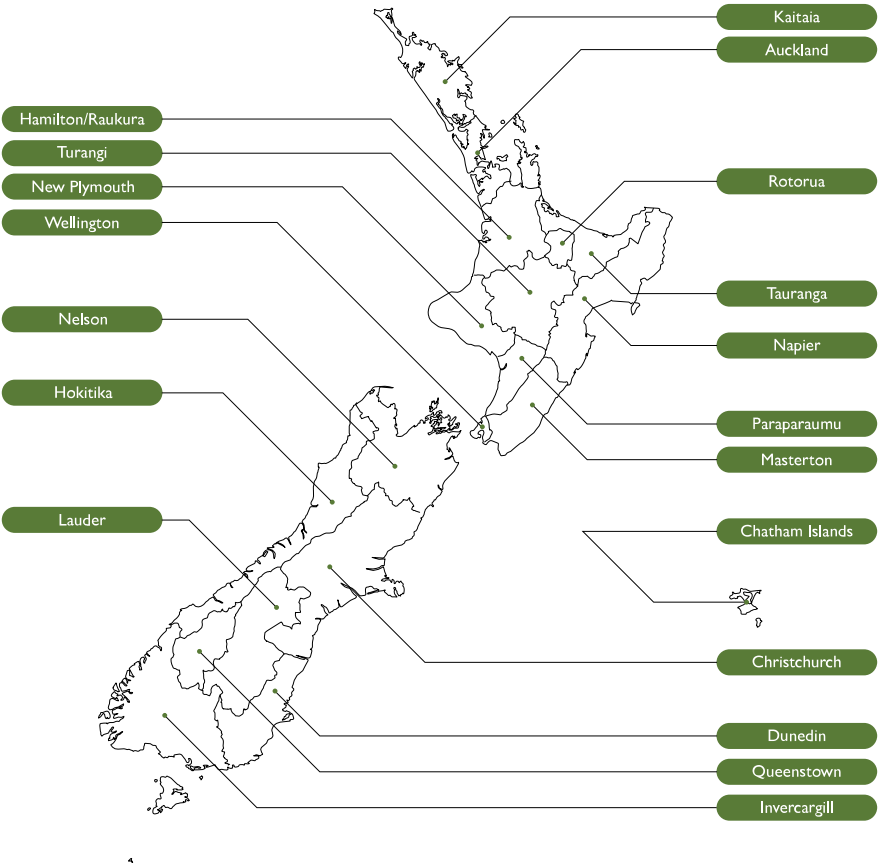
Changes to the design and the different elements can be explored in the computer model until the right combination is achieved. Budget is also taken into account. For instance, overall insulation performance can be achieved in different ways; more affordable windows could be balanced by increasing insulation levels in the floor and ceiling.

It also makes for a lot of flexibility. With Passive House, it doesn't matter if your site doesn't have optimal solar gain. It's not always possible to face a house north on a small city site; or perhaps neighbours or other structures create a lot of shading. Maybe the gorgeous view or the potential for a private courtyard lies to the south or west. Passive House can accommodate such requirements because it works with the design as a whole, not as discrete elements.

What you also get is reliability. A lot of research in many different climates proves that Passive House predictive modelling is accurate: as long as the construction is done according to the design, your home will perform very close to what was predicted.

> It's easy, fast and cheap to make changes at the design stage compared to fixing problems once a home has been built. That's the power of design-stage energy modelling.
>
> There is an emerging problem with new conventional homes overheating in summer. What should be a sanctuary and a delight to live in is instead like an oven. The problem is usually inherent in the design and only symptomatic relief is possible. That's producing some very expensive bills for air-conditioning and cases where people are keeping their curtains drawn during the day for weeks or months at a time.

Passive House climate zones in New Zealand



New Zealand is remarkable for its climatic diversity, which comes from being comparatively narrow islands spanning a lot of latitude. Passive House designers work with 19 different climate zones based on detailed NIWA data. The zones take into account factors like average temperatures, altitude and whether the site is inland or coastal.

Illustration: Sustainable Engineering Ltd

Excellent insulation

A certified Passive House home is cocooned in a continuous layer of insulation. How much and where varies according to the specifics of your project and takes into account the design, your choice of materials and your specific climate zone.

Mechanical ventilation with heat recovery

Clean fresh air is great and it's guaranteed in a Passive House, thanks to a continuous mechanical ventilation system. Your home is airing itself without you needing to do anything. The ventilation system is small but mighty and acts as the lungs of your home. It's constantly removing stale, damp air from bathrooms and the kitchen and delivering fresh, filtered air to living rooms and bedrooms.

A clever heat-exchange system can recover up to 95% of the energy in the stale air being expelled. This is used to warm the incoming air if it's cold outside (or cool the air when it's hot). This prevents unpleasant draughts. It's the secret to keeping an even temperature right throughout the house and keeping heating and cooling costs down.

In areas with high outdoor air pollution, the standard filters in the MVHR system can be upgraded. Specialist filters will remove even very small particulate matter, such as is found in bushfire haze.

A mechanical ventilation system with heat recovery (MVHR) for a single-family home is typically only the size of a clothes dryer and is often installed in a cupboard in the laundry or hallway. The ducting is concealed in the ceiling with small vents in each room. The system is very quiet and uses less energy than a 50w light bulb.

Did you know?

Ventilating a conventional home relies on occupants opening doors and windows, turning on extraction fans (if fitted) — or on air leaking in through gaps in walls or from the sub-floor or roof space. That air can be musty, damp or even carry mould spores or particles of rodent droppings and carries with it any outdoor air pollution from traffic, pollen or smoke.

Airtight building envelope

A Passive House has an uninterrupted airtight building envelope that keeps warm air in during winter and cool air in during summer. It's a crucial reason why Passive House buildings need so little energy to heat or cool: the airtight layer prevents unwanted leakage of heat, draughts and cold spots. The excellent insulation keeps the internal temperature stable, no matter what the weather outside. Lastly, the ventilation system isn't fighting against the uncontrolled movement of air.

Vapour control (managing the movement of moisture) and the airtightness layer combine with appropriate insulation to prevent moisture damage to the building structure. This is key to Passive House durability.

Creating this building envelope is a core task for builders. Passive House certified builders pay attention to the airtightness layer throughout the whole construction process, making sure it is continuous and uncompromised. They carefully brief sub-trades, who need to run plumbing and cabling through the airtight layer, ensuring that every penetration is properly sealed. The effectiveness of the airtight layer is verified by blower-door testing at key stages.

High-performance windows and doors

Even the very best windows let more energy pass through compared to a wall and this is why Passive House buildings have high-quality, very energy-efficient doors and windows. Double- or triple-glazing is used depending on specific climate or comfort requirements. For instance, triple-glazed windows are great for reducing noise if your new home is beside a busy road or under a flight path.

Glazing performance is typically improved in a Passive House by using high-performance spacers between the glass panes, glass coatings and argon fill (a gas introduced in the gap between the panes of glass).

Window and door frames are a thermal bridge and need careful consideration. Ordinary windows and doors with thermally-conductive aluminium frames readily let heat in and out. When it's colder outside than inside, the thermal bridge will cause condensation to form on the inside surface of the glass and the window frame. This can lead to mould, air quality issues and can damage the frames and surrounding wall.

There's something else a bit different about Passive House-quality windows: they usually open inward, not outward like we're used to in New Zealand. And most often, they can be tilted (and locked slightly open) as well as turned and fully opened.

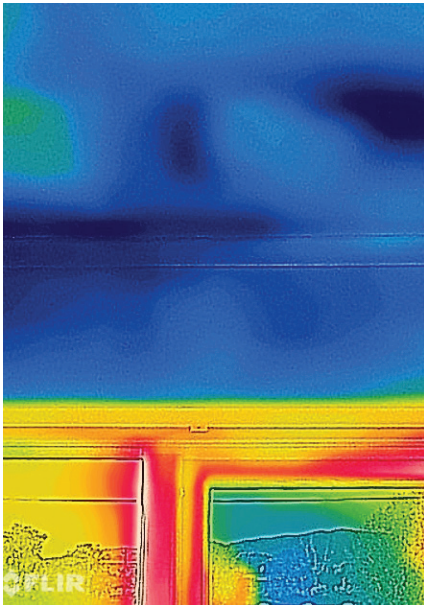
In a Passive House home, the door and window frames and the glass stay at a similar temperature to the air inside the building, so condensation and mould are avoided. Heat loss is reduced by about three-quarters compared to thermally-conductive frames.

Passive House standard doors and windows are now being built locally, but many projects import joinery that meets the exacting standards required.

Minimising thermal bridges

Thermal bridges are pathways for heat to travel in and out of a building. They contribute to significant indoor temperature fluctuations and can also lead to moisture and mould problems. Passive House design minimises or eliminates thermal bridges. This is a key part of why the temperature inside stays so comfortable, no matter what the weather outside.

In conventional buildings, significant thermal bridges are typically created where the foundation meets the walls, the walls meet the ceiling and roof and where conductive materials like steel penetrate the exterior of the building. Passive House



This thermal image of a conventional house shows much greater heat loss through windows (red and yellow areas). The junction between the ceiling and the wall is also visible, along with a section of missing ceiling insulation (darker blue).

designers are careful to avoid creating thermal bridges and builders pay special attention to these details.

Also included

Design and energy modelling of a Passive House also considers orientation, the building materials used, shading and something called 'form factor'.

Orientation refers to the direction your house faces. A north-facing orientation has the greatest potential for bringing sunlight and warmth into your home but this depends on shading. Both these things are factored into design stage energy modelling. This includes shade from for instance, neighbouring houses, trees or hills.

"Thermal mass" (dense materials that store heat from the sun and slowly release it as the air temperature drops) may or may not be used in a Passive House. It may be helpful to include in specific projects, but is not a requirement. Whatever materials are used for walls or floors for example, their degree of thermal mass and effect on internal temperatures will be modelled during the design stage.

People always talk about how pleasantly warm a Passive House home is in winter, often with no or minimal added heat. But we want to stay in that

Photo: Energy Architecture/Mike Craig Builders

'Goldilocks zone' (not too cold, not too warm) in summer too, so *preventing overheating is vital*. In some situations, it's necessary to introduce shading to prevent a house getting too hot in summer. There are lots of possibilities: planting trees and shrubs, increasing the depths of eaves, building a pergola for a deciduous vine or installing integrated external shutters (motorised and automated or otherwise).

In almost all New Zealand climate zones, it's important to shield your home from the late afternoon/evening summer sun, which comes from the west and is very strong. It's quite common to see Passive House buildings with relatively small or few windows facing west or south.

The form factor is a ratio, reached by dividing the area of the building's external surface by the treated floor area (TFA), the useful internal floor area of the house.

What this boils down to is a simple shape like a square or rectangle will have a lower form factor than a more complex shape. A lower form factor will need less insulation to achieve the necessary level of performance and will be cheaper to build and to heat and cool.

It makes sense to use energy-efficient lighting and appliances in your Passive House home. LED lighting invariably features and heat pump water heaters are also common. It's worth researching the energy-efficiency of fridges, freezers, clothes dryers and washing machines.

Retrofits

Most of the buildings New Zealanders will call home in 50 years have already been built. We can build much better new homes, but it's also important to improve the performance and health of existing ones. There is a special Passive House Institute standard for retrofitting existing buildings called *EnerPHit*. It offers two routes to certification by either using prescribed components or meeting energy performance targets. It is slightly less stringent compared to Passive House given the logistical challenges of retrofitting older buildings—especially creating airtight envelopes. Nonetheless, some European retrofits have achieved the full Passive House standard.

There's a lot more to a top-quality retrofit than stuffing insulation into walls and (perhaps) installing some form of ventilation. Excellent planning is essential and energy modelling is more important than ever, especially if the improvements are intended to happen in stages over time. Each step needs to be carefully planned so it doesn't compromise later improvements, either financially or technically. It's also vital to avoid unintended consequences such as trapping moisture, which can lead to decay or mould.

Certifications, green ratings and consents

Flexible and co-operative

The Passive House standard focuses on creating the ideal conditions for our comfort and health, along with extraordinary energy efficiency. It's brilliant at achieving these crucial fundamentals it focuses on. Yet many homeowners want to achieve more. Happily, Passive House works beautifully alongside other sustainable or specialist certifications.

For instance, Homestar automatically provides many credits for projects that also obtain Passive House certification. A building could also meet both Passive House and Living Building Challenge targets.

Other considerations might include such things as:

- low embodied carbon
- locally sourced materials
- rainwater harvesting
- low-maintenance finishes
- use of recycled materials
- low-impact building materials
- designing for ageing in place
- use of prefabricated components.

Passive House and building consents

Passive House certification is not currently a replacement for complying with any part of the New Zealand Building Code. You'll still apply for a building consent and must meet the requirements of the Code.

As the numbers of completed Passive Houses grow in New Zealand, so does the knowledge and experience of consenting officials. Proposed changes to the Building Code may streamline consenting for Passive House projects further. However, at time of writing it is still common for some aspects of Passive House design to use the "Alternative Solutions" pathway to demonstrate compliance. Your Passive House designer will provide additional documentation and be available to answer any questions consenting officials may have.

Passive House is **affordable**

If you value all the benefits Passive House delivers, it's possible to have a Passive House home without increasing your budget for an architecturally designed house. However, it is almost certain to cost more if you try to graft Passive House performance onto an already finished design. Specify high-performance from the beginning and ensure Passive House expertise on your design team.

Some other strategies new homeowners have used to control costs on their project overall include:

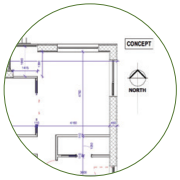
- **Slightly reducing the footprint.** With clever design, shrinking the house by 5-10% often isn't even noticeable.
- **Simplifying the shape of the building.** The more corners, the more thermal bridges, the more and bigger windows all have an impact on cost and performance. A simpler form will be cheaper and faster to build than a complex shape.
- **Rethinking the fit-out budget.** Kitchens and bathrooms are the big-money rooms. Significant savings can be made here, while still ensuring rooms that are highly-functional, durable and appealing. It's also much easier and cheaper to upgrade your kitchen in years to come compared to upgrading your building envelope.
- **Reconsidering what is essential:** is that third toilet or a triple garage really more important than clean fresh air and tiny power bills? Fundamentals before fashion.

Beware those designers and builders that try to talk you out of higher performance: misconceptions abound and not everyone has kept up with building science developments. Some people are only comfortable with the way they've always done things.

Best advice: get certified Passive House professionals involved at the beginning of your project. Select a Passive House architect or designer, or involve one as a consultant on the project, providing energy modelling services and support to the architect of your choice.

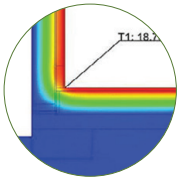
Find a current list of Passive House certified designers, consultants and tradespersons at passivehouse.nz/resources

The four stages of a **Passive House project**



Concept or preliminary design stage

It's early days in your project. Your Passive House designer will be considering basic questions of form, orientation, shading and the type of components needed to reach the standard. The Passive House certifier can offer advice or make recommendations if needed.



Design stage review

Certifiers call this the pre-construction review and it's vital that it does happen before construction begins!

Your Passive House designer's energy model in PHPP indicates what materials are required to meet the standard, for instance how much insulation and what type of windows and doors.

The detailed drawings and technical data are reviewed by the independent Passive House certifier. They will assess the design, flag any problems and ask any clarifying questions. At the end of this process, your project passes the pre-construction review, an important milestone. From this point, you have the security of knowing the design is correct and, if built according to the design, will result in a home able to meet its certification target.

Construction review

During this stage, the integrity of construction is being assessed and confirmed. There may be site observations and guidance provided to builders or project managers if needed. The project manager makes sure there is no unauthorised substitution of materials. Any variations made to the design are checked for their impact on performance.

On-site testing and calibration is carried out. Blower door testing is done twice at different stages of construction and the ventilation system is commissioned (tested and adjusted). Key parts of the construction process are carefully recorded with photographs and supporting documentation.

Final certification

Certification of a Passive House isn't something tacked onto the end of the project. It is deeply integrated throughout the design and build stages, adding significant benefit and quality assurance at every stage.

The Passive House designer will provide evidence for the components used and the construction process along with results of onsite tests. The certifier reviews all of the documentation against the Passive House standard to verify the home was built according to the design and has met its performance targets. Once filed with the international Passive House organisation, a plaque and certificate are issued.

Certification keeps designers and builders alike extremely focused on the required outcomes and quality of construction that ensure a Passive House works. It is a very small additional cost for the certainty that it provides.

Certification provides an independent, third-party review and is your assurance that you get the home you paid for.

While Passive House isn't a trade mark, consumer protection law means a person must have evidence if they describe a building as a Passive House. Be particularly wary of vague claims about using "Passive House principles".

The PHINZ booklet, *Claiming the Passive House Standard* has more information. It's available from the downloads section at passivehouse.nz.

Passive House Institute NZ strongly encourages certification of all Passive House projects.

Te Tōpūtanga o te
Whare Korou ki Aotearoa
Passive House Institute NZ

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